Innovation Steps Towards Efficient Goods Distribution Systems for Urban Areas

Arjan van Binsbergen
and
Johan Visser

Innovation Steps Towards Efficient Goods Distribution Systems for Urban Areas

Efficiency Improvement of Goods Distribution in Urban Areas

Dit proefschrift is goedgekeurd door de promotoren:
Prof. dr. ir. P.H.L. Bovy
Prof. dr. ir. H. Priemus

Samenstelling Promotiecommissie:

Rector Magnificus, voorzitter
Prof. dr. ir. P.H.L. Bovy, Technische Universiteit Delft, promotor
Prof. dr. ir. H. Priemus, Technische Universiteit Delft, promotor
Prof. dr. ir. R.E.C.M. van der Heijden, Technische Universiteit Delft
Prof. dr. M.B.M. de Koster, Erasmus Universiteit Rotterdam
Prof. dr. P. Rietveld, Vrije Universiteit Amsterdam
Prof. ir. J.C. Rijsenbrij, Technische Universiteit Delft
Prof. dr. A.J.M. Vermunt, Katholieke Universiteit Brabant

Printed in The Netherlands

Preface

Co-operation is a key-notion in this thesis. It is also the basis for this book.
Co-operation between players in a particular field, between researchers in the area of urban goods distribution in our case, enables bundling and efficiency gains. The size of this book clearly proves the fact that co-operation leads to bundling. However, we leave the prove that co-operation leads to an 'efficient thesis', to the reader. In our case, it clearly did not result in efficiency gains in time. Nevertheless, we still strongly support the idea of co-operation.

The thesis has a strong qualitative and conceptual bias. If possible, quantitative information is used. However, our analyses show that it isn't easy to gain insight in urban distribution processes by looking at the figures alone. In addition, the amount of mathematical expressions is fairly limited, but speaking with Terry Pratchett's Sergeant Colon[*]: "*There's al-gebra. That's like sums with letters. For ... for people whose brains aren't clever enough for numbers, see?*"
This isn't to say we have chosen the easy way: it was a complicated effort to set up a concise but comprehensive framework. It was even harder to make this understandable for the reader.

We are convinced that by means of this thesis we contribute to the search for well thought out concepts and applicable ideas for urban goods distribution processes for the benefit of companies, inhabitants and – in a broader perspective – economy and ecology.
We hope that the reader can take advantage of our ideas. We wish the reader the necessary perseverance to cope with the task of reading this book. Perhaps the same perseverance is necessary to cope with the real problems in the urban areas.

The long period of co-operation has led to a large number of publications and studies. The co-operation was so close that the respective names of the authors were regularly seen as being synonymous with each other. Of course, the co-operation wasn't always flawless, but these hick-ups were compensated for by periods of enjoyment and mutual support.

---

[*] From: T. Pratchett (1998) *Jingo, a Discworld novel*, London (Transworld Publishers).

Table of contents

PART I
Problem definition

CONTENTS OF PART I

1.   Problem definition and scope of research

1.1   Introduction

The distribution of goods for urban areas is vital for the prosperity of these areas. With respect to basic goods like food and other resources, urban areas are not self-supporting. In their role as a central focus of trade and retail commerce, urban areas cannot function without an adequate goods transport system. Nevertheless, there are various problems related to the urban goods distribution process. First, goods distribution vehicles cause pollution in the form of noise and exhaust emissions, reduce traffic safety, and physically obstruct the flow of other traffic. Second, goods traffic contributes to the accessibility problems of passenger transport that affect most urban areas. Finally, the efficiency of the urban goods distribution process itself is hampered by congestion, which can be exacerbated by public policy measures that were intended to reduce other problems. The combination of environmental and accessibility problems, both for passenger transport as well as for goods distribution, endangers the sustainability of urban areas. This implies that the way goods are currently distributed seriously jeopardises the attractiveness of these vulnerable areas for their present and future users, thereby endangering their future economic development and role in society.

The problems outlined above occur in the urban areas of all developed societies in Europe, America, Asia, and Australia. In a multitude of cases, policy measures have been designed, proposed, and implemented to deal with these problems. Nonetheless, the problems still occur and even tend to increase.

We argue that it is only possible to take effective measures if players understand the process of goods distribution for urban areas and act accordingly. Furthermore, we argue that policies can only be effective if a comprehensive set of policy actions is implemented, that addresses the problem at different geographical scales and at various functional levels of the urban

goods distribution system in concert. These functional levels refer to the organisational aspects of the system (logistics), the goods transport and goods traffic means, the infrastructures, and the spatial system in which the urban goods distribution process must function. Progressive innovation is needed on all these levels to arrive at an efficient urban goods distribution system, efficient both from the point of view of commercial interests as well as from society as a whole. These problems, measures and innovations will be analysed in the context of urban goods distribution in the Netherlands.

This thesis is structured on the basis of this line of thought.
In this first part, (Part I) we will further elaborate the problems and the foreseen developments of these problems. We will introduce our research questions and our research approach and will define the scope of the study. This part therefore results in a comprehensive, qualitative, and quantitative description of the problems related to goods distribution for urban areas.

Because we must first understand the urban goods distribution processes before we can design solutions, in Part II of this thesis we will construct a framework ('layer model') with which we can analyse the complex urban goods distribution system. The layer model will also be used to identify and categorise potential problem-solving measures. In Part II we will also apply existing micro-economic theory and logistics theory to enable a thorough understanding of the urban goods distribution system. The results of Part II will be used as a conceptual framework that will provide a basis for the development of an integrated and consistent set of measures that help to solve problems related to urban goods distribution.
The various levels at which solutions can be developed, are elaborated in Part III (Logistics), Part IV (Transport systems) and Part V (Spatial Networks). These parts result in a set of attuned, interrelated measures that lack only context to be meaningful. In Part VI, these measures will be assigned to potential players, then translated into an implementation strategy, and placed within a time-frame, in the context of an institutional framework. This framework is an elaboration of the layer model approach we developed in Part II.
Finally, we will determine which results (targets) can be achieved in a range of time-spans, and thence construct the framework for an implementation plan. This plan can then be executed by the concerned parties to achieve the targets in each time period. To conclude Part VI, we will show that the comprehensive set of policy measures indeed help to reduce the problems related to urban goods distribution.

1.2   Goods distribution for urban areas: problems and opportunities

Goods transport in urban areas is receiving more and more attention from policy makers at different governmental levels. Efficient goods distribution is a condition for competitive, vital cities, and yet is associated with the problems of urban liveability and accessibility, particularly in the inner city. While goods traffic in urban areas is essential to the delivery of goods and therefore for the local economy, it also generates high societal costs everywhere by producing pollution and noise in urban areas. Although trucks account for only 10 percent of all transport operations in urban areas, they produce over 40 percent of the pollution and noise caused by local traffic (COST 321 Action, 1997). In effect, goods traffic contributes

disproportionately to pollution, and thus to the reduction of the quality of life in urban areas. Goods traffic also contributes to a large share of local traffic safety problems. From both an environmental and from a traffic safety point of view, goods traffic is unwelcome in urban areas. Attempts to resolve the problem in order to protect the quality of life in particular areas and to make certain areas attractive for visitors have been made, restricting goods traffic is in many urban areas to certain routes and/or certain times. These solutions have caused their own problems, as shops and business in urban areas are hardly accessible at certain places and on certain times for goods traffic due to these restrictions and the resulting congestion.

These problems occur in most urban areas in the world and are as old as civilisation itself. To some extent, society tries to live with it. Each actor tries to find his own solution to the problem. In most cases, these solutions lead to a situation that is less than optimal from a societal and economic point of view of efficiency. For this reason, local governments, as well as regional and national governments, are interested in solving the problems related to urban goods distribution.

To illustrate this we take the situation in the Netherlands between the year 1990 and the year 2000 as an example.
The political attention in the Netherlands for the distribution of goods in urban areas can, to a large extent, be illustrated by the introduction of the urban distribution centre concept in the Second Transport Structure Plan (SVV II; Ministerie van Verkeer en Waterstaat, 1990).
An urban distribution centre can be described as a consolidation centre at the border of an urban area where goods are transshipped and consolidated into smaller 'environmentally friendly' vehicles. This concept should provide a long-term solution for the environmental and accessibility problems related to urban goods distribution. A discussion started between transport companies and local governments in the year 1991 in the Netherlands about the desirability and the feasibility of that concept as a solution to the problems in urban areas. However, this concept and other versions that were developed have not led to any promising results. Due to the lack of results and lack of public acceptance, the Ministry of Transport, Public Works and Water Management has taken a more pragmatic approach since 1995. They have chosen to only support private initiatives that lead to consolidation (for instance, through co-operation between private organisations) rather than developing long-term public actions. Although this approach is quite attractive from a actor's point of view, there is some question whether this is a very effective policy for the long term.
It is expected that both social and technological developments will affect the delivery of goods at shops, restaurants, and people's homes in the 21st century. The demand for goods transport in urban areas is likely to be changed by demographic, spatial, technological, and economic trends. In the meantime, technological developments will affect the way goods are bought and delivered. Particular innovations in information technology, such as E-commerce and semi-continuous customer response systems, will play a role. One of the most important changes currently taking place lies in the acceptance of external costs of transportation.
Thus, the future offers challenges as well as opportunities to change the urban goods distribution system into a more sustainable system.

This results in the following problem definition:

> *There is no clear insight as yet into how the future urban goods distribution system should look in order to support the concept of sustainable development, nor is it clear how these challenges and opportunities should be dealt with in order to implement the necessary changes in the urban goods distribution system. This research seeks to provide this insight.*

1.3   Driving forces for long term scientific research

There are two major driving forces for long-term research in the field of urban goods distribution in the Netherlands and in other developed countries; current problems and future technological change.

There are two larger current problems affecting urban goods distribution: the ineffectiveness of traffic control measures and the failure to meet environmental targets due to the growth of goods traffic. First, current measures, such as vehicle and time restrictions in sensitive areas, are proving ineffective, and may even create negative side effects. Second, long-term targets in environmental policy cannot be met due to the annual growth of goods traffic. New long-term prognoses for the Dutch economy show an annual growth of more than two percent in domestic goods transport during the next 20 years. This should cause a corresponding increase in economic and social costs due to congestion and environmental problems related to road transport (the bulk of domestic goods transport, the dominant factor in the total goods transport by road, is related in some way to urban goods distribution). The current policies of national governments and local governments do not provide a clear long-term vision to address these changes.

There is a growing awareness that technological and organisational changes in goods transport offer opportunities to make goods transport more sustainable. In September 1997, the Dutch Governmental Programme for Sustainable Technology Development published a report on a new sustainable logistic concept for commodity transport within urban areas (Brouwer et al., 1997a and 1997b). This new logistic concept was based on automated transport of commodities through small underground tube networks between shopping areas, residential areas, and industrial estates and between regions. In the aftermath of this report, the question came up whether new intermodal concepts, based on rail or new dedicated infrastructures, could lead to a consolidation of transport flows on less polluting transport modes, and in this way to a reduction of social costs.

Thus, the following driving forces can be identified:

> *The first major driving force, problem-driven, asks for a long-term problem-solving vision. The second driving force, a technology-push, needs an integrated and 'implementable' design, based on available technologies.*

1.4   Scope of the research

The scope of the thesis will be delimited by four factors: the geographic scope of the study; the social problems addressed through sustainability; logistic and technological developments relevant to the study; the type of goods flows that form a part of urban goods distribution.

Geographic scope
The cases in this thesis are related primarily to the situation in the Netherlands. However, the study has an international relevance, as the kind of problems at hand and the developed concepts to solve these problems also apply to a multitude of comparable situations throughout the developed world. The primary focus for our research is aimed at urbanised areas: areas with high densities for housing, commercial activities, and industry. It is, however, very difficult to find a generally (and internationally) accepted and usable definition for an 'urban area' (see Buursink, 1980). Especially in The Netherlands and in similar countries or areas in the developed world, we can recognize a continuum in built-up areas where variations in densities occur and where no sharp distinction between 'city' and 'rural area' can be made. Therefore, we leave the formal definition open and refer to urban areas as high-density areas with a large variety of types of activities.

Sustainability: environmental and economic issues
This thesis will develop concepts that are based on the idea of sustainable development (see also Section 1.5): that is, an environmentally sound and economically attractive development of the urban areas. We will also apply this notion to the goods distribution process for urban areas. This process should help to ensure the urban economic vitality by improving the accessibility for goods[1] at acceptable costs[2] (business efficiency). At the same time, the environmental burden must be limited to enhance the liveability of urban areas, again at acceptable costs (societal efficiency). With respect to the economic aspects, we will take into account the transport and logistic performance and costs of urban goods distribution. With respect to environmental issues, we will take into account the use of space, vehicle emissions, energy use, noise pollution, and also traffic safety.

Logistic and technological developments
The thesis focuses on the logistical and technological developments and opportunities for enhancing the efficiency of urban goods distribution. We focus on the feasibility of a modal shift in short-distance goods distribution, enabled by new logistic concepts. These intermodal concepts will be based on new goods transport technologies, the effective use of dedicated infrastructures (road, rail or other) between urban areas and the application of specialised systems within the urban environment.

Goods flows
In this study, we will focus solely on goods distribution in urban areas. Goods transport in urban areas in a broad sense is characterised by the nature of the goods (including consumer goods, mail, parcels, express delivery, building materials for building sites, and waste), the means of transport (mostly by road), size of shipments (relatively small), and the number of stops (large). The term *goods distribution in urban areas* as used here covers the transport of goods to, from and within urban areas, and deals with the delivery of mostly consumer goods to shops, department stores, supermarkets, hospitality industry, offices and directly to the

---

[1]   And the accessibility for people, insofar as it is influenced by goods transport.

[2]   This means that the transport costs must stay within acceptable limits, so that the competitive position of urban areas is not endangered.

homes of customers[3]. The focus is on goods distribution within urban areas but the interregional moves related to goods distribution will be included as well. Other kinds of goods transport that also take place in urban areas, such as transport of building material, garbage or traffic generated by ports or industrial areas which happen to be situated in or near urban areas, will not be considered here. These goods are rather bulky, and although they can constitute a large share in the transport volumes in urban areas, they are not part of the general focus of this study.

1.5   Research objectives and research questions

1.5.1   Introduction
In this thesis, we want *to develop an integrated long-term problem-solving vision of a future urban goods distribution system that supports the concept of sustainable development and a strategy to implement the necessary changes in the goods distribution system for urban areas.*
Thus, the general objective focuses on the following issues:
- Integrated vision: combining relevant logistics, technological and spatial aspects;
- Long term vision: aiming at a period more than ten years and up to thirty years;
- Problem-solving vision: meant to reduce obstacles and to improve accessibility, environmental quality and traffic safety;
- Sustainable development: supporting the social function of urban areas by enabling an efficient urban goods distribution system, both from a societal and business perspective;
- Implementation strategy: applying a consistent framework of institutional (public and private) measures to overcome the differences between the current practice and the envisaged system;
- Goods distribution system for urban areas: the whole of logistics organisation, traffic means, infrastructures, and other elements that enable the distribution of goods within cities and other dense, built-up areas.

From these issues, we will derive three research objectives; for each of these objectives, we will formulate research questions.

1.5.2   Research objectives
Although goods distribution in urban areas occurs daily, and local, regional and national governments do have a long term experience with policy making in this field, practice shows that there is still *no clear understanding* of the system: how it works and how it relates to environmental and accessibility issues. Overestimating the effectiveness of policy measures and underestimating the negative side effects of said measures happens all too often in public policy making.
Therefore, the following research objectives result:

---

[3]   In the literature on logistics, this kind of physical distribution is referred to as final distribution.

(1) Develop a clear *understanding* of the goods distribution process for urban areas and the way it is related to environmental and accessibility problems.

The analysis needed to achieve insight into the goods distribution process for urban areas is a necessary first step in developing various solutions for the defined problems. Some of these solutions will be based on trends that are already taking place, while other solutions can be characterised as new or even revolutionary. It is critical, however, to account for the fact that the various possible solutions will affect each other. The effects of these mutual interactions are not well known, therefore, these interactions must be analysed in a systematic way, to be able to develop an integrated concept:

(2) Analyse, develop possible solutions for the problems related to urban goods distribution, and establish an *integrated concept* for an efficient goods distribution process for urban areas.

In such an integrated concept, various possible solutions are combined to be able to reach the optimum result: an urban goods distribution system that a) improves the liveability (environmental quality) of urban areas by reducing the negative side-effects of goods transport and b) enhances the accessibility (and thereby helps to strengthen the economic vitality) of urban areas, by enabling sufficient and reliable goods transport options. The introduction of this integrated concept requires concerted actions from both public and private players, over a long span of time, *a type of policy planning that has not been proposed before*. What is therefore required is to:

(3) Develop a comprehensive policy plan for implementing effective policy measures, which aims at improving the efficiency of the goods distribution process for urban areas.

Within this comprehensive policy plan, the distinct players, their roles, and the timing of actions must be defined.

The study results in an integrated design of a goods distribution concept for urban areas, including the related policy plan, consisting of the needed institutional framework and implementation plan. The study focuses on designing a comprehensive concept for the distribution of goods for urban areas. We will deliberately pay attention to both the public sector and the private sector, although eventually the emphasis will lie on the public policy making in the field of urban goods distribution. Historically, governments have only had limited control over the privately operated urban goods distribution system, compared to their ambitions. However, at the same time, public policy measures have strongly impacts private operations, if only indirectly. In some cases, public policy implications have even contributed to the urban goods distribution problem. Therefore, we seek an integrated approach in which public and private actions are combined ('concerted actions'). Both the approach in itself (the policy making process) as well as the contents of the policy plans, are part of this study.

Some of the terms used in the above stated research objectives need further clarification because they are used in a specific manner throughout this thesis.

    Efficiency is defined as the ratio of the normative costs to achieve certain results and the actual perceived costs (including negative effects) and deals in this context with economic costs as well as social costs. We define social efficiency improvement as the reduction of

the total social costs of transport with the same or improved ability to transport goods in the desired amount and variety to and from urban areas from the viewpoint of sustainable development. Economic efficiency improvement means the reduction of the total costs at the same or improved quality level of transport.

The future urban goods distribution must fit within the concept of sustainable development. *'Sustainable development'* is defined as: "Development which meets the needs of the present, especially of the world's poor, and protecting the ability of future generations to meet their needs" (World Commission on Environment and Development, 1987). This implies that there is a need to find a balance between economic growth and environmental conservation. The social and economic efficiency of the urban goods distribution system becomes the indicator for the sustainability of the system.

With *exogenous developments*, we refer to developments in society (demography, general policy), economy (income, price levels), and technology that are not significantly influenced by the process of goods distribution for urban areas.

In Section 2.2 of this thesis we will define these terms in more detail.

1.5.3   Understanding the goods distribution process for urban areas

The first research objective of this thesis deals with developing a clear *understanding of goods distribution in urban areas* and its relationship with environmental and accessibility problems. From this, we derive the following research questions:

- Which problems related to urban goods distribution can be determined , what is the magnitude of these problems and what are the expected developments in this respect?
- How can we explicate the goods distribution system for urban areas in a methodological and systematic way?
- What developments are taking place in the various levels of the urban goods distribution system (organisational developments, technological developments, and infrastructure developments)?

The first research question results in qualitative and quantitative insights into the problems related to goods distribution for urban areas, both currently and in the future (this question is particularly addressed in Part I of this thesis).

The answer to the second question is laid down in a systematic description of the goods distribution system ('layer model'), an adapted and applied micro-economic random utility theory, and in an adapted and applied logistics theory (the fundamental aspects of this question are addressed in Part II of this thesis, the application within the logistic theory is addressed in Part III).

The answers to the third question are given and used throughout Part I (external, autonomous developments in demography, economic development and spatial development), Part III (logistical and organisational developments), Part IV (technological developments) and Part V (spatial developments, directly related to urban goods distribution processes).

1.5.4   Analysis and development of solutions and establishment of an *integrated concept*

The second research objective, which deals with the analysis and development of solutions to urban goods distribution problems and develops an *integrated concept* for an efficient goods distribution process for urban areas, is translated to the following research questions:

- What logistical concepts could lead to an efficient (and sustainable) urban goods system?

- Which conditions (infrastructural, spatial, and technological) could support the implementation of these logistical concepts?

These research questions are addressed in the Parts III (logistics), Part IV (technology), and Part V (spatial issues), respectively.

1.5.5   Development of a comprehensive policy plan

The third research objective concerns developing a comprehensive policy plan that aims at improving the efficiency of the goods distribution process for urban areas. From this objective, we derive the following research questions:

- How does public policy-making and planning on urban goods distribution take place? How should it take place in the future?
- How could the urban goods distribution system be designed in order to improve the efficiency of urban goods distribution in the future?
- In order to implement these innovations in the urban goods distribution system, what should a consistent and integrated set of policy measures look like, which public policy actions can be defined, who should perform these actions and in what order should these actions occur?
- Does the integrated concept for urban goods distribution lead to the required level of efficiency improvement and is the implementation of the concept feasible?

The answers to these research questions result in the formulation of a policy framework that describes the various players and the types of roles they can play, and a policy implementation plan that describes the policy actions (measures) that each of the players must take, placed within a timeframe. Although attention is paid to both private and public policy actions, the emphasis lies on public policy. These research questions are addressed in Part VI of this thesis.

1.6   Scientific and societal relevance of the thesis

Frederick Betz (1998) describes science as "the discovery and understanding of nature". The purpose of scientific research is (1) to discover new elements and aspects of nature and (2) to achieve understanding of nature through observation and experiments, leading to the development of a theory. In this study, we will try to discover and understand the nature of the urban goods distribution system, as well as the complex interactions between this system and society. We will observe the art of policy making in the field of urban goods distribution and will try to discover how policy making and the policies in this field can be improved. In two areas, we will contribute to theory formulation. The theory of logistic concepts will be elaborated according to our three-step approach (describe, explain and design). The institutional framework will attempt to bridge the gap between theory and practice in the policy making process regarding the participation of actors, and will try to define the role of analysis and modelling.

This thesis is the product of multi-year research in an under-researched field. This has offered us opportunities to discover new developments and to come up with original and sometimes innovative ideas. Our objective was to conduct a comprehensive study in that area. We have

tried to establish innovation into each building block of our design, into the integrative part and the design process. Some of these innovative thoughts were developed as co-productions with consultants and our 'clients' during applied research projects (see also Section 2.3).

The scientific contributions of this thesis consist of:

- Systematic analysis of the urban goods distribution process as an extended transport multi-layer model, and thereby adapting and applying the integrated systems approach of solving problems related to urban goods distribution (introduced in Part II and applied throughout the thesis).
- Adaptation of micro-economic random utility theory to the process of goods distribution for urban areas (see part II).
- Adaptation of general logistics theory (describing the trade-offs between basic logistic activities) to the process of goods distribution for urban areas (see Part III);
- Application of the notion of intermodal goods transportation to the specific field of goods distribution for urban areas (short distance intermodal transport, see Parts III and IV);
- Development and application of the notion of 'concerted actions' of public and private parties within the field of urban goods distribution (see Part VI).

The topic of urban goods distribution is studied mainly from a technical (transportation engineering) standpoint. We used in this thesis economic theory in order to develop a common platform (in terms of approaches and terminology) for different related topics in urban goods distribution.

Apart from the scientific contributions, the study also has strong societal relevance; we try to provide answers for a socially relevant question, namely, the various problems related to the goods distribution for urban areas, in particular, environmental and accessibility problems. We address both private and public interests within the process and define an integrated policy that takes into account both points of view. We argue that an understanding is needed into the goods distribution process, both with regard to the content as well as from a methodological point of view. With regard to the content, we examine the types of problems and the magnitude of the problems, described in a quantitative and qualitative way.

The methodological view defines which players are involved, what roles they play, what interactions can be identified. This understanding helps to formulate a consistent and integrated set of possible solutions, on organisational, technological, and spatial levels. This insight also helps to develop a policy framework that can be applied to put the required policies into practice. We can therefore suggest some practical, applicable solutions, and make recommendations for policy makers, both in the field of policy processes, as well as in the field of policy 'content'.

1.7   Summary and conclusions

Goods distribution is vital for urban areas, but also causes problems. By clearly identifying the problems, by systematically analysing the system, its components and their mutual interactions, we can try to understand the processes and interactions. This understanding helps us to develop alternative processes and the needed private and public policies to implement these alternatives.

2. Structure of the thesis

2.1 Introduction

The intriguing but complex research area of urban goods distribution cannot be thoroughly analysed without a systematic approach, therefore such an approach - the layer model - is used throughout this thesis and is also used to structure this thesis. The following will introduce the different steps in the approach and will also go into related research that preceded the accomplishment of this thesis.

2.2 Stages in the research

The thesis is structured in six parts (see *Figure 2-1*), following the conceptual development of steps to an efficient goods distribution system for urban areas. First, we will identify and analyse the problems related to this distribution process. Then we will seek, modify, and apply theories and methods that help us to understand the process, and that we will also use to structure the development of alternative approaches. Then we will systematically take an inventory of developments, identify opportunities, and develop concepts for the distribution of goods for urban areas. Eventually, we propose a policy plan for implementing these concepts.
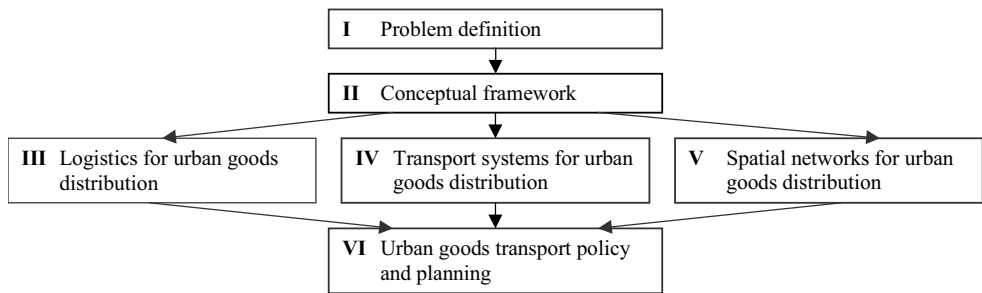
Figure 2-1: Interrelated Parts of the thesis

The six parts of this thesis are described below.

Part I: Problem definition and research objectives
In Part I, we will define the problem area, establish the research objectives and research questions, and present the research approach.
Part I is dedicated to the first research objective of the thesis: "develop a clear *understanding* of goods distribution in urban areas and the way it is related to environmental and accessibility problems". The goods flows related to urban goods distribution are defined and analysed by investigating information on the characteristics of urban goods distribution. This information is used for categorisation, quantification and checked for information gaps. The magnitude of the problems and the share of urban goods distribution with respect to all goods transport are estimated. In addition, exogenous developments are analysed and their effects on the urban goods distribution process and the related problems are forecasted. The first part results in a quantitative and qualitative determination of the problems at hand, setting the stage for solutions. Part I also forms the basis for the construction of the conceptual framework and the analyses of the other parts of the thesis.

Part II: Conceptual framework
Part II is devoted to the theoretical and methodological issues related to urban goods distribution. Micro-economic random utility theory will be linked to urban goods distribution. The concept of markets, as derived from this micro-economic utility theory, will be used to structure the system of urban goods distribution as a layer model. The principles of optimising urban goods distribution will be defined in terms of efficiency improvement. Part II provides the fundamentals for the integrated approach of problem solving as is proposed in this thesis.

Part III: Logistics for urban goods distribution
Part III introduces general logistics theory, which is subsequently adapted and applied to the urban goods distribution process. We will attempt first to understand how different activities interrelate, then, to help to conceive new (or adapted) logistic systems for distributing goods for urban areas. This part presents new (intermodal) logistic concepts that are needed to perform efficient goods distribution. These organisational concepts use technologies and spatial arrangements that are subsequently developed in Parts IV and V. The essence of these

intermodal logistic concepts is that they are more efficient in terms of social and economic costs, as will be demonstrated in the evaluation of Part VI.

Part IV: Transport systems for urban goods distribution
Part IV goes into the development of transport options, in particular the technological innovations necessary to support the development of the new logistic concepts. From Part IV we learn that the most efficient systems for inner city transport differ substantially from the most efficient systems for inter-urban transport, thereby stressing the importance of intermodality (as is supported by the logistics organisation as developed in Part III). Part IV results in a comprehensive set of potential technologies that can be used for urban goods distribution, options that will become available in different time periods.

Part V: Spatial networks for urban goods distribution
The logistic concepts (as developed in Part III) and the related transport technologies (as developed in Part IV) need adequate infrastructures and spatial requisites. New logistic concepts will make use of transshipment, sorting and temporal storage facilities that should be included in logistic parks. Advanced traffic systems will use new infrastructures that should be allocated within corridors to ease the implementation. Part V sums up the spatial conditions for new logistic concepts and transport options related to urban goods distribution.

Part VI: Urban goods transport policy and planning
Parts III, IV, and V in fact form the building blocks (with respect to the contents) for the policy plan that must lead to the implementation of these concepts. Because a multitude of players is involved and some concepts will take a long time to introduce, a good definition of players and roles is necessary. Therefore, Part VI develops a policy framework and a policy implementation plan. Part VI develops a long-term strategy to implement the new integrated concepts, in particular from a policy-making viewpoint. The new integrated concepts are evaluated in terms of their contribution to efficiency improvement of the urban goods distribution system.

2.3   Related research programmes

This thesis is the elaboration and synthesis of research that has been accomplished by the authors. These researches dealt with urban goods distribution issues, intermodal goods transport, and other related issues. The results yielded significant elements for this thesis. At the same time, the research for this thesis is part of a larger research program on automation of goods transport. Figure 2-2 outlines the interrelation between the different research projects.

```
┌─────────────────────────────────────────────┐
│             Urban goods distribution         │
│    Distribution in future urban areas (1993) │
│      City distribution in Delft (1994-1997)  │
│             Nederland 2030 (1996)            │
│           [COST 321 (1995-1998)]             │
└─────────────────────────────────────────────┘
```

┌──────────────────────────────────────┐   ┌─────────┐   ┌──┐
│ Problems in Agglomerations (1990-1994)│───►   │   │   ◄───│   Intermodal goods transport   │
└──────────────────────────────────────┘   │ FTAM   │   │ Rail Distribution in the Netherlands 1996)│
                                                 │   │   │   Standardised Load Units (1998)   │
┌──────────────────────────────────────┐   │   │   └──┘
│   Long-term spatial planning   │   │   │
│   North Holland (1995)   │───►   │dissertation│   ┌──┐
│   RuimPad (1994-1997)   │   │   │   │   Underground goods transport   │
│   Nederland 2030 (1996)   │   │   │   │   State-of-the-art (1995)   │
└──────────────────────────────────────┘   │   │   │   Potential use of underground transport │
                                                 │   │   │   (PbIVVS; 1995)   │
┌──────────────────────────────────────┐   │   │◄── │   Underground goods transport in urban   │
│ Environmental friendly goods transport│   │   │   │   areas (DTO; 1995-1998)   │
│   Trendbreach Scenario (1993)   │───►   │   │   │ Nation-wide underground logistics system │
│   SYRENE (1994)   │   │   │   │   (IPOT; 1997-1999)   │
│   Transport of polluted soil (year)   │   │   │   │ Underground Logistics System Schiphol   │
└──────────────────────────────────────┘   └─────────┘   │   (OLS; 1996-1999)   │
                                                                └──┘

Figure 2-2:   Related research projects

Urban goods distribution

From the end of the 1980s, urban goods distribution policy became a point of interest for Dutch policy makers. Various solutions were suggested and some of them were put into practice for a short time. Visser (1992) studied the efficiency of these measures and thereby laid the groundwork for this thesis. The research on 'Goods Distribution in Future Urban Areas' (Van Binsbergen and Schoemaker, 1993), as carried out for the Traffic Research Centre of the Dutch Ministry of Transport and Public Works, developed and analysed various options for reducing problems related to urban goods distribution. The research was undertaken in a period when, in the Netherlands, the first experiments with government-operated 'urban distribution centres' were proposed (see also Part VI). Van Binsbergen and Schoemaker proposed a co-operative, joint-distribution approach and introduced the licensing-system concept; these concepts are elaborated and adjusted in this thesis (see Part III).

For the Dutch city of Delft, Visser and Van Binsbergen (1997) investigated the appropriateness of an 'urban distribution centre' for Delft. Although the conclusion was a negative one, they proposed a successive implementation plan that would allow the municipality to take short-term measures that would fit in a long-term policy. This implementation plan was the basis for the plan as we propose in Part VI of this thesis.

Visser (see COST 321 Action, 1997) contributed to the European Union action COST 321 that resulted in an analysis of the state-of-the art in Dutch urban distribution policy. The co-operation within COST 321 also produced valuable information about policies in other European countries (see also Part VI).

(Short-distance) intermodal transport

The Dutch railway operator, NS-Cargo (now Railion Benelux), developed a concept called 'Rail Distribution in the Netherlands' (RDN) that aimed at using cargo trains for the distribution of various goods within the Netherlands (distances of about 100 - 150 kilometres). This idea was the basis for the trunk line or backbone network concept as

proposed in this thesis (see Part III on Logistics and Part IV on vehicle technology). Van Binsbergen et al. (1997) researched the optimal locations for transfer points for this system, and also investigated the potential role for standardised load units. Van Binsbergen et al. (1998) extended this research on load units for the application in road, rail, and underground systems (see also below and Part IV).

Underground goods transportation
In studies for various companies and governmental institutes, the authors researched the possibilities for applying underground systems for the distribution of goods. Visser et al. (1999) sketched an international overview of the state-of-the-art for proposed underground systems. Van Binsbergen, Shoemaker & Van Goeverden (1995) investigated the fundamental advantages of underground transportation and in fact introduced the notion that one of the main advantages of underground transport is the fact that it can be 'undisturbed' transport (see Part IV).
Visser and Van Binsbergen also contributed to the large, government sponsored, research program about the Underground Logistics System Schiphol (OLS; see CTT, 1997), that envisages connecting the logistic activities of the Flower Auction in Aalsmeer with the nearby Amsterdam Airport (Schiphol), and a newly-to-build railway goods-terminal nearby. An automated, underground transport system, with a length of about 15 kilometres, should interconnect these logistic activity centres. These 'OLS' studies formed the basis for similar studies for applying underground systems within urban areas. Visser et al. designed such a system for the cities of Utrecht and Leiden (see DHV/TRAIL Onderzoekschool, 1996; Buck Consultants et al. 1999). These researches not only resulted in a design philosophy for such systems, but also resulted in a good insight into the goods flows to be transported within urban areas, and in insight into the possible application of standardised load-units (see Part IV).
The authors also researched the possibilities for a nation-wide system that would interconnect the local underground networks (IPOT Nation-wide Network; Visser et al., 1998; see also IPOT 1999, 2000). Based on the ideas of Vermunt in this IPOT study and the concepts as developed in the RDN-study, the 'network-logistics' concept was developed (see Part III).

Other related studies
Other studies not specifically aimed at the problems of urban goods distribution, turned out to be quite valuable for this subject as well. In 'Problems in agglomerations', Visser made an inventory of environmental and accessibility problems in urban areas, and thus formed the basis for the problem analysis in this thesis (see Visser, 1991).
Van Binsbergen, Visser et al. were involved in different scenario-studies for the far future in spatial planning in the Netherlands (commissioned by the Dutch government: 'Ruimpad' (see Van Binsbergen, Egeter, Van Goeverden & Schoemaker, 1995) and 'Nederland 2030' (Van Binsbergen et al., 1996) that explored the potential of the spatial concept of corridors for line-infrastructures; this concept is elaborated in Part V of this thesis.
In early studies about the possibility of diminishing the environmental burden of goods transport, the possibility of short-distance combined transport (Trendbreach Scenario project, Schoemaker et al., 1993; Van Binsbergen and Walstra, 1994) and the energy-saving options of advanced engine technologies (SYRENE-project, Van Binsbergen, Erkens & Hamel, 1994)

were explored. These studies formed the basis of the logistics intermodal approach (Part III) and the survey of technological options for urban goods distribution (Part IV).

Freight Transport Automation and Multimodality (FTAM)
The research that was carried out for this thesis forms a part of a larger research programme 'Freight Transport Automation and Multimodality' (FTAM)[4]. This research programme focuses on the feasibility of a modal shift, created by new logistic concepts, in hinterland as well as domestic goods transport. New logistic concepts will be based on inter-modality, and will make use of automated transport systems on dedicated infrastructures (road, rail or other). One of the projects (FTAM-project "Multimodal transfer points and automated goods transport for urban areas") concerns urban goods distribution. In this project, current urban goods distribution problems are analysed and strategies are developed to ascertain how technological and organisational changes could lead to a more sustainable urban goods distribution system. This thesis is part of this FTAM-project.

2.4   Summary and conclusions

We argue that only a thorough analysis of the problems, a systematic analysis of the goods distribution system, a methodical development of alternatives, the design of an integrated concept, and the design of a comprehensive and coherent policy plan can help to reduce the problems related to goods distribution for urban areas. The structure of this thesis follows this line of thought, by first defining the problems, and then sketching the conceptual framework. From this, solutions for the identified problems are developed at different levels, and these solutions are integrated in a coherent policy plan.

The thesis is based on a number of research projects that were conducted in various fields, which resulted in valuable ideas, which are then used and elaborated throughout this thesis. The combination of fundamental and applied research gave us the opportunity to collect relevant data material and to test ideas in practice. This approach also led to a fast dissemination of findings, even preliminary results. However, it should be noted that this approach requires a relatively long lead-time.

---

[4]   The original framework for the FTAM project was created in the 'Beek'-project Efficiency Improvement of Goods Transport in Urban Areas (1994-1997).

3. Goods distribution: some facts

3.1 Introduction

This chapter focuses on the first research objective of this study: *to develop a clear understanding of the goods distribution in urban areas*. This chapter is therefore the first part of the problem definition of this thesis.

In this chapter, we define the notion of 'urban goods distribution' and structure the information on the characteristics of urban goods distribution. This provides us with a quantitative base to illustrate the relevance of urban goods distribution in comparison with the whole of goods transport. Information provided in this chapter will be used in the subsequent parts of the thesis.

In this chapter, we will first elaborate the definition of goods distribution in urban areas in more detail. We will distinguish goods distribution traffic for urban areas, the focus of this study, from the other types of goods traffic that we do not consider. We will then describe the distribution of goods in urban areas in term of its characteristics. We will use data from literature that apply to the Netherlands. We will then use the situation in the Netherlands as a case that to a large extent is representative for the situation in comparable areas in other developed countries. Finally, we will develop an estimation method with which we will estimate the volumes in terms of traffic and transport, and we will estimate the transport performance of urban goods distribution on a national level for the Netherlands. With this information, it will be possible to get a quantitative insight into the significance of urban goods distribution within the total goods traffic flows in the Netherlands. This will provide us with an indication of the magnitude and thus the importance of goods distribution, and with qualitative and quantitative information about the process, that we will use in later parts of this thesis (Parts III and VI) to formulate concepts for urban goods distribution.

3.2   What is included and what is excluded?

Goods distribution in urban areas covers the transport of consumer goods to, from, and within urban areas, and deals with the delivery of consumer goods to shops, department stores, supermarkets, the hospitality industry, offices, and directly to the homes of customers. We established a typology that specifies types of destinations with comparable distribution characteristics (see Table 3-1). The goods distribution for urban areas concerns the final distribution of consumer goods to these destinations. Other goods traffic, which may also take place in urban areas, is not studied explicitly in this thesis.

Table 3-1:   Types of destinations in relation to goods distribution for urban areas and the related (Dutch standardised) chambers of commerce codes (Source: DHV 1999 (extended and adapted))

Code	Type of activity	Classification codes of the Chambers of Commerce (BIK-code)
A	Supermarkets	5211
B	Grocery stores (specialised)	5212
C	Other food and personal care	522, 523
D	Fashion	5241, 5242, 5243
E	Living	5244
F	Electro-technical stores	5245
G	Books	5247
H	Other retail stores	5246, 5248, 5249, 5250, 527
I	Hotels and restaurants	551, 553
J	Bars and pubs	554
K	Recreation	911, 912, 921, 922, 923, 924, 9261
L	Offices	65, 66, 67, 70, 72, 73, 74, 75, 80, 85, 93
M	Homes	-

Each individual branch (depicted as A through L in Table 3-1) can be expressed in a (combination of) Dutch standardised code for firms (BIK-code), where a two-digit code stands for a higher aggregation level than a three-digit code.

The weekly street markets, which mainly take place in the inner cities, also cause goods traffic in the downtown areas. The stalls and trucks that occupy space cause a temporary decrease in parking and traffic space in the inner city. The provisioning of daily and weekly markets is included in the discussion, but it constitutes a target group that is not easily quantifiable due to its ambulant character.

Daily shopping activity and the resulting goods traffic by consumers is in itself of utmost importance in both the final distribution process and in resulting traffic performance; nevertheless, in this thesis we will focus on goods distribution by firms. Delivery traffic to homes (e.g., that caused by e-commerce) is, however, a direct point of attention.

We use four criteria for good flows that should be met to be included in the definition of urban goods distribution in this study:

1. *Type of goods:* consumer goods;
2. *Place in the logistic chain:* final distribution;
3. *Situation:* destination within an urban area;
4. *Objective:* primary objective of the movement should be the transportation of goods.

It should be noted that there are considerable goods traffic flows in the urban environment, such as building and demolition traffic, the provisioning of industry with raw materials and semi-manufactured articles, and the provisioning of the wholesale trade, that are excluded by the definition stated above. Therefore, the results of this thesis will not, in themselves, solve all problems related to goods transport (in general) in urban areas.

3.3   Classification of goods

3.3.1   Introduction

The nature of products and the type of packaging (together forming the physical characteristics of goods) determine a part of the primary requirements for the physical distribution process that transports the goods from the origins to the destinations. The marketing characteristics of goods and goods flows have an impact on the additional requirements for this process. Together, the product characteristics (see Section 3.3.2) and the marketing (channel) characteristics (see Section 3.3.3) form the 'shipment characteristics'. These shipment characteristics (see Section 3.4) form the complete set of requirements for the physical distribution process.

3.3.2   Physical characteristics of goods

The physical characteristics of goods (also named 'product characteristics in a restricted sense') determine the way goods have to be physically treated in relation to exposed forces, humidity, temperatures, accelerations etc. These characteristics are:

- Form: distinction between packed and unpacked goods, dry and wet (fluid) bulk, general cargo, and outsized general cargo.
- Physical density – the weight to volume ratio.
- Package and package density – the type of package and the number of packages per cubic metre (by definition, the package density of bulk goods is low).
- Degree of standardisation (of packages) – highly standardised packaging allows mechanisation and automation in the distribution process and generally leads to lower costs and faster and more secure (reliable) services.
- Value density – the value of a product related to the volume or weight.
- Perishability – the rate of functional decay in time.
- Vulnerability – the sensitivity for damage of goods for external impacts (shock, temperature changes, humidity, and light).
- Danger – the risk that products pose to their environment.

Form and packaging

Table 3-2 shows that most goods in the urban distribution process are packed in boxes or are transported in another specialised way (e.g. hanging garments). The table also shows that only a relative small share of shipped goods is stowed on or in larger load units like pallets, containers, or crates.

Table 3-2: ***Type of packaging (share of all shipments) in Dutch inner city shopping centres (source: Hoofdbedrijfschap Detailhandel (HBD), 1992)***

Type of packaging	%
Box	49
(Other) package	5
Pallet	4
Container	8
Crate	6
Other: hanging garments etc.	26
Unknown	2
Total	***100***

Package and volume density

For determining the suitability of logistics concepts for the movement of specific goods types, a portfolio type of classification can be used. The portfolio, or matrix, applies to cargo and discriminates between value density and package density and thus defines four cargo categories (see: Van Goor et al., 1992):

A: *Low value density, low package density* (low value bulk cargo); e.g.: crude oil, cereals;

B: *High value density, low package density* (high-value bulk goods or outsized general cargo); e.g.: chemical by-products, machines);

C: *High value density, high package density* (high value, relative small goods); largely end- or consumer products like clothing and food;

D: *Low value density, high package density* (low value, relative small goods); e.g.: flowers, bulbs, manufactured building materials.

The breakdown of logistic costs (storage, handling and transport costs) differs per goods category, as can be derived from Table 3-3.

Table 3-3: ***Share of storage, handling, and transport costs in total logistics costs (Van Goor et al., 1992; adapted)***

Costs categories	Group A	Group B	Group C	Group D
Storage costs	10	40	45	10
Handling costs	10	10	30	45
Transport costs	80	50	25	45

From the table, Figure 3-1 can be derived:

share of storage costs	low package density	high package density		share of handling costs	low package density	high package density		share of transport costs	low package density	high package density
high value density	**B** high	**C** high		high value density	**B** low	**C** high		high value density	**B** high	**C** medium
low value density	**A** low	**D** low		low value density	**A** low	**D** high		low value density	**A** very high	**D** high

Figure 3-1: *Share of storage, handling, and transport costs in total logistics costs*

Now, in urban goods distribution, most of the relevant goods fall within the 'C' category, and much of the rest of the goods within the 'D' category. This would render the above categorisation almost useless, because it would not discriminate between goods. However, we can use the same basis of the categorisation to subdivide the 'C' category, resulting in the following subcategories (see Table 3-4). Note that some product types (food, domestic appliances, clothing and furniture) have a wide range in value density. Therefore, the same product types can occur in different subcategories.

Table 3-4: *Subcategories of goods with some examples*

	Value density	Package density	Examples
Ca	low	low	DIY-products, food, clothing
Cb	high	low	cars, furniture, large domestic appliances
Cc	high	high	jewellery, glasses, perfumes, medication
Cd	low	high	food, shoes, clothing, books

Perishability, vulnerability and danger (dairy, dirty, difficult)
To distinguish goods that are suitable for urban distribution processes from goods that are not, the latter group has been defined as dairy, dirty or difficult[5] (Coopers & Lybrand, 1991a and 1991b):
- *Dairy* goods represent the category of goods that must be cooled or, more generally speaking, be handled and transported under strict conditions concerning temperature and/or humidity (perishable goods).
- *Dirty* goods represent goods that may contaminate or damage other goods and includes for example, waste and dangerous chemicals (dangerous goods).
- *Difficult* goods are large and/or heavy goods that cannot be handled by using standard handling equipment (vulnerable or heavy goods).

These goods require special treatment and are not suited to being distributed by 'standard' distribution processes and 'standard' vehicles. Table 3-5 shows the importance of this type of goods for different branches of trade: overall, almost 27% of the shipments ask for special requirements. Contrary to the original opinion of Coopers & Lybrand (1991a and 1991b), we argue that part of these special care shipments can still be distributed via an urban goods distribution system that is adjusted to some of their requirements. Large retailers show that

---

[5]   To be seen as 'caricature' words, meant to easily describe categories

combined distribution of special care goods is quite possible and - apparently - efficient (see also Part III: composite distribution).

Table 3-5:   ***Share of shipments with special-care requirements (per sector in Haarlem, 1995) (source: Heidemij 1995)***

	Clothing	Non-clothing	Hotels and catering industry	Other	Offices	**Total**
Fresh	0	3.2	1.1	0	0	*2.4*
Hanging	54.7	0.4	0	0	0	*7.4*
Cooled	0	11.1	31.1	0	0	*10.8*
Dangerous	0	0.5	1.1	1.0	0	*0.6*
Other*	0	7.1	0	8.9	37.7	*5.6*
Total	**54.7**	**22.3**	**33.3**	**9.9**	**37.7**	**26.9**
* other special requirements						

3.3.3   Marketing characteristics of goods

Product characteristics in a broad sense determine the required quality of the logistic system in terms of speed, accuracy, (promptness) and costs. These product characteristics are (see McKinnon, 1989 and Van Goor et al., 1992):

- *Rate of replenishment* – the frequency with which goods are sold, bought, or replaced, respectively; goods with high replenishment rates require 'continuous' transport systems while goods with low replenishment rates (slow movers) may also be distributed on an ad-hoc basis.
- *Search time* – the average time a consumer spends in searching for a particular product; goods with long search times allow for less reliable distribution systems, as the consumer is likely to return to an outlet if the product is temporarily out-of-stock. Products with short search times require frequent and reliable distribution systems as an out-of-stock means that other (competing) products are bought.
- *Gross margin*: products with large gross margins allow for higher costs in the distribution process and do generally not need a high turnover[6]; products with low gross margins require high turnovers (and a transport system that supports such volumes, but that is rather cheap per unit).
- *Perishability*: the speed with which a product depreciates; quickly depreciating goods require fast and reliable transport systems.
- *Stage in product-life-cycle*[7]: newly introduced, as well as 'declining' products require higher reliability in transport processes than products in a stable market.

These marketing characteristics of goods set the requirements for the distribution process and therefore for the logistics concepts (see Part III) and related transport systems (see Part IV) that should be used to distribute the goods in a most appropriate way.

---

[6] Products in an up-market (price) segment.

[7] Product-life cycle here refers to the stage in the market development cycle (introduction – growth – stabilisation – decline), not to the life cycle of the individual product (production – use – disuse/recycling).

3.4   Shipment characteristics

Product characteristics, together with the characteristics of the marketing channel in which they are sold (see Part III), form the 'shipment characteristics'. We have defined four categories, each consisting of two groups - resulting in eight 'shipment characteristics'. The shipments can consist of different types of goods.

Fast movers / slow movers
Fast movers are goods that are traded in large (physical) volumes; these are generally goods with a high rate of replenishment, a short searching time, a relative high degree of standardisation (of packages) and a stable market position. The gross margin of these goods is often (but not necessarily) relative low. Slow movers generally have the opposite characteristics.

Commodities / specialities
Commodities are goods that are traded widely (intensive distribution marketing type): most retailers in a certain branch of trade sell these products. Generally, commodities, like fast movers, have a low gross margin. Contrary to commodities, only specific retailers sell specialities.

Time critical / non time-critical goods
Time critical goods must be distributed within a tight time schedule; otherwise, the value of the goods is lost or strongly reduced. Perishable and high-value goods are often time-critical goods, most other goods categories are less or non time-critical.

Homogeneous / heterogeneous shipments
Shipments can be either homogeneous or heterogeneous with regard to a specific characteristic. Therefore, homogeneity is no 'absolute' characteristic. A shipment can be regarded as being 'homogeneous' from the viewpoint of one characteristic while it is heterogeneous with regard to other characteristics.
In practice, homogeneity will be regarded from the (combined) viewpoint of:
- Physical characteristics of goods, such as the type of packaging;
- Marketing characteristics of goods, such as the economic perishability of goods;
- (Other) shipment characteristics.
Generally, homogeneous shipments are easier to deal with because of the - relevant - similar characteristics of the goods they consist of. Homogeneous goods can be treated in a standardised way, although 'standardised' can be considered from a number of different viewpoints, including physical handling (loading, unloading, transshipment) and transport.
The homogeneity of the shipment is a significant factor in relation to transport costs. Goods that are homogeneous with respect to their packaging, can, for example, be transported more efficiently than heterogeneous goods. Homogeneous shipments generally allow higher load factors resulting in lower relative space occupation and lower transport prices.
Within the physical distribution channel (see below), a pattern can be seen where mostly homogeneous shipments can be found before rearranging activities, and heterogeneous

shipments after; these activities may be performed in distribution centres (see Visser et al., 1998).

Shipments should, in field research in urban goods distribution, be described, at minimum, by the following characteristics:
- The size of the shipment;
- The condition under which it is transported (frozen/chilled, hanging and so on);
- The used load unit (box, pallet, rack and so on).

This can be considered as a minimum requirement for data collection.

3.5   Characteristics of goods flows

3.5.1   Introduction

To prove the relevance of urban goods distribution in the total goods transport volumes, it is important to develop a quantitative information base for which it is necessary to describe the distribution of goods by using certain characteristics and classifications. The purpose is to extract standardised key-figures that can be used for further quantification of the distribution of consumer goods in areas for which relevant quantitative information is not yet available.

The distribution of goods is characterised by its goods flows. A goods flow is defined (DHV, 1999) as:

> *"A group of goods that is delivered by one organisation and/or collected, always in the same way (same vehicle type, conditioning and so on), to the same receiver/collection or delivery address".*

Goods flows themselves have certain characteristics by which they can be categorised. The characteristics of goods flows include the total volume, the shipment size, and the composition of the flow. The total volume is strongly related to the type of marketing channel that is used, and especially relates to the trade volumes (usually related to the floor area of the outlets). The shipment size depends on the total volume and the delivery frequency. The distribution of goods can be described in more detail by the following characteristics of goods flows:
- Distribution characteristics of goods flows:
  - destination of the goods flows;
  - distribution channels that are applied;
  - frequency and size of the deliveries;
- Transport characteristics of goods flows:
  - type of carrier;
  - type of vehicle that is used;
  - number of stops;
  - trip length;
  - trip time and speed;
  - transport distance and origin;

These characteristics can be derived by analysing the results of empirical research carried out in different urban areas. Based on this information, we draw conclusions on the impact of urban goods distribution.

3.5.2   The demand for goods in urban areas

The demand for goods distribution, expressed in the total volume of delivered goods, can be estimated using the following methods:

- Direct observations;
- Distribution characteristics of the flows towards the addressees (method I);
- Economic characteristics of the addressees (methods II and III).

Figure 3-2 illustrates the latter two categories of methods of estimating the demand for goods distribution (volume).
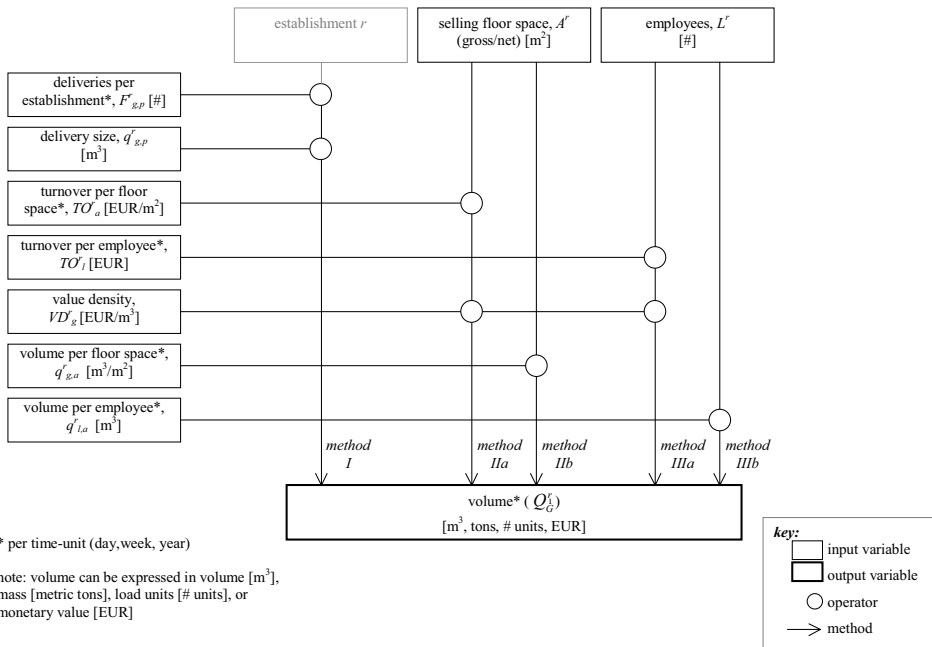
Figure 3-2: Estimation methods for the volume of goods distribution in a study area

The demand for goods distribution can be expressed by different dimensions:

- Mass (metric tonnes);
- Volume (cubic metres);
- Number of units or packages (boxes, pallets, racks, etc.);
- Monetary value (EUR).

In most generalised goods transport statistics today, mass is used as an indicator for transport volumes. Related to this, mass is also used to indicate load factors (load related to load-capacity). However, in urban goods distribution relatively lightweight goods are transported. Therefore, volume (m^3) is a more appropriate measuring unit, and in cases where pallets or roll-cages are used, required floor space (m^2) is also an appropriate measuring unit. In

practice, the number of units or packages is also used in statistics on urban goods transport. For economic analysis, the monetary value of the transported goods is the most relevant measuring unit (see also Section 3.3.3). Because all four measuring units (mass, volume, required floor space and monetary value) are relevant for specific analysis, all data must either be collected through empirical research, or must be calculated using conversion factors (such as volume density).

Determining the demand by using distribution characteristics (method I in Figure 3-2)
If we have information on the number of deliveries per establishment in an urban area as well as information about the delivery size, we are able to estimate total demand. The calculation can be more precise if this information is available for distinct goods categories (see expression 3-1):

$$Q_G^r = \sum_{p=1}^{P} \sum_{g=1}^{G} q_{g,p}^r \bullet F_{g,p}^r \qquad (3\text{-}1)$$

With:

Q_G^r :   Demand for goods distribution to a destination r (receiver) for all goods $\overset{1}{G}$ the receiver needs over time-period P.

$q_{g,p}^r$:   Size or volume q of a distinct delivery (on average) for goods type g per time unit p.

$F_{g,p}^r$:   Number of deliveries (delivery frequency) per time unit p for goods type g.

Estimating the demand by using economic characteristics of the addressees (methods II and III in Figure 3-2)
If adequate information is available, we may estimate the total demand by using economic characteristics of the addressee, such as the total or selling floor space and the turn over per square metre of floor space, or the number of employees and the turn over per employee. Moreover, we also need to know the (average) value density of goods.
Taking the turnover per unit of floor space as a leading indicator (method II), we use expressions 3-2a and 3-2b to calculate the total volume:

$$Q_G^r = A^r \bullet \sum_{g=1}^{G} q_{g,a}^r \qquad (3\text{-}2a)$$

With:

$$q_{g,a}^r = \frac{TO_a^r}{VD_g^r} \qquad (3\text{-}2b)$$

And:

$q_{g,a}^r$:   Turnover (on average, expressed in volume) q of goods of type g, per standard unit of floor space a;

A^r :   Total (relevant) floor space of the establishment of receiver r.

TO_a^r :   Financial turnover (on average, expressed in monetary units) of a standard unit of floor space a of the establishment of receiver r.

VD_g^r :   Value-density of goods type g.

Some studies (see for instance Starkie, 1969) have compared the quality of key figures based on the number of employees and on selling floor space as a basis for calculating demand. These studies proved that selling floor space is a more reliable base for key figures. Nevertheless, if we take the turnover per employee as a leading indicator (method III), we can argue along the same lines, (see expressions 3-3a and 3-3b):

$$Q_G^r = L^r \bullet \sum_{g=1}^{G} q_{g,l}^r \qquad\qquad\qquad\qquad\qquad\qquad \textbf{\textit{(3-3a)}}$$

With:

$$q_{g,l}^r = \frac{TO_l^r}{VD_g^r} \qquad\qquad\qquad\qquad\qquad\qquad\qquad \textbf{\textit{(3-3b)}}$$

And:

$q_{g,l}^r$:   Turnover (on average, expressed in volume) q of for goods type g, per employee l;

L^r :   Number of employees with receiver r.

TO_l^r :   Financial turnover (on average, expressed in monetary units) of an employee l with receiver r.

In Section 3.5.3 we will present the required empirical data needed to estimate the demand for goods distribution.

3.5.3   Distribution characteristics of goods flows for urban distribution

As is explained in the previous section, distribution characteristics are used to estimate the total goods demand for receivers. These distribution characteristics are also needed to categorise the specifics of the process of distributing goods. These characteristics (destinations, types of goods and their packaging, distribution channels, frequency and the size of the deliveries) will be discussed below.

Destinations (receiver)

The distribution of goods in urban areas is characterised by the type of destination of the goods flows, such as the retail trade, the hospitality industry, the service industry (both profit and non-profit), and individual customers. A classification of destinations should contain the relevant classes and in a balanced way.

Currently, no general-use classification exists for urban goods distribution research. In terms of destinations, it is most appropriate categorise them by the different types of retail businesses. In this study, whenever possible, we will use the classification presented earlier in Table 3-1, which was recently developed for this purpose (see DHV, 1999).

 As shown in Table 3-6, the retail sector, and fashion in particular, is an important destination for goods distribution. Approximately 26% of shipments are destined for fashion stores. Other important destinations are grocery stores, other retail stores, and catering establishments. Significant variations may occur, depending on the local situation.

Table 3-6:   *Relative importance of deliveries to businesses in the inner city shopping*
                   area of the Dutch city of Venlo (%) (Source: HBD, 1992)

Destinations	National average	City of Venlo
Fashion stores	26	23
Grocery stores	16	17
Catering establishments	14	26
Other retail stores	14	10
Shoe stores	8	4
Electro-technical stores	7	6
Household and luxury goods	5	6
Personal care	5	4
Furniture stores	3	3
Other destinations, including residential	3	1
Total	*100*	*100*

Table 3-6 demonstrates that local differences do occur. In Table 3-6 the city of Venlo in the
Netherlands is compared with the national Dutch average. The size, the service function
within the region, and the economic structure of an urban area influence the number and type
of businesses in that area. Therefore, it is necessary to collect data on the level of destinations
(businesses) and aggregate these to the level on which the research is aimed at.

In Table 3-1 we propose a preferred categorisation of types of destinations, although field
surveys in the area of the distribution of consumer goods provide little information to apply
such a categorisation. So, with respect to existing empirical data, we are forced to use other
classifications to get insight into the distribution processes, even though these data are not
ideal for our research purposes.

A field survey in the Dutch city of Utrecht shows that an average type of branch has 1.9
different types of goods flows (as defined in Section 3.3). Table 3-7 shows the average
number of types of goods flows for each type of establishment.

Table 3-7:   *Key figures on the number of goods flows per establishment within the*
                   centre of Utrecht, 1999 (Source: DHV, 1999)

Branch	# goods flows per establishment	Branch	# goods flows per establishment
Supermarkets	3.5	electro-technical stores	1.8
Grocery stores	5.3	books	2.0
Other food and personal care	3.1	other retail stores	1.8
Fashion	1.3	hotels and restaurants	2.3
Living	1.8	bars and pubs	2.5
Weighed average	*1.9*		

Distribution channels

Goods distribution is also characterised by the channels that are used for distributing goods. As we will show in Part II, we can only have a good understanding of the goods distribution process if we look not only to goods characteristics in itself, but also to the distribution characteristics (together forming the 'goods flow characteristics').

There are many different distribution channels (see Part III). The main classification of distribution channels is based on the number and type of intermediaries within the distribution channel. The final destination is the consumer of the goods (the consumer at home or at the workplace). The retail and catering industries have intermediary positions between producer and consumer.

The retail trade, for example, adopts three different types of distribution channels, namely distribution from wholesaler, from a distribution centre and from producer (see Figure 3-3). Traditionally, a relatively large share of the distribution of goods is carried out by wholesalers and by distribution centres that are owned by producers, importers, branch organisations, and logistic service suppliers. Figure 3-3 and Table 3-8 show the share of current distribution channels per branch
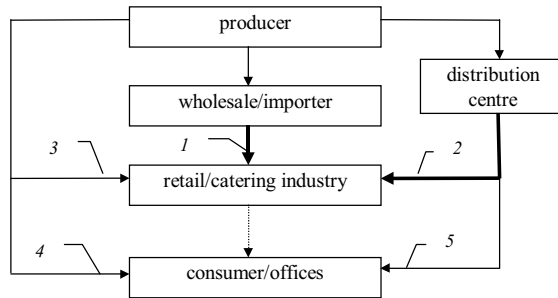
Figure 3-3:   ***Distribution channels in the retail trade***

Table 3-8:   ***Share of different distribution channels for different types of products (in percents) in deliveries and transport weight (Source: HBD, 1995)***

Share in deliveries	Fresh food	Groceries	Fashion products	Luxury goods
By producer [3]	8.8	34.9	21.1	43.1
By wholesaler/importer [1]	74.8	43.8	76.2	51.7
By distribution centre [2]	16.4	21.3	2.7	5.2
Total	*100*	*100*	*100*	*100*
Share in transported weight				
By producer [3]	5.1	43	21	62
By wholesaler/importer [1]	59.6	37	70	35
By distribution centre [2]	35.3	20	9	3
Total	*100*	*100*	*100*	*100*

E-commerce makes use of different distribution channels. With E-commerce, goods are ordered using telecommunications (telephone, Internet) and then directly delivered to the consumer at home. For the actual delivery of goods, E-commerce makes use of other distribution channels that bring goods directly to the consumers (4 and 5 in Figure 3-3).

Because E-commerce is only starting to receive a significant share in total traded volumes, there is no generic, quantitative information available yet about the structure of these channels.

Volume per delivery
We define a *delivery, sending or provisioning* as:
   The quantity of goods that is transported in one trip for one consignor from one loading berth to one discharging berth for one consignee.
As explained in Section 3.5.2, the volume or quantity of a delivery can be expressed in terms of mass (metric tonnes), volume (cubic metres), number of packagings (boxes, pallets, racks, etc.), or the monetary value. Table 3-9 gives an overview for a sample of Dutch cities of the volume per delivery, expressed in cubic metres. Because the sizes of receivers (addressees) differ considerably and the physical structure of cities influences the maximum vehicle size that can be used (and therefore influences the maximum volume of a delivery), the volumes per delivery vary strongly over the different cities.

Table 3-9:   *Volumes per delivery in different Dutch cities, different years (Source: Heidemij Advies, 1995)*

$[m^3]$	Utrecht	Leiden	Eindhoven	Maastricht	Breda	Haarlem
Volume per delivery	0.8	2.0	2.1	1.7	4.6	3.6

Table 3-10:   *Volumes per delivery for different branches in the Dutch city of Haarlem, 1995 (Source: Heidemij Advies, 1995)*

$[m^3]$	Fashion stores	Other retail	Hotel and catering	Other business	Offices	*Total*
Volume per delivery	5.2	4.5	2.0	1.7	0.4	*4.0*

Table 3-11 shows that while most shipments are relatively small (less than one cubic metre), 40% of the shipments are more than one cubic metre – indicating the wide range in shipment sizes that can occur.

Table 3-11:   *Delivery sizes (volume) to inner city shopping districts in the Netherlands (Source: HBD, 1992)*

Size (volume)	Share
Less than 1 m^3	56%
More than 1 m^3	41%
Unknown	3%

The shipment sizes per sector differ considerably (Table 3-10). This is the result of the fact that quite different physical distribution systems (driven by different marketing channels) are used. First, there are large, consolidated flows of a wide range of products that are distributed towards large stores (supermarkets, department stores). In these channels, shipment sizes are large, transport volumes are large, the transport vehicles are large, and load units are

intensively used. Nonetheless, the share in total shipments (and thus the share in trip ends and vehicle movements) is relatively small.

On the other hand, there are numerous small outlets that operate within strongly segregated marketing channels (containing multiple intermediaries). The physical distribution systems of these channels result in numerous small shipments in which no use is made of load units, and which therefore account for large numbers of trip-ends and vehicle movements.

Coopers & Lybrand (1991a and 1991b) conclude that almost thirty percent of the deliveries have a volume of more than 1 cubic metre. By contrast, a study carried out by HBD (1992) shows results of 41 percent for the same size of shipment (see Table 3-11). When comparing different research results, we can conclude that they vary significantly. Apparently, the interview methods easily lead to estimation errors; therefore, the resulting figures are not very reliable. In another study carried out by HBD (1995), it was shown that the information on volumes was not reliable. Nevertheless, we may also conclude that delivery volumes vary strongly, that 30% to 40% of the deliveries are larger than one cubic metre, and another 60%-70% are smaller. These small shipments particularly require a well-organised logistics system to enable efficient distribution.

From the figures shown in Table 3-12, we can conclude that supermarkets, and to a lesser extent, smaller grocery stores and fashion stores, have large volume deliveries.

Table 3-12: ***Volumes per delivery per branch in the centre of the city Utrecht, 1999 (Source: DHV, 1999)***

Code	Branch	Volume of deliveries $[m^3/delivery]$	Code		Volume of deliveries $[m^3/delivery]$
A	Supermarkets	22.68*	G	Books	4.42
B	Small grocery stores	5.10	H	Other retail stores	1.08
C	Other food and personal care	1.11	I	Hotels and restaurants	0.78
			J	Bars and pubs	0.40
D	Fashion	5.10	K	Recreation	unknown
E	Living	1.15	L	Offices	0.43
F	Electro-technical stores	0.51	M	Homes	unknown

* adjusted after publication (see: Visser with Boerkamps, 2000)

The mass of a delivery (expressed in mass) is difficult to determine in field research. The number of transport units and the monetary value of a delivery are, however, significant indicators; these indicators provide the most reliable information about the goods distribution traffic (and the related problems) and the economic importance of flows. This information is registered in the transportation documents.

Frequency of deliveries
The number of times that a receiver at his business location is provisioned, per day or per week, is called:
    The frequency of delivery or *the frequency of provisioning*.

The frequency of delivery is largely dependent on the turnover time for consumer goods at the establishment. In general, it can be said (for incoming flows of goods) that every establishment is provisioned between one and ten times per week (with an average of five times per week). This is illustrated in Table 3-13, where the average number of deliveries per store establishment per day for a number of Dutch cities is shown, assembled from different sources. These data only concern store establishments however, excluding other types of business such as the hospitality industry.

When measuring the number of deliveries, in most cases no distinction is made between the delivery and the collection of goods at an address. A comparison of the frequencies of delivery leads to the conclusion that this parameter can be quite different among cities. The frequency of deliveries per establishment per day varies from 0.4 in Haarlem to 4.2 in Zaanstad. Investigations in 1980 in Delft yielded a value of 0.9 for the average of deliveries per establishment per day, while comparable research in 1976 provided an average value of 3.5.

Table 3-13: ***The average number of deliveries in the Netherlands per store establishment per day (from different research sources), 1976-1993 (Sources: *Schins, 1985; ** Coopers & Lybrand, 1991a and 1991b; *** Van den Akker et al., 1992; **** Oranjewoud, 1993))***

Location	Deliveries per establishment per day	Location	Deliveries per establishment per day
Zaanstad*	4.2	Amsterdam*	1.5
Delft (1976)*	3.5	Ermelo*	1.5
Purmerend*	3.1	Winschoten*	1.5
Arnhem/Maastricht**	3.0	Tilburg***	1.4
Amersfoort*	2.4	Maastricht****	1.0
Arnhem*	2.1	Breda*	0.9
Veendam*	1.7	Delft (1980)*	0.9
Schoorl*	1.6	Haarlem*	0.4

Table 3-14 gives a comparison of the provisioning per type of business (branch) for the Dutch cities of Leiden and Arnhem, while Table 3-15 presents these data for the city of Utrecht (note that both the years and the branch-categorisations are different). The data show that there are remarkable differences not only between the cities but also between the different types of businesses.

Table 3-14:   *Average number of deliveries per establishment per week for different branches in the Dutch cities of Leiden and Arnhem (Source: DHV, 1987)*

Branch	City of Leiden	City of Arnhem
Grocery stores	14.9	10.4
Shoe stores	2.3	3.3
Fashion store	7.2	4.0
Furniture stores	5.6	6.9
Household stores	7.8	4.6
Electro-technical stores	5.1	6.9
Department store	2.2	26.3
Personal care stores	14.3	5.0
Other durable goods stores	7.6	6.1
Catering establishments	11.5	4.8
Desk services	23.6	4.6
Handicraft	9.1	1.9
Pharmacies	-	16.3
Art galleries	-	4.3
Weighed average per week	*10.1*	*7.0*
Weighed average per day	*1.8*	*1.3*

Table 3-15:   *Average number of deliveries per establishment per week, for different branches, within the city centre of Utrecht, 1999 (Source: DHV, 1999)*

Branch	Inner city of Utrecht	Branch	Inner city of Utrecht
Supermarkets	7.0 (20)	Electro-technical stores	7.4
Grocery stores	25.0	Bookstores	6.0
Other food and personal care stores	8.0	Other retail stores	6.6
		Hotels and restaurants	4.3
Fashion stores	3.6	Bars and pubs	5.5
Furniture stores	6.5		
Weighed average:	*5.7*		

The number and types of establishments in a city (economic structure of a city) is the first significant reason for the differing findings for the average number of deliveries in an urban area. HBD (1992) has concluded that the different lines of business exhibit quite different provisioning patterns. Grocery stores (excluding supermarkets) are provisioned between two and three times per day. Supermarkets are provisioned more often, approximately four to five times per day. Fashion stores and other non-nutrition lines of business are provisioned with a relatively low frequency, on average 0.5 to one times per day. The service centres are provisioned 1.7 times per day on average. HBD has concluded that other research, for instance the feasibility study in the city of Maastricht (Coopers & Lybrand, 1991a and 1991b) often shows higher frequencies. The Coopers & Lybrand (1991a) research shows that the retail trade is provisioned on the average of three times per day per address, while with the service centres the average is around 1.7 delivery per day.

Differences in the number and type of establishments only explain to a limited extent the differences between the findings in different cities. In Visser (1993), additional influencing factors are given, such as:

- Differences in business size;
- Differences in logistics, as will be explained in part III;
- Seasonal changes in the demand for goods distribution;
- Differences in research methodology (type of survey, moment of survey, used definitions and classifications).

Volume per employee

As is explained in Section 3.5.2, the total delivered volume of goods per employee is a useful key-figure for determining total volumes for branches or for a specific urban area. Table 3-16 shows the volumes per employee for various branches, for the inner city of Utrecht.

Table 3-16: *Volume (m^3) per employee per week, per branch, and per establishment within the city centre of Utrecht, 1999 (Source: DHV, 1999)*

Branch	Volume per employee, per establishment, per week [m^3]	Branch	Volume per employee, per establishment, per week [m^3]
Supermarkets	0.76	Electro-technical stores	0.47
Grocery stores	0.47	Bookstores	0.25
Other food and personal care	1.15	Other retail stores	0.67
Fashion stores	1.76	Hotels and restaurants	0.26
Furniture stores	0.73	Bars and pubs	0.14

The table suggests that the trade in fashion is quite 'bulky' in terms of volume per employee, even more than the trade in supermarkets or grocery stores. This may be related to the specific composition of the questionnaire in which only relatively small supermarkets were interviewed (Visser and Boerkamps, 2000).

Demand for goods distribution

With the indicators of volume and frequency of deliveries, the total volume delivered (by size or mass) per day or per week can be calculated by using expression 3.3-1. From a study by Heidemij Advies (1995) in the Dutch city of Haarlem, based on interviewing shop-owners, the volumes for each sending and the total volume per week can be derived (see Table 3-17).

Table 3-17: *Total volumes per establishment in the Dutch city of Haarlem, 1995 (Source: Heidemij Advies, 1995)*

[m^3/establishment]	Fashion stores	Other retail stores	Hotel and catering	Other business	Offices	total
Volume per week	16.0	27.4	10.8	3.6	1.3	19.8

In Table 3-16 the demand for goods distribution is expressed per employee. It shows that there are important differences between branches. Expressing the demand per employee does not compensate for the differences in demand between branches.

3.6   Transport characteristics of goods flows

3.6.1   Introduction
The distribution of goods in urban areas can further be characterised by transport characteristics, such as:
- Organisation that carries out the distribution of the goods (the carrier);
- Types of vehicles that are used;
- Number of stops;
- Trip length;
- Trip time and speed;
- Transport distance and origin.

The first two characteristics enable us to categorise the type of transport that takes place on behalf of urban goods distribution. Trip length, the related traffic performance, and the number of stops are characteristics that can be related to accessibility issues. Traffic performance (or vehicle mileage) can also be linked to environmental issues (see also chapter 4). The notion of transport performance (expressed in tonne-kilometres) can be used to assess the relative importance of goods distribution for urban areas within the total field of goods transport.

3.6.2   Determining transport performance and traffic performance
Given a total transport volume in a certain service area, and the (average) delivery size, the total number of deliveries for that area can be derived.

From this, the loaded-traffic performance can be derived, and by using an empty trips factor, the total traffic performance as well. From the loaded-traffic performance, the transport performance can be estimated.
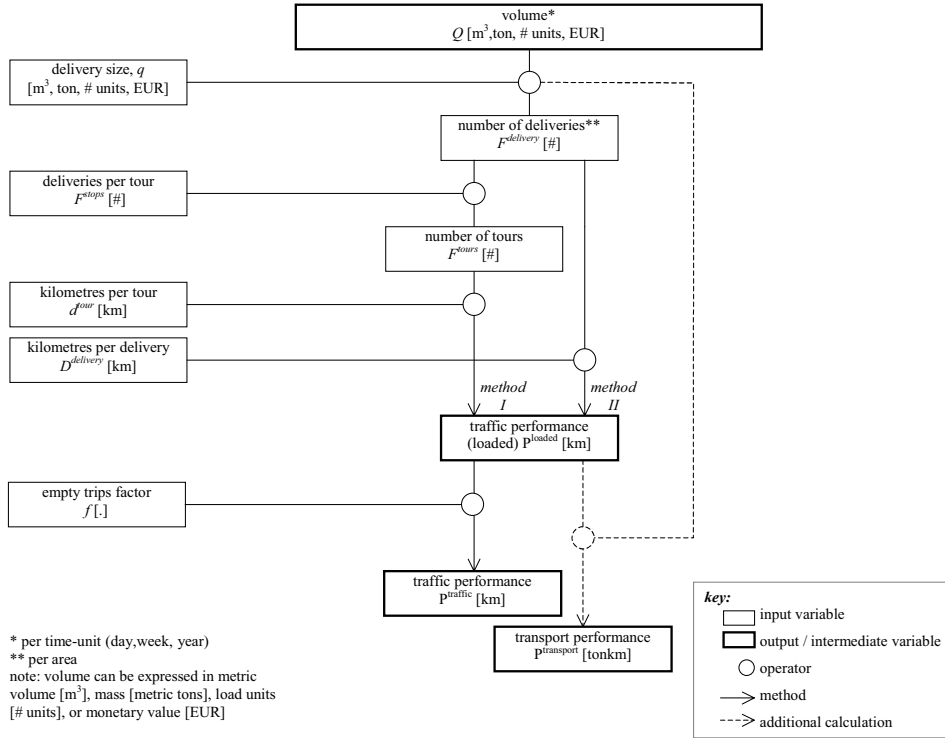
Figure 3-4: *Estimation methods for the traffic performance and transport performance in a study area*

Thus, in order to calculate the traffic performance $P_M^{traffic}$ we use expressions 3-4a (following method I in Figure 3-4) or 3-4b (following method II in the same figure):

$$P_{1M}^{traffic} = \sum_{m=1}^{M} \sum_{g=1}^{G} \left(\left(F_{g,m}^{delivery} / F_{g,m}^{stops} \right) \bullet d_{g,m}^{tour} \bullet f_{g,m}^{empty} \right) \qquad \textbf{\textit{(3-4a)}}$$

$$P_{1M}^{traffic} = \sum_{m=1}^{M} \sum_{g=1}^{G} \left(F_{g,m}^{delivery} \bullet d_{g,m}^{delivery} \bullet f_{g,m}^{empty} \right) \qquad \textbf{\textit{(3-4b)}}$$

With:

$P_M^{traffic}$ = Traffic performance for all types of vehicles[8] $\overset{1}{M}$ (with $m = 1$ to M).

$f_{g,m}^{empty}$ = Empty-trips factor (increases the calculated amount of loaded vehicle kilometres to obtain the total amount of traffic kilometres); with $f_{g,m}^{empty} \geq 1$.

$F_{g,m}^{delivery}$ = The overall delivery frequency of goods g by a certain vehicle type m.

$d_{g,m}^{delivery}$ = The transport distance for a delivery (loaded trip) of goods g by vehicle m.

---

[8]   Please note that a 'total' traffic performance generalised over different vehicle types is not necessarily useful because different vehicle types will have different traffic characteristics (size, speed, acceleration, etc.).

$F_{g,m}^{stops}$ =   The number of stops in a tour of distributing goods *g* by vehicle *m*.

$d_{g,m}^{tour}$ =   The transport distance for a tour (loaded) distributing goods *g* by vehicle *m*.

With these formulas (or similar information derived from other sources), we may determine the transport performance, see expression 3.6-2:

$$P_M^{transport} = \sum_{m=1}^{M} \sum_{g=1}^{G} \left(p_{g,m}^{traffic} \bullet q_{g,m} \right) \tag{3-5}$$

With:

$P_M^{transport} =$ The transport performance of all vehicles $\overset{1}{M}$.

$P_{g,m}^{traffic}$ =   The traffic performance of vehicle type *m* for goods *g*.

$q_{g,m}$ =   The vehicle load of vehicle *m* loaded with goods *g*.

Type of carrier

Goods traffic can be divided, on the basis of who performs the transport, into professional transport and transport on own account transport. The provisioning takes place by means of:

- Transport on own account on an ad-hoc basis (on call), performed by the retail trade and catering establishment. The goods are collected from the firm's warehouse, the wholesale establishment, the manufacturer (importer), the retail trade organisation, or the auction. This transport usually occurs by means of a passenger car (station wagon), delivery van, or small truck.
- Organised transport on own account by the supplier or retail chain. The supplier (producer, wholesaler, or purchasing agent) or retail chain delivers the goods to the recipient by means of his own vehicle fleet (trucks) and by a regular service.
- Professional transport. Professional transport companies transport goods on call:
  - in commission for a specific transshipper (exclusive or dedicated service);
  - a specific group of transshippers (group transport), or
  - for each transshipper ('public' transport: general distribution or courier and parcel services).

The form of transport and the type of transporter differ considerably between markets. The transport of fresh products for the retail trade and the provisioning of the hospitality industry often occur via transport on own account by the store owner and the transshipper.

The proprietary vehicle fleet often provides several branch establishments. Organised transport on own transport often occurs with suppliers, wholesalers, and retail chains. It must be noted, however, that during the past years, a clear trend towards outsourcing (towards professional transport) has taken place.

The transport of clothing is often handled by specialised transporters. These specialised transporters also perform additional logistical services (for example, storage, labelling).

According to Coopers & Lybrand (1991a and 1991b), retail traders themselves pick up 19 percent of the shipments. In the service sector, this percentage is up to 29 percent. In the research of the "Werfkelder"-area in the city of Utrecht, approximately 20 percent of the incoming flow of goods is transported by the supplier or receiver himself, while 44 percent of the outgoing flow of goods is transported in this way. The professional and remaining own transport therefore has shares of 80 and 55 percent in the incoming and outgoing flow of

goods, respectively. These remaining 80 and 55 percent each consist of 35 percent professional transport, and 65 percent own transport.

Table 3-18:   ***Share of transporters per line of business of the total number of deliveries in the Dutch city of Haarlem, 1995 (%) (Source: Heidemij, 1995)***

	Fashion (clothing and shoes)	*Other retail*	*Hotel and catering*	*Other business*	*Offices*	*Total*
On own account (self)	3.3	13.3	21.0	5.0	0.9	12.9
Chain	32.4	8.8	1.7	0.0	25.5	10.9
Professional transport	64.3	56.2	9.8	45.8	63.9	48.5
Supplier	0.0	21.8	67.5	49.2	9.6	27.8
Total	*100*	*100*	*100*	*100*	*100*	*100*

Smaller stores in particular, such as clothing boutiques, provide their own goods transport by means of passenger cars or small delivery vans. Supermarkets and department stores have their own distribution structure using large trucks and large shipments (semi-proprietary or own transport). The distribution often takes place from a national point-of-distribution (bookstores, for example), or from regional points-of-distribution (department stores and supermarkets). Use is also made of the distribution trade that works in city distribution. Goods with certain characteristics, such as value, vulnerability, or perishability (for example, chilled and frozen goods) offer only limited distribution possibilities.
Some kinds of goods, such as furniture and refrigerators, are delivered directly to home addresses. The distribution is often managed by the store itself, and takes place on a local or regional scale.

Expressed in terms of deliveries, the share of professional transport in the city of Haarlem is the largest (Heidemij, 1995; see also Table 3-19). Companies that provide a general regional or city distribution service have the highest share. Within professional transport (and in terms of deliveries), they have a market share of more than 80 percent.

Table 3-19:   ***Share of different professional transport companies in the number of deliveries in the Rijnmond region, 1994 (%) (source: KPMG, 1994)***

Transport companies	*Share*	*Transport companies*	*Share*
Van Gend & Loos	25.6	Correct Express	1.9
CCBB/NPD	22.9	Faxion	1.9
PTT Post	22.7	Salters	1.6
Van Duuren	5.1	UPS	1.6
Bleckmann	2.5	Others	12.1
Dentex	2.1		
Total:	*100*		

It is not surprising that professional transport has a large share in the distribution of goods in urban areas. National data on transport show that professional transport is becoming increasingly important.

Since 1990 (see Figure 3-5), professional and transport on own account have been diverging, where the share of own transport has been steadily decreasing, while that of professional transport has been increasing. A comparable development can be detected in the transport performance (expressed in load tonne-kilometres). This can be explained in part by the improved quality level of services, in particular the increased diversity of services.
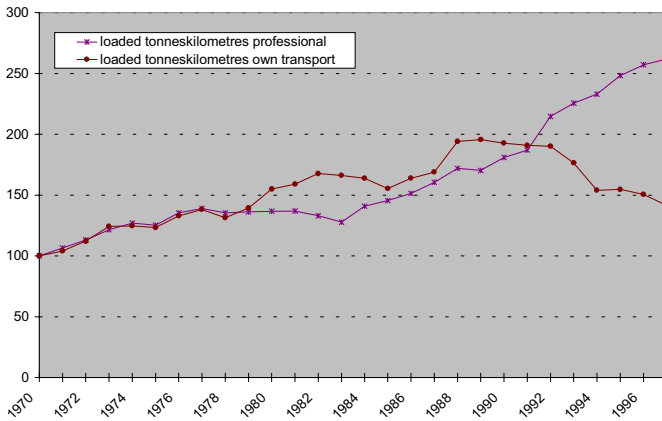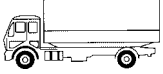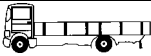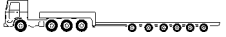

Figure 3-5:   ***Development of the national goods traffic volume by road for professional transport and own transport 1970-1997 [index 1970 = 100] (Source: CBS statistics (various years)).***

Modal split and vehicle types

In urban goods distribution, one can hardy speak of a modal 'split' because urban goods distribution is dominated by one mode, namely road transport. One can, however, make a distinction between several vehicle types as different modes. For road vehicles, a number of categories exist, such as the classification shown in Table 3-20. This classification is based on the vehicle matrix, developed by the Dutch platform on urban distribution (Platform Stedelijke Distributie, PSD) and the Dutch association of transport firms (Transport en Logistiek Nederland, TLN).

Table 3-20:   Classification of vehicle types (Source: PSD/TLN, 1999 (adapted))

Category One vehicles	Typical form	Specific characteristics	
Type: van, light		*Weight:* < 3.5 tonnes *Wheel base: not specified* *Length: not specified*	*Width*: max. 2.3 m *Height*: max. 3.2 m
Type: van, heavy		*Weight:* < 3.5 tonnes *Wheel base: not specified* *Length:* max. 5.1 m	*Width*: max. 2.3 m *Height*: max. 3.2 m
Type: Truck		*Weight:* 3.5-7.5 tonnes *Wheel base:* < 4.5 m *Length:* max. 7.5 m	*Width*: max. 2.3 m *Height*: max. 3.2 m
Category Two vehicles			
Type: Truck		*Weight*: 7.5-18 tonnes *Wheel base*: < 5.5 m *Length*: max. 10 m	*Width*: max 2.55/2.6 m *Height*: max. 3.6 m
Category Three vehicles			
Type: Solo-truck		*Weight*: > 18 tonnes *Wheel base*: > 5.5 m *Length*: max. 12 m	*Width*: max 2.55/2.6 m *Height*: max. 4 m
Type: Tractor-semi-trailer		*Weight*: < 40 tonnes *Wheel base*: too divers *Length*: max 16.5 m	*Width*: max 2.55/2.6 m *Height*: max. 4 m
Type: Articulated truck		*Weight*: < 40 tonnes *Wheel base*: too divers *Length*: max. 18.75 m	*Width*: max 2.55/2.6 m *Height*: max. 4 m
Category Four vehicles			
Type: Special transport		*Weight*: > 40 tonnes *Wheel base*: *not specified* *Length*: *not specified*	*Width*: *not specified* *Height*: *not specified*

An alternative classification is based on vehicle types as used in urban goods distribution (Table 3-21). Vans and medium sized trucks are most commonly used for urban goods distribution, although figures of the Dutch cities of Leiden and Arnhem show a relatively high share of truck use. In Amsterdam, the use of passenger cars and vans is relatively high.

Table 3-21:   ***Vehicle use in urban goods distribution, various years (percents) (Source:***
derived from Schins, 1985; Coopers & Lybrand, 1991a and 1991b; Van den
Akker et al., 1992; and Oranjewoud, 1993)

Vehicle type [%]	Delft	Breda	Amsterdam	Leiden	Arnhem	Maastricht*
Car	21	4	38	2	1	11
Van	40	43	38	23	16	31
Truck	36	50	22	68	64	36
- one axle	-	-	-	46	37	
- more than one axle	-	-	-	22	27	22
Articulated truck	2	3	2	7	19	
- with trailer	-	-	-	1	6	
- with semi-trailer	-	-	-	6	13	
Total	*100*	*100*	*100*	*100*	*100*	*100*

The types of vehicles that are used depend strongly on the organisation that carries out transport. Table 3-22 shows the modal split for professional transport and transport on own account, in terms of types of road vehicles that are used.

Table 3-22:   ***Share of different vehicle types in vehicle use in urban areas in own***
transport and in professional transport, 1993 (% of total) (Source:
Oranjewoud, 1993)

Vehicle type [%]	Professional transport	Transport on own account	
		organised	non-organised
Passenger car	19	0	20
Van	31	0	60
Light truck	30	54	20
Heavy truck	20	46	0
Total	*100*	*100*	*100*

The table shows that there are differences in vehicle use between professional transport and own transport. Professional transport, depending on the specialisation, makes use of vans, light trucks and to some extent, heavy trucks, while organised own transport makes use of both light and heavy trucks. Unorganised own transport only makes use of light vehicles, vans in particular. This explains to some extent the differences in the type of vehicles that deliver the goods at certain destinations (Table 3-23).

Table 3-23: *Share of vehicle types for each branch in the total number of deliveries in the city of Haarlem, 1995 (%) (Source: Heidemij, 1995)*

Vehicle type [%]	Fashion (clothing and shoes)	Other retail	Hotel and catering	Other business	Offices	Total
Car	2.6	8.1	7.6	1.0	1.1	6.9
Van	18.4	20.4	41.2	66.6	24.5	25.6
Truck	79.0	56.9	31.8	32.4	74.4	54.9
Unknown	0.0	14.6	19.3	0.0	0.0	12.7
Total	*100*	*100*	*100*	*100*	*100*	*100*

The use of trailers is, as is shown in Table 3-24, mainly limited to semi-trailers. Trailers are hardly used in combination with trucks, vans, or cars.

Table 3-24 *Vehicle types used to deliver the shipments (per week) in the city of Utrecht, 1999 (Source: DHV, 1999)*

Vehicle type [%]	Car	Van	Truck	Tractor*	Unknown	Total
Without trailer	7.5	45.0	36.2	0.5	--	--
With trailer	1.5	0.0	0.8	5.5	--	--
Total	*9.0*	*45.0*	*37.0*	*6.0*	*4.0*	*100*

* tractor without or with semi-trailer

Stops per trip

Another significant aspect of the distribution is the number of stops per trip. In order to estimate the number of trips in an urban area it is important to know how many stops a vehicle makes in each trip. Several studies pay attention to this, for instance Van Riet et al (1995). One difficulty is that particularly in the Netherlands, a vehicle may easily visit more than one city in a trip. There is little information available on the number of stops per city or urban area.

Table 3-25: *Average number of stops per trip in transport carried out by professional transport companies and transport on own account within the Netherlands, 1995 (Source: Van Riet et al., 1995)*

Professional transport	Average number of stops per trip	Transport on own account	Average number of stops per trip
General distribution	10.2	Food industry	5.5
Physical distribution	11.9	Metal industry	9.7
Frozen and chilled	8.0	Wholesale	6.5
		Retail	1.3
Average of professional transport	*10.1*	*Average of transport on own account*	*4.2*
Total (overall average):	**7.5**		

About 53 percent of vehicles that deliver goods in the Werfkelder (inner-city) area of Utrecht, also make stops in other cities (De Rijke, 1991). De Rijke also found that the average number of stops is 7.6 stops per trip, with about 60 percent of the trips having two to nine stops, and eleven percent having more than twenty stops. This contrasts strongly with the figures in Table 3-25. Because the research of De Rijke took place within a specific city, while the Van Riet et al. research covered the whole of the Netherlands, we argue that the differences are related to the specific conditions of distributing goods within cities.

Coopers & Lybrand found an average of 3 stops per vehicle in one city (Maastricht). In the Dutch city of Tilburg Van den Akker, et al., 1992 found an average of 9 stops in the inner city per trip. Both sources agree upon the number of stops per trip for the organised city distribution by companies, such as Van Gend & Loos and the Nederlandse Pakketdienst. On average, the trips of these distribution companies count about 14 to 15 stops per trip in a city and 80 in total.

Trip length

A survey carried out in the retail sector (HBD, 1995) showed that the average trip length has increased as a consequence of the more frequent delivery. Table 3-26 shows that trips for the delivery of fresh food and groceries are relatively short compared to the delivery of fashion products and luxury goods. Although in the delivery of fashion products and luxury goods, more stops per trip are made, it does not automatically lead to a comparable trip length per stop (see Table 3-27). However, if the average trip length per stop is compared for different kinds of goods, fashion products and luxury goods still have the highest trip length.

Table 3-26: *Trip length, including return trip (in km) for the Netherlands, 1995 (Source: HBD, 1995)*

Transport performer [km/trip]	Fresh food	Groceries	Fashion products	Luxury goods	***Total***
Supplier	216	297	468	456	***408***
Self collecting	56	32	164	71	***71***

Table 3-27: *Trip length per stop in kilometres, including return trip for the Netherlands, 1995 (Source: HBD, 1995)*

Transport performer [km/trip.delivery]	Fresh food	Groceries	Fashion products	Luxury goods
Producer	13	15	57	90
Wholesale/importer	19	24	34	45
Distribution firm	15	70	42	73
Total	*18*	*33*	*39*	*76*
Self collecting	56	32	164	71

The trip lengths in this table are high compared to the information from other sources. According to CBS, about 61 percent of the trips made in domestic goods transport are shorter than 50 kilometres. The truck manufacturer DAF Trucks estimates the average trip length at

150 kilometres per trip, which has not changed in the last ten years. For vans, this might be different.

Trip time and speed
Another characteristic, strongly related to trip length is trip travel time. Speed is related to both. Although speed and travel time are the most privately registered characteristics of transport (at least with transport companies) by means of the tachograph, there is no public information available for urban goods distribution.

Transport distance and origins
Transport distance relates to the distance between the origin of the deliveries and the destination, and is not the same as trip length. It should be noted that most deliveries in the Netherlands have their origin outside the city or region (see Table 3-28). Almost sixty percent of the deliveries have their origin outside the region around the particular urban area. This explains, to a large extent, the long trip lengths listed.

Table 3-28: ***The origin of incoming deliveries for different types of destinations in the Dutch city of Haarlem, 1995 (%) (Source: Heidemij, 1995)***

Origin [%]	Fashion (clothing and shoes)	Other retail	Hotel and catering	Other business	Offices	Total
City	4.4	5.4	18.1	26.5	3.8	8.9
Region	2.7	0.9	11.6	2.9	0.0	3.3
Outside the region	79.0	62.2	34.6	70.6	76.0	58.4
Other	0.0	21.8	13.0	0.0	19.9	16.9
Unknown	13.9	9.7	22.8	0.0	0.3	12.5
Total	*100*	*100*	*100*	*100*	*100*	*100*

With these transport characteristics, it is possible to estimate the vehicle-mileages that are produced in order to transport and distribute the deliveries with a research area.

3.6.3   Conclusions
This section tried to develop a clear understanding of goods distribution in urban areas. It has shown that a lot of research has been carried out on a local level in urban areas. This information is used to categorise and quantify the aspects of urban goods distribution.

All transport processes aim at bringing (or removing) the right goods at the right time at the right spot: to users or consumers, to retailers and to other players. To fully understand the transport and logistic processes, one must know the characteristics of goods and the characteristics of shipments. The wide variety of goods (and shipments) requires a variety of services, transport equipment, handling equipment and facilities. To enable efficient transport and logistics operations, goods should be grouped. Grouping only makes sense if the characteristics of the different goods match. Because there are different types of needed operations and there are different players involved, different ways of grouping (and thus categorising) goods are possible.

First, goods can be categorised on basis of physical and marketing characteristics. These categorisations are helpful, but are not sufficient to account for the precise requirements of the physical distribution process because evidence shows that exactly the same goods can be distributed along different physical distribution channels. Therefore, additional characteristics are necessary; these characteristics especially relate to the marketing channel used. The resulting 'shipment characteristics' suffice to describe the requirements of the physical distribution channel, as will be illustrated in Part III. This does not mean that there is only one type of categorisation: for different research and development purposes, different types of categorisations may be applicable.

We described the distribution of goods through the characteristics of goods flows and proposed a classification for each characteristic. The purpose was to extract some standardised key-figures for further quantification of the distribution of consumer goods. In this section, we have defined characteristics of goods flows:

- Distribution characteristics (destinations of the goods flows, type of goods, frequency and the size of the deliveries, distribution channels that are applied);
- Transport characteristics (organisation that carries out the distribution of the goods, types of vehicles that are used, number of stops, trip length, trip time and speed, transport distance and origin).

Urban goods distribution is quantified through public information on destinations, such as retail businesses, combined with key-figure data derived from field surveys.

The distribution characteristics define the demand for goods distribution. A formula is presented to determine the volume of urban goods distribution. The demand for goods distribution can be expressed by the dimensions of its characteristics:

- Mass (tonnes);
- Volume (cubic metres);
- Number of transport units (boxes, pallets, racks, etc.);
- Monetary value.

The distribution characteristics are also used to categorise the distribution of goods.

In order to develop more reliable key-figures, classifications for destinations are used. As stated previously, no general-use classification exists for urban goods distribution research. Based on research experience in this area, destinations for urban goods distribution have been divided into thirteen categories.

If we look at the destinations of the deliveries, then the conclusion can be drawn that supermarkets or grocery stores, warehouses and fashion stores are the most important retail destinations in the distribution of consumer goods in urban areas. Most deliveries in an urban area have fashion stores, including clothing shops and shoe-shops, as a destination.

The goods flows to these destinations can be categorised by the type of goods and the distribution channel that is used. The type of goods is strongly related to the type of destination. A field survey in the Dutch city of Utrecht shows that an average branch has 1.9 different goods flows. Goods flows make use of distribution channels. A classification of distribution channel is therefore proposed, based on the number and type of intermediaries within the distribution channel, (e.g. directly from the producer to the retail or catering industry or consumers, via wholesale organisations or via distribution centres of retail

organisations). Tangentially, E-commerce has introduced new distribution channels but the main flow of goods is still distributed by the wholesaler/importer or large retail chains.

Another significant distribution characteristic is the volume of the deliveries. The volume or quantity of a delivery can be expressed in mass (tonnes), volume (cubic metres), number of transport units (boxes, pallets, racks, etc.) or monetary value. A common way to quantify the volume of the delivery of goods is to estimate the total volume delivered in cubic metres per delivery. Destinations, such as grocery stores (5.1 cubic metre/delivery), fashion stores (5.1 cubic metre/delivery) and, in particular, supermarkets (22.7 cubic metre/delivery), have large-volume deliveries, compared to other destinations (0.5-1.0 cubic metre/delivery).

The number of times that a receiver at his business location is provisioned, per day or per week, is called the frequency of delivery. In general, it can be said (for incoming flows of goods) that every establishment is provisioned between one and ten times per week (with an average of five times per week). However, grocery stores are most frequently provisioned, with about 12.7 deliveries per week. The overall average delivery per establishment in a day in an urban area lies between 0.4 and 4.2 loading and unloading movements (delivery or collection of a sending).

The results of studies vary greatly. This is probably related to:

- Type of businesses;
- Differences in business size;
- Differences in logistics;
- Seasonal changes in the demand for goods distribution;
- Differences in research methodology (type of survey, moment of survey, used definitions and classifications).

With the characteristics volume and frequency of deliveries, the total volume delivered (in either cubic metres or tonnes) per day or per week can be calculated. The demand for distribution can be expressed as a ratio of volumes and the following indicators for size:

- Sales per time period;
- Number of (full-time) employees;
- Selling floor space.

Selling floor space is a reliable base for key figures. The reliability of the factor of sales as a base for expressing the 'size' of an establishment is not investigated.

The distribution of goods in urban areas can further be characterised by transport characteristics, in particular, based on the carrier who performs the transport:

- Own transport by the retail trade and catering establishment.
- Organised own transport by the supplier or retail chain.
- Professional transport. Professional transport companies transport goods on call:
  - in commission for a specific transshipper,
  - a specific group of transshippers (grouped transport), or
  - for each transshipper (general distribution or courier and parcel services):

Almost fifty percent of the deliveries are made by professional transport organisations. The role of own transport has been steadily decreasing since 1990. Companies that provide a general regional distribution service have a large market share, more than 80 percent.

For further analysis, a classification of vehicle types is needed. Such a classification is based on the vehicle matrix developed by PSD and TLN. Four categories of vehicles are suggested, based on van and truck types. Most deliveries take place by truck and van. In particular, in the retail sector and offices, truck use is more than 50 percent. Vans have also a high share in the 'modal split', in particular in the hospitality industry. Passenger cars are also used. This needs special attention because the use of cars for the delivery of goods is difficult to register.

Another aspect of the distribution of goods is the number of stops per trip. For the retail sector an average of 1.3 number of stops per trip is found. Other studies show that in urban areas, higher numbers of stops per trip are found. In particular, the organised city distribution services have about 14 to 15 stops per trip in an urban area.

The average trip length has increased as a consequence of more frequent deliveries. Trips for the delivery of fresh food and groceries are relatively short compared to the delivery of fashion products and luxury goods. Surveys in this area did not provide reliable data.

Another characteristic, strongly related to trip length, is trip travel time. There is, however, no public information available on travel speed and travel time.

Finally, a transport characteristic is the distance between the origin and the destination of the delivery. Of concern is that most deliveries in the Netherlands have their origin outside the city or region. Almost sixty percent of the deliveries have their origin outside the region around the particular urban area.

With these transport characteristics, it is possible to estimate the vehicle mileages that are produced in order to transport and distribute the deliveries.

3.7   Share of urban goods distribution at local level

3.7.1   Introduction
Section 3.2 made it clear that urban goods distribution does not represent all (goods) traffic moves within an urban area. In order to get an understanding of the share of urban goods distribution in all traffic moves, we present some information on traffic moves within urban areas.

3.7.2   Number of trips
Research, such as that by Coopers & Lybrand (1991a and 1991b), provides insight into the number of vehicle movements in the urban area, where they registered the number of goods trips. The average number of trips per address served is about two per day. This mounts up to about 4000 trips for an urban area with 2000 addresses (in this case only businesses as described earlier).

Table 3-29: ***Number of addresses served, number of trips and number of shipments per day in the inner cities of Arnhem, Groningen, Leiden and Maastricht, 1991 (Source: Coopers & Lybrand, 1991a and 1991b)***

Municipality	Number of addresses served per day	Number of trips per day	Number of trips per address served
Arnhem	1610	3200	2.0
Groningen	2070	4200	2.0
Leiden	1896	4500	2.4
Maastricht	1891	3800	2.0

The number of trips made for urban goods distribution has to be compared with the total number of goods trips within urban areas to get an idea of the magnitude of urban goods distribution in total goods traffic. This information is not available.

3.7.3 Traffic share

Traffic intensities are, in general, determined by means of a traffic census, where attention is only paid to categories of traffic, and not to goods traffic specifically. Trucks, for instance, are classified with buses in the category of heavy vehicles. In some surveys, attention is paid to goods transport. According to Bouman et al. (1990), the share of goods traffic is eighteen percent in the total traffic on inter-local through-roads, and only one percent on domestic streets (see Table 3-30).

Table 3-30: ***Share of goods traffic in total traffic in urban areas, 1990 (Source: Bouman et al., 1990)***

Type of road [%]	*Percentage goods traffic*	*Of which:*	
		Light	*heavy*
Inter-local through-road	*18.0*	9.9	8.1
Bypass road	*14.0*	9.1	4.9
Main structural road	*8.0*	6.0	2.0
Access road	*6.0*	5.1	0.9
Domestic street	*1.0*	0.95	0.05

Not all this goods traffic is related to urban goods distribution. Section 3.2 mentions categories of goods traffic that cannot be considered as urban goods distribution. For instance, building and demolition traffic accounts for seven percent, waste transport for four percent and removal trucks for one percent of the goods traffic in German cities (Köhler en Strauß, 1997). For Dutch cities, this might be different. There is, however, little information available. It appears that part of the goods traffic in the city is in transit. In the city of Delft 47 percent of the goods traffic movements are transit (Veeke and Jansen, 1989). This component therefore has no destination (or origin) in the city in question. The situation in the city of Delft is exceptional. It is estimated that generally, about 15 percent of the goods traffic is transit.

Although this section provides no information that can be directly used to estimate the share of urban goods distribution, the purpose is to indicate that urban goods distribution only

represents a small share of total traffic and a considerable share of all goods traffic moves. There are no relevant sources for reliable estimates.

3.7.4   Conclusions

The share of urban goods distribution in all traffic moves at local level is difficult to determine. To some extent, the share of all goods traffic can be determined by traffic surveys in urban areas. Although most traffic surveys distinguish heavy, medium, and light traffic, such a distinction is not enough for goods traffic analysis.

Goods traffic is made up of different categories. There are no local traffic surveys available that make a distinction between different categories of goods traffic.

3.8   Urban goods distribution at national level

3.8.1   Introduction

In this section, we will estimate the share of urban goods distribution in the total transportation of goods in the Netherlands. We will also attempt to focus attention on some developments that occurred in urban goods distribution. These trends are made clear by national data on domestic transport. While there is no historical data available on urban goods distribution, we assume that trends in domestic goods transport also apply to urban goods distribution.

Existing data sources provide some information on urban goods distribution but do not present a detailed and complete overview. Data from the Statistics Netherlands (CBS) in the Netherlands provide some general insights in this matter. The magnitude of goods traffic and urban goods distribution, in particular, will be described in total annual transport volume, the transport performance (tonne-kilometres per year), annual traffic volume (vehicle kilometres per year).

3.8.2   Estimation of the share of the distribution of goods in urban areas

It is expected that a large share of the domestic goods transport in the Netherlands concerns the delivery of consumer goods to urban areas. There is no official information available to support this hypothesis. Based on data collected in different urban areas in the Netherlands, a first estimate was made. The estimates are carried out by using expressions 3.6-1 and 3.6-2 from Section 3.6. The estimates are based on the number of businesses (per category) registered at the Chambers of Commerce (first of January 2000).

The number of deliveries of consumer goods in urban areas is about two million deliveries each week on average. The total volume is 2 million cubic metres or one million tonnes to all destinations (except for recreation facilities, for which there is no data).

These distribution activities (except recreation and offices) generate about 60 million vehicle kilometres each week. This includes vehicle kilometres within and outside urban areas.

With this information, it is possible to estimate the annual transport volumes and performances (see Table 3-14). The number of deliveries is about 106 million deliveries in a year with a volume of 107 million cubic metres or 53 million tonnes. Calculations with other sources (HBD, 1995; TLN, 2000) show that these estimates lie within the same range. HBD

(1995) estimated the total transported volume for the retail sector at 47.8 million tonnes per year, which can be regarded as a minimum level. HBD (1995) estimated the annual traffic performance related to the delivery of goods to the retail sector to be about 1.57 million vehicle kilometres (including interurban movements). Another figure, estimated for another purpose by NEA/DHV (1998), sets 137.5 million tonnes as an upper limit for the total transported volume by goods distribution in the year 1995. This figure concerns all the goods transported domestically in standardised load units (for example, boxes and pallets) in volumes of less than one cubic metre.

Table 3-31:   ***The number and volumes of deliveries of urban goods distribution in the Netherlands, 1999 (Source: own calculations, mainly based on DHV, 1999)***

	Number of deliveries per year	*Total volume per year [m³/year]*	*Total weight per year [tonne/year]*	*Total traffic performance [vehiclekm/year]*
Own estimates	$106 \bullet 10^6$	$107 \bullet 10^6$	$53 \bullet 10^6$	$3.1 \bullet 10^9$

Comparing the total weight of the deliveries in urban areas with the total weight of domestic transport in the year 1998 (CBS, 1999) shows that the share of the deliveries in urban areas is about ten percent. Other sources (for instance: HBD, 1995) find a share of at least 12-15 percent.

The total traffic volume by goods traffic was estimated at 17.6 billion vehicle kilometres (about 16 percent of total traffic). Urban goods distribution generates about 18 percent of the traffic volume. Some sources say that the share of urban goods distribution is even higher. The deliveries in urban areas are carried out mainly by vans and smaller trucks. This means that more vehicles have to be made for the transportation of a similar amount of volume or mass compared to other domestic transport kinds where large trucks and semi-trailers are used.

3.8.3   Historical data on urban goods distribution

New developments are occurring in urban goods distribution. These trends are made clear by national data on domestic transport. There is no historical data available on urban goods distribution. Domestic transport can be expressed in terms of vehicle kilometres (traffic volume), in terms of tons (transport volume) or in terms of tonnekilometres (transport performance).

Information on the transport volume of goods traffic can be found for the Netherlands in the statistics of domestic goods transport and the statistics for import, export, and throughput, as published by the CBS. These statistics use a mass measure (tonnes per year) as the indicator for the transport volume. These statistics give some information on urban goods distribution. There are, however, some drawbacks. These data sources do not, by definition, include transport in small volumes. No distinction can be made between destinations, such as industrial areas or inner cities. Information can, at best, be desaggregated to the city level. The survey that is the base for this data source, only includes transport with vehicles with a loading capacity larger than 1000 kilograms. Vans and cars are excluded. Since 1997, information is also collected by CBS on the use of vans for own transport. CBS also collects data on domestic goods transport for different types of vehicles the annual traffic volumes

(vehicle kilometres per year) and also the load-tonne-kilometres per year. The data on traffic volumes contains the category traffic volumes for urban roads, which is interesting but traffic volumes on urban road are used as a remnant from a statistical point of view, and therefore the data unreliable. The actual traffic volumes within urban areas are higher. Despite these remarks, the data show some relevant developments that might also take place in urban goods distribution.

Traffic volume

The growth of traffic volume, expressed in vehicle kilometres, is responsible for the increase of emissions, and can be treated as a significant of such. The total traffic volume by road traffic in the Netherlands in 1995 was estimated at 111 billion vehicle kilometres. The total by goods traffic was estimated at 17.6 billion vehicle kilometres (about 16 percent).

Vans and trucks (including articulated trucks) accounted for about 22 percent of the total traffic volume in urban areas in the year 1995 (see Table 3-32). Thus, vans generate 18 percent and trucks 4 percent of the traffic volume. It should also be noted that:

- Vans are also used commercially for passenger transport. The statistics do not pay take this into account;
- Some own transport takes place by cars, and this is also not included in these figures.

It is clear that goods transport has a limited share in the traffic volume in urban areas. Passenger cars and busses account for more than 82 percent of the total traffic volume in urban areas.

Table 3-32: ***Traffic volume in urban areas from 1986 until 1995 [million vehicle kilometres] (Source: CBS, 1996)***

Year	Vans	Trucks	Articulated trucks	Goods traffic	Total road traffic
1986	4,107	898	364	5,368	28,819
1988	5,368	846	414	6,627	-
1990	6,186	839	456	7,481	-
1992	6,904	819	401	8,124	-
1993*)	5,073	489	543	6,105	-
1994	5,228	460	549	6,237	-
1995	5,353	483	597	6,434	29,334

*) From 1993 on, a different method was used to calculate the vehicle kilometres by vans within urban areas.

One striking result, however, is the fast growth of the use of vans, as shown in Table 3-32. In the city centre of Rotterdam in the Netherlands, for example, the number of vans per day has shown a growth of 28 percent in the period 1990-1993, while the number of trucks decreased by 17 percent in the same period (KPMG, 1994). While this is not typical of the Dutch situation, in other countries similar developments are also taking place, for instance in the UK (Browne, 1997). In 1993, the vans that were used for the purposes of goods transport, making up only 20 percent of the total number of vans, produced 60 percent of the total of 10 billion vehicle kilometres produced by all vans.

According to these statistics, goods traffic is constantly growing. Urban goods distribution related to the distribution of consumer goods is, however, only a part of this traffic. There are no clear indications if goods traffic related to urban goods distribution grows shows the same or a different trend.

Transport volume

In 1995, domestic goods transport in terms of transport volume by road in the Netherlands mounted to about 398 million tonnes per year (see Table 3-33). About 219 million tonnes was transported at distances shorter than 50 kilometres and about 179 million tonnes at longer distances. Urban goods distribution is represented by both categories. There is no one-on-one relationship with any one of these road transport categories.

Table 3-33: *Transport volumes in tonnes per year in 1986 and 1995 by road (million tonnes per year) and, annual growth in the period 1986-1995 in the Netherlands (Source: Adviesdienst Verkeer en Vervoer(AVV), 1997)*

		1986 10^6 [tonnes]	1995 10^6 [tonnes]	1986-1995 average increase [% per year]
Total transport volume (road, waterborne and rail)		**1,070**	**1,185**	**1.1**
Domestic		*453*	*488*	*0.8*
	Road < 50 km	227	219	-0.4
	Road > 50 km	137	179	3.0
	Road total	*364*	*398*	*1.0*
International transport by road		*92*	*147*	--
	import/export	78	123	5.2
	transit	14	24	6.2

The annual growth of goods traffic in the last ten years in the Netherlands can hardly be explained by the growth of domestic transportation of goods. Table 3-33 shows that domestic road transport grew by 1.0 percent per year at average between 1986 and 1995 in transport volume. The table also shows that road transport on a transport distance longer than 50 kilometres grew by 3.0 percent per year while on distances shorter than 50 kilometres a reduction by 0.4 percent per year took place. The table also shows that international transport by road, import/export, and transit traffic increased by 5.2 and 6.2 percent per year. This is much more than domestic transport.

Transport performance

Short (1999) concludes that in various countries, about 80 percent of the transport performance of goods traffic (measured in tonne-kilometres) takes place within urban areas. There are no concrete figures to validate this for the Netherlands. Table 3-34 presents the transport performance of goods traffic in the Netherlands. It shows that domestic road transport has a large share in the transport performance. However, if we compare this with the estimated transport performance by urban goods distribution (3.1 billion tonne-kilometres), the transport performance within urban areas is much less than 80 percent (at maximum 11

percent because this figure also includes the transport performance of urban goods distribution outside urban areas).

Table 3-34:   *Transport performance in tonne-kilometres per year in 1986 en 1995 by road (billion tonne-kilometres per year) and annual growth in the period 1996-2002 in percentages per year in the Netherlands (Source: AVV, 1997)*

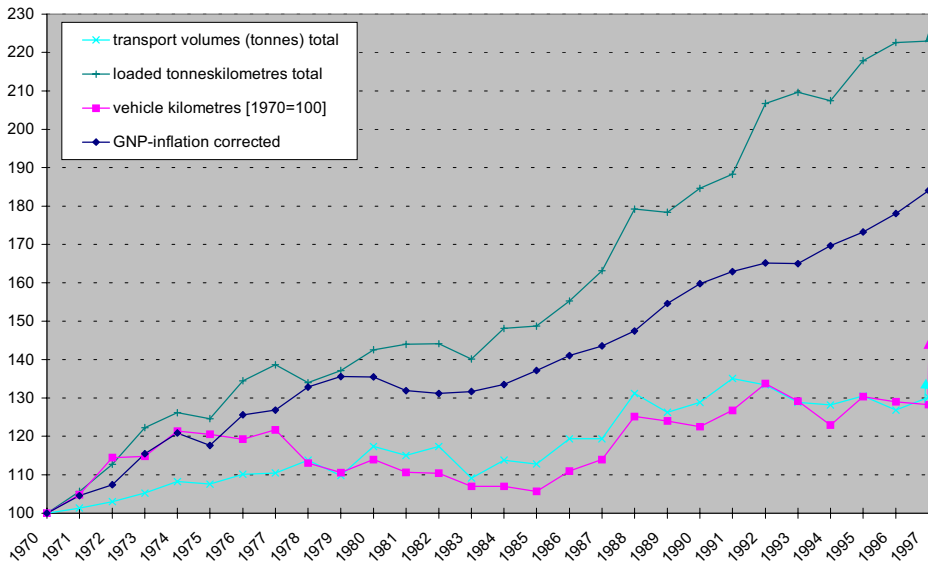|		1986 10^9 [tonne-kilometres]	1995 10^9 [tonne-kilometres]	1986-1995 average increase [% per year]
Total transport performance (road, waterborne and rail)		**57.3**	**67.4**	**1.8%**
Domestic, in which		27.4	34.6	2.6%
	Road < 50 km	6.2	7.2	1.7%
	Road > 50 km	13.0	19.7	4.7%
	Road total	*19.2*	*26.9*	*3.8%*
International road transport, in which		6.9	11.8	--
	import/export	5.5	9.3	6.0%
	throughput	1.4	2.5	6.7%

The annual growth of goods traffic in the last ten years can be explained by the growth of the transport performance, also by domestic transportation of goods. Domestic transport by road increased yearly by 3.8 percent as shown in Table 3-34, mainly by an annual increase of 4.7 percent of domestic goods transport at a distance longer than 50 kilometres.

If we consider a longer period of time, the situation is different to some extent. Figure 3-6 shows that, in domestic goods transport, the annual growth of transported volumes (in tonnes) and vehicle kilometres is relatively low in the period of 1970-1997. It barely keeps up with the growth of the Gross National Product (GNP) (corrected for inflation). The growth of the loaded tonne-kilometres is remarkable: the transport performance, expressed in tonne-kilometres of domestic goods transport, shows an annual average growth of 4 percent, while the transport volume remained almost constant during the last ten years at a level of about 500 million tonnes each year (de Kok, 1998).

These figures show that the annual transport performance exceeds the annual growth of the GNP. These figures, however, only show goods transport by truck. Data on transportation by van are only available for the year 1997.
Recent data show a sizeable increase in 1997, due to the inclusion of proprietary transport delivery vans of up to 1.5 tonnes load capacity (before 1997, these were not included in the statistics). However, vans of this capacity are not included in the statistics on national professional transport, due to their limited use (only by courier services).
An analysis of these figures shows that the growth of the average travel distance, in combination with an increase of the average loading capacity of trucks, is responsible for this increase in transport performance.

*Figure 3-6   Transport and traffic volumes of domestic goods transport in the
             Netherlands between 1970 and 1997 compared to the annual gross national
             product, inflation corrected [index 1970=100] (Source: CBS, 1999)*

Note: Since 1997 the Statistics Netherlands (CBS) also registers the use of vans. The arrows in this graph
indicate the increase in tonnes and vehicle kilometres in 1997 when vans are included.

Figure 3-6 also shows that the traffic volume, expressed in vehicle kilometres, has remained
relatively stable. If we include the use of vans for the year 1997, however, a strong increase is
shown. The growth of the traffic volume can be explained by the following factors:
- A relatively small growth of the transported volume;
- A strong growth of the average transportation distance (from 41 kilometres in 1970 to 70
  kilometres in 1997);
- A growing share of the use of vans.

The growth of the traffic volume, however, keeps lagging behind the transport performance
due to an increase in the average transport weight per trip from 5.9 tonnes per truck trip in
1970 to 10.4 tonnes (8.8 tonnes if we include the use of vans) per trip in 1997.

3.8.4   Forecasts for urban goods distribution

For domestic goods transport in the Netherlands some forecasts are also available. It is
expected that these forecasts also represent the expected trends in urban goods distribution.
For this reason it is relevant to consider the expectations.

Domestic goods transport in the Netherlands is expected to increase, according to the goods
transport forecasts for 1997-2002 (AVV, 1997) in transport volumes (tonnes per year) by 1.1
percent per year (0.8 percent on distances shorter than 50 kilometres) and by three to four
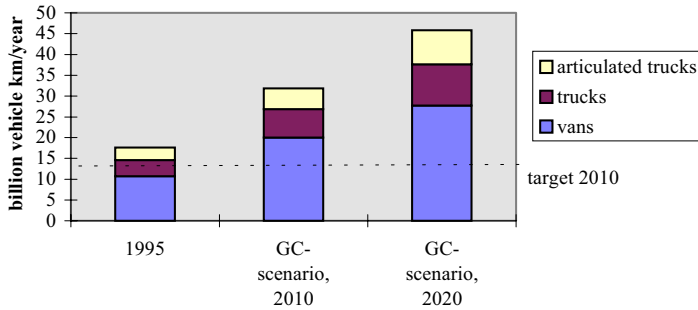percent per year (RIVM, 1997) in terms of vehicle kilometres.

Figure 3-7:   Goods traffic volume: in 1995, with forecasts for 2010 and 2020 (Source: RIVM, 1997)

Note: Vans are also used for purposes other than goods transport. No distinction is made in this figure between vans for goods transport and for other purposes.

RIVM (1998) produced forecasts for domestic goods transport in terms of transport volume, transport performance, and traffic volumes according to three scenarios. Table 3-35 summarises these forecasts for these three aspects. This gives an indication of the developments that can be expected. For instance, the transported volumes in tonnes will grow by about 22 percent between 1995 and 2020, while the traffic volume, measured in vehicle kilometres will increase by 64 to 153 percent for vans and trucks.

The transport performance, in particular, will still increase as a result of economic growth, the relatively strong growth of foreign trade to and from the Netherlands and the related logistical and spatial developments (JIT-concepts and de-concentration of logistic activities). A strong growth of the transport performance will be caused by a modest growth of the transport volumes, but mainly by increasing transport distances (caused by spatial upscaling processes, such as concentrating distribution on a European level).

Table 3-35:   Forecasts of transport volume by domestic transport by road in the Netherlands in the years 2010 and 2020, measured in tonnes (Source: RIVM, 1998)

[index 1995 = 100]	1995	2010	2020
Transport volume (tonnes)	100	113	122
Transport performance (tonne-kilometres)			
- van	100	138-184	164-280
- truck (including tractor-trailer)	100	145-200	170-320
Traffic volume (vehicle kilometres)			
- van	100	138-183	164-253
- truck	100	136-173	164-253
- tractor-trailer	100	120-167	141-272

Part of that growth will occur within urban areas. At present, the number of goods transport trips is expected to increase more than proportionally. Local traffic measures will have to ensure that the growth in goods transport will shift to the main roads within or outside built-

up areas. The RIVM-report (1997) assumes that, due to the implementation of restrictive measures and the implementation of city-logistics concepts, the growth of goods traffic will be limited within urban areas. It is not clear, however, if these strategies will work. Some local planners are already seeing an increase of goods truck movements in areas with time restrictions.

3.8.5   Conclusions

In this section, we estimated the share of urban goods distribution in the total transportation of goods in the Netherlands and focussed the attention on some developments that are occurring in urban goods distribution. These trends are made clear by national data on domestic transport.

With the information presented in Section 3.3, an estimate was made of the annual transport volumes and performances of urban goods distribution. According to these estimates, the number of deliveries is about 106 million deliveries in a year with a volume of 107 million cubic metres or 53 million tonnes. Comparing the total weight of the deliveries in urban areas with the total weight of domestic transport in the year 1998 shows that the share of the deliveries in urban areas is about ten percent. Urban goods distribution generates about 18 percent of the traffic volume; some sources indicate that the share of urban goods distribution is even higher. In the last ten years, domestic goods transport, and possibly also urban goods distribution, has grown by 1 percent yearly in terms of transport volume (tonnes per year) and 3.8 percent in terms of transport performance (tonne-kilometres per year).

In the future, this growth will most probably continue. The transported volumes in tonnes are projected to grow by about 22 percent between 1995 and 2020, while the traffic volume, measured in vehicle kilometres may increase by 64 to 153 percent for vans and trucks. Part of that growth will occur within the urban areas if local measures are not effective.

3.9   Summary and conclusions

This chapter focussed on the first objective of this study*: to develop a clear understanding of the goods distribution in urban areas*. We defined urban goods distribution, structured the information on the characteristics of urban goods distribution, and provided a quantitative information base to prove the relevance of urban goods distribution and to describe trends.

We will draw our conclusions on:
*   The definition of urban goods distribution;
*   The characteristics (categorisation, quantification and availability of information);
*   The magnitude and share of urban goods distribution;
*   Forecasts and developments.

We have shown that much research has been carried out on a local level on the distribution of goods in urban areas; however, this information is fragmented. Through the use of information from these studies carried out in different urban areas, an attempt was made to quantify the aspects of urban goods distribution as much on a local level as on a national level. On the national level, some forecasts are available for domestic goods transport. The conclusions from these forecasts also apply to some extent to urban goods distribution.

Goods distribution in urban areas covers the transport of goods to, from, and within urban areas, and deals mostly with the delivery of consumer goods to shops, department stores, supermarkets, hospitality industry, offices, and directly to the homes of customers.

There are four simple criteria for good flows that had to be met to be included in the definition of urban goods distribution in this study:

1. Type of goods: consumer goods;
2. Place in the logistic chain: final distribution;
3. Situation: destination within urban area.
4. Objective: primary objective of the movement should be the transportation of goods

For a good flow, these four criteria should be met. Other, although considerable, traffic flows in the urban environment, such as building and demolition traffic, the provisioning of industry with raw materials and semi-manufactured articles, and the provisioning of the wholesale trade, were not considered.

We have described the characteristics of the distribution of goods and of goods flows, and proposed a classification for each characteristic. Goods were categorised in terms of physical characteristics, characteristics of form and packaging, volume density, handling characteristics (i.e., perishability, vulnerability and risk), marketing characteristics and shipment characteristics. We also extracted some standardised key-figures for further quantification of the distribution of consumer goods. The characteristics of goods flows were considered in terms of the following characteristics:

*   Distribution characteristics (destinations of the goods flows, frequency and the size of the deliveries, distribution channels that are applied);
*   Transport characteristics (organisations distributing goods, types of vehicles used, number of stops, trip length, trip time and speed, transport distance and origin).

The distribution characteristics determine the volume of urban goods distribution. The dimensions of its characteristics can express the demand for goods distribution: mass (tonnes), volume (cubic metres), number of transport units (boxes, pallets, racks, etc.) or monetary value. Characteristics such as the type of goods, destinations, and distribution channel are then used to categorise the differences between goods flows.

*   The types of goods are further characterised by the destination of the goods, the condition under which they are transported (frozen/chilled, hanging and so on), the load unit used (box, pallet, rack and so on).
*   Based on research experience in this area, destinations for urban goods distribution are divided into thirteen categories. The size of a destination (an establishment) is relevant in relation to the demand of goods. The size of an establishment can be measured in sales per time period, number of (full-time) employees, or selling floor space.
*   The classification of distribution channels is based on the number and type of intermediaries within the distribution channel.

Quantitative information on the frequency and size of deliveries is mostly available per type of destination. These factors depend on the type and size of the destinations and use of distribution channels.

With the transport characteristics of goods flows, it is possible to estimate the traffic volume or, in other words, the vehicle mileages that are produced by urban goods distribution.

Transport characteristics, such as type of carrier and vehicle type, are used for categorisation purposes.

- The type of carrier category can be divided into professional transport (in commission for a specific transshipper, group transport, general distribution or courier and parcel services) and own transport (by receiver or shipper).
- A classification of vehicle types, based on the vehicle matrix developed by PSD and TLN is suggested. Four categories of vehicles are proposed, based on van and truck types.

Quantitative information on the number of stops, trip length, trip time, and speed, transport distance is currently insufficient. This makes it more difficult to determine the total traffic volume generated by urban goods distribution.

With the information derived from the literature survey, an estimate was made of the share of urban goods distribution in the total transportation of goods in the Netherlands. Unfortunately, this information is neither detailed nor accurate. This means that this estimate gives only a rough indication of the annual transport volume and performance of urban goods distribution. According to these estimates, the number of deliveries in the Netherlands is about 106 million deliveries in a year with a volume of 107 million cubic metres or 53 million tonnes. Comparing the total weight of the deliveries in urban areas with the total weight of domestic transport in the year 1998 shows that the share of the deliveries in urban areas is about ten percent, while urban goods distribution generates about 18 percent of the traffic volume. On a national level historical data and forecasts are available in the Netherlands for domestic goods transport. However, domestic goods transport only represents urban goods distribution to some extent. According to these forecasts, transported volumes in tonnes will grow with about 22 percent between 1995 and 2020, while the traffic volume, measured in vehicle kilometres will increase by 64 to 153 percent for vans and trucks. To improve the quality of this estimate, it would be necessary to develop a more standardised data-collection with options for detailed analysis. The proposed classifications of goods flows can be used for this purpose.

In this chapter, we have shown the significant share of urban goods distribution related transport within the whole of goods transport. Goods distribution for urban areas is therefore an important issue for policymakers, as we will elaborate further when discussing the actual problems related to urban goods distribution, in the following chapters. We have explored the urban goods distribution process, a process that turns out to be very complex: a multitude of factors determines the choices players make with respect to vehicle choice, the choice for logistics concepts, and the types of flows that may be expected within the urban areas. These factors include the physical structure of an urban area, the competitive position of an urban area in comparison with other areas, and the composition of the collection of establishments (types and sizes). We will use this information later on to analyse the logistic processes in more detail and to develop better alternative logistics concepts (part III), to evaluate existing transport systems and to design new ones (part IV), to develop appropriate spatial concepts (part V) and eventually, to develop integrated policy-schemes that are able to solve part of the problems as signalled here.

4.   The sustainability of urban goods distribution

4.1   Introduction

Continuing the problem definition, that started in chapter 3, this section analyses the problems related to urban goods distribution in greater detail. Chapter 3 analysed and quantified the process of urban goods distribution in detail. This chapter will analyse the sustainability problems related to urban goods distribution and the underlying relationships.

The sustainability problems related to urban goods distribution (and other goods traffic in urban areas) have both a local and a global dimension. Two local issues are:

- The contribution of goods traffic to the reduction of the quality of life in urban areas (air pollution, nuisance, traffic safety, use of space);
- The reduction of the accessibility of urban areas for passenger traffic and goods traffic at certain places and at certain times (congestion, vehicle restrictions).

Urban goods distribution also contributes to global sustainability problems, especially those that affect the environment (emissions, exhaustion of natural resources, waste). While the contribution of the distribution of goods in one urban area to the global environmental problems is small, the contribution of all urban areas combined is significant. We therefore take into account both local and global environmental issues. We will analyse these environmental issues in Section 4.3, and in Section 4.4 we will analyse the accessibility issue. In Section 4.2, we consider the underlying relationships between these problems and developments.

In this chapter, we will aim at analysing and quantifying the sustainability problems related to goods distribution for urban areas. The analysis will be used later on to develop new logistics schemes, using appropriate transport systems and spatial systems that can help to reduce the

indicated problems (parts III, IV and V). The quantification and the determining methods will help to evaluate our proposed solutions in part VI.

4.2   Underlying relationships between developments and problems in urban goods distribution

4.2.1   Introduction

Figure 4-1 summarises the most significant factors and relationships leading to problems of urban goods distribution. A significant driving force for the demand for the distribution of goods in urban areas concerns the consumption of consumer goods. Three important trends influence consumption in terms of what, how much and where: economic growth, demographic developments, and spatial developments (such as urban revitalisation, including the development of shopping facilities). The distribution of the consumer goods in urban areas leads to traffic and thus induces conflicts, such as nuisance, congestion, and global environmental problems.

Local nuisance is generally the basis for access restrictions. These restrictions and congestion cause another conflict, namely accessibility problems. The accessibility influence the organisation of goods transport on an operational level, namely changes in trip and route planning and on a strategic level, this means changes in logistic systems. Accessibility is also an important location factor for shopping facilities. Therefore, accessibility influences the development of shopping centres. The public attention to global environmental problems leads to the use of cleaner vehicles and in combination with local accessibility to new distribution concepts.
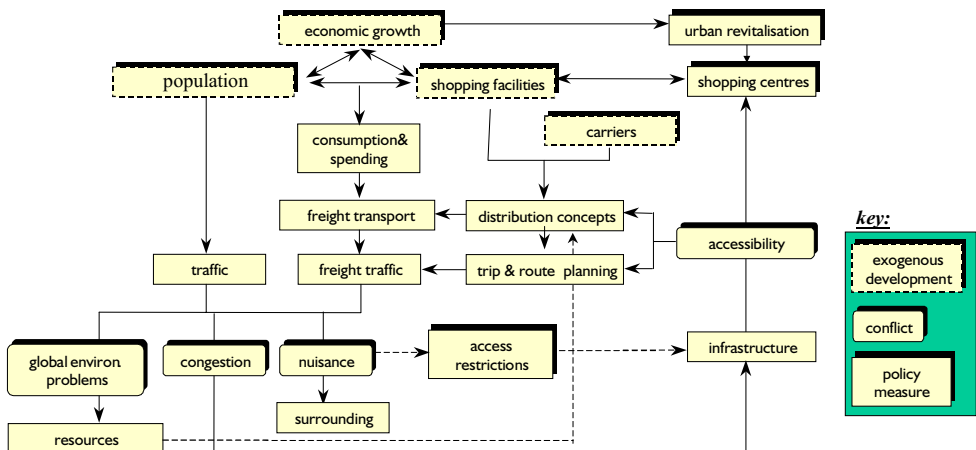

Figure 4-1:   Conflicts diagram

These conflicts are influenced by a large number of trends that already take place or start to take place. A significant group of trends is related to the supply and demand of consumer

goods. These trends influence the demand for urban goods distribution. Within the system of goods distribution, we can recognise trends, for instance in the area of logistics and transport. The available infrastructure for goods distribution is changing and spatial developments have an influence on urban goods distribution. Some of these trends make the problem worse but some of them improve the situation. We will now discuss these trends. In parts III, IV and V we discuss them more in depth.

4.2.2   Systematic and integrated approach

The conflicts are influenced by a large number of trends that are occurring or starting. These trends can be classified as follows:

- Trends in supply and demand of consumer goods;
- Trends in logistics and transport;
- Trends in transport means, infrastructure and infrastructure-use (traffic);
- Spatial developments.

The goods distribution process is a part of complex economic and social processes where different players (private and public) play a role and where actions influence each other.

Economic growth, demographic developments, and spatial developments lead to changes in consumption patterns, and therefore lead to changes in the urban goods distribution processes. Developments in consumer demand support the general belief that the transport volumes related to the distribution of consumer goods will increase.

Logistic trends, such as the outsourcing of distribution, new forms of co-operation and the spatial upscaling trends related to shopping areas, can cause more consolidation.

With respect to traffic conditions, these developments counteract each other: an increase in transport volume would imply an increase in traffic volumes. However, a higher level of consolidation would probably decrease the volumes. The expected expansion of shopping areas outside the inner cities will have a traffic calming effect on the traffic volumes in inner cities. In all, we expect that these trends will have a calming effect on the *growth* of the traffic volumes but will not in themselves significantly decrease problems in urban areas. In particular the trends (including government measures) regarding road transport, lead to an overall reduction of accessibility.

These trends are only autonomous and exogenous to some extent, but are entirely mutually exclusive. Developments in one sector (e.g.: spatial developments and resulting real estate prices) will necessarily influence developments in other sectors (e.g.: the way goods are distributed, hence the logistics organisation), as developments in all sectors and levels of the goods distribution process are strongly interrelated. Therefore, measures[9] taken in one sector or at one level will influence developments in various sectors and on various levels (and conversely, the effects of some measures will be hampered by a lack of associated measures at other levels or in other sectors).

4.2.3   Conclusions

These developments cannot be regarded as autonomous, but are a result of complex interactions between players and the actions they take. In Part II, we will use micro-economic

---

[9]   We see measures as all actions of private and public players that aim at improving the urban distribution process in one way or another.

utility theory and apply the layer model for transport to understand and clarify these interactions with respect to urban goods distribution.

The trends identified sometimes support, and in other cases hamper the efficiency improvement we aim for in urban goods distribution. Knowledge of these trends and interactions is necessary to develop (Parts III, IV and V) and to implement (Part VI) new urban goods distribution schemes. Therefore, in Parts III and IV, these trends will be analysed in greater detail.

4.3   Environmental issues

4.3.1   Quantification of the problem: environmental indicators

Environmental indicators can be divided into three groups. The first group concerns the emissions that lead to global impacts, such as climate change and acidification. The second group concerns environmental problems on a more local level. This group is referred to as nuisance. The third group concerns the exhaustion of materials, energy and the use of space.

Table 4-1:   Indicators related to urban goods distribution

Issues	*Indicator*
Emissions with global impacts	
• Climate change	emissions of CO_2 and greenhouse gasses (N_2O and CH_4)
• Acidification	concentrations/emissions of NO_x, SO_2 and VOC
Local issues	
Air pollution	concentrations of CO, NO_2, HC, aerosols and Pb
Nuisance, such as:	
• Noise	Noise levels
• Traffic safety	Lethal accidents, accidents with severe injuries (traffic)
• Risk	Monetary effects; lethal accidents and injuries (transport)
• Physical hindrances	-
• Vibration	-
Exhaustion	
• Fossil fuels	Energy in terms of Mega-Joules
• Materials	Mass of used materials
• Use of space	Surface

In the Netherlands, policy targets for environmental objectives are set only in particular areas. In particular, local environmental objectives are worked out by legislation.

4.3.2   Global environmental issues

Goods transport problem is not simply a local environmental problem. Much effort has to be made before goods transport can become sustainable. National environmental targets related to traffic (and to some extent, based on the concept of sustainable development), cannot be met, with respect to goods transport and in particular urban goods distribution. In the second Dutch national environmental policy document (Nationaal Milieubeleidsplan 2 (NMP-2)), for

instance, a maximum growth in vehicle kilometres by goods trucks of 40 percent was set as a target for the period 1986 to 2010. The growth during that period is expected to be between 75 and 132 percent.

The following global environmental problems have been identified:

- Emissions which influence climate change, such as carbon dioxide (CO_2) and the greenhouse gasses (N_2O and methane (CH_4)) and acidification (oxides of nitrogen (NO_x), sulphur dioxide (SO_2) and hydrocarbons (HC));
- The exhaustion of natural resources, such as materials and fossil energy;
- Dumping of waste materials.

According to the 'Fourth National Scan on the Environment' ('Nationale Milieuverkenning 4'; RIVM, 1997), the national targets in the Netherlands for NO_x-emission of goods traffic in the year 2010 cannot be met by current policy instruments. The emission of NO_x by goods traffic in 2010 in the Netherlands is expected to be four times higher (amounting to between 85 and 110 kilotonnes) than the national target of 25 million kilograms NO_x per year for that year. The implementation of the Euro-4 standard for trucks in the year 2005 will have a considerable impact on emissions, but will probably not be enough. Another target that will not be met is the CO_2-emission of all traffic (from 1986 to 2010), which will not grow by 10 percent but by 90 percent (!). The national targets for noise and CH-emission will also fail to be met with current policy measures (RIVM, 1997). These targets can only be met if stringent measures to reduce the goods traffic volume ('volume-measures') are taken, or if a breakthrough in new technology occurs.

Targets and determining methods for emissions

The general method for determining emissions is to estimate the performance of traffic (expressed in vehicle-kilometres per vehicle type), (in this case, goods traffic within urban areas) and to multiply this by an emission factor (average emission in kilograms per vehicle kilometre). This can be done for the reference base, current situation or future situation. In the national environmental plans in the Netherlands, such as Nationaal Milieubeleidsplan 3 (NMP-3) (VROM, 1998) national targets are defined for road traffic and goods traffic. Logically, these targets also apply to urban goods traffic. Figure 4-2 describes the method. The data are derived from the National Environmental Scan 4 ("Nationale Milieuverkenning 4"; RIVM, 1998)).
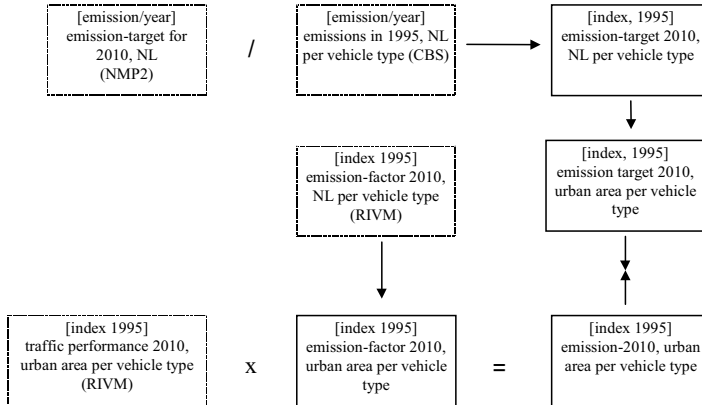
Figure 4-2:   Calculation method for emissions

Table 4-2 shows the expected emissions in 2010 calculated using this method, and the policy targets for comparison. In order to be able to apply the method, it is must be clear what the future emission factors will be for different vehicle type and the future traffic volumes of goods transport in urban areas. No policy target is available for N_2O.

Table 4-2:   Policy target and expected emissions in 2010 in urban areas by goods traffic (Source: derived from national figures from RIVM)

GC-scenario [index 1995 = 100]	Emissions in 2010			
	CO_2-emission	NO_x-emission	SO_2-emission	HC-emission
Van	90	76	18	41
Truck	109	73	25	66
Articulated truck	108	72	26	70
Policy target	76	23	85	44

Overall target: limited growth
In order to get an overall reduction of emissions and other issues, a target was set in the Dutch National Environmental Plan (NMP2) to limit the growth of goods traffic to 40 percent between 1986 and 2010.

4.3.3   Exhaustion
This group of environmental objectives concerns the exhaustion of materials, the consumption of energy, and the use of space, all of which are *irreversible processes*. Although the exhaustion of material and the use of space are relevant objectives, currently, the are no policy targets formulated suitable for use in this thesis . Although energy use, in particular the reduction of the use of fossil fuels, is an important issue , it has a strong relationship with the reduction of CO_2; this was the reason that no separate target for energy use was formulated in SVV II (Ministerie van Verkeer en Waterstaat, 1990).

Targets and determining methods for exhaustion

Research in the field of sustainable development (Opschoor & Weterings, 1992) has developed policy targets for energy use. These targets have been formulated on a global level and can only be applied here when urban goods distribution has contributed to energy reduction at the same rate as the other sectors. Significant for urban goods distribution is the reduction of the use of petroleum by 68 percent between 1990 and 2040. This means a reduction of about 1 percent each year.

The energy use of traffic consists of (Schoemaker et al., 1988):

- The energy for the movement of vehicles;
- The energy for the production and transport of energy or fuels (see Boustead, 1979);
- The energy for the construction and maintenance of the vehicle(see Henham, 1983);
- The energy for the construction and maintenance of the infrastructure (Bos, 1997).

Normally only the energy use for the movement of vehicles (direct energy use) is considered. The energy use related to the production of the vehicles and the infrastructure is called indirect energy use. Here, we will only look at the direct energy use.

Table 4-3   *Formulated target for the direct energy use in 2010 for urban goods traffic in urban areas.*

Target group	Share energy use in 1995 [%]	Target in 2010* [PJ]	Target in 2010 [index 1995 = 100]
Road traffic, such as	100 (=378 PJ)	325	86
Goods traffic	32.7	106	86
Goods traffic in urban areas, from which:	11.1	36	86
- vans	5.8	19	86
- trucks	2.1	7	86
- articulated trucks	3.2	10	86

* based on a 1 percent reduction each year.

4.3.4   Local environmental issues

Goods traffic contributes to air pollution, and thereby reduces the quality of life in urban areas in general. Improvements within the passenger car fleet, such as the breakthrough of catalysts and more environmentally friendly fuels, may have caused goods transport to visible rather than passenger cars as an environmental problem.

The following environmental and nuisance problems are *local*:

- Local air pollution such as carbon monoxide, nitrogen dioxide, ozone, aerosols, benzene and lead;
- Traffic noise;
- Traffic safety (reduction of number of traffic accidents);
- Other forms of nuisance such as risk, smell, physical hindrance and vibration;
- The consumption of urban space for transport infrastructures and delivery points.

Lindkvist and Swahn (1997) note that recent reports on measurements of the level of air pollution in Swedish cities indicate that the total pollution has actually been falling during

recent years. A similar development of increasing local air quality in cities can be expected in many European cities. Despite this expected decline, it is still very difficult to meet legislated standards for noise and local air pollutants such as CO, NO_2 and aerosols, and targets for traffic safety are still difficult to meet. Smells, physical hindrance, vibration and the use of urban space strongly affect the quality of life in urban areas but are nonetheless difficult to measure. Risk, as a form of nuisance, is well legislated when it comes to the transport of dangerous goods although problems still occur.

Goods transport plays an important role in the discussion of the quality of life in urban areas. In particular, urban goods distribution plays a significant role because a large share of the traffic moves take place in traffic-sensitive areas, such as inner cities. In these areas with a high density of population and mixed use of the public space, such as streets and market squares, the negative, external costs of transport are easily felt. The situation in other advanced countries will probably be similar.

Table 4-4:   *Expected growth of hindrance of noise by traffic in the years 2010 and 2020 according to the 'Fourth National Report on the Environment' (1995=100) (Source: RIVM, 1997)*

Noise *[index 1995 = 100]*	*2010*	*2020*
Hindrance	98	117
Severe hindrance	108	131

Targets and determining methods for air pollution

The calculation method for determining local air pollution, developed for local governments, is referred to as CAR (Calculation of Air pollution from Road traffic), (see Sliggers (1989)). The limits for local concentrations are based on environmental legislation in the Netherlands ('Besluiten Luchtkwaliteit', based on the 'Wet inzake de Luchtverontreiniging').

Table 4-5:   *Limits to local concentrations for traffic situations*

	January 1st, 1992 until January, 1st 1995	*January 1st, 1995 until January 1st, 1998*	*January 1st, 1998 until January 1st 2000*	*From January 1st, 2000*
Carbon monoxide [µg CO/m^3 for 98-percentile of 8-hour average]	12750	10500	8250	6000
Nitrogen dioxide [µg NO_2/m^3 for 98-percentile of one-hour average]	150	150	150	135
benzene [µg C_6H_6/m^3 for yearly average concentration]	20	15	15	10

Note: a 98-percentile of one hour average means the concentration that during 98 percent of a year will not be exceeded.

For aerosols and lead, there are no legislated limits for local concentrations. A set of limits has been proposed but not yet implemented (see Table 4-6).

Table 4-6:   *Limits for local concentration of aerosols*

	[µg/m³ for 98-percentile of 24-hour average]
Aerosols	90
Lead	2

Note: Other limits relate to for instance the 24-hour average. Not shown here.

In relation to air pollution, there are only limits set, but no specific targets have been formulated. Because of the reduction of lead emissions, this may no longer be as relevant an environmental issue.

Targets and determining methods for noise hindrance
Noise levels in urban areas are regulated by legislation. There are different limits for noise levels for different situation. On the other hand, EU-legislation limits the noise production of goods vehicles. And finally the National Transport Structure Plan (SVV II - D (p.18) (Ministerie van Verkeer en Waterstaat, 1990) defines a national target for traffic noise, based on the total area with a certain noise level. As norm or target is set that the number of houses with a noise level (at the front side) of more than 55 dB(A) caused by local traffic should be 50 percent less than in 1986. No specific target has been set for goods traffic.
In Dutch noise pollution legislation, a distinction is made between urban and rural areas, new or existing buildings, planned and existing roads. Depending on the situation a limit of 60, 65 or 70 dB(A) is valid.

Targets and determining methods for traffic safety
A target for traffic safety has been suggested: a reduction of number of lethal accidents by 2010, with the rates 40 percent lower than in the year 1986. Currently, about 25 percent of the lethal traffic accidents, trucks or vans are involved. No target has been formulated for goods traffic in the National Transport Structure Plan (Ministerie van Verkeer en Waterstaat, 1990). Based on information from the traffic accident registry, the targets outlined in Table 4-7 can be formulated. It is assumed that the 40 percent target is also valid for accidents with severe injuries.

Table 4-7:   *Target for the year 2010 regarding traffic safety based on 40 percent reduction of lethal accidents and accidents with severe injuries for goods trucks, compared to the year 1986 (Source: Ministerie van Verkeer en Waterstaat, 1990)*

	1986		2010	
	Severe injuries	*Lethal*	*Severe injuries*	*Lethal*
Total, including:	41574	1584	24944	950
Trucks	1874	213	1124	128

Targets and determining methods for other forms of nuisance
There are no indicators for risk, physical hindrance, vibration, and smell developed with clear targets or limits. In relation to the transportation of dangerous goods, the limits for risks are legislated, but are not relevant in this research.

4.3.5   Conclusions
There are no targets set specifically for urban goods distribution formulated by national environmental policies. Therefore, we may assume that the targets that are set for (goods) traffic in general are applicable as well for goods transport in urban areas. Table 4-8 shows these targets.
Given the high densities of users of urban areas (inhabitants, employees, visitors), local environmental targets should probably be even stricter.

Table 4-8   *Derived targets for urban goods distribution (Opschoor & Weterings, 1992)*

Target (index reference year)	Policy source	Reference year	Target year(s)	Target(s)
Goods vehicle kilometres	NMP2	1986	2000 and 2010	134 and 140
Emissions CO_2 for road traffic NO_x for goods traffic NO_x for goods traffic	NMP2 NMP2 DTO	1986 1986 1990	2000 and 2010 2000 and 2010 2040	100 and 90 59 and 20 22.5
SO_2 total traffic	NMP2	1995*	2000 and 2010	99 and 85
SO_2 total traffic	DTO	1990	2040	22.5
Hydrocarbons (CH) for goods traffic	NMP2	1986	2000 and 2010	65 and 25
Nuisance Noise, total traffic	NMP2	1985	2000 and 2010	100 and to be determined
Smell	NMP2	1985	2000 and 2010	100 and. to be determined
Local air pollution	NMP2	-	2000 and 2010	no exceeding of limits set
Exhaustion Energy - of which mineral oil	DTO DTO	1990 1990	2040 2040	103.4 32

* derived from SO_2-emissions in 1995

4.4   Accessibility issue

4.4.1   Introduction: the problem

Accessibility problems, in terms of urban goods distribution, refer mainly to the restrictions on time, load, or size for goods traffic imposed by local authorities to improve the quality of life in certain zones.. At the same time, there is an increasing demand for goods transport due to economic growth, despite de-materialisation processes in the economy. Congestion, vehicle restrictions, and less than accessible infrastructure for goods traffic reduce the efficiency of goods transport in urban areas. Lead-times, routes and vehicles all need to be adjusted to local regulations and circumstances in urban areas.

The problems means higher costs for moving the goods at a minimum, but they also lead to an increase in fuel consumption and, in case of congestion, an increase in wear on transmission systems, driver stress and in the likelihood of accidents. Currently, there are no estimates of the economic costs of this reduced accessibility.

The demand for more frequent deliveries, in smaller quantities (just-in-time-delivery), coupled with longer opening hours for shops, makes efficient delivery more difficult. The situation is aggravated by the fact that the shippers keep raising their standards for transport, making more stringent demands on delivery time, reliability, frequency, and costs. There is a constant pressure for lower costs in all stages of the logistic and distribution processes. The current logistic trends have led to more transport in order to generate trade-offs in earlier stages of the logistic chain. It is becoming increasingly difficult for the carrier to comply with those standards in an efficient way.

Also, the continuous growth of many traditional and new city functions puts new and increased demands on urban goods distribution. One major concern is how to serve the shopping areas in the inner cities. Most of the bottlenecks in terms of accessibility as well as environmental concern are concentrated there. It is essential for the inner cities that they maintain their economic and social functions. Thus, accessibility becomes a societal issue. Paradoxically, a successful improvement of the economic vitality of inner cities will probably lead to more stringent demands upon the urban goods distribution process. It is obvious that urban goods distribution is situated at the crossroads of conflicting interests.

In sum, accessibility problems relate to:

- Reduced access due to restrictions in time, load or size of vehicles;
- Congestion both approaching and within urban areas;
- A road infrastructure, including unloading and parking facilities, not well equipped for goods vehicles.

These problems have consequences for:

- The efficiency and performance of urban goods distribution in a direct way;
- The economic development; and
- The urban structure, indirectly.

Improvements in accessibility lead to higher efficiency and performance of urban goods distribution and can have considerable impact upon the operation of transport, directly by lower user costs and higher utilisation and indirectly by travel time savings, as well as reduction in personnel, material and fuel costs, and finally through logistic improvements, (e.g.: reduction of temporary storage costs). Efficiency gains and better transport performance

can also have macro-economic effects and changes in the urban structure, caused by spatial differences in accessibility. Although most of these consequences are hard to quantify, they play a major role in discussions related to accessibility.

4.4.2   Quantification of the problem: accessibility indicators

Here we only want to consider indicators for the efficiency and performance of urban goods distribution as proxies for accessibility. Although there have been accessibility indicators developed for evaluation purposes on a national level, they are of limited use for this purpose.

In the process of finding indicators for accessibility, it is appropriate to make a distinction between accessibility itself (the qualification by an individual) and the importance of it for a group (the overall qualification of accessibility as a matter of aggregation). Literature (e.g. Hilbers and Verroen, 1993; Koenig, 1980; Pirie, 1979) provides us with a theoretical base and a large variety of indicators for accessibility taking into account the level of aggregation. It is worth noting that most of these indicators only indicate the *importance* or *relevance* of accessibility rather than indicating the *level* of accessibility itself.

In order to select a relevant, specific formulation of accessibility indicators, a first step consists of determining what kind of approach should be followed. First, we will define the accessibility as a policy objective more thoroughly. Then we will consider the type of indicators available.

Accessibility is an attribute of a location. A frequently used definition of accessibility is the amount of time, money, and discomfort for an individual or group of individuals to travel between their starting point and their destination. What is missing in this definition is that accessibility is by nature a qualitative term. Therefore, references, norms or targets are very significant . As stated before, such a target is based on subjective value judgements and is related to the player concerned. As a qualification by an individual, or in other terms player, it is case-sensitive. This means that the qualification can differ between persons (or players) and differ in moments of time and space.

What is also missing in this definition is that accessibility is not only related to completed trips (or more generally: interactions) but also to the opportunity to travel (potential interactions). If accessibility is related only to actual trips taken, then a certain potential demand will not be included. Trips or interactions that are needed but do not take place because the location is inaccessible (latent demand for travel) are not considered in such an approach.

If accessibility is considered as a qualitative term, it could be defined as follows: "The whole of attributes and features (travel costs, travel time and so on) of a (transport-) product or service (walking, car, public transport) that are of importance for satisfying certain determined or obvious needs for mobility for persons and transportation for goods".

As a target or norm for accessibility in urban goods distribution, the following rule is used in general: The accessibility of a destination (shop or shopping area) must be of such a quality that the economic functioning of this destination is guaranteed. This is often translated into "sufficient connections of a desired level of quality without congestion".

As a policy objective related to urban goods distribution, this would mean that the costs and the performance of transport to a destination, such as distribution of goods to a shopping

centre, should be of such a quality that it will not endanger the economic function of that destination. In practice, this would mean that accessibility is not sufficient when the delivery affects the sales at that the shopping centre (e.g.: goods cannot be delivered, costs are too high, times are inappropriate, or goods are damaged). This can be considered as a threshold level of accessibility (minimum level).

As a policy target, on the other hand, it means that the delivery of goods must be carried out in the most efficient way (in terms of minimising logistic costs under the condition that the social costs are taken in consideration).

Table 4-9: Accessibility related to interests of players

Relevant players	Interest	Target
Transport company (specialised in market segment of specific shippers)	Connections inwards and outwards, movement within area, unloading	Optimisation of routes (time, costs, access restrictions) between shopping centres and certain industrial areas or the exits and entries of highway system, within and unload capabilities
General distribution and couriers	,, + connections within, movement within area, unloading	Optimisation of routes (time, costs, access restrictions) within urban areas, unload capabilities
Own transport – shipper	Connections inwards and outwards, movement within area, unloading	Optimisation of routes (time, costs, access restrictions) between shopping centres and certain industrial areas or the exits and entries of highway system, within and unload capabilities
Own transport – receiver	+ parking	+ Parking facility
Public policy	Competitive shopping centres, optimal performing road network	Minimising economic, social and infrastructure costs.

There are two commonly practised approaches to formulate accessibility indicators, namely the empirical approach and a micro-economic approach.

4.4.3   The empirical approach to 'accessibility'

The first approach can also be referred to as a "common sense approach". In this approach, accessibility is basically an intuitive and qualitative concept. 'Accessibility' is used as a blanket term for a variety of quality indicators that are related to the process of distribution goods, for example, the probability of encountering congestion when using the highway system, as is defined by SVV-II (Ministerie van Verkeer en Waterstaat, 1990), or the checklist-approach to accessibility in city-centres by HBD (1997).

The most important indicators that are related to the notion of accessibility are time-related. Significant indicators in this respect are:

- Transport time (speed) and delivery time;
- Flexibility in time;
- Reliability in time, punctuality;

All these factors can also be translated into costs (see also below: the value of time). Other attributes that are mentioned as aspects of accessibility are nearness or distance and access. Nearness defines the distance to travel and relates to the spatial structure. Access is also more or less related to the spatial structure. Access relates to difficulty to enter a destination area, because of obstacles (physical or due to regulation). It should also be noted that qualitative criteria such as security (accident risk, damage risk, theft) are considered attributes of accessibility.

The capacity of the available infrastructures (line-infrastructures as well as nodes such as intersections, transfer points and distribution centres) and the use of these infrastructure provisions determine the level of accessibility This applies to multi-user infrastructures, such as most of the road infrastructure for urban areas, not only for urban goods related use, but also as the other users determine the level of service.
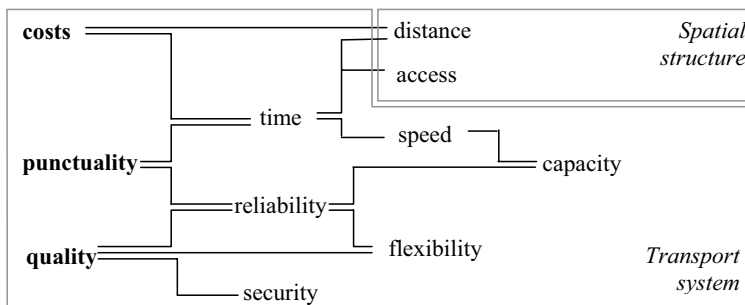
Figure 4-3: *Attributes that determine the dimensions of accessibility (Based on Muconsult, 1994)*

Accessibility is also considered a subjective indicator, because the required 'level' of accessibility depends on the type of transport that must be performed and the related demands. For example, express deliveries will demand a high level of service. Decisions by various players may thus influence the experienced level accessibility. For example:

- Travel period;
- Vehicle type (size, weight, vehicle capacity);
- Routing (including making tours);
- Load factors.

These choices are made by shippers or carriers, but can be strongly influenced by regulations and restrictions put into effect by governments.

Nevertheless, in general terms, accessibility indicators can be measured:
- Given the transport distance and time, transport time (speed) and delivery time can be predicted;
- Given the available (remaining) capacity, an indication can be given about the flexibility in time;
- Given the travel moment and the (remaining) capacity, an indication can be given about the reliability in time or the changes of encountering congestion; and
- Frequency as a level-of-service.

The following table (Table 4-10) sums up the appreciation of various aspects of deliveries as perceived by different players. The figures suggest that fast delivery is more important than low costs for shippers but punctuality is less important (however, reliability is an important issue). It is uncertain if this prioritisation can be used. It can be biased for instance by certain problems in the current delivery system.

Table 4-10:   ***The appreciation of aspects of deliveries (Source: NIPO, 1997)***

Aspects of deliveries [% of times mentioned]	Industry	Construction	Wholesale	Retail	Services	Average shipper
Fast deliveries (time)	46	43	52	51	55	50
Low costs	31	15	37	15	16	26
Reliability	22	11	25	12	23	20
Fulfil agreements	16	22	18	10	14	15
Damage free	10	17	8	25	15	14
Punctuality	7	3	6	6	10	7
Quality*	5	3	4	3	17	6
State of the material	8	6	5	6	0	5

* The marked quality indicators do not directly refer to 'accessibility' although some indirect relations can be derived.

4.4.4   The micro-economic approach to 'accessibility'

In a second approach, we make use of micro-economic welfare theory based on the concept of consumers' surplus and the concept of behavioural random utility maximisation. Here we assume that the notion of accessibility of a location represents the desire of an individual or of a group to visit that location.

For goods distribution processes, this has two major implications. First, the attractiveness of urban areas for consumers, is related to the 'level' of accessibility; this attractiveness has a supposed direct influence on the need for (consumer) goods in that area. Second, the 'level' of accessibility of cities also directly influences the goods distribution process and has an impact on (for instance) transport costs - these costs in their turn may influence the attractiveness of an urban area for consumers.

The above already suggests that there are different ways of interpreting the 'level' of accessibility; these are:

- Impedance or deterrence as the one and only indicator for accessibility.
- The impedance or deterrence combined with the relative (competitive to other locations) attraction for potential visitors as an indicator for accessibility.
- The impedance or deterrence combined with the absolute attraction for potential visitors as an indicator for accessibility.

Impedance or deterrence as an indicator for accessibility

The impedance or deterrence of a trip represents the effort of moving people or goods from an origin *i* to a destination *j*. In the most simple form, impedance or deterrence can be expressed in travel time or travel costs (monetary value). However, in practice, the impedance or deterrence is a combined or integrated indicator of costs, time and other quality aspects at the same time. An often-used approach to generate a quantitative indicator is to monetarise all relevant attributes; the deterrence is then represented as 'generalised costs'. Note that monetarisation always has a subjective touch in it because various attributes must be 'valued' and the valuation of these attributes varies between logistic channels, travel purposes, types of goods etc. The transformation from time into costs takes place by using value-of-time information. For this the different approaches are available (De Jong et al., 1993):

- Factor costs method: in this approach the value of time is determined as the change in the cost-components (fixed and variable costs) by a change in travel time.
- Choice models (revealed or stated preference): in this approach, the trade-off between travel time and costs is determined by estimating the preferences with logic models for carriers and/or shippers.

Table 4-11: *Relative importance of different attributes (Source: De Jong et al, 1993)*

Road transport	Costs or rates	Travel time	Security (risk of damage)	Punctuality (% not on time)
Consumer goods time-critical (meat, fruit)	1.00	0.93	0.51	0.47
Other consumer goods	1.00	0.83	0.48	0.64

Note: A change in travel time accounts for a factor 0.93 in change of costs

Table 4-12: *Calculation of value of time (in Euro*, 1st of January 1992) (Source: De Jong et al, 1993)*

Road transport	Transport costs per consignment [EUR/hour]	Trade-off ratio	Value of time per consignment [EUR/hour]
Consumer goods time-critical (meat, fruit)	30.40	0.93	28.28
Other consumer goods	31.31	0.83	25.99

(* original source: in Dutch guilders)

If we agree on a method for establishing the measuring unit for the deterrence (i.e., by using generalised costs), we can determine the accessibility of a certain destination *j* (see expression 4-1):

$$Ac_j = D(Z_{ij}, X_i)$$ **(4-1)**

With:

Ac_j: Accessibility of destination *j* (location or activity) from origins *i*.
Z_{ij}:   Generalised costs of the movement of persons (or goods) from *i* to *j*.
X_i: Number of potential visitors (or amount of goods) from origin *i*.
D(..):   Distribution.

The resulting accessibility indicator *Ac_j* is not a single figure, but is a distribution of potential visitors or goods from origins *i* that will experience a certain deterrence when visiting (persons) or being distributed (goods) to the destination *j*.

The distribution of deterrence over potential visitors or goods can take the form of:

- Potential measures. In this case, opportunities are weighed by impedance.
- Isochronic measure. In this case, it reflects the number of opportunities or interactions that can take place given a certain willingness to pay.

The potential measures can for example be represented in a graph, the isochronic measures can be represented in a map (see Figure 4-4).
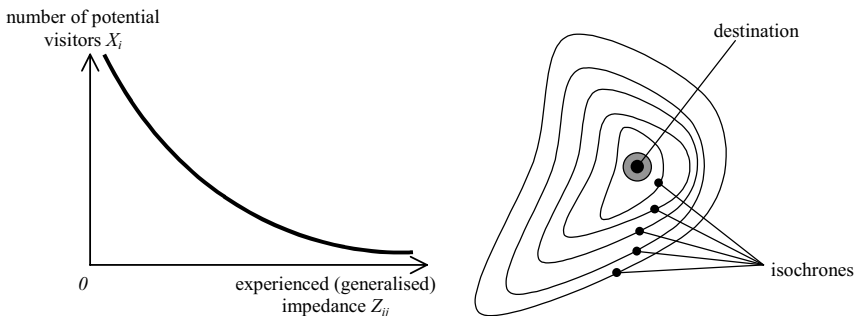
Figure 4-4:   *Example of a distribution of impedances over potential visitors (illustrative)*

The distribution of the impedances of a certain destination *j* can be compared to other destinations to get an insight into the relative (quality of the) accessibility.

Combining impedance and relative attraction as an indicator for accessibility

The distribution of impedances does not directly provide information about the potential use of a site. With help of micro-economic random utility theory, however, we are able to derive functions by which we can calculate the expected number of visits (or the expected amount of goods to be transported).

Micro-economic theory is based on the idea that players (consumers, potential visitors, transport companies etc.) have various choice options for activities, of which they choose the one that renders the highest 'utility' (see Part II for an extended analysis).

This utility is determined by:

- The utility of not changing the activity i at the current location (U_i).
- The utility of starting another activity j at another location (U_j).
- The (generalised) impedance of going from i to j (Z_{ij}).

The total utility of starting an activity in j instead of staying in i is represented as U_{ij}, with $U_{ij} = U_j - U_i$. The resulting or net utility of starting an activity in j is given by $U_{ij} - Z_{ij}$.

The utility of the destination j derives, among other factors, from the attractiveness; in Part III of this thesis, we identify the assortment of available products and shops as one aspect of this attractiveness.

The attractiveness of the destination can be included in the utility of that destination; the expected number of visitors also depends from the potential number of visitors from origin i and is represented as X_i. In an alternative approach, the attractiveness of the destination can be included in the potential 'interactions' between i and j; these potential interactions are then represented by X_{ij}.

Following the latter approach, a generic description of this accessibility indicator would look like expression 4-2:

$$Ac_j = D(Z_{ij}, X_i) \tag{4-2}$$

Or, more precisely:

$$Ac_j = \sum_i (f(U_{ij} - Z_{ij}) * X_{ij}) \tag{4-3}$$

With:

Ac_j: Accessibility of destination j (location or activity) from all relevant origins i;

U_{ij} :   Utility of the movement of goods from i to j, with: $U_{ij} = U_j - U_i$; the utility can be expressed as the 'willingness to pay' or as 'potential benefits' (see Part II);

Z_{ij}:   Generalised costs of the movement of goods from i to j;

$f(..)$:   (Impedance) function;

X_{ij}:   Potential interactions in terms of movement of goods from i to j.

In this approach, Ac_j is a single figure that represents the expected number of visitors.

Of course, the form of the impedance function is very important. The function should take into account all competing destinations and thereby takes into account the relative attraction of all potential destinations. Although this expression is theoretically sound, in practice, it is very difficult to establish the exact utility of alternative destinations. The utility variable U_{ij} is related to characteristics of an individual person, sending or load. Therefore, in some indicators, a distribution function is used to randomise this variable (resulting in a random utility theory, see Koenig 1980 and also Part II). This makes an indicator more complicated. Therefore, a simpler approach is often employed, in which the 'absolute' attraction of a potential destination is used.

The combined impedance and absolute attraction as an indicator for accessibility

Possibilities for simplification the above derived deterrence function are:

- Relational (one relation) in stead of integrated (many relations) accessibility indicators;
- Potential (estimated) in stead of actual utility;
- Objective in stead of subjective utility;
- Absolute in stead of relative utility;
- Deterrence only in stead of net utility;
- Deterrence functions for unimodal instead of multimodal transport.

In the case of the utility, U_{ij} in itself is omitted from the indicator, and the remaining determining factors are X_{ij} (potential relations) and Z_{ij} (deterrence). The resulting general expression is (expression 4-3a):

$$Ac_j = \sum_i (f(Z_{ij}) * X_{ij}) \qquad \textbf{\textit{(4-3a)}}$$

For the deterrence function, alternative formulations like 4-3b or 4-3c can be used (Koenig, 1980):

$$Ac_j = \sum_i \left(X_{ij} * a * e^{-b*Z_{ij}} \right) \qquad \textbf{\textit{(4-3b)}}$$

$$Ac_j = \sum_1 X_{ij} * -\frac{1}{b}\log(e^{-b*Z_{ij}}) \qquad \textbf{\textit{(4-3c)}}$$

With:

a, b: constants.

However, this approach has some shortcomings. Although accessibility is expressed in one indicator, this indicator is difficult to understand and to interpret. Including the potential interactions as a weighing factor also can lead to misinterpretation of the results.

4.5   Conclusions

The problems related to urban goods distribution (and other goods traffic in urban areas) are:

- The contribution of goods traffic to the reduction of the quality of life in urban areas (air pollution, nuisance, traffic safety, use of space);
- The contribution to climate change and acidification due to emissions, exhaustion of natural resources and waste;
- The reduction of the accessibility of urban areas for goods traffic at certain places and at certain times (congestion, vehicle restrictions).

It is clear that urban goods distribution cannot be neglected in sustainability issues. Compared to other types of goods transport, urban goods distribution, in terms of costs per volume-unit (per tonne or cubic metre), generates relatively high social and environmental costs. Due to specific circumstances in urban areas, the productivity is relatively low (much time loss and low speeds). These aspects are generally recognised by the actors involved, but have not yet led to any fundamental change.

There are no specific targets for urban goods distribution formulated by national environmental policies. However, targets can be derived from national policy objectives for (goods) traffic. In this section, we found policy targets that also apply to urban goods

distribution. With respect to accessibility, many indicators have been developed. For urban goods distribution, no policy targets exist; this makes it more complicated to operationalise economic efficiency improvement, as will be discussed in Part II.

5. Summary and conclusions of Part I

Sections 3 and 4 are dedicated to the first research objective of the thesis: "develop a clear *understanding* of the goods distribution in urban areas and the way it is related to environmental and accessibility problems".

Section 3 defines urban goods distribution and discusses what kind of goods transport is included or excluded by this definition. Urban goods distribution is analysed by investigating information on the characteristics of urban goods distribution. This information is used for categorisation and quantification, and is then checked for information gaps. The magnitude and share of urban goods distribution is estimated and forecasts are analysed. The available quantitative information is not very reliable, and information on the number of stops, trip length, trip time and speed, transport distance is not easily available. This makes it more difficult to determine the total traffic volume generated by urban goods distribution.

With the information derived, an estimate was made of the share of urban goods distribution in the total transportation of goods in the Netherlands. According to these estimates, the number of deliveries in the Netherlands is about 106 million deliveries in a year with a volume of 107 million cubic metres or 53 million tonnes. The share of the deliveries in urban areas is about ten percent, but urban goods distribution generates about 18 percent of the traffic volume. According to national forecasts, transported volumes in tonnes will grow with about 22 percent between 1995 and 2020, while the traffic volume, measured in vehicle kilometres will increase by 64 to 153 percent for vans and trucks.

To improve the quality of this estimate, it would be necessary to develop a more standardised data-collection with options for detailed analysis. The classifications of goods flows, proposed in this section can be used for this purpose.

Section 4 analyses the problems related to urban goods distribution and the underlying relationships. The problems related to urban goods distribution (and other goods traffic in urban areas) are:

- The contribution of goods traffic to the reduction of the quality of life in urban areas (air pollution, nuisance, traffic safety, use of space).
- The contribution to climate change and acidification due to emissions, exhaustion of natural resources and waste.
- The reduction of the accessibility of urban areas for goods traffic at certain places and at certain times (congestion, vehicle restrictions).

These problems can be measured with help of indicators that are explained in Section 4.

The conflicts are influenced by a large number of trends that are already occurring or about to soon. Some of these trends make the problem worse but then again, some of them will improve the situation. These trends can be classified as follows:

- Trends in supply and demand for consumer goods;
- Trends in logistics, and transport;
- Trends in traffic and infrastructure;
- Spatial developments.

Within these developments, barriers as well as opportunities can be found to improve the current situation in terms of solving the problems. The trends can either function as constraints or pre-conditions for changes in the system or as opportunities, so as starting points for the development of a new urban goods distribution system. In parts III and IV, these developments will be discussed in more detail.

References

Adviesdienst Verkeer en Vervoer (AVV, 1997) *Vervoer-Economische Verkenningen 1997-2002* (in Dutch), Den Haag (SDU).

Akker, P. van den, J. Visser, & E. Wieme (1992) *Stedelijke distributie in Tilburg* (in Dutch), Tilburg (NHTV).

Betz, F. (1998) *Managing technological innovation*, New York (John Wiley & Sons).

Binsbergen A.J. van, B. Egeter, C.D. van Goeverden & Th.J.H. Schoemaker (1995) *Ruimpad: denkbare vervoersystemen* (in Dutch), Delft (TRAIL Onderzoekschool/TU-Delft).

Binsbergen, A.J. van & J.G.S.N. Visser (1997) *Haalbaarheidsstudie stadsdistributiecentrum Delft, transferpunt voor goederen met een binnenstedelijke bestemming* (in Dutch), Delft (TRAIL Onderzoekschool).

Binsbergen, A.J. van, A.J. Klein Breteler, J.W. Konings, J. Rijsenbrij, J. Katgerman, D. Piebenga (1998), *Continental loading units for intermodal transport*, Schiedam, (TRAIL/RUPS/CTT/ Ministry of Transport, Public Works and Water Management).

Binsbergen, A.J. van, C. Maat, Th.J.H. Schoemaker, J.G.S.N. Visser (1996) *Nederland Beweegt! Een discussiescenario voor de mobiliteit in 2030* (in Dutch), Delft (TRAIL Onderzoekschool).

Binsbergen, A.J. van, J. Walstra (1994) *Vergelijking emissies weg- en gecombineerd vervoer - grondtransport bodemsanering Aagrunol* (in Dutch), Groningen/Delft (IWACO-Noord/TU-Delft).

Binsbergen, A.J. van, J.G.S.N. Visser & C. Maat (1997), *Project korte-afstand gecombineerd vervoer ten behoeve van stedelijke distributie: locatiekeuze terminals en netwerkvorming* (in Dutch), Delft (TRAIL Research School).

Binsbergen, A.J. van, Th.J.H. Schoemaker & C.D. van Goeverden (1995) *Ondergrondse transportmogelijkheden doorgrond, een systematische verkenning* (in Dutch), Delft/Den Haag (TRAIL Onderzoekschool/Projectbureau Integrale Verkeers- en Vervoerstudies)

Binsbergen, A.J. van, Th.J.H. Schoemaker (1993) *Morgen Bezorgen, Distributie in stedelijke gebieden van morgen* (in Dutch), Delft (TU-Delft).

Binsbergen, Arjan, Arjan Erkens & Bob Hamel (1994) *Long-term energy efficiency improvement for transport - technology assessments*, Delft (TU-Delft).

Bos, S., & H. Moll, (1997) Het indirecte energiegebruik en de indirecte emissies van het transportsysteem (in Dutch), in: *Colloquium Verkeer, Milieu en Techniek 1997*, RIVM (Bilthoven).

Bouman, P.A., P.J.L. Kluit, Th.J.H. Schoemaker & J. v.d. Waard (1990) *Goederenvervoer en leefmilieu. Inventarisatie van emissies en verstoring door goederenvervoer* (in Dutch), Delft (Faculteit der Civiele Techniek, Vakgroep Verkeer, TU Delft).

Boustead, J., & G.F. Hancock (1979) *Handbook of Industrial Energy Analysis*, Chichester.

Brouwer, W., W.E. van Lierop, G.A.A. Erens, A.F.C. Carlebur & J.G.S.N. Visser (ed.) (1997a), *Buisleidingtransport (BLT) voor Stedelijk Goederenvervoer, deel A* (in Dutch), DTO-werkdocument M9. (DTO), Delft.

Brouwer, W., W.E. van Lierop, G.A.A. Erens, A.F.C. Carlebur & J.G.S.N. Visser (ed.) (1997b) *Buisleidingtransport (BLT) voor Stedelijk Goederenvervoer, deel B* (in Dutch), DTO-werkdocument M10. (DTO), Delft.

Browne, M. & J. Allen (1997) Strategies to reduce the use of energy by road freight transport in cities, in: *PTRC 25th European Transport Forum, proceedings of seminar B: Freight, volume P412*, London, (PTRC), pp. 79-96.

Buck Consultants/TRAIL OnderzoekschoolRUPS Adviseurs (1999) *Gaat Leiden Ondergronds, hoofdrapport* (in Dutch), Rotterdam (RUPS Adviseurs).

Buursink J. (1980) *Stad en Ruimte, Inleiding in de stadsgeografie*, Assen (Van Gorcum)

Centraal Bureau voor de Statistiek (1996) *Statistiek van het binnenlands goederenvervoer 1995* (in Dutch), Voorburg/Heerlen (CBS).

Centraal Bureau voor de Statistiek (1999) *Statistiek van het binnenlands goederenvervoer 1998* (in Dutch), Voorburg/Heerlen (CBS).

Coopers & Lybrand Management Consultants (1991a) *Plaatsen van stadsdistributiecentra: definitiestudie* (in Dutch), Rotterdam (Coopers & Lybrand).

Coopers & Lybrand Management Consultants (1991b) *Plaatsen van stadsdistributiecentra: naar een bereikbare en leefbare binnenstad van Maastricht, plan van aanpak* (in Dutch), Rotterdam (Coopers & Lybrand).

COST 321 Action (1997) *COST 321 Urban Goods Transport, final report*, Brussels (COST).

CTT (1997) *Ondergronds Logistiek systeem (OLS), hoofdrapport deel 1: Definitiestudie* (in Dutch), Rotterdam (CTT).

DHV (1999) Pilot OLS Utrecht, *Inventarisatie goederenstromen* (in Dutch), Amersfoort (DHV).

DHV, CIMK, Ministerie van Verkeer en Waterstaat en Ministerie van Economische Zaken (1987) *Onderzoek relatie verkeersmaatregelen-effecten op het goederenvervoer, hoofdonderzoek* (in Dutch), Amersfoort (DHV).

DHV/TRAIL Onderzoekschool (1996) *Illustratieproces Buisleidingtransport ten behoeve van Stedelijke Distributie, fase 1: Logistiek concept* (in Dutch), Delft (DTO).

Heidemij Advies (1995) *Marktverkenning Encilog Haarlem, rapportage fase 1 en 2* (in Dutch), Arnhem (Heidemij).

Henham, A., & M. Jacobson (1983) The motor car. Energy demands and potential for conservation, in: *Resources and Conservation, nr. 10*, pp. 161-174.

Hilbers, H.D. & E.J. Verroen (1993) *Het beoordelen van de bereikbaarheid van lokaties: definiëringen, maatstaven, toepassing en beleidsimplicaties* (in Dutch), rapport INRO-VVG 1993-09, Delft (INRO-TNO).

Hoofdbedrijfschap Detailhandel (HBD) (1992) *Bevoorrading van detailhandel in binnensteden. Een studie naar de haalbaarheid en effecten van stadsdistributiecentra* (in Dutch), Den Haag (HBD).

Hoofdbedrijfschap Detailhandel, HBD (1995) *Mag het ook een kilometertje minder zijn? Kwantificering van de vervoerbelasting naar de achterdeur van de detailhandel en*

beschrijving van de (on)mogelijkheden om deze te beinvloeden (in Dutch), Den Haag (HBD).

Hoofdbedrijfschap Detailhandel, HBD (1996) *Jaarboek Detailhandel 1996-1997*, Den Haag.

Hoofdbedrijfschap Detailhandel, HBD (1997) *Bereikbaarheid Stadscentra, 'Een wegingsinstrument'* (in Dutch), Den Haag (HBD).

Interdepartementale Projectorganisatie Ondergronds Transport (IPOT) (1999) *Transport onder ons: schakel in de keten* (in Dutch), Den Haag (IPOT).

Interdepartementale Projectorganisatie Ondergronds Transport (IPOT, 2000) *Transport onder ons: van visie naar realisatie* (in Dutch), Den Haag (IPOT).

Goor, A.R. van, M.J. Ploos van Amstel, W. Ploos van Amstel (1992), *Fysieke distributie: denken in toegevoegde waarde* (in Dutch), Leiden/Antwerpen (Stenfert Kroese).

Jong, G.C. de, M.A. Gommers & J.P.G.N. Klooster (1993) De reistijdwaardering in het goederenvervoer (in Dutch), in: *Tijdschrift vervoerswetenschap* (1993) nr. 1, pp. 77-85.

Koenig, J.G. (1980) Indicators of urban accessibility: theory and practice, in: *Transportation 9* (1980), Amsterdam (Elsevier Scientific Publishing Company), pp. 145-172.

Köhler & Strauß (1997) City-Logistics concept in Kassel, in: PTRC 25th European Transport Forum, *proceedings of seminar B: Freight, volume P412*, London (PTRC), pp. 97-101.

Kok, T. de, (1998) Goederenvervoer schrikbarend inefficiënt (in Dutch), in: *Logistiekkrant, nr. 9*, 21 mei.

Koster, M.B.M., & Neuteboom, A.J., 2000, *De logische logistiek van supermarktketens, een vergelijking*, Amsterdam (Elsevier Bedrijfsinformatie bv)

KPMG Klynveld Management Consultants (1994) *Eindrapportage Stedelijk Distributie Centra Rijnmond* (in Dutch)*, Rotterdam (KPMG).

Lindkvist, A & H. Swahn (1997) Towards environmentally friendly freight transport in cities, CEMT, 1997, *Round Table 108 Freight Transport and the City*, Paris (OECD).

McKinnon, A.C. (1989), *Physical distribution systems*, London (Routledge).

Ministerie van Verkeer en Waterstaat (1990) *Tweede Structuurschema Verkeer en Vervoer; deel d: regeringsbeslissing* (in Dutch), Tweede Kamer 1989-1990, 20922 nrs. 15-16, Den Haag (SDU).

Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer (1998) *Nationaal Milieubeleidsplan 3* (in Dutch), Den Haag (VROM).

MuConsult (1994) Operationalisatie Bereikbaarheid (OBER), Amersfoort (MuConsult).

NIPO (1997) Verladersmonitor (NIPO Monitoring Shippers), Amsterdam (NIPO).

NEA/DHV (1998) *Eindrapport referentiekader vervoer ondergronds transport* (in Dutch), Rijswijk/Amersfoort (NEA/DHV).

Opschoor, J.B. & R.A.P.M. Weterings (1992) *De milieugebruiksruimte als uitdaging voor technologie-ontwikkeling* (in Dutch), Rijswijk (Raad voor het Milieu- en Natuuronderzoek).

Oranjewoud (1993) *Effecten van stadsdistributie op het gebied van vervoer, verkeer, energie en milieu, onderzoek naar goederenvervoer en -verkeer in Maastricht* (in Dutch), Rotterdam (Oranjewoud).

Pirie, G.H. (1979), Measuring accessibility: a review and proposal, in: *Environment and Planning A*, 11, p. 299-312.

Platform Stedelijke Distributie (1999) *De vitale stad, bereikbaar in drie stappen, Tipper 2* (in Dutch), Den Haag (PSD).

Riet, O.A.W.T. van de (1999) *The Value of Using a Systems Approach for Defining Policy Problems*, Delft (TRAIL Onderzoekschool).

Rijke, B.J. de (1991) *Bevoorrading in het Utrechtse werfkeldergebied, een inventariserend onderzoek naar goederenstromen in en bevoorradingsalternatieven voor het Utrechtse werfkeldergebied* (in Dutch), Utrecht.

Rijksinstituut voor Volksgezondheid en Milieuhygiene (1997) *Nationale Milieuverkenning 4 1997-2020*, Alphen a/d Rijn (Samsom).

Rijksinstituut voor Volksgezondheid en Milieuhygiëne (1998) *Verkeer en vervoer in de Nationale Milieuverkenning 4 1997-2020* (in Dutch)*,* Bilthoven (Rijksinstituut voor Volksgezondheid en Milieuhygiëne).

Schins, A.L.J.E. (1985) *Het goederenvervoer in binnensteden nader onderzocht* (in Dutch), Delft (TU-Delft).

Schoemaker, Th. J. H., H.C. van Evert & M.G. van den Heuvel (1988) *Trendbreukscenario vervoer en verkeer* (in Dutch), Delft (TU-Delft).

Schoemaker Th.J.H., A.J. van Binsbergen (1993*) Trendbreukscenario Goederenvervoer: het Groen Transport Scenario* (in Dutch), Delft (TU-Delft).

Short, J. (1999) Goederendistributie in steden. Enkele vergelijkingen tussen landen, in: Terlouw, J.C. & W.J. J. van der Heide (1999) *Stadsdistributie, de bevoorrading van binnensteden* (in Dutch), Assen (Van Gorcum).

Sliggers, C.J. (1989) *De meerjarenberekening versus de berekening van jaar tot jaar* (in Dutch), Den Haag (VROM/DGMB, directie Lucht, afd. Luchtkwaliteit).

Starkie, D.N.M. (1969) *Traffic and Industry*, London (Weidenfeld & Nicolson).

Transport en Logistiek Nederland (2000) *Nieuwe wijn in oude zakken* (in Dutch), Zoetermeer (TLN).

Veeke, P.J.A.M. & G.R.M. Jansen (1989) Het Delftse vrachtverkeer: resultaten van een empirische studie (in Dutch), in: *Verkeerskundige Werkdagen 1989*, Ede (C.R.O.W.), pp. 403-416.

Visser, J.G.S.N. (1991) Terugdringen van stedelijk vrachtverkeer mogelijk? Discussie omtrent de effectiviteit van stedelijke distributiecentra, in: Tanja, P.T. (red.), *Colloquium Vervoersplanologisch Speurwerk -1991-, De prijs van mobiliteit en van mobiliteitsbeperking* (in Dutch), Delft (C.V.S.), pp. 299 - 315.

Visser, J.G.S.N. (1992) *Effectiviteit van het beleid inzake stedelijk goederenverkeer, Toetsingsmethode voor het stadsdistributiecentrumconcept*, OTB-werkdocument 92-10 (in Dutch), Delft (Delftse Universitaire Pers).

Visser, J.G.S.N. (1993) Bevoorrading van bedrijven in de binnenstad (in Dutch), in: Th.A.M. Reijs & P.T. Tanja (red.) (1993) *Colloquium Vervoersplanologisch Speurwerk -1993- Grenzen aan de vervoersplanologie*, Delft (C.V.S), pp. 1175-1194.

Visser, J.G.S.N., A.J. van Binsbergen & Toshiro Nemoto (1999) Urban Freight Transport Policy and Planning, in: E. Taniguchi & R.G. Thompson (1999) *City Logistics I*, Kyoto (Institute for Systems Science Research).

Visser, J.G.S.N and J.H.K. Boerkamps (2000) Interview.

Visser, J.G.S.N., A.J.M. Vermunt, and A.J. van Binsbergen (1998) *Ruimtelijke concepten ondergronds transport* (in Dutch), Delft/Hoeven (TRAIL Onderzoekschool).

World Commission on Environment and Development (Commission Brundtland) (1987) *Our Common Future*, New York.

PART II
Conceptual framework

CONTENTS OF PART II

6. Introduction to the conceptual framework

6.1 Introduction

In Part I of this thesis, we identified and analysed the economic and social problems related to the process of goods distribution for urban areas. We concluded that improvements in the process are necessary both to preserve the important position of urban areas, and to reduce the problems related to urban goods distribution. In this thesis, we propose a fundamental and integrated approach to cope with the main problems; Part II forms the basis of that approach. This section introduces some essential notions, typologies and methods that will be used extensively throughout this thesis. The 'fundamental' aspects of this approach include a thorough analysis of the whole of the urban distribution process (consisting of the logistics process and the related transport system) and the use of this analysis to develop new, improved concepts. The 'integrated' aspects of this approach include the combination of logistical, technological, organisational, and institutional partial solutions into one overall framework. The basic notions that are introduced in Part II are applied in all other parts of the thesis; the integrated approach will result in a private and public policy implementation strategy that will be elaborated in Part VI.
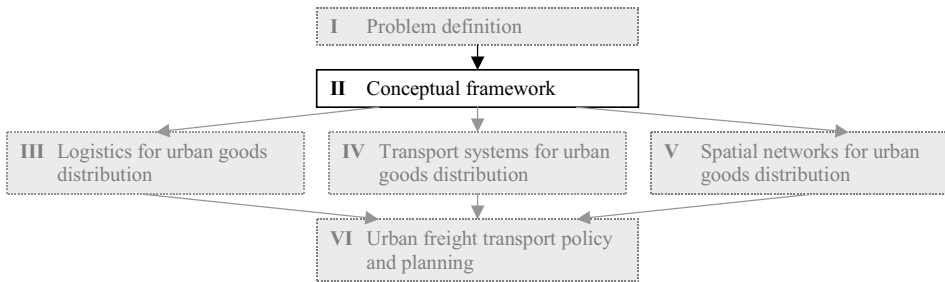
Figure 6-1: Part II related to the other parts of the thesis

Because this part provides the foundation for all other parts of this thesis, it necessarily addresses all three research objectives:

(1) Develop a clear understanding of the goods distribution process for urban areas and the way it is related to environmental and accessibility problems.

Part II provides a conceptual framework to enable a clear understanding of the urban goods distribution process: it therefore discusses the basic micro-economic behaviour of actors.

(2) Analyse and develop possible solutions for the problems related to urban goods distribution and develop an integrated concept for an efficient goods distribution process for urban areas.

Part II introduces a description of the goods transport system that shows the interrelations between different 'services' and possible improvements within those services (elaborated in Parts III – VI). Part II introduces and explains the methodologies for development of the integrated design and offers tools for evaluation purposes. The contents of the integrated design will be structured using the system description of the goods distribution process.

(3) Develop a comprehensive policy plan for implementing effective policy measures that aims at improving the efficiency of the goods distribution process for urban areas.

Part II presents the notion of 'system optimisation' and defines the basic elements of the policy making process.

Part II provides the conceptual framework for analysis, design and assessment of the goods distribution system for urban areas in a methodological and systematic manner.

6.2   Contents of Part II

6.2.1   New insights and applications

Applying micro-economic utility theory to get insight in the basics of urban goods distribution processes with an explicit distinction between objective and subjective utilities.
In understanding consumer behaviour in terms of choice, micro-economic utility theory distinguishes between objective and subjective utilities. We will use this theory to describe a variety of private and public actors' behaviour with respect to urban goods distribution.

Linking different choice behaviour models and tools to micro-economic utility theory.
In micro-economic utility theory, 'random utility choice models' have been developed; these models can in their turn be used in network choice models. We will introduce this network choice approach for choice processes that relate to urban goods distribution.

Applying the system description of transport to the urban goods distribution process.
We will adapt and apply the system description of transport (the 'layer scheme' approach) to the urban goods distribution process; so that we can systematically analyse the process and develop innovative concepts. We will also use the layer scheme to show the important interrelations between the different 'services'.

Introducing a comprehensive classification of goods that are distributed in urban areas.
We will adapt, combine and apply different classifications of goods into one comprehensive system of classifying goods, based on physical characteristics and marketing characteristics. This will lead to a systematic analysis of the requirements of goods flows with respect to logistic services.

Defining the notion of integrated societal optimisation of urban goods distribution processes.
We will define the notion of a balanced method of establishing an integrated societal optimisation of the urban goods distribution processes.

6.2.2   Overview of the contents
Part II contains the conceptual framework for the thesis and is based on the theoretical and methodological issues that are addressed in the following parts. All processes in urban goods distribution are based on behaviour: actors, such as consumers, producers, retailers, transport companies, and governments, all perform roles within the urban goods distribution system. We must understand their actions, their goals and their drives to be able to understand urban goods distribution processes and to be able to develop alternative distribution systems. Therefore, we will first explore the micro-economic utility theory that describes the (economical) behaviour of actors. We will link this theory to urban goods distribution and introduce the choice behaviour models and tools that are used later on in this thesis.
Micro-economic utility theory uses the concept of 'markets' to represent the interaction of actors, for instance within the field of urban goods distribution. These markets are also the

basis of the conceptual 'transport system layer scheme', in which the transport system is subdivided into 'service layers' that interact by means of markets. This scheme is elaborated in Chapter 8 and applied throughout the thesis to make a systematic analysis of the urban goods distribution system possible. In Part I, we concluded that the system of urban goods distribution is essential, but also causes a multitude of problems, both for the actors directly involved in the distribution process and for society as a whole. The aim of this thesis is to identify and develop avenues for improving and optimising the urban distribution process by making it more efficient (both from a business and from a societal point of view). Therefore, in Chapter 7, we will also introduce the formal notions of efficiency and inefficiency and highlight the main 'types' of inefficiency. We will further elaborate the notions of economies of scale, scope, density and chains. Finally, we will expand on the concept of consolidation. These basic notions will form the foundation of all optimisation strategies that are developed in Chapter 9 and further on in this thesis. In Chapter 10, we will describe different methodologies for policy development and conceptual evaluation. The relationship between the chapters in Part II is shown in Figure 6-2.
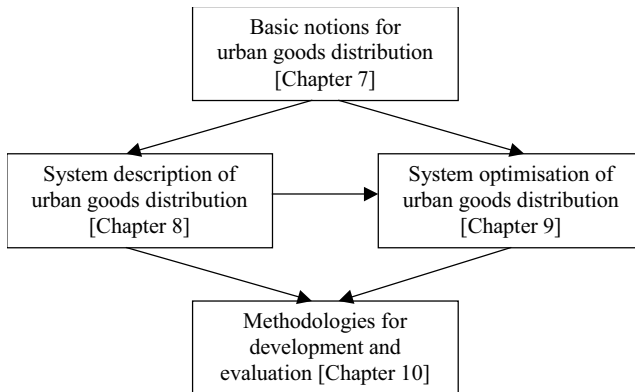

Figure 6-2: The structure of Part II

7. Basic notions for urban goods distribution

7.1 Introduction

The basic notions that are analysed in this chapter form the theoretical background for the analysis of urban goods distribution. In this chapter, we will use the insights such as offered by micro economic utility theory to analyse urban goods distribution processes. We will introduce the formal concepts of 'utility' and 'disutility', as well as those of 'efficiency' and 'effectivity' in relation to urban goods distribution. We will also sketch the basic outlines for choice behaviour models and tools (such as the network representation and the cost-benefits and multi-criteria evaluation methods). These notions are used throughout the thesis, both for qualitative analysis and for development and evaluation purposes.

7.2 Micro-economic utility in urban goods distribution

7.2.1 Introduction

To be able to explain the behaviour of actors involved in the urban goods distribution process, in a theoretical and systematic way, we make use of micro-economic utility theory. We can use this theory to estimate the results of choice processes of actors. We will use the theory to introduce the notions of 'utility' and 'disutility'. Based on these notions, we will also define the notions of 'efficiency', 'effectivity' and 'productivity'.

Moreover, we will distinguish between objective and subjective choice criteria. We also show how 'goods' (alternatives from which actors can choose) are valued based on goods characteristics that can be valued differently by different actors. These elements will form the basis for different choice models found in Section 7.3.

7.2.2 Choice behaviour and utilities

In this thesis, we make use of some of the theories of individual choice behaviour to explain the behaviour of various actors within the process of urban goods distribution. In this section, we generally follow the approach of Ben-Akiva and Lerman (1985).

First, they view a choice as an outcome of a sequential decision-making process that includes the following steps:

- Definition of the choice problem;
- Generation of alternatives;
- Evaluation of attributes of the alternatives;
- Choice;
- Implementation.

Ben-Akiva and Lerman apply the theory on choice behaviour in transportation, but as the theory is based on classical economic and discrete choice theory, we can also apply it to other choice processes[1].

Then, Ben-Akiva and Lerman (1985) define the following elements in the choice theory:

- Decision-maker;
- Alternatives;
- Attributes of alternatives;
- Decision rule.

In this thesis, the decision-maker (or actor) may be a consumer, a transport company, a governmental institution or a retailer. We refer to all 'alternatives' within a choice process by the general notion of 'goods', where goods can represent either physical goods or services.

Ben Akiva and Lerman (1985) assume that an individual consumer is choosing a consumption bundle $\overset{1}{G}$:

$$\overset{1}{G} = \{q_1, ' \quad , q_G\} \tag{7-1}$$

where $q_1, ' \quad , q_G$ are the quantities of each of the commodities and services $g = 1, 2, ' \quad , G$.

The consumer is assumed to have preferences over alternative consumption bundles and, in this respect, 'rational behaviour' is defined in the sense of a transitive preference ordering of alternative consumption bundles. It is also assumed that the consumer has the ability to compare all possible alternatives.

Under these assumptions there exists an ordinal utility function

$$U_G^a = f\{q_1, ' \quad , q_G\} \tag{7-2}$$

that expresses mathematically the preferences of consumer a.

Within random utility theory, the total utility should be split into deterministic and random components and both components should be specified:

$$U_G^q = V_G^a + \xi_G^q \tag{7-3}$$

---

[1]   Ben-Akiva and Lerman remark that their approach is coarse relative to recent developments in psychological research, but that they choose this approach because of their interest in a wide range of applications, and their emphasis on making operational predictions for a large number of individuals.

where V_G^a is called the systematic or representative component of the utility and ξ_G^a the random element. $V_{G'}^a$ is a deterministic (non-random) function; ξ_G^a may also be functions, but they are random from the observational perspective of the analyst (Ben-Akiva and Lerman, 1985; p.60; see also Pauck (1983), p.182).

For the deterministic function, Ben-Akiva and Lerman introduce a vector $x_{g,k}$ that represents the attributes of any alternative and the (socio-economic) characteristics of the decision-maker. We define $\overset{1}{K}$ as the set of attributes we know the decision-maker takes into account (the observed utility). This is only a part of all the attributes the decision-maker takes into account: the larger set $\overset{1}{K}'$, so $\overset{1}{K} \subset \overset{1}{K}'$; see also Bovy (1990; p. 19).

Ben-Akiva and Lerman (implicitly) define V_G^a as a function of the vector $x_{g,k}$ and vector of unknown parameters α_k^a:

$$V_{g,\overset{1}{K}}^a = f\left(\alpha_k^a, x_{g,k}\right) \quad \forall (k \in \overset{1}{K}) \tag{7-4}$$

They observe that a function that is linear in the parameters is chosen in most cases of interest; this results in:

$$V_{g,\overset{1}{K}}^a = \sum_{k=1}^{K} V_{g,k}^a = \sum_{k=1}^{K} \left(\alpha_k^a \bullet x_{g,k}\right) \tag{7-5}$$

For the total utility, so by taking into account the random part of the utility, this would mean:

$$U_{g,\overset{1}{K}}^a = f\left(\alpha_k^a, x_{g,k}, \xi_g^a\right) \tag{7-6}$$

where ξ_g^a includes all attributes from set $\overset{1}{K}'$ that do not belong to $\overset{1}{K}$ (the non-observed part of the utility).

If we assume that the subjective utilities $\overset{1}{K}$ of a good g to be *linear in the parameters* (see for example Ben-Akiva and Lerman, 1985), we can express the total value (utility) of a good g as it is perceived by a actor a as follows:

$$U_{g,\overset{1}{K}}^a = \sum_{k=1}^{K} u_{g,k}^a + \xi_g^a = \sum_{k=1}^{K} \left(\alpha_k^a \bullet x_{g,k}\right) + \xi_g^a \tag{7-7}$$

The values of α_k^a are to be determined by the calibration process of the choice behaviour model. The values α_k^a are the same for all actors a. If different (groups of) actors are believed to have entirely different parameters α_k^a, then it is possible to develop an entirely distinct model for each subgroup (market segmentation, Ben-Akiva and Lerman, 1985; p.64).

From this notion, and from Dommencich and McFadden (1975, p. 23 and p.54) we learn that the vector $x_{g,k}$ and the parameters α_k^a can be defined in such a way that the vector $x_{g,k}$ holds the objective (values) of the attributes k of a good g, while α_k^a holds the subjective perception of the attributes k (see also Bovy, 1990; p.36). For a given good g we can now determine its subjective utility as perceived by a specific actor by applying the appropriate 'weighting' set α_k^a. Actors that have similar weighting sets form homogeneous groups (with respect to the valuation of the specific good g).

To fulfil all his needs, an actor a tries to obtain a set of goods $\overset{1}{G}$, with $\overset{1}{G} = \{1...G\}$ (see also equation 7.1). If we again assume a linear additive function for the total utility, the total subjective utility of this set of goods can be represented as:

$$U_{\overset{1}{G}}^{q} = \sum_{g=1}^{G} u_g^a \tag{7-8}$$

And, if we explicitly take into account the weighing for all relevant characteristics, as:

$$U_{\overset{1}{G},K}^{q} = \sum_{g=1}^{G} \sum_{k=1}^{K} u_{g,k}^a = \sum_{g=1}^{G} \sum_{k=1}^{K} \left(\alpha_k^a \bullet x_{g,k} \right) + \xi_g^a \tag{7-9}$$

Or using a vector-matrix representation:

$$U_{\overset{1}{G},\overset{1}{K}}^{q} = \overset{a}{}_{(K)} \bullet \mathbf{X}_{(G \times K)} + \xi_g^a \tag{7-10}$$

With:

$$\overset{q}{}_{\overset{1}{K}} = \left\{ \begin{matrix} \alpha_1 \\ (\\ \alpha_K \end{matrix} \right\}^a \quad \text{and} \quad \mathbf{X}_{\overset{1}{G},\overset{1}{K}} = \left\{ \begin{matrix} x_{1,1} & {}' & x_{1,K} \\ (& * & (\\ x_{G,1} & {}' & x_{G,K} \end{matrix} \right\}$$

Which results in:

total subjective utility of characteristics $\{1...K\}$ over all goods of the set $\overset{1}{G}$
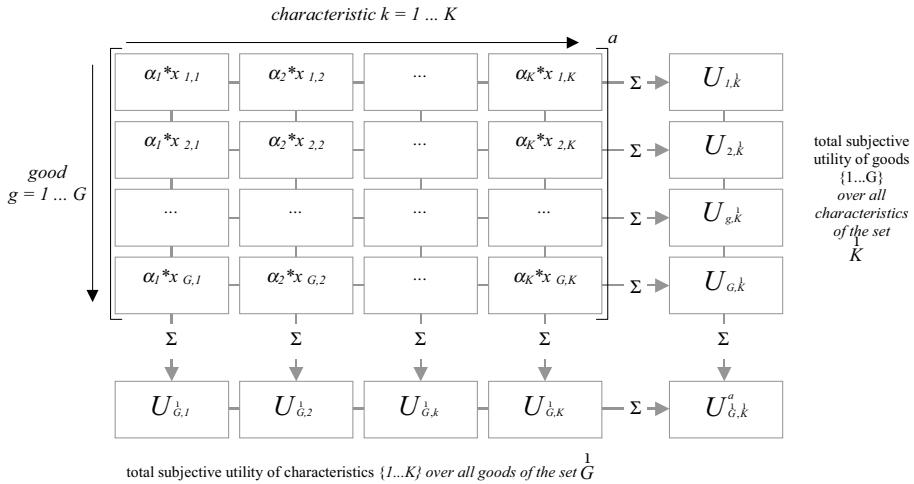
A set of goods $\overset{1}{G}$ can also be seen as a 'new' good that consists of a number of component parts and can be analysed as a good in itself. Later on in this thesis (part III), we will use this notion to explain that an assortment of goods in a shop and even an assortment of shops in a shopping centre can be modelled as being a good with a (subjective) utility for an actor (consumer).

The total utility of a given characteristic k of the complete set $\overset{1}{G}$ of goods as perceived by actor a is represented by:

$$U_{\overset{1}{G},k}^{q} = \sum_{g=1}^{G} u_{g,k}^a = \sum_{g=1}^{G} \left(\alpha_k^a \bullet x_{g,k} \right) = \alpha_k^a \bullet \sum_{g=1}^{G} \left(x_{g,k} \right) + \xi_g^a \tag{7-11}$$

To return to the example of food products: by the above-mentioned expression, the total (summed) perceived 'nutrititive value' of the set $\overset{1}{G}$ of food products can be determined (see for example Lancaster, 1971).

7.2.3   Benefits and costs

The partial utilities can be perceived as either positive or negative. Positive utilities can be regarded as 'benefits', where the sum renders the 'gross utility' (gross earnings). Negative utilities can be seen as 'disutilities', or costs[2].

For some analyses, it can be helpful to explicitly distinguish between positive and negative utilities.

Therefore, we use the following definition for negative partial utilities:

$$z_{g,k}^{a} = -u_{g,k}^{a} \quad \forall u_{g,k}^{a} < 0 \qquad \text{with} \quad g \in \overset{1}{G} \text{ and } k \in \overset{1}{K} = \{1...K\} \qquad \textbf{\textit{(7-12a)}}$$

And for positive partial utilities:

$$y_{g,k}^{a} = u_{g,k}^{a} \quad \forall u_{g,k}^{a} \geq 0 \qquad \text{with} \quad g \in \overset{1}{G} \text{ and } k \in \overset{1}{K} = \{1...K\} \qquad \textbf{\textit{(7-12b)}}$$

The total disutility, or costs of acquiring a good g, as perceived by an actor a, taking into account all relevant cost-characteristics ($\overset{1}{K}$) can now be represented as:

$$Z_{g,\overset{1}{K}}^{a} = \sum_{k=1}^{K} z_{g,k}^{a} = \sum_{k=1}^{K}\left(\alpha_{k}^{a} \bullet s_{g,k}\right) + \zeta_{g}^{a} \qquad \textbf{\textit{(7-13a)}}$$

With:

$Z_{g,\overset{1}{K}}^{a}$:   total or gross disutility (costs) of a good g (as perceived by actor a taking into account all relevant characteristics of set $\overset{1}{K}$);

$z_{g,k}^{a}$:   subjective partial disutility for the characteristic k of a good g (as perceived by actor a);

α_{k}^{a} :   subjective weighting factor for the characteristic k of the objective partial disutility (as perceived by the actor a);

$s_{g,k}$:   objective partial disutility of the characteristic k of a good g; with

$$s_{g,k} = -x_{g,k} \,\forall x_{g,k} < 0$$

Thus, the total generalised costs for a good g are a summation of the costs of different characteristics, representing different *types* of cost; Button (1993) uses such a generalised cost function for a public transport study. He does not, however, explicitly take into account actors' perceptions.

The total costs involved in obtaining a set of goods $\overset{1}{G}$ can be expressed as follows, omitting the stochastic term (please note the resemblance with the total utility expression):

$$Z_{\overset{1}{G},\overset{1}{K}}^{a} = \sum_{g=1}^{G} \sum_{k=1}^{K} z_{g,k}^{a} = \sum_{g=1}^{G} \sum_{k=1}^{K}\left(\alpha_{k}^{a} \bullet s_{g,k}\right) + \zeta_{g}^{a} \qquad \textbf{\textit{(7-13b)}}$$

Or using a vector-matrix representation:

$$Z_{\overset{1}{G},\overset{1}{K}}^{a} = \ _{\mathbf{(K)}}^{\mathbf{a}} \bullet \mathbf{s}_{\mathbf{(K \times G)}} + \zeta_{g}^{a} \qquad \textbf{\textit{(7-13c)}}$$

In analogy, we define:

---

[2]   Not necessarily '*monetary*' costs.

$$Y_{g,K}^{a} = \sum_{k=1}^{K} y_{g,k}^{a} = \sum_{k=1}^{K} \left(\alpha_{k}^{a} \bullet r_{g,k} \right) + \zeta_{g}^{a} \qquad (7\text{-}14a)$$

Thus:

$$Y_{G,K}^{a} = \sum_{g=1}^{G} \sum_{k=1}^{K} y_{g,k}^{a} = \sum_{g=1}^{G} \sum_{k=1}^{K} \left(\alpha_{k}^{a} \bullet r_{g,k} \right) + \zeta_{g}^{a} \qquad (7\text{-}14b)$$

And:

$$Y_{G,K}^{a} = \mathbf{^{a}_{(K)}} \bullet \mathbf{r_{(K \times G)}} \qquad (7\text{-}14c)$$

Therefore, the total net subjective utility of a set of goods as perceived by actor *a* is:

$$U_{G,K}^{q} = Y_{G,K}^{q} - \left| Z_{G,K}^{q} \right| \qquad (7\text{-}15)$$

7.2.4 Effectivity, productivity and efficiency

Effectivity, productivity and efficiency are widely used notions, but they are not so easy to define. 'Effectivity' can be defined as the ratio of the realised results (or output) of a process $Y_{G,K}^{a,realised}$ and the normative, maximum achievable results $Y_{G,K}^{a,norm}$ of a process given certain costs (or input) $Z_{G,K}^{q}$ (see In 't Veld, 1988). Therefore:

$$\chi_{G,k}^{a,realised} = \frac{Y_{G,k}^{a,realised}}{Y_{G,k}^{a,norm}} \qquad (7\text{-}16)$$

Productivity is then defined as the ratio of the results (output) and costs (input), so:

$$\theta_{G,k}^{a,realised} = \frac{Y_{G,k}^{a,realised}}{Z_{G,k}^{q,realised}} \qquad (7\text{-}17)$$

Efficiency is defined as the ratio of normative costs (minimum input) to achieve certain results and the realised costs (input) for the process, so:

$$\varepsilon_{G,k}^{a,realised} = \frac{Z_{G,k}^{q,norm}}{Z_{G,k}^{q,realised}} \qquad (7\text{-}18)$$

'Efficiency' is a subjective notion: an actor will only regard the efficiency of a given process from a certain perspective. This preference is laid down in the subjective weighting set α_{k}^{a} of the benefits and costs.

Lower values of $\varepsilon_{G,K}^{q}$ imply 'low' efficiencies, where $\varepsilon_{G,K}^{q} \rightarrow 0$ is the theoretical minimum. On the other hand, higher values of $\varepsilon_{G,K}^{q}$ represent 'high' efficiencies, with $\varepsilon_{G,K}^{q} \rightarrow 1$ being the 'normative efficiency'. Theoretically $\varepsilon_{G,K}^{q}$ can be greater than one, when the realised costs are even lower than the normative (envisaged minimum) costs.

Efficiency can be improved by cutting down the costs $Z_{G,K}^{q,realised}$ without diminishing the benefits (or with a relative small decrease in benefits); this is what we call '*conservation*'.

$$\left(\varepsilon_{G,k}^{a} \right) \uparrow = \frac{\left(Z_{G,k}^{q,norm} \right)}{\left(Z_{G,k}^{q,realised} \right) \downarrow}$$

Conservation can be achieved by, for instance, transport automation and energy-use reduction technologies (both introduced in Part IV).

Productivity can be achieved by enlarging the benefits without increasing the costs; this we call '*utilisation*' and can be expressed as:

$$\left(\theta_{G,k}^{a}\right)\uparrow = \frac{\left(Y_{G,K}^{a,realised}\right)\uparrow}{\left(Z_{G,K}^{a,realised}\right)}$$

The notion of 'economies of scale' (see Section 9.4.1) and the related consolidation strategies (as introduced in Section 9.5 and further elaborated in Parts III, IV and V) relate to utilisation[3].

The notions of 'efficiency', 'productivity' and 'effectivity' can not only be applied to 'real' production, but also to organisational processes and public policy processes (see In 't Veld, 1988).

7.2.5   Micro-economic choice behaviour

Micro-economic theory states that actor a maximises his total net utility (benefit, profit) by choosing the particular set of goods $\overset{1}{G}$ that renders the largest total utility. In choice situations, where micro-economic utility theory is applicable, budget restrictions apply. If choice criteria refer to monetary values, these budget restrictions can for example be the income of an actor. Other choice criteria may have other (types of) budgets.

In ideal market conditions, every time a choice is made to take some sort of action, the utility of alternative actions is determined, and the most attractive one is chosen. In reality, some choices are fixed in time, for example, when yearly transport contracts are made[4]. In that case, the gross utility (earning) is generally fixed, but the disutilities (costs) are not.

Optimisation within a given contract period generally comes down to *minimising the costs*, a notion that is widespread and is often (but not necessarily correctly) seen as a goal in itself.

$$\min\left(Z_{G,K}^{a}\right) = \min\left(\sum_{g=1}^{G}\sum_{k=1}^{K}z_{g,k}^{a}\right) = \min\left(\sum_{g=1}^{G}\sum_{k=1}^{K}\left(\alpha_{k}^{a}\bullet s_{g,k}^{a}\right)\right) \qquad \textbf{\textit{(7-19)}}$$

7.3   Choice behaviour of actors

Different actors within the process of urban goods distribution have to make choices at various moments. First we will introduce a general framework that describes the different

---

[3]   If for the higher $Y_{G,k}^{a,realised}$ a new norm $\left(Z_{G,K}^{a,norm}\right)'$ is established, the

Efficiency $\left(\varepsilon_{G,k}^{a}\right)' = \left(Z_{G,K}^{a,norm}\right)' \big/ \left(Z_{G,k}^{a,realised}\right)$ will also be higher. From that perspective, a higher productivity can also be regarded as a (special form of) a higher efficiency. Therefore, we will use the term 'efficiency' for both a 'utilisation' and a 'conservation'.

[4]   The fact that long-term contracts are made can also be regarded as a result of economic behaviour: in that view, the utility of such a long-term deal is apparently higher than the utility of a series of short-term contracts.

possible roles of actors within a choice process; we will then show that the framework is applicable to both the private as public sector.

Although choice processes are complex, we can use the insights we can get from micro-economic utility theory and the derived choice behavioural models, to achieve insight into these processes. This allows us to formulate qualitative prognoses for choice behaviour. Therefore, we will look to 'random utility discrete choice models' that render *probabilities* of certain (discrete) choices being made by actors, given their preferences and taking into account the fact that there are individual preferences that are hidden or cannot yet be modelled. We will then deal with choice behaviour tools that do not necessarily forecast the behaviour of actors, but *list choice options* in order of attractiveness. These tools can be used to analyse complex choice processes. For choice processes where a string of subsequent choices must be made, we will introduce the network representation tool. For choice processes where a wide variety of choice-influencing factors and opinions (actors' preferences) may play a role, we introduce the cost-benefit analysis and multi-criteria evaluation methods.

7.3.1   Decision making framework

The decision-makers within the field of urban goods distribution are actors who act in terms of certain long-term goals (quite probably only qualitatively formulated) and short-term targets (possibly quantifiable). In the case of private parties, executives and managers will play the roles of actors; in the case of public parties, governments or their institutions play these roles. The decision-makers do not usually act on their own, but represent others: shareholders (private parties) or 'actors' (public parties).

From economic market theory, we can distinguish between different types of roles that also apply to the public sector (see Table 7-1).

Table 7-1:   Different types of markets in public and private sectors

public sector	*private sector*	*type of market*
dictatorial	monopoly	suppliers' market
stimulating, anticipating	oligopoly	↓
co-operative, consultation	free market/polypoly	↑
demand responsive	monopsony	buyers' market

A dictatorial public sector has (or aims to have) full control over other actors' actions. The public sector can lay down laws, and all actors will have to abide these laws. Usually, the private sector only plays this role in cases where fundamental issues are at stake. In a 'planned economy', this role is extended to the whole of the economic system and indeed, to the whole of society. The role is comparable to that of monopolistic suppliers in an economic market, although monopolistic suppliers cannot 'enforce' their plans.

In a stimulating or anticipating role, the public sector tries to influence processes so that they develop in such a way that they comply with established goals. This strategy can be used to introduce new technologies. The role is comparable with the role of an oligopoly, where a limited number of actors control the market.

The co-operative or consultation role that the public sector can play is comparable to the free market model. No individual actor (neither a supplier nor a user) has a significant influence on the market as a whole.

In a demand-responsive market the public sector reacts only to developments that are already occurring, and tries to reach its aims by mitigating (or other) measures. This role is comparable to the monopsony market situation, where user demand decides what happens.

7.3.2   Random utility choice behaviour models

If a choice must be made between different discrete[5] alternatives within a set $\overset{1}{G}$, the probability that an actor chooses alternative $g \in \overset{1}{G}$ is a function of the costs of all alternatives:

$$P\left(g\Big|\overset{7}{G}\right) = f\left(Z_{1,K}^{\;7'}\quad Z_{G,K}^{\;7}\right) \tag{7-20}$$

This probability can be calculated using choice models. Examples for the application of such models can be found in traffic assignment problems, where $\overset{1}{G}$ is the set of potential alternative routes. Bovy (1990) distinguishes between deterministic models and probabilistic models.

Deterministic models, such as the 'logit' function, directly calculate the probability that one alternative (g) from a set alternatives ($\overset{1}{G}$) is chosen (see expression 7-21).

$$P\left(g\Big|\overset{7}{G}\right) = \frac{e^{z(g)}}{\displaystyle\sum_{i=1}^{G} e^{z(i)}} \tag{7-21}$$

This kind of model is especially suitable for estimating the probability of the choice of an alternative g in a set of independent alternatives $\overset{1}{G}$. If alternatives are interdependent, ideally models should be used that take these interdependencies into full account. The 'probit' function is an example[6] (Bovy, 1990).

Both types of models can be used for relatively simple[7] choice processes. The models can be applied in succession for multi-stage choice processes (see below).

7.3.3   Network representation of choice processes

A network representation of choice processes makes it easy to analyse, understand and predict complex, multi-stage choice processes[8]. A network representation allows modelling of quite different decision processes in almost the same manner and allows the use of well-known solution methods to find optimal solutions or to forecast behaviour. In this respect, the 'shortest path algorithm' is the most important solution method, but network representation also allows critical path analysis, selected link analysis and capacity analysis. We will

---

[5]   Individually identifiable and independent alternatives.

[6]   The 'logit' formula is an easy-to-use model and is therefore often applied in traffic models. However, the nature of networks and the resulting characteristics of alternative routes (overlaps) result in less reliable results of the 'logit' estimations.

[7]   Choice processes where all choice criteria can be expressed in one value.

[8]   A multi-stage choice process is a choice process with multiple, successive and mutual related choices.

illustrate the wide range of potential issues that can be addressed using a network representation below.

A network consists of nodes and links, both with 'attributes'. Depending on the issue at hand, the links can represent actions, line infrastructures or good flows.

The nodes can either represent decision points or moments or given actions.

In a traditional network representation, all links (and all nodes) represent similar elements of the issue at hand.

For example, in a network representation of a road infrastructure network, all links represent roads, and all nodes represent crossings or junctions. The costs for using a network element include the costs for the use of the infrastructure, the transport, and traffic means. We can regard a network element as being a 'good' $\overset{1}{G}$ consisting of 'components' g. The network elements' costs (deterrence) will then be:

$$Z^q_{\overset{1}{G},\overset{1}{K}} = \sum_{g=1}^{G}\left(z^a_{g,\overset{1}{K}}\ Z^a_{g,\overset{1}{7}}\right) = z^a_{trafficmeans,\overset{1}{K}} + z^a_{transportmeans,\overset{1}{K}} + z^a_{inframeans,\overset{1}{K}} + ... \qquad \textbf{\textit{(7-22a)}}$$

The set cost factors $\overset{1}{K}$ can for instance include (the actors' a subjective perceptions of) 'time' and 'distance' costs. The component costs of the traffic means $z^a_{trafficmeans,\overset{1}{K}}$ are:

$$z^a_{trafficmeans,\overset{1}{K}} = \sum_{k=1}^{K}\left(z^a_{trafficmeans,k}\right) = z^a_{trafficmeans,time} + z^a_{trafficmeans,distance} + ... \qquad \textbf{\textit{(7-22b)}}$$

In 'hyper' networks, links and nodes may represent different elements or actions, as long as the most relevant attributes stay the same. For example, one can construct a hyper network of an intermodal transport system, including transfers and even procedures, as long as all attributes relate to time (travel time, transfer time, organisational time) or costs (see also Crainic, 1999).

A route through a network is a specific collection of route-elements. Therefore, a specific route can be regarded as a 'good' in itself ($\overset{1}{G'}$). The total costs (deterrence, resistance) $Z^q_{\overset{1}{G'},\overset{1}{K}}$ of the route $\overset{1}{G'}$ are expressed as:

$$Z^q_{\overset{1}{G'},\overset{1}{K}} = \sum_{g=1}^{G'}\ \sum_{k=1}^{K}\left(Z^a_{g',k}\right) \qquad \textbf{\textit{(7-23)}}$$

Figure 7-1 illustrates a network representation, where route $\overset{1}{G'}$ consists of the network elements *n1,l1,n4,l5,n5,* so: $\overset{1}{G'} = \{n1,l1,n4,l5,n5\}$. The total costs of route $\overset{1}{G'}$ can be decomposed as is illustrated with Figure 7-2.
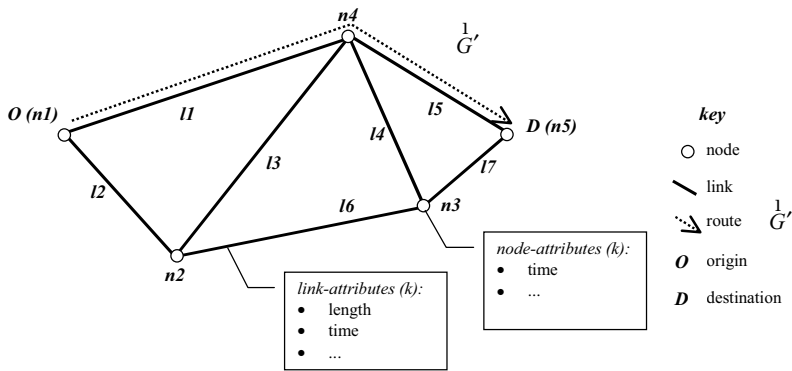
Figure 7-1: Network representation using nodes and links

In a network representation, the total disutility can be calculated 'on the run', a method that is used in shortest-route algorithms, such as the Dykstra algorithm. Such an approach only holds if the elements are truly additive (or if the attributes concerned can be regarded as being additive). In case the disutility of a route $\overset{1}{G}'$ consists of non-additive aspects or is dependent on the use, other methods must be used to calculate the total disutility[9]. For example, the travel time of a network link depends on the use; therefore $Z_{\overset{1}{G}'} = f(q,\ )$.

Some applications of a network representation, relevant for urban distribution, are described below. In parts III, IV and V, the different representations are elaborated.

As explained further in Part III, *marketing channels* represent the different 'trade routes' a product can follow from a producer to the final consumer. A network representation of available (and possibly potential) marketing channels can be used to analyse consumer behaviour (e.g., which retailers will the consumer choose), but also to fine-tune marketing channels from either a producers' or retailers' point of view.
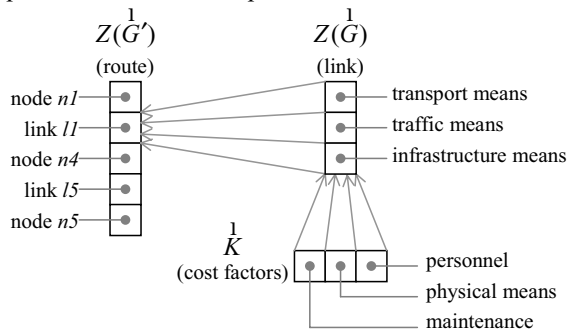

Figure 7-2: Cost composition (and decomposition) of a route in a network

Physical distribution channels (see also Part III) represent the alternative (potential) routes through which a product is distributed from a supplier to a final consumer. At the strategic

---

9   One method is route-enumeration: establishing all ('feasible') routes and calculating the total disutility of each of those routes.

level, suppliers, logistic service providers and retailers can analyse how channels can be optimised and where consolidation would be effective (depot, line).

Physical distribution service networks represent the total physical distribution system (performed by one or more logistic service provider) and can be used to optimise logistic processes at a tactical level (see Part III). The costs for using the service network depend on the use, so $Z_G^{L} = f(q,')$: to some extent, a higher use can lead to lower costs due to economies of scale. Excessive intensities can also lead to higher costs (capacity overflow).

Physical infrastructure networks represent (existing, future and envisaged) infrastructural links and nodes. By means of the representation, estimations and predictions can be made for the quality of the service and the intensities on the network. The models can be used at all levels: at the operational level for fine-tuning and controlling traffic flows, at the tactical level for designing distribution strategies (timing, routes), and at the strategic level for developing new infrastructures.

In *policy making*, the involvements of and the interactions between the different actors in the policy making process are represented as links and the participants as nodes. These network approaches are used in a descriptive way; some experiments have also been done with forecasting the outcomes of policy making processes through network-representation of this policy making process (see for example Duin et al., 1999).

7.3.4   Cost-Benefit Analysis and Multi-Criteria Analysis

Choices can also be complex due to the multitude of (cost and benefit) factors that play a role, as well as the large range of choice alternatives. In those cases, more elaborated choice (support) methods can be used.

To enable a good choice, three types of information are required:

- *Alternatives*. These are the options that are open.
- *Criteria*. The factors that play a role in the choice of decision-making process and that are related to the policy objectives and certain conditions and constraints such as financial resources.
- *Weights*. The relative (mutual) importance of the criteria.

The choice-making process itself consists of several steps. These steps include:

1. *Screening*. In most cases a wide range of options is proposed. In that case, a first filtering out of relevant[10] options takes place.
2. *Grouping*. Evaluation also means comparing options. For this process, options must be comparable, or must be compared on the basis of similar types of characteristics. For instance, differences in development stage (prototype, common practice), differences in

---

[10]   For a given choice, a multitude of solutions (theoretically sometimes an infinite number) can be constructed. To be able to handle the choice process in an efficient way, a pre-selection must be made. Such a pre-selection is often based on 'insight' and 'present knowledge', and is therefore referred to as a heuristic approach. By introducing a heuristic element into the decision making system, a mathematical optimum solution can no longer be guaranteed.

system level (new engine type versus new vehicle type), and differences in application area (urban freight versus hinterland transport) make options difficult to compare. In that case, regrouping is necessary. Then the choices can be made between and within groups.

3. *Comparing*. The options are compared using criteria.
4. *Ordering*. After the process of comparing the options, some ordering will take place.
5. *Selecting*. The ordering makes it possible to select the best option(s).
6. *Prioritising*. A given set of options can be chosen, say, in order to work out a strategy. Putting them into a time frame (for reasons of budget or effectiveness) requires some prioritising.

In a *cost-benefit analysis,* the costs and benefits of an action (option) are monetarised. Most actors will strive to a maximum result (see expression 7-25; compare with expression 7-15).

$$Y_{G,K}^{a\,1} - \left| Z_{G,K}^{a\,1} \right| \geq 0 \tag{7-25}$$

The net results can be used to determine the (relative) appropriateness of the options. Button (1993) describes some experiences in commercial and social approaches to investments that also include future revenues and future (probable) costs.

In the *multi criteria analysis* (MCA) method, criteria and the weighing of those criteria are explicitly separated. The different aspects (criteria) of the various options are valued on a basis that is most appropriate for the respective criterion; the values can be cardinal or ordinal and may have different measuring units. A process of standardisation transforms all criteria into cardinal values. This results in an option-criterion matrix $\mathbf{M}_{(O \times C)}$.

Then at least one weighting set is composed (vector $\mathbf{w}_{(C)}^{a}$), giving a weight to each of the criteria such as perceived by actor *a*.

For different actors, or different policy strategies, different weighting sets can be defined.

The resulting vector $\mathbf{r}$ ($\mathbf{r} = \mathbf{w} \bullet \mathbf{M}$) renders the relative appropriateness of the different options from the viewpoint of the applied weighting set $\mathbf{w}$.

If:

$$\mathbf{M} = \begin{Bmatrix} m_{o1,c1} & ' & m_{O,c1} \\ (& * & (\\ m_{o1,C} & \& & m_{O,C} \end{Bmatrix} \qquad \text{and} \qquad \mathbf{w}^{a} = \left\{ w_{c1}, w_{c2}, {}' \ , w_{C} \right\}^{a}$$

With:

$m_{o,c}$ = MCA-matrix value for option *o* and criterion *c*;

w_{c}^{a} = weighting set value for criterion *c* as perceived by actor *a*.

Then:

$$\mathbf{r} = \mathbf{w} \bullet \mathbf{M} \qquad \text{with} \qquad \mathbf{r}^{a} = \left\{ r_{o1}, r_{o2}, {}' \ , r_{O} \right\}^{a} \tag{7-26}$$

With:

r_{o}^{a} = total result (value) of option *o* as perceived by actor *a*.

The MCA methodology is very similar to the way we described the utility functions. The main difference is that the resulting vector **r** in the MCA is only used to determine an ordering (of appropriateness) of possible options, while the utilities represent (monetarised) values, which are cardinal. We consider the multi-criteria analysis (MCA) and the cost-benefit analysis (CBA) as specific applications of micro-economic utility theory. In this thesis we especially use the mindset that is the basis of micro-economic utility theory for interpreting and anticipating choices of actors. With the theory in mind, we are able to understand why different actors make different decisions given – objectively – similar choice sets and sets of preconditions. We do not, however, elaborate the theory in a quantitative way: neither the empirical quantitative data nor the necessary qualitative information to make such an comprehensive analysis is available.

7.4   Conclusions

By using the way-of-thinking that forms the basis for micro-economic utility theory, and by applying this mindset to urban goods distribution processes, we are able to understand the choice processes that actors make in a systematic (mathematical) way. It is an approximation, because we know that, in practice, the market requirements stated by the theory are not fully met (for example, because the vast external effects are not taken into account).

The theory defines 'utilities' and highlights the fact that these utilities are perceived differently by different actors, even if they refer to the same (objective) characteristics. This difference can be used later on to describe the differences in choice behaviour of private and public actors.

By distinguishing between positive utilities (benefits) and negative ones (costs), we can also systematically describe the notions of 'efficiency' and 'efficiency improvement'. With respect to efficiency improvement, we have defined the concepts of 'utilisation' (increasing the use without changing the need for resources) and 'conservation' (using less resources without changing the use). We introduced choice behaviour models and tools that can be applied for forecasting actors' behaviour in different (complex or less complex) choice situations.

These basic notions will be used later on in this thesis when we deal with logistics systems, transport systems and the spatial issues of urban goods distribution.

8.   System description of urban goods distribution

8.1   Introduction

In this chapter, we will introduce the 'layer scheme' for the transport system, as applied to the urban goods distribution system. This layer scheme enables a systematic analysis of the system and helps to formulate new urban distribution concepts. The scheme classifies the primary functions and services of the goods distribution system, identifies different roles and names the actors that can play these roles. The layer scheme will be used throughout this thesis to position the different parts and subjects and to show their interrelations.

8.2   Layer scheme applied to urban goods distribution

8.2.1   Introduction

For this analysis, a systems approach to the transport system is required; it will ease the development of new concepts and technologies, and define the role of public authorities more clearly. Such an approach is helpful in:

- Identifying the actors, services and relationships related to the distribution of goods;
- Identifying the levels of intervention in the system;
- Developing a common terminology;
- Defining the borders of the system.

The purpose of a freight transport system is to provide transport services for the movement of goods or consignments from the origin to the desired destination, under given conditions, and to facilitate logistic activities, such as storage or value-added logistics.

In order to describe the freight transport system in detail, the system is subdivided into layers in a layer scheme.

8.2.2   Layer scheme for transport

We will expand and utilize the general layer scheme for transport to develop a dedicated version suitable for the analysis of urban goods distribution processes[11]. In current research and policy studies, numerous systematic descriptions of the transport system have been presented. The OSI (Open Systems Interconnection) layer model, a reference model for telecommunication services, has been the basis for most of these models.

Figure 8-1 shows the OSI model adjusted for the transport system. In the Transport layer model, each layer represents a specific service that is required to transport goods. In this example, three layers represent the transport service network. The other three layers represent the physical network (that is, the infrastructure network and the spatial network).

- User: actor who wants goods transported from origin A to destination B.
- Agent: offers access to the transport system; the one who represents the service desk or counter of the system.
- Integrator: the organiser; the one who establishes the organisational connection from A to B.
- Carrier: the operator; the one who conducts the physical transport from one point to another (either the complete trip from A to B, or only a part thereof).
- Traffic management: the controller of the traffic flows that use infrastructures.
- Infrastructure: the physical facilities required for transport.
- Corridor & nodes: space (in the air, above ground, or underground) for infrastructure and physical movement of goods.
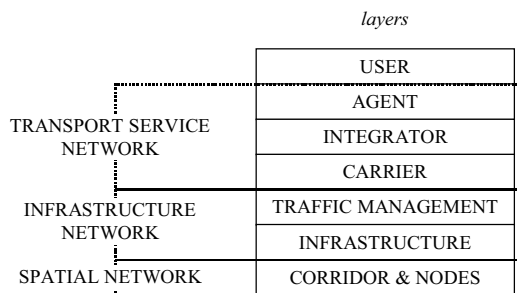

Figure 8-1: The OSI layer model applied to the transport system

8.2.3   Basic layer scheme: phenomena and primary services

Here we will elaborate further on the layer scheme. The layers not only represent networks but also users and suppliers of services. Therefore, we have adjusted Figure 8-1 and have developed a more comprehensive and more sophisticated new layer scheme. In the layer

---

[11]   For a detailed elaboration of the general layer scheme for transport see Schaafsma et al (2000).

scheme in Figure 8-2, the transport system is defined in terms of service layers. Each layer represents a further step of specialisation that occurs within transport.

Historically, due to specialisation, consumers and producers became spatially separated, which made transport essential. In due time, goods transport was no longer carried out solely by consumers or producers, but became the responsibility of specialised carriers. The next phase of the process was the separation between the provision of the transport service (*Transport*) and the actual movement of vehicles carrying the goods (*Traffic*). Specialised actors now act as service desks, while the carriers concentrate on performing the actual transport. Economic and technical developments have enabled this kind of specialisation.

With the introduction of each specialisation, new market situations have emerged. Each service layer represents such a market situation, in which a specific service is demanded and provided in order to act as one transport system. The market situations are referred to as *Phenomena*, while the associated service levels are referred to as 'primary services'. The primary services or service layers represent the main transport functions.

Each layer has its distinct input and output: a layer provides a service to the preceding ('higher') service and requires services of subsequent ('lower') services. Inputs and outputs of successive layers function in markets (see Figure 8-2).
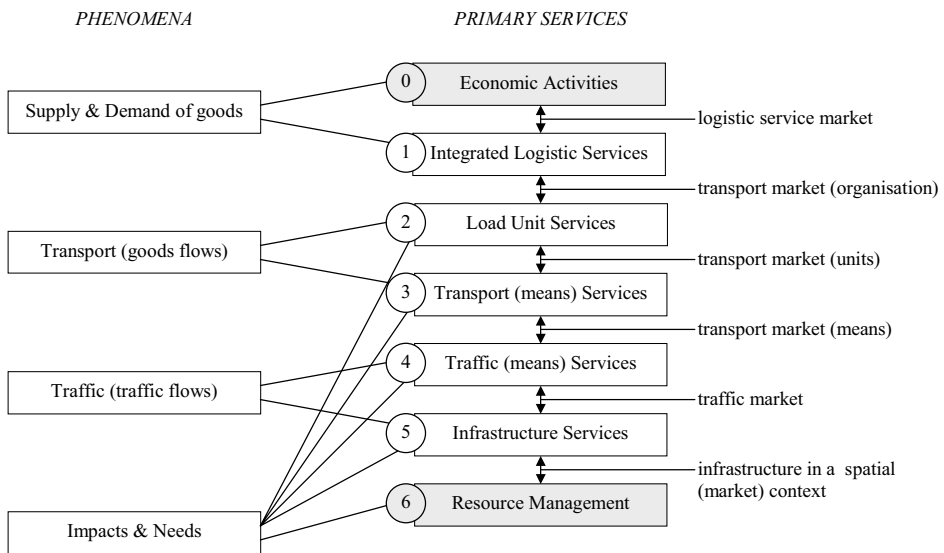

Figure 8-2: 'Phenomena', service layers and markets in the goods transport system

In order to describe the freight transport system more fully, we have introduced a differentiation into seven primary services (of which five layers are the basic 'transport' layers; see Table 8-1).

Table 8-1:   Inputs and outputs of primary services

	primary service	*input (demand)*	*output (supply/service)*
0	economic activities		shipment order
1	integrated (logistic) services	transport request	transport 'plan'
2	load units services	cargo hold (detachable)	load unit movement
3	transport means service	cargo hold	transport means movement
4	traffic means service	propulsion, guidance	vehicle movement
5	infrastructure service	link in space & time	infrastructure capacity
6	resource management	space, energy, 'environment'	

Thus, integrated logistic services interact between the 'economic activities' that require transport (tasks) and the transport system that is able to physically perform this task.

Together, these services (layers) function as an integrated transport service.

The differentiation enables a fundamental description and analysis of roles (tasks), which can be performed by different actors. The apparently close relation between roles and actors, which we see in practice, can sometimes be overturned by new developments. For example, recent European legislation urges governments to clearly split infrastructure providers from infrastructure operators and users. This has had profound implications, especially in railway transport.

In distinct practical applications, some primary services (service levels) will be skipped, but others may be combined. For example, some transport processes do not explicitly use specific load unit services (although most urban distribution products are packed in some way). In addition, in some processes there is no distinction between transport and traffic means, because they form a physical unit (such as the case of non-articulated trucks and sea-going vessels).

The five transport service layers interact mutually and also interact with 'economic activities' and 'resource management'.

8.3   Primary services

8.3.1   Primary services, roles and actors

Primary services are the basic services within the transport system. The primary services can be related to 'roles'. Most primary services include the roles of 'providers' and 'operators' (see Figure 8-3). Providers supply the required physical means, for instance the supply of load units, transport means and vehicles. Providers own these means; rental and lease companies are examples of providers. Most primary 'provider' roles include some form of regulation – in effect, control over a multitude of operators within the service level. Operators use the means for transport.

Different actors can perform one or more of the roles of the primary services. They can be both 'provider' and 'operator' within the same layer (owner and user of means), or they may perform different roles in different layers – thus, in Figure 8-3 some types of actors appear in several different places.

In operating and providing the units, transport means and/or traffic means, specific actors play different roles:

- Self-transporting shippers can own and operate these vehicles or can use rented or leased vehicles;
- Professional transport companies can be subdivided into:
  - owner/drivers with their own traffic unit or vehicle (truck, locomotive, river push-barge) and, possibly, their own transport units (trailer, semi-trailer, rail wagon);
  - transport companies who own, rent, lease their units or make use of the services of owner/drivers;
  - logistic service providers or integrators who own their units or who employ the services of transport companies.

PRIMARY SERVICES	PRIMARY ROLES	ACTORS
Economic Activities	Shipper (consigner), Receiver (consignee)	producers, consumers, retailers
Integrated Logistic Services	Integrated Service Providers	logistic service provider, integrators
Load Unit Services	Load Unit Operators	carriers
	Load Unit Providers	container leasing companies
Transport (means) Services	Transport means Operators	carriers
	Transport means Providers	transport means leasing companies
Traffic (means) Services	Vehicle (Traction) Operators	traction providers, carriers
	Vehicle (Traction) Providers	traffic means leasing companies
Infrastructure Services	Infrastructure Operators	traffic managers & regulators (government)
	Infrastructure Providers	infrastructure owners (private, government)
Resource Management	Resource Managers	regulators (government)
	Resource Providers	exploration/mining companies

∗ resources relate to all 'means'

Figure 8-3: Primary roles and actors related to the service levels

8.3.2   Primary services, means and associated measuring units

After the roles and actors, we define 'primary means'. These primary means are the physical instruments required to perform the primary services (see Figure 8-4 for examples). These means can be measured; therefore associated measurements are also defined.

PRIMARY SERVICES   PRIMARY MEANS   DIMENSIONS

PRIMARY SERVICES	PRIMARY MEANS	DIMENSIONS
Economic Activities		
Integrated Logistic Services	Goods/Products	value, weight, mass [ton]; volume [m3]
Load Unit Services	Cargo	value, weight, mass [ton]; volume [m3]
	Load Units (containers)	units [#]; unit-kilometres [km]
Transport (means) Services	Transport Means (trailers, carriages, barges)	transport performance [tonkm]
Traffic (means) Services	Traffic Means (trucks, locomotives, pushboats)	traffic performance [veh.km] trips, stops [#]
Infrastructure Services	Infrastructure Means (roads, tracks, waterways, nodes)	traffic intensities [veh/hr]
Resource Management	Resources (space, energy, 'air')	space utilisation [m2] emissions [kg], energy use [J]

*

tonne = metric tonne (1000 kgs)

\# = number (no dimension)   * resources are used by all 'means'

Figure 8-4: Primary Services, Means and Measuring Units

8.4   Service layers, roles, actors and means

Below the seven primary service layers (including the five primary services related to the freight transport system) and associated roles, actors and means are elaborated.

Economic activities
Economic activities lead to supply, trade and demand of goods and products. Economic activities determine what should be transported, the origins and destinations and the quality criteria required from the transport system[12]. On the other hand, the characteristics of the transport system define the parameters of the economic activities.
The supply and demand of goods is 'regulated' in economic markets. Shippers or consigners give orders to ship goods, and receivers or consignees receive those goods. Producers, consumers and trade intermediaries are the actors that play these roles. Traded volumes can be expressed in monetary units, in physical volumes (m^3) or in weight/mass units (kilograms or metric tonnes).

---

[12]   In Part III, we will arrange the economic activities that determine goods flows into 'marketing channels'.

Integrated Logistic Services
Integrated logistic services 'transform' goods/products into cargo – goods to be transported. Thus, they form the first element in the 'transport' phenomenon. The role of logistic services is to find optimal ways (from an organisational and physical perspective) to transport goods from the origin to the required destination, thereby using all logistic and technological means provided by the other primary services. In simple, straightforward organisations, shippers, receivers or carriers can play this role themselves. In more complex organisations, specialised actors such as logistic service providers or integrators play this role. In the abstract, cargo can be seen as the 'means' (goods to be transported in a transport system) with the associated measurements of monetary units, physical volumes or weight/mass.

Load Unit Services
The primary load unit service offers opportunities to smooth the transport and handling of cargo by combining small packages into larger units; it makes transport and goods transfers more efficient. The service is a second element of the 'transport' phenomenon. Two associated roles are assigning the load units to transport orders (operating load units) and making the load units available (providing in load units)[13]. Container transport companies and carriers can perform the operations, while lease companies and pooling-organisations can be unit-providers. Of course, a single carrier can also perform the roles of operating and providing load units. The means that are used by load unit services include all kinds of containers: swapbodies, pallets, roll-cages, crates, boxes etc. The measurement to represent the flows is simply a 'unit', with the important attribute of 'loaded/unloaded' (or, alternatively, the load factor).

Transport Means Services
The transport means services deal with all transport objects holding cargo. The services form the third element of the 'transport' phenomenon. The associated roles include the operation of transport means and the provision of these means[14]. Transport means include railway carriages or wagons, trailers and semi-trailers in road transport, and non-motorised barges in inland waterway transport. Especially in road and inland waterway transport, transport means are often physically integrated with traffic means (see below). Closed transport means (lorries or carriages with a closed load space or cargo hold) exclude the use of large load units such as containers. The measurements of transport means are 'units' with respect to the means itself, and transport performance (tonne kilometres) and trips with respect to the movements. An important attribute of the 'trip' measuring unit is the load factor or the 'empty'/'full' attribute[15].

---

[13]   This distinction is necessary because the company that owns the load-units (and provides the units) is not always the same company as the one that actually uses the load units (thus 'operates' the units);

[14]   This distinction is similar to load units: the owner of the transport means (provider) may be not the same as the one who runs the transport means (operator).

[15]   Note that in most statistics, a transport means loaded with a load unit such as a container or swapbody is always regarded as 'loaded', regardless of whether the load unit itself is loaded or not (i.e., full or empty).

Traffic Means Services

The traffic means services deal mainly with propelling and guiding the transport means. Traffic means services refer to the moving elements of the 'traffic' phenomenon. The associated roles are operating these traffic means (running the vehicles) and making the vehicles available (providing in traffic means).

Actors operating these means are often carriers, but may also be shippers or receivers (transport on own account), or specialised companies that hire out traction services. Actors providing traffic means may be carriers, shippers and receivers or specialised actors who lease or hire out this kind of equipment.

Examples of pure traffic means are trucks (for semi-trailers), locomotives and push or towboats. Especially in road and inland shipping, transport and traffic means are physically integrated, in non-articulated trucks, and motorised barges and other vessels.

The measurements of this type of service relate to the number of vehicles in use, the traffic performance, measured in vehicle kilometres and to the movement of the means, measured in trips per day or number of stops per trip.

Infrastructure Services

Infrastructure services supply the physical network (made up of linear and node infrastructures) and form the 'static' part of the traffic phenomenon. The main existing inland infrastructures for carrying physical goods are roadways, railways, inland waterways and pipelines.

Traffic regulators can perform the role of operating infrastructure (regulating the access[16]), while the role of providing infrastructure can be played by investment companies.

Often the roles are combined; governments often fulfil both roles. As stated earlier, (European) legislation may force a separation between the roles of providing, operating and using infrastructures. For railways, European 'liberalisation' (or 'deregulation') legislation is already in use, although it has only been brought into practice by a limited number of member states. In some countries, there are plans to 'privatise' the operation of some infrastructures (although in most cases, the provision of these infrastructures is privatised). The parameters of the use of infrastructures are intensities (measured in vehicles per lane per hour or per day), while the parameters for describing infrastructures are kilometres of line infrastructure, number of nodes and capacity of the links and nodes.

Resource management

The last 'phenomenon' in the layer scheme represents *impacts and needs*. Although there is no real market situation for the *Impacts*, such as noise and emissions, there is some kind of a market situation for the *Demands* because natural resources such as energy, materials and space can be traded. *Governments* act usually as regulators, while *Society* can be seen as the providing actor. In this figure, the Spatial Network layer from Figure 8-1 is included as spatial planning by the government as regulator. Besides the direct resource use by transport, the indirect use of resources also has to be recognised.

---

[16]   Infrastructures can be accessible to all types of users (mixed use) or be accessible only to specific user classes (dedicated infrastructures). The type of access can be either fixed in time or changed on a temporal basis.

This concerns very different types of resources; thus different measurements are used:

- Air pollution is measured in grams or kilograms;
- Noise in decibels;
- Energy in Joules;
- Space utilisation in square or cubic metres.

8.5   Specialisation, diversification and secondary services

Each of the five primary transport services can be fulfilled by a wide variety of means. For instance: the infrastructure service can be based on road, rail, inland waterways or pipelines. Infrastructure means can be combined with different traffic (means) services, transport (means) services, load unit services and integrated logistic services; thus a broad range of combinations of different primary services exist.

'Specialisation' and 'diversification' have led to the wide and varied supply of transport services. *Specialisation* means that a specific transport service is set up to accommodate a specific physical distribution channel. This eventually leads to many different sub-transport systems, parallel to each other.

Diversification is quite the opposite. Through *diversification*, a transport service is set up as robustly as possible, to deliver as many different kinds of services using the same means. Diversification makes it possible to accommodate different distribution channels with a single transport system (this will be further explained in part III).

The transport system is built up of different activities in order to perform its service. Each activity can become a separate entity or primary service, as shown in Figure 8-2. Each sub-layer represents a primary service that is required to perform the overall service as a transport system. The division into sub-layers is called *differentiation*. There are different reasons for differentiation; they can be commercial or legal. For example, the splitting up of the national railways into different organisations is an example of differentiation for legal reasons.

The reverse process is called *integration*. Integration means that activities or sub-layers are joined together as a single activity (represented by combining sub-layers in the layer scheme. There are fewer examples of integration. In the case of own transport, such as buying at an auction and transporting the goods to the shop, the *Supply and Demand* layer is combined with the *Transport* layer. In the case of the transport of fluids and gasses by pipeline, no vehicles are required, only infrastructure.

After primary services (that are all directly transport-related services), secondary services can be defined. These secondary services include repair services, maintenance, and catering. The preparation of shipments and the filling in the documents can also be considered secondary services.

8.6   Conclusions

The goods transport system has now been subdivided into service layers, where specific actors execute specific tasks. The phenomena of 'supply and demand of goods', 'transport', 'traffic' and 'impacts and needs' each refer to one or more 'primary services'.

These services are 'economic activities', 'integrated logistic services', 'load-unit services', 'transport means services', 'traffic means services', 'infrastructure services' and 'resource management'. Roles are associated with each primary service. Actors can perform one role (specialisation), or more roles (integration). In this thesis, the layer scheme with the roles, actors and means will be used extensively to define and analyse the goods transport system in general, and urban freight transport in particular.

9. System optimisation of urban goods distribution

9.1 Introduction

Within this chapter, some of the basic notions introduced earlier are operationalised specifically for urban goods distribution analysis. First, we will deal with the efficiencies and inefficiencies of the distribution process, then we will describe the way optimisation can take place.

We will also introduce the notions of economies of scale, scope, density, and chains, and show their relationship to different types of consolidation – a widely applicable method for enhancing the efficiency of the urban goods distribution process.

9.2 Efficiency and inefficiency

9.2.1 Theoretical notion of private and public efficiency

Transport generates large private and societal benefits, but it also has some important negative effects (e.g., costs for the private sector, negative 'external' effects for society). Therefore, it is appropriate to weigh the costs against the benefits, as perceived by the different actors (private actors, and, as representatives of the society, public actors). For this, we can use the notion of 'efficiency'.

Economic efficiency improvement means the reduction of the total logistical costs with the same or improved quality of transport. The relevant actors (grouped as 'private sector') try to maximise their efficiency: $\max\left(\varepsilon_{G,K}^{private\cdot sector}\right)$.

We define social efficiency improvement as the reduction of the total social costs of transport with the same or improved ability to transport goods in the desired amount and variety to and from urban areas from the viewpoint of sustainable development.

In analogy, this comes down to $\max\left(\varepsilon_{G,k}^{public\text{-}sector}\right)$.

Environmental and accessibility problems can be defined as social or economic inefficiencies. This results in maximising the efficiency for the whole of the society.

9.2.2   Occurrence of inefficiencies

Inefficiencies occur in the different levels of operations in the transport system. For instance, the volume of goods we consume (or at least buy) is always less than the volume that is transported. This is due to the simple reason that we need packaging material and/or load units to transport these goods. There is also a statistical phenomenon that occurs. Goods that are transported by using a transfer point, such as a consolidation centre, are normally registered twice in transport statistics. This has two consequences. A statistical increase in transported volumes does not necessarily mean that more goods are transported, but it can also signify that the same goods are transported more than once. Another consequence is that this may look inefficient, but that it could be an efficiency improvement due to consolidation (an efficiency improvement on a lower level).

The routing of goods through the logistic chain can cause other inefficiencies: there is an almost natural difference between the Euclidean distance and the actual transport distance between the origin and destination of a flow of goods. Other inefficiencies are introduced by means of insufficient consolidation, which leads to a relatively high number of vehicle kilometres compared to the actual transport performance. Finally, inefficiencies can also occur because of the way the vehicles are operated, for instance, the use of oversized vehicles and deadheading.

Strategies to solve these inefficiencies can be defined at several levels in urban freight transport, as was described before as a layer system. Between each layer, a market inefficiency can be introduced, as shown in Figure 9-1. Some considerations must be taken into account when assessing 'inefficiencies'.

First, trade-offs can occur between layers. An efficiency improvement at one level can lead to inefficiencies at another level, or vice-versa. In addition, trade-offs between economic and environmental efficiencies are possible, as are trade-offs between local and regional efficiencies.

Second, efficiency improvements within a system can lead to inefficiencies outside that system, or vice versa. For instance, the reduction of the flow of waste packaging materials by using re-usable packaging materials can turn efficient, highly consolidated transport flows of waste materials into inefficient, hardly consolidated, return flows.

9.2.3   Different types of efficiency

In this section, we will specify the different types of efficiency that can be derived from the layer scheme and Figure 9-1.

Consumption and spending

Consumption can be measured in monetary units (for instance Euro), by weight (kilograms) or by volume (cubic metres). The annual growth of the real value of products consumed and

the weight or volume of the products consumed provides information on the level of consumption and spending. For instance, a growth of the real value of products consumed of 10 percent and a decrease of the average weight by 2 percent, as was the case in the UK food and drink sector between 1983 and 1991 (McKinnon and Woodburn, 1995), actually leads to a 7.8 percent increase in the weight of products consumed.

PRIMARY SERVICES   *EFFICIENCY*   *UTILISATION*

Economic Activities		
Integrated Logistic Services	produced volume/ transported volume ratio	
Load Unit Services	load ratio (load unit capacity) loaded/unloaded trips ratio	number/time/mileage of used loaded units
Transport (means) Services	load ratio (vehicle capacity) loaded/unloaded* mileage ratio loaded/unloaded* trips ratio loaded/unloaded* time ratio	number/time/mileage of used transport means
Traffic (means) Services	loaded/unloaded** mileage ratio loaded/unloaded** trips ratio loaded/unloaded** time ratio	number/time/mileage of used traction means
Infrastructure Services	travel time	
	intensity/capacity ratio	intensity
Resource Management	energy use, emisions per veh. kilometre	emissions (air quality), energy use (fuel consumption), emitted noise

* a flat carriage loaded with a load-unit is regarded as a loaded trip, irrespective of the contents of the load-unit

** loaded means: pulling one or more transport means

Figure 9-1: Overview of system-inefficiencies

Volume-efficiency
One indicator of volume-efficiency is the handling factor. The handling factor is the quotient of the produced mass or volume and the transported mass or volume. The volume-efficiency is actually the reciprocal of the handling-factor. An illustration can be drawn based on the UK food and drink sector in the period 1983-1991 (McKinnon and Woodburn, 1995). The handling factor increased by 13 percent in that period, meaning that 13 percent of the weight was transported twice. A growth of consumed tonnes of 7.8 percent coupled with an increase in the handling factor with 13 percent should mean an increase of the transported tonnes of 21.8 percent. McKinnon and Woodburn (1995) concluded, however, that the transported tonnes increased by only 10 percent during that same period.

Transport volume

The transport volume is nothing more or less than the volume of goods that are transported; normally weight is used as the measurement of volume but for the distribution of goods, and for this study, volume in terms of cubic metres is more relevant. In the following examples volume will be expressed in tonnes. If the volumes of consumption and production, and the volume-efficiency, are known, then the transport volume can be estimated.

Logistic efficiency

Logistic efficiency can be defined as the ratio between the transport volume (tonnes) and the transport performance (loaded tonne kilometres per year). It reproduces the reciprocal of the transported distance. The shorter this distance, the better the logistic efficiency. The following figure shows that in the Netherlands the average transport distance grew from 41 kilometres in 1970 to 70 kilometres in 1997.
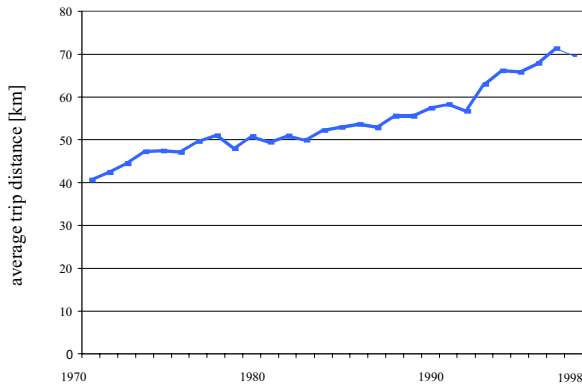
Figure 9-2: Average transport distance in domestic goods transport in the Netherlands between 1970 and 1997 for goods trucks (source: CBS, 1999)

An increase of the transport volume (transported tonnes) of 10 percent and an increase in the average length of a freight move of 26 percent, leads to an increase of the transport performance (or loaded tonne kilometres) of 39 percent (= 1.1 x 1.26).

Transport performance

Transport performance is normally measured in tonne kilometres, but for the purposes of this study, cubic metre kilometres would be more appropriate. The trends in transport performance are discussed below. If the transport volume and the logistic efficiency are known, then the transport performance can be calculated.

Transport efficiency

Transport efficiency can be defined as the ratio of traffic performance (in terms of vehicle kilometres per year) to transport performance (in terms of loaded tonne kilometres per year). It reproduces the reciprocal of the load factor and the loading capacity of a vehicle. Table 9-1 shows the maximum loading capacity of different types of vehicles. The transport efficiency in Figure 9-3 gives some indication of the development of the load factor of trucks in the Netherlands.

Table 9-1:   Transport efficiency of different vehicles (source: Bouman et al., 1990)

Year 1995	Cars	Vans [diesel]	Light trucks	Trucks	Articulated trucks
Maximum loading capacity [tonnes/vehicles]	0.25	0.94-1.43	4.73	9.68-13.99	25.5-25.8
Transport efficiency [veh.km/tonnekm]	4	0.7-1.06	0.21	0.07-0.1	0.04

If we take a closer look at the data on domestic freight transport, it is clear that there is a decrease in the utilisation in terms of load factor of road transport, (that is, if we assume that volume or mass are proper indicators for capacity of road transport). Figure 9-3 shows that there is a steady decrease in the ratio of the loaded tonne kilometres to the load capacity tonne kilometres. Two important factors are responsible for this: a decrease in load factor and an increase in empty vehicle kilometres. The situation in urban freight transport becomes worse when examining the national figures (the average load factor in 1997 was 41.8 percent). The reasons for this include: own transport has a relatively high share in urban freight transport, and the average load factor in own transport is relatively low compared to professional transport (35.9 percent and 43.8 percent, respectively, in 1997). In urban freight transport, the share of smaller trucks and vans is relatively high, while the average load factor of these vehicles is relatively low (25.3 percent for vans in 1997).
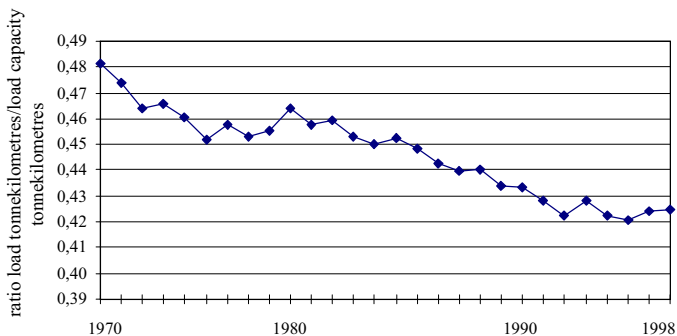
Figure 9-3:   The average load factor between the years 1970 and 1998, expressed in the ratio loaded tonne kilometres/ load capacity tonne kilometres (source: CBS, 1999)[17]

The ratio of loaded vehicle-kilometres to total vehicle-kilometres is another indicator of the efficient use of vehicles. If this ratio is high, it means that the total for vehicle-kilometres driven empty is rather low, and vice versa. Figure 9-4 shows that between 1970 and 1997, the percentage of loaded kilometres decreased from 73 to 72. In 1990 it was at its lowest, at 70

---

[17]   Note that a load factor based on weight is not a very suitable indicator for the analysis of the (final) distribution of goods. Indicators like cubic metres or even square metres would be more appropriate, but are not available in these kind of statistics yet; see also Section 21.5 in Part IV.

percent. This means that vehicles, trucks in this case, are again increasing the number of kilometres driven while empty. Since 1992, the percentage has gone up to 72 percent.
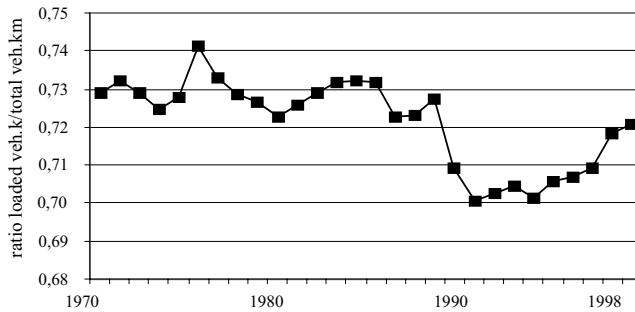
Figure 9-4: ***Ratio loaded goods vehicle kilometres versus total vehicle kilometres between the years 1970 and 1999 (CBS, 1999)***

Environmental efficiency

Environmental efficiency has many measurements, including the quantity of emissions. Table 9-2 shows the emission-efficiency of different vehicles. If we combine this with transport-efficiencies in Table 9-1, then we are able to construct an integrated efficiency-coefficient. Thus, we can compare different vehicle types and even different logistic concepts.

Table 9-2: ***Freight traffic in urban areas and emission indicators (Source: CBS 1996; Poppe, 1997)***

Year 1995	Cars	Vans [diesel]	Trucks	Articulated trucks	Total
Traffic volume [mln veh.km]	-	5353	483	597	6400
Primary Energy [MJ/km]	3.5	4.1	16.0	19.7	6.4
CO_2 [g/veh.km]	254	297	1174	1441	469
NO_x [g/veh.km]	0.84	1.13	13.53	20.54	-
SO_2 [g/veh.km]	0.069	0.248	1.139	1.401	0.422
VOC[*] [g/veh.km]	0.65	0.77	4.72	8.09	-
CO [g/veh.km]	2.9	3.5	6.7	10.2	-
Benzene [mg/veh.km	92	91	182	182	98
Aerosols [g/veh.km]	0.009	0.29	0.972	1.003	-
Traffic safety [lethal accidents/mln veh.km]	6	4	30	29	
[severe injuries/mln veh.km]	78	58	106	--	
[*] VOC: Volatile Organic Compounds					

The following indicators must be elaborated for this methodology:

- Transport cost efficiency. Transport costs are a simple indicator, but speed and reliability must also be included in some way;
- Social cost efficiency. This is normally done by monetarisation of, for instance, emissions and noise pollution.

These indicators can be used to analyse logistic channels on their efficiency. Performing such an analysis, we could reasonably conclude that, under the given circumstances, the logistic channels in itself are already optimised to a certain level (see also Part III, Section 13.4). It seems, therefore, an attractive solution to integrate the different logistic channels, both from a logistic management as well as from a public policy-making perspective, as this could lead to further optimisation. Possible means of integration include the outsourcing of the distribution activities, and co-operation between companies. In the field of urban freight transport, the term city logistics is used to refer to these kinds of integration.

9.3   System optimisation

9.3.1   Introduction

Optimising the urban freight transport system in this context entails reducing the social costs of the system with the proviso that the same or improved quality of transport is offered. In the current situation, optimisation is undertaken by the private sector as a profit maximisation or a production costs minimisation, or by the public sector as social costs minimisation. Each path leads to a different optimisation.

9.3.2   Optimisation in the private sector

The optimisation for the private sector can be simplified through logistics. There are several generic logistics concepts developed for the organisation of transport flows (see Part III), some of which apply to private-sector optimisation. Each transport flow requires a logistic channel. A logistic channel is the logistic organisation of a transport flow. Within each logistic channel, the logistic costs for each layer should be minimised, either by minimising the costs within the layer, or by minimising the costs of the total logistic channel. In the case of shippers, their objective as a group should be the minimisation of the total logistic costs. The mathematical description of optimisation focuses on cost reduction, under the assumption that the demand (and benefits) for freight transport is fixed[18]:

$$\max\left(U_{G,K}^{firm}\right) = \max\left(\sum_{g=1}^{G} \sum_{k=1}^{K} u_{g,k}^{firm}\right) = \max\left(\sum_{g=1}^{G} \sum_{k=1}^{K} \left(\alpha_{g,k}^{firm} \bullet x_{g,k}\right)\right) \qquad \textbf{\textit{(9-1)}}$$

Here, $\overset{1}{G}$ represents the set of all 'goods' (including services) that a firm needs to maximise its utility $U_{G,K}^{firm}$. With respect to goods distribution in urban areas, we deal with firms that produce, sell, store and transport goods. As we will explain in Part III, all these firms perform strings of basic logistic activities, each rendering a particular net, partial utility, which can be either positive or negative.

---

[18] According to the logistic literature, logistic organisation is not considered a strategic tool.

The term $u_{g,k}^{firm}$ can here be seen as the partial subjective utility of performing the activity g.

As explained earlier, all negative partial utilities can be rendered as disutilities or costs. Most activities that relate to physical goods distribution can be regarded as 'costs'[19]. If applied with care (taking into consideration that the total net utility must be optimised), one can reduce the total optimisation problem to minimising the physical distribution costs:

$$\min\left(Z_{\overset{1}{G},K}^{firm}\right) = \max\left(\sum_{g=1}^{G}\ \sum_{k=1}^{K} z_{g,k}^{firm}\right) = \max\left(\sum_{g=1}^{G}\ \sum_{k=1}^{K}\left(\alpha_{k}^{firm} \bullet s_{g,k}\right)\right) \tag{9-2}$$

where $\overset{1}{G}$ represents the set of G cost factors g, such as the costs for transport, storage and handling. For the whole of the private sector, this can be represented by:

$$\min\left(Z_{\overset{1}{G},K}^{private\cdot sector}\right) = \min\left(\sum_{g=1}^{G}\ \sum_{k=1}^{K} z_{g,k}^{private\cdot sector}\right) = \min\left(\sum_{g=1}^{G}\ \sum_{k=1}^{K}\left(\alpha_{k}^{private\cdot sector} \bullet s_{g,k}\right)\right) \tag{9-3}$$

9.3.3 Optimisation within the public sector

In a system where the mobility of persons, information and goods is structuring society, the role of transport is of the utmost importance. According to Ogden (1992) freight transport is essential to modern urban civilisation. Urbanisation means that large numbers of people are concentrated in areas that are remote from the resources of food, the sources of raw material for industry, the markets for industrial products, and the places to dispose waste. The concept of urbanisation therefore requires a freight system to sustain it. No urban area can exist without a massive, sustained, and reliable flow of goods to, from, and within the area. Facilities for the movement of goods must therefore be provided in any urban area. Against these benefits we must weight the cost of distributing goods in urban areas, including transport costs, obstructions to other traffic, and damage to the environment. These 'costs' are a burden on society and are therefore referred to as social costs.

From a societal point of view, the freight transport task should focus on social benefit maximisation. According to the economic literature, changes in the transport system cannot generate extra social benefits. Therefore, we must instead focus on cost minimisation: urban goods distribution should be performed with the lowest total social costs (including economic costs) possible. Therefore, the total amount of resources consumed, and the disadvantages created in performing the freight task should be minimised (Hicks, 1977). Considering the problems related to urban freight transport mentioned earlier, this social optimum has not been reached in the current situation[20].

The expected growth of freight transport and the related increase in air pollution, energy consumption and noise pollution (see Part I) lead to the conclusion that social costs will increase.

To reach a societal optimum, policy measures must be taken to reverse this process. Hicks (1977) defines an important policy task for policy makers: "The discovery and effective implementation of measures which reduce the total social cost of goods movement to the

---

[19]   These activities are performed nevertheless because the movement of goods to a specific destination location has a large positive 'utility': i.e., the goods can be sold at that destination.

[20]   Thus, a new system $\overset{1}{G}'$ can be formulated (instead of the current systems $\overset{1}{G}$) for which $\varepsilon_{\overset{1}{G}',k}^{society} > \varepsilon_{\overset{1}{G},k}^{society}$.

lowest possible level commensurate with the freight requirements and objectives of society".
Such a formulation assumes that a policy maker has an adequate insight into:

- The total social costs of freight transport;
- The lowest possible level of social costs as a balance between the demands for transport and the objectives of society;
- The measures and the extent to which they reduce the social costs.

Even if policy makers have such an insight, it is still questionable whether they have the effective means at their disposal to achieve this optimum situation. With respect to transport, governments act more as facilitators and regulators than as actual market players. This has certainly important policy implications, as it also limits the role of governments.

The public sector focuses on maximising the societal utility of transport and, for some practical reasons, on minimising the external costs given a certain level of transport performance. These costs relate to the societal costs of production and consumption, transport, infrastructure and the use of resources.

Different actors within the public sector (for instance 'departments') may look to different aspects or different layers of the layer scheme presented in Section 8.1 and try to optimise the system within that layer. The public sector, as a whole will look at different aspects (layers) at the same time. While the public sector will generally aim at formulating an integrated approach, in practice, this is often not the case. Nevertheless, the objective of the public sector is to minimise the total social costs as perceived by this sector or by actors within that sector. Therefore, the following formula can be used:

$$\min\left(Z_{G,K}^{public \cdot sector}\right) = \min\left(\sum_{g=1}^{G}\sum_{k=1}^{K} z_{g,k}^{public \cdot sector}\right) = \min\left(\sum_{g=1}^{G}\sum_{k=1}^{K}\left(\alpha_{k}^{public \cdot sector} \bullet s_{g,k}\right)\right) \qquad (9\text{-}4)$$

If only one actor in the public sector is involved, the weighting set $\alpha_{K}^{public \cdot sector}$ may include several zero-values (corresponding with aspects that are not taken into account and representing the focusing on only one specific sector or layer). If all actors in the public sector are combined, most values of the weighting set $\alpha_{k}^{public \cdot sector}$ will be non-zero (thus: most aspects will be taken into account).

9.3.4   Integrated, societal optimisation

The difference between the different types of optimisation lies in the different perception of the costs aspects and the aspects that are taken into account. These aspects are included in the respective weighting-sets $\alpha_{K}^{private \cdot sector}$ and $\alpha_{K}^{public \cdot sector}$.

Note, that there is no real 'barrier' between the private and public sector: for the private sector, optimisation of societal costs can also become important, for instance, in the case of taxation.

Still, the two approaches (that is, of the private and the public sector) may lead to different optimisations. Some strategies however, could support both cost-minimisation approaches. This is called a win-win situation[21]. Such a situation is sometimes hard to predict, because actions (policy measures) produce reactions that may render unexpected results.

---

[21]   Although, even in a 'win-win' situation, there can be individual actors that have to take some 'losses'; 'win-win' refers to the overall situation.

For example, if access restrictions are implemented, these will on the short term reduce emissions, noise pollution, etc. (these are the reasons the measurement is implemented). The direct result for the private sector may be a decrease in accessibility. However, in the long term it may induce efficiency measures that render an overall improvement of the distribution system, and may even lead to an improvement in accessibility.

The challenge is to minimise the societal costs across logistic channels (column) and layers (row) and for corporations and society to act together, in order to find a more integrated way to further social costs reduction. One example of such an approach is the co-operative outsourcing of logistics by shippers: this renders a direct reduction of logistic costs for shippers, but at the same time can reduce societal costs, by reducing nuisance factors such as traffic performance or pollution..

A mathematical description of the societal (integrated private and public sector) optimisation problem could look like this:

$$\min\left(Z_{G,K}^{society\,1\,1}\right)= \min\left(\sum_{g=1}^{G} \sum_{k=1}^{K} \left(\alpha_k^{society} \bullet s_{g,k} \right) \right) \qquad\qquad (9\text{-}1)$$

With:

$$\alpha_k^{society} = f\left(\alpha_k^{private\cdot sector}, \alpha_k^{public\cdot sector} \right),$$

For instance:

$$\alpha_k^{society} = \alpha_k^{private\cdot sector} \qquad \text{if} \quad \alpha_k^{public\cdot sector} = 0$$

$$\alpha_k^{society} = \alpha_k^{public\cdot sector} \qquad \text{if} \quad \alpha_k^{private\cdot sector} = 0$$

$$\alpha_k^{society} = f_2\left(\alpha_k^{private\cdot sector}, \alpha_k^{public\cdot sector} \right) \quad \text{if} \quad \alpha_k^{public\cdot sector} <> 0 \text{ and } \alpha_k^{private\cdot sector} <> 0$$

The function $f_2\left(\alpha_k^{private\cdot sector}, \alpha_k^{public\cdot sector} \right)$ determines the value for $\alpha_k^{society}$ in case both the private sector and the public sector take the cost factor at hand into consideration in their choice process. Then, the two points of view must be merged; for example by taking the higher of the two weighting factors: $\alpha_k^{society} = \max\left(\alpha_k^{public\cdot sector}, \alpha_k^{private\cdot sector} \right)$.

9.4   Economies of scale, scope and density

9.4.1   Economies of scale
The term 'economies of scale' implies that, given the same production means, a larger production volume results in lower average production costs per unit[22]. The production means include personnel, machines, buildings and other infrastructures and also includes the organisational structure of a firm.
In urban freight distribution, economies of scale play a role at different levels.

---

[22]   Only to a certain extent: if total produced volumes become too large, the capacity of the production means is reached, and new means must be introduced.

From an organisational point of view, larger organisations can operate at lower costs per (service-) unit: for large producers, retail organisations, service providers and transport companies, the relative overhead costs per unit (goods, transport order, trip) can be lower than those for small companies. We say that the costs 'can' be lower, because in practice some large organisations tend to expand without increasing the efficiency, returning even higher average costs per produced unit.

Physical means (vehicles, infrastructures, buildings) can also be used more efficiently when used more intensively (see Button, 1993; De Wit & Van Gent, 1996). This is because the costs of operating physical means are partly 'fixed costs' that are virtually independent from the use of the means. The share of the fixed costs in the product-unit price, thus the total unit price, will be lower if the production level is higher.
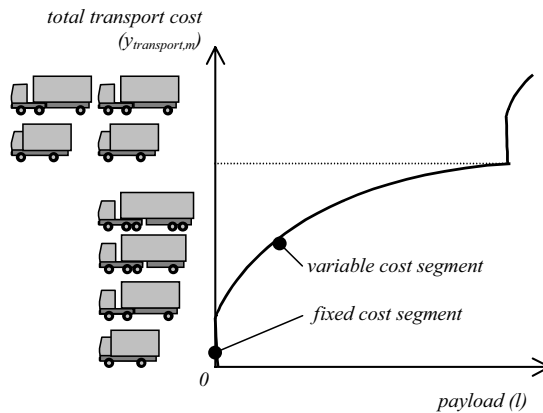
Figure 9-5:   *Transport costs as a function of the payload*

Economies of scale are limited by the capacity of production means. The capacity can be limited for technological reasons, for economic reasons and/or for legislative reasons. For example: extended (longer) trucks could lower the relative share of the drivers' cost component in transport costs, but may not allowed for legislative reasons. If the maximum capacity of an individual vehicle is reached, an additional vehicle is necessary – this implies a sharp increase in costs (see Figure 9-5).

9.4.2   Economies of scope

The term 'economies of scope' implies that given the same production means, different ranges of products can be produced, so that different niche markets can be served (see for example Button, 1993). Especially in transport, this is a very important issue, because both transport demand and supply are very much time-bound. Unlike normal production, it is not possible to make an inventory of transport 'products'. If the transport means (drivers, vehicles, infrastructures) can be used to serve different markets (demand) at different times, then the means can be used more efficiently. This would imply that, in general, multi-purpose transport means are more attractive than specialised means. In practice, market conditions can force suppliers to offer dedicated production means. Only if demand is sufficient (e.g., by bundling demand), can this kind of specialisation be made efficient.

9.4.3   Economies of density
The 'economies of density' relate to both service and network advantages.

Network advantages refer both to network-services (marketing channels and physical distribution channels) and to the physical infrastructure. A higher network density provides the users with multiple transport opportunities ('paths') or a higher service quality (speed, frequency).

'Economies of density' also enable a differentiated palette of services and allow for specialisation. In normal market conditions, specialised production means may be underused and therefore inefficient. By economies of density, demand is 'bundled' and specialised means become attractive and efficient. Bundling enables offering dedicated (organisational) services, dedicated vehicles, dedicated infrastructures etc.

9.4.4   Economies of chains, economies of experience
Other 'economies' can also be identified, such as 'economies of chains' and 'economies of experience'. Both economies can only be realised by achieving a certain (minimum) 'critical mass' of activities. The integration of logistic chains (see Part III) leads to 'economies of chains' with respect to physical means, information and control (Jaspers, 2000): in chains, it becomes possible to attune different activities so that they generate overall benefits (see also Part III: trade-offs). If physical means (vehicles, load units and equipment) are standardised, load/unload, storage and transfer operations throughout the chain can be made more efficient. Standardisation and the exchange of information can smooth out the logistic process and ease control procedures. The 'learning-by-doing' element in many transport activities will result in 'economies of experience' that can also reduce costs (Button, 1993).

9.5   Consolidation

9.5.1   Introduction
In this thesis, consolidation in various forms is the main means for achieving efficiency improvements. Consolidation can be defined as the bundling (or bringing together) of the movement or flows of goods in time as well as in space. By consolidation, activities, goods and/or means are combined to achieve economies of scale, scope or other benefits such as a transport quality improvement, increased (service) network advantages or reduced total space occupation (see also Button, 1993). The purpose of consolidation (see also Figure 9-6) in transport is basically:

1. To bundle movements or flows of goods in order to improve the *utilisation* of the transport system and thereby generate all kinds of economies of scale and scope (see paragraph 9.4);
2. To decrease the use of various means (*conservation*) in order to reduce cost-factors without changing the output;
3. A combination of (1) and (2), for example, providing a level of critical mass (utilisation) for more efficient transport systems (conservation), such as intermodal transport, which requires high transport volumes, but also for implementing new technologies.
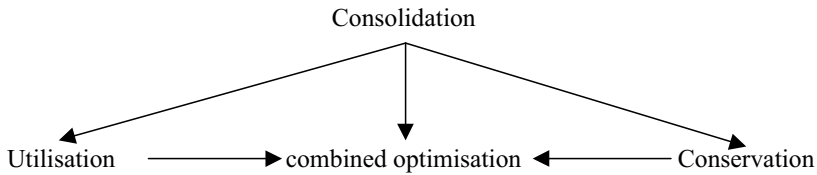
Figure 9-6:   Purpose of consolidation

There are different ways to consolidate: consolidation in time, route consolidation, consolidation in place, terminal consolidation and activity consolidation (combining pick-up and delivery in one route). Different ways of consolidation can be applied to different fields and levels. Consolidation should lead to the following improvements:

- More efficient urban freight transport, because the transport means can be used more efficiently (for instance by higher occupancy rates or reduction of costs).
- Profits, or at least in a reduction of the social (environmental) costs.
- Economic, but also social efficiency gains.

At the same time, consolidation (or the actions required to enable consolidation) also result in costs, such as:

- Investment costs for equipment;
- Organisational costs.

Only if the total benefits are greater than the (initial) costs of consolidation, can consolidation be effective. The initial costs result in a 'threshold' for applying consolidation.

9.5.2   Consolidation in time

Just-In-Time logistic concepts have changed the movement of goods into high-frequency, low-volume transport flows. Driving forces, such as the high costs of storage are not eternal. It is possible that new logistic thinking leads to the solution that goods which were meant to be sent in smaller volumes at a high frequency can now be combined into fewer sendings at a lower frequency (see Bowersox et al., 1986).
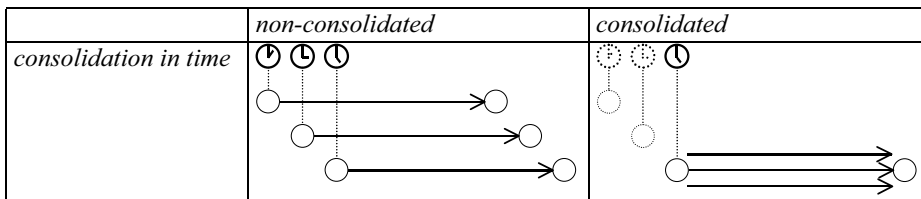
Figure 9-7:   Consolidation in time

9.5.3   Organisational consolidation

Consolidation within the trade and logistics field takes the form of mergers, take-overs and strategic alliances between different producers, sales organisations, logistic service providers and transport companies. Due to Internet developments, 'virtual' consolidation is also occurring: consumers[23] are banding together to negotiate bargain deals and discounts.

---

[23]   Including producers that need supplies, for example in the car manufacturing industry.

Strategic alliances or co-operation between organisations on a more operational level can mean either:

- The mutual use of each other's services;
- Collective use of certain facilities, personnel, knowledge;
- Collective use of third-party services.

Outsourcing is a one form of co-operation. *Specialisation* can be an important driving force behind co-operation and outsourcing.

Consolidation is often aimed at 'economies of scale'; however, some groups, especially in the field of logistics and road transport also can also profit from network benefits. The costs of consolidation relate mainly to (re-) organisation and communication costs.

In terms of operating physical distribution systems, the consolidation of pick-up and delivery processes can occur, as well as the consolidation of services (see also part III). These forms of consolidation can use assets such as vehicles, infrastructures and other means more efficiently.

	non consolidated	consolidated
activity		
route		
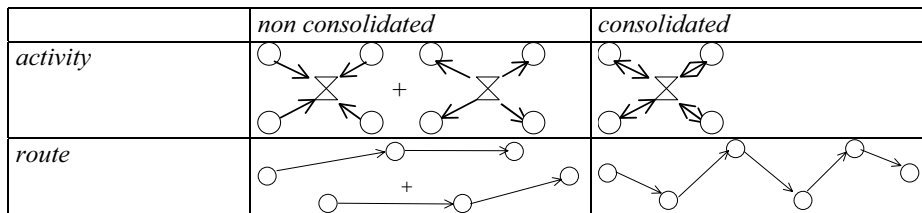
Figure 9-8:   *Organisational consolidation of activities and consolidation of routes*

9.5.4   Physical consolidation

In physical consolidation, physical entities are combined, so that they may be handled and transported more efficiently (that is: by using fewer personnel, transport means and/or infrastructures).

Consecutive forms of physical consolidation include:

- Products in packages (boxes);
- Packages in load-units (containers);
- Load-units on transport means (such as trailers or rail wagons);
- Transport means into traffic means (such as 'trains');
- Traffic means into 'convoys'.

The costs of these forms of consolidation relate mainly to the actual handling of the goods and units in transfer points. Other costs include organisational and control costs[24].

Within infrastructure networks, traffic flows can be bundled on main links, which can also be seen as a form of consolidation. If traffic flows are consolidated, infrastructure can be used more efficiently. This in turn enables (and necessitates) investments in higher-quality

---

[24]   Control costs can rise because consolidation can result in more complex logistics.

systems[25]. Costs are related mainly to detours, because bundled infrastructures offer fewer direct connections.

	non-consolidated	consolidated
route		
terminal (depot)		
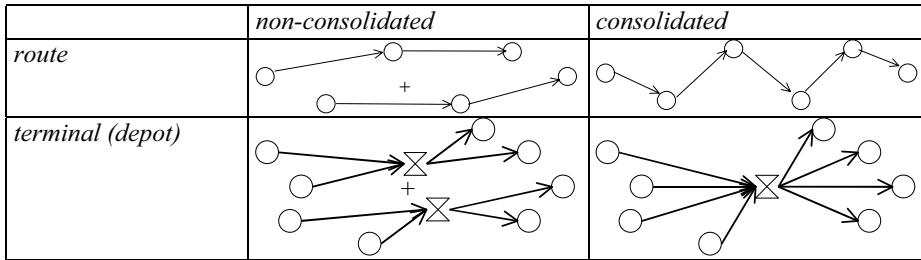
Figure 9-9:   Physical consolidation of routes (line-infrastructures) and terminals

Finally, different types of infrastructure can also be combined.

Nodes, such as distribution centres, warehouses, and depots, can be used to facilitate different physical distribution processes and channels (see also Part III). This form of consolidation increases the efficient use of these infrastructural means. The costs of this kind of consolidation relate to organisational costs and transport costs: combined depots usually result in longer transport distances.

Different types of line infrastructure can be bundled together into corridors to reduce the total (direct and indirect) space utilisation. The locations where the different infrastructure networks connect can be bundled and be turned into multimodal nodes. Here, 'spatial efficiency' must be balanced with higher construction costs.

9.5.5   Limits to consolidation

Although consolidation generally leads to certain economies, there is a limit or optimum, economically or environmentally speaking. For instance, the collection of extra shipments requires an extra detour and generates extra costs this way. This is discussed by Taylor and Button (1999). There is an optimum level of consolidation in any given situation. More consolidation in that situation will lead to higher costs, but again, this is quite situation-dependent.

---

[25]   This argument may seem to be a circular reasoning: consolidation increases intensities, higher intensities enable high-capacity (quality) infrastructure but at the same time need higher quality infrastructure because of the higher intensities and detours. Nevertheless the reasoning is valid, because in the end the result is a high-quality network.
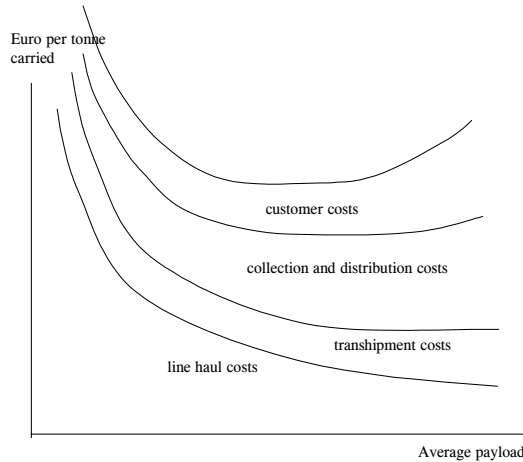
Figure 9-10:   Freight consolidation costs (represented cumulatively) (Source: Based on Taylor and Button, 1999)

9.5.6   Costs of efficiency improvement

Efficiency improvement measures aim at reducing the relative costs of a process or product. However, there can be short-term costs involved in taking these measures, such as costs related to investments in new equipment, or the costs for a re-organisation process. Figure 9-11 (left) shows the transition costs from an existing situation I to a new, more efficient situation II via a transition (introduction, implementation) period II. The transition costs can be paid all at once (a policy often used with public parties), or they can be spread over a longer period in the future (by loans, as is often applied by private parties; see Figure 9-11 – right). The latter implies that the net efficiency gains can only be achieved a certain time after the real introduction (see Part III); actors will only consider such an investment if they can spread the transition costs over a longer period.
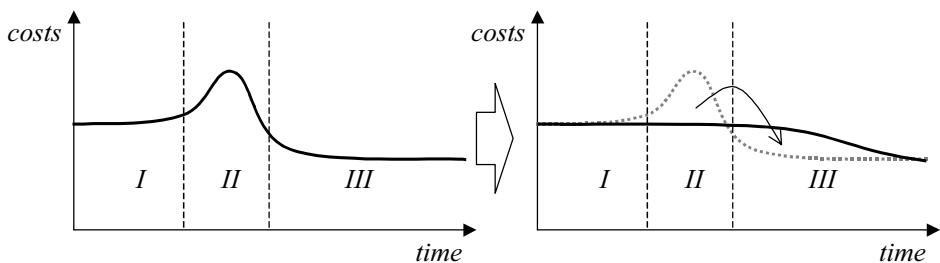
Figure 9-11:   Costs in time as a function of 'consolidation'

The transition 'threshold' (II in Figure 9-11) may dampen the enthusiasm of actors to take the efficiency-improvement step, even if there are foreseeable advantages on the longer run.

The situation above refers to the longer-term (strategic) planning level. However, a comparable situation occurs at the short-term (operational) planning level. Most forms of efficiency improvement that make use of the concept of consolidation require actions that

initially increase the costs of a process. Yet, because the consolidated process itself is 'cheaper' and is effectively used, net cost reductions may occur.

Examples include:

- Intermodal transport, where transfers (initial costs) are necessary to enable the use of efficient, large-scale transport systems;
- The use of highways, where detours (access, egress: transport costs) are necessary to enable the use of the coarse network of high-quality (efficient) roads;
- Load consolidation in time, where delays (interest costs) must be accepted to enable the use of efficient, high capacity vehicles;
- Load consolidation in place, where transfers must be accepted, and equipment is required to enable the use of efficient, high capacity vehicles.

Therefore, efficiency-improving measures are generally only effective if the improved process can make sufficient use of these measures, which means that the gross efficiency gains must surmount the initial costs (operational level) or transition costs (strategic level).

9.6   Conclusions

We have shown that the theoretical notion of 'efficiency' (and the related 'inefficiency') can successfully be operationalised for the urban goods distribution process. We have also shown that 'efficiency' can be valued both from the point of view of private parties as from the point of view of public parties, and explained how 'societal' optimisation can be based upon these two kinds of public and private goals. We have further introduced the notions of 'economies of scale', 'economies of scope', 'economies of density' and 'economies of chains', which all describe benefits of combining activities.

Consolidation is the main mean to achieve these efficiency improvements. Consolidation combines different actions in time or place. The 'consolidating' action in itself requires effort (time, money), so the efficiency gains should at least be larger than these initial efforts to make consolidation effective. This requirement sets the lower limit of the application of specific consolidation concepts.

Efficiency enhancement by means of consolidation can be based upon 'utilisation' (increase in the utilisation of the system using the same resources) or on 'conservation' (reducing the need for resources without changing the use of the system).

This section linked integrated societal optimisation to the notion of efficiency improvement. It also linked efficiency improvement to consolidation of goods flows. An important conclusion is therefore that consolidation is essential for the optimisation of urban goods distribution. Our integrated design as we will elaborate in Parts III, IV and V, will focus on consolidation in urban goods distribution and ways to facilitate it.

10. Methodologies for policy development and evaluation

10.1 Introduction

This chapter introduces methodologies for development and evaluation of concepts and measurements aimed at the efficiency improvement of urban goods distribution processes. First, we will introduce the backcasting methodology that is used to compose the package of policy measures that enable the envisaged efficiency improvements. The method first sets goals and then backtracks the necessary instruments and developments to achieve these goals. Secondly, we will specify the different ways of evaluating the proposed instruments and developments. We will conclude with operationalising objectives (as developed in Part I) into indicators that are required to perform the necessary evaluations later.

10.2 Policy making processes

To achieve private, or integrated societal optimisation, firms or governmental institutions have to develop a policy (a private and public policy respectively). If we consider a 'policy' as a product, we can define different stages in the 'policy life cycle':

- Issue awareness and recognition, in combination with policy research (I);
- Policy formulation (II);
- Policy making (III);
- Policy implementation (IV);
- Policy evaluation (V).

In theory, such a distinction in steps is certainly valid, but in practice it is very difficult to follow this policy development process step by step. During the life of the process, new issues may arise, or new solutions or insights may become available. As a result, policy-making is certainly not a linear process. Policy making, is indeed a continuous process of these five stages happening simultaneously. Because of the continuity of this process, monitoring rather than ex-post policy evaluation becomes important. The process also requires regular consultation with the actors (public and private).

The policy development process can be illustrated with help of Figure 10-1:
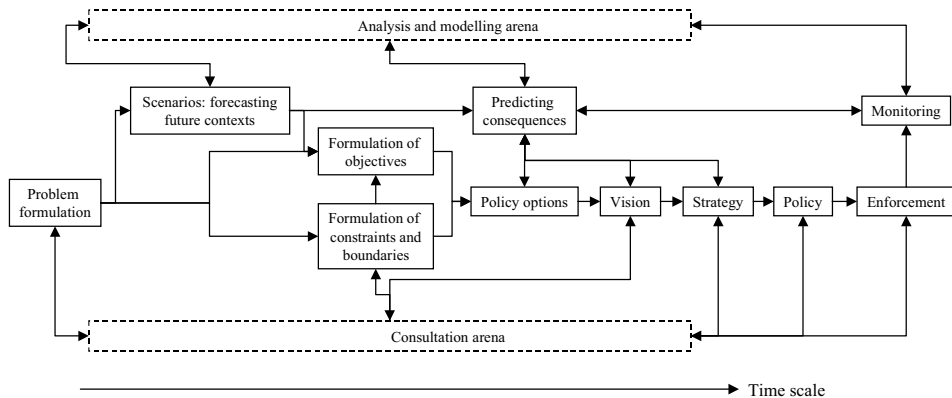
Figure 10-1:   The process of policy-making (based on Miser & Quade, 1985)

All policy plans start with the formulation of problems and objectives, possibly with the help of scenarios; for instance, both private and public parties use scenarios to scan alternative 'possible' futures.

Then a range of possible solutions is developed (using 'ex ante' evaluation tools) that, together with a 'vision' (corporate philosophy, government vision of the future), results in the formulation of a strategy, or integrated set of various solutions. The strategy is then transformed into applicable policy (policy measures). The results of these policies should be monitored (ex post) and used for new policy development.

10.3   Scenario methodologies for policy development

10.3.1 Introduction

The Dutch Governmental Programme for Sustainable Technology Development (DTO) developed a methodology, based on backcasting, for developing policies for the implementation of sustainable technologies (see DTO, 1997). This type of policy-making relates strongly to the backcasting approach in scenario building. The backcasting method is different from current approaches to developing policies. We can refer to the traditional method as the forecasting method.

10.3.2 Forecasting

Forecasting is used for questions like 'What would happen if actual developments continue?'. Methods for forecasting include trend extrapolation and behavioural modelling techniques.

In essence, forecasts can be non-normative and 'policy free', or can be made using a kind of 'ceteris paribus' condition. Forecasts of this type have only limited future value, because in reality, conditions change especially on longer timelines.

Trend-extrapolation, for example, cannot predict or assess the effects of trend breaches. Neither can it predict the effect of developments of either type or magnitude other than in the reference period – the period on which the trend extrapolation is based. Even economic growth models may 'miss' specific developments that render results useless in the long term.

10.3.3 Scenario-building

With scenario-building, questions such as 'What would happen if significant changes in developments happen', can be answered. Shell Oil Company has made well-known applications of this kind of model, to evaluate the effects of different oil-prices.

The Netherlands' Central Planning Bureau also makes extensive use of scenarios, a policy that is now also used by other national planning institutes. Scenario building is a special form of forecasting in which conditions are deliberately changed. Thus, the effects of anticipated trend breaches, spatial and technological developments can be predicted (note that neither trend breaches nor most technological breakthroughs can predicted by the methodology).

Scenarios are a useable policy tool, because the robustness of policy measures can be evaluated (testing the measures against the possible conditions). On the other hand, the effect of alternative policy measures or the effect of different grades in effectivity of policy measures can also be studied by constructing scenarios. Here, scenarios are normative.

10.3.4 Backcasting

In the backcasting methodology, questions like 'Which developments would be necessary if we should reach a given situation' can be answered. Backcasting generally deals with normative or desired future situations and helps with finding the appropriate policy measures or actions. Objectives are defined, matching scenarios are developed, and strategies are formed to reach the desired situation[26].
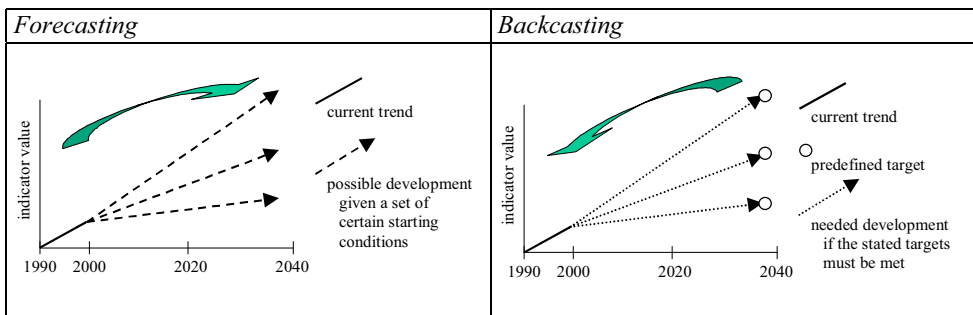
Figure 10-2:   Forecasting versus backcasting

---

[26] See for example the OECD 'Environmentally Sustainable Transport project' (OECD, 1996)

In many cases, these methods lead to very different results. With respect to the role of development of technology, forecasting will lead to incremental improvement in existing technologies, while backcasting will lead in general to new technologies by technology jumps. The differences are summarised in Table 10-1.

Table 10-1: Differences between forecasting and backcasting

Methodology	*Forecasting*	*Backcasting*
Starting point:	Current situation/problems	Future scenarios/objectives
Target:	Feasibility	Effectiveness
Orientation:	Incremental improvements	Technology jumps
Result:	Existing technologies	New technologies

Traditional policy making, when we are allowed to call it forecasting, leads to policies that are based on measures that are, in general, implementable, but hardly lead to spectacular trend breaches. The backcasting method, however, leads to measures that can deal with problems of feasibility but score high in terms of effectiveness when trend breaches are expected.

This study has a long-term focus. Therefore, our approach is set up as a backcasting approach.

10.4   Evaluation Analysis

10.4.1   Need for evaluation analysis

Evaluation is an essential element in the policy process. During the policy process, as described earlier, there will be certain moments when decisions have to be made on the choice of options, or processes have to be monitored. Therefore an evaluation framework is essential. An evaluation framework is based on the operationalisation of policy objectives. First, we will describe the characteristics of such an evaluation framework, then we will describe two types of evaluation methodologies that can be used in the policy making and evaluation process. Both methods – the cost-benefit analysis and the multi-criteria analysis – enable the comparison of choice alternatives, based on different criteria.

Figure 10-3 shows the different roles of an evaluation framework in the policy process.
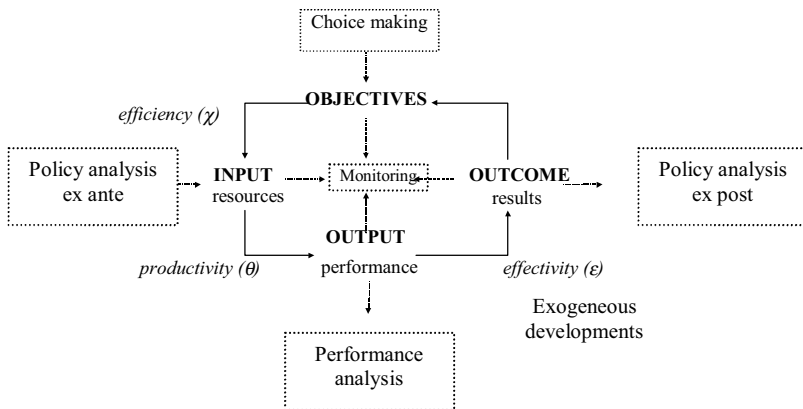
Figure 10-3:   Role of evaluation frameworks in the policy process

Evaluation also plays an important role in the monitoring of processes. In this continuous process of evaluation, no specific decisions will be made in terms of choice of options rather than continuing the current policy process, adjusting it or starting up a new policy process. Still, some criteria have to be defined for the monitoring. These criteria do have a strong relationship with the policy objectives.

Evaluation in the field of public policy making should of course be an integral part of the process. This means considering all social aspects. However, public interests and opinions change over time. Certain processes change people's ideas and notions and might affect certain policy objectives or their importance. Evaluation frameworks should therefore be robust enough to produce the same results using the same criteria and weighting sets, but must also be flexible enough to be adjusted to changing ideas and notions.

The criteria not only have to reflect the policy objectives but also certain interests of actors. Their problems must be solved. With the right choice of policy objectives, most of the interests of actors will be taken care of. In that case only the relationship between the indicators for the policy objectives and the personal interest of that actor must be clear and interpretable by the actor. Not all these aspects can be part of the evaluation framework as separate criteria. Therefore, a process of thickening and aggregation of aspects must take place to reduce complexity. Further more, non-discriminating criteria will have to be filtered out.

10.4.2 Cost benefit analysis and multi-criteria analysis

For the private sector, the calculation of costs and benefits is a relatively straightforward task. Only costs and benefits that are realised in the future require a special interpretation, for instance the net present value method. In a social cost-benefit analysis (CBA) all different types of criteria that are relevant for the choice process, are converted into monetary values (monetarisation). Because at the end of the translation process all criteria are expressed in the same (monetary) unit, they can – just as in a private CBA – be simply added up, resulting in a 'net' cost or benefit for each of the alternative options. The option rendering the highest net benefits will usually be regarded as the 'best' option. In a cost benefit analysis, the weighting of the different criteria (if appropriate) is integrated in the monetarisation process.

In a social cost-benefit analysis, direct and indirect effects are taken into account.

Direct effects are the effects, or implications of a given option, that are already integrated (internalised) into the economic market process. The direct effects of a given option can be determined by establishing the difference in the consumer-surplus of a situation with and a situation without the implemented option[27]; this is the 'with-without' method. Under strict conditions[28], market prices could also be used.

Determining indirect effects is much more complicated. These effects refer to non-priced 'goods' that are nevertheless scarce. These goods must be valued or monetarised. Here, two types of methods can be used.

First there are 'factor costs methods'. Within that category, we can distinguish between 'behavioural' and 'non-behavioural' methods (see De Wit and van Gent, 1996).

In the behavioural method, we can use 'surrogate markets', in which we compare the actors' preferences for goods (alternative options, policies) that are the same in all aspects, except for the external effects. We can also use 'hypothetical markets' in which we propose (non-existing, imaginary) alternatives to the actors and monitor their choice behaviour (stated preference).

The non-behavioural method monetarises the indirect effects by calculating the costs of the resulting damage; this method is not really appropriate for societal cost-benefit analysis, because damage costs play no role in consumer preference .

Finally, there is the main method of determining the effect-reduction, prevention or repair costs.

Using these methods, we can value aspects such as travel times (transport times), the social costs for emissions, traffic accidents, noise pollution and physical obstructions (Cole, 1998). However, the different methods render quite different results, even if the same effect is taken into account (for example, low and high monetarisations for CO_2-gasses vary by a factor of 10; see Verhoef, 1994). The valuation of non-priced goods is often disputed[29]. Derived methods, such as cost-effectivity analysis, eliminate some of the disadvantages of the social cost-benefit analyses.

By using the multi-criteria analysis methodology, there is no need for monetarising the different cost factors. The objective values for 'utilities' and 'disutilities' can be weighted with different sets mimicking the preferences of different types of actors.

---

[27]   This implies a 'ceteris paribus' analysis, and also that it is possible to find examples of situations where the options are implemented, and where they are not (yet) implemented. These implications, which are in fact requirements, bear far-reaching consequences and are difficult to meet.

[28]   Conditions with respect to the function of the market.

[29]   This is one reason why the CBA-method is hardly used (in the Netherlands) for formal policy making processes (De Wit and Van Gent, 1996).

10.5   Operationalising objectives into indicators

An important part of the evaluation framework deals with how to make policy objectives operational for evaluation purposes. The following steps are defined:

- Definition of the policy objective;
- Finding indicators;
- Formulating a measurement or observation method.

The policy objectives have already been described. In this section, we will deal with finding the proper indicators and formulating a measuring or observation method.

An indicator is, in general terms, an operational representation of an attribute of a system (quality, characteristic, property). A policy objective can be defined as a quality attribute of a system, for instance, the accessibility of the transport system or the quality of air. An indicator can be defined as an operational representation of a policy objective. The use of indicators is worked out in more detail by Moldan et al. (1995).

The major functions of indicators are (Moldan et al., 1995):

- To assess conditions and trends;
- To compare across places and trends;
- To assess conditions and trends in relation to goals and targets;
- To provide early warning information;
- To anticipate future conditions and trends.

In theory, indicators should be devised for all attributes of the whole system to which the policy objectives refer (not only the elements but also the inter-linkages). In order to find the relevant indicators, a conceptual scheme of the system, in this case goods distribution in urban areas, and the interactions with society should be available. In certain cases, indicators can be found that have no direct or only an indirect relation with the attributes of the system, but that still show a strong correlation with these attributes; for example, the average age of trucks can be an indicator for the profitability of the transport sector.

Indicators can adopt different levels or states (value). Some of the values are allocated a subjective value judgement. These values are called 'threshold', 'standard', 'norm', 'target', 'reference value' or 'benchmark'. Here, we would like to use the word target.

Indicators should fulfil certain requirements. Some universal practical requirements are listed below (Moldan et al., 1995):

- The values of the indicators must be measurable (or at least observable).
- Data must be either already available or they should be obtainable (through special measuring or monitoring activities).
- The methodology for data gathering, data processing, and construction of indicators must be clear, transparent and standardised.
- Means for building and monitoring the indicators should be available. This includes financial, human, and technical capacities.
- The indicators or sets of indicators should be cost effective.
- Political acceptability at the appropriate level (local, national, international).
- Participation of, and support by, the public in the use of indicators is highly desirable.

In order to use indicators in the field of urban goods distribution some aspects must be worked out. The following aspects are relevant:

- Level of aggregation and generalisation (street, neighbourhood, local, regional, national or global).
- Situation (the dimensions time and space play a role).
- Target group. This means the relevant group of actors.

10.6   Conclusions

The backcasting (scenario) methodology is a good option for identifying necessary developments and measures to reach predefined goals. This in contrary to what-if scenario studies that do not really provide a good impression of what actions are required to reach predefined targets or goals. For analysing the (effects) of developments and measures, the multi-criteria methodology is most attractive because it explicitly takes into account different actors' opinions (different weighting sets) and does not give the false impression of accuracy that some other methods do.

11. Summary and conclusions of Part II

11.1   Basic notions

In order to understand the urban goods distribution process and to be able to develop new schemes, insight in the actions of relevant actors is necessary. By applying micro-economic utility theory to urban goods distribution processes, we are able to describe the choice processes that actors make in a systematic (mathematical) way. The theory defines 'utilities' and 'disutilities' that are used to value 'goods'; these goods can either be real (physical) goods or services. We show that the (dis) utilities can be perceived differently by different actors, even if they refer to the same objective characteristics. This enables us to understand the different choices of actors given the same choice options (alternatives). Actors can be either private parties (firms, consumers) or public parties (governmental bodies).

Their choice behaviour can be modelled by using micro-economic utility theory (random utility choice models). Complex choice processes can be modelled and supported by using a network representation of the successive choices or by using a cost-benefit analysis or multi-criteria analysis. These methods will be used later on to find the 'most appropriate' solutions for the problems, related to urban goods distribution.

We also showed how we can use micro-economic utility theory to formally define the notions of 'effectivity', 'efficiency' and 'productivity'.

11.2   System description

The distribution of goods in urban areas can be perceived as a single system. To analyse this system, we use a layer scheme approach. Each layer in the transport layer scheme represents a

subsystem within the transport system. Each layer, or subsystem, can be described in terms of:

- Phenomena, the physical appearance of the subsystem;
- Primary services, the services that are performed within the system;
- Primary roles, the classification of the relevant actor;
- Primary means, the physical means that are used in the subsystem;
- Actors, the key players in the subsystem.

Each layer has a specific measurement that makes the primary service performed by the subsystem quantifiable. The problems related to transport in general, and urban goods distribution in particular, can be described as frictions between layers.

Based on the transport system, a freight transport service can be differentiated into five primary services. Each primary service is performed by a subsystem, or layer. The five primary services include:

- Integrated (logistic) services;
- Load units services;
- Transport means service;
- Traffic means service;
- Infrastructure service.

Each freight transport service that is provided can be defined or categorised as combinations of one or more primary transport services. Each primary service can be performed in different ways. This makes it possible to generate new alternative options.

The transport layer scheme also contains two other layers:

- Supply and demand. This refers to the economic activities that generate the goods transport.
- Impacts and needs. This refers to the use of natural resources and the impacts on society.

Both layers represent the relationship of transport with society.

The representation as a layer scheme makes it possible to describe and to find alternative ways to improve the distribution of goods in urban areas more systematically.

11.3   System optimisation

We have shown that the theoretical notion of 'efficiency' (and the related 'inefficiency') can successfully be operationalised for urban goods distribution processes. We have also shown that 'efficiency' can be valued both from the point of view of private parties and from the point of view of public parties, and have explained how 'societal' optimisation can be based upon these two kinds of public and private goals.

We further introduced the notions of 'economies of scale', 'economies of scope', 'economies of density' and 'economies of chains'; these all describe benefits of combining activities. We then introduced the different types of consolidation that can be used to reach these economies. We have also identified 'utilisation' (that is, the increase in the use of the system using the same resources) and 'conservation' (the reduction in the need for resources without changing the use of the system). Finally, we introduced various methods of consolidation.

This section linked integrated societal optimisation to the notion of efficiency improvement. It also linked efficiency improvement to consolidation of goods flows. We therefore conclude

that consolidation is essential for the optimisation of urban goods distribution. Our integrated design, as elaborated in Parts III, IV and V, will focus on consolidation in urban goods distribution and ways to facilitate it.

11.4   Methodologies for development and evaluation

The backcasting (scenario) methodology is a good option for identifying necessary developments and measures to reach predefined goals. This is contrary to what-if scenario studies that do not really give a good impression of what actions are necessary to reach predefined targets or goals. For analysing the effects of developments and measures, the multi-criteria methodology is most attractive because it explicitly takes into account different actors' opinions (different weighting sets) and does not give the false impression of accuracy that other methods can.

11.5   Relationship to the following parts

The theories and methodologies presented in this methodological framework will be used in the following parts:

- Part III focuses on the layers in the transport layer scheme that relate to the logistic organisation of urban goods distribution.
- Part IV focuses on the layers that relate to the physical elements of the transport system, such as the load units, the traffic means and the infrastructure.
- In part V, the spatial elements are elaborated.

References

Ben-Akiva, M. & S.R. Lerman (1985) *Discrete Choice Analysis: Theory and Application to Travel Demand*, Cambridge (The MIT Press).

Button, K. (1993), *Transport Economics*, Aldershot (Edward Elgar Publishing).

Bleijenberg, A.N., W.J. van den Berg & G. de Wit (1994), *Maatschappelijke kosten van het verkeer* (in Dutch), Den Haag (Ministry of Transport and Public Works).

Bouman, P.A., P.J.L. Kluit, Th.J.H. Schoemaker & J. v.d. Waard (1990) *Goederenvervoer en leefmilieu. Inventarisatie van emissies en verstoring door goederenvervoer* (in Dutch), Delft (Faculteit der Civiele Techniek, Vakgroep Verkeer, TU Delft).

Bovy, P.H.L. (1990) *Toedeling van verkeer in congestievrije netwerken* (in Dutch), Delft (Rijkswaterstaat).

Bowersox, D.J., D.J. Closs & O.K. Helferich (1986), *Logistical management: a systems integration of physical distribution, manufacturing support, and materials procurement*, New York (Macmillan Publishing Company).

Centraal Bureau voor de Statistiek (1996) *Luchtverontreiniging emissies door het wegverkeer 1996* (in Dutch), Heerlen (CBS).

Centraal Bureau voor de Statistiek (1999) *Statistiek van het binnenlands goederenvervoer 1998* (in Dutch)*, Voorburg/Heerlen (CBS).

Cole, S. (1998), *Applied transport economics; policy, management and decision making*, London (Kogan Page).

Crainic, T.G. (1999) Long-haul freight transportation, in: R.W. Hall, *Handbook of transportation science*, Dordrecht (Kluwer).

Dasgupta A.K. & D.W. Pearce (1972), *Cost Benefit Analysis, Theory and Practice*, Basingstoke (Macmillan).

Domencich T.A. & D. McFadden (1975) *Urban Travel Demand, A Behavioral Analysis*, Amsterdam (North Holland).

DTO (1997) *Verplaatsen, Ontwerp van duurzame vervoersystemen* (in Dutch), Den Haag (ten Hagen & Stam).

Duin, J.H.R., P.W.G. Bots & M.J.W. van Twist (1999) *Dynamic Actor Network Analysis for Logistics Concept Development, case: Introduction of City Distribution*, Delft (TRAIL Research School).

Goor, A.R. van, M.J. Ploos van Amstel & W. Ploos van Amstel (1992), *Fysieke distributie: denken in toegevoegde waarde* (in Dutch), Leiden/Antwerpen (Stenfert Kroese).

Heidemij Advies (1995) *Marktverkenning Encilog Haarlem, rapportage fase 1 en 2* (in Dutch), Arnhem (Heidemij).

Hicks, S.K. (1977) Urban freight, in: Henscher, D.A., *Urban Transport Economics*, Washington D.C., (Cambridge University Press), pp. 100-130.

Hoofdbedrijfschap Detailhandel (HBD) (1992) *Bevoorrading van detailhandel in binnensteden. Een studie naar de haalbaarheid en effecten van stadsdistributiecentra* (in Dutch), Den Haag (HBD).

Kageson P. (1993), *Getting the prices right*, Brussels/Stockholm (European Federation for Transport and Environment).

Lancaster, K. (1971), *Consumer demand: a new approach*, New York/London (Columbia University Press).

McKinnon, A.C & A. Woodburn (1995) *Logistical restructuring and road traffic growth: An empirical assessment*, Edinburgh (Herriot-Watt Business School).

Miser, H.J. & E.S. Quade (1985) Handbook of systems analysis, overview of uses, procedures, applications, and practice, Chichester (John Wiley & Sons).

Mishan E.J. (1982), *Cost Benefit analysis, an informal introduction*, London (Allen and Unwin); cited in De Wit and Van Gent (1996).

Moldan, B., S. Billharz et al. (1995) *Sustainability indicators, Report of the project on Indicators of Sustainable Development*, West Sussex (John Wiley & Sons).

OECD (1996) *Environmentally sustainable transport: outcome of the Vancouver conference and progress in the EST project*, Group on Pollution Prevention and Control, Paris (OECD).

Ogden, K.W. (1992) *Urban Goods Movement: A guide to Policy and Planning*, Aldershot (Ashgate).

Pauck, R. (1983) *Mikroökonomische Modelle des städtischen Verkehrs, Theoretische und empirische Grundlagen zur Analyse und Projektion der Verkehrsvorgänge in Städten*, Baden-Baden (Nomos Verlagsgesellschaft).

Pearman, A.D., & K.J. Button (1981), *The Economics of Urban Freight Transport*, London (The MacMillan Press).

Poppe, F., J.P.M. Tromp en L. Braimaister (1997) *Risicocijfers naar voertuigcategorie* (in Dutch), Leidschendam (SWOV).

Rietveld, P., A. van Binsbergen, T. Schoemaker & P. Peeters (1998), Optimal speed limits for various types of roads: a social cost-benefit analysis for the Netherlands, in: R. Roson & K.A. Small, *Environment and Transport in Economic Modelling*, Dordrecht/Boston/London (Kluwer Academic Publishers), pp. 206-225.

Taylor, S. & K. Button (1999) Modelling urban freight: what works, what doesn't work? in: E. Taniguchi and R.G. Thompson, 1999, *City Logistics I*, Kyoto (Institute for Systems Science Research), pp. 203-217.

Veld, J. in 't (1988) *Analyse van organisatieproblemen: een toepassing van denken in systemen* (in Dutch), Leiden (Stenfert Kroese).

Verhoef, E. (1994), External effects and social costs of road transport, in: *Transportation Research A, 28*, New York (Pergamon), pp. 273-287.

Wit, J. de & H. van Gent (1996), *Economie en Transport* (in Dutch), Utrecht (Lemma).

PART III
Logistics for urban goods distribution

CONTENTS OF PART III

12. Introduction to logistics for urban goods distribution

12.1 Introduction

Part III, "Logistics for urban goods distribution", deals with the organisation of urban goods distribution processes. Insight into these processes is needed to understand, develop and evaluate (improved) logistic processes for urban goods distribution so as to enable economic and societal efficiency improvements. Part III forms the first concrete step in designing advanced urban goods distribution concepts to solve the efficiency problems defined in Part I. This Part focuses on the organisational aspect part of these concepts. It applies the methodologies introduced in Part II: micro-economic utility and system optimising theory form the basis of the logistics theory, especially the optimising components. The adapted layer scheme is applied to define the function of logistics organisation within urban distribution. In addition, the concept of *consolidation* will be applied, and the network representation methodology will be used to explain choice processes within marketing and physical distribution channels as well as physical distribution networks.
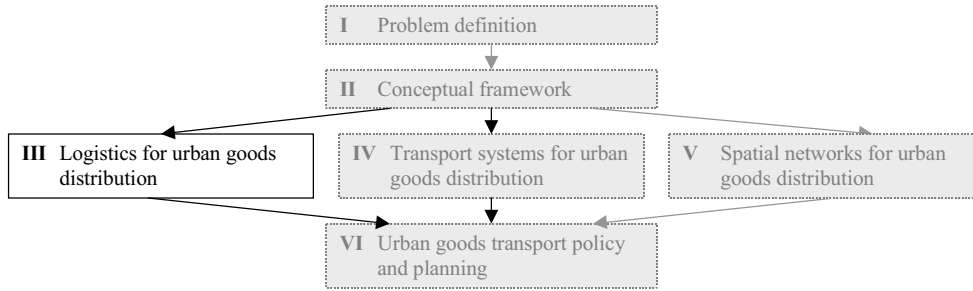
Figure 12-1: Part III related to the other parts of the thesis

Together with the organisational alternatives as developed in Part III, Part IV and V provide the building blocks for the policy making process that will be developed in part VI.

In this Part we will address the following research questions:

(1) Develop a clear understanding of the goods distribution in urban areas and the way it is related to environmental and accessibility problems.
This Part will formulate the logistics and organisational background of current goods distribution processes in urban areas and shows the interactions between different basic logistic activities. It will also show why certain actors are so influential within the organisation of urban distribution processes.

(2) Develop an integrated concept and survey and analyse possible solutions related to the concept that may lead to a more efficient urban freight transport system.
The organisational aspects also form the basis for the integral concepts. Therefore, in this Part, we will introduce, adapt, and develop new logistics concepts, including network logistics and city logistics.

12.2   Contents of Part III

In this part we introduce or apply the following insights:

'Logistics' as the first building block for new, integrated concepts for urban goods distribution
Unlike most public and private policy plans, we aim to develop an integrated optimisation strategy for urban goods distribution that includes logistic co-operation, the optimised use of transport systems, an optimal use of available space, and a reduction of the environmental burden. The logistics concepts proposed in this Part form the (organisational) basis for this integrated approach (see Chapter 18).

Explicit distinction between marketing and physical distribution channels
A sound understanding of urban goods distribution processes requires a good understanding of its driving forces. The marketing of consumer goods is a one of the main driving forces,

which culminates in *marketing channels* that guide the physical distribution processes (see Chapters 15 and 16).

Explicit distinction between physical distribution channels and service networks
While marketing channels and even physical distribution channels can be regarded as the 'demand side' of the physical distribution process, physical distribution service networks form the whole of the supply side. We make this explicit distinction, because in the public and private policy making process, the physical distribution service networks are the easiest to implement, without interfering too much with the trade patterns (see Chapter 17).

Concept of network logistics
The main contribution to the new urban goods distribution concepts is the concept of network logistics that optimise different kinds of shipments, while allowing for their respective characteristics. These concepts are introduced in Chapter 18.

Concept of cross-firm optimisation
Cross-firm optimisation is a key issue in our concepts because it is the foundation of network logistics, and is also critical to a successful implementation of other city logistics concepts. In contrast to some earlier approaches, we regard co-operation as being the main tool for implementing new urban goods distribution concepts (see Chapter 12).

Assortment composition in a broad scope
We will broaden the scope of the notion of assortment to the whole of an urban area: not only do products in a shop form assortments, but shops in a shopping centre and shopping areas in a city can also do so. We will use this broad perspective to highlight the importance of central urban shopping areas as the main target areas for the new urban goods distribution concepts (see Chapter 14).

Chapter 13 introduces the basic logistic activities that form the logistics system, which produces, stores, transports, and sells products to consumers and other users in urban areas. These basic logistic activities are all needed to fulfil the fundamental logistic task of supplying the right goods at the right time and at the right place. The basic activities interlink in such a way that changing the operational characteristics of one activity has an impact on the characteristics of other activities. These mutual impacts can be used to design a comprehensive and efficient logistic system; these optimisation procedures are represented in the trade-*offs* between the basic activities. These interacting logistic activities are combined in what we define as *logistic units* (further elaborated in Chapter 14). These units are then interlinked in *channels*. From a sales perspective, the succession of trading actors forms the *marketing channel* (see Chapter 15). Actors in this channel largely determine the type of goods to be exchanged, especially the related quality requirements of the needed distribution system. The succession of actors involved in the actual movement of goods is represented by the *physical distribution channel* (further elaborated in Chapter 16). This channel then links with the required transport means, infrastructures and logistic centres, as discussed in part IV.

Chapter 14 will examine the basic logistic activities to achieve a better understanding of the channels they constitute. It will also present some of the strategies that actors use to optimise the basic logistic activities, or *roles*, that they perform. We will highlight the often-neglected importance of *assortment composition*. Assortments ease the task of collecting the products required to meet consumer demand. Assortments also strongly affect the composition of product flows in marketing channels, and thus the composition of goods flows through distribution channels. Assortments thereby strongly influence the way these flows should be distributed. We will also show that optimisation strategies in production are based on the same principles as optimising strategies within the marketing channel.

Chapter 15 deals with the marketing channels that represent the trade-relations. It analyses the structure of the channels and the different types that can be defined.

We will also introduce the notion of the *channel director*, the most powerful actor in the channel who strongly influences the way the channel is organised. This chapter discusses the importance of developments such as retail mergers, internationalisation and the introduction of e-commerce.

Marketing channels result in demands from shippers to logistic service providers: the marketing channels therefore refer to the demand side of the urban goods distribution services. We will show the links between marketing channels and physical distribution channels and networks, which are elaborated in the Chapters 16 and 17. We will also specify product characteristics, and focus especially on the characteristics of the *assortments of goods* flowing through different marketing channels. We will show that goods characteristics alone are not sufficient to understand and develop physical distribution systems, but that insight in marketing channels is also important. In Chapter 18, we will use this knowledge to assign goods flows to specific urban physical distribution services.

Physical distribution channels are discussed in Chapter 16. These channels represent the consecutive actors that take care of physically moving goods. We will show how marketing channels are related to physical distribution channels and then analyse the importance of the concept of *consolidation*.

Chapter 17 will explain how physical distribution service networks can accommodate physical distribution channels. It will therefore refer to the supply side of the urban goods distribution services. The chapter will introduce network principles and show how these principles relate to requirements set by the physical distribution channels.

We will describe physical distribution network services and show that concepts developed and applied by individual private parties (sometimes in other transport branches) can also be used in cross-firm applications to optimise urban goods distribution processes.

In Chapter 18, we will combine all the elements from the preceding chapters to analyse and build new concepts for urban goods distribution. First, we will rehearse the preconditions and policy requirements derived from Part I. Then, we will define the basic physical urban goods distribution concepts that are also further elaborated. In this chapter, we will introduce new concepts such as *consolidated urban distribution*, *network logistics* and *non-consolidated* concepts.

We will also show the suitability of the different urban goods distribution concepts for the distribution of different types of goods flows (as defined in Chapter 16).

These concepts make use of transport systems that will be described in Part IV.

Figure 12-2 shows the structure of this Part III and the interrelated chapters.
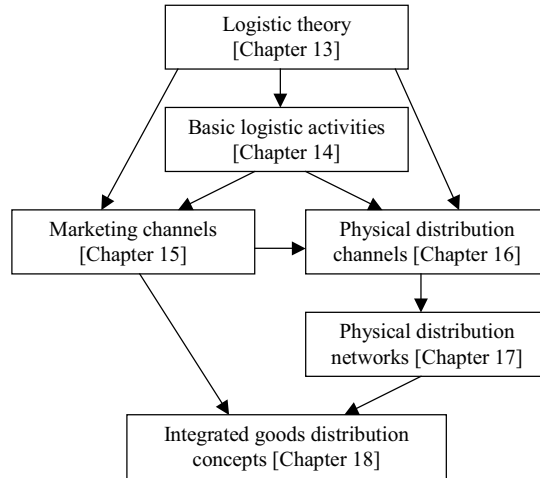

Figure 12-2: Structure of Part III, Logistics for urban goods distribution

12.3   Logistics in the urban goods distribution process

Logistics entails the management of the goods flow through a logistics chain; that is, the sequence of consecutive actions that must be performed to enable the production of and then delivery of a product to the end-user. It concerns the management of goods flows in very different stages of that chain. Therefore, the main stages of the logistics chain are classified as follows (Van Goor et al., 1993):

- Physical supply chain - encompassing the part of the logistics chain that deals with the supply of goods to production facilities;
- Material management - covering the goods flows within production facilities;
- Physical distribution - comprising the part of the logistics chain that deals with the distribution of end-products (consumer goods) over end-users (consumers);
  - Reverse logistics - covering the collection and processing of packagings, returned products, and waste materials.

Although we will focus mainly on the final distribution of consumer goods in urban areas, insight in related logistics processes is also important to understanding and optimising the physical goods distribution processes for urban areas.

The layer schemes, as depicted in Figure 12-3 and Figure 12-4, clearly show the interrelations between the different *primary services* (for an in-depth description of the layer-model, see Part II, Chapter 8).

All goods movements result from economic activities, which form the first *service layer* in the scheme. In this layer, production, trade and consumption occur, organised along logistic chains. For urban goods distribution, trade relations are especially important; these trade relations are represented in *Marketing Channels*. Within that layer, we focus especially on actors such as retail-organisations, and to a lesser extent, on producers and consumers.

To function properly, economic activities need transport services that are directed by *Integrated Logistic Services*. Their most important role is to integrate the various transport, traffic and infrastructure services into a single, integrated service, or physical goods distribution channel, for a specific set of economic activities. The Integrated Logistic Services layer therefore controls and interacts with the subsequent layers of the scheme and its associated actors, especially those with an operational role.
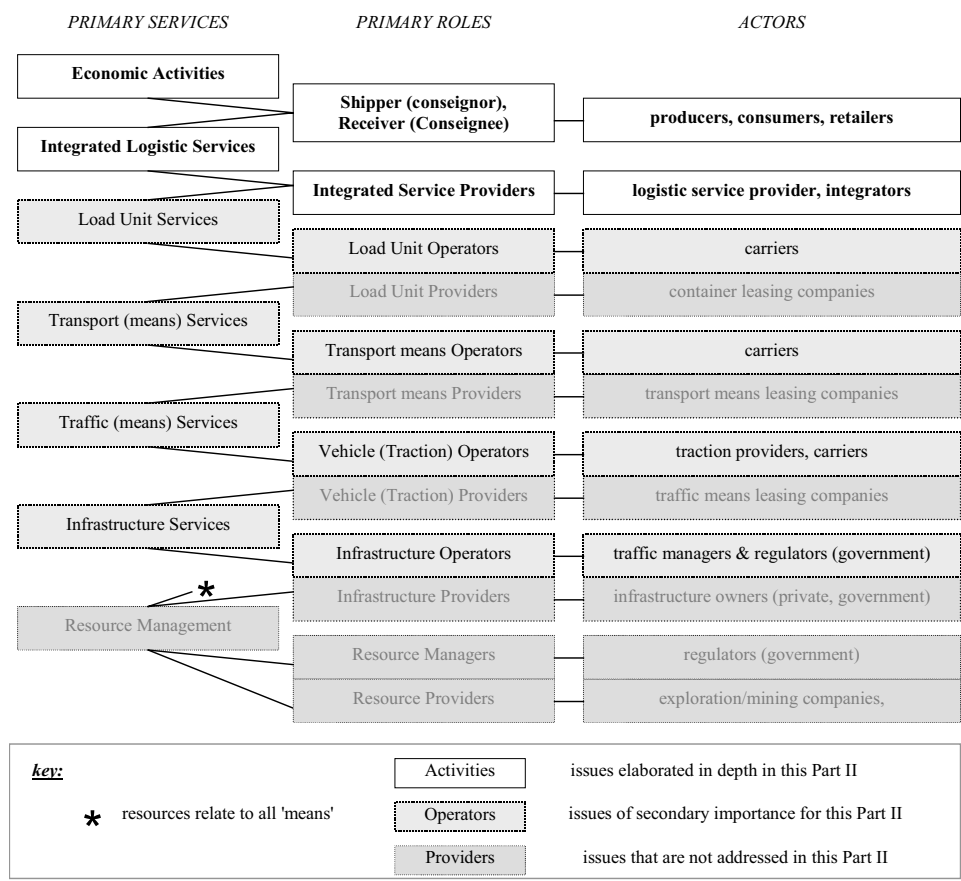

Figure 12-3: Primary services, roles and actors related to logistics for urban goods distribution
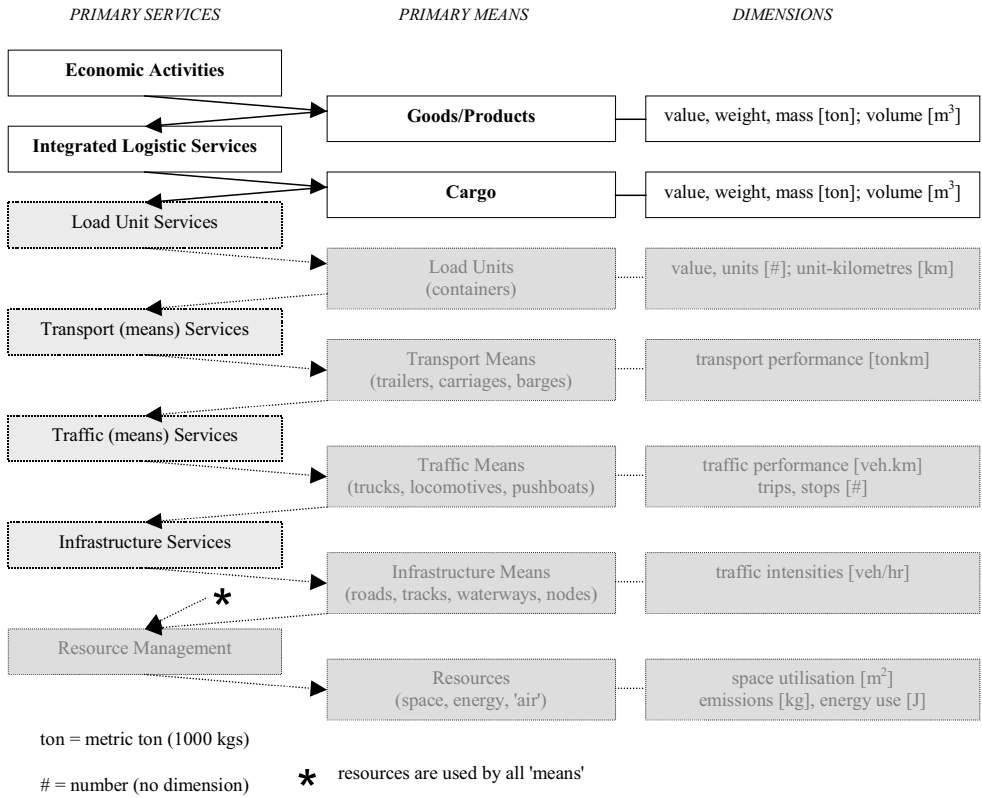
Figure 12-4: Primary services and means related to logistics for urban goods distribution

13. Logistics theory for urban goods distribution

13.1 Introduction

This chapter introduces the basic notions of logistics theory that we will apply to urban goods distribution processes. First, we will refer to basic logistic activities that we will then combine into *logistic units*. These units form the basis for *logistic chains*, representing the succession of actors and actions involved in supplying consumers with products. We will highlight the importance of interactions between the basic logistic activities (see Chapter 14) and explain the strategies that both private and public actors can use to optimise the chains. We will then introduce the notions of *marketing channels* and *physical distribution channels* and their mutual interactions. Marketing channels represent the succession of trade activities (see Chapter 15); while physical distribution channels represent the succession of distribution related activities (Chapters 16 and 17). The formal description of these channels forms the basis for the analysis and development of new, efficient urban goods distribution concepts (Chapter 18).

13.2 Logistics theory and urban goods distribution

13.2.1 Introduction

The basic function of logistics is to supply the right goods in the right quantity at the right time, and in good order at the desired place (see the *utilities of logistics*; Part II). Multiple actors are involved in logistic operations, including producers, logistic service providers, retailers, transport companies, and consumers. In terms of transport, actors can play roles as

shippers, receivers, and transporters (see the layer scheme, Section 12.3). The actors perform different logistic activities that are mutually tuned to obtain an optimised logistics system.

13.2.2 Basic logistic activities

To fulfil consumer demand, consumers must be supplied with products. To that end, the products must be produced, stored and transported. Therefore, a string of activities must be performed. Here, we define a set of *basic logistic activities*: single, fundamental, uniquely identifiable logistic operations performed on goods.

These basic logistic activities include (McKinnon, 1989; Ruijgrok, 1991):

- Searching for Suppliers, Supply (**Ss**): searching for suppliers of the desired goods (including basic materials and resources, and half products);
- Production (**P**): the processing of incoming goods (e.g. basic materials, half products of components) to other products. Production can be seen as a *modification* (of goods and products) *in appearance*[1].
- Inventory (**I**): the storage of ready made products, basic materials etc. Inventory is a means to bridge the differences in the rate of supply and demand of goods, or *a shift in time*;
- Transport (**T**): the movement of goods; can be regarded as *a shift in place*.
- Searching for Consumers, Sales (**Sc**).

McKinnon (1989) adds to these five activities:

- Breakdown of bulk, order picking and putting together an assortment of goods (**A**); also to be seen *as a change in the composition of a collection*;
- Consumption (**C**), including the use of (durable) goods.

These seven basic logistic activities are analogous with to five the *logistic utilities* as defined by Vermunt and Olsthoorn (1995), and Ogden (1992):

- *Translation* or *place utility*: change of goods in space (Transport);
- *Stabilisation* or *time utility*: change of goods over time (Inventory);
- *Transformation* or *form utility*: change of goods in form or quality (Production);
- *Decomposition utility*: change of composition of a shipment (Assortment composition/breakdown of bulk), order picking or assortment composition;
- *Commercial utility*: change of ownership (Sales).

The logistic utilities do not explicitly include the basic logistic activities of Consumption (which can be seen as a special form of 'transformation or form utility') and Searching for suppliers (though this can be combined with 'Sales').

All basic logistic activities are aimed at increasing the net value of a product, either directly or by improving the potential net value of a product. In inventory, value is added if demand occurs at other times than production, while in transport value is added if demand occurs at other places than where production takes place. Searching for consumers can increase the potential market area thus boost sales, whereas searching for suppliers can lower the price and increase the quality of component parts goods, and therefore can help to increases the net margin. Putting together *assortments* increases the potential value of products if assortments

---

[1]   Here we consider all activities related to goods as being 'logistics' activities.

fit consumers demand. Within the physical distribution process, assortments are composed and decomposed to enhance transport efficiency; assortment composition is then referred to as *consolidation* (see Part II).

Evidently , all of the above activities also bring about costs, therefore the activities only take place if benefits outweigh the costs, and thus the net added value is positive. Chapter 14 elaborates the basic activities and their impact on urban goods distribution in depth, but first we will discuss the overall relationships between these basic activities.

In accordance with McKinnon (1989), we explicitly include the activities of *breakdown of bulk* and *assortment composition* in our theory, because we consider these as being key logistic activities in the urban distribution process. In addition , Bowersox et al. (1986) identify the 'adjustment' activity as a basic function. That adjustment activity consists of *concentration* (assortment composition) and *dispersal* (breakdown of bulk). Assortment composition is one basic competition element amongst retailers (and thus marketing channels). Likewise, consolidation is a basic method to increase the efficiency of various logistic activities.

 Equally, we regard *consumption* as a basic element in the logistic process. For policy reasons, it is important to see consumption as an integral part of the logistic process because it stresses the importance of customers and customer service. The GoodTrip model (as proposed by Boerkamps 1999) is an example of a supply chain based transport model that fully takes into account the pulling role of consumers – in fact, the modelling process starts with estimating consumer demand. Although we are fully aware of the importance of consumer action and we also strongly support the viewpoints of Boerkamps, in our approach we limit our scope to professional transport and transport on own account by retailers. We thereby limit the scope of this section to the supply of retail outlets, offices, hotels, restaurants etc. (see Part I).

Even the basis logistic activities consist of partial activities or lower order activities. The activity of production, for example, may consist of a multitude of actions, together forming the production process. A generic partial activity is the handling of goods of products: picking up, putting down goods and moving goods (in vehicles, storage facilities, factories etc.). Although handling is a generic activity (see Part IV, Chapter 21)., we do not define handling as a separate basic activity but we assign handling activities to the basic activities mentioned above

13.2.3 Trade offs / design dilemmas

The seven basic logistic activities can be optimised individually, as is the case in more traditional production and distribution processes. On the other hand, multiple, successive logistic activities can also be optimised as a whole. In total, this should result in a more efficient process, although some basic activities may in themselves become less efficient.

An actor *a* will maximise the overall utility of the logistic unit $\hat{G}$ that he controls:

$$\max\left(U_{\hat{G},\bar{K}}^a\right) = \max\left(\sum_{g=1}^{G} u_{g,\bar{K}}^a\right) \qquad (13\text{-}1)$$

Where $u_{g,\bar{K}}^a$ represents the partial utility of one basic logistic activity *g*.

From the equation we can already conclude that partial utilities may compensate each other. Now, the partial utility of a singular basic logistic activity depends on the way the other basic activities function. To give a down-to-earth example: the *sales* activity can only render a utility if there are products available, and is therefore dependent on the *production* activity.

If q_g represents the *functioning* of the basic activity *g*, we can introduce expression 13-2:

$$u_{g,K}^{a} = f^{g}(q_1 \cdots q_G) \tag{13-2}$$

Here, the function $f^{g}(q_1 \cdots q_G)$ is specific for a given basic logistic activity g. The function represents the *trade-offs* or interactions between the basic activities. Trade-offs are often described in pairs (see also below). If one actor controls multiple basic activities, an overall optimisation is most appropriate. The following gives some important examples of trade-offs between pairs of basic activities; in chain optimisation multiple basic activities will be optimised.

P (Production strategy) ↔ *I (size of inventories)*   A producer can use inventories to optimise the production process. Inventories enable batch production and allow work in advance; furthermore, they can overcome differences that occur between the rates of consumption and production. Producers must balance the costs of stock keeping with the benefits of optimising their production process. In case of mass-production of goods, the efficiency of production is the most important factor, whereas in case of lean production, the minimising of stock is the most important factor (see Section 14.3 for a more extensive discussion about inventories).

C (Consumption 'strategy') ↔ *I (size of inventories)*   Much like producers, consumers can tune the rate of replenishment, and thus the size of the inventories, to the rate of consumption.

T (Transport frequency) ↔ *I (size of inventories)*   Delivery frequencies and shipment sizes, both characteristics of transport, affect the necessary inventories, given a certain rate of consumption. While high-frequency deliveries will lead to low storage costs but relatively high transport costs, minimising transport costs and delivery frequencies, can reduce transport costs, but increase storage costs. For example, the Just-In-Time principle is based on the minimising of stock (and thereby the costs of stock-keeping) while accepting higher transport costs. This trade-off can be made for inventories, where incoming goods or supplies must be processed, but can also be made for outgoing goods. This trade-off can be made by producers as well as wholesalers, retailers, and by consumers. The problem of choosing the right number (and location) of depots in relation to the transport costs can be considered as a special form of trade-off between transport (costs) and inventory (costs).

Ss (Search area for suppliers) ↔ *T (Transport costs)*   Often, there are several sources that can provide the desired goods. The price of these products (or additional services provided by the supplier) determines the choice to a large extent. Given the price, the transport costs determine the actual choice (when two suppliers can provide the desired goods at the same price, the one which leads to the minimum transport costs will normally be chosen; see Button, 1993). The relatively low level of transport costs can thus encourage the internationalisation of trade (see Section 15.4 on internationalisation of retail chains[2]).

Sc (Search area for consumers) ↔ *T (Transport costs)* The search of suppliers for consumers is comparable to the search of consumers for suppliers: only the point of view is different. When several suppliers offer the same product for the same price, the transport costs will, to a large extent, determine the possible sales area or market. When consumers are located far away, they will, in some cases, be more interested in a local supplier than in a supplier far away (assuming that the quality and price of the goods are equal).

---

[2]   A retail chain is a large retailer owning multiple outlets (shops) or a group of co-operating retailers.

A (Composing supply assortments) ↔ *T (Transport costs)*   By composing *supply assort-ments*, suppliers can ease consumers' shopping tasks, because they need less effort (especially transport) to gather the products they need. Of course, the suppliers themselves may encounter higher transport efforts if they compose larger assortments (Section 14.2 shows the important role of assortment composition).

The above implies that changing the urban physical goods distribution systems, for example, by implementing specific traffic regulation that have an impact on transport, will influence the other logistic activities as well. As a reaction, companies will make other trade-offs, resulting in changes in the distribution system as a whole. In the end, the new urban goods distribution concepts (to be presented in Chapter 18) must show trade-offs that result in net positive effects: an overall efficient urban distribution system should emerge.

13.3   Related basic activities

13.3.1 Introduction
As the trade-offs already suggest, there is a close relationship between the different basic activities. In this section we will show that two or more basic logistic activities may be combined into logistic units. If we regard the basic logistic activities as 'roles', actors may perform one or more of these roles within a logistic unit. These units (and thus the actors) are in their turn linked to logistic chains. These chains form the basis for the marketing channels and physical distribution channels

13.3.2 Logistic units
Closely related logistic activities may be combined, forming what we will call *logistic units*. A logistic unit is a specific combination of closely related or dependent logistic activities controlled by a single actor. These actors perform one main activity (*main role*) that may be supported by a string of supplementary activities (roles, see also McKinnon (1989)):

Production: the producers' main role is production **P**, an activity that can be supported or combined with other basic activities such as **Ss**, **I**, **C**, **Sc** and **T**. First, producers must search for their suppliers, then incoming goods are usually stored, however, certain logistic strategies try to minimise these pre-production inventories. Production then occurs (also involving consumption, of energy, as well as raw materials). The products often have to be stored until they can be moved to the next stage: consumers or traders who are interested in buying the product. When a producer provides his own transport facilities, transport can also be a part of the logistic unit.

Wholesale: the wholesalers' prime roles are assortment composition **A** and sales **Sc**. These main roles can be supported by basic activities such as **Ss**, **I**, and **T**. Besides the activities of searching for consumers (sales) and searching for suppliers, wholesalers have often to regroup the incoming goods flows to create the desired outgoing goods flows. They can also transport goods.

Consuming combines the basic activities of **Ss**, **A**, **T**, **I**, and **C**: the main tasks are assortment composition and consumption.

Transport encompasses transport **T,** and can also include storage activities **(I)**; *Integrators* combine **T** and **I** while *logistic service providers* combine **T**, **I**, **P**, and **A,** giving opportunities for *value adding* (production) activities.

Note that the term of the concept of *value added logistics* (VAL) may suggest that other logistic activities do not add any value, but this is not the case: all activities of a logistic service provider can be seen as activities that add (potential) value to products. VAL is defined as the inclusion of basic assembly or production activities in the processes of a logistic provider.

13.3.3 Logistic chain

Logistic activities are combined into logistic units (representing actors) that link to a logistic chain. An example of a logistic chain is displayed in Figure 13-1, but note that different actors can execute different basic activities.
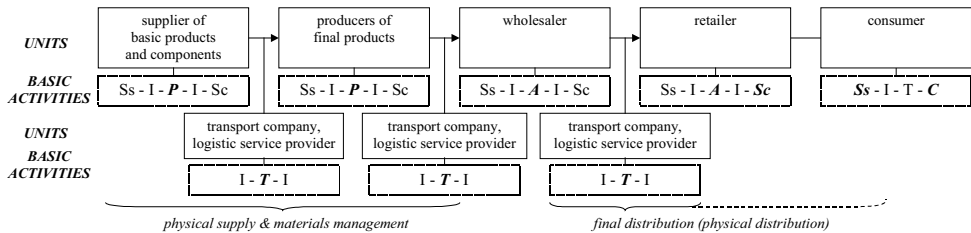

Figure 13-1:   ***Materials management and physical distribution***

The aspect of logistics that deals with goods flows within production facilities is referred to as *materials management,* and is of no direct concern in this thesis.

All activities involved with supplying factories with goods are referred to as *physical supply*, which is also not of direct importance for urban distribution processes.

We focus on the final distribution or *physical distribution* part of the logistic chain, dealing with the organisation of distributing goods to and from retailers in urban areas. The bulk of goods transport[3] in urban areas is related to these final parts of logistic chains. A minor share of goods transport in urban areas relates to other parts of logistic chains, for example physical supply related goods transports that originate from factories within the city borders.

The organisation of the return flow of waste materials and reusable packaging materials is referred to as *reverse logistics*. Reverse logistics organisation has strong correlations with final distribution, but the flow is in the opposite direction. Often, specialised actors are involved in reverse distribution systems. An increasing flow of returned products, waste materials and packagings can be observed in the retail trades (HBD, 1996).

---

[3]   As expressed in mileage.

Currently, the return flow is either:

- Taken back by a carrier (on behalf of the retailer, the producer, the consumer):
  This affects certain transport units (pallets, cardboard coverings, empty roll cages), packing (empty bottles), unsold or defective products.
- Picked up by municipal or private waste collectors or recyclers:
  This affects glass, paper, rubble, industrial, or domestic waste.

Manufacturers are becoming, to an increasing extent, responsible for the return of old or defective consumer goods, as well as of empty packing material. They will, therefore, start to determine how to deal with this waste. This will be regulated by means of central collection points, and could potentially be combined with other logistic activities.

13.3.4 Marketing and physical goods distribution channel

A logistic chain is a formal representation of the succession of logistic units (and thus of the basic logistic activities). The logistic channel basically starts with the production of materials and ends with the distribution of final products. Much like Bowersox et al. (1986) and McKinnon (1989), we distinguish physical distribution channels (the physical goods flow channel) from marketing channels (the transaction channel)[4].
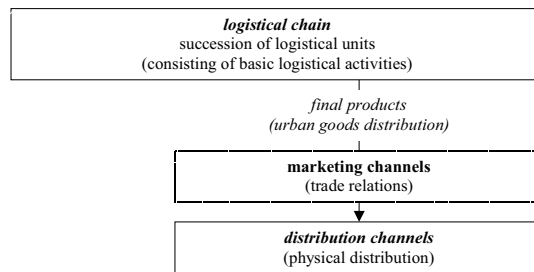

Figure 13-2:   Logistic, marketing and physical distribution channels

The marketing channel represents the succession of actors who are involved in trade-relations and deal with the sales process of products. Within the marketing channel, there is no flow of goods, only of information (about goods) and money (see Bowersox et al, 1986; McKinnon, 1989). Activities within the marketing channel initiate and control the physical distribution process. This physical distribution channel represents the succession of actors that are responsible for the actual movement of goods (and also deal with the related flows of information). In Chapter 18, we will use the concept of the physical distribution channel to develop new urban distribution concepts and to compose the set of physical requirements for the urban transport systems (vehicles and infrastructures, see part IV).

Insight into the physical distribution channel as such is adequate for a superficial analysis of the urban distribution process. In Chapter 15, we will show that insight into the marketing channel is needed to analyse these processes in depth: next to *goods characteristics*, we also need *product characteristics,* as well as *marketing channel characteristics* to be able to analyse and optimise the physical distribution process.

---

4   For reasons of convenience, we consider the marketing channel as being a part of the logistic chain.

13.4   Optimisation of logistic activities and chains

Actors can optimise the specific basic logistic activity they control via the normal business-economical optimising strategies (by balancing the inputs of capital, man-power and capital goods). In business logistics, total chain optimisation can some efficient solutions. In our approach, we try to stretch the limits even further, and propose concepts that aim to optimise distribution processes at supra company level. In practice, also partial optimisations occur, varying from production/sales optimisations in combination with production/physical distribution optimisations, to the optimisation of all individual processes. The latter can be regarded as rather 'old fashioned', but can turn out to be the only feasible optimisation strategy in chains without truly dominant players.

Figure 13-3 shows the partial optimisation through the column optimisation strategies.

If an actor controls only one basic activity (g), only the activities within that single base activity can be optimised, this can be expressed as $\max\left(u_{g,K}^a\right)$ (see also Part II). The relationship to other base activities is fixed on the short term (given prices for activities, given volumes, etc.). For instance, truckers (transport performers owning one vehicle) can only optimise their own process (T) by optimally allocating their vehicles and drivers (or labour time); the demand of goods transport (the amount of goods to be transported and their transport characteristics) is given and cannot be changed[5].

If an actor controls a larger part of the logistic chain in a production column, he is able to tune the G different successive basic activities of that chain to obtain an overall optimisation. This strategy is also referred to as *Fordism,* because when the Ford motor company operated its mass production lines, it also controlled the supply and sales segments of the logistic chain. The single actor (single company) total chain optimisation strategy is nowadays often replaced by a multi-company co-operation strategy. Here also total chain optimisation takes place, but by the different actors (companies) A within the column: $\max\left(\sum\limits_{a=1}^{A}\sum\limits_{g=1}^{G}u_{g,K}^a\right)$.
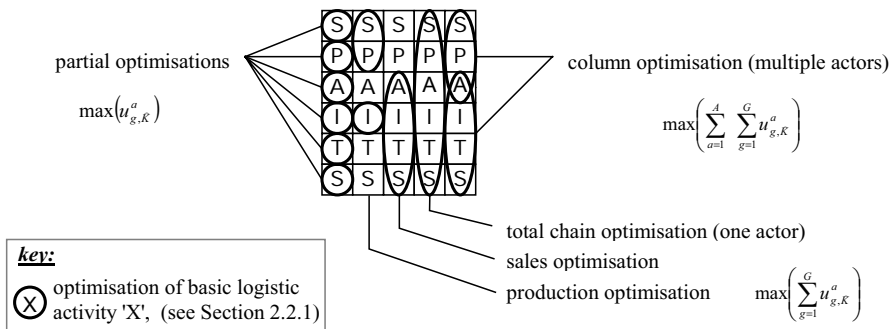

Figure 13-3:   *Examples of the scope for optimisation by firms, arranged along 'columns' (vertical optimisation)*

---

[5]   Although, in time, demand will of course be influenced by supply: the transport capacity, quality and tariffs.

Specialised companies can optimise their 'ore activities and can make these activities available for parallel channels (*horizontal optimisation*); see Figure 13-4. Companies can also cooperate to achieve horizontal optimisation. For instance, different transport companies can join their activities to be able to offer their customers in different production columns a better service or cost to quality ratio. This is an example of cross-firm, partial optimisation for a specific basic logistic activity g: $\max\left(\sum_{a=1}^{A} u_{g,K}^{a}\right)$.

Multiple basic logistic activities in different columns can also be optimised simultaneously:

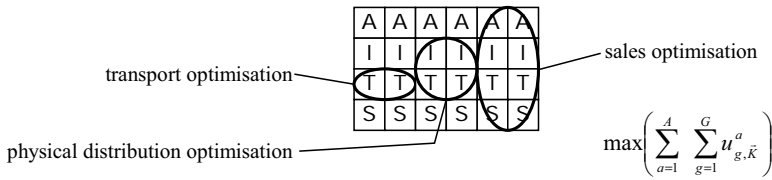$$\max\left(\sum_{a=1}^{A}\ \sum_{g=1}^{G} u_{g,\bar{K}}^{a}\right).$$

Figure 13-4:   Examples of the scope for optimisation by firms along 'rows' (horizontal optimisation)

Optimisation the trade-offs between multiple basic logistic activities (of multiple firms) means that for the sake of total efficiency, some partial inefficiencies may occur en must be accepted. This is clearly the case in just in time strategies where inventory (I) costs reductions can only be achieved by allowing less efficient transport (T). In *cross firm optimisation* this can imply that some firms may profit and others may encounter some losses to obtain an overall optimum.

Public policy usually aims at certain sectors and tries to optimise processes such as production or transport, for instance, to limit the production of waste materials (see Figure 13-5). Public policy actors do not control basic logistic activities and can only impose measures to guide decisions that should lead to societal optimisation. Public policy actors anticipate on actions of other actors, they influence processes indirectly. Therefore public policy actors will also influence trade-off decisions: between different types of activities (for example: transport and storage), between actors etc.

To achieve an overall, societal, transport system optimisation, inefficiencies may be introduced for individual actors, just as is the case in chain or multi-company optimisation with private partners. The main difference between private and public actors is that they look at different aspects or use a different weighing of aspects (indicated as $\bar{K}$, examples are: costs for manpower and equipment, pollution, and space utilisation).
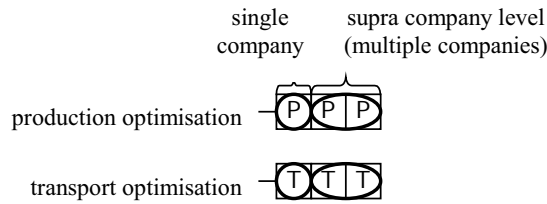
single   supra company level
company   (multiple companies)

production optimisation

transport optimisation

Figure 13-5:   *Examples of the scope for (persuaded) optimisation by public policy actors.*

In advanced public policy optimisation, sectoral optimisation is still the main goal, but all relevant processes in the logistic chain are taken into account. We will also try to achieve this kind of optimisation: cross-firm optimisation where public policy goals also play a significant role. Therefore, to optimise urban goods transport, other basic logistic activities must be taken into account as well. Figure 13-6 illustrates how the new integrated logistic concepts, as developed in the following chapters, are based on the idea of transport optimisation by multiple, but independent firms (see also Thoma, 1995).
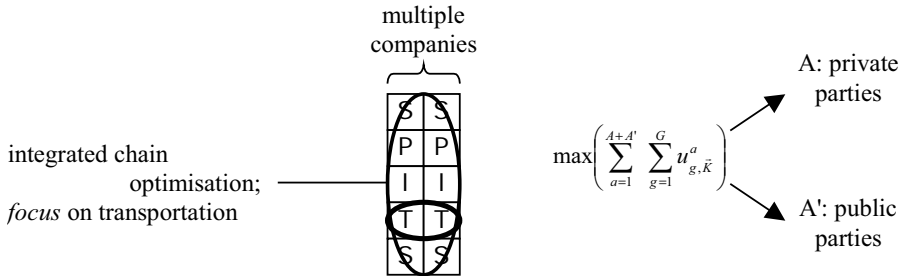
multiple
companies

integrated chain
optimisation;
focus on transportation

$$\max\left(\sum_{a=1}^{A+A'} \sum_{g=1}^{G} u_{g,\tilde{K}}^{a} \right)$$

A: private
parties

A': public
parties

Figure 13-6:   *Integrated chain optimisation for multiple firms (cross-firm optimisation)*

This integrated chain optimisation for multiple firms *A*, that also takes into account public policy goals from actors *A'*, with the focus on transport, means that:

- There are trade-offs between different basic logistic activities within a single logistic chain (*vertical optimisation*): in favour of more efficient transport, possibly less efficient supply, production, inventory or sales may result;
- Trade-offs will *emerge* between different firms, possibly resulting in less efficient processes in one firm to the benefit of other firms and for the sake of improved comprehensive efficiency (horizontal optimisation).

In Western society, governments are reluctant to interfere directly with business operations; therefore, regulations, market forces (specific taxes, subsidies etc.) and facilitating policies will be used to reach the objectives (see also part V). Therefore, in the above issues, trade-offs will not be 'made' directly by governments, but should result from impartial policy actions.

13.5   Conclusions: the use of 'urban logistics theory'

General logistics theory explains the way products or goods are treated to deliver them in the right shape, quantity, time and place to users. The fundamental approach of describing basic

logistic activities that are linked to a logistic chain can be effectively used for analysing urban distribution processes. Because in urban distribution the emphasis lies on the *end-distribution* of consumer goods, we have added basic activities related to sales, supply and *assortment composition*. *Trade-offs* represent the decision dilemmas when optimising pairs of basic logistic activities. The trade-offs show that these activities are interrelated. We introduced the concept of *logistic units*, which group related basic logistic activities and represent the different actors in a logistic chain. Within that chain, we define *physical distribution channels* (representing the actual goods movement process) that are controlled by *marketing channels* (representing the trade relations for products). Although the transport processes within urban areas are essentially a manifestation of the physical distribution process, we also need the notion of marketing channels to adequately analyse the goods flows in urban areas. This is because the marketing channel demands have a strong impact on the requirements set for the physical distribution process. We have also shown the different ways that the chains can be optimised. Optimisation ranges from optimisation of individual basic activities via *horizontal optimisation* (where basic activities of the same type are jointly optimised) to *vertical optimisation* (where basic activities within a chain or column are jointly optimised) or integration. We show that after optimisation within individual firms, cross-firm optimisation can be defined, using exactly the same principles and optimising strategies. Cross-firm optimisation is especially suited to optimising urban distribution processes, because in urban areas, the activities of multiple actors physically come together and have to share scarce space and other resources.

The basic activities introduced in this chapter are further elaborated in Chapter 14. In Chapter 15, we will further explain the role of marketing channels, while in Chapters 16 and 17, the related physical distribution channels and networks are discussed.

All these elements are used in Chapter 18 to introduce new integrated urban goods distribution concepts that make use of physical means as analysed in Part IV.

In urban goods distribution policy and planning (Part V) these 'building blocks' are used to design policy plans and an implementation strategy to achieve an efficient urban goods distribution system.

14. Basic logistic activities

14.1 Introduction

This chapter elaborates the basic logistic activities introduced in Chapter 13, linking these basic activities to the urban distribution processes. It therefore stresses the importance of distribution related activities. In this chapter, we will introduce the notion of urban shopping areas as assortments, and we will explain the importance of these assortments for consumers by demonstrating the efficiency benefits of composing those assortments. We will show that while production activities in themselves may be of minor importance in urban areas, production strategies strongly affect physical distribution processes. We will also demonstrate that some of the production strategies can be modified for use in trade and distribution.

We will describe different strategies in storage (centralised and decentralised depots) and link these strategies in order to be able to develop urban distribution concepts (namely network logistics). We will use the knowledge from this chapter to analyse marketing channels (Chapter 15) and physical distribution channels (Chapter 16) that we will eventually use to adapt and design urban distribution concepts (Chapter 18).

14.2 Assortment composition, supply and sales

14.2.1 Introduction
An *assortment* is a specific selection from all available products brought together by a given actor to maximise the utility. Bowersox et al. (1986) analyse the Alderson's process of decid-

ing who identifies the sub-tasks of sorting out supply, accumulation, allocation and assortment composition; these subtasks have to be performed to assemble assortments.

The notion of assortments is important for urban goods distribution for several reasons:

- Urban areas and shopping centres can be regarded as large assortments that play a key efficiency-enhancing role in the distribution of products to end-users; see Section 14.2.2;
- The size and composition of assortments (especially the variety of types of products) affect the complexity of the logistic chain and thereby the complexity of the physical distribution processes;
- The fact that consumers do not actually need an assortment of products, but rather an assortment of product-characteristics (Lancaster, 1971), positions assortment-suppliers in a relatively powerful position within the marketing channel – they are therefore important actors in the physical goods distribution process.

Different types of actors need different types of assortments for different purposes.

A consumer needs a *demand assortment* of products to fulfil his needs[6], within budget restrictions.

A trade intermediary will compose a *supply assortment* in such a way that it complies best with the demand assortments of the intended customers. The composition of these supply assortments is a main marketing tool because it is a primary discriminating factor between retailers. These supply assortments can be brought together physically within shops (outlets) or virtually on the Internet or in catalogues.

Collecting the appropriate demand assortment takes effort (time, money). The larger the required demand assortment, the larger the total effort, although in composing assortments, there will be some economies of scale. If suppliers and retailers manage to compose adequate or convenient supply assortments, users can save effort in composing their own demand assortments by accepting the assortment of the supplier.

With help of utility theory as explained in Part II, we can first assume that a set of products $\hat{G}$ renders a utility that is made up of partial utilities of the respective products g of the set:

$$U_{\hat{G}}^{a} = \sum_{g=1}^{G} u_{g}^{a} \qquad \text{with} \quad \hat{G} = \{1...G\} \qquad (14\text{-}1)$$

The partial utilities are composed of benefits and costs:

$$U_{\hat{G},\hat{K}}^{a} = Y_{\hat{G},\hat{K}}^{a} - \left| Z_{\hat{G},\hat{K}}^{a} \right| \quad \text{where} \quad Z_{\hat{G},\hat{K}}^{a} = \sum_{g=1}^{G} z_{g,\hat{K}}^{a} \qquad (14\text{-}2)$$

The partial disutilities $Z_{g,\hat{K}}^{a}$ for instance relate to the 'shopping' activity (an activity that is definitely perceived differently by different actors). By composing supply assortments, some of the disutilities will become smaller.

Consumers can often choose between different supply-assortments (different retailers for example). If we, on a higher level, regard a supply-assortment as being a product in itself, so $g' = \hat{G}$ we can use the micro-economic choice theory to analyse the consumers' choice proc-

---

6   For theoretical reasons, Lancaster (1971) assumes that consumers not so much need specific products as well as a range of product characteristics (or services provided by these products).

esses. The probability that a certain supply-assortment g' is chosen over other assortments of the set $\hat{G}'$ is (applying the random utility choice theory, see also Section 7.2.5, Part II):

$$P(g') = f\left(U_{1,\hat{K}} \cdots U_{G',\hat{K}}, \xi\right) \qquad \qquad (14\text{-}3)$$

Below the different viewpoints of *searching for suppliers/assortment composition* are described in depth and the relevance for urban goods distribution will be shown:

- Levels in assortment composition.
- Virtual assortments.
- Different actors that compose assortments.

14.2.2 Different levels of composing physical supply-assortments

Well-known supply assortments are products, products on shelves and products in shops.

We also consider a *constellation of shops* to be an assortment. Users can also look for assortments of suppliers. These assortments can be found in shopping malls or shopping districts. One reason to support urban goods distribution is to maintain these efficient assortments of suppliers within urban areas. As with all types of assortments, the effort to compose large (convenient) supplier assortments may be translated in higher product prices. Because users can profit from these efforts (they themselves need less effort to compose their demand assortments), these higher prices will be accepted[7].
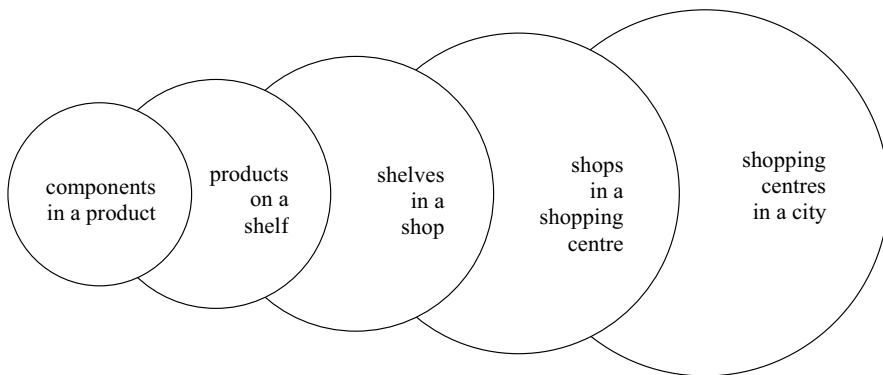

Figure 14-1:   Levels of composed assortments

Assortments of shops in a shopping area

In a city centre or a shopping mall, a specific combination of shops, and thus suppliers, are assembled by actors such as municipalities, real-estate investors and retail chains. In most *central shopping areas* a wide variety of shops can be found, and in general, more specialised shops can be found in very large centres (though there are some important exceptions). In most city centres, there are not many supermarkets or even traditional food shops; rather, convenience shops such as clothing, household goods, electronics, small furniture, toys and media shops dominate city centres. The composition of the assortment of shops naturally affects the type of goods that are distributed to these areas (D&P, 1999).

---

[7] This accounts for the difference in *upmarket* and *downmarket* retail strategies: very large assortments with relatively high product prices versus small assortments and discount product prices.

Increasingly competing with the old, existing central shopping districts are the shopping malls, which, in the Netherlands are mostly situated in newly built urban areas. Although these shopping malls are large, in general not many highly specialised shops can be found. The malls are largely filled with *chain stores* or *franchises*, as well as some department stores and supermarkets. Specialised shopping malls can be found especially in the fields of furniture, home decoration and the DIY market segment,. In the Netherlands, special spatial regulations apply to these peripheral[8] and large-scale shopping centres that may only contain large-scale stores in specific categories.

Assortments of products in shops
Products are displayed in a shop, in *aisles* and on *shelves*. Especially in terms of grocery products, these shelves form the ultimate battleground for competing producers. The way products are placed on a shelf makes it easier for a customer to pickup products and combine products to form an assortment; assortment composition can also be used as a marketing tool to make consumers buy a range of products. Given this importance of location, in specific cases producers or wholesalers may themselves maintain racks and shelves or even aisles. The complete distribution system of such companies is aimed at stocking the shelves in a store. However, in most cases retailers are responsible for the placement of products in their stores. This makes retailers important, powerful, actors within the marketing channel (see also Section 15.3.5).

The width and depth of assortments
The type of assortment that is brought together varies from *specialised* (deep) to *generalised* or *broad* (wide). The type of assortment strongly influences the physical distribution process because this process has to deal either with comparable products (*homogeneous assortment*) or with highly different products (*heterogeneous assortment*). The type of assortment can also affect consumer behaviour, especially *transport behaviour,* because shops range from single-product shops, such as clothing shops, via single producer (brand) shops to department stores claiming they sell everything. This results in different types of shopping patterns, such as *multi-trip*, *multi-stop* and *one-stop* shopping (see Figure 14-2).

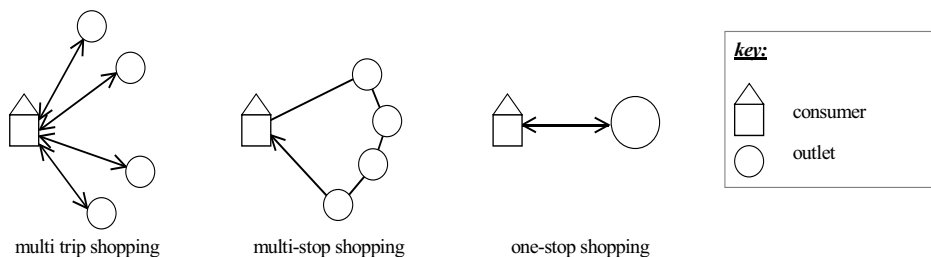multi trip shopping   multi-stop shopping   one-stop shopping

Figure 14-2:   Multi-stop versus one-stop shopping

---

8   Peripheral in relation to the central shopping areas; these centres are only allowed within a limited number of large built-up urban areas.

Assortments of outlets, such as city centres and shopping malls ease the consumer task of composing their assortments (multi-trip shopping can be replaced by single trip, multi-stop shopping). Combining wide assortments in single outlets can ease the task even more. Unlike inner city shops, this type of outlet does not need other shops in its direct surroundings.

In sum: the assortment composition at various levels strongly affects the complexity of the urban goods distribution process, the way the process is organised, and the shopping behaviour including transport behaviour, of consumers.

14.2.3 Virtual supply-assortments

Products can be virtually brought together through a paper or electronic catalogue and can then be chosen and ordered. The consumer composes an assortment virtually. Theoretically, no physical composition of assortments is necessary – each product can be delivered individually to the consumer. In that case, the teleshop retailer is only a virtual intermediary, involved in the marketing channel, but not involved in the physical distribution channel. For incidental deliveries, this can be an adequate system, but for larger volumes (and for more diverse assortments), this system is quite inefficient.

Then, some physical order-processing intermediate must be put in place – very much in the fashion of traditional distribution centres. However, there is one significant difference from traditional distribution centres: the outgoing individual shipments are quite small (intended for one consumer only), and the order-picking process occurs at the product level. The order-picking process is therefore very labour-intensive, and is no longer performed by the consumer, but by the shipper.

The distribution centre can be operated either by a singular *tele-retailer,* or by a generic logistic service provider that serves different tele-retailers.

Individual tele-retailers can distinguish themselves by the width and/or depth of the assortment[9], the pricing and the quality in delivery. In the future, this method of assortment composition may become quite important; it also fits neatly in the concept of network logistics, which will be introduced in Chapter 18.

On one way or another, goods must, in the end, be physically brought together to make it possible to use them. In the case where showrooms, teleshopping or mail order systems are used, the physical composition of the goods occurs in the ultimate destination (the home of the consumer, the office etc.) or in intermediate distribution centres.

In the case where other retail systems are used, the actual composition of goods occurs in two ways: the retailers and supplier compose the supply assortment (the products that are displayed in the shop), and the consumer composes the demand assortment, by picking a selection of goods from the shelves. The consumer does the end-distribution, to the final destination.

14.2.4 Relevance of assortment composition for urban distribution

The size and composition of supply assortments of retailers affect the complexity of the physical goods distribution processes. The assortments determine if the physical goods distribution process has to deal with heterogeneous or homogeneous shipments, and whether the process has to deal with small or large transport volumes.

---

[9]   Width: the number of different types of products; depth: the varieties in product qualities.

In the analysis of the marketing and distribution channels, later on, *power in the channel* plays a key role. Because retailers compose demand assortments, they often play a very important role in these channels (see Section 15.3.5).

Physical supply assortments ease the task of selecting and buying goods for consumers. Assortment composition may optimise transport for consumers as it physically concentrates the products they need within a compact area (or even within one shop). If the transport distances from the consumers to these supply assortments are sufficiently short (a requirement that is usually met with inner urban shopping areas), total transport distances may be reduced. In addition, walking, public transport and bicycling remain attractive transport modes – in contrast to stand-alone shops and malls outside urban areas.

From a logistics point of view, traditional shopping can be rather efficient because consumers compose their assortments themselves (order picking by the consumers) and often take care of the transport of the goods to their homes. In alternative systems, such as mail-order services and e-commerce, there is no direct need for physical assortments. Order picking and transport will become a task for shippers and will thus require fundamental changes in logistics.

14.3   Inventory

14.3.1 Introduction

The basic function of inventory is to act as a buffer between fluctuations in the volume of demand and supply of goods and even out other incompatible characteristics of demand and supply. The fluctuations have temporal as well as geographical aspects: inventories can overcome fluctuations in demand at certain places during a given span of time. For urban distribution, the stock keeping policy and the location where inventories are kept, are especially important: some advanced urban goods distribution concepts (as described later on) explicitly use storage facilities at different places for different types of goods, and also use the concept of *rolling inventories*.

14.3.2 Stock keeping policy

In the logistic chain, there are different reasons for storing goods for a given time-span. This storage is mostly a buffer between differing requirements in demand and supply. These requirements include timing, uncertainties, production batch sizes and speculative reasons. Here, we will only examine the first and second requirements.

If supply and demand do not occur at the same instance, phase, or pace, stocks are required to span the time gap. Neither demand nor supply are continuous processes, rather, they are discrete, or even batch, processes. For example, the supplying of retailers occurs in batch processes. The batch sizes depend both on the throughput of the retailer and the supply and stock keeping policy. This policy relates to the trade-off between inventories and transport as described in Section 13.2.3. If, at a given throughput or sales rate, delivery frequencies are increased, stock levels can be decreased. Here, the trade-off is the balance between transport costs (that are generally higher at higher delivery frequencies) and storage costs (depreciation costs that relate to the value of goods that are stored and also to the required storage space and operational storage costs; see Lancaster and Lomas, 1985).

To be able to understand such strategies, a distinction must be made between logistic control systems that directly respond to demand (*demand responsive systems*) and control systems that only react on user demand over the long term (*supply driven systems*).

In *supply driven systems*, products are distributed in bulk over the service area to retailers without advance knowledge about the actual demand. This system can be used for products for which demand is predictable and/or constant, for high sales-volume products, and for products for which storage costs are low. The associated physical distribution process should be able to distribute large quantities of goods at regular intervals; reliability and flexibility are not main requirements.

In *consumer response driven systems*, user demands directly influence the logistic process. As an example, Effective Consumer Response (ECR) is based on knowledge about consumer behaviour (sales), and directly uses the turnover information for making new orders.
This ECR can be based both on Molenberg & Schaaf (1992) and Van Goor et al. (1993):

- Advanced *order entry system* (OES), in which personnel order products by scanning product-specific bar codes at the shelves in the store and providing additional order information in terms of quantities.
- Checkout systems, in which products are scanned at the checkout counters, thus measuring sales; this information is directly transformed into orders.

The physical distribution system must be flexible and highly reliable. The physical distribution control system must be able to monitor and readjust the process. They must be able to alter destinations and inform addressees about expected times of delivery and delays. This way, addressees can anticipate on the deliveries and fine tune their internal organisation as well. Safety-stock minimisation is one of the reasons for implementing direct consumer response strategies. Everyone in the logistic chain is economising on supplies and storage, even if this means more transfers. Distribution centres of the future will therefore be more like places that actually distribute, and not act like storage facilities any longer. The interval between deliveries will decrease, the size of the shipment will also decrease in relative measure, and the time between ordering and delivery (lead-time) will become shorter. These logistic concepts can be realised for goods with short supply lines, and for organisations with a high degree of organisation and implementation of information technology
Direct consumer response requires high-frequency deliveries of products to retail outlets or to consumers directly. Rolling stock concepts require advanced logistic control systems. One setback for 'Just in time' distribution is that the system depends strongly on the reliability of the transport system. Weather conditions, congestion and other factors can affect the quality of the transport system, and thus affect the supply to outlets.

Large, consolidated flows are sometimes controlled by the consumer response systems as described above; this also applies to the distribution of books by a central delivery system, and other highly specialised logistic service providers or product categories.
In most other cases, flows are only controlled in an approximate manner. Trips are planned, but ad hoc deliveries can compensate for faults in the pre-planned scheme. Still, there are fewer possibilities to fine-tune the distribution process. Note that these less advanced ways of

logistic organisation control the largest part of the total distribution process, and therefore the largest share in goods traffic flows.

14.3.3 Location of depots: centralised or decentralised warehousing

If an operator handles multiple products, there is the potential for large differences in demand-characteristics (speed in turnover).

Therefore, actors such as retail chains especially use the well known 80-20 'rule of thumb', which expresses that about 80% of turnover (in currency) is realised by sales of products that count for only 20% of the product assortment (number of different available products). These products therefore are important and require special attention in stock policy and in the total logistic chain. This special attention relates to the number and location of depots, also known as the dilemma between centralised or decentralised storage concepts.

With centralised storage, there are only a few depots from which a broad service area can be supplied. This results in longer transport distances between the depot and the users, but induces a better insight in stock-levels and prevents the necessity of repositioning goods if market conditions in different service areas do not meet expectations. Centralisation of stock is appropriate:

- When the distribution network is designed for inter-company transfer or known quantities of replacement goods.
- When a broad range of high value per volume products[10] is required over a wide geographical area.

In decentralised depot concepts, products are stored rather close to the intended users.

A well-spread, and thus decentralised network of depot/warehouses is desirable:

- When rapid service for sale is needed.
- Because the inherent nature requires short transport distances (e.g., food products).
- At intensive competition, especially when it concerns products with a low value/volume ratio[11].
- Lower transport costs because of homogeneous loads.

The specific characteristics of centralised versus decentralised depots are, combined with product characteristics, used to build the logistics network concept.

14.3.4 Inventories on the move

If an operator handles multiple products, there is the potential for large differences in demand-characteristics (speed in turnover).

Therefore, actors such as retail chains especially use the well known 80-20 'rule of thumb', which expresses that about 80% of turnover (in currency) is realised by sales of products that count for only 20% of the product assortment (number of different available products). These products therefore are important and require special attention in stock policy and in the total logistic chain. This special attention relates to the number and location of depots, also known as the dilemma between centralised or decentralised storage concepts.

With centralised storage, there are only a few depots from which a broad service area can be supplied. This results in longer transport distances between the depot and the users, but in-

---

[10] Comparable to the group of 'speciality products' and 'slow movers', introduced later.

[11] Comparable to the group of 'commodity products' and 'fast movers', introduced later.

duces a better insight in stock-levels and prevents the necessity of repositioning goods if market conditions in different service areas do not meet expectations.

Centralisation of stock is appropriate:

- When the distribution network is designed for inter-company transfer or known quantities of replacement goods.
- When a broad range of high value per volume products[12] is required over a wide geographical area.

In decentralised depot concepts, products are stored rather close to the intended users.

A well-spread, and thus decentralised network of depot/warehouses is desirable:

- When rapid service for sale is needed.
- Because the inherent nature requires short transport distances (e.g., food products).
- At intensive competition, especially when it concerns products with a low value/volume ratio[13].
- Lower transport costs because of homogeneous loads.

The specific characteristics of centralised versus decentralised depots are, combined with product characteristics, used to build the logistics network concept.

14.3.5 Relevance for urban goods distribution

Efficient transhipments of goods and consolidation and deconsolidation activities may require the introduction of intermediate storage at urban distribution centres. If this becomes an additional storage point within the logistic chain, overall levels of stock and thus costs could increase. However, these intermediate storage points can also be used to:

- Centralise urban storage facilities for multiple outlet chains.
- Provide storage at relatively low costs near (but not within) inner cities.
- Relocate storage facilities in indirect distribution channels.

The intermediate storage facilities can also be used to optimise logistic chains. If a storage facility in a *local* or *regional transfer point* (LTP/RTP) acts as a replacement or better still, as a concentration of stock elsewhere, the total amount of stock that must be kept can be reduced. Thus, in general, the creation of storage facilities on LTPs must not be ruled out as a bad idea: these facilities *can* be used in such a way that total inventory decreases, and total storage costs can therefore be reduced.

14.4   Conclusions

In this chapter, we have shown that the basic logistic activities are each relevant for urban distribution and for the development of new logistic systems.

We have shown that *assortment composition* is a basic logistic activity that eases the product-gathering task of users (including consumers). Assortments can be composed at different levels. An *urban shopping area* is one of the ways of consolidation that is quite valuable for consumers, and therefore needs support.

---

[12]   Comparable to the group of 'speciality products' and 'slow movers', introduced later.

[13]   Comparable to the group of 'commodity products' and 'fast movers', introduced later.

Together with the cost of individual goods, the assortment of retailers and the availability of the assortment are the main competitive tools within marketing. The physical distribution process must be tuned to the characteristics of the various assortments and related required levels of service to ensure this element of competition. This implies that new physical distribution systems must allow differences in delivery quality (related to costs) and must enable the efficient management of various types of assortments.

The new logistic systems must be able to handle different types of *inventories*, ranging from high-volume flows of 'fast movers' to relatively small flows of 'slow movers'. The inventory system must handle high and low value goods, general groceries and perishable goods. The new logistic systems can use insights about the desire for centralised inventories for *specialities* and the desire for decentralised inventories for *commodities*. Centralised inventories must be located close to suppliers, while decentralised inventories close to the users.

From a theoretical point of view, inventory-keeping policies demonstrate that high-frequency deliveries reduce storage levels because supply can better be attuned to demand. This principle can, in general, be applied to other decision-making processes: shortening the 'interval-times' between decisions will diminish inefficiencies and may increase efficiency. If transport fits the needs of shippers exactly, minimum safety stocks are needed: the transport process occurs just in time.

15. Consumer demand and marketing channels

15.1 Introduction

Two significant trends that affect the demand for goods are demographic and economic developments. Both types of developments influence the type quantity of goods that are in demand, as well as the location where demand increases. However, these can be characterised as exogenous developments.

The marketing and goods distribution processes must follow this changing demand. Marketing channels represent the way products are traded and eventually are sold to consumers: the structure of the marketing channel must be adapted to the demands. Actual goods flows are not necessarily a physical representation of the marketing channel, because some actors in the marketing channel can be bypassed in the physical distribution process (and some actors in the physical distribution process may not be active actors in the marketing channel). Nonetheless, it is critical to analyse marketing channels because these channels strongly influence the way physical goods distribution in urban areas is organised. This chapter will therefore introduce the actors of the marketing channels, and will analyse who has the 'power in the channel' and how this influences the physical distribution system. First, we will classify the different forms of marketing channels, then we will analyse the relationship between marketing and physical distribution channels (the latter will be elaborated in Chapter 17).

15.2   Developments in consumers demand

15.2.1 Introduction
The volume and type of goods traded depends on demographic developments, including the size and composition of the urban population, and economic developments. These developments indirectly influence the way the marketing channels must be structured.

15.2.2 Demographic developments
The relation between population size and volumes of transport of goods is evident. However, population composition also plays a role. For instance the ageing of the population will certainly have an impact on consumption. However, a transition, for the purpose of using it in models, to freight moves is missing.

In the period from 1990 to 1997, the Dutch population has grown with by average of 0.6 percent each year. The population size in 1995 was 15.5 million people.

For the Netherlands in the year 2020, a population size between 16.2 and 17.7 million people is expected (CPB, 1997). Such a population growth will have an impact on the total annual consumption of consumer goods and thus on transport volumes. A simple conclusion is that with an increase of the population, the demand for goods will rise in a linear fashion.

15.2.3 Economic developments
There is a strong relationship between economic growth, consumption and the distribution of goods. However, it is no singular relation. Economic growth leads in general to consumption of more expensive goods. Economic growth also means the use of more 'expensive' transport and distribution means. Higher transport demands introduce specialisation in transport, and thus, market segmentation.

The annual economic growth between the years 1974 and 1995 in the Netherlands was 2.2 percent per annum. For the period of 1995-2020, the annual economic growth will be somewhere between 1.5 and 3.3 percent (CPB, 1997). The elasticity of freight transport volume in relation to economic growth for the period of 1995-2020, will be between 0.80 and 0.89: per percent economic growth a percentage of 0.80-0.89 increase of freight transport (in tonnes per year) is expected. In the period from 1964 to 1995, this figure was 0.64 for all freight transport, and 0.44 for domestic freight transport.

Income development and consumer spending have a more direct relationship with the demand for consumer goods than the economic growth indicator. The real disposable income in the Netherlands has grown. This means that private consumption has also grown. In 1995, about 377 billion Dutch guilders was spent on consumption, for an average of 24,400 guilders per year per inhabitant, or 57,800 guilders per household.

The consumer spending per inhabitant has grown yearly on average in the Netherlands with 4.1 percent in the period from 1990-1997 (not corrected for inflation). This growth also led to an increase in consumer spending on food and durable consumer goods. About 42.3 percent of it was spent on goods and 56.3 percent on services (HBD, 1996). About 72 percent of the goods were purchased in shops. The share of spending on foods in total consumer spending amounts to about 14 percent in 1997. At the same time, the share of consumer spending on durable consumer goods decreased to about 18 percent. This means that less and less of the

income growth was spent on goods. This process, known as dematerialization, can have serious consequences for the expected relationship between economic growth and the distribution of goods.

Dematerialisation

In a number of economic sectors, dematerialization trends are noticeable (Geurs & Van Wee, 1996). Dematerialization concerns a shift from the consumption of consumer goods to consumer services. This also means a reduction of weight per guilder good (value-density) or added value. This development is influenced by technological developments but also by an increase in well-being (increase of the consumption of more expensive consumer goods). This means that an increase of spending on, products such as consumer durables will not necessarily mean a proportional increase of transported weight.

Differentiation of consumer demands

In relation to current consumer behaviour, the term mass-individualisation has been introduced. The coupling of the efficiency of mass-production and mass-distribution systems to meet the individual needs of the consumer which is needed because the consumer operates in a more individual fashion ("individualisation"). This is expressed in different ways:

- The average consumer is more experienced, spoilt and demanding than ever before, not only near the quality of the product, but also in relation to the price, choice and the ambience within shops. This leads to an increasing demand for better quality products, better quality shops and direct-on-the-spot delivery. It also leads to a consumer preference for large shopping facilities with a broad variety of products to choose from.
- There is also an large group of 'have nots', who depend on discount shops;
- There is also a group of seniors. This is a growing market, due to the ageing of society. However, besides a reasonably well-off middle group, there is an elite group of *golden enjoyers* as well as a group of *minimum wage earners*. These groups show different consumer behaviour.
- More and more retail concentrates on non-native inhabitants or is started by non-native inhabitants; this is known as *cultural diversity*.

These trends lead to further market fragmentation in terms of products and shops. In terms of the distribution of goods, this means that the goods flows will become more diffuse.

15.3   The structure of marketing channels

15.3.1 Introduction

A marketing channel is a string of actors that, as a collective, perform all actions to interconnect producers and users (consumers) aimed at fulfilling the marketing-task (Verhage, 1995); adapted). The marketing task is the task of selling products to users (consumers) in such a way that the actors' objectives are best fulfilled. Actors can be producers, trade intermediaries or retailers; their objectives can be represented as 'utilities'. The different actors fulfilling the marketing requirement in fact form a network that accommodates marketing channels (see Section 15.3.4).

15.3.2 Direct and indirect marketing channels

Products can be directly delivered from the manufacturers to the consumers - this is the case in *direct marketing channels*; these channels do not include trade intermediaries.

In *indirect marketing channels* one or more trade-intermediaries is included[14], where the intermediary that sells the products to end-users (consumers) is referred to as the 'retailer'. Retailing can take the form of direct sales, tele-shopping or mail-order sales, but is usually performed in retail outlets.

A product can be sold via one channel or one type of channel (exclusive marketing), via multiple, parallel marketing channels (intensive marketing, mass marketing), or via an intermediate type (selective marketing).

The choice strongly depends on the marketing characteristics of products (see Part II). Intensive marketing can be used for speciality goods and some 'slow movers'. Intensive distribution is most appropriate for goods with short searching times and 'fast movers' (Verhage, 1995).

Various authors have described the *taxonomy* of distribution, trade or logistic channels in which trading intermediates and storage facilities are introduced (see for example Huijbregts, Jansen and Simons, 1997 and Weijers and Janssen, 1997). We use a fundamental approach in which a distinction is made between the marketing channel (describing all market intermediates) and the physical distribution channel, (describing the physical distribution channel) (McKinnon, 1989). This distinction is relevant because the actors within the distinctive channels can be different and *trade flows* may be quite different from actual *goods flows*. The analysis of marketing channels is relevant, because the marketing channels steer the physical distribution process.

Figure 15-1 shows examples of marketing channels that start with *suppliers:* that is*,* manufacturers or importers of final products or consumer products.
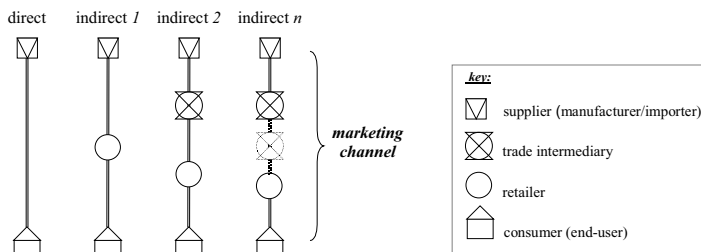

Figure 15-1:   Examples of marketing channels

15.3.3 Trade intermediaries

There is a multitude of suppliers and there are even more consumers. Therefore, there would have to be an enormous number of trade relations if each consumer for each product had to deal with the products' producer and vice versa. Trade intermediaries reduce the number of trade relations and thereby simplify trade and reduce total transaction costs: if the number of producers is *n* and of consumers is *m*, there are $n \bullet m$ direct trade relations.

---

[14]   Bowersox et al. (1986) distinguish a whole range of trade intermediaries: regular wholesalers, industrial distributors, drop shippers, cash-and-carry wholesalers, wagon distributors (jobbers), rack jobbers, assembling wholesalers, and semi-jobbers.

By introducing one trade intermediary, the total number of trade relations drops to $n + m$ (McKinnon, 1989; see Figure 15-2):
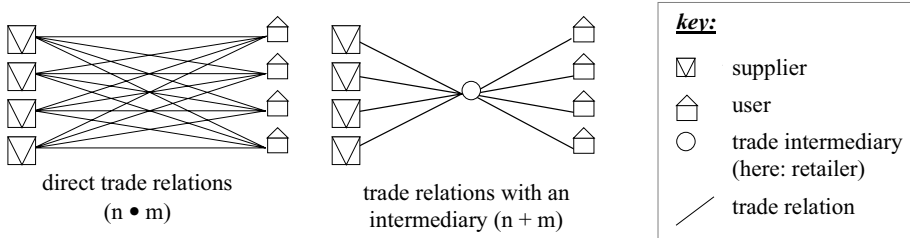

direct trade relations
$(n \bullet m)$

trade relations with an
intermediary $(n + m)$

key:

☑   supplier

⬠   user

○   trade intermediary
(here: retailer)

╱   trade relation

Figure 15-2:   Introduction of intermediaries reduces the number of interactions

It is efficient to use intermediaries for trade, because for individual consumers it would take too much time to select and collect the products they need from the numerous producers (assortment composition). For the producer, it would not be very efficient either if they had to deal with all individual consumers. It should be noted that there are exceptions, especially in the fields of high-value consumer products, agricultural products, and handmade products (including art), where direct trade relations do exist.

In some cases, producers still deliver products directly to their consumers. They thus have a direct (trade-) relation. More often, wholesalers and/or retailers function as intermediaries. They become the temporary owner of the products they process. In these cases, a marketing channel is formed: successive parties in this channel (temporarily) own the products, before reselling them to their consumers.

15.3.4   Alternative channels for similar products

The marketing channels that are used to sell products emerge from the interactions between suppliers, producers, trade intermediaries and retailers. Product and market characteristics of the actors influence these interactions, as is explained in Section 15.3.5.

These different channels will generally have different price and service characteristics that are expressed in consumer prices, availability and additional features such as after-sale services. For marketing actors, the alternative marketing channels offer different 'utilities' of which they choose the most appropriate one or ones, because actors can also choose to market their goods via dual or parallel channels (Verhage, 1995). If products are sold via parallel channels, users (consumers) can choose between these alternative channels to obtain a given product.

Figure 15-3 (top) shows how a *marketing network* can represent the *trade links* and actors that all have *price* , *quality* or other attributes[15]. All feasible paths through the marketing network represent potential marketing channels, alternatives that can be generated and represented using the *enumeration* methodology (Figure 15-3; bottom). These enumerated alternative channels (numbered 1 ... 5 in the example) return an individual net utility. Using standard network analysis methodologies, the behaviour of various actors[16] in the marketing channel can be modelled.

---

[15]   Another criterion may be 'assortment' that can be associated with a node (intermediary) in the network; also 'composite criteria', such as generalised costs, may be used.

[16]   These actors can be producers, trade intermediates and also users (consumers), though all actors may have a different perception of the respective utilities of the alternative channels (see also Part II on 'utilities').
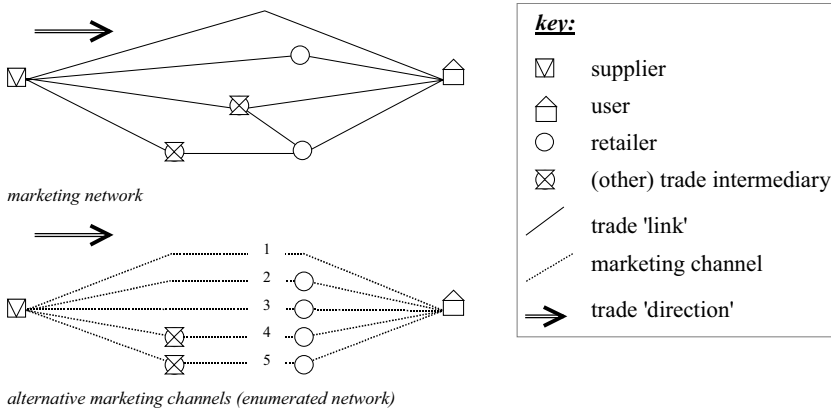
marketing network

alternative marketing channels (enumerated network)

Figure 15-3: ***A network representation of alternative marketing channels***

Suppliers can use a representation of potential channels to choose the most appropriate channel(s) to sell their products. Intermediaries can use a network representation to either estimate the throughput of their outlets (*intensity estimation*) or to analyse their competing position (*selected link* analysis). For these types of analyses, all relevant users, suppliers and competing outlets must be included in the network representation.

15.3.5 Channel director: the power in the marketing channel

The most powerful actor in the marketing channel can, to a large extent, decide how the marketing channel must be organised and thus also influences the organisation of the physical distribution channel. For the analysis of urban distribution activities, it is therefore important to know that different channel directors can have different optimising strategies, that then lead to different types of distribution channels (see also Verhage, 1995).

Consumers can seldom directly express their preferences, which are influenced by available assortments or by advertisement campaigns. Generally, individual consumers do not have much influence on producers and retailers and thus on the marketing channel. Only if the individual consumer's demand strongly impacts the production process (artisanal and piece production) or the required logistics, can one argue that consumers have a strong influence on a specific channel. If consumers unite as a group, they can negotiate deals with suppliers.

In most marketing channels, ***retailers*** are the last link that interacts with consumers. Therefore, retailers often have direct insight into consumer preferences and can influence consumer decisions about purchases. Because consumers often do not have preferences for specific products, but merely for product characteristics (Lancaster, 1971), this implies that assortment composers (retailers, wholesalers) are able to modify consumer demand for specific products.

Retailers can operate on their own, but are increasingly organised in some way or another. Most common are (see Verhage, 1995):

- Central buying organisations, working for independent retailers.
- Franchise organisations in which independent retailers use a uniform *formula* including the marketing organisation, product range and so on.
- Retailer chains.

In addition, some combinations are possible.

By composing supply-assortments, retailers can decide which products to include in their assortment. They can therefore strongly influence the success of a product, new or old. This means that within this type of marketing channels, retailers are quite powerful.

Retailers can gain influence in the channel (directed to producers):

- If they control a major share of the market, especially so if they are organised in some kind of chain.

and by (directed to consumers):

- Marketing (advertisements, including image building).
- Pricing.
- Creating specific assortments, as in the case of *authorised dealerships*.
- Customer service (after sales).

As **wholesalers** have generally no direct contact with consumers, it is difficult for them to gain a strong position in the marketing channel. The only way in which wholesalers can become indispensable is to become a really large market player (in relation to the niche market they are operating in), and thus influential. Wholesalers can gain influence in the marketing channel if they obtain exclusive selling rights for some products, or if a large share of producer output and retailer supply is directed via the wholesaler (*monopolist* or *oligopolist)*. In marketing channels that incorporate relatively small retailers, wholesalers can be influential, and therefore deserve attention in urban logistics analysis.

Large **producers** seldom have direct trade relationships with consumers – intermediates such as wholesalers and retailers usually interact with consumers. Therefore, it is difficult for producers to obtain a dominant position in a marketing channel. Only producers with a well-known name (brand) or product that has a large turnover can dominate the marketing channel, sometimes even to such an extent that retailers (and wholesalers) are more or less *obliged* by their consumers to include certain products of these producers in their assortment. Examples of such products and related producers include: Coca-Cola (Coca-Cola Inc.), Windows (Microsoft), Heineken beer (Heineken) and Douwe Egberts coffee (DE-Sara Lee). Note that the power of such producers is often based on a relatively limited range of *products*, although they may produce a broad assortment.

For most urban goods distribution activities (expressed in transport volume), retailers or retail organisations are the most powerful players – they strongly influence the marketing channels and thus the physical distribution channel organisation. Nevertheless, some market-branches producers, wholesalers and even consumers can direct the channels.

This means that when designing new urban distribution concepts, the role of retailers must be taken into account quite seriously. Their distribution preferences must be very well accommodated.

15.4   Marketing channels related to physical distribution channels

15.4.1 Introduction

Marketing channels represent the succession of trade intermediaries that are involved in trading goods from producers to consumers. The strategies that are used to sell products significantly influence the physical distribution processes because the type of goods, the requirements with respect to the distribution quality, and the destinations of the goods are determined by the marketing channels. Therefore, an analysis of these marketing channels is essential for a good understanding of the physical distribution channel.

15.4.2 Traditional marketing channels

In 'traditional' marketing channels, products are sold via retail outlets. Consumers buy their products in those shops: they have a customer relationship with the shop-owner or retailer. In turn, the retailer will have a trade relationship with suppliers (who may be producers, wholesalers or importers). The associated physical distribution channel can be quite similar to the marketing channel, but may include some additional intermediate storage and sorting activities. Logistic service providers may perform these tasks (see Figure 15-4 for an example).

Where goods and product characteristics provide some important handling and transport preconditions that affect the setting-up of the physical distribution channel, this channel is also strongly influenced by the marketing philosophy – or the market niche that the retailer aims at, and thus the type of supply assortment of the retailer.
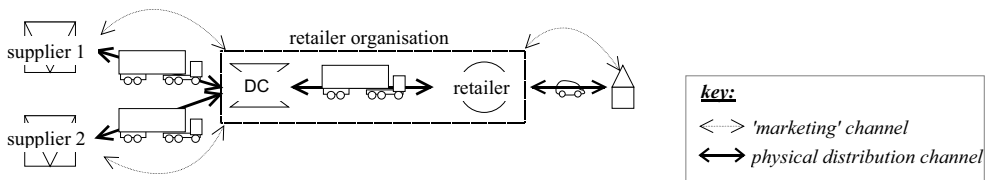

Figure 15-4:   *Example of a 'traditional' marketing and physical distribution channel*

The required service quality, the assortment characteristics, and the size of the total throughput have an impact on the structure of the physical distribution channel.

The required service quality affects the required response of the supply organisation in terms of demand. Optimisation of the supply organisation can be aimed both at consumer satisfaction and/or at minimisation of stocks. In efficient consumer response (see Section 14.3.2) both aims are united. The required service quality relates especially to the swiftness, accuracy and frequency of the distribution system. The characteristics of the supply assortment will influence the complexity of the physical distribution process. It determines the number of suppliers, the need for collection depots, and the opportunities for consolidation. As stated above, the individual goods characteristics of the assortment will set some preconditions.

The total volume will determine the intensity of the distribution. It therefore has an impact on the vehicle size that can be chosen and also on the delivery frequencies.

Broad assortments require integrated collection/distribution systems, because a wide range of products from various suppliers must be brought together. Generally, broad assortments lead to complex goods flows that require advanced logistic control systems.

With respect to the distribution process, a required high quality service usually requires a specialised distribution system that enables or assures tight quality control and offers either high-frequency or right on time' delivery. Large throughput volumes require a high-capacity distribution system that results in the use of large vehicles and/or high delivery frequencies.

Note that the type of marketing channel influences the structure of the physical distribution channel, but that there are other influences as well. Traffic and geographical conditions, the available traffic systems and the way transport companies are organised themselves (various ways of co-operation) also influence the structure of the physical distribution channel.

15.4.3 Shopping facilities

In 1995 in the Netherlands, about 181,300 sales points were registered (Centraal Registratiekantoor (CRK)), of which 65 percent were enterprises with one sales point, 22 percent were franchise companies and 13 percent were street trading. There are about 900 daily and weekly street markets in the Netherlands where street trading occurs.

Shopping facilities (with the exception of street trading) can be expressed in floor space (square metre sales floor space). In the Netherlands about 16 million square metres of sales floor space is available (HBD, 1996). Bolt (1995) observes a linear relationship between the growth in consumer spending and growth of sales floor space. A one percent growth in consumer spending goes together with, on average, a one percent growth in sales floor space. About 1.3 million square metres floors space was in a planning stage (in 1995), among which 0.85 million square metres at peripheral locations at the border of urban areas in *peripheral retail establishments* (PDVs) and *large-scale retail establishments* (GDV). Besides these locations, factory outlets have also been introduced in the Netherlands.

Peripheral retail establishments (PDV)
For a long time the development of stores "out in the fields" did not fit into the spatial planning policy. As a result, peripheral retail establishments (in Dutch: "perifere detailhandelsvestigingen (PDV)") were narrowly defined: these locations were originally intended for sales of goods that posed a risk of fire or explosion, as well as and for bulky goods. These types of establishments at the time included interior decoration and furniture stores, construction supply stores, garden centres, kitchen centres, and mobile home dealers. The location of these establishments was peripheral in the sense that it was outside of, or not connected to, an existing concentration of stores. The problem is that these establishments are now growing into centres with many more types of goods for sale. Besides mobile homes, there are now also tents and camping articles for sale, and besides furniture, stores also carry clocks and dinnerware. As time went by, "bulky goods" became "many, many choices", so that now many different types of stores have established themselves in these locations. For the traditional cities, the development of the peripheral retail establishments meant a change in the passenger and freight traffic streams. As a result, certain kinds of traffic problems have disappeared from the inner city. For the city as a whole, however, there is a shift from the use of slow and public transport to private cars. The peripheral centres are, as the name implies, less centrally lo-

cated, and are "at a greater distance for more people". Because they are situated in C-type locations (locations without public transport), they are also designed mainly for the car driver.

Large scale retail establishments (GDV)

A recent development is the "large scale retail establishment" (in Dutch: "Grootschalige Detailhandel Vestiging (GDV)", permitted by the government on "B-locations" (locations with simple public transport facilities) within the 13 main urban areas of the Netherlands. Each type of retail trade is allowed, in principle, to establish itself at these GDV locations, a minimum size of 1500 m^2 gross sales surface per store being the only regulatory condition.

The question here is if municipalities other than those of the 13 urban junctions might not also like the concept of the GDV. Through expansion of peripheral retail establishments (PDV), it is obviously possible to create "pseudo GDVs". If this development cannot be opposed effectively, the mobility effects will of course be considerably larger. Peripheral shopping centres are almost ideal with respect to freight traffic: the accessibility of the centres from the through roads is usually optimal, and the provisioning is relatively simple (there are provisions here so that other traffic is not bothered during loading and unloading). In spite of their location within the urban junctions, the accessibility of the GDVs is expected to be reasonably good. Special loading facilities will be created at the GDVs as well.

Factory outlets

For commercial and strategic reasons, in some branches, the production industries try to find ways to bypass the wholesale and retail establishment in order to deliver directly to the consumer, for instance by developing their own retail chains. An example of this is the factory outlet. Another strategy of the production industry is to use teleshopping as a tool for direct sales to the consumer. Factory outlets can be found in the USA and resemble suburban shopping centres. The difference is that the shops are related to certain production companies and sell mostly luxury goods of particular brands, based on clearance sales. Initiatives have been taken in the Netherlands to introduce these, but they have not been welcomed by the national government.

Competition

The city centre has played an important role for a long time as a market place for consumer goods. The shopping areas in city centres face competition from shopping malls such as those dedicated to home furnishing ("woonboulevards" in Dutch) in suburban areas. These areas are accessible by road and have cheap and large parking facilities for customers. Most shopping areas in city centres are poorly accessible by road due to congestion and vehicle and time restrictions, which also influence urban freight traffic. This will make inner cities less attractive for shopping activities, and in combination with competition from new shopping areas outside city-centres, this can endanger the economic and other functions of inner cities. The economic function is very important for the overall attractiveness of the inner city. For this reason, it is important to find methods that guarantee an efficient distribution of goods in urban areas from an environmental and economic point of view.

Peripheral shopping facilities and main shopping centres show strong growth potential. Based on investments in shopping facilities, Bolt (1995) estimated the growth expectations of different types of shopping centres (Table 15-1).

Table 15-1:   ***Growth expectations of different types of shopping centres (Bolt, 1995)***

Type	Growth expectations
Theme centres, outlet factories, PDV, GDV	++
Agglomeration-, regional main shopping centre	+
Local shopping centre	0
Quarter, district or large neighbourhood shopping centre	0
Neighbourhood centres	-

This potential has to do with the upscaling processes that are occurring. In order to attract more customers, shops and shopping centres become larger, provide more choice in their assortments or provide more expensive products. All these things demand a larger service area. This process is referred to as the spatial upscaling process. For instance, the number of supermarkets in the Netherlands has decreased, but at the same time, the total floor space has increased. This means fewer but larger supermarkets. This process favours the new shopping areas at locations where enough space is available. A competitive battle for the consumer is occurring, especially between shopping centres that have a regional service function. The municipal authorities, in particular, by renewing and enlarging the shopping facilities, are doing their utmost to prevent the leaching of purchasing power to the competing municipalities.

Teleshopping

Teleshopping makes it easier for consumers to order their goods somewhere else and to get it delivered at home. The technical facilities for teleshopping are increasing. The chances that these facilities will be used are also increasing. It is therefore likely that home delivery of goods will increase. In certain markets, the share of teleshopping has already risen. These goods also will be delivered in smaller quantities. It is expected that these goods come from longer distances. At the moment teleshopping only involves certain specialities (books, CDs, electronic equipment) but it is expected that in the future, daily goods, such as groceries will be ordered by teleshopping. A small-scale introduction is already occurring in several countries.

Home delivery is traditionally the purview of large transport companies that are specialised in regional or local distribution, for instance PTT and Van Gend en Loos (transport companies specialised in post and parcel service respectively). With teleshopping, international couriers, such as UPS and TNT will also enter the market. Couriers principally use vans or small trucks. Their service is based on speed and reliability. At the moment, consolidation hardly occurs at the regional level. However, because of the expected growth of vehicle movements of vans and light trucks in urban areas, this aspect must be considered seriously.

 Searching for suppliers, as an activity performed by retailers, is strongly influenced by the way the retailers are organised. Mergers, strategic alliances and virtual co-operation[17] (such as the WorldWide Retail Exchange, see Rost van Tonningen, 2000; Retail Industry, 2000) lead to internationally operating retail organisations. These co-operating retailers search for suppliers at an international scale, especially in the field of food retail (supermarkets, groceries), household articles (department stores) and to a certain extent, electrical appliances (department stores and speciality stores).

---

[17]   Electronic trade between firms: 'business-to-business' (B2B).

At the same time, mergers and alliances are also unifying suppliers. At first sight, these developments would seem to have no direct impact on urban distribution; however, these developments will have a strong impact on long-haul transport. The *regional* character of urban distribution will shift to a national and even international level. This opens perspectives for logistic concepts that treat long haul transport and short distance distribution differently, for example concepts for intermodal transport. Eventually, these consolidation developments will have a strong impact on the design of new urban physical distribution concepts (Chapter 18).

E-commerce (or E-retail) is a specific type of marketing channel in which the physical occurrence of a shop is omitted[18]. As explained earlier, supply assortments may only be virtually composed. Theoretically, different suppliers can use their own physical distribution channels to bring different products to the user, forming a *demand assortment* no earlier than at the premises of the user. In most cases, the e-retailer will have (or control) a dedicated physical distribution process that composes the demand assortment somewhere earlier in the channel. An example is the Dallas, Texas (USA) based GroceryWorks, which has no shops, but rather distributes goods from their own warehouses and directly from suppliers' warehouses (*virtual warehousing)* to consumers (NT, 2000). In e-commerce distribution, professional transport companies bring goods to consumer homes (see Figure 15-5).
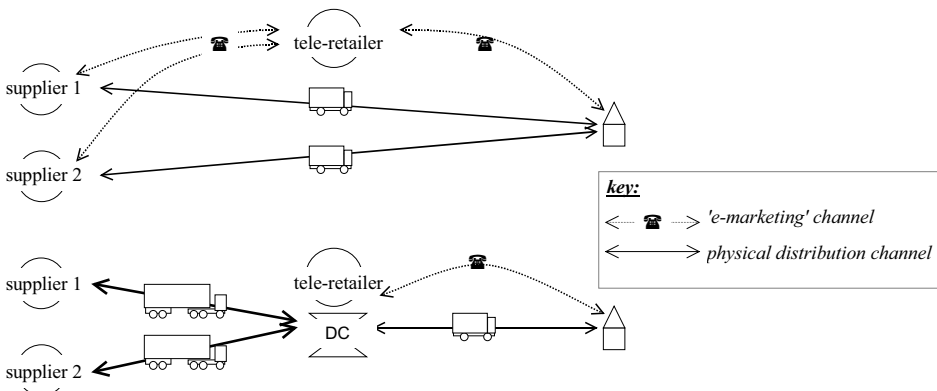

Figure 15-5:   *Examples of e-commerce marketing and physical distribution channels*

Order picking and end-distribution to final addressees are very expensive logistic activities. Therefore, in the future it might become uneconomical to deliver products that are sold via e-commerce channels, directly to the homes. As an alternative, goods can be delivered to neighbourhood distribution centres. From there, consumers can collect their products.

E-commerce can be performed by either (traditional) retailers or wholesalers, but also by producers (direct sales) and 'new' e-retailers (or mail order retailers). Traditional retailers are likely to start using the existing logistic systems for the distribution of products sold via e-commerce. If traded volumes rise, the logistic systems can be fine-tuned to the e-commerce marketing channel. In a way, most new e-commerce and mail order retailers also use existing distribution channels ; not their own channels, but 'public' distribution channels such as postal, package and express services. If trade volumes rise, the 'public' physical distribution channels may no longer be sufficient, and new distribution channels will have to be developed.

---

[18]   Electronic trade between firms and consumers: 'business-to-consumers' (B2C).

Eventually, both the 'old' and 'new' players in the e-retail channel will use one of the four possible channels:

- A dedicated, newly developed physical distribution channel, if trade volumes are high;
- An existing traditional marketing channel with some adaptations for end-distribution to consumers for medium volume trade volumes;
- A joint/combined channel for different e-retailers, also for medium trade volumes;
- A public distribution channel, like the postal service, for relatively small trade volumes.

15.4.4 Developments in retail activities

The general trends in the retail trade include:

- Market fragmentation and specialisation;
- Shorter product life cycles of products;
- Broadening of the assortment;
- Decrease of storage space;
- Development of convenience shops;
- Co-operation and internationalisation;
- Sliding and extending of shop opening hours;
- Embedding of information technology in logistics services and customer services.

Market fragmentation and specialisation

Increases in scale and specialisation are current trends in the spatial organisation of shopping facilities. In traditional urban shopping districts, certain types of stores, such as food and furniture stores, have virtually disappeared. Although developments seldom occur in only one direction (supermarkets, for instance, are now returning to the centres of the big cities), it is possible to conclude that a certain amount of specialisation is occurring:

- Franchise and branch businesses, and possibly department stores in the city centres ("main streets");
- Small scale retail trade also in the city centres ("side streets");
- Supermarkets, and small scale retail trade serving the local area, in the neighbourhood shopping centres;
- Large-scale retail trade (measured by store area) to the peripheral areas.

Shorter product life cycles

Products now have shorter life cycles. This has to do with technological progress but also with trends in fashion. The individualisation mentioned before, has led to a variety of fashions and also leads to mergers between them. This process generates a fierce competition between 'equal' products and reduces the life cycle of products. Shorter product life cycles are one of the driving forces of Just-In-Time logistics.

Broadening of the assortment

In the supermarkets, in particular, a broadening of the assortment of articles offered has taken place. The average number of articles carried by a supermarket has increased from 1000 in 1960 to 6500 in 1996 (Boerkamps et al., 1999) and up-market chains such as the Dutch Albert Heijn chain, currently carry approximately 13,000 different items, depending on the size of

the supermarket. Department stores, on the other hand, have not followed this strategy. The competition with the supermarkets and the specialised retail trade has led to a narrowing of the assortment offered.

Decrease of storage space
The retail trade hardly keeps any stock in the store any more. What supplies that are stocked are kept in the store. A further reduction of what is kept in stock is hardly possible.

Convenience shops
In addition to the stores in the shopping neighbourhoods and in the peripheral locations, a type of convenience store is developing where the consumer happens to be at the moment, such as gas stations, train stations, sports fields, schools, and offices. These outlets sell mainly convenience items (HBD, 1996). All supermarket chains have plans to create convenience stores, either alone or in combination with the catering industry to create fast food formulas.
The ambulant trade is becoming more prominent. Retailers with fixed stands are appearing at locations where the consumer arrives by car, or at public transport transfer locations.

Co-operation
Besides the establishments of well-known large stores, more co-operative efforts between medium and small sized enterprises are becoming visible. These may be franchise establishments or individual stores. Examples are supermarkets that operate under a "formula name" (HBD, 1996). The formulas are developed by the supplier or wholesaler, or sometimes by the manufacturer. HBD (1996) concludes that there is an increase in co-operation between businesses representing different branches of the retail trade, as well as between different business sectors. Of concern here are co-operation in the areas of logistics, advertising and promotion, but also the sharing of store space (HBD, 1996). An increasing number of retail businesses are operating on an international scale. In the Netherlands, approximately one hundred retail businesses are active internationally (HBD, 1996). This may mean that provisioning will acquire an international character.

Sliding and extending of shop opening hours
Changes in the legislation on store opening hours have initiated a trend towards extended and *sliding* store hours, where stores have longer opening times, but may also close and open at later times. Shopping patterns then adapt to this trend, so that the customers start to shop at different hours. The periods of time in which stores can be provisioned are becoming ever shorter. Increasingly, stores do not open before 10:00, or even 10:30 a.m. This would mean that transporters who have to deliver goods to personnel might have only one hour or one half hour left to make their trip through the downtown area (usually, entrance time limitations start at 11:00 a.m.). This creates a problem for the transporter who has to visit several addresses. As the number of zones with restricted traffic increases, more and more businesses will be confronted with this problem.
A second point of interest is that the liberalised store hours can cause changes in the locations where people shop (to different stores or shopping centres). Stores, that are open longer hours, can benefit from increased business at the expense of those stores that do not.

Information technology
The use of scanning and email technology (EDI) allows an optimal fine-tuning in the supply-chain in the area of information exchange between retail trade and suppliers. This improves provisioning. It is not clear whether this leads to more or to less consolidation.

15.4.5 Consequences for the distribution of goods
After having described trends at the level of demand and supply of consumer goods, it is necessary to summarise the consequences for the distribution of consumer goods in urban areas. In Table 15-2, the consequences for the distribution of goods are presented.

Table 15-2:   *Consequences for the distribution of goods*

Influencing factor	Trend	Consequences for the distribution of goods
Demand		
population growth economic growth dematerialisation consumer demands	• growth of population • overall growth, increase • increased disposable income • increased spending in the food- and non-food, but relative decrease • mass-individualisation, continuing differentiation consumer demands • teleshopping • preferences for larger shopping areas	• increased transport volume • increased transport volume • diffusion of flows • levelling off the increase of transport volume • increase road traffic • increase share use of vans • increase use of vans • opportunities for consolidation
Supply		
shopping facilities retail	• expansion and new shopping areas • upscaling • specialisation • competition • PDV/GDV/factory outlet • teleshopping • market fragmentation and specialisation • shorter life-cycles of production • decrease of storage space • new formula: convenience shops • new forms of co-operation • widening (shifting) opening hours • internationalisation • implementation of EDI in the organisation	• increase road traffic • consolidation, less road traffic • diffusion of flows • shifting transport flows • avoidance of traffic in urban areas • increase use of vans • diffusion of flows • smaller shipments but more frequent • smaller shipments but more frequent • spread, and thus more traffic • consolidation, avoidance of extra traffic • shift to delivery in the evening, but also to a mismatch between delivery time and opening time • longer travel distances • high demand on fast delivery

Some conclusions can now be drawn. Based on trends in the demand and supply of consumer goods, an increase of the volume of goods to be transported can be expected. This growth is related more to cubic metres or monetary value than to volume in terms of kilograms or tonnes. The increase in transport volume does not lead to bulkier goods flows. The flows will be smaller in size but more frequent. Diffusion of flows will occur, as will but also concentration of flows near large shopping facilities. This does not necessarily mean that more traffic will be generated, because possibilities for consolidation of goods flows will arise. From the side of the supply and demand of goods, no trend breach is expected.

15.5   Conclusions

First of all, awareness of the structure and multitude of possible marketing channels and the impact they have on physical distribution is necessary to be able to construct and evaluate new concepts for urban distribution. The existence of parallel channels to sell products proves that there is no single *optimum* solution, and therefore urban distribution concepts must offer alternative paths for distribution. The organisation of the physical distribution process is strongly determined and controlled by the marketing channel director. Large retail organisations are channel directors, although for specific products and niche markets, producers may also play this role. The channel director is, to a large extent, in charge of logistic operations and strongly influences the physical distribution process. For different product groups or even for different products in one group the logistic operations, as well as the channel directorship, can be different. It is therefore of great importance to include the main channel directors in plans for urban distribution concepts. These concepts certainly cannot be aimed at transport companies alone.

With the introduction of e-commerce, new types of marketing channels are evolving. Some of the 'new' channels function analogously to 'traditional' channels, with the possible exception of the existence of a physical outlet. In other e-marketing channels, fundamental shifts in *power in the chain* may result. It will shift to consumers or consumer organisations or to suppliers. However, consumers will not be able to really 'direct' the process; rather, other intermediaries must fulfil this task.

Evidence shows that goods characteristics alone do not account for the vast difference in distribution strategies. Identical goods can be distributed along completely different marketing and distribution channels. This can only be explained by accepting the importance of the organisation within marketing channels. These findings show that future urban distribution concepts must be able to accommodate different types of marketing channels.

16. Physical distribution channels

16.1 Introduction

This chapter will analyse the distribution channels that are used to distribute goods to and within urban areas and thus carry out the transport orders that are generated by the marketing channel. Direct distribution – where suppliers directly deliver goods to the consignee – is the simplest form, but not always the most efficient one. We will show that indirect distribution systems comprising intermediaries to re-arrange goods over alternative paths, obtain high efficiencies, often combined with high levels of service and relatively low costs. To achieve these efficiencies, consolidation is required. We will show that consolidation can occur at different stages of the physical distribution process, resulting in different types of physical distribution channels. The differences are related mainly to the number of intermediate consolidation and inventory points, and to the actor who is in control of the channel. Physical distribution can be performed by transport on own account and by professional transport. We will show the important differences, especially in relation to the ability to consolidate flows. We will also show that transport on own account and professional transport can often be used alongside each other. In the end, the requirements set by the marketing channels (and the products that are traded via these channels) must be matched with the characteristics of the physical distribution channels. We will show that marketing channel and product characteristics result in preferences for specific physical distribution channels.

16.2   Types of physical distribution channels

16.2.1 Introduction

With respect to urban goods distribution, we will aim especially at the *final distribution* aspect of the total distribution chain. Within this final distribution, a distinction can be made between direct and indirect distribution. In this section, we will discuss these different means of distribution and the most important types of distribution channels that are (or can be) used within urban goods distribution. We will need this information to develop improved logistics concepts.

16.2.2 Final distribution

In this Chapter, we will focus on the final distribution of goods, because this is most relevant for urban distribution. With respect to marketing channels, this implies that we focus on the supply of the last physical link[19] (outlet, trade intermediary) in the marketing channel, excluding the end-users. Figure 16-1 introduces the standard representation of the relevant part of the marketing channel as is used from now on. The supplier of this last trade intermediary may be a producer, an importer or another trade intermediary, such as a wholesaler.
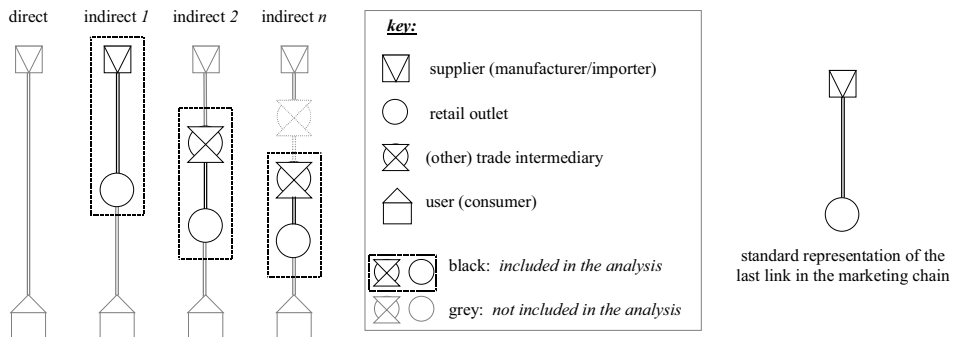

Figure 16-1:   Final distribution: focus on the last link in the marketing channel

From now on, we will not examine direct trade relations between suppliers and end-users (households). However, direct trade relations between suppliers and large end-users such as offices, hotels and restaurants are comparable to trade relations between suppliers and trade intermediaries. Therefore, these types of relations are included in the analysis.

16.2.3 Direct distribution

In direct transport, goods are transported directly from a supplier to one addressee[20] without intermediate transfers or storage. This most direct way of transporting goods can be planned

---

[19]   The points where end-users collect their goods, thus excluding 'virtual' trade intermediaries. This also excludes home-delivery services.

[20]   Where suppliers and addressees can be seen as trade partners, so for example relations between producers and retailers, retailers and consumers, producers and consumers, or wholesalers and (other) retailers.

fully to the wishes of the principal. In direct distribution a system of *call and go* can be used as well as a form of consolidation in time. In call and go systems goods will be transported at the very moment goods are available, consolidation of goods does not take place. If shipment sizes vary, it is very likely that the available transport capacity is not used in the optimal way, but no time is lost to consolidate goods. If shipments are always of the same size, the transport capacity can be adapted to this shipment size and the available transport capacity can be most efficiently used[21]. In supplier-driven direct distribution, transport is organised by the supplier (wholesaler, producer, trade intermediary) and can be executed either on-demand or on supply. Examples of the latter are mobile sales representatives and direct sales. As non-planned visits can easily be unsuccessful, the amount of goods that is transported is generally limited – the largest known examples in urban areas are probably mobile shops (groceries, vegetables and fruit, dairy products) and similar services.

There can also be contracts between suppliers and addressees to supply on a regular basis (but at the suppliers' risk). This form of supply resembles customer-driven demand.

16.2.4 Consolidation and indirect distribution

In indirect distribution, physical distribution intermediaries are involved in storing and rear-ranging goods to optimise the transport flows between suppliers and addressees. Indirect distribution enables consolidation and, as will be elaborated in depth in Section 5.1, consolidation of goods flows enables running more efficient services. The physical distribution intermediaries can be related either to shippers or receivers, or be logistic service providers. The intermediaries combine different flows and therefore use distribution centres with (intermediate) storage facilities. There is a strong relationship between the number of physical distribution intermediaries in a physical distribution channel and the physical distribution network that is used (this is elaborated in Chapter 17).

16.2.5 Types of distribution channels

A physical distribution channel is described as a succession of the basic logistic elements inventory (I), transport (T) and the specific physical distribution activities of consolidating and deconsolidating load. The origins of the physical distribution channels as depicted below are suppliers (producers, importers, trade intermediaries); destinations are addressees (the last trade intermediaries of the associated trade channel). Figure 16-2 shows various types of distribution channels between these suppliers and addressees.

---

[21] Within the conditions of 'direct distribution' that is, indirect distribution may result in even higher economic and societal efficiencies.
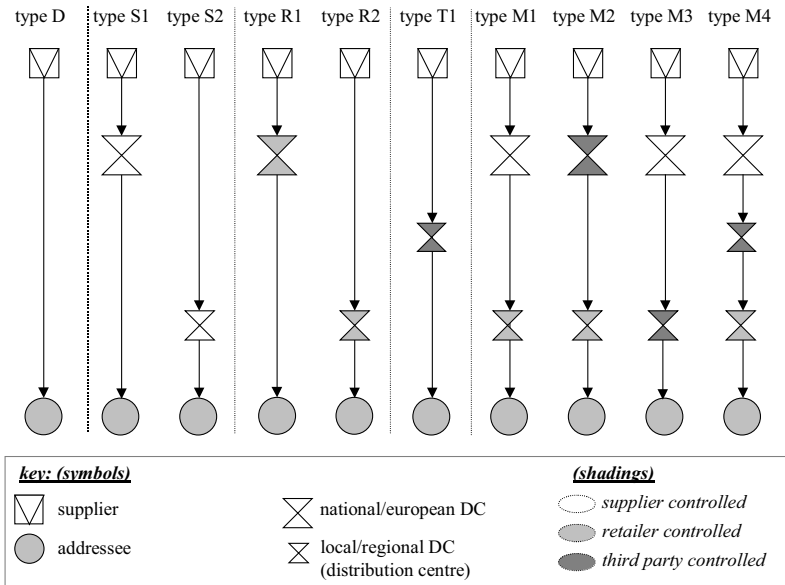
Figure 16-2:   *Taxonomy of physical distribution channels*

These types include:
- Direct distribution, type D.
- Channels including distribution centres operated by (or for) suppliers, types S1 and S2.
- Channels including distribution centres operated by (or for) retailers, types R1 and R2.
- Channels including third party distribution centres, type T1.
- Mixed-type channel which distribution centres operated by (or for) manufacturers, retailers or third parties (types M1 and M2).

Note that the described channels have some important physical consequences. First, each intermediary in the physical distribution channel involves at least one transfer ('cross docking') – and mostly two (DC-in and DC-out). Second, the homogeneity / heterogeneity of transported cargo strongly depends on the activities that precede the loading. Order-picking activities form heterogeneous loads that are more expensive to transport than homogeneous cargo, however, homogeneous cargo can generally be stowed more economically (Vermunt in Visser et al., 1998). This means that transport will be cheapest in logistic chains where order picking is postponed to the latest possible instance (types S2, R2 and M1, M2, and M3). This notion is the basis for some newly developed logistic systems.

Note that in all cases mentioned above, the final part of the logistic chain (the movement of goods between the retailer and the final consumer) is not included.

Experience shows that most goods delivered to urban areas follow indirect marketing (involving a wholesaler) or physical distribution channels. Large retail chains all use centralised and/or decentralised depots (distribution centres) and often operate different physical distribution channels for different types of goods.

Direct distribution plays an important role in case of durable goods, groceries and clothing. Producers still play a very important role in the physical distribution process; with respect to transported weight, they are even the most important distributing actors (see Part I).

16.3   Professional transport and transport on own account

16.3.1 Introduction

The physical distribution channels as presented in Section 16.2, can be operated by the shipper or receiver of the goods (*on own account*) or by a third party (*professional*). Third party physical distribution services can be provided as a *dedicated* service, a *restricted* service or a *public* service. Transport on own account can also be combined with third party services. Transport on own account provides direct control for the shipper over timing, handling, and costs ('private carrier', see Bowersox et al., 1986). Additional advantages include marketing (vehicles as running billboards), simplicity of planning, and direct contacts with suppliers or customers, especially for 'after sales[22]'.

A relevant restriction is that (under Dutch regulation) transport on own account is not entitled to fulfil transport orders from other parties. Therefore, if the transport activities only deal with small transport flows, the opportunities to achieve high efficiencies are limited; physical distribution strategies that rely heavily on consolidation will therefore be of limited value.

With transport on own account, planning transport activities and tuning them to other activities can be quite simple, as only one company (and in some cases only one person) is involved. Small companies especially use transport on own account. They usually operate quite simple 'networks' of direct links or round-trips.

In larger companies, logistic planning of transport on own account will become more complex. Often a 'transport subsidiary' is formed as a division (legal, economic) of the firm. This subsidiary may have to deal with large transport volumes and can apply more complex logistic concepts that make use of advantages of scale by consolidating flows.

16.3.2 Professional transport

For efficiency and for purely financial reasons, retail companies often outsource transport activities and sometimes also outsource logistic (physical distribution) activities. Financially attractive offers can be made because companies whose core business is transport have certain scale effects, can optimise their fleet and may have lower wages for personnel[23]. Scale effects can be achieved in investments (strong negotiation perspectives for fleet-owners), maintenance (either on own account or in large service contracts) and overhead (specialised personnel). Fleet optimisation can take place because professional transport companies can outbalance peaks in demand and can operate 'specialised' vehicles for different customers[24].

---

[22]   All kinds of services related to the delivery of goods.

[23]   Differences in wages for the same type of jobs in different Collective Agreements.

[24]   The mechanism of professional transport can be compared with centralised stocks – peaks and depths in demand can be outbalanced, in storage capacity or vehicle capacity (both total fleet capacity as individual vehicle capacity).

There are three main categories of professional transport services, namely:

- Dedicated transport services;
- Restricted transport services;
- Public transport services.

Dedicated transport is a special form of professional transport in which a transport company uses its fleet, or part of it, for one shipper exclusively (comparable to the US 'contract carrier', see Bowersox et al., 1986). From the functional point of view, dedicated transport can be compared to 'transport on own account'; the most important differences are related to financial (labour contracts) and juridical aspects.

Restricted transport (group transport) operates for a limited group of consignors, offering services that almost resemble *dedicated* services, but leave more space for consolidation.

Public transport services are open to every shipper. Transport companies in the sector of general distribution provide these services. Examples are postal package and express services.

Providers of professional transport specialise in transporting certain types of goods, sizes of consignments (in weight), and often in certain types of shippers. Specialisation in certain types of goods occurs when these goods have special requirements, and is only be viable if the equipment and organisation can be used for multiple customers. Examples include heavy-load transport, the transport of hanging garments or high-value goods. Specialisation is a strategic instrument for a carrier, who can then provide more customised service and a higher level of flexibility. It should lead to a better performance, more customer satisfaction and greater competitiveness. Specialisation also leads to more exclusive distribution concepts with specialised vehicles, mostly vans.

Bottom-line financial reasons are also a major reason for outsourcing: often, wages in transport or logistic companies are lower than those in the retail sector. This reason does not necessarily support the idea of shared use of facilities. For market reasons, some transport companies or service providers are forced to perform forms of *dedicated transport* that leave no room for co-operation, and in fact can only partially make use of the efficiencies of scale. The tendency to outsource non-core transport business to transport companies or logistic service providers fits perfectly with the introduction of 'brand-less distribution' concepts. The ownership of vehicles that are used for urban distribution gives insight in the importance of transport on own account and professional transport respectively.

16.3.3 Mixed use

Transport services can be partially contracted out to professional transport.

One reason is *peak shaving*: the regular transports that can be planned well in advance are performed on own account, while irregular or peak transports are performed by professional transport companies.
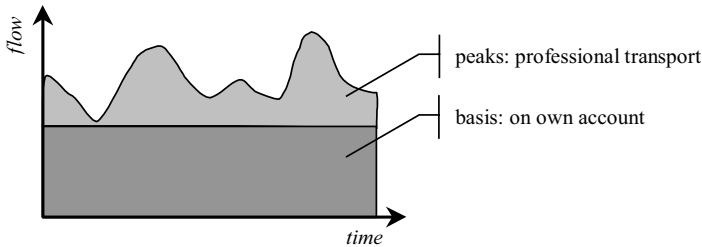
Figure 16-3:   *Peak shaving*

In this way, investment costs in own personnel and vehicles can be limited, but the regular transport is in full control of the consignee. Although the professional haulers have to deal with less predictable and high-volume flows, still optimisation of processes is possible as the professional hauler chooses consignees that are liable to have peak volumes at different times.

The transportation of specific goods can also be contracted out, while regular transport stays on own account. The reverse is also possible: for example, if shippers or receivers wish to pay extra attention to specific goods, they can transport these goods on own account and leave the 'regular' goods to professional haulers.

With respect to peak shaving, both load capacity[25] on the one hand and drivers and traction capacity[26] at the other, can be contracted out independently. Load capacity peak shaving is applicable for shippers that make use of common transport equipment (e.g., for breweries) while driver & traction capacity peak shaving occurs in transport of load units (waste removal, specific retailers) and railway operations.

16.4   Choosing an appropriate physical distribution channel

As explained in Section 15.4.1, there is a strong relationship between the structure of a physical distribution channel and the type of marketing channel that is chosen to sell a product. Research (Visser, 1993) shows that there is no direct link between product characteristics and physical distribution characteristics: exactly the same products in the same *market branch* can still be sold via different marketing channels and can use different physical distribution channels.

The basic form of a physical distribution channel depends on shipment characteristics (derived from characteristics of type of marketing channel and product characteristics) and the geographical market conditions (for instance the distance between suppliers and users and the type of destination area in which users are concentrated), see also Figure 16-4.

---

[25]   Load units and transport means; see also Part IV.
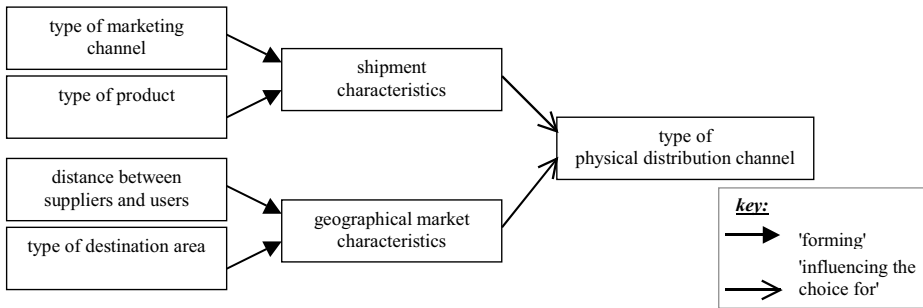
[26]   Traffic means; see also Part IV.

Figure 16-4:   *Influencing factors on the choice of a physical distribution channel*

The type of marketing channel sets requirements for the directness of the physical distribution channel (number of intermediates), the required service level, the intensity (number of outlets), and the volume and the composition (assortment) of the total goods flow. The type of product may set specific additional requirements, especially with respect to handling.

Furthermore, the geographical market characteristics will have an impact on the choice for the physical distribution channel. In case of substantial differences between geographical market characteristics, different physical distribution channels will be chosen for different markets. For example: an outlet in a suburb may be supplied by a large-scale distribution system, while an outlet of the same firm in a historical inner city is supplied by a small-scale distribution system. This means that there is neither a one-to-one relation between marketing and physical distribution channels, nor between certain products and physical distribution channels.

Physical alternative distribution channels can be represented as links in a network model[27]. Different routes or paths represent the alternative options (an example is depicted in Figure 16-5). Suppliers, receivers, retailers and logistic service providers can use such a representation to make a choice between different options or to optimise their strategies. The links and nodes within the network can have attributes, such as 'price', 'time' or 'quality', on which the choices can be based.
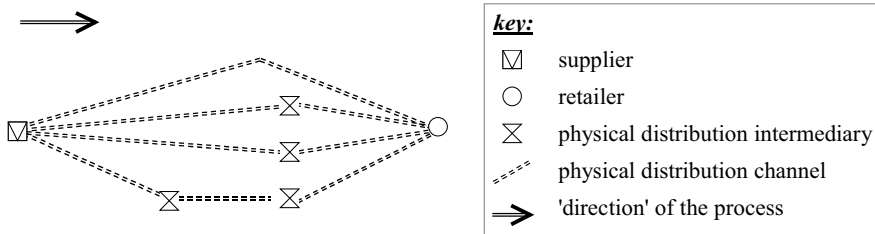

Figure 16-5:   *An enumerated network representation of the choice alternatives for physical distribution channels*

---

[27]   Note that this network representation illustrates the parallel physical distribution channels; this is however no representation of the physical distribution networks, such as described in Section 5.1. One can interpret the alternative available physical distribution channels as an enumeration of the physical distribution network of Section 5.1.

With standard network analysing methodologies, user behaviour (the behaviour of a shipper looking for the most appropriate distribution channel(s)) and system optimisations can be modelled. Typical network characteristics such as 'link capacity' also hold for this application: at some point in the process, a preferred physical distribution alternative may become 'overloaded', so that alternatives must be used as well – the 'peak shaving' strategy (see Section 16.3.3) is a practical example.

16.5   Conclusions

Goods are distributed through physical distribution channels. Products can be distributed fairly easily using different physical distribution channels: there is not so much risk that newly designed distribution concepts will 'exclude' certain goods. In direct distribution (channels), goods are transported from the suppliers directly to the addressees, without interference by other processes and without the opportunity to consolidate flows. All other physical distribution channels include physical distribution intermediaries and these intermediaries enable consolidation.

The type of operator of the physical distribution channel also influences the opportunities for consolidation. With transport on own account and dedicated transport, the opportunities for consolidation are restricted to the goods flows generated by one firm. This is not necessarily inefficient, because some firms generate such transport volumes that optimisation processes are very well feasible.

With the other operational types, goods flows of multiple firms can be integrated.

The characteristics of the marketing channel and goods characteristics set requirements for the physical distribution channel: they have an impact on the required intensity, directness and the service quality of the channel. There is, however, no one-to-one relationship between characteristics of the marketing channel and the chosen physical distribution channel. Products that are traded within a given marketing channel can be distributed via different types of physical distribution channels, for example because of the different market conditions (local/regional intensities). On the other hand, a specific type of physical distribution channel can be used for transporting goods for different marketing channels.

17. Physical distribution service networks

17.1 Introduction

A physical distribution channel consists of a succession of basic transport, consolidation/deconsolidation and inventory activities. Physical distribution service providers operate either on their own or in a joint effort with others. The sum of the services offered by logistic service providers form the physical distribution service networks. These physical distribution service networks have both spatial and time dimensions.

In its simplest form, direct distribution, the service networks' starting points are directly linked to destination points without intermediate actions. Direct distribution cannot, therefore, be combined with other services. In 'indirect distribution', for efficiency reasons, distribution channels are combined, and thus goods are grouped (consolidated) and ungrouped (deconsolidated) in *activity centres* and are transported between those centres.

From these basic elements, we will form different network configurations, each rendering specific advantages and disadvantages with respect to the physical distribution channels they have to accommodate.

We will then formulate different network services that operators can offer to further optimise the physical distribution services and to be able to meet the service requirements set by the users.

We will conclude with matching the different physical distribution network types and operator types with the physical distribution channels as described in Chapter 16.

In Chapter 18, we will use the physical distribution networks to construct integrated urban distribution concepts. Ideally, the 'set' of physical distribution networks should be as small as possible, to achieve maximum efficiency and a most transparent organisation.

We will show that within a single ('rigid') physical distribution network, a differentiated palette of services (service levels, tariffs) can be offered.

17.2   Physical distribution channels and service networks

Physical distribution service networks 'accommodate' physical distribution channels, or to put it another way: different physical distribution channels make use of the same physical distribution network. Where marketing and the related physical distribution channels in fact express the suppliers' (shippers') demand side, physical distribution service networks express the supply side of physical distribution.

Physical distribution service networks enhance efficiency, because they bundle resources (such as distribution centres with their personnel, equipment, and storage facilities): facilities can therefore be jointly used. A physical distribution service network is the integrated set of distribution services offered by one or a group of co-operating providers.

The type of marketing channel defines the directness (number of intermediates), the required service level, the intensity (number of outlets), the volume and the composition (assortment) of the total goods flow. For groups of products within a single marketing channel, different physical distribution systems may be chosen. On the other hand, a particular physical distribution system can also be used for the distribution of goods from different marketing channels.

The physical distribution network can be represented in a network model. Different routes or paths represent the alternative physical distribution options within that network (an example is depicted in Figure 17-1). The physical distribution service providers in particular can use such a representation to optimise their operations. The links and nodes within the network have 'price', 'quality' or other attributes, on which the choices can be based.
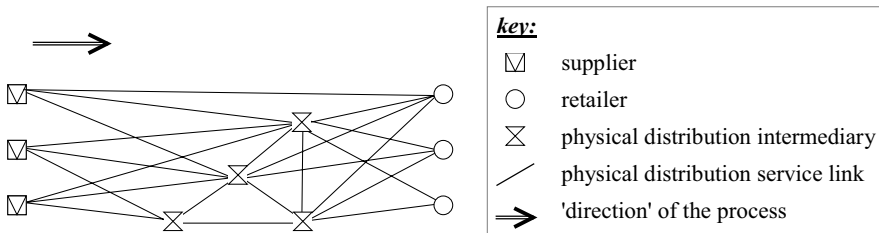

Figure 17-1:   *A network representation of a physical distribution service network*

Network analysis methodologies such as assignment methods and 'selected link' analyses can help the service providers to indicate weak spots and to redesign the service network.

17.3   Physical distribution service network principles

17.3.1 Introduction

Like all network representations, physical distribution service networks consist primarily of nodes and links. A link represents a service for moving goods from one physical location to another. Nodes represent all other *activities* related to goods that are part of the physical distribution process. These activities include:

- Loading goods into a vehicle;
- Offloading goods from a vehicle;
- Storing the goods;
- Sorting the goods.

17.3.2 Basic physical distribution activities

The basic physical distribution activities can be combined for:

- *Combining* goods or small shipments to (large) shipments: *consolidation*;
  an action that in fact combines sorting and loading goods in a specific manner;
- *Splitting* (large) shipments to small shipments or goods: *deconsolidation*;
  an action that combines unloading and sorting goods in a specific manner;
- *Cross-docking*; an action that combines offloading, sorting and loading, without intermediate storage.

Direct connections, line services or shuttles provide direct transport between one origin (place of loading) and one destination (place of unloading). No intermediate logistic activities occur. Indirect distribution normally implies some form of consolidation. As explained in part II, the main objective when performing any form of consolidation is to gain efficiency improvements.

Figure 17-2 shows that goods can either be consolidated in a consolidation centre or in a vehicle ('on the run'). At the end of the consolidated transport, the load has to be deconsolidated in a centre ('break-bulk warehouse') or 'on the run' (see Bowersox et al., 1986).
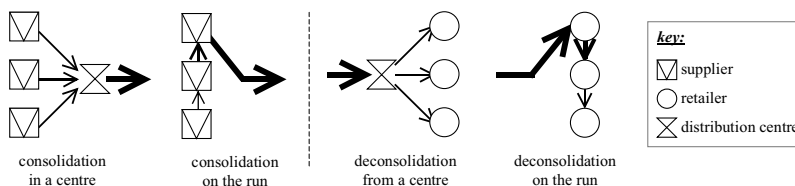

consolidation in a centre	consolidation on the run	deconsolidation from a centre	deconsolidation on the run

Figure 17-2:   Different ways in consolidating goods

If collection, consolidation, distribution and deconsolidation are all combined in one service, this is referred to as the Chinese postman system.

17.3.3 Hub-and-Spoke and Collection/Distribution service networks

For 'many-to-many' relations, various types of collection/distribution service networks will be used (see Figure 17-3). These service networks combine flows into consolidated flows using transfer points.

In hub-and-spoke networks (see for example Button, 1993; Thoma, 1995), goods flows from one origin and designated for different destinations can be combined, as well as flows originating from different origins and designated to a single destination. Consolidated transport occurs in the 'spokes', while goods are transhipped and re-arranged at the central hub.

Consolidation/deconsolidation networks can be operated if the distances between origins and destinations are large (spokes would be too long) or if there are opportunities to increase the level of consolidation. In a consolidation network, consolidation occurs at a consolidation centre, and deconsolidation occurs in a deconsolidation centre. If the flows are reversed, the centres switch their function; therefore the centres can, in general terms, be better referred to as activity centres. Between these activity centres, consolidated transport occurs along 'trunk lines' or a 'backbone network'.
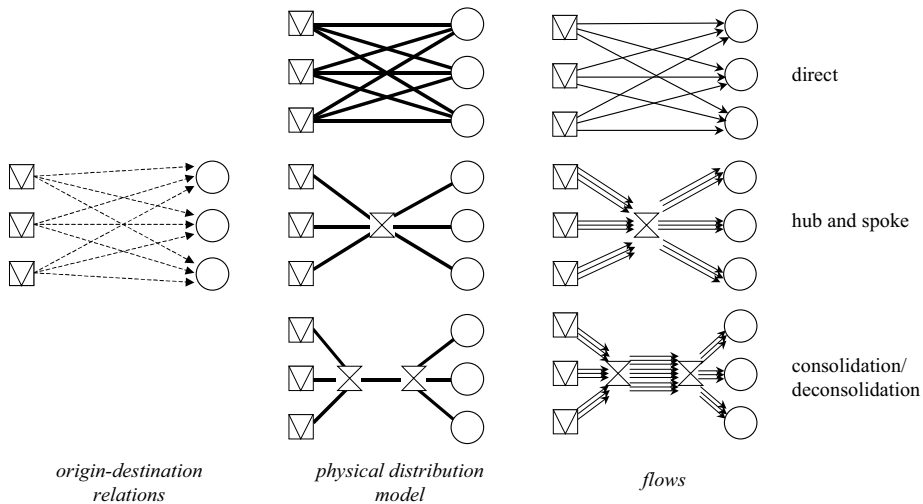

direct

hub and spoke

consolidation/
deconsolidation

origin-destination   *physical distribution*   *flows*
relations   *model*

Figure 17-3:   Direct and consolidated physical distribution service network

17.3.4 Hierarchical networks

In hierarchical logistic networks, different levels of consolidation, deconsolidation, collection, distribution and consolidated transport are combined[28]. All network types can be extended and/or combined to hierarchical networks. For example, local or regional hub-and-spoke networks can be interconnected via a main (primary) hub, resulting in a hierarchical hub-and-spoke network as depicted in Figure 17-4.

---

[28] In hierarchical physical networks, load does not need to be transhipped – vehicles can be consolidated on infrastructures.
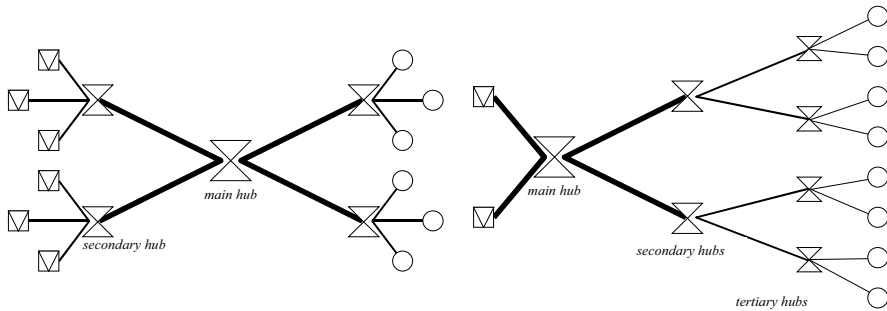
Figure 17-4:   *Hierarchical Hub-and-Spoke physical distribution service networks*

Of course, multiple stages can be introduced; they have their uses, especially in international or even intercontinental goods flows. If goods flows in one direction dominate, a multi stage, tree-like distribution collection system can be used; see Figure 17-4 (right).

17.4   Physical distribution service network shapes

17.4.1 Introduction
In the previous sections the abstract, basic physical distribution service network configurations have been described. The real service network lay-out depends on:
- Location of suppliers and addressees (retailers);
- The chosen physical distribution strategy;
- The chosen physical distribution network type;
- The location of distribution centres and depots.
At the detail level, the network configuration of the chosen physical (infrastructure) network also determines the definitive shape, but this aspect is left aside in this part (see part IV).

The location of suppliers and destinations that should be serviced by the physical distribution network depends on the choices of the physical distribution service provider. The provider (which may also be a retailer or supplier working 'on own account') deals with customers – retailers and/or suppliers – and negotiates the type of service and the service area. This results in a pattern of origins (suppliers) and destinations (retail outlets or other addressees) that should be serviced.
The preferred physical distribution service network strongly relates to the marketing strategy (characteristics of the marketing channel). Centralised warehousing strategies, (*speciality goods*), require centralised physical distribution services. Decentralised warehousing strategies, (*commodities*), allow decentralised and hierarchical physical distribution services.
The preferred physical distribution service network type (see Section 17.3) also depends on the relative number of *origins* with respect to *destinations* as well as the transport volumes. If the numbers of origins and destinations are in the same range, as is the case in postal and package service, hierarchical networks with interconnected distribution centres are the most appropriate service network types. If the number of destinations' far exceeds the number of

origins, non-interconnected distribution service networks are the most efficient (tree-type network)[29]. This is also the case in the reverse situation (the number of origins exceeds by far the number of destinations). In addition, in case of large transport volumes, distribution systems in which detours can be prevented are preferable.

Of course, the location of distribution centres or depots very much determines the final shape of the physical distribution network. These locations depend on a multitude of factors, including land prices, accessibility and distribution issues. The latter group refers to the distance[30] between the location of the depot and that of the origins and destinations, as well as the expected transport volumes.

17.4.2 Centralised or decentralised physical distribution networks

In a centralised physical distribution system there is one central distribution centre. All suppliers deliver their goods to this centre and all destinations (outlets or other customers) are serviced from this centre. This centralised physical distribution network is compatible with the *central inventory* strategy (see Figure 17-5, left). On the national (the Netherlands) and international (European) level we see a tendency to centralisation: the number of distribution centres is reduced or concentrated[31]. Trends away from decentralised distribution to centralised distribution indicate an increase in scale. Fewer distribution points simply signify that the distance between distribution point and final destination has increased. This development may be advantageous for local or regional distribution, since the flows (that is, the consolidated *European* flows) will have to be broken down again somewhere; this leads to a hierarchical system with centralised high-level and decentralised low-level or local distribution points.
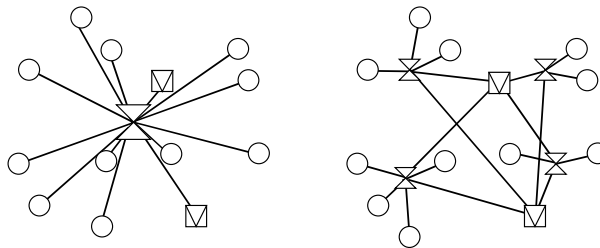

Figure 17-5:   *Centralised versus distribution centre service network*

In decentralised physical distribution networks, there are multiple distribution centres, which are located 'near' destination areas. The decentralised physical distribution system implies a decentralised storage of goods. All distribution centres receive goods directly from suppliers, from the distribution centres local or regional destinations (outlets or customers) are serviced (Figure 17-5, right.). By interconnecting the local or regional distribution centres, goods can easily be transferred from one distribution centre to the other. In addition, suppliers may deliver their goods to only one of the distribution centres, from which the goods are either distributed to the other local or regional distribution centres or to the local or regional destina-

---

[29] Physical distribution services with least detours, so preferably no Hub-and-Spoke types of networks.

[30] Or to be precise: the generalised costs or disutility associated with the distance.

[31] Note, however, that in this context, the term "regional" indicates regions such as "Northwestern Europe".

tions (see Figure 17-6). Other configurations of origins and destinations will result in other physical distribution network shapes, such as *trunk - side-line* networks.
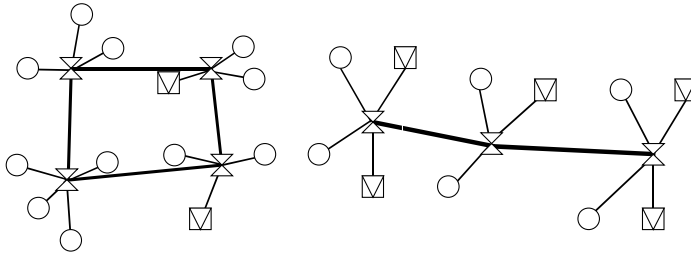

Figure 17-6:   Decentralised, interconnected local/regional distribution centres service network

17.4.3 Mixed physical distribution service networks

An interconnection between local or regional distribution centres can also be achieved via a main, central distribution centre. Thus, a mixed hierarchical physical distribution system emerges. In the hub-and-spoke terminology, this results in one main or primary hub and several secondary hubs. Suppliers deliver their goods either to one of the local/regional distribution centres or to the central distribution centre

The alternative, in which suppliers deliver their goods to the central depot, will generally be chosen if the number of suppliers is limited. The other alternative will be chosen if the number of suppliers or of origins is high. The *spokes* of the primary hub can of course be extended, so that multiple trunk lines emerge from the primary or main hub. Especially in hinterland connections, such network configurations can be found.

If different goods flows within the system should be dealt with in a different way, parallel physical distribution systems may be used. Especially with supermarkets and department stores, we find this kind of mixed physical distribution strategies, in some cases performed by the same service provider.

17.5   Network services

17.5.1 Introduction

In the previous sections, we analysed the shapes of physical distribution service networks. Within the same network configurations, different services can be performed. These services differ particularly in service levels, the types of goods or goods flows that are transported, and tariffs.

17.5.2 Co-operation, information exchange and standardisation

Close co-operation implies tuning the logistics organisation of different firms that operate within the logistics network (both *parallel* and *sequential*). One key element in efficient co-operation is an adequate exchange of information concerning the shipments that have to be transported (destination, required time of delivery, special handling requirements etcetera).

Standardisation of the means of identification of the shipments and standardisation of the information exchange increases the interchangeability of shipments between parties.

Therefore, standards must be developed for:

- Bar coding for shipments. A uniform bar code (UPC) has been developed. The advantage of this code is that transporters are now able to read each other's bar codes, which increases the interchangeability;
- Standardisation of labels. A standard label has been developed to go with the uniform bar code. This makes it easier to read, and therefore improves the interchangeability;
- Message traffic. Electronic data exchange (EDI) is used increasingly in transport. There are now accepted standards for messaging the status of a shipment. The messages can now easily be read on different systems. The tracking and tracing of multi-transporter shipments is thus improved.

For example, some main transport organisations that operate within the Netherlands have started to work together to develop standards. EDI standards have been developed by international bodies (such as the United Nations Economic Commission for Europe). With respect to load units, handling equipment, transport means and traffic means, standardisation is also essential for efficient co-operation (see Part IV). As mentioned earlier, physical distribution service networks can be used to accommodate different physical distribution channels having different requirements with respect to service quality (speed, accuracy, and reliability). If only one service uses the service network, there can be only one service level. Normally, the service level (quality) of the network, (for example expressed in throughput time and related reliability), is determined by the quality of the different network parts and its structure. This can be expressed in terms such as network density and entrance-point density, specifically:

- Terminal throughput times (unloading, sorting, intermediate storage, loading).
- Operational vehicle speed at trunk and sidelines.
- Average waiting times (determined by frequencies and capacities of line services).

Especially in relation to urban distribution, different goods in different marketing and physical distribution channels will require different levels of quality, and related, different tariffs.

In direct distribution, this poses hardly any problems, as each batch of goods with similar characteristics can be dealt with independently, as shown in Figure 17-7. Each shipment can theoretically be transported by a tailor-made transport system.
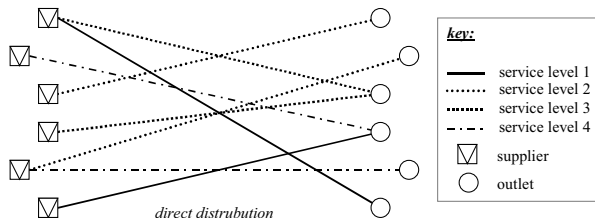

Figure 17-7: *Direct distribution with four levels of service*

A service network can mimic this wide variety of service levels (four in the example) by offering different levels of service for all network parts (thus: side links, main links and terminals) in *parallel*. This strategy reduces the options for consolidation, especially on the main

links. An alternative strategy only offers a limited set of *parallel* service levels at the main links. However, by adapting terminal and secondary link services, operators can offer a *virtual* full set of services to the suppliers and addressees.
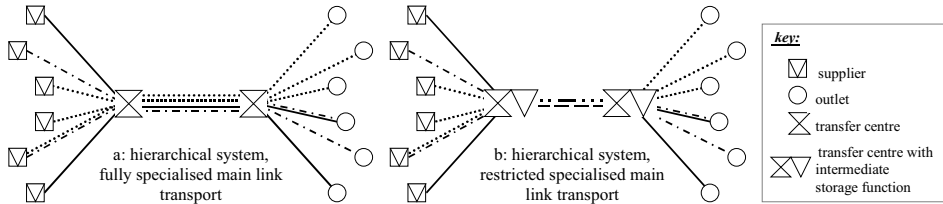

Figure 17-8:   Full service (left) and limited main line service (right) networks

For the user, the 'limited main line service' network offers approximately the same service levels as the full-service alternative, but the limited main line service network can operate more efficiently because it holds more opportunities for consolidation.

A systematic analysis of shippers' demands may pose an opportunity to operate a 'lean' main transport system, consisting of a very limited number of specialised services. The remaining part of the special service is dealt with at the service points (*depots*). If there are, for example, four services at different speed – low, normal, high and express – these services can also be maintained at the main link. However, the operator can also choose a system that operates only at *express* and *normal* speed at the main links. Most cargo is transported at normal speed, but high-speed shipments receive high priority at the service points and low-speed shipments low priority. In some cases, the express service can also be used for high-speed services. Thus, important gains can be achieved in consolidation at the main link.

17.5.3 Different types of goods to be transported by the service network

The design of the service network for physical goods distribution can be optimised for the transport of specific types of goods. In that case, for different types of goods, different sub-networks must be used. For instance, the transport of refrigerated products has to meet requirements other than those of the transport of hanging garments. These differences imply both physical (vehicle) adaptations and logistic (physical distribution service) adaptations.

Therefore, retail outlets offering large assortments of a wide variety of goods are often supplied by different yet parallel physical distribution channels, and thus by different networks. Especially in food retail, separated physical distribution channels for general groceries, fresh products (flowers, dairy foods, bread) and sometimes deep-frozen goods are used. In some cases, different channels are used for *fast movers* and *slow movers*: fast movers are distributed via a decentralised depot, slow movers via a central depot (see also: decentralised and centralised distribution in Section 17.4). This leads to mixed physical distribution forms as depicted in Figure 17-9.
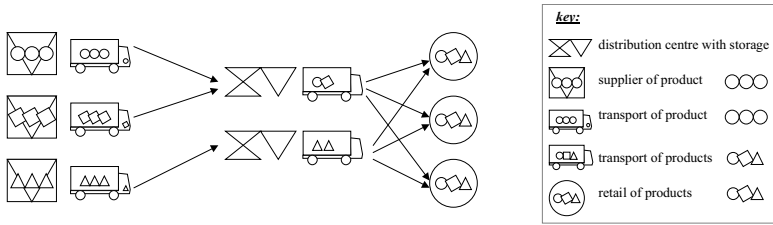
Figure 17-9:   Mixed distribution

In *composite distribution*[32], *all* goods to be distributed to the outlets, irrespective of their characteristics, are concentrated in either central or decentral warehouses and from there transported to the final destinations (see Figure 17-10); this is a specific form of *depot consolidation* as defined in Part II.

Composite distribution is primarily used in grocery retail, giving a special meaning to the fact that all goods are combined: the warehouse enables storage of fresh, dairy and perishable goods as well as other grocery products.

In composite distribution, suppliers deliver their goods to the distribution centres, not to the final destinations (i.e., stores). Composite distribution enables consolidation in the final stage of distribution, which results in cost reductions. The consolidation and the fact that suppliers no longer deliver to the stores, reduces the number of vehicle trips in the destination area. Consolidation also allows the use of larger semi trailer or city trailer (see part IV) road vehicles. The concept provides the retailer with better control in the final part of the distribution channel. The power of the retailer therefore increases.
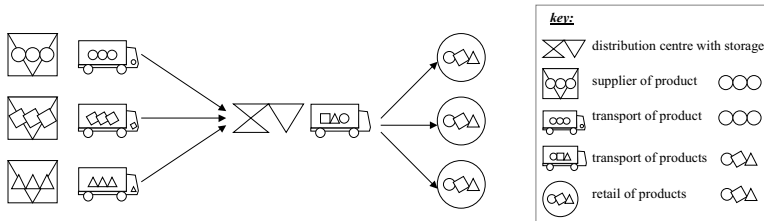

Figure 17-10:   Composite distribution

17.5.4 Different tariffs within a physical distribution service network

The *split and combine* or *pipeline* concept allocates shipments or parts of shipments in the most efficient way over trips (times and routes) and vehicles. For operators, this opens the road for tariff differentiation.

The concept was originally developed in digital communication, and has been adapted for use in airway goods transport (see Koekenberg, 1999). At the starting point of the distribution channel, the shipments are optimally allocated (and sometimes split); at the end-point, the component parts of the shipments are combined again.

---

[32] In practice the concept is used under the name *composite warehousing*.

The split and combine concept consists of three parts:
- Split time.
- Split place (route).
- Split load.

Split time optimises the transport time distribution. It allocates shipments as much as possible to trips in off-peak periods. Naturally, express-, and other goods that need immediate transport, are allocated to the first possible trip. *Split place or route* allocates shipments to those routes (trips) that have most spare capacity – these are not necessarily the shortest trips, but are rather the most efficient trips. *Split load* allocates parts of shipments to different vehicles (possibly running at different times and routes). This last option sometimes conflicts with legislation and must then be omitted.
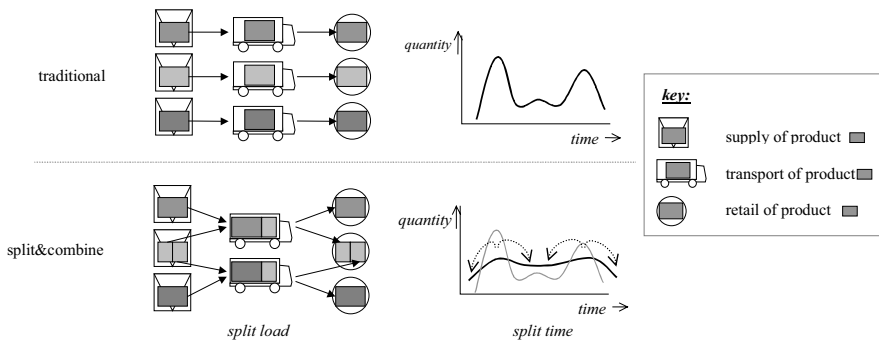

Figure 17-11:   Split & combine (pipeline) distribution

Ideally, the system resembles the concept[33] of Internet messaging. The user sends the messages, but the actual transport of data is organised by the service providers. The messages (shipments) can be split up and may follow different routes, but are eventually put together and delivered to the addressee.

The *split and combine* distribution strategy enables a most efficient use of available network capacity, especially for those goods and goods flows that are non-time critical. For these flows, special discount distribution rates can be offered.

17.6   Conclusions

Through the basic actions of consolidation, deconsolidation and transport between activity centres, physical distribution networks can be formed. The act of consolidation is aimed at achieving efficiency improvements. Net advantages result when the costs of consolidation and deconsolidation are less than the benefits of consolidated transport; the latter is a result of economies of scale. Consolidation of flows in networks also results in network advantages (as explained in part II). In hub-and-spoke networks, goods are consolidated and transported via

---

[33]   In practice, reliability and speed in Internet messaging are not yet optimal – also a potential danger for the advanced logistic systems.

the spokes to the central redistribution centre, or hub, and from there are transported to the destinations. In consolidation / deconsolidation networks, there are multiple redistribution centres, mutually connected by trunk links, also offering consolidated transport. In hierarchic physical distribution networks, multiple, successive consolidation / deconsolidation steps occur to achieve the highest possible net advantages of scale.

The physical network forms are based on the location of suppliers and destination, the chosen physical distribution channel and network type and the preferred location of depots and (re) distribution centres. At the same physical distribution network, different services can be offered, resulting in a differentiation in tariffs and service quality.

Therefore, the physical distribution networks make it possible to offer versatile services for urban goods distribution. This chapter has shown that by using the same physical distribution network type, different services can be offered. This supports the idea that a limited set of physical distribution concepts and networks for urban goods distribution can sufficiently accommodate a variety of distribution channels (thus marketing channels).

18. Integrated goods distribution concepts

18.1 Introduction

The previous chapters provided the building blocks required for designing new or adapted urban distribution concepts that optimise the efficiency of urban distribution. We have already shown that a physical distribution system (network) can function for different physical distribution channels and at different levels of service and costs, thus meeting different demands from different marketing channels. Thus, we are able to design a new physical distribution system, without interfering with trade relations. In this chapter, we will start by defining a limited set of basic urban physical distribution concepts that are built from the elements discussed in earlier chapters. We will then go deeper into the different concepts, which, in practice, will be used in parallel, depending on market needs. The concepts are based on the principle that optimally loaded, dedicated vehicles are to be used within the urban areas, and therefore all concepts are based on the notion that both consolidation and/or a transfer of goods can be required. The differences between the alternatives are related to the question of how various actors can be combined. We will describe the organisational changes that are needed for—or result from—the application of new urban distribution concepts. The physical distribution concepts, as proposed, will enable optimal use of available and future vehicle and infrastructure technologies, as analysed in part IV, and will then form the basis for policy plans as proposed in part V.

18.2   Basis physical distribution concepts

18.2.1 Introduction

In this section, we will introduce a limited set of basic physical distribution concepts for goods distribution for urban areas; these concepts will be worked out in the following sections. First, we will introduce some important marketing channel and physical distribution channel developments that both set requirements for future distribution concepts and at the same time open opportunities to introduce these concepts.

18.2.2 Marketing and physical distribution channel developments

The basic logistic activities are, each in their specific way, relevant for urban distribution and for the development of new logistic systems. For some market niches (especially supermarket retail) the quality of the distribution system (*transport*) in terms of costs and reliability is a decisive characteristic that distinguishes one retailer from the other. For them, quality is an important competitive tool. Some future urban distribution concepts will diminish the differences between the physical distribution systems of retailers. Therefore, other distinguishing characteristics will become more important. In most other market niches, transport quality is not of paramount interest, as long as some basic quality criteria are met.

In future, *assortment composition,* in combination with delivery quality and costs will be main competition issues. This means that the new logistic systems must allow differences in delivery quality (related to costs) and must enable the efficient management of various types of assortments (*narrow* versus *broad*).

Small-scale *production* will be relevant for urban distribution, so future distribution systems must be able to handle goods that are used in (small-scale) industry. The nature of the industries does not require highly advanced logistic systems (such as just in time or JIT), but does require flexible (ad hoc), low-volume logistics. From a logistics management point of view, urban logistic organisation can employ some of the principles used in managing production processes. The transport system can then be seen as an outdoor extension of the storage policy for retailers. This JIT transport requires a very high level of service from the transport company, an excellent means of data-interchange and complete mutual trust. As each transport process is influenced by external factors such as weather and traffic conditions, this also goes for JIT. To cope with possible delays caused by external influences, some form of emergency stock will be needed or, alternatively, a setback in the logistic performance must be accepted. Efficient transport operations need transhipments of goods for consolidation and deconsolidation activities. The needed interchange points can be very well integrated in newly designed logistic systems. New urban distribution concepts should be based on the consolidation of small shipments for both inner-city transport as well as for inter-urban goods transports.

The new logistic systems must be able to handle different types of *inventories*, ranging from high-volume flows of *fast movers* to relatively small flows of *slow movers*. The inventory system must handle high and low value goods, general groceries and perishable goods. The new logistic systems can use insights about the desire for centralised inventories for *specialities* (mostly slow moving high-net profit goods) and the desire for decentralised inventories for *commodities* (mostly fast moving, low net profit goods). Centralised inventories must be

located close to producers (or importers), decentralised inventories close to the destination areas. From a theoretical point of view, inventory-keeping policies show that frequent deliveries reduce storage levels because supply can better be attuned to demand.

Although we will not discuss these aspects in depth, the new logistic systems must also be able to deal with *reverse logistics*, the logistic management of return flows of goods to be repaired or to be disposed of. Furthermore, the systems must be able to manage direct deliveries to homes (related to teleshop or e-retail activities).

18.2.3 Basic physical urban distribution concepts

We have based our designs for new urban distribution concepts on the principle that only optimally loaded, dedicated, vehicles can be used within vulnerable urban areas; we will elaborate the specific requirements in Part IV. We refer to this type of distribution as *Full Urban vehicle Load* [FUL] distribution. The inter-city goods distribution vehicles either comply or do not comply with the *FUL* requirement. If they do not comply, transfers are necessary in the Local Transfer Point (LTP) or a Regional Transfer Point (RTP). Because the inner urban destinations (*outlets*) can either by directly supplied or by roundtrips, this results in six basic physical urban distribution concepts:

- Direct distribution originating from the suppliers [FULdirect];
- Round-trip distribution originating from the suppliers [FULround];
- Urban distribution with direct distribution from a LTP [LTPdirect];
- Urban distribution with round-trip distribution from a LTP [LTPround];
- Network distribution with direct distribution from a RTP [NETdirect];
- Network distribution with round-trip distribution from a RTP [NETround].

These concepts are explained in detail below.

18.3   Full vehicle load concepts

In full vehicle load concepts [FVL = FUL], shippers themselves try to compose full vehicle loads in vehicles that comply with the urban distribution requirements. Therefore, they can use concepts such as *composite warehousing*, as described earlier. This results in either direct distribution or round-trip distribution, originating from the suppliers (or the suppliers' distribution centres); see also Figure 18-1.
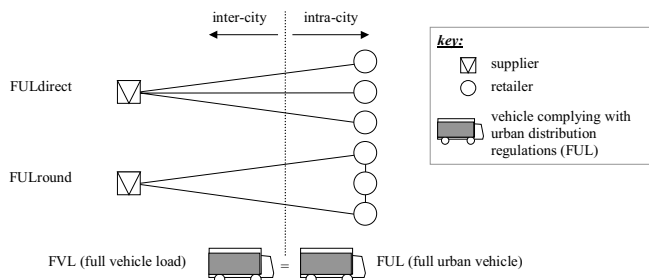

Figure 18-1:   ***Full vehicle load concepts: FULdirect and FULround***

In some cases, traditional trucks are appropriate for distributing the goods, in other cases vans or (specialised) small trucks must be used.

If the vehicles that are used for long-haul transport do not comply with the requirements for vehicles for urban distribution, there will be a need to tranship the goods to those specialised urban distribution (FUL) vehicles. The resulting concept is the a [LTP/NETdirect or round] scheme.

18.4   City Logistics Concepts

In the city logistics concepts, goods that are transported by a distribution system that does not comply with the requirements for inner urban goods distribution are transferred to a dedicated urban distribution system. Distribution systems that do not comply with the requirements include, for instance, systems operating vehicles that are too large or vehicles with low load-factors (see Part VI for the sets of possible requirements for urban distribution). Figure 18-2 outlines the functioning of such a city logistics concept, where the Local Transfer Point (LTP) is used to transfer goods from too large vehicles (FVL) or vehicles with low load factors (LVL) to urban distribution vehicles (FUL). Note that there can be additional requirements that necessitate a transfer.
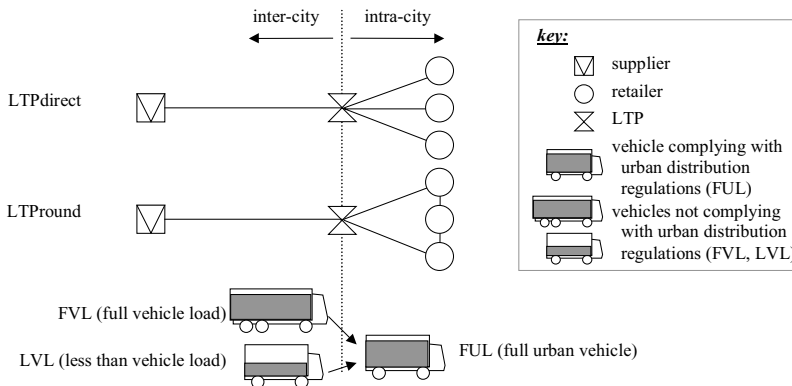

Figure 18-2:   City Logistics concept [LTPdirect/LTPround]

City logistics has been developed in the field of urban freight transport as a logistic concept that aims at using an integral approach to minimise the societal costs of urban freight transport. Ruske (1994), Thoma (1995), Köhler & Strauβ (1997) and Taniguchi et al. (1999) describe the concept of city logistics in more detail. Taniguchi et al. define city logistics as a process for the total optimisation of the logistics and transport activities by private companies in urban areas, while considering the traffic environment, the traffic congestion and energy consumption within the framework of a free market economy. According to Taniguchi et al., the aim of city logistics is to globally optimise logistics systems within an urban area by considering the costs and benefits of concepts to the public as well as the private sector. This optimisation is generally based on consolidation of transport flows by means of co-operation between transport companies or shippers. Examples of joint distribution of goods within ur-

ban areas can be found in Germany (known as City-Logistik) and in Japan. In these examples, transport companies within an urban area set up a joint service. Visser et al. (1999) explain that by consolidating the goods flows, improvements can be achieved in terms of cost reduction (fewer vehicle kilometres) and/or quality improvement (transport services with higher frequency).

The keyword in city logistics is *consolidation*, extended to the multi-company level. Consolidation leads to a more efficient urban freight transport because the transport means can be used more efficiently (for instance by higher occupancy rates or reduction of costs; see Thoma, 1995). Furthermore, in large fleets it is easier to operate different vehicle sizes next to each other. This enables optimisation of the used vehicle size with respect to the shipment size[34].

By consolidating transport flows by joint distribution, it becomes possible to optimise to a higher extent than when optimising a single physical distribution channel. This is proven in practice, as described by Nemoto (1997) for the case of Fukuoka (Japan), where 29 trucking companies started to work together in 1978 by setting up a collective delivery and pick-up service to and from the congested Central Business District. Compared to what it would have been if the 29 companies had operated separately, this service reduced the volume of truck traffic by 60 percent.

Consolidation must be supported by organisational changes in logistics. The network-based logistic concept, or the *brandless* distribution concept will be the next evolution in logistics. In this approach, the distribution and storage activities are carried out in a non-dedicated fashion, by a network of interconnected by geographically- dispersed distribution centres.

One of the main driving forces is the outsourcing of logistics by shippers and co-operation between transport companies. This concept can be supported by planning that focuses on the spatial concentration of logistic activities, such as distribution centres in regions.

Consolidation could provide a sufficient level of critical mass for existing large-scale transport systems, such as rail, but also new technologies. These systems need high transport volumes (see also part IV).

What the 'new' logistic concepts described in this section have in common is that they are no longer based on optimisation processes of a single company, but on optimisation of all logistic processes together. This is also referred to as *urban logistics* or *city logistics*, though in fact only the transport part (physical distribution) of the logistics operations are involved in the optimisation process. Other logistic activities are still the responsibility of individual companies. Physical distribution is optimised under preconditions posed by the individual companies and the community as a whole. This is expressed in transfer and transport time requirements on the one hand and various restrictions at the other hand.

In *retail group distribution*, all outlets of a given retail type are served by an *independent* (e.g. not related to one of the stores) logistic system. One or more transport companies or even logistic service providers operate this logistic system. Logistic service providers offer storage, sorting and other logistic activities next to transport.

Thus far, initiatives for joint or even public urban distribution systems have not been very

---

[34] Small transport firms generally operate relatively large vehicles that can load most shipment sizes, but are in fact inefficient for the individual transport of small shipments.

successful (see also Section 36, Part VI). The most likely reasons for these failures are the required disinvestments in existing facilities, the high transition costs (both organisational and in terms of physical means), competitive objections (concerns for monopolies, fear for leakage of sensitive information), and a fear for losing direct control. Above that, there was often a lack of supportive public policy measures and/or enforcement (see also Van Binsbergen and Visser, 1997). The reluctance for adopting these new concepts can partly be overcome by offering an efficient system on the long run (see also below), by maintaining a minimal level of competition and by assuring confidentiality with respect to sensitive data. Further more, the conditions set by necessary policy measures with respect to space utilisation and the relaxation of the environmental burden, will create better opportunities to implement such concepts (see also Section 19 of this Part and Part VI (Section 38).

18.5   Network Logistics Concepts

In Network Logistics Concepts, goods are first collected in Regional Transfer Points (RTP) near the suppliers, and are then transported via trunk-links (the network) to RTPs close to the destination areas. In Network Logistics, interregional physical distribution activities of different providers are combined to achieve efficiency improvements. These improvements can be achieved by consolidating flows that in turn enable the operation of large-scale transport systems (see also Part IV for the relevant transport systems and Part V for the spatial consequences).
Figure 18-3 illustrates the concept of network logistics.
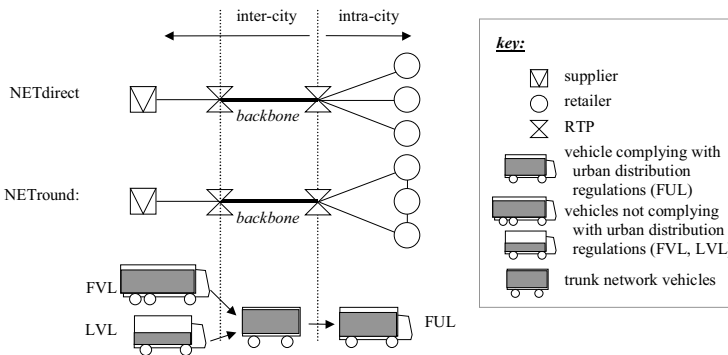
Figure 18-3:   **Network Logistics Concept [NETdirect/NETround**]

In Network Logistics Concepts, goods are first collected in Regional Transfer Points (RTP) near the suppliers, and are then transported via trunk-links (the network) to RTPs close to the destination areas. In Network Logistics, interregional physical distribution activities of different providers are combined to achieve efficiency improvements. These improvements can be achieved by consolidating flows that in turn enable the operation of large-scale transport systems (see also Part IV for the relevant transport systems and Part V for the spatial consequences).
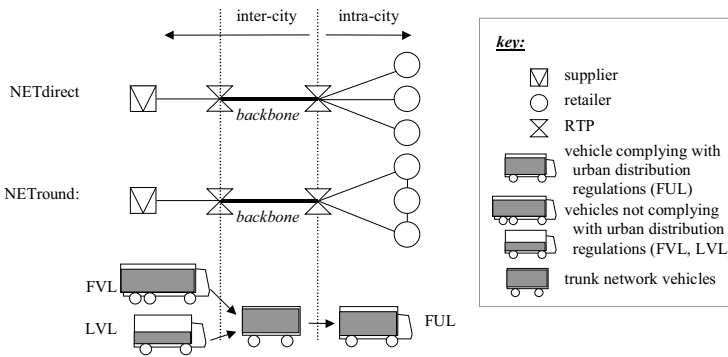Figure 18-3 illustrates the concept of network logistics.

Figure 18-4:   Network Logistics Concept [NETdirect/NETround]

On the national level in the Netherlands, such schemes are proposed by the Dutch railways (Rail Distribution in the Netherlands; see Van Binsbergen et al. 1997) and in the IPOT research programme (see Visser et al., 1998). These schemes are in a sense already partially implemented by national operating logistic integrators such as VGL, TPG (TNT), NPD, DHL and UPS. These integrators are directors of chains: they manage the chain, while the execution of the logistic activities is contracted out (e.g., transport to the transport firms). To do so, the integrator pulls in specialists such as carriers and distribution centres. The arrival of integrators in national transport will lead to a situation where a few large firms will perform the logistic management, and the execution of transport and other logistic activities will be contracted out to the smaller carriers. A number of these carriers will then assume responsibility for the collection and actual distribution, while others will take care of the point-to-point movements between consolidation and de-consolidation points. By centralising the directive tasks, it would be possible to consolidate loads more than is the case at present.

The concept of network logistics is advanced because it does not simply combine existing physical distribution processes, but modifies these processes to achieve efficiency gains. By distinguishing fast movers (high transport-volume goods, for example commodity goods with low net margins) and slow movers (low transport-volume goods for example speciality goods with high net margins), a fundamentally new way of setting-up an integrated logistic network will become possible. Developments in the logistic processes of food-retails already show what these kinds of future physical distribution channels will look like[35].
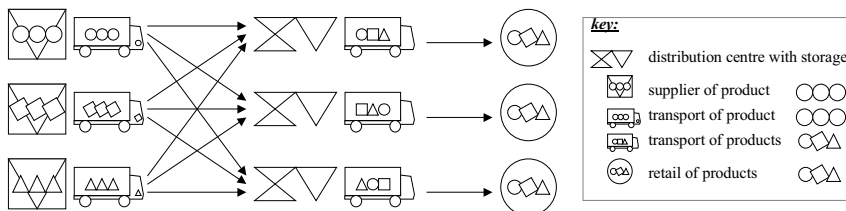

Figure 18-5:   'Traditional' physical distribution channels

---

[35]   Food retails make up the largest part of total sales (value and volume); other products may be distributed using other, sometimes less sophisticated, concepts.

In traditional physical distribution channels, commodities are first transported to the distribution centres of retail chains by the suppliers, and are then combined with other goods and transported to the outlets by the retailers (see Figure 18-5). In the network logistics concept, fast movers are transported to logistic centres near these suppliers. From there on, the goods are directly transferred to logistic centres near the customers (urban or regional transfer points). Because fast movers'[36] flows are relatively large, there is no need for consolidation at present. Experience shows that this kind of homogeneous or standardised transport is relatively inexpensive (Bowersox et al., 1986; Vermunt in: Visser et al. 1998). The fast movers are stored in warehouses in the various regional logistic centres and function thus as semi-decentralised[37], fast-accessible storage depots. These warehouses may be (but are not necessarily) brandless. From these depots, the various retailers are supplied with the desired quantities of fast movers.
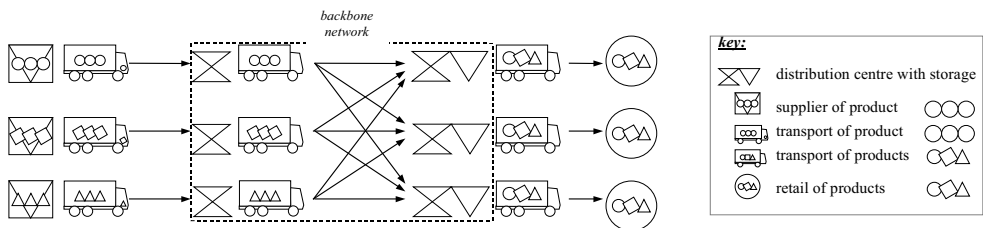

Figure 18-6a: Network logistics high transport volume goods / fast movers

Note that the actual goods transport between the different terminals can take different shapes (Figure 18-6a depicts a direct distribution variant).

Slow movers[38] or low transport volume goods will be delivered to urban distribution parks by consolidated transport services and from there either directly or via very short intermediate storage delivered to the final addressees (see Figure 18-6b). This end-distribution can be performed by the retail organisation, or by urban distribution service providers.

Specialities are goods that are regarded as very important for the image of a specific retail chain. Transport of these (often) slow movers remains largely the responsibility of the chains themselves. Nevertheless, the actual transport and distribution process can be integrated in the logistic process of other slow movers. If necessary, slow mover goods can be stored centrally at the logistic centres at the supply-side of the logistic network.

---

[36] 'Fast' refers to the rate of replenishment of the good (the sales volumes) and not necessarily to the required transport speed.

[37] At shorter distance to the consumers than national and even retail depots, but still 'regionally' centralised, so that unnecessary repositioning of the stock can be prevented.

[38] Again, 'slow' refers to the replenishment rate (sales volumes), not to the required transport speed: in fact, 'slow movers' can often resemble express goods.
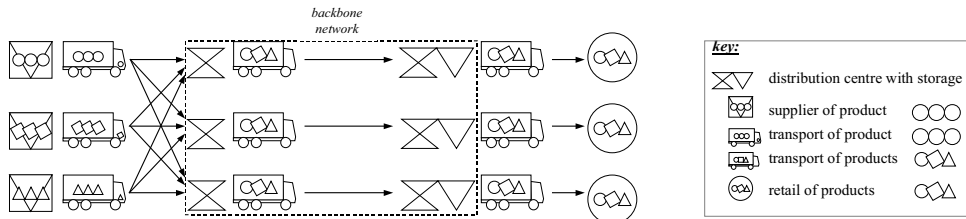
Figure 18-6b: Network logistics for low transport volume goods / slow movers

The concept is supported by the following tendencies:

- Eliminate logistic activities from the channel that do not generate any clear added value (storage).
- Centralise production and warehousing activities (triggered by the creation of the Single European Market, the relatively low transport costs and the fierce competition).
- Introduction and use of highly advanced stock- and supply management systems that can eventually be directly driven by sales (automatically registered at checkout counters).
- Shift from transport on own account to professional transport.

In these modern logistic systems, the share of consolidated transport is increased and use is made of distribution centres close to (or owned by) producers and close to market areas.

These developments show that in designing systems for urban freight distribution, attention must be paid to the main developments in logistics.

18.6   Organisational models

In a traditional physical distribution system, the main leg service provider distributes goods directly to the destinations (see Figure 18-7).

In urban distribution models, there will be a *local distribution system*, probably making use of full-loaded dedicated urban distribution vehicles.

In the *sequential model* the main leg or backbone service provider[39] transfers the goods as well as the responsibilities to the local service provider. This means that together with the physical transfer of the goods, some form of control of the goods (state, quantity, timing etc.) has to occur. Both service providers are directly responsible for their part of the channel. In first instance, the consignor deals with the main leg service provider and the consignee with the local service provider – but if something goes wrong, it can become quite complicated.

Another possibility is to opt for an integrated approaches for which there are two alternatives. In the first one, the main stage service provider has responsibility for the channel and puts the local service provider under contract (just as he may put other haulers under contract).

Now consignor and consignee formally have only to deal with the main leg service provider and if something turns wrong, this service provider has to deal with the contracting party (local service provider). Again, some control during the transfer of the goods must occur. Control can be maintained by random sampling, because we may expect that there will be a dura-

---

[39] This service provider may be a transport company or a logistic service provider, such as an integrator with hauliers under contract.

ble relation between the contracting partners. In the other alternative, an integrator contracts both the main leg service provider and the local service provider. This can turn out to be a very complicated structure, as the main leg service provider may also have some contracting parties. Although this subject will not be discussed in depth, it is a very important issue to be solved before an intermodal system can be put in practice. Thoma (1995) describes a variety of formal organisational models for urban goods distribution. These can be interpreted as is shown in Figure 18-7.
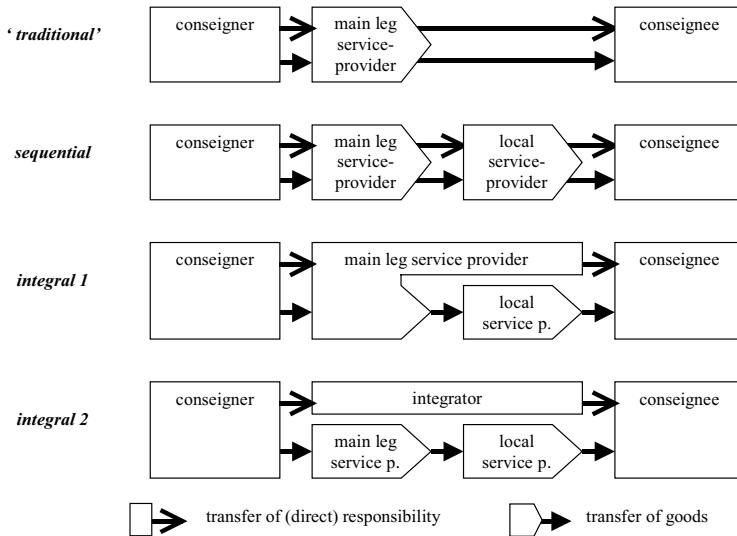

Figure 18-7:   ***Organisational models for urban distribution***

18.7   Timing of physical distribution activities

18.7.1 Introduction

Timing plays an important role in distribution processes: goods should be delivered right on time, vehicles may enter some urban areas only within certain time windows, and accessibility problems are also strongly time dependent. In this section we will compare the timing of access and egress transport in both traditional and new urban distribution concepts, and we will thereby show the advantages of introducing a time shift (break) in the distribution channel. We will also show how the new concepts allow various forms of nighttime distribution.

18.7.2 Timing of access and egress transport in traditional urban distribution

In direct distribution [FULdirect], goods are directly transferred to their final destination in the urban area and the delivery vehicle leaves the urban area immediately after the delivery has taken place. The difference between the entering and leaving times is the travel time and the load/unload time within the urban area (see Figure 18-8). Round-trip type goods distribution [FULround] delivers goods to different outlets within the urban area. From these outlets, goods may also be collected. If both distribution and collection occurs (even if the latter

means collecting empty packaging or reusable waste), vehicles will be (partly) loaded both in the inbound and the outbound direction. Both driving and loading/unloading takes time, accounting for the lapse of time between entering and leaving the city. If entrance time limitations apply, both entrance and leaving time must fall within this time frame..
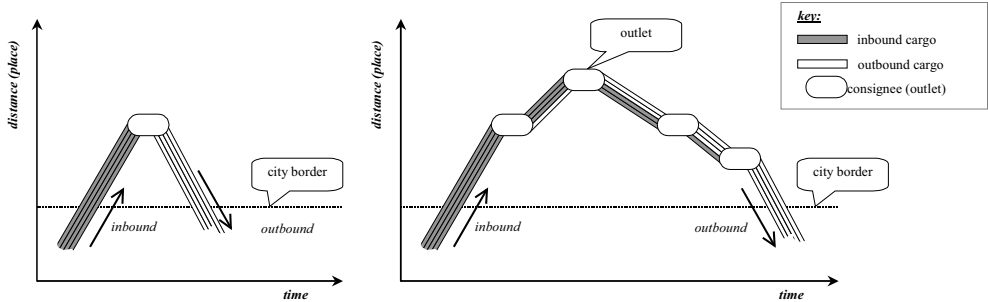

Figure 18-8:   Goods delivery and collection; left: [FUL direct], right: [FUL round]

18.7.3 Timing of access and egress transport in new urban distribution concepts

If a physical distribution system is used in which goods are transferred in a Local or Regional Transfer Point (LTP), a two-stage system applies. In the first stage, goods are delivered to and collected from outside the city, both to and from the LTP; in the second stage, the goods are distributed through or collected from the urban area with the LTP as a base.

Without an advanced logistics system, this could imply that vehicles that operate for the first phase have to wait at the LTP until the second phase (cycle) of the distribution/ collection has ended. This, of course, is not an efficient solution.
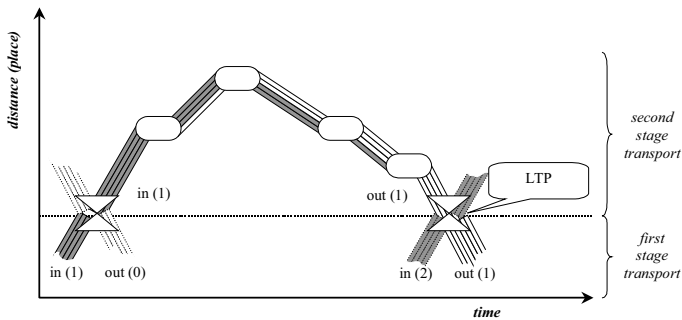
Figure 18-9:   Goods delivery and collection using a Local/Regional Transfer Point

For an efficient system, a phase-shift is necessary (see Figure 18-10). First stage transport delivers goods for further distribution at the LTP ('in (1)') and then loads already collected goods from a previous trip ('out (0)'). Then the second stage is performed, delivering collected goods to the LTP ('out (1)') that are collected by the first stage transport that just delivered goods for distribution ('in (2)'). This system requires a well-planned and executed distribution/collection scheme and also requires intermediate storage capacity at the LTP. This is because it cannot be expected that outbound flows always arrive 'just in time' at the urban distribution centre to be cross-docked to the first-stage transport system (see Figure 18-10).
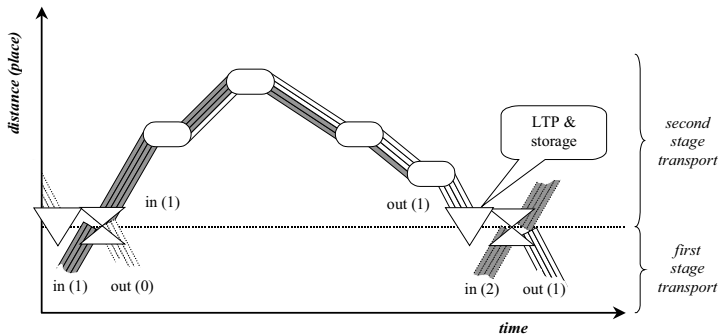
Figure 18-10:   *Intermediate storage at LTPs*

18.7.4 Night-time distribution

The introduction of some form of urban distribution centre enables night-time transport in the backbone system (supplying the LTPs with goods) and to some extent also night-time distribution of goods in cities. Transport during the night has two advantages. First of all, the drivers do not have to deal with the congestion on the highway system and the heavily used urban road network. Second, a shipment is at its destination right in the morning, in advance of the shop-opening times. Important disadvantages of night-time distribution are noise pollution for urban inhabitants (both caused by running vehicles and by the on/off loading processes) and possible organisational problems for receivers because night-time delivery often implies delivery of goods at shops when no one is present to receive the goods. Therefore, night-time distribution requires special measures for the addressees to be able to receive the ordered goods.

With respect to the environmental demands (noise), specially adapted vehicles should be used that run silently and allow silent load and unload procedures. The LTPs enable an efficient use of such specialised night-time distribution vehicles (se also Part IV). From an organisational point of view, for the deliveries either personnel or specific facilities should be available at the receivers' side. An example of such a specific facility is a locker that from the street-side is (only) accessible by the delivery system and from the other side only by the addressee. Such locker systems already exist for the delivery of dairy products to supermarkets and the collection of exposed films with photo shops. Without transhipments and intermediate storage, night-time intra city distribution also implies night-time transport on main links. By introducing transhipment and intermediate storage facilities at transfer points, a time shift can be made so that main link transport can deliver goods to an urban logistics centre all day long.

18.8   Appropriate urban logistics concepts for different goods flows

18.8.1 Introduction

In the previous sections, various urban distribution concepts have been proposed.

The main discriminating factors between these concepts are *directness* (direct/indirect), *control* (on own account, dedicated, restricted or public, see Section 16.3) and the type of service

of the inner urban distribution (LTPdirect/LTPround). In practice, there is almost no opera-
tional difference between transport on own account and dedicated transport; therefore, these
types are taken together. This results in the following set of possible combinations, of which
seven are feasible or logical (see comments in Table 18-1):

Table 18-1:   Categorisation of the different urban distribution concepts

distribution concept	type of operator	feasible*	comment
FULdirect	own/dedicated	yes	
	restricted	no	'restricted direct' is to be regarded as 'direct dedicated' transport
	public	no	'public direct' is to be regarded as 'direct dedicated' transport
FULround	own/dedicated	yes	
	restricted	yes	
	public	no	'public round' (so without a transfer) is to be regarded as 'restricted' transport
LTPdirect NETdirect	own/dedicated	no	the transfer (at the local or regional transfer centre) frustrates 'full control'
	restricted	yes	
	public	yes	
LTPround NETround	own/dedicated	no	the transfer (at the local or regional transfer centre) frustrates 'full control'
	restricted	yes	
	public	yes	
*	'no' indicates that the combination does not make much sense, but does not indicate that the specific combination is 'unthinkable'		
LTP	Local/regional Transfer Point concept, distribution concept including a transfer.		
NET	Network logistics concept, distribution concept including two transfers and a back-bone network		

In the following sections, the appropriateness of the different concepts is shown on basis of
the goods and goods flow characteristics.

18.8.2 Physical goods characteristics and urban distribution concepts

The *manifestation and packaging* of goods is an important issue when implementing logistic
systems that incorporate transfers (indirect distribution). Only packed goods, and especially
goods packed in load-units, can be transferred quickly, cheaply and securely (see also part
IV). In the current situation, large load-units are used infrequently. Therefore, fundamental
changes are needed in the use of load units to enable the introduction of these indirect distri-
bution systems. Although load-units are used only in a limited share of the shipments , in
terms of shipment volumes, load-units are more important. In large shipments load units are
often used, because this eases load/offload processes.

The combination of *package and volume densities* lead to the portfolio-categorisation as in-
troduced in Part II. Where handling costs are high, indirect distribution is less attractive (this

applies to the subcategories Cc and Cd). The sub-categories for which transport costs are important, must take full advantage of consolidation opportunities (Ca, Cb and Cd) that include a transfer. However, if transfer costs are relatively high, a transfer via a LTP is not so attractive; nonetheless, if load units are used, this disadvantage is less important.

Goods that need special care need specific distribution systems. Although (public) urban distribution concepts were originally seen as inappropriate for *dairy, dirty, difficult* goods, specialised (but shared) services can deal with these goods after all. Some retailers have shown that it is perfectly possible to handle and transport fresh goods, outsized goods and certain types of waste together with other goods. Table 18-2 summarises the appropriateness of the different urban distribution concepts for the distribution of goods with special care requirements.

Table 18-2:   ***Appropriateness of distribution concepts for specific goods types***

	FULdir	FULround		LTPdirect		LTPround	
	own	*own*	*res*	*res*	*pub*	*res*	*pub*
portfolio Ca				**	**	**	**
portfolio Cb	*	**	**	**		**	
portfolio Cc	***	***	***	*		*	
portfolio Cd	***	***	***	*	*	*	*
'dairy, dirty, difficult'	***	***	***	*		*	
key: *** = most appropriate, * = least appropriate; empty cell = not appropriate							
dir = direct, res = restricted, pub = public							

18.8.3 Shipment characteristics and urban distribution concepts

Fast movers are often distributed using decentralised distribution systems. Due to the large volumes, direct distribution is preferred. Public services would be too expensive. If goods flow volumes are sufficient, LTP-distribution concepts are preferable. *Slow movers* may be distributed by public or restricted services, as direct distribution is quite expensive.

Commodities may be distributed directly or indirectly (see Section 18.5); LTP-distribution concepts are preferable. Because retailers would prefer to keep maximum control over *specialities*, direct or dedicated services are most appropriate; restricted services are a less relevant option.

Time-critical goods are best transported via direct distribution (on own account) or other networks; especially if the volumes are low, specialised public services may be used.

Table 18-3 summarises the appropriateness of the different urban distribution concepts for goods with specific marketing characteristics.

Table 18-3:   *Appropriateness of distribution concepts for specific marketing characteristics*

	FULdir	FULround		LTPdirect		LTPround	
	own	own	res	res	pub	res	pub
fast movers	***	***	***	*	*		
slow movers	*	*	***			**	**
commodities	*	**	**	***	***	***	***
specialities	***	***	**	*		*	
time critical	***			*	*		
key: *** = most appropriate, * = least appropriate; empty cell = not appropriate							

18.8.4 Goods flow characteristics and urban distribution concepts

If goods flow volumes are large, high capacity distribution is necessary (or: possible). Direct transport or round trips on own account will often be most appropriate. If volumes are somewhat limited, restricted distribution with round trips is an option. If an LTP must be included within the distribution channel, direct restricted (LTPdirect-restricted) distribution is preferable. If goods flow volumes are small but shipments are large, restricted distribution (LTPround – restricted) may be a good option. With small volumes and small shipments, shared distribution concepts are most appropriate, thus restricted or public LTP concepts. Table 18-4 summarises the appropriateness of the different urban distribution concepts for distributing different types of goods flows.

Table 18-4:   *Appropriateness of distribution concepts for goods flow characteristics*

	FULdir	FULround		LTPdirect		LTPround	
	own	own	res	res	pub	res	pub
large volume/ large shipments	***	*					
large volume/ small shipments			***	**			
small volume/ small shipments				*	*	***	***
key: *** = most appropriate, * = least appropriate; empty cell = not appropriate							

18.9   Conclusions

New urban distribution concepts should improve the economic and societal efficiency of goods distribution processes. Key concepts for achieving efficiency gains are *consolidation* and *specialisation* (a concept that will receive special attention in part IV).

Under preconditions set by marketing strategies and policy requirements, and the developments therein, we propose a limited set of new urban distribution concepts.

The set can be *limited*, because we have shown that within a given physical distribution network (or scheme), different levels of quality and tariffs can be offered, resulting in the required flexibility in distribution products.

We therefore propose a *set* of concepts to accommodate the already optimised distribution systems of private firms and to accommodate different types of flows controlled by different types of marketing strategies.

We propose three main physical distribution concepts, with six sub-concepts:

- Full vehicle load distribution [FULdirect, FULround];
- City Logistics [LTPdirect, LTPround];
- Network Logistics [NETdirect, NETround].

The full vehicle load distribution concept interferes least with (optimised) strategies of private firms. The concept only accommodates transhipments that may be needed to operate dedicated vehicles for specific destination areas.

The city logistics concepts are aimed especially at mid-sized firms that are not able to fully optimise to adapt their logistics system for urban distribution (or who rather outsource). City logistics will also be focused on relatively short-distance distribution. The different variants refer to the way goods are distributed within urban areas.

The Network Logistics scheme aims at long-distance distribution by large suppliers, retail organisations or logistic service providers (integrators) controlling large goods flows.

The direct and round-trip (FUL) services without interchanges enable direct distribution to consignees if the vehicles used meet all criteria set.

The indirect services require transhipments at a Logistic Transfer Point, either to enable consolidation or to transfer the goods to dedicated urban distribution vehicles.

All concepts provide in differentiated services and try to achieve optimised load factors for dedicated urban distribution vehicles and, at the same time, try to optimise inter-city haulage (see also Thoma, 1995).

The new distribution concepts require (sometimes fundamental) changes in physical distribution organisation. We propose alternative organisational forms and explain the consequences of the new concepts for the timing of access – egress transport to the urban areas. We show that decoupling inner city distribution activities from access and egress transport, including a shift in distribution and collection phases, can smoothen the overall distribution process. Travel times will be shorter and may occur at most convenient moments by introducing intermediate storage facilities.

In the end we showed that, for all relevant goods, shipment and goods flow characteristics, appropriate distribution concepts can be found.

19. Summary and conclusions of Part III

19.1 Efficiency improvement of goods distribution by logistics optimisation

As recognised in Part I, urban goods distribution activities are vital, but are at the same time hampered by a variety of reasons and can cause various sorts of pollution, and traffic problems. Based upon the transport system theory as proposed in Part II, we argued that only integrated transport system solutions could result in comprehensive efficiency improvements, both for the urban distribution process itself and for the urban environment.

One of the key issues in optimisation of urban distribution processes is the optimisation of the organisation of those processes – after all, the logistic organisation steers the physical distribution processes and thus the related traffic flows.

In this part III we developed a limited set of advanced urban distribution concepts. For inter-urban distribution and – in general – distribution outside cities these include:

- Full Vehicle Load distribution [FULdirect, FULround];
- City Logistics of Less than Vehicle Load distribution [LTPdirect. LTPround];
- Less than Vehicle Load Network Logistics [NETdirect, NETround].

The direct services and round trip services [FULdirect, FULround] can be operated on own account or by dedicated professional providers. They are particularly suitable for transporting relatively large goods flows to a limited number of destinations within the urban area.

City logistics concepts are especially suitable for short distance distribution (origins of the flows in the proximity of the urban areas) and for relatively small shipment sizes and transport flows.

Network logistics concepts aim especially at longer distance (interregional, national) distribution of large flows and shipments by large suppliers, retailers or logistic service providers.

The relatively limited set of distribution options offers opportunities for consolidation and efficiency, but at the same time enables the operation of a wide variety of logistic services. They are also able to cope with foreseeable future developments in logistics.

The proposed new urban distribution systems fundamentally alter the way distribution is organised. Instead of single-company single channel optimisation, these new systems try to find real, comprehensive, optimal solutions. The concepts are not tied to certain companies, but include all activities of a certain type (integrated, cross-firm optimisation).

The concepts are based on existing but adapted optimisation strategies as used by firms and comprise parallel ways of distributing goods. Although the physical distribution network has changed, the marketing channels do not need to be changed at all (nonetheless, new types of marketing channels can be accommodated).

19.2   Marketing and distribution channels

The new urban distribution concepts are in fact specialised physical distribution networks. These networks are formed from the basic principles of *consolidation*, *deconsolidation* and *transport* between *activity centres*. Through consolidation, economies of scale can be achieved and thereby various efficiency improvements. The networks themselves pose other advantages of scale that enhance efficiency.

At the local scale, the Local or Regional Transfer Points (LTPs/RTPs) function like hubs in a hub-and-spoke network: goods are consolidated and transported via the spokes to the LTP (hub) and from thereon further transported to the destinations.

LTPs also function as logistic centres in consolidation/deconsolidation networks, enabling goods transport at longer distances. In fact, the consolidation/deconsolidation networks with the interconnecting trunk lines form the basis of the *Network Logistics* concept. The basic physical distribution principles, the configuration of the urban areas, the mutual positioning and the location of (important) suppliers determine the physical network shape – as will further be elaborated in part IV.

The same physical distribution network can offer different services thereby supporting the operation of different types of physical distribution channels, representing different configurations of physical distribution actions.

Changes in the urban distribution system can potentially interfere with relationships between actors in existing channels and therefore the *channel-directorship*. Therefore, new urban physical distribution concepts may to some extent influence the competitive position of actors within the marketing channel. However, these shifts in competitive positions are not necessary to make the new concepts work.

Because products can be distributed fairly easily using different marketing and physical distribution channels, there is not much risk that new urban distribution concepts will exclude the distribution of specific goods.

19.3   'Urban logistics theory'

Physical distribution channels and marketing channels consist of mutual related logistic units or actors, such as producers and suppliers, trade or logistic intermediaries and consumers. These actors perform different basic logistic activities, namely searching for suppliers, production, inventory, transport, searching for consumers (sales) and assortment composition (consolidation in physical distribution terms).

Of course, all channel activities are, in the end, aimed at selling products to customers, and thus sales are of paramount importance. The sales or marketing strategies strongly influence the way the distribution channel must function and therefore have an impact on the design of the new urban distribution concepts.

Large-scale production is usually of minor direct importance for urban areas and is not the primary focus in urban distribution, but small-scale production must be taken into account. Moreover, production processes have an impact on the organisation of the physical distribution process. In addition, production strategies can be modified to fit marketing strategies, especially with respect to the organisation of the supply (deliveries and inventories).

Inventory management strategies relate strongly to production or marketing strategies. Nowadays, most integrated logistic concepts try to minimise inventories by adjusting delivery intervals and shipment sizes to the sales volumes. Efficient transport operations can profit from various types of consolidation because consolidation implies advantages in scale; often, a rearrangement of goods at logistic centres (transhipment centres) is necessary to obtain an optimal level of consolidation. Some of the new urban distribution concepts developed (namely the LTP-types) include such transhipments.

Assortment composition is the marketing equivalent of consolidation. Assortment composition entails bringing together different types of products in one location; this process can be performed at different levels. Urban areas can be regarded as assortments of shops, and shops in themselves supply assortments of products. The characteristics of the retailers' assortments (expressed in variety and types of products) strongly influence the demands to the physical distribution process, even more than product characteristics on their own.

We have adapted logistics theory in order to clarify the relationship between different basic logistic activities to analyse and understand urban distribution activities.

The interactions or the trade-offs are an important tool for optimising the different basic logistic activities. We have shown that optimisation can occur along columns (from supplier to consumer) or along rows (similar activities), mostly controlled by a single actor. We also have shown that these trade-offs can also be used for cross-firm optimisation. In fact, network logistics and city logistics concepts are cross-firm optimisation schemes, aimed especially at transport, but also including basic activities such as inventory-keeping and assortment composition/consolidation.

19.4   Discussion of the results so far

19.4.1 Opportunities

The proposed logistic concepts are based on ongoing developments in logistics, namely professionalisation (from transport on own account to professional transport; more advanced lo-

gistic systems) and centralisation of production and logistic facilities (even internationally). Shippers and receivers get accustomed to the situation that goods flows are handled and organised by third parties. They experience that it is still possible to monitor (tracking and tracing) and control these flows and that the reliability is at an acceptable level.

Increased attention for accessibility and environmental problems have raised both interest in finding new ways for urban distribution as for short-distance (national) goods transport. Although a necessary 'believe' in market forces to optimise logistics remains, several governmental organisations begin to see the necessity of stronger incentives. They do not longer rely only at market initiatives, but are also looking to the policy options they have themselves to direct developments in a desired direction.

19.4.2 Threats

Probably the most important players in the field of urban goods distribution are transport companies, logistic service providers and especially retailers. Although some of these companies support ideas of City and Network logistics (especially larger logistic service providers), often there is a lack of support with these companies for profound changes in logistics.

This can be partly related to the sometimes quite 'ad-hoc' based way goods transport takes place – especially small companies are hardly accustomed to apply advanced logistic systems. Shop owners rely on their (direct) relations with suppliers and/or transport companies. A lot of small transport companies have a rather limited scope with regard to logistic operations. These groups are generally not in favour of new logistic concepts.

This also applies to very large retail chains – these companies already use highly advanced logistic systems and often make use of dedicated distribution facilities and specialised transport equipment. They have optimised their processes very well – that is: within their own organisations. Also these large companies are reluctant to participate in urban distribution concepts although participation in larger scale (national) distribution concepts may be an option.

Other objections against joint and public distribution schemes are the high disinvestments and transition costs, and the fears for a monopolised distribution market, the potential leakage of sensitive information, and the loss of (direct) control. The advantages of the newly developed distribution concepts (with the associated technological means as discussed in Part IV, and the spatial preconditions as discussed in Part V) should together with the public policy support (as discussed in Part VI) largely overcome these objections. The urban distribution concepts developed are all based on the premises that urban areas of rather high densities exist and that it is possible to concentrate transport flows spatially. Both premises can be put in question if some autonomous developments are taken into account.

One can argue that in the case of spatial dispersion of urban activities, there may be less need for advanced logistic concepts that are based on consolidation. And, even worse, that it will be almost impossible to bundle the (tiny) flows to consolidated flows of reasonable size – so that the new concepts can be used efficiently. This argumentation is valid – if spatial dispersion occurs and there is no drive for concentration, it makes less sense and it will be more difficult to use logistic systems that are based on the concept of consolidation. Nevertheless, due to other policy goals – namely accessibility of various facilities by 'slow' transport modes and public transport – we assume that unlimited spatial dispersion will not be accepted by (Western European) policy makers.

Nowadays 'privatisation' and the blessings of the free market interfere with notions that pol-

icy makers should intervene in urban logistic processes. Transport companies, shippers and receivers should be free to find their own solutions, only the government can stimulate and facilitate those private initiatives and can set some limitations.

19.4.3 Recommendations

We certainly do not propose the introduction of municipal freight transport services, controlled by urban politics. But we argue that given the fragmentary nature of goods distribution, companies on their own can not come to optimal overall solutions. Only some very large logistic service providers or shippers can develop and operate seemingly efficient distribution systems (seemingly, because from traffic perspective some further optimisation will certainly be possible). This could lead to the infamous prisoners' dilemma: if large groups of companies would work together, they could find better solutions, but the first ones to take action are likely to be competed to 'death'. Government action can help 'first movers' to overcome the short-term barriers to reach a long-term better solution. This can be 'pull-actions', measurements that make alternative forms of distribution more attractive (creating new infrastructures, transport systems or information systems) and also be 'push-actions' that force companies to take another path in logistic developments.

Both types of action should be taken at the same time, because they reinforce each other. Furthermore, pull-actions can make push-actions more acceptable.

When speaking about an 'optimised' logistic system, we realise that the consumer market is a very volatile one. Optimised logistic systems may never be completely rigid systems. Still, some (literally) fixed points in the system must be accepted – notably the (location of) urban logistic parks and the routes of (dedicated) infrastructure.

19.5   Logistics, transport systems and policy

The logistics systems form the organisational basis for the efficient urban goods distribution systems that we will combine in Part VI. First, we have to look to the physical aspects of the goods distribution system. These physical systems enable the goods distribution in practice and, at the same time, cause the actual problems that we have to deal with (Parts IV and V).

We will show that there is a large variety of possible developments in physical means for goods distribution. The application of these means ask for a well-tuned logistics system, that is introduced in this Part III: we will show that the requirements of the advanced logistics systems we propose, fit neatly to the performance of new transport technologies. In Part VI we will show that the new logistics systems enable the application of the most advanced transport technologies.

References

Binsbergen, A.J. van (1994), System-optimizing in city logistics; in: *Proceedings OECD conference Reconciling Transportation, Energy and Environmental Issues*, Paris/Budapest (OECD).

Binsbergen, A.J. van (1999) Standaardisatie voor stedelijk goederenvervoer (in Dutch), in: R.H.J. Rodenburg and A.L. Kruse (eds.), *Bijdragen Vervoerslogistieke Dagen 1999*, Delft, (Connekt).

Binsbergen, A.J. van & Th.J.H. Schoemaker (1993), *Morgen Bezorgen: goederen distributie in steden van morgen* (in Dutch), Delft, (Delft University of Technology).

Binsbergen A.J. van, J.G.S.N. Visser (1997) Haalbaarheidsstudie stadsdistributiecentrum Delft, transferpunt voor goederen met een binnenstedelijke bestemming (in Dutch), Delft, (TRAIL Onderzoekschool).

Binsbergen, A.J. van, J.G.S.N. Visser & C. Maat (1997), Project korte-afstand gecombineerd vervoer ten behoeve van stedelijke distributie: locatiekeuze terminals en netwerkvorming (in Dutch), Delft, (TRAIL Research School).

Boerkamps, J.H.K., Binsbergen, A.J. van, Bovy, P.H.L. & W. Brouwer (1999) *GoodTrip-Evaluatiemodel voor alternatieve concepten van stedelijke distributie*, Delft (Technische Universiteit Delft).

Bolt, E.J. (1995) *Produktvorming in de detailhandel, handboek*, Merkelbeek (WBN).

Bowersox, D.J., D.J. Closs & O.K. Helferich (1986), Logistical management: a systems integration of physical distribution, manufacturing support, and materials procurement, New York, (Macmillan Publishing Company).

Browne, M., J. Allen (1997), Strategies to reduce the use of energy by road freight transport in cities, in: *25th European Transport Forum, proceedings of seminar B: Freight, volume P412*, London, (PTRC), pp. 79-96.

Brugge, R. ter (1991), Logistical developments in urban distribution and their impact on energy use and the environment, in: *Freight transport and the environment*, Amsterdam, (Elsevier Science Publishers), pp. 331-342.

Button, K. (1993) *Transport Economics*, Aldershot, (Edward Elgar Publishing).

Coopers & Lybrand Management Consultants (1991), Plaatsen van stadsdistributiecentra: definitiestudie/naar een bereikbare en leefbare binnenstad van Maastricht/startfase SDC in Maastricht (in Dutch), Den Haag, (Coopers & Lybrand / Ministerie van Verkeer en Waterstaat).

COST (1997), *COST 321 Urban Goods Transport, final report,* draft version, Brussels, (COST 321 Action European Union).

COWI (1996), Rationalisation of Urban Goods Transport, Lynby/Aalborg, (COWI/NTU).

Cox, M.D. (1997), *LogisticsWorld Logistics Glossary*; [logistics@logisticsworld.com].

Centraal Planbureau (CPB) (1997) *Economie en fysieke omgeving, beleidsopgaven en oplossingsrichtingen 1995-2020*, Den Haag (Sdu).

D&P (1999), *Retail handboek, kentallen voor de detailhandel* (in Dutch), Den Haag, (D&P Onderzoek en Advies).

Dufour, J.G. & D. Patier (1997), Introduction to the discussion based on the experience of the French experimental and research programme, in: *CEMT Round Table 108 Freight Transport and the City*, PAris, (CEMT).

ECMT (1984), *Round Table 61 Goods Distribution Systems in Urban Areas*, Paris, (European Conference of Ministers of Transport).

Geurs, K.T. & G.P. van Wee (1996) *Koppeling van nationale economische ontwikkelingen aan goederenvervoerprognoses*, Bilthoven (RIVM).

Goor, A.R. van, W. Monhemius & J.C. Wortman (ed.) (1993), *PolyLogistiek zakboekje* (in Dutch), Arnhem, (Koninklijke PBNA).

Goor, A.R. van, M.J. Ploos van Amstel & W. Ploos van Amstel (1992), *Fysieke distributie: denken in toegevoegde waarde* (in Dutch), Leiden/Antwerpen, (Stenfert Kroese).

Hoofdbedrijfschap Detailhandel HBD (1996) *Jaarboek Detailhandel 1996-1997*, Den Haag (HBD).

Huijbregts, P., B.J.P. Janssen & L. Simons (1997), A comparison of logistics strategies and structures of freight flows of grocery retailers in four European countries, Den Haag, (NEA/PbIVVS).

Koekenberg, M.S. (1999), *De ULD in de pijplijn* (in Dutch), Delft (Technische Universiteit Delft).

Köhler, U. (1997) An innovating concept for city-logistics, in*; Proceedings 4th World Congress on Intelligent Transport Systems*, Berlin, [CD-ROM].

Köhler & Strauß (1997), City-Logistics concept in Kassel, in*: 25th European Transport Forum, proceedings of seminar B: Freight, volume P412*, London, (PTRC), pp. 97-101.

Lancaster, K. (1971), *Consumer demand: a new approach*, New York/London, (Columbia University Press).

Lancaster, G. A. & R. A. Lomas (1985), *Forecasting for sales and materials management*, Houndmills, Basingstoke, Hampshire/London (Macmillan Publishers).

Lewis, A. (1997), Alternative Urban Freight Strategies, synthesis report: Alternative Strategies for Urban Freight Transport Management, Oxfordshire.

McKinnon, A.C. (1989), *Physical distribution systems*, London, (Routledge).

Molenberg, F.J.L. & H. G. Schaaf (1992), *Af fabriek naar publiek, logistiek voor de detailhandel* (in Dutch), Alphen aan den Rijn (Samsom BedrijfsInformatie).

Nemoto, T. (1997) *Area-wide inter-carrier consolidation of freight in urban areas, Transport Logistics*, Vol 1, No 2.

NT (2000), Supermarkt zonder winkel groeit als kool (in Dutch); in: *Nieuwsblad Transport*, 14 juli 2000, Rotterdam (Elsevier Bedrijfsinformatie)[see also: www.groceryworks.com].

Ogden, K.W. (1992) *Urban Goods Movement: A guide to Policy and Planning*, Aldershot, (Ashgate).

Pearman, A.D., & K.J. Button (1981), *The Economics of Urban Freight Transport*, London, (The MacMillan Press).

Retail Industry (2000), *Eleven major retailers form new B2B exchange*, About.com; [http://retailindustry.about.com/library/weekly/aa033100a.htm].

Riet, J. van, P. Prak, & A. Vieveen (1996), *Nachtdistributie en nachttransport in het wegvervoer* (in Dutch), Delft, (INRO-TNO).

Rost van Tonningen, B. (2000), *E-consumer-marketing and the old world*, Holland Business Publications [http://management.hbp.net/zoekmachines/222.htm].

Ruske, W. (1994) City Logistics – Solutions for urban commercial transport by cooperative operation management, in: *OECD Seminar on Advanced Road Transport Technologies*, Omiya, Japan (OECD).

Ruijgrok, C.J. (1991), *Vervoer met PIT*, Leiden, (Stenfert Kroese).

Taniguchi, E., R.G. Thompson & T. Yamada (1999) Modelling City Logistics, in: E. Taniguchi & R.G. Thompson, 1999, *City Logistics I*, Kyoto (Institute for Systems Science Research).

Tavasszy, L.A., B. Smeenk & C.J. Ruijgrok (1998), A DSS for modelling logistic chains in freight transport policy analysis, paper presented at the Seventh International Special Conference of IFORS Information systems in logistics and transportation, Gothenburg, Sweden 16-18 june 1997, Amsterdam, (IFORS/Pergamon-Elsevier Science) [Int. Trans. oppl Res. Vol. 5, No. 6, pp. 447-459].

Thoma, L. (1995), *City Logistik: Konzeption, Organisation, Implementierung*, Wiesbaden, (Gabler Verlag/Deutscher Universitäts Verlag).

TNO-Inro (1998), Goederenvervoer uit de knoop, hoofd- en achtergrondrapport, Den Haag, (TNO-Inro/PbIVVS).

TRB (1986), *Twin trailer trucks, Special Report 211*, by the Committee for the twin Trailer Truck monitoring study, chairman Kenneth. W. Heathington, Washington, (Transportation Research Board).

Urwin, D. (1997), *Department of Politics and International Relations*, Aberdeen, U.K., (University of Aberdeen) [http://www.abdn.ac.uk/~pol028/index.htm].

Verhage, B. (1995), *Inleiding tot de marketing* (in Dutch), Houten, (Stenfert Kroese).

Vermunt, A.J. & F.M.C. Olsthoorn (1995) Verschijningsvormen van logistieke knooppunten, in: *Praktijk Magazijnen/Distributiecentra*, (Kluwer bedrijfswetenschappen).

Visser, J.G.S.N. (1993), Bevoorrading van bedrijven in de binnenstad, in: Th.A.M. Reijs, P.T. Tanja (red.), *Proceedings Colloquium Vervoerplanologisch Speurwerk, 'Grenzen aan de vervoerplanologie'* (in Dutch), Delft, (CVS), pp. 1174-1194.

Visser, J.G.S.N., A.J.M. Vermunt, & A.J. van Binsbergen (1998), *Ruimtelijke concepten ondergronds transport* (in Dutch), Delft/Hoeven, (TRAIL Research School).

Visser, J.G.S.N., A.J. van Binsbergen & Toshiro Nemoto (1999) Urban Freight Transport Policy and Planning, in: E. Taniguchi & R.G. Thompson, 1999, *City Logistics I*, Kyoto (Institute for Systems Science Research).

Weijers, S. & B. Janssen (1997), Changing logistic strategies and structures in retailing in: *Proceedings Vervoerlogistieke Werkdagen 1997*, Rotterdam, (VLW), pp. 21-38.

Wit, J. de & H. van Gent (1996), *Economie en transport*, Utrecht, (Lemma).

PART IV
Transport systems for urban goods distribution

CONTENTS OF PART IV

20. Introduction to transport systems for urban distribution

20.1 Introduction

Part IV deals with the physical aspects of the urban distribution system and provides the elements that are necessary to physically implement the logistics concepts elaborated in Part III. The layer scheme methodology, as introduced in Part II, is used extensively throughout this part to highlight the interrelations between the different features of the physical transport system. The concept of *consolidation* will be applied to the transport system, to facilitate understanding the advantages of applying larger transport means and bundling infrastructures.
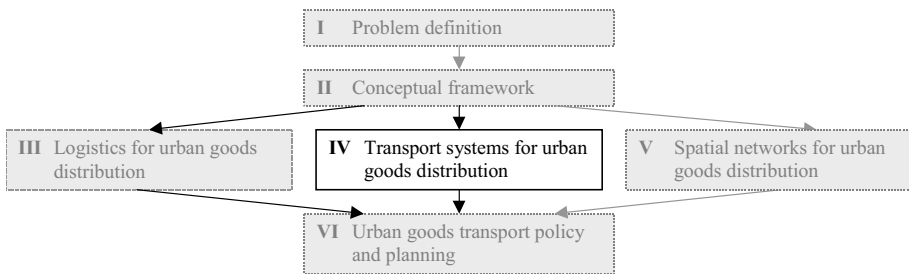
Figure 20-1:   *Part IV related to the other parts of the thesis*

The physical elements elaborated in this Part IV form, together with the organisational aspects as developed in Part III, and the spatial aspects as will be worked out in Part V, the building blocks for the policy making process which will be elaborated in Part VI.

This Part especially aims at the following research questions:

(1) Develop a clear understanding of the goods distribution in urban areas and the way it is related to environmental and accessibility problems.

The logistics organisation, as analysed in Part III, employs technical means to perform the task of transport goods to and within urban areas. It is important to comprehend the characteristics of the technical means to be able to fully comprehend the goods distribution process and the relation to its environment.

(2) Develop an integrated concept and survey and analyse possible solutions related to the concept that may lead to a more efficient urban freight transport system.

The integrated concepts use (new) technological means at their optimum to improve the quality of the distribution process and to limit the unwanted effects.

20.2   Contents of Part IV

Part IV presents a number of new insights and applications, which we specify below.

Introducing the concept of intermodality for urban goods distribution.

Intermodality is generally seen as only a long-distance alternative to road transport. We will demonstrate that road transport can also be intermodal transport, if we consider the large differences between different types of road vehicles. We introduce, adapt and apply various applications of intermodal transport (rail-road, road-underground, rail-underground) for urban goods distribution.

Proposing the application of load-units for urban goods distribution.

We will show that the use of load-units enables the mechanisation and automation of transfer processes and therefore eases the application of intermodal concepts and advanced logistic concepts.

Introducing a systemisation of load-units.

We will propose a systematic categorisation of load-units applicable for urban goods transport.

Proposing the application of various technological developments in transport means and traffic means in urban goods distribution.

We will demonstrate and introduce developments in transport means and traffic means, including the enlargement in scale of road transport, a reduction in scale of rail transport, improvements and new developments in propulsion technology, and show their possible application in urban goods distribution systems.

Proposing the application of dedicated infrastructures for urban goods distribution.
We will propose the application of dedicated infrastructures or restricted-access infrastructures in urban areas, both at surface level and underground.

Introducing different management strategies for dedicated infrastructures
We will introduce different management strategies for dedicated infrastructures, and will show the various impacts of these strategies on the expected utilisation of these infrastructures and the possible consequences for infrastructure (network) design..

The contents of this Part is as follows.

Chapter 21 introduces some basic notions that are necessary to understand current developments and proposed changes of physical means for goods transport. The chapter will explore the concepts of *consolidation* (now applied to physical transport systems) and *intermodality*, and outlines the framework that is necessary to assess the quality of the transport system.

Following the layer scheme methodology, in Chapter 22 we will describe the use of load-units, which play a prominent role in intermodal operations. We will propose a modular set of units that can be used in different stages of the distribution process, with different transport modes.

Chapter 23 elaborates the transport means that carry the load or load-units to be transported. We show the different options to enhance transport efficiency by enlarging the scale of road transport and 'downscaling' railway and inland waterway transport. The latter is necessary to enable applying these transport modes for urban goods distribution. We also elaborate the underground transport means.

In Chapter 24, we will introduce the different options to improve the efficiency of operating traffic means, the means that propel and guide the transport means. We will discuss developments in transport automation and propulsion technology. We will show how these developments can be applied to the different transport modes, and discuss the costs aspects of traffic means.

The different types and characteristics of infrastructures are introduced in Chapter 25. We will describe line infrastructures for road, rail and underground transport and we will introduce the concept of freight and transfer centres (node infrastructure). We will introduce different infrastructure management strategies and we will demonstrate the (sometimes) far-reaching consequences of these strategies for the infrastructure use and the repercussions on network design. We will also show that the implications of some commercial management strategies may conflict with certain policy objectives.

In Chapter 26, we will combine all the elements that were developed in the previous chapters to an integrated, intermodal physical goods transport system for urban areas. We will show the applications of new developments for inner urban and extra-urban distribution processes and we will highlight the importance of transfer centres.

The applications are illustrated with practical examples.
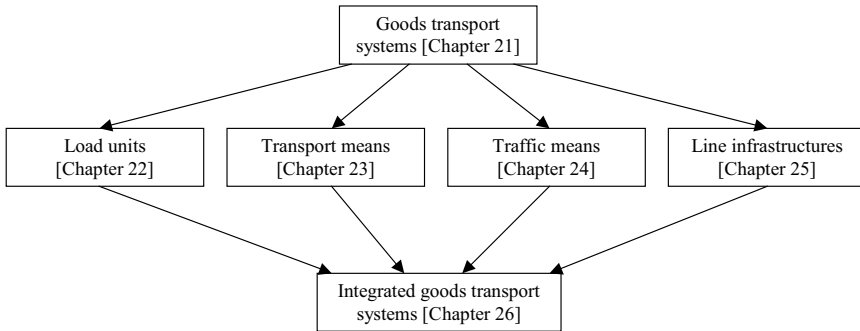
Figure 20-2:   ***Structure of Part IV, Transport systems for urban goods distribution***

20.3   'Transport systems' in relation to urban goods distribution

Figure 20-3 shows the primary services, roles and actors related to physical transport systems for urban goods distribution. In Part IV, we focus especially at *load-units*, *transport means*, *traffic means* and *line nfrastructure* and we will discuss the impacts of these elements on *resource management*. In Part IV we will focus primarily on physical means, rather than on services, roles or actors. These means are highlighted in Figure 20-4.
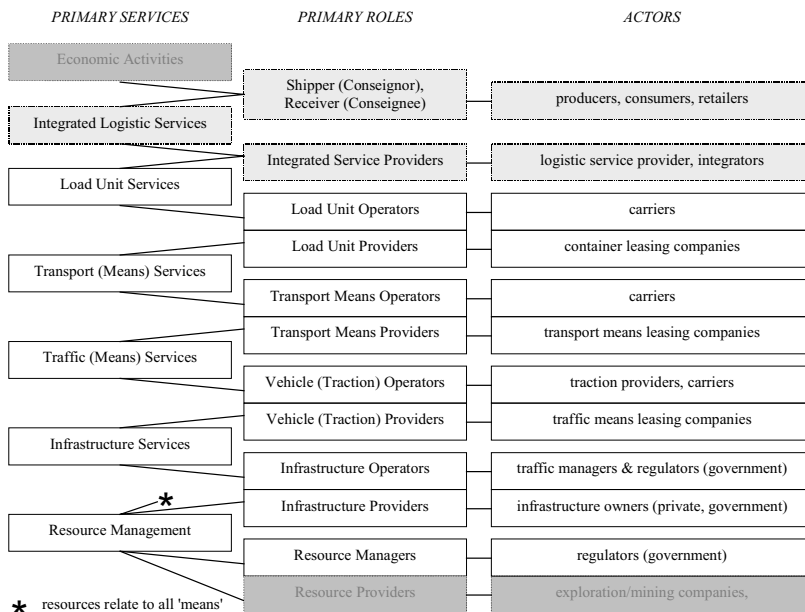
Figure 20-3:   ***Primary services, roles and actors related to physical transport systems***

PRIMARY SERVICES	PRIMARY MEANS	DIMENSIONS

Economic Activities

Goods/Products → weight, mass [ton]; volume [m^3]

Integrated Logistic Services

Cargo → weight, mass [ton]; volume [m^3]

Load Unit Services

Load Units (containers) → units [#]; unit-kilometres [km]

Transport (means) Services

Transport Means (trailers, carriages, barges) → transport performance [tonkm]

Traffic (means) Services

Traffic Means (trucks, locomotives, pushboats) → traffic performance [veh.km] trips, stops [#]

Infrastructure Services

Infrastructure Means (roads, tracks, waterways, nodes) → traffic intensities [veh/hr]

*

Resource Management

Resources (space, energy, 'air') → space utilisation [m^2] emissions [kg], energy use [J]

ton = metric ton (1000 kgs)

\# = number (no dimension)   *   resources are used by all 'means'

Figure 20-4:   Primary services and means, related to physical transport systems

21. Goods transport systems

21.1 Introduction

In this chapter, we introduce some of the basic concept required to understand the ideas and concepts that we will develop in Part IV. In Section 21.2, we will define the different ways in which the physical goods distribution system can be subdivided (modes and submodes). In Section 21.3, we will explore the notion of *consolidation*, as is first introduced in Part II, but in terms of the physical transport system. We will then explain the notion of *intermodality* in Section 21.4. In Section 21.5, we will deal with the disutilities of the transport system. We will finish this chapter with some important conclusions. All these ingredients are used later on to describe, develop and evaluate physical transport systems for urban goods distribution.

21.2 Transport modes

Transport systems can formally be characterised by the types of:
- Transport means;
- Traffic means, subdivided into the aspects of:
    - vehicle-infrastructure contact;
    - vehicle guidance;
    - propulsion technology;
- Infrastructure or type of physical support.

Transport means are typically characterised by the load capacity and also by the type of hold (that is, open/closed, detachable, loading/offloading mechanism, etc.).

Traffic means are especially characterised by technical features of aspects. The vehicle-infrastructure contact can be rubber tired wheels, steel wheels, air or electromagnetic cushions, among others. In addition, the propulsion system can vary (combustion engine, electric engine). Furthermore, there are differences in vehicle guidance systems (manual, automated, and different systems in vehicle automation).

Infrastructure can be subdivided into physically guiding infrastructures (different types of rail) and non-guiding infrastructure with examples such as road and water infrastructure and terminal infrastructures such as airports and sea harbours.

Each feasible combination of different basic components can be regarded as a distinct transport mode. Within these modes, sub-modes can be distinguished that differ in few non-essential, but nonetheless important aspects, such as load-capacity or degree in automation.

Infrastructure is often chosen as the implicit basis for distinguishing the transport modes, such as is already suggested by the terms: *road transport*, *inland waterway transport* and *railway transport*.

21.3   Consolidation

As is explained in Part II (Section 9.5), *consolidation* consists of bringing entities together with the objective of attaining efficiency improvements through advantages of scale.

In terms of load and vehicle consolidation, we distinguish four types (see also Figure 21-1):

- I: consolidation of products in colli;
- II: consolidation of colli in one vehicle, cargo hold or load-unit;
- III: consolidation of different vehicles or wagons in a 'train', or load-units in a vehicle;
- IV: consolidation of different train-parts to a (larger) train or small vehicles into large vehicles.

I: products in colli

II: colli in vehicles or in load units

III: wagons in trains,
load units in vehicles

IV: short trains in long trains,
small vehicles in large vehicles
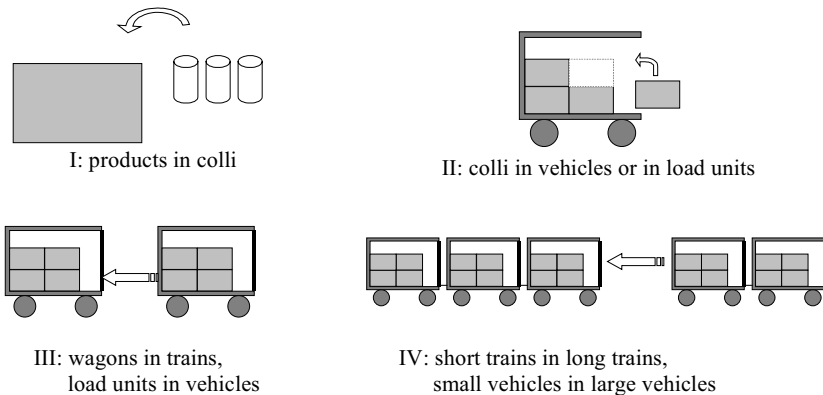
Figure 21-1:   Different types of load and vehicle consolidation

With respect to the physical transport system itself, three additional ways of consolidation (bundling) are relevant:

- Bundling vehicles on infrastructures;

- Bundling (grouping) separate but parallel connections to one single connection (or: bundeling traffic from alternative parallel routes onto one route);
- Spatially bundling different types of infrastructure in a limited area.

Through consolidation, use can be made of larger vehicles, high quality infrastructure and high performance equipment – all due to the economies of scale. In general, consolidation enables the use of high performance technology. High performance technology is generally more expensive, though the higher productivity can render lower costs per unit of transport service. The act of consolidation also costs time: one has to accept detours, the consolidation and possibly extra stops. These initial costs will only be accepted if these losses are more than compensated by the savings due to the economies of scale.

Consolidation activities often ask for transhipments of goods or load-units (note that coupling wagons to trains and bringing vehicles together on high-capacity infrastructure takes time, but is not regarded as transhipment). The transhipment activities can take place in specially designed transfer facilities, such as Local or Regional Transfer Points (LTP, RTP).

21.4   Intermodality

Transport subsystems can only be used in a specific area of application. Even road transport, which is virtually ubiquitous on land, has its limits when it comes to intercontinental transport. In addition to physical limitations, there are various practical and economical limitations for the area of application of a certain transport (sub-) mode. Therefore, intermodal concepts may also be appropriate for urban goods distribution. Consolidation is one such reason to chose for intermodal transport (see also Section 26.4).

In practice, the following terms are used for specific forms[1]:

- Integrated: different modes using the same load-unit (container);
- Bimodal: different infrastructures are used by the same vehicle;
- Dual mode: different guidance systems are combined within the same vehicle;
- Hybrid: different propulsion systems are combined within the same vehicle;
- Multimodal: different modes transport the same shipment.

In integrated and multimodal transport, goods must be physically transferred between vehicles, whereas in the case of integrated transport, this transfer is eased by the use of standardised load-units. In the other types of intermodal transport, the goods stay in the same vehicle.

With respect to urban freight distribution, intermodality provides the option of using another modality besides road transport. In specific circumstances, advantages in scale and economy can make railway, inland waterway, underground and other transport modes attractive alternatives to road transport. The circumstances relate to the precise characteristics of the transport (sub) modes, the transport distance, the available infrastructure and its quality, and the fact that intermodal transport always requires at least one transfer. Only if the advantages of the alternative mode are larger than the disadvantages of the transfer, intermodal transport will be feasible. The perspective of the feasibility can either be economic or environmental - this does not change the fundamentals of the concept.

---

[1]   These are the actual terms currently in use, as betrayed by the non-systematic vocabulary.

Figure 21-2 displays a comparison between unimodal road transport and an intermodal alternative. The figure compares travel costs or transport times for alternative transport options (Rutten, 1995; Crainic 1999), but a similar graph can be drawn to compare other distance related aspects such as exhaust emissions or energy use (Van Binsbergen and Schoemaker, 1993b).

costs or time >

unloading

urban area

c_{uni}

c_{multi}

unloading

main route (road)

urban area - egress

transhipment

'large mode'

transhipment

urban area
(access)

distance >

d_{uni} d_{multi}

d_{uni}	distance by unimodal transport
d_{multi}	overall distance covered by multimodal transport

c_{uni}	costs for unimodal transport
d_{multi}	costs for intermodal transport

key:
unimodal transport for urban areas will generally be road transport;
multimodal transport can be road - rail - road transport.

Figure 21-2: *Break-down of costs (time) in intermodal versus unimodal transport*

The figure shows that the different components of both the unimodal and intermodal transport alternatives contribute in their own way to the distance covered and the increase of costs (or the transport time, or the distance-related emissions). Efficient transport (sub) modes result in lower costs per covered unit of distance than less efficient modes. Higher inefficiencies of activities are represented by a steeper segment of the graph in the figure. In the example, the unimodal alternative (unbroken line) is compared with an intermodal alternative (dotted line). The example shows that the advantages of the intermodal alternative (lower running costs per kilometre) exceed the disadvantages (transhipment costs). Although the total distance covered by the intermodal alternative is even larger than that of unimodal transport, the total expenditures are lower.

Figure 21-3 illustrates that for short-distance transport, intermodal transport mostly does not result in gains over unimodal transport.

costs or time >

c_{multi}

c_{uni}

higher costs (or: longer transport times) and a longer transport distance for multimodal transport than for unimodal transport

distance >

d_{uni} d_{multi}
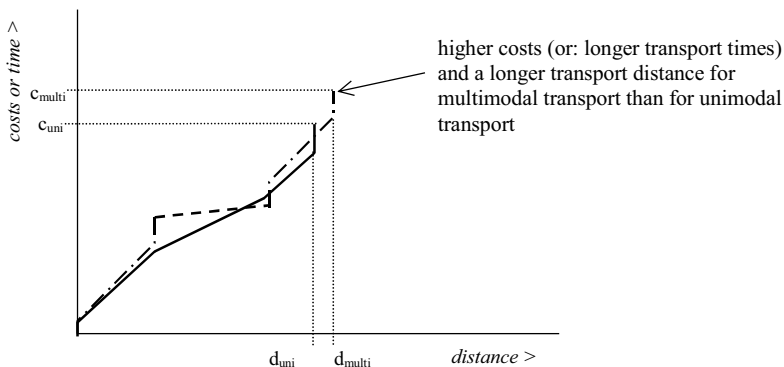
Figure 21-3: *Ineffective intermodal transport at short distances*

This is typical for intermodal transport: a break-even transport distance can be determined. Below that break-even distance, unimodal transport is more feasible, while above that distance the intermodal alternative is the better choice (note that the same line of argument can be applied to assess the benefits of consolidation).

The break-even distance cannot only be calculated for transport costs, but equally well for transport time and other distance-related disutilities (such as certain emissions and energy use; see Van Binsbergen & Schoemaker, 1993b).

21.5   Disutilities of the transport system

21.5.1 Introduction
As is explained in Part II (Section 7.2), transport activities render both utilities and disutilities. The utility of transport is that it enables the availability of goods at another geographical location than they are produced. With spatial specialisation in mind, this is of course a paramount utility. Being aware of this benefit, we can enhance the transport efficiency by reducing transport disutilities. Therefore, in this analysis we limit our scope to disutilities.

21.5.2 Cost factors and transport costs
There are distutilties for the private sector (operating and investment costs) and the public sector (different kinds of nuisance). Within urban distribution, the most important representations of disutilities are transport time, transport costs, emissions, noise and nuisance.

Different actors perceive these disutilities in different ways. For instance, an addressee will be primarily interested in transport cost and delivery time. A transport company will also be interested in transport distance, and a municipality will be interested in emissions and nuisance. The disutilities are interrelated; for instance, transport time is related to transport distance via operational transport speed.

The total costs for a transport activity g as perceived by an actor a can be mathematically represented by, for example, a linear-additive disutility function such as is derived in Part II:

$$Z_{\hat{G},\hat{K}}^{a} = \sum_{g=1}^{G}\ \sum_{k=1}^{K}\left(z_{g,k}^{a}\right) = \sum_{g=1}^{G}\ \sum_{k=1}^{K}\left(\alpha_{k}^{a} \bullet s_{g,k}\right) \qquad\qquad (21\text{-}1)$$

With:

$\hat{K}$:   set of different types of disutilities;

$z_{g,k}^{a}$:   partial disutility k of a good g as perceived by actor a;

$s_{g,k}$:   objective disutility k of a good g;

α_{k}^{a} :   perception (valuation) of disutility type k by actor a.

If we, for instance, assume the following interpretation:

    a: firm: transport company (the 'actor');

    g: road: road transport (the 'good');

    $k(1)$:   time: transport time;

    $k(2)$:   dist: transport distance;

    $k(3)$:   cost: transport costs.

This results in:

$$Z^a_{g,\hat{K}} \rightarrow Z^{firm}_{road,\hat{K}} = \left(\alpha^{firm}_{time} \bullet s_{road,time}\right) + \left(\alpha^{firm}_{dist.} \bullet s_{road,dist}\right) + \left(\alpha^{firm}_{\cos t} \bullet s_{road,\cos t}\right) \qquad \textbf{\textit{(21-2)}}$$

In this example we assume the different disutilities to be linear additive (in their terms). This implies that the disutilities must be expressed in generalised terms. In a qualitative analysis, this is not necessary; the mathematical expression can than be used to identify the various influencing factors and their (approximate) interrelations.

A door-to-door transport may consist of multiple stages (parts), each rendering specific costs. If we define the total door-to-door transport as a set $\hat{G}$ of stages g, we can determine the total costs as perceived by actor a as follows:

$$Z^a_{\hat{G},\hat{K}} = \sum_{g=1}^{G}\left(Z^a_{g,\hat{K}}\right) \qquad \textbf{\textit{(21-3)}}$$

Here, $\hat{K}$ again represents the set of relevant cost-characteristics (disutilities) for actor a.

21.5.3 Costs of intermodal transport
The succession of stages in an intermodal door-to-door transport can be illustrated as in Figure 21-4.
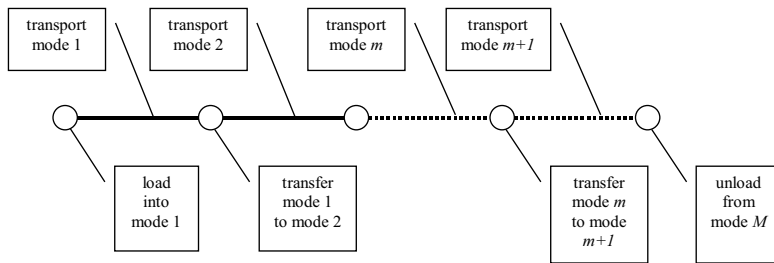
Figure 21-4:   *Representation of intermodal door-to-door transport*

The total costs of this kind of intermodal door-to-door transport (using M modes) as perceived by actor a (taking into account the weighting set $\hat{K}$, although this symbol is omitted in the expressions), can be expressed as depicted in expressions 21-4a and 21-4b:

$$Z^a_{\hat{G}} = \sum_{g=1}^{G}\left(Z^a_g\right) = Z^a_{(load,1)} + \sum_{m=1}^{M}\left(Z^a_{(transport,m)} + Z^a_{(transfer,[m,m+1])}\right) + Z^a_{(unload,M)} \qquad \textbf{\textit{(21-4a)}}$$

With:

$$Z^a_{(transfer,[m,m+1])} = 0 \qquad \text{for} \qquad m=M;$$

When only one mode is used:

$$Z^a_{(transport,m)} = Z^a_{(transportmeans,m)} + Z^a_{(trafficmeans,m)} + Z^a_{(inframeans,m)} \qquad \textbf{\textit{(21-4b)}}$$

And:

$Z^a_{\hat{G}}$ subjective perception of actor a of the total transport costs, with $\hat{G}$ representing the total transport chain consisting of stages g;

$Z^a_{(load,1)}$ subjective perception of actor a of the costs of loading goods in transport means $m=1$;

$Z^a_{(transfer,[m,m+1])}$ subjective perception of actor a of the costs of transferring goods from transport means m to transport means $m+1$, except for $m=M$;

$Z^a_{(unload,m)}$ subjective perception of actor a of the costs of unloading goods from transport means M (so $m=M$ by definition).

$Z^a_{(transportmeans,m)}$ subjective perception of actor a of the costs of operating transport mode m;

$Z^a_{(trafficmeans,m)}$ subjective perception of actor a of the operating costs of mode m;

$Z^a_{(inframeans,m)}$ subjective perception of actor a of the costs of using infrastructure (for) mode m.

All these cost components will be elaborated in the following sections.

21.5.4 Payload

Most cost functions as introduced in the preceding sections relate to the transported *payload*. The amount of payload can be expressed in several units, including *volume* (m^3), *weight* (kg or metric ton), *surface use* (m^2), or *value* (monetary units). Additional goods characteristics include the type of packaging, the homogeneity of the goods, and any requirement for specific handling.

The most appropriate unit depends on the type of good, the type of packaging and the type of vehicle. For example, if we take a small truck, for lightweight goods the volume of the payload determines the amount of goods that can be loaded. For heavy goods, the mass will be decisive. For payload that is placed onto or into load-units (such as pallets), the surface use is the most appropriate indicator. Therefore, there is not one single preferable measuring unit. In some cases different measuring units must be regarded at the same time.

For example: the homogeneity of goods can play an important role. As Vermunt (in Visser et al., 1998) states, homogeneous goods can generally be stacked more efficiently than heterogeneous goods. Therefore, homogeneous goods render higher package densities, thus lower relative volumes than heterogeneous goods. Furthermore, due to their place in the logistic chain, heterogeneous goods are often transported using load-units, rendering a less efficient volume use (because height restrictions apply). Given a certain vehicle, this all results in the fact that the vehicle can transport a higher quantity of homogeneous goods than of heterogeneous goods (see Part VI, Section 28-3, for a quantitative comparison of cost estimations). By defining the concept of payload by a measurable unit, the cost functions as defined earlier can also be expressed as *costs per measuring unit of payload*. Given the complex nature of the payload properties, it is difficult to define a generalised measuring unit. Therefore, in practice often a few attributes are used (e.g.: weight or volume rather than a generalised term for weight and volume)[2]. These attributes are outlined below:

- For *loading and unloading costs*, weight and volume are important properties. Furthermore, the *special care requirement* and the type of load-unit/packaging used are important.

---

[2] It is important to be aware of the negative consequences of such a restricted view. For example: if the load ratio in urban transport is expressed in weight measuring units only (metric tonnes), low load ratios must be expected because in urban distribution usually lightweight goods are transported. Even the load ratio expressed in volume may be low, because a large share of the goods is transported using load-units.

- For *transport means costs*, weight as well as volume or needed surface, are the decisive measuring units. Important characteristics include the special care requirements, the level of homogeneity, and, to a lesser extent, the type of packaging. All these factors determine the amount of goods that can be transported using 'one' transport means unit.
- For *traffic means costs*, especially the total cargo weight is especially important, as well as the number of transport means used (with lightweight goods, the weight of transport means plays a role) and the value of the goods (see below).
- For *infrastructure means costs*, the number and characteristics of the traffic and transport means are important; goods characteristics play no direct role. Value plays an indirect role, because infrastructure and traffic means determine the (transport) speed and thereby have an impact on the interest costs for the transported goods.
- For *transhipment costs,* weight and volume are important properties. Furthermore, the care requirement, the type of load-unit/packaging used, and the value (with respect to intermediate storage) are very important.

Table 21-1:   *Importance of goods properties/characteristics for transport costs*

	Load/unload	Transport	Traffic	Infrastructure	Transfer
Volume	**	**	*	*	**
Weight	**	**	**	*	**
Surface		**	*	*	
Packaging	**	**			**
Homogeneity		**			
Special care	**	**	*		**
Value			*	*	**

Key: * = important, ** = very important.

21.6 Conclusions

In this chapter we have (informally) defined the notion of transport modes and the aspects on which a classification can be made (see also Section 26.4). Each of the transport modes has specific characteristics and a most appropriate field (range) of application.

We explored the notion of physical consolidation and identified four different levels of consolidation.

We also introduced the notion of intermodal transport and described different types of intermodal transport. We analysed the costs and benefits of intermodal transport, and we concluded that the appropriateness of using intermodal alternatives depends on the characteristics of the transport modes and the transhipment costs. In fact, the same line of thought can be applied to consolidation: consolidation can induce scale advantages but the act of consolidation takes effort. Therefore, both consolidation and intermodal transport have a lower limit of effective application – the break-even point (or break-even distance in case of intermodal transport),

This notion can be extended to an even broader perspective: to be able to make use of a more efficient (new) system, transition effort is involved. This effort should be smaller than the envisaged efficiency gains (see also Part VI).

22. Load-units

22.1 Introduction

Following the layer-scheme systemisation, the first optional service after *integrated logistic services*, are the *load-unit services*. After all, goods can be loaded into load-units and these units can, in their turn, be loaded into or upon transport means (see Figure 22-1).

| PRIMARY SERVICES | PRIMARY MEANS | DIMENSIONS |

Integrated Logistic Services

Cargo — weight, mass [ton]; volume [m³]

Load Unit Services

Load Units (containers) — units [#]; unit-kilometres [km]

Transport (Means) Services

Transport Means (trailers, carriages, barges) — transport performance [tonkm]

ton = metric ton (1000 kgs)

= number (no dimension)
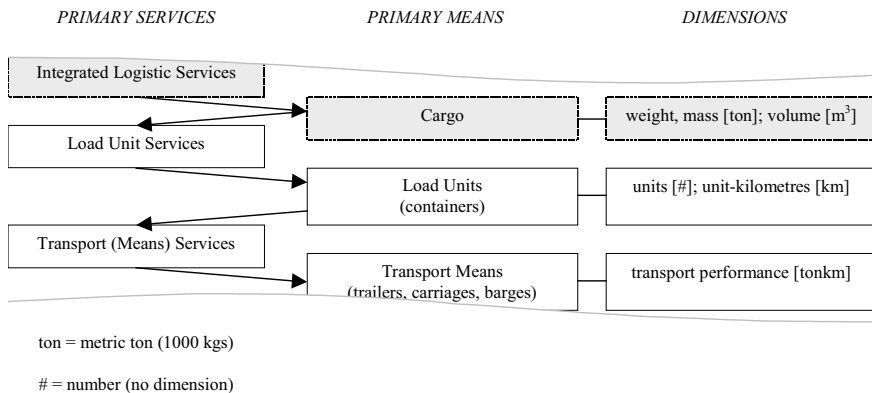
Figure 22-1:   Load-units (services) within the transport system

Load-unit services provide all services that enable the use of load-units. The concept of load-units covers a wide range of load platforms (pallets), boxes, crates, roll cages, racks and containers, all designed to hold and protect cargo. Load-units ease the handling of goods, at loading and unloading, and also at transhipments. Therefore, load-units ease the application of

intermodal transport. Small load-units, such as pallets, boxes, roll cages, and crates are widely used in urban distribution. Larger units, such as swap bodies or continental containers are less frequently used, especially because intermodal transport plays no important role in final distribution yet. As indicated in Part III (and will be further elaborated in Chapter 26), intermodal transport may, in the future, become essential in urban distribution. Unitisation (packing goods into standardised load-units) supports new urban distribution concepts.

This chapter deals with the role of standardised load-units within the process of urban distribution. We will define the different types of units and propose a modular standardised system with attuned internal and external dimensions. Moreover, we will examine the ways of handling these units and discuss the way load-units can be used in combination with transport means.

22.2   Load-units for urban goods distribution

Three main reasons why load-units can be beneficial in goods distribution activities are:
- Reduction transhipment costs in intermodal transport;
- Reduction handling costs of cargo in distribution centres;
- Reduction loading and unloading costs at points of origin and destination.

Thus far, one of the principal objections against intermodal transport over short distances is the relative high cost of transhipment. These costs can be reduced drastically if the transhipment can be mechanised or automated. The introduction of standardised load-units is one of the essential prerequisites to implementing (fully) automated transhipment facilities.

Without load-units, for urban goods distribution, no efficient use can be made of alternatives to road transport such as rail transport or inland navigation. New developments in road transport such as road trains or automated road transport, as well as developments in rail transport such as CargoSprinters, are only applicable when cheap and fast transfer technologies can be applied. The feasibility of these technologies often depend on (standardised) load-units. New systems like automated underground transport systems, simply can not operate without standardised units (Visser & Van Binsbergen, 1996; see also Chapters 23 and 24). At a smaller scale (in terms of individual packaging sizes) in distribution centres there is also a need for automation, both for efficiency reasons, but also for the improvement of labour conditions ("Arbo"[3]). Operating automated handling, sorting and storage systems ask for standardised load-units.

Loading and unloading times make up a significant part of total transport time, especially in final distribution. The use of load-units combined with handling equipment speeds-up loading into and unloading from vehicles.

The different issues each require different types of standardised load-units with specific characteristics. Standardisation includes physical characteristics like dimensions, maximum gross weight, strength, maximum allowed distortions, and fittings and entries for handling equipment. Though not discussed in depth in this chapter, the other important components of standardisation are the means of unique identification of the unit and its load .

---

[3]   Legislation that lays down requirements for the physical environment and handling by employees and for example limits the maximum weight an employee may lift by hand.

22.3   Categorising load-units

Different types of load-units can be distinguished, based on the dimensions; see Table 22-1:

Table 22-1:   Approximate external dimensions of load-units

	Length [m]	*Width [m]*	*Height [m]*
Collo-modular units	0.60	0.40	0.20 – 0.40
Minibox: pallet-sized box	0.82 - 1.22	1.02	1.35 – 1.80
Midibox: city box	2.55	2.15	2.15
Logistic box	1.30 – 4.10	2.50 – 2.55	2.50 – 3.00
Swap body/inland-container	3.40 - 13.50	2.50 – 2.55	2.50 – 3.00
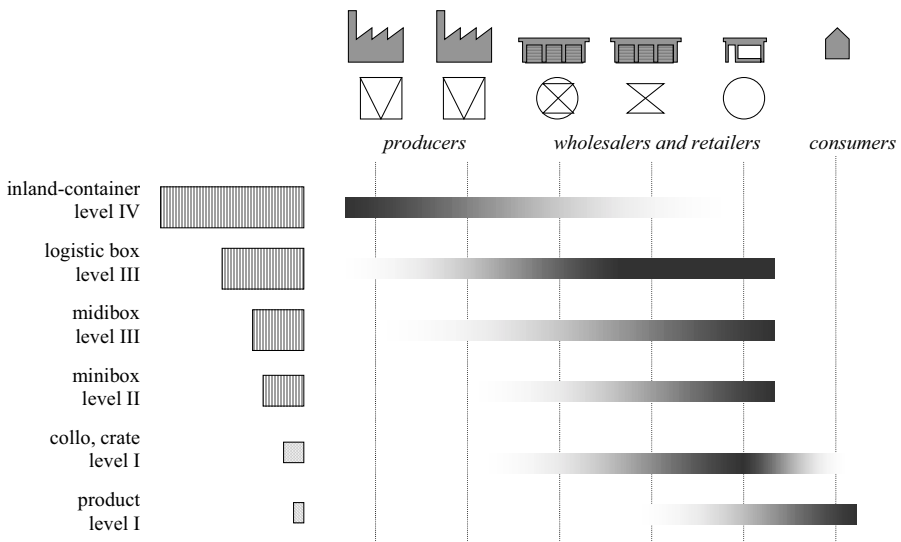
Figure 22-2:   Typical use of different load-units (Van Binsbergen et al., 1998)

Figure 22-2 shows the typical use of different sizes of load-units. For the transport of large flows of goods, large units like maritime containers, land containers and swapbodies will be used. In the distribution chain, smaller units including (small) swapbodies, logistic boxes, and midiboxes can be used. And in final distribution, small units such as miniboxes, colli and product packages are most appropriate.

We can distinguish four levels of standardised units, of which level III is subdivided in a smaller and a larger variant:

- Level I: collo-modular units: product packages, crates or 'collo-boxes';
- Level II: minibox: pallet-sized units, roll cages, pallets and palletboxes;
- Level III: midibox: threebox, citybox;
              logistic box;
- Level IV: swapbody, (inland) container, (maritime container).

In a modular system, load-units of level I fit into or onto units of level II, units of level II fit into or onto units of level III and IV. Load-units of level III however *do not* fit into or onto units of level IV, but share relevant dimensions (see also Van Binsbergen et al., 1998).

22.4   Dimensions

22.4.1 Introduction

Ideally, a system of standardised load-units is fully modular in its dimensions. This means that smaller units fit neatly in larger units, at different levels. In a full modular system, the external dimensions of a certain unit in the range are equal or larger than the total of:

- External dimensions – including any handles or other protrusions - of the smaller unit(s) that should fit into the larger one(s).
- Stowing clearance.
- Wall thickness.

The requirement of a neat fit means that the inner dimensions of the doorway of the larger unit are at least of the same dimensions as the unit itself. This means that hinges, corner-castings[4], corner posts, bolts, reinforcing bars and other structural elements (contour) of the smaller unit may not conflict with the required minimal internal dimensions of the larger one.
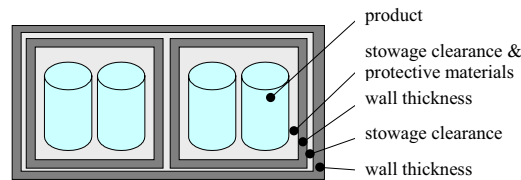
Figure 22-3:   The Chinese-box problem (example)

If load-units are repeatedly placed into each other (nested), the 'Chinese box' or 'Matroushka' effect arises: each box needs space for its own construction and its necessary stowing clearance, so that the actual net space that is left for cargo is reduced. The relative share of gross space (stowage clearance and unit construction) related to the net space requirement (the space used by the cargo) increases if the number of nested units increases. Van Binsbergen et al. (1998) propose the following set of modular load-units.

22.4.2 Small size load-units (level I)

The internal measures of load-units should be related to the dimensions of goods to be transported. The wide variety of consumer goods makes it difficult to establish standard measures. In one example, the Dutch grocery sector, collo-modular packaging units are widely used. Collo-modularity principally refers to the footprint dimensions of packages – 600 x 400 mm external[5]. The height of the modules is not determined, though some informal standardisation does occur: the height generally does not exceed 400 mm. Because most consumer products have smaller dimensions, generally multiple products are placed into a collo-modular box.

---

4   Attachment points for specialised handling equipment.

5   Complies with ISO 3394 (1984) ISO International Standard.

22.4.3 Medium size load-units (level II)

Over time, the ISO and EURO pallet dimensions have become the de-facto standard sizes for medium load-units, although almost half of the pallets used in distribution and industry are 'off standard'. The ISO footprint[6] (800 x 1200 mm) and EURO footprint (1000 x 1200) are compatible with the external dimensions of collo modules.

Today, the height of most common load-units like loaded pallets or rolling-containers does generally not exceed 1.80 metres. There is a tendency to limit the overall height of medium load-units (pallets, but also newly developed load-boxes) to approximately 1.50 metres. This would allow personnel to overlook the units when manoeuvring them in distribution centres and shops. If the load-units come in the form of boxes, the external dimensions increase because of the necessary construction space. The modularity-requirements pose a series of serious challenges to technicians and constructors, especially with respect to wall-thickness.

Given the demands for minimal internal dimensions and maximal external dimensions, the gross thickness of a single wall of a medium load-unit may only be 10 mm. This results in external dimensions of the medium size load-units of about 820/1020 x 1220 mm.

22.4.4 Large load-units (levels III and IV)

The external dimensions of the large load-units must both be related to the vehicles that have to carry those units as well as to the cargo that has to be transported.

In practice, this comes down to adapting external dimensions to *road vehicle* dimensions, as it has proved to be a sheer impossible task to alter the legal basis of these dimensions in a reasonable time span. Therefore, at least one of the dimensions of width and/or length of the large unit should not exceed 2.55 metres[7], corresponding to the maximum width of road vehicles in the European Union. The internal dimensions of the large unit should be compatible with the (external) dimensions of the medium unit, so at least a multiple of 800, 1000 or 1200 mm plus the necessary stowage clearance. The external dimensions of medium sized boxes of course exceed these dimensions because of the needed construction space. If real modular use is aimed for, the 820/1020 x 1220 mm measurement must be taken into account. Studies show (Van Binsbergen et al., 1998) that by using sophisticated materials and by allowing minimal stowing clearances, a modular system could fit neatly within the 2.55 metre (external) width requirement. The maximum single wall thickness of the units should not exceed 30 mm.

In the EU, the maximum height of a truck is 4.00 metres. Given a normal vehicle height (wheels, chassis) of about 1 metre, the resulting external unit height can be approximately three metres. In current operations, this resulting height is sufficient, especially in distribution transport. The tendency to introduce 1.50-metre height units challenges to consider the possibility of stacking medium units into larger ones. Then, the *internal* height of a large unit should at least exceed 3.00 metres (stowage clearance is necessary). The resulting height for road chassis and wheels will in that case be at maximum 0.80 – 0.90 metre. Such a development would require a complete new road vehicle park.

---

[6]   Because a pallet is only a loading board (with no external construction), 'internal' dimensions are equal to footprint (external) dimensions.

[7]   For insulated vehicles the maximum width is 2.6 metres.

22.5 Handling

22.5.1 Introduction

Load-units must ease the handling of goods because load-units bundle single goods into one package. This package itself must, of course, also be handled. The efficiency of this handling is very important: severe time losses or risks of damage cannot be tolerated. First of all, it must be relatively easy to fill and empty the units (or to construct the units around the load). Then, the handling of the units themselves must be easy to allow the load-units to be effective means within the intermodal transport chain.

22.5.2 Filling and emptying

For stuffing (filling) and stripping (emptying) load-units there are basically two possible procedures. Looking to stuffing we can:

- Place products on a base and construct a shell around the products (component load-units).
- Place products into a load-unit (closed load-units).

The first type can be applied to small load-units. The KLM AirModule®, that is discussed later, is an example. This way of stuffing units ensures good accessibility to the goods and the knocking-down system reduces the transport volume of an empty unit. The same applies to knock-down roll-cages. Important negative aspects are that constructing the box takes time (and can hardly be automated), and can damage component parts of the load-unit.

closed unit   component unit
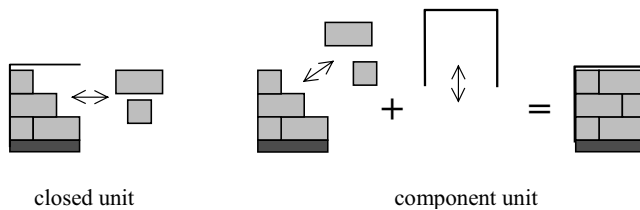
Figure 22-4:   Closed units and component units

The second way of using units is more common: the box-type load-unit is filled with cargo. Therefore, the load-unit should be equipped with doors, curtain-sides or detachable wands. Filling a box can be done automatically and does not take a lot of time. A negative aspect is that the load is only accessible via the doors.

Some empty load-units can be folded to reduce the empty trip volume. Other load-units cannot be folded; in that case, an empty unit is as large as a loaded one.

22.5.3 Handling the units

For horizontal and incidental vertical transport of load-units, the units can be handled by special equipment, like fork lift trucks or automated storage systems. The load-units must be adapted to be handled by these different techniques:

- Rolling requires mounted wheels or a flat bottom.
- Lifting by means of twin tines (the fork) requires forklift entries or fork pockets at the bottom-side of the unit; horizontal transport of small units by pallet-carts also requires holes in the bottom plate.
- Lifting by other equipment may require additional fittings.

| load-unit equipped with wheels | load-unit for roller bed (flat bottom) | load-unit to be handled with a fork lift truck (fork pockets) | load-unit to be handled with other equipment (fork pockets) |
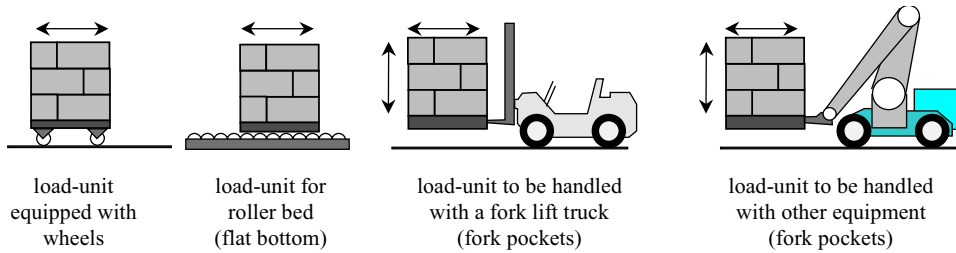
Figure 22-5:   *'Horizontal' handling of units*

Wheels mounted on load-units have proved to be rather fragile and can lead to inefficient space utilisation, so an ideal solution would be to use no wheels at all or to introduce some form of detachable wheels (a standard load-unit that can be temporarily equipped with wheels). Furthermore, the set of requirements for load-units includes fork pockets, additional (as yet unspecified) fittings, a flat bottom surface and holes in the bottom allowing for the use of pallet carts. The last two requirements seem to conflict, but with careful design, both requirements can be met. Although units add mass and dimensions to the cargo that has to be moved, they can also greatly simplify the handling process – a large number of products is handled in one movement. This strongly reduces handling costs.

22.5.4 Storage
Though load-units can be regarded as storage units themselves, in distribution areas the units must be stored (temporarily).

Large units will be designed in such a way that storage in open air must be possible – the units protect their contents against precipitation, light, wind and other weather conditions, and some units will protect the cargo against humidity and large temperature fluctuations. To make efficient use of available space, it can be wise to stack the units. Dependent on the requirements for transport (see below), the units should be placed directly on top of each other, or be placed in racks. The small units are merely transport units, and can protect the cargo against climatic influences during a short period, but not for a prolonged time. The small units therefore must be stored within buildings or in larger load-units.

22.6   Use of load-units with transport means

The primary task of *transport means* is transporting cargo, including load-units). Important associated additional tasks are loading and/or unloading the units, and possibly even shifting the units to relocate them in a (large!) vehicle.

The following questions arise when looking to the use of load-units on vehicles:

- Should the units be stacked?
- Should the units be mounted to the vehicle?
- Should the units be sorted on-board the vehicle?
- Will the units be stuffed on-board the vehicle?
- Will the units be stripped on-board the vehicle?
- How should the units be taken aboard/from board?

The dimensions of some vehicles allow load-units to be stacked. In relatively small vehicles such as trucks, this obviously is related to small units, but in large vehicles like trains and inland vessels, it also may apply to large units. The follow-up question is if it is necessary to stack the units directly on top of each other, or if racks will be used. The answer to this question has direct implications for the construction of the unit and the handling procedures. If units are to be stacked directly on top of each other, the unit must be strong enough to carry the weight. The accessibility of the lower units in a stack is limited. If units are placed in racks, the accessibility of individual units can be assured, and the strength requirements for the units are less strict. However, the handling of the unit will be more complicated. As long as inland shipping is not included in transport operations, stacking (larger) units on top of each other is not necessary, but given the public policy attention to intermodal transport it may be a step too far to exclude inland shipping for load-unit operations. Therefore, limited stacking capabilities are likely to be included in the set of requirements for the units.

In container transport, containers are really mounted on (most) ships and trucks, but are merely placed on trains. Mounted includes the use of twist-locks or other equipment to fix the unit to the vehicle or to other units. This improves transport safety, but reduces the speed of transhipment and makes it harder to automate transhipment procedures. Ideally, some automatic locking device should be used, so that automatic handling of the units can occur. Vehicles and units must be equipped so that this automatic handling can occur.

In large vehicles, load-units can be sorted. Already, new inland vessels are on the drawing board that will allow sorting operations for load-units. Shifting load-units requires the appropriate machinery (cranes or automated stacking systems) in the ships. If load-units must be stuffed or stripped while they are loaded upon a vehicle, this may require special adaptations to the vehicles and/or load-units, for example, cargo lifting equipment and the location of loading doors.

A problem related to the use of load-units in road transport is that these units are placed on top of the vehicle chassis. This means that for filling and emptying a height of about 0.80 – 1.00 metre must be bridged, compared to street level. This requires special handling equipment or adaptations to infrastructure or buildings (loading docks, low level loading points). Recent developments in low-floor trailer construction, in which wheels are placed more or less beside the cargo hold, are not applicable for vehicles that transport load-units.

Different transport modes and the characteristics of the units require different equipment.

Nowadays most large load-units are lifted, from the top in the case of maritime containers, or from the bottom by means of grappler arms, in the case of swap bodies. This requires the application of gantry, container or stacking cranes, mobile telescopic cranes or forklift trucks. Smaller units can be transferred by special equipment or by roller beds. This last system requires the fewest adaptations to the load-units and is therefore an interesting option, (also for larger units). For ships in which units are stacked, only container cranes or similar cranes can be used, while in ships where units are placed on decks other equipment (like FLTs) or roller beds can be used. For trains and trucks, vertical (cranes) as well as horizontal (roller beds) transhipment can be used, as long as the transfer occurs at well-equipped transfer centres. An important issue is loading/unloading units to and from trucks at destination areas, for example in cities (as an alternative to stuffing and stripping while the units stay on the vehicle). Cranes are not likely to be available there, so alternative solutions must be found. This requires equipment on board the vehicle.

22.7   Load-units for urban distribution

22.7.1 Introduction
In a number of examples, we will discuss some of the prominent standardised load-units already in use or in a test phase (See: Van Binsbergen & Visser, 1997; Van Binsbergen et al., 1998). We will present an overview of examples for small size units (Section 22.7.2), medium size load-units (Section 22.7.3) and large load-units (Section 22.7.4)

22.7.2 Small size units (level I)
Especially in the Dutch grocery retail sector, collo-modular packaging units are widely used. As was explained before, the external dimensions are in effect standardised. Neither strength nor material use is included in the standardisation, but all users accept the desire for (limited) stackability. Most boxes are made of carton – the boxes themselves are single-use; the carton is recycled. For the transport and handling of vegetables, plastic containers have been developed and are widely used. Some collo-modular sized boxes and crates are re-usable and are included in a pool system. In that case, the pool-owner cleans, repairs or replaces the boxes when necessary.

In spite of the apparent success at local markets, it is proving to be difficult to use the collo-modular packages for all grocery retail activities.

First, there are obvious physical restrictions in the use of collo-modular units as some products exceed the dimensions of the standard. Though in some cases the products themselves can be made to fit, there will always be categories of goods that cannot be transported in collo-modules.

Second, the collo-modular dimensions conflict with some other (informal) standards, such as the dimensions of cans for soft drinks.

Third, the collo-modularity is used mainly in the Netherlands. In other countries, standardisation on this level has not yet been applied, and producers are not generally very interested in adapting their whole production process to a partial market.

As the collo-modular standard closely fits into the pallet-standard, in the long term a more general and international adaptation of the standard may be expected.

Therefore, we propose an overall introduction of the (external) collo-modular dimensions for all relevant urban distribution activities.

22.7.3 Medium size load-units (level II)
Pallets or load-boards are widely used in industry and distribution as they offer a cheap means to handle bundles of products. There is also a wide variation in pallets in use. Informal or formal standards exist within geographical areas (Europe, Japan, Northern America) and/or within economic sectors (air transport, car industry, and chemical industry). It will be no surprise that those standards do not interrelate. In Europe, ISO/industry-pallets and Euro-pallets are the most widely used (total share mounts to 50%).

Most of these pallets are wooden platforms with a height of about 0.13 metres, which allows the use of forklift tines from forklift trucks, pallet-carts or similar equipment.

The Logicon minicontainer aims especially at use in city distribution. Its external dimensions are 2.20 x 1.17 x 1.12 metre. The measures are tuned to the dimensions of maritime containers: miniboxes fit into these containers. The minibox should replace pallets (they do not fit in

the box), and should eliminate packaging material. The internal dimensions do not fully comply with collo-modular measures. The box is stackable: up to four (loaded) or six units (empty). The Logicon minicontainer was developed by Lunzen, Veth and Daihatsu Holland (Konings, 1998); some 20 prototype containers have been built.

There is a wide variety of standardised aircraft containers, or igloos. Only the non-contoured, rectangular containers can efficiently be used in intermodal transport. Although air transport has no (direct) connections to urban distribution whatsoever, developments in load-unit fit remarkably well with the requirements for urban goods distribution. To fill main-deck aircraft pallets efficiently, KLM has developed its AirModules®. The concept of these modules resembles the ideas for small, standardised load-units, as described in earlier sections. The AirModules® are of the knockdown type: they can be disassembled and their components can be efficiently stored. The module consists of an aluminium and carbon fibre base, panels and an aluminium and carbon fibre top. Different types of modules have been developed, which differ mainly with respect to the material use of the panels. The first generation of modules used reinforced cardboard, the second-generation aluminium and the third generation composite, layered materials (aluminium surface, polypropylene honeycomb and a carbon fibre lining). The base has forklift capabilities but has no flat under-surface (and is not geared to be used in roller-ball transfers). The 1.22 x 1.02 x 1.50 metre box (external dimensions) can hold about 500 kg of cargo.

The 1.50 metre height of the box complies with the requirement for stacking two boxes on an aircraft main deck area, but also concurs with the desired maximum height of load-units with respect to handling. Thus far, AirModules® have mainly been used in test situations, except for some large customers, who make full use of the units. Some 600 AirModules® are in use.

For urban distribution, we propose the introduction of three alternative medium sized boxes, namely (measures in: external length x width x height):
- Threebox, non stackable, 2.55 x 1.28 x 1.35 or 1.80 m;
- City box, empty stackable, 2.55 x 2.15 x 2.15 m;
- Midibox, stackable to four loaded units, 2.55 x 4.30 x 2.90 m.

All proposed boxes must be fitted with corner castings (especially on the bottom-plate); a flat under-surface to enable roller beds, and fork pockets to enable handling with forklift trucks and similar equipment.

As mentioned above, all medium sized units should be stackable to a certain degree (up to three or four loaded units). Stackability eases the use of inland shipping for urban distribution and also decreases storage costs (less floor space, no need for racks). Combined with the strict requirements for wall-thickness, the stackability requirement asks a lot from the designers. Still, such requirements seem to be technologically feasible (Van Binsbergen et al., 1999).

22.7.4 Large load-units (level III and IV)

Various manufacturers have built boxes for (urban) distribution. The width of these boxes varies between 2.45 m to 2.60 m (Scandinavian countries), the length from 1.26 m to 4.10 metre. The German railways agency (DBAG) has developed the concept of logistic boxes, which should be used in intermodal rail-road transport. Three types of boxes have been developed: LOG4 (1.70 m), LOG5 (2.10 m) and LOG6 (2.50 m), all with a width of 2.50 m and a height of 2.47 metre (all external measures). The boxes are equipped with vertical sliding

doors or traditional doors in hinges. The boxes can be mounted on a frame so that a set can be handled as being one unit. In addition, some other boxes can be coupled using frames Taxi-/Fabrikbox® (Kögel). Some other manufacturers propose clickable units that can be handled as one, larger unit (Flexbox®).

Most boxes can be handled by using forklift trucks; some of the boxes use self-discharging systems. Most boxes are only used in tests, but the Japanese FR Freight 12 ft container (3.72 x 2.45 x 2.50 m) is widely used. Swap bodies are self-discharging units that range in size from 3.40 m to 13.50 m (length) with a typical width of 2.50 m (external measures), except for some Scandinavian types with a width of 2.60 m. The units are equipped with foldable legs that are used to discharge the unit from (or to load it upon) a road vehicle. Some length measures are DIN/CEN standardised.

A prominent example of world-wide standardisation is the maritime container, used for intercontinental transport. The usual internal width of these containers is not compatible with ISO pallet sizes and collo-modular sizes as described above. Therefore, application for urban distribution is not very appropriate. However, the system of standardising the maritime units (shape, external dimensions, requirements with respect to strength and stiffness etc.) is also applicable to the standardisation of other units.

22.8   Load-unit, load/unload and transfer costs

22.8.1 Introduction

Transhipments of non-standardised, small, separate goods are time-consuming and expensive. With help of load-units, these transfer costs can be reduced. Intermodal transport can only compete with unimodal (direct) transport if the costs for load-units (the units themselves, the process of loading and unloading units, and the transfer of units) can be low.

22.8.2 Cost for using load-units

The layer-scheme (see Part II, Chapter 8) comprises *load-units*. As with all means, the disutility of using a load-unit for an actor is equal to the tariff set by the *load-unit service*. This tariff usually reflects the costs for this service, but is not necessarily equal to these costs.

This total disutility function for load-units refers only to the units as a means. The relative simple function does not include the operational (handling) costs:

$$Z^q_{(loadunits,m),\hat{K}} = \sum_{k=1}^{K} \left(\alpha_k^a \bullet s_{(loadunits,m),k} \right) \quad with \quad s_{(loadunits,m),k} = f(l,q) \qquad \textbf{\textit{(22-1)}}$$

And:

$Z^q_{(loadunits,m),\hat{K}}$:   total (subjective) disutility over all cost categories of set $\hat{K}$ of 'using transport means *m*' ;as perceived by actor *a*;

$s_{(loadunits,m),k}$:   objective partial disutility (cost category) *k* for 'using transport means *m*';

α_k^a :   subjective weighting of cost category *k* by actor *a*;

f(...):   is a function of ...

    l: transported load (payload);

    q: the (type of) load-unit.

22.8.3 Costs of loading and unloading

The costs of loading and unloading strongly relate to the type of goods that is transported (properties such as type of packaging, vulnerability, size and weight) and the type of load/unload system. This results in a cost function for loading that has the form of:

$$Z^a_{(load,1),\hat{K}} = \sum_{k=1}^{K} \left(z^a_{(load,1),k} \right) = \sum_{k=1}^{K} \left(\alpha^a_k \bullet s_{(load,1),k} \right) \quad with \quad s_{(load,1),k} = f(l,p,q) \qquad \textbf{\textit{(22-2)}}$$

And:

$Z^a_{(load,1),\hat{K}}$:   total (subjective) disutility over all cost-categories of set $\hat{K}$ of the activity 'loading goods in the first mode' (the first mode in the transport chain); as perceived by actor a;

$z^a_{(load,1),k}$:   subjective partial disutility (cost-category) $k \in \hat{K}$ of the activity 'loading goods in the first mode' as perceived by actor a;

$s_{(load,1),k}$:   objective partial disutility (cost category) k of the activity 'loading goods in the first mode';

α^a_k :   subjective weighting of cost category k by actor a;

$f(...)$ is a function of ...

  l :   transported load (payload[8]);
  p :   personnel;
  q :   the load system of the first transport mode or the used equipment.

In analogy, the cost function for unloading goods from the last used mode M is:

$$Z^a_{(unload,M),\hat{K}} = \sum_{k=1}^{K} \left(z^a_{(unload,M),k} \right) = \sum_{k=1}^{K} \left(\alpha^a_k \bullet s_{(unload,M),k} \right) \qquad \textbf{\textit{(22-3)}}$$

With:

$$s_{(unload,M),k} = f(l,p,q)$$

For instance, for unloading rolling containers from a trailer, four basic systems exist, each resulting in different unload times (one of the cost-categories $k \in \hat{K}$), see Figure 22-6 (based on own observations).

hydraulic load/unload door

30 rolling containers in approx. 20 minutes

load/unload dock

30 rolling containers in approx. 15 minutes

low-floor trailer

30 rolling containers in approx. 15 minutes

detachable swapbody

(30 rolling containers) in swapbody approx. 5 minutes

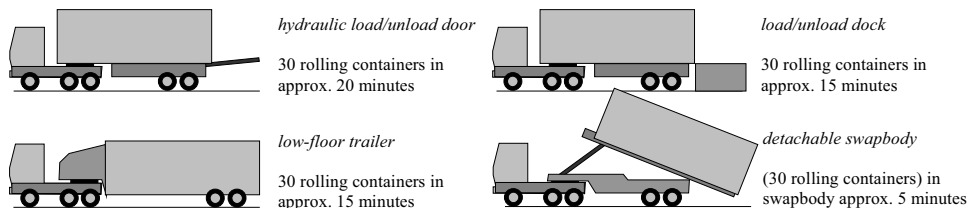**Figure 22-6:**   ***Different unload systems resulting in different unload times***

---

[8]   'Payload' must be interpreted as a generalised notion of the relevant properties of a load that determine the transport costs. These properties can be weight, volume or occupied surface but may also comprise factors as special care requirements (perishability, vulnerability, value) and the type of applied load-unit.

22.8.4 Costs of transfers

Transfers (or transhipments) of cargo between modes make no part of the primary functions of the layer scheme. Still, transhipments are essential in intermodal goods transport operations. In transfers, goods are transhipped from one transport mode (in fact: transport means) to another. This requires a handling of goods and in some cases, some form of intermediate storage. Transfer costs include all investment and operation costs for equipment, buildings and other facilities. This results in a cost function very similar to that of traffic means: when the capacity of the transfer-equipment is reached, additional equipment will be necessary (compare with Button, 1993), see Figure 22-7.
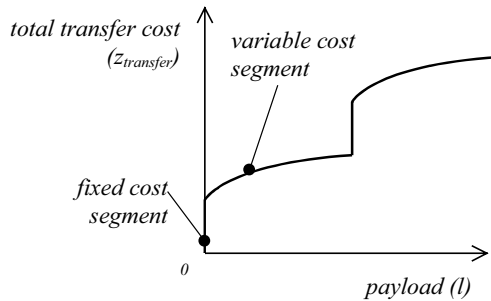
Figure 22-7:   *Transfer (transhipment) costs to payload relationship (example)*

The cost function of a transfer can be expressed as follows:

$$Z^a_{(transfer,[m,m+1]),\hat{K}} = \sum_{k=1}^{K} \left(\alpha^a_k \bullet s_{(transfer,[m,m+1]),k} \right) \tag{22-4}$$

With:

$$s_{(transfer,[m,m+1]),k} = f(t,l,p,q)$$

And:

$Z^a_{(transfer,[m,m+1]),\hat{K}}$:   total (subjective) disutility over all cost-categories of set $\hat{K}$ of 'transferring goods from mode *m* to mode *m+1* (except if *m=M*); as perceived by actor *a*;

$s_{(transfer,[m,m+1]),k}$:   objective partial disutility (cost category) k of 'transferring goods from mode *m* to mode *m+1* (except if *m=M*)';

α^a_k: subjective weighting of cost category *k* by actor *a*;

f(...):   is a function of ...

t: transfer time, including the time for intermediate storage;

l: transferred load (payload);

p: personnel;

q: the (type of) transfer equipment.

22.9   Conclusions

The use of load-units will reduce costs and will speed-up transhipment processes. This presents the opportunity for operating intermodal transport and thereby enables the application of new transport modes for urban distribution.

The load-units must fit into a logistic system that has to largely use existing buildings, vehicles and equipment and will mostly transport the same goods as today. This influences internal and external dimensions, the size and placement of handles, and other physical characteristics.

A full modular set of load-units, which starts with standardised packaging and ends with (inter) continental containers, is not economically feasible due to the fact that current standards in transport are in effect non-compatible. Still, a highly modular system, in which the possibility of placing smaller units in larger ones is somewhat limited, turns out to be feasible.

Such a set of modular units is based on the collo-modular package unit, with the 600 x 400 mm base (level I). The level II boxes consist of closed, lightly protective pallet-units, with internal dimensions of 800 x 1200 mm or 1000 x 1200 mm, and external dimensions of about 820/1020 x 1220 mm. The height of the units can be either 1.35 metres (allowing use in existing vehicles) or 1.50 metres.

Level III boxes are also closed, protective transport units that come in three types:

- Threebox, non stackable, 2.55 x 1.28 x 1.35 or 1.80 m (length x width x height);
- City box, empty stackable, 2.55 x 2.15 x 2.15 m (l x w x h);
- Midibox, stackable to four loaded units, 2.55 x 4.30 x 2.90 m (l x w x h).

These third level boxes cannot be placed into each other.

The fourth level is the swap body or land-container that should be made compatible with second level pallet-based modules. Third level boxes are not designed to fit into fourth level swap bodies, but the dimensions of a set of third level boxes are the same as those of certain types of swap bodies. Therefore, they can be considered as being modular as well.

The preferred internal height of the level III and IV units is somewhat more than three metres. This allows level II 1.50 metre units to be stacked into the level III/IV unit. However, this three metres plus unit height requires dedicated road and rail vehicles.

To enable the use of standard vehicles, an overall height of only 2.90 metres is allowed. In that case, only level II 1.35 metre units can be stacked.

Traditional handling equipment like forklift trucks, reach stackers and cranes should be able to handle the units, so they must be equipped with fork-pockets and corner fittings. Moreover, the units should be suitable for use on roller beds. This requires an almost flat under-surface on the base of the units. Ideally, the units should be stackable up to about four loaded or six unloaded units. This provides the opportunity to use them in inland vessels without the need for racks or decks. Furthermore, stacking means more efficient storage.

The desire for stackability especially stresses technological possibilities to a maximum.

From a technological perspective, it seems to be feasible to construct a set of load-units that can be used quite effectively in future urban logistic systems. The units allow automated handling and transhipment and can thus help to reduce logistic costs and enable the use of new transport technologies.

23. Transport means

23.1 Introduction

Transport means are in fact load carriers (see Figure 23-1). In some modes, there is no clear distinction between transport and traffic means. For example in railway transport there is: wagons or railway carriages are real transport means.

Transport means carry load (cargo), the load can be put into load-units (which were addressed in Chapter 22). When using the concept transport means, we refer to either the cargo hold of a rigid vehicle or a wagon, carriage or trailer of an articulated vehicle or train.
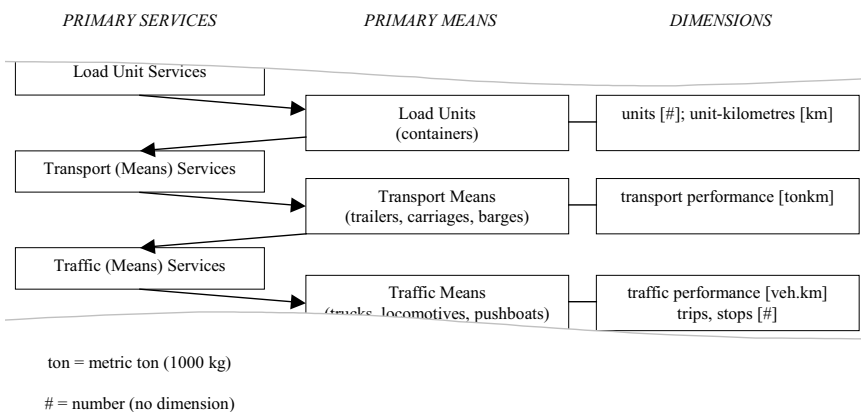

ton = metric ton (1000 kg)

= number (no dimension)

Figure 23-1:   *Transport means (services) within the transport system*

With respect to transport means, for urban goods distribution there are two conflicting desires. For economical reasons, an enlargement of scale usually enhances efficiency. In high capacity vehicles, the relative costs for traffic means (drivers, engines) are low because the same means can produce more transport. On the other hand, within urban areas large transport means are generally not very appropriate because they cause a lot of hindrance. A compromise can be found in either operating medium sized transport means or operating different transport means in different conditions. The latter results in multimode use (intermodal transport), of which the concept will be elaborated in Chapter 26. In this Chapter 23, we will describe both high capacity as low capacity transport means, for road transport, railway transport, inland shipping (if appropriate) and underground transport.

23.2   High capacity vehicles

23.2.1   Introduction
A way to improve efficiency (both environmental and economical) is to increase vehicle load capacity. If trade relations (markets) and handling facilities allow the use of these high capacity systems, for most technologies the economies of scale will induce lower relative transport costs.

23.2.2   Increased capacity for road vehicles
By increasing the length and carrying capacity of road vehicles, economic efficiency can be enhanced as fewer drivers and fewer traffic means[9] are required for each transported tonne or cubic metre of cargo. The most effective opportunity in enhancing load capacity in road transport is increasing the total vehicle length. First, one can think of an 'evolution' of current vehicle length of 18,75 metre[10] to 20-25 metre. In some countries and states, such vehicle lengths are allowed: in Arizona (USA) vehicle lengths of 65ft (19,8 m) to 75 ft (22,9 m) are allowed, in Australia 25 metre (B-Doubles[11]) and in Sweden and Finland 25,5 metre. A NEA study (NT, 1998) calculated that the use of a double semi trailer combination - 'EcoCombi' - of 25,5 metre and a carrying capacity of 50 ton payload would result in 37% extra load capacity, expressed in volume (m³) or 51% extra load capacity, expressed in metric ton. For operations, in ideal conditions this would mean 33% less trips, 36% less emissions of CO_2 and NO_x per ton-kilometre and 36% less energy-use when compared to a 18,75 metre 33 ton payload road vehicle. Vehicle combinations of these lengths are regarded as relatively safe, nevertheless specific regulations apply to the use of these vehicles.

Second, a revolution in allowed vehicle lengths would be an increase to 36,5 metre / 79 tonnes GVM[12] (Australian double road train[13]) or even 53,5 metre / 115,5 tonnes GVM (Austra-

---

[9]   All traction and guiding related means (engine, power supply, guiding systems etc.); see also chapter 24.

[10]   Maximum allowed combination length in the European Union (Directive 96/53/EC of July 25th 1996 – 396L0053).

[11]   A combination consisting of a prime mover (a motor vehicle built to tow a semi-trailer) towing two semi-trailers of which the second semi-trailer is mounted on the rear of the semi-trailer being hauled by the prime mover.

[12]   Gross Vehicle Mass.

lian triple road train). For capacity and safety reasons, these types of vehicles may usually only use specific roads. Technological innovations may enable the use in more common (high-) ways.

Though most gains can be achieved by increasing the length of road vehicles, also heightening vehicles can be attractive. Heightening, and a more efficient stacking of load (for example by using medium sized load-units[14]) can enable *double stacking'* of load (units) within road vehicles. Bridge and other infrastructure clearances limit the vehicle height, therefore in most countries, the vehicle height is legally limited (within the EU to 4.00 metres, except for Great Britain where no formal height restrictions apply). Even in countries with limited clearances, some forms of 'double stacking' can be adopted. This requires specific solutions such as a goose-neck construction. Such an adaptation reduces the increase of usable loading-surface, so the gains compared to a standard semi-trailer are limited to about 30%.

23.2.3 Increased capacity for rail vehicles

The load capacity for traditional rail vehicles (trains) is already high compared to the needs of urban distribution. In addition, for long distance transport, double-stacking containers or other load-units can achieve further advantages of scale. For short distance transport this probably makes less sense. Double stacking of large (Level IV) containers in Europe raises serious problems, as standard railway gauges do not allow double-stacked containers. Tunnels, bridges and other infrastructure elements require extra clearance to allow the passage of double stacked or high trains. Nevertheless, there is still an interesting aspect to the concept of double stacking for urban distribution. If small (level II) load-units will be developed for use in underground logistic systems, double stacking of these units will be necessary to achieve efficient railway-operations. Using a clever carriage design, the double stacked (level II) units will not exceed the current envelope[15], but double stacking requires specific transhipment equipment.

23.2.4 Increased capacity for waterborne modes

As in railway operations, load capacities for inland shipping are currently too high rather than too low, so trying to increase capacity may not be a primary goal in relation to urban distribution activities. However, new developments in inland waterborne container transport for main links do show enhancements in scale: 398 TEU motor vessels (135 x 17 m) and even larger coupled vessels like of 480 TEU (135 x 11.45 m motor vessel plus 90 x 11.45 m push barge; see: Schuttevaer, 1998). These large vessels enable low-cost point-to-point transport of containers, but are probably too large for urban distribution related activities.

---

[13] Consisting of a prime mover and two semi-trailers of which the first semi trailer is mounted on the prime mover and the second semi trailer is mounted on a 'converter' that is towed by the first semi-trailer;

[14] 'Level II' units of 1.35 metres height for standard cargo holds up to 1.50 metres height for adapted vehicles.

[15] The contour (cross section) of a moving train.

23.3   Limited load-capacity vehicles

23.3.1 Introduction

Unlike enlargement in scale, limitations in load capacity (downscaling) of road vehicles may be necessary in specific (urban) conditions. Limiting capacity – and the related vehicle size – can improve versatility and manoeuvrability, and can decrease handling times and costs. Rail transport and inland waterway transport come within the scope of urban distribution activities when the scale and size is decreased ('downscaling').

23.3.2 Limited capacity vehicles in road transport

Vans have become increasingly popular as a means for urban goods distribution. A survey in the Netherlands (NIPO, 1997) indicates that the most important reasons for companies to chose vans are the bad accessibility of cities, logistical reasons (Just-in-time (JIT) concepts, the use of regional distribution centres), the use of local subcontractors, cost considerations and the fact that for driving a van, no special driving license is necessary. The distribution of small shipments within dense urban areas requires small, versatile, well manoeuvrable low-emission vehicles. Next to the existing assortment of vans and small trucks, specific *urban distribution vehicles* or *distri-trucks* should be further developed. These vehicles are easier to manoeuvre and cause fewer problems for the environment; for example, they may run on electricity (see Section 24.3). By contrast, for large shipment sizes, larger vehicles are more efficient. Because the vehicles are used mainly in *single-stop* distribution activities, manoeuvrability is not such a major requirement. Still, the nature of urban infrastructure may not allow the use of standard semi-trailers. Therefore, specially designed shortened City Trailers equipped with a single steering rear axle should be used.

23.3.3 Limited capacity vehicles in railway transport

The characteristics of traditional rail systems do not complement the requirements for short distance distribution transport. In traditional rail transport, the consolidation is of an order too large and the processes of train forming, reordering (shunting), and splitting takes too much time. For short distance distribution, *cargo* trains offering only limited capacity would be most appropriate. This can be achieved in two different ways: by decreasing the capacity of traditional trains or by adding cargo transport capabilities to passenger trains.

Trains consisting of about five or six wagons could theoretically offer some advantages of scale with respect to road transport, without requiring the far-too-large scale of consolidation of traditional trains. In practice, these advantages are not feasible because personnel, traction and infrastructure costs are too high for relatively short trains. Compared with traditional railway transport, making trains short is fiddling with the basic consolidation principle of rail transport. In current practise, shorter trains would mean a decrease of advantages of scale. However, some technological solutions may improve the competitive position of short trains (see Section 24.4.3). As an alternative, passenger trains can in some cases be modified to enable the carriage of cargo. This can be achieved by either adding cargo carriages to passenger trains, or by developing combi carriages (CombiRail) in which passengers and cargo can be jointly loaded (see Figure 23-2; see Van Binsbergen et al., 1998; Boomers, 1999; Jaspers, 2000). Both alternatives bear far-reaching operational consequences. Both alternatives bear far-reaching operational consequences.

First, physical modifications in station layout are necessary to enable parallel load/unload processes for both passengers and cargo, and to facilitate the intermediate storage of cargo;

Second, the passenger and cargo flows within the premises of the station must be dealt with separately, requiring both physical and organisational adaptations;

Third, both the train and logistic operations must be adapted to allow loading/unloading cargo into or from a passenger train within a tight time schedule.

Nevertheless, combined railway operations promise to offer interesting opportunities for the transport of specific goods categories[16] to and from urban areas, also on long distances, for example by using high speed trains between large conurbations.

Mixed operations

Combined operations
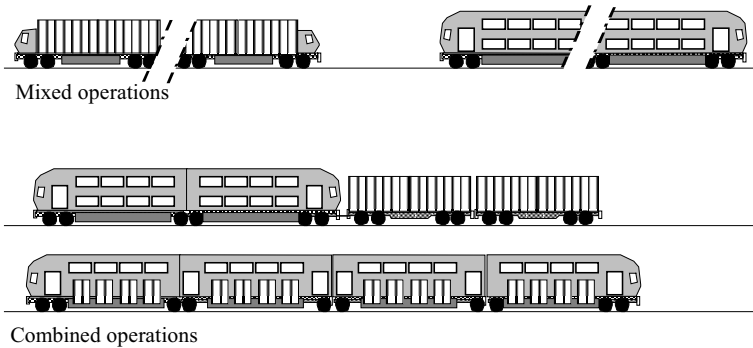
Figure 23-2:   Options to mix passenger transport with urban goods rail distribution

The process of loading and unloading trains must be speeded up. In the end, shipments (colli) must be stowed in a train but loading and unloading colli in train wagons may not take too much time for the train itself. Furthermore, the handling of individual colli is not attractive from a logistical perspective. Therefore, the use of transport-units (containers of some sort) is required. The train itself is only loaded and unloaded with those transport units, and the units can be stuffed or stripped elsewhere (Van Binsbergen & Visser, 1997). In Germany and France, developments are occurring to automate the transhipment of containers between trains and, in a later stage, between trains and other transport modes (e.g. trucks). Although these projects do not directly correspond to short-distance freight transport, some results can be used for future developments. (Rutten, 1995).

23.3.4 Limited capacity in waterborne transport

As expressed above, inland waterborne transport means may be too large to be useful for transport related to urban distribution. Therefore, the development of rather small, but manoeuvrable, fast and easy to load and unload container vessels is important for the backbone networks (regional and larger distance transports). Small inland waterway container vessels (such as Neo Kemp for Dutch waterways) can be used at most navigable waterways and therefore have a high degree of penetration. These ships can carry from 32 up to 48 TEU (63 x 7 metres, approximately 800 metric tonnes). Even smaller ships (River Hopper), with a load capacity of only 24 TEU, have also been developed (NT, 1999).

---

[16]   Especially time-critical and high value/low weight goods.

If small load-units for urban distribution were developed and used, the number of units to be transhipped would increase. Where the time (and costs) of loading and unloading current load-units (containers) are already major disadvantages for inland shipping, these will become even worse if smaller units are to be used. Therefore, new technologies should be developed that allow fast loading and unloading procedures with large numbers of small units.

At a very limited scale, in the Dutch cities of Utrecht and Amsterdam, small boats for the distribution of specific commodities (beer, parcels) are already working. Because the historic canal system in these cities is very dense, the accessibility of shops via the canals is reasonably good.

23.4   Underground transport means

Distribution of goods in urban areas using vehicles driving through underground tunnels (*underground transport*) is an interesting alternative for traditional surface distribution. The system uses underground, dedicated infrastructures of which there are different tunnel diameter variants (see Section 25.4).

The (internal) tunnel diameters have an impact on the size of the largest vehicle that can use the tunnel, and therefore also on the size of the largest applicable cargo hold (or load-unit). Furthermore, there are different ways of moving goods through the tunnels, varying from individual self-propelled vehicles to train-like systems. With respect to the functional aspects of transport means, however, underground systems resemble very much road or railway transport. Only the size can differ, implying that underground transport systems will always be a part of a larger, intermodal transport system. Therefore, the use of load-units (in stead of cargo holds fixed to vehicles) is most appropriate.

23.5   Overview and comparison

The different developments in transport capacity result in a situation where the different transport modes in the future will have overlapping capacity ranges. This improves the chances of alternatives for road transport (see Figure 23-3).
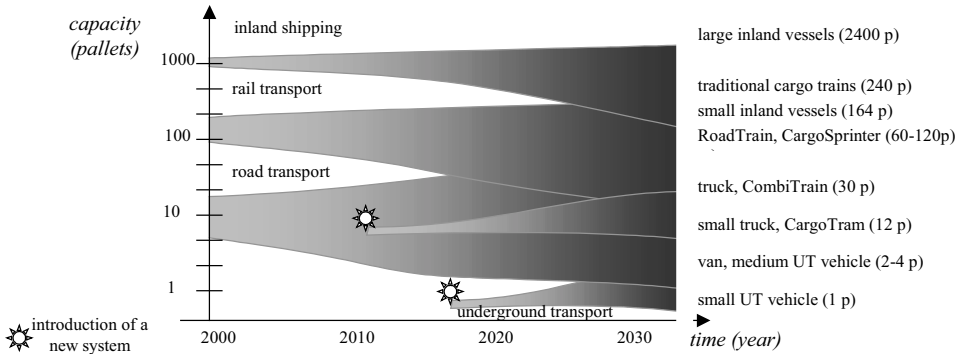
Figure 23-3:   Developments in vehicle capacity (indicative; p=pallets)

23.6   Costs of transport means

The layer of transport means (see Figures 8.3 and 8.4 in Part II) comprises the means of carry-ing cargo (the cargo holds). To get a (qualitative) insight in the type of disutilities that are related to using transport means, we can construct a 'cost function'.

Similar to load-units[17], the disutility of the transport means for an actor is equal to the tariff of the *transport means service*. This tariff usually reflects the costs for this service, but is not necessarily equal to these costs. The total tariff mainly relates to the tariff of the production means. Other tariffs (covering personnel and operational costs) make part of the tariffs of traf-fic means. This results in the following total disutility function for transport means:

$$Z^a_{(transprtmeans,m),\hat{K}} = \sum_{k=1}^{K} \left(\alpha^a_k \bullet s_{(transportmeans,m),k} \right) \tag{23-1}$$

With:

$$s_{(transportmeans,m),k} = f(l,q,t)$$

And:

$Z^a_{(transprtmeans,m),\hat{K}}$:   total (subjective) disutility over all cost categories of set $\hat{K}$ of 'using transport means m' ; as perceived by actor a;

$s_{(transportmeans,m),k}$:   objective partial disutility (cost category) k for transport means m;

α^a_k :   subjective weighting of cost category k by actor a;

f(...):   is a function of ...

l: transported load (payload);

q: the (type of) transport means;

t: the time span the means are in use.

The 'total transport means *costs*' to 'payload' relationship can be depicted as in Figure 23-4.

---

[17]   A transport system either uses transport means with detachable units or transport means with fixed holds. Therefore, the cost structure of using transport means is very similar to that of load-units. If a transport sys-tem uses load-units, of course a carrying device (transport means) is needed as well.

The following costs-elements can be identified:
- Fixed or initial costs segment, representing the non-variable (with respect to the payload, see Section 21.5.4) costs of the transport means;
- Variable costs segment (variable with respect to the payload):
    - 'continuous' costs that exactly follow the increase of the payload;
    - 'discrete' costs that step-wise follow the increase of the payload.

As we will explained in Section 21.5.4, there are multiple payload characteristics that have an impact on the needs for the cargo hold. In the mathematical representation, we use the abstract notion of payload (l) as being the generalised indicator for these properties. For reasons of clarity, we can take the payload 'volume' as an indicator. If the volume of a payload increases and exceeds the load capacity, a larger load capacity will be necessary. An increase in load capacity can either come in a continuous or in a discrete form. For example, the cargo holds of a railway wagon can be extended in a continuous way until the (legal or practical) limits of the wagon sizes are reached. Then there is an option to add a wagon to the train. This is a discrete extension, because a wagon has a (practical) minimum size.
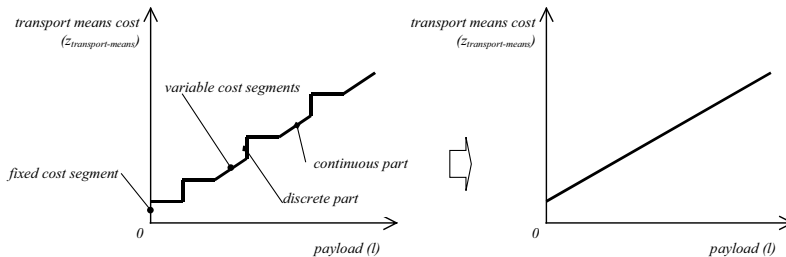
Figure 23-4:   **Transport means cost to payload relationship (indicative; simplified version on the right-hand side)**

Figure 23-4 shows an example of the costs of transport means as a function of the 'amount' of payload. The actual *tariff* that the user has to pay depends on the market conditions.

23.7   Conclusions

Transport means actually carry cargo, either in fixed cargo holds or in load-units. In some systems, transport means are integrated with traffic means (vans, rigid trucks, self propelled trains, ships or underground transport vehicles) or are propelled by traffic means (wagons towed by a locomotive, (semi-) trailers towed by a truck). In general, enlargement in scale of the transport means induces scale advantages with respect to the necessary traffic means. In terms of urban distribution, this is especially relevant for road transport means that serve main connections (trunk lines) outside urban areas. In addition, the application of *double stacking* of load or load-units into road vehicles is an example of enlargement of scale. For transport modes like railway transport and inland navigation, enlargement of scale is not necessarily in the interest of urban distribution. In most cases, *downscaling* is more appropriate. This would result in shorter trains or trains for combined cargo and passenger transport, and in smaller

inland vessels. To preserve the scale advantages of these modes, additional (technological) developments are necessary.

Downscaling may also be appropriate for inner city distribution: small, highly manoeuvrable vehicles (thus transport means) cause less hindrance than non-adapted vehicles. Only for large goods flows and large shipment sizes, intermediate transport means (as large as possible given the urban circumstances) are appropriate. Both increasing the load capacity of road transport means and downscaling the load capacity of railway and inland waterway transport means strongly relate to the efficient use of traffic means and infrastructures, as will be addressed in the following chapters.

24. Traffic means

24.1 Introduction

Traffic means provide traction and steering or guidance means and thus enable the actual movement of the transport means (see also Figure 4-1). In some cases, transport and traffic means are integrated, such as is the case with cars, vans, rigid trucks, inland vessels, self propelled trains and self propelled underground transport vehicles. Other transport systems use separated traffic means, such as trucks for (semi-) trailers, locomotives for trains, push or tow boats for barges and locomotives for underground transport trains.

This chapter elaborates a wide range of technologies that enhance the economic and societal efficiency of traffic means (thus transport systems). We will discuss the developments in guidance automation and in propulsion technology. We will then show how these new technologies can be applied into the different transport modalities and we will explain how these developments have an impact on (the effects of) urban goods distribution processes.
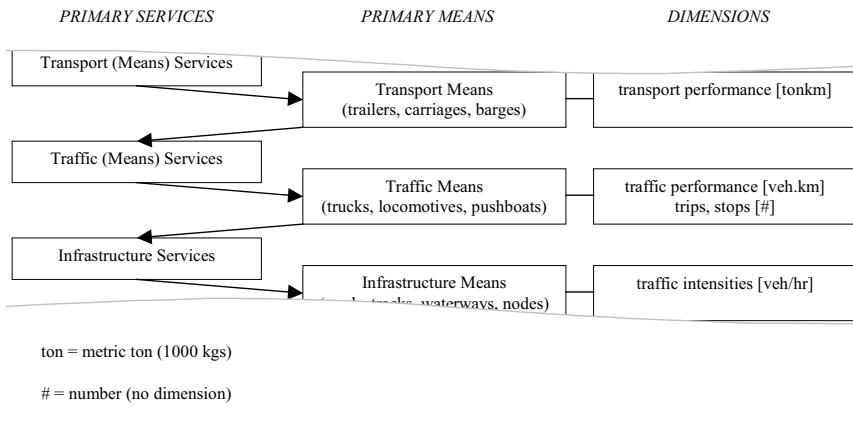
PRIMARY SERVICES   PRIMARY MEANS   DIMENSIONS

Transport (Means) Services

Transport Means
(trailers, carriages, barges)   transport performance [tonkm]

Traffic (Means) Services

Traffic Means
(trucks, locomotives, pushboats)   traffic performance [veh.km]
                                              trips, stops [#]

Infrastructure Services

Infrastructure Means
(~~roads, tracks, waterways, nodes~~)   traffic intensities [veh/hr]

ton = metric ton (1000 kgs)

= number (no dimension)

Figure 24-1:   Traffic means (services) within the transport system

24.2   Transport automation

24.2.1 Introduction

Transport automation deals with the automation of the guidance and steering system of traffic means – functions that influence the longitudinal and lateral position of vehicles on the infra-structures. Automation can make transport systems operate at lower costs because automation may reduce labour costs and can enhance productivity and reliability. Through automation, new transport systems become feasible, both in inner city goods distribution (underground transport and eventually perhaps surface transport by automated guided vehicles) as well as at trunk connections (automated road, rail or even inland shipping systems).

24.2.2 Levels of automation

Figure 24-4 shows that different levels of vehicle automation can be distinguished.

Automation can *assist* the drivers, and is in that respect an evolution of mechanisation. The systems transform drivers' commands in a multitude of machine actions. Automation also *can take over some of the drivers' tasks*; either easing the drivers' task, or taking over all tasks in case of near-accidents. These systems are already in use in some passenger cars (automated braking systems, automated traction control and the automatic operation of airbags and other protective systems). This form of automation can also be used in semi-automated systems where drivers only check speed and acceleration, but rely on automated lateral guidance systems.

Then there are *remote-controlled* transport means that execute most of the tasks themselves, but receive basic instructions from human operators. In fully *automated systems*, all drivers' tasks are automated. This includes routing, vehicle-environment interaction, vehicle-vehicle interaction and all driving related actions. Only the command to commence a trip and the instructions to end the trip at a given destination are derived from another source, either a human operator or an automated system (see also Minderhout, 1999).
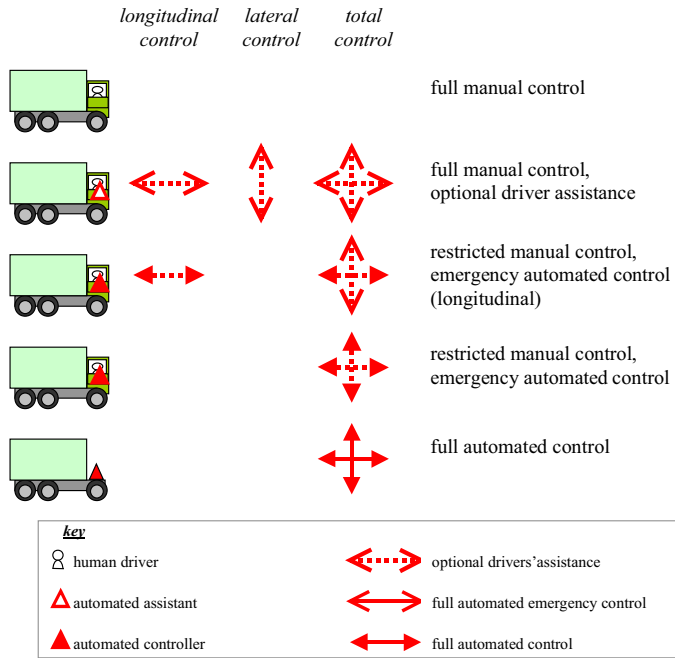
Figure 24-2:   ***Different levels of automation***

Automation can aim at the longitudinal position of the vehicle (the position of the vehicle in the direction the vehicle aims to move) or/and at the lateral position of the vehicle (at right angles longitudinal position). With physically (rail) guided systems, there is no need for automated lateral control.

Although fully automated systems will have detection and actuation systems to prevent collisions with persons, objects and vehicles that obstruct the track, complete safety cannot be guaranteed. Presumably, in the near future, collisions between human-driven and automated vehicles will not be acceptable (even if the risks would be small). Moreover, on short term it is a very difficult and expensive task to build automated vehicles that can drive safely in mixed-traffic conditions. Therefore, for the time being, automated systems will only function on dedicated infrastructures, as dedicated sub-systems that are not used (at the same time[18]) by other non-automated systems. In the further future, automated systems running in mixed traffic conditions may someday become feasible.

24.2.3 Technologies for transport automation

There are different available technologies to enable automated vehicle control. In terms of infrastructure-use, the most important technological issue is the way the location of the vehicle on the infrastructure is determined and influenced. Now, this position can be seen as the *virtual path* for the vehicle, on which the vehicle, at any given time, has a *lateral* and *longitu-*

---

[18] One can think of 'temporally dedicated infrastructures', that during certain periods only may be used by automated vehicles and in other periods are used by traditional traffic.

dinal position. Figure 24-3 displays different positioning technologies that transport automation can use..
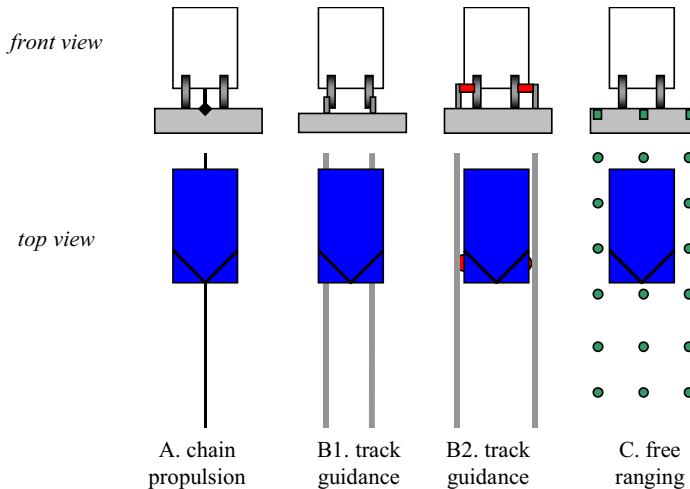
Figure 24-3:   Positioning technologies

Both the lateral and longitudinal position of a vehicle can be determined by physical means, as is the case in a chain-propelled system – a very simple form of vehicle automation. Another way is to secure the lateral position by physical means while determining the longitudinal position by detectors. These detectors can be placed either in the infrastructure or within the vehicles (odometers). Physical guidance is enabled by a track that steers the wheels directly (like in a train); B1 in Figure 24-3 or interacts with the steering mechanism (guided busses), and also one variant of CombiRoad[19]; B2 in Figure 24-3).

Then there can be systems that are able to detect a pre-arranged track that can for example be painted (optical recognition); this way, the lateral position can be secured. The longitudinal position is determined by using (in-vehicle) detectors. In this case, there are no physical barriers for the vehicle to leave the pre-designated route.

Free ranging systems (C in Figure 24-3) determine their position by generating co-ordinates, which are matched with pre-programmed routes. The co-ordinates can be derived from GPS-systems, grids of magnetic pins or transponders or other detecting systems. The predefined routes are programmed into a computer and can be changed if necessary.

Section 24.4 discusses the application of automation to different types of transport means.

24.3   Propulsion technology

24.3.1 Introduction

Within the field of propulsion technologies, internal combustion engines and electric engines are the two main technologies that can be applied in vehicles for urban goods distribution.

---

[19]   A proposed system for road-based trucks that can tow either semi trailers or railwagons (CTT, 1996).

Internal combustion engines are the most widely used in road transport and inland navigation, and to a certain extent also in railway transport. Electric engines are rarely used in road transport, but are often used in urban rail transport. Developments on internal combustion engines result in cleaner and more energy efficient vehicles. Developments in electric engines, and especially in the energy-supply (batteries, combustion engines, fuel cells, external power sources), could make them quite appropriate for applications within urban areas and on dedicated infrastructures.

24.3.2 Internal combustion engines

Diesel internal combustion engines (D-ICE) are the most widely used in urban distribution. Diesel engine technology still allows significant improvements, engines can be made more fuel-efficient, less polluting and less noisy. However, consumer demand and the legislation in the field of emissions (sound as well as exhaust gases) do not necessarily point in one single direction for development. Sound insulation measures, for example, may increase vehicle weight and thus increases fuel consumption. Significant fuel-consumption reducing technologies reduce CO_2 emissions, but may decrease NO_x-emissions to a lesser extent or even increase those emissions. Consumer demands for maintenance-free engines (thus durability and robustness) may interfere with the requirements of clean and efficient (very well tuned) engines. Potentially, cost effective fuel consumption efficiency gains ranging from 15% for trucks to 30% for vans (1995 – 2010) should be feasible (see: Van Binsbergen et al., 1994). Petrol, gasoline or Otto-engines are widely used in passenger cars and vans. The period 1995-2010 may presumably see comparable efficiency gains as in diesel technology: some 20 to 35% (Mitsubishi, 1998). Honda's LEV (Low Emission Vehicle) project resulted in an engine that substantially reduces toxic emissions[20] (see: Honda, 1997; AutoWeb, 1998). It can be expected that those developments in the near future will influence engine technology in vans.

24.3.3 Electric engines (EE)

Electric engines use energy from batteries, external power sources (such as overhead wires), internal generators (transient internal combustion engines) or fuel cells.

Batteries are expensive, heavy and voluminous and therefore can slightly limit the usability for goods transport in urban areas. The chain-efficiency of battery - electric powered vehicles is hardly any better than that of combustion engines, but the local emissions are zero and the noise production is very low (Van Binsbergen et al., 1993a).

Developments in battery-technology and fuel cells may enhance the performance of future full electric vehicles (FEV). External power supply for electric vehicles (see Section 25.5.2) is only applicable at dedicated infrastructures, but extends the range 'indefinitely'

To date, full electric powered vehicles are mostly used by fleet-owners operating fleets of vehicles that travel limited distances. The radius-of-action and the performance of electric vehicles makes them well-suited for urban travel, but less attractive for long-distance, high speed travel.

The development of hybrid (ICE/EE) vehicles combines the advantages of electric drive (local emissions) to those of combustion engines (performance, range).

---

[20] More than 90% compared to 1998 Australian government standards (AutoWeb, 1998).

Hybrid propulsion systems can be regarded as an in-between between the current ICE-engines and future FEV-systems that render the same performance results, but equally well as a suitable (long-term) alternative for full ICE systems.

There are basically two forms of hybrid systems:

- Parallel hybrid where either a (small) ICE or an EE propels the vehicle, thus enabling a long range (ICE-drive) and, when necessary, rendering zero local emissions (EE-drive);
- Serial hybrid, where the electric energy for the EE propulsion system is generated (on-board) by a transient ICE.

Various intermediate variants have been developed, each with their own advantages and disadvantages (see Van Binsbergen et al. (1993a) for an extensive analysis of available propulsion technologies in different time periods). For vans for urban distribution activities, full electric drive or hybrid alternatives would be most appropriate because these systems cause least local emissions deliver sufficient performance.

24.3.4 Traffic means and appropriate propulsion technologies

The different propulsion technologies as described above have different fields of application that relate especially to the relative size and weight of the engine and the power systems. Given the traditional combustion engines as a reference (vehicle range and performance), electric engines are less heavy and less voluminous. Compared to the power supply of traditional fuels, alternative fuels are generally somewhat more voluminous. Battery and fuel cell (including the fuel) electric power systems are generally quite heavy and voluminous; the one exception is an external power supply. Table 24-1 displays the appropriateness of propulsion systems for urban and inter urban transport systems. Section 24.4 provides more information on this subject.

Table 24-1:   Application of engine technologies for different transport modes

	Combustion		Electric		
	Trad. fuel	Alt. fuel	Battery[*1]	Fuel cell	External[*2]
Urban road	*		*	**	
Interurban road	***	**		*	
Interurban dedicated road	**	**		*	***
Rail	*			*	***
Inland shipping	***	***		*	
Underground transport		*	**	*	***
[*1] includes hybrid variants			[*2] includes induction		
* possible			** good/appropriate		
*** optimal (environment & performance)					

In all, electric driven vehicles are very attractive from a local environmental point of view and very well suitable for inner urban distribution and for the propulsion of vehicles on longer stretches of dedicated infrastructures (external power source). For longer distance transport (about 50 kilometres and more) on non-dedicated infrastructures and for heavier loads (larger

vehicles than vans), electric drive for road transport is no good alternative to fuel powered vehicles.

24.4   Applications of technological innovations in traffic means

24.4.1 Introduction

The technologies as described in the preceding sections can not be applied to all transport means in all circumstances: most (newly developed) technologies require special provisions to be applicable. This initial disadvantage must however be eliminated, because the new technologies are very promising with respect to the (environmental) problem solving potential in specific areas of application. Therefore, intermodal transport concepts are indispensable; Part III (Section 18.5) already sketched the logistic basis for such concepts.

24.4.2 Applications in road transport

Automation technologies can be used in different ways in road transport, as depicted in Figure 24-4. For the application of fully automated systems, in the foreseeable future dedicated infrastructures will be most appropriate. Automated guided vehicles can in that case operate on terminals, dedicated line infrastructures and in underground transport systems. Automate assisted systems, where there is an overall control by a human driver who is assisted by automated functions (mutual distance control, lateral position control etc.), may be allowed on mixed-traffic roads.
In the further future, fully automated systems may mix with non-automated vehicles.
Commercial examples of automated road vehicles can be found in passenger transport (people movers: small, cab-like shuttle systems) and in container transport at container terminals (Automated Guided Vehicles at the Rotterdam ECT terminal). Both systems use the FROG grid positioning system. For both inter-terminal transport (of containers) and medium distance transport, the CombiRoad system has been developed in the Netherlands (CTT, 1996). In the trial phase, different position technologies (varying from physical guidance to a FROG navigation system and manual drive at terminals) are being tested. The Japanese initiative of Dual Mode Trucks are able to run either in automated mode at dedicated infrastructures or in manual mode in mixed traffic conditions (hence the name; see Koshi, 1992).

Advanced combustion engine technologies can be applied very soon, both on trunk line systems as in an urban environment. These technologies are used to comply with European standards for emissions by cars and trucks. From October 1st of 2000, 'Euro-3' standards apply to new trucks. In 2005 and 2008, new trucks have to meet the 'Euro-4' and 'Euro-5' standards; see Table 24-2.
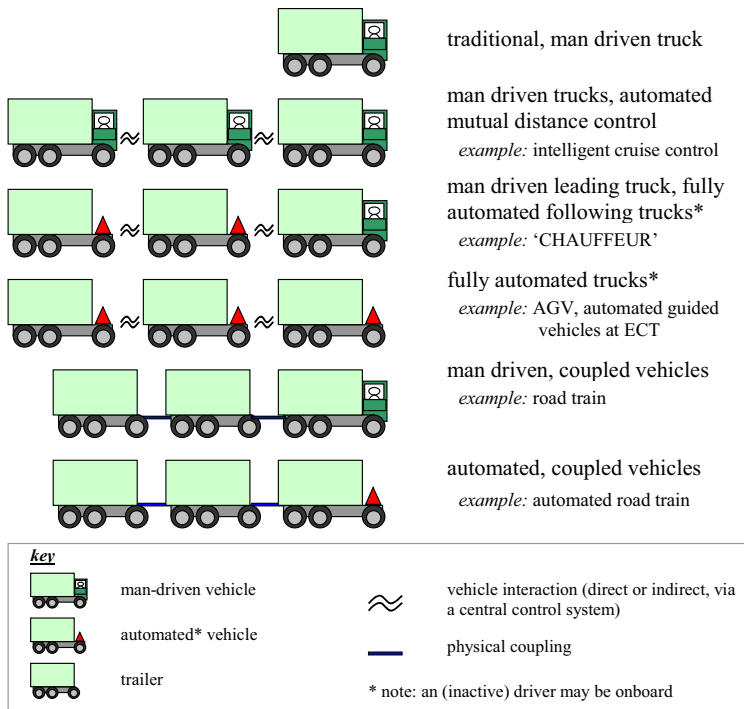
Figure 24-4:   Automation in road transport (AHSRA, 1999)

Table 24-2:   European standards for emissions by trucks (g/kWh)

	NOx	HC	CO	Particulate Matter (PM)
ECE 49 (<1988)	18,0	3,5	14,0	
Euro-0 (1988)	14,4	2,4	11,4	
Euro-1 (1992)	8,0	1,1	4,5	0,36
Euro-2 (1996)	7,0	1,1	4,0	0,15
Euro-3 (2000)	5,0	0,66	2,1	0,10
Euro-4 (2005)	3,5	0,46	1,5	0,02
Euro-5 (2008)	2,0	0,46	1,5	0,02

Source: Smit & Poppink, 1999

Electric engines and hybrid systems are especially well suited for applications in an urban environment (battery powered) and within tunnels or on dedicated infrastructures (either battery powered or using external power supply). On trunk lines fuel cell systems may become an alternative to traditional fuel[21], on dedicated trunk lines external power supply may be an appropriate option.

---

[21]   Fuel cell systems tend to be large and will probably function best within larger vehicles - the relative size will be limited in that case.

24.4.3 Applications in rail transport

Automation in rail transport is already used in shunting operations and for passenger transport systems. In the foreseeable future, automated (goods) trains can be expected on main tracks as well. In Germany and Switzerland, the *CargoSprinter*® serves as a test project (see DB 1996b and 1996c; Kreutzberger, 1999; Zürcher, 1999). The train consists of up to five carriages, the end ones are powered by a small diesel motor or an electric engine (in that case, the *CargoSprinter*® should be extended with an extra carriage with a pantograph system - see Zürcher, 1999). The end carriages have a control cab, in addition to the cargo space. All carriages can carry up to two 20 ft containers. At the test phase, the *CargoSprinters*® are manned, but automated operation is envisaged for the future. The aspect of automated guided trains is also studied in the German automated locomotive project (DB 1996a). In addition, individual, self propelled and automated guided railway wagons can be an alternative option, especially to ease shunting operations (for longer haul transport, individually running carriages are not very efficient). If the short freight trains could operate at speeds of about 120 - 160 km/hour, mixing with *intercity* trains would be possible, thus offering more flexibility in creating train-paths in the schedules[22]. The higher speed may conflict with the 'environmentally sound' performance of railway operations. Newly developed advanced engines and, for example, the use of light weight wagons should reduce these negative side effects. Wagons equipped with these new engines possibly can use regenerative breaking systems. Because the trains are used in the distribution process and will usually transport lightweight goods, wagons can be made lightweight. This also reduces energy use.
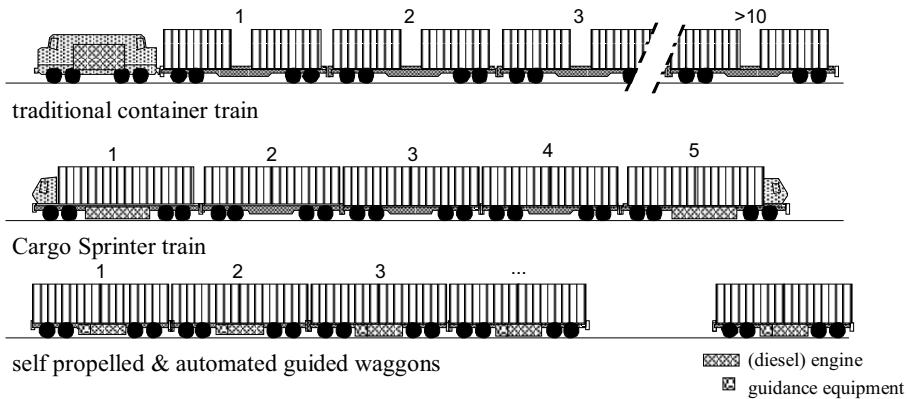
Figure 24-5:   Options to adapt rail transport systems to urban distribution

24.4.4 Applications in waterborne transport

In waterborne transport, automation is not a hot issue, and only assistance systems to shippers are likely to evolve in the near future. However, in the further future a higher degree in automation might be (economically) feasible. This will only be the case if these systems can further reduce the transport costs and/or can make the system more time-reliable and safe. Theo-

---

[22] Note that on the relative short distances in distribution transport, the higher 'track-speed' hardly influences transport time - eliminating waiting times as a result of scheduling problems has a much larger impact;

retically, a GPS or fixed beacon system can be applied to automate inland navigation. The scale advantages of inland shipping and the low operational speeds result in a positive 'environmental performance'. However, the internal combustion engines of inland vessels are sometimes outdated. Newer engines, maybe even electric engine – fuel cell systems, would limit emissions and energy use even more.

24.4.5 Applications in underground transport

Underground systems in technical terms either resemble dedicated infrastructure road systems or railway systems. The new concepts for underground transport rely very much on automation. First, to limit the (overall) operational costs of driving the vehicles as well as for operating the tunnels. Second, automation may reduce some building (thus investment) efforts as fully automated systems pose fewer requirements than manned systems. Of course, the dedicated nature of underground systems also enables automation. To further decrease investment and operational costs, ideally there are no exhaust gasses to deal with within the tunnel system. Therefore, electric propulsion systems seem to be most appropriate, especially those using an external power supply. However, in some studies (OLS Schiphol) traditional combustion engines are considered as well, because in that case the vehicles are fully self-supporting and do not need to make contact with an external power supply system (see Pielage, 2000).

24.5   Costs of traffic means

As explained in the layer-scheme (Part II, Figures 8.3 and 8.4) the layer of traffic means comprises all means of steering and propelling vehicles.

From this viewpoint, the most important cost categories are:

- Personnel costs (drivers, controllers);
- Production means (vehicles and their components);
- Operational costs (fuel, maintenance).

Personnel costs are related to personnel involved in the transport activities, especially in relation to vehicle guidance and steering (drivers). Production means (vehicles and components) costs refer to the needed traffic means.

Figure 24-6 (left) depicts the 'traffic means costs to payload' relationship. The personnel costs relate to the shipment size (payload) because the shipment size determines how much traffic means (and thus drivers) are needed. If we take the railway transport as an example: at a certain point the extension of a train reaches its legal or practical limits ($l_c(1)$): the train length reaches a maximum. Then, an additional train will become necessary to enable the transport of the payload. The personnel cost-to-payload relationship can be interpreted as being discrete: up to a certain payload size (traffic means capacity), the personnel costs are fixed. If the payload size increases, additional traffic means are necessary which leads to a higher level of personnel costs. The same goes for the costs for the production means (vehicles and components), which are made up of interest costs and depreciation costs. These cost components can be regarded as 'fixed costs' as long as the traffic means capacity is not exceeded.

The variable costs relate to the operational costs, consisting of fuel expenses and maintenance costs (including costs for repairing 'wear and tear'). These costs increase continuous with the increase of the payload size.
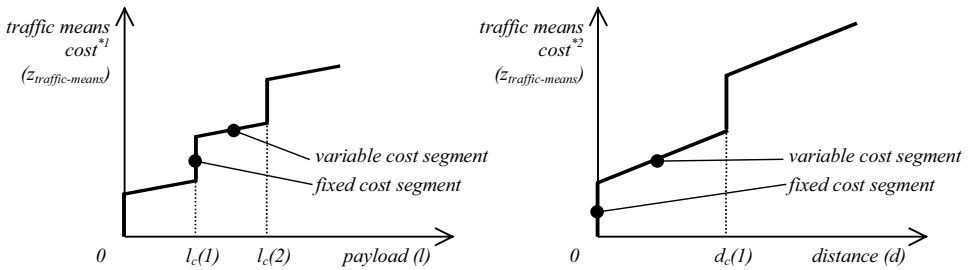
cost functions are illustrative and are not represented to scale
*1:   given a certain transport distance;
*2:   given a certain payload size.

Figure 24-6:   Traffic means cost to payload and distance relationships (illustrative)

Figure 24-6 (right) depicts the traffic means costs to distance relationship. The personnel costs relate to the transport distance (or time; see Section 21.5.2 for the interaction between travel time and costs). An increase in the transport distance will (at a given speed) result in longer driving times and will thus result in longer labour times. This increase is continuous, until a certain threshold time or distance ($d_c(1)$) is reached, then the costs may increase sharply due to the maximum labour times regulations. For production means in itself, there is hardly any interrelation between transport distance and production means costs.

The operational costs however (especially fuel costs), are strongly influenced by the transport distance: an increase in transport distance will lead to an increase in operational costs.

In reality, the costs functions will be curved due to some economies of scale with larger payloads and longer distances (for example related to fuel efficiency and tear and wear).

If we assume an additive, linear 'total disutility' (costs) function for traffic means can have the form of (see also Part II, Section 7.2):

$$Z^a_{(trafficmeans,m),\hat{K}} = \sum_{k=1}^{K} \left(\alpha^a_k \bullet s_{(trafficmeans,m),k} \right) \qquad \textbf{(24.5-1)}$$

With:

$$s_{(trafficmeans,m),k} = f(d,t,l,p,q)$$

And:

$Z^a_{(trafficmeans,m),\hat{K}}$:   total (subjective) disutility over all cost-categories of set $\hat{K}$ of 'using traffic means m'; as perceived by actor a;

$s_{(trafficmeans,m),k}$:   objective partial disutility (cost category) k of 'using traffic means m';

α^a_k :   subjective weighting of cost category k by actor a;

$f(...)$:   is a function of ...

   d: transport distance;

   t: transport time;

   l: transported load (payload);

   p: personnel;

   q: the (type of) traffic means (vehicles).

Tariffs will usually reflect the costs to be covered, both for the transport as for the traffic means. For analysing and optimisation purposes, we might use cost-functions to get an insight in the real cost factors related to urban goods distribution.

However, in the real market conditions, tariffs apply and these tariffs are a result of a complex system of trade negotiations, cost-assignments, (cross-) subsidies etc.

To name a few examples:

- In long-distance road transport, return trips are 'subsidised' by the main trips - transport companies offer bargain deals to get return load; this to prevent 'empty return trips';
- In distribution, transport companies or logistic service providers often have 'package deals' with shippers that comprises a lump sum payment for all distribution activities within an areas during the contract period;
- Drivers (of trucks or locomotives) might have different labour contracts, resulting in different wages;
- Firms may or may not compensate losses in distribution activities with earnings in other units within the firm.

In the basic economic theory that is based on full market insight and knowledge (transparency) and full competition, tariffs will eventually reflect costs perfectly. In reality, there are so much disturbing factors (borders, governmental subsidies and taxes, monopolistic and oligopolistic market behaviour, a lack of transparency) that this situation will never be reached.

24.6   Conclusions

Traffic means take care of the actual movement of transport means and use propulsion and guiding/steering systems for that task. Because road transport is the prominent transport mode in urban distribution, combustion engines and manual drive are the current key systems. In the future, these traditional systems will still be important, but developments in transport automation, propulsion technologies and other sectors can help to make the transport system more efficient.

Transport automation reduces the need for personnel and enables continuous operations, higher accuracy, higher reliability, and, under certain circumstances, a higher level of safety.

Developments in propulsion technology, such as cleaner combustion engines and electric engines (plus the necessary power supply systems) enable silent and clean vehicle operations.

The technological developments each set specific requirements that affect the appropriateness of application for the different transport operations and modes.

In the near future, transport automation will probably only be acceptable on dedicated infrastructures. In time, however, automation could be feasible in mixed traffic conditions. New types of dedicated infrastructures, such as underground infrastructures or dedicated terminals, enable the introduction of automated transport systems.

Developments on traditional propulsion technologies, such as combustion engines, still go on – important improvements in the performance to energy use ratio are to be expected while emissions and noise pollution will be further reduced. These technologies are very appropriate for road transport, especially on trunk lines. The systems are also very appropriate for inland shipping.

Electric drive reduces the local emissions (exhaust gases) to zero or almost zero. In addition, noise production is very low. As a drawback, the effectivity of those systems is limited when the size and weight of the internal power supply system is compared to the performance. Only on short distance road transport and within very large vehicles (trains and inland vessels) are these systems appropriate. Electric drive can also use an external power supply. These external power systems need infrastructure adaptations and limit the freedom of (lateral) movement of vehicles. For line infrastructures, this poses no problems, but on terminals special (costly) provisions are needed. External power supply is therefore especially suited for longer-distance transport.

25. Line infrastructures

25.1 Introduction

Infrastructures carry and guide transport and traffic means. Infrastructures physically connect geographically separated activity centres. Infrastructures have a strong impact on the spatial environment because they influence the location behaviour of firms and households by changing the (relative) accessibility of a location, they consume space and they may cause spatial separation problems (see Figure 25-1).
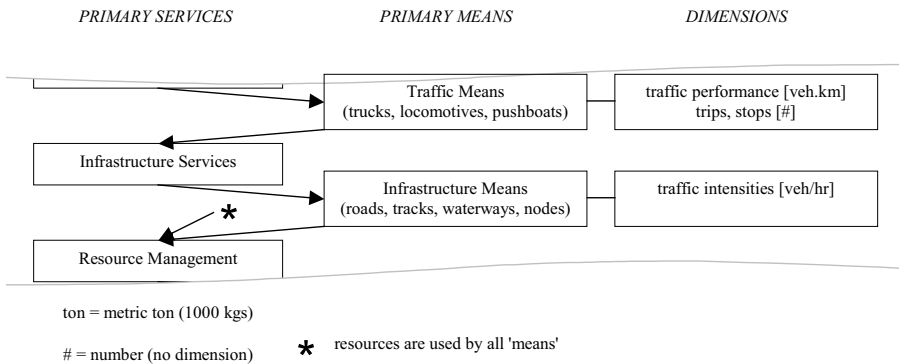
Figure 25-1: *Infrastructure (services) within the transport system*

In this chapter, we will elaborate the characteristics and the developments of the different types of line-infrastructures for various transport modes: road, rail and underground sys-

tems[23]. Furthermore, we will discuss the function of infrastructure nodes (transport centres) within the framework of urban distribution (this topic will be further elaborated in Part V). Then we will explain what additional functions infrastructures can have next to the function of carrying and guiding transport and traffic means. Attention will be given to both inner city infrastructures as infrastructures outside urban areas (trunk lines).

25.2   Road infrastructure

25.2.1 Introduction
This section describes the types of road infrastructure that can be used for urban goods distribution and introduces some important developments on road infrastructure that enables, amongst others, the introduction of automated road transport systems.

25.2.2 Main links road infrastructures (highways)
In the opinion of Dutch policy makers, the main transport links between the Port of Rotterdam, Amsterdam-Schiphol Airport and the 'Hinterland' should be almost congestion free. Therefore plans are developed, and partly executed, to introduce dedicated (exclusive) infrastructures for goods transport at certain links and intersections. At some known bottlenecks, reserved lanes for freight vehicles have been built and will be built[24]. These free or reserved lanes could be extended for short-distance freight transport for urban areas, forming *free or reserved networks* (see Van Binsbergen & Schoemaker, 1996, and Green, 1999). With some modifications, such systems can be the start of a fully independent freight transport network, aimed at the Hinterland connections but also at short(er) distance, regional freight transport, which accounts for more than half of total freight transport by road.
Pilot projects have been initiated to check the feasibility and safety of extended road vehicles called 4 TEU trucks. The pilot took place in the Port of Rotterdam and was aimed at improving the efficiency of container transport. The European Commission has proposed legislation that allows member states to use 25-metre trucks within their borders. This seems to be the first step in accepting longer trucks on certain routes (see also Section 23.2.2).
The primary advantages of transport automation have been discussed in Chapter 24. Secondary advantage of automating vehicles are the possibilities of increasing the capacity of infrastructure and decreasing the width of infrastructure (less lateral movements (see: CTT, 1996).

Automated guided road trains are a logical follow-up of automated guided vehicles and road trains. The net gains will be somewhat less because road trains are efficient transport modes already. Perhaps some additional gains can be achieved by optimising the actual manoeuvring control. Technical adaptations and automatic steering corrections make it possible to use narrower infrastructures.

---

[23]   We refrain from discussing waterway infrastructures.

[24]   This separate infrastructure is used as dedicate infrastructure, but could theoretically also be used as 'temporal dedicated' lanes – for example in rush hours only.
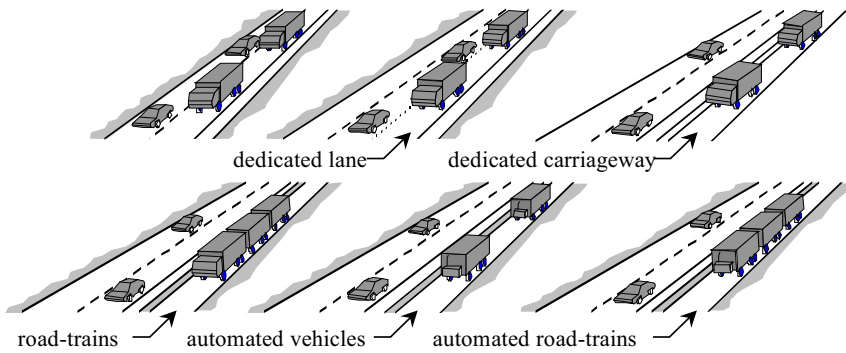
dedicated lane   dedicated carriageway

road-trains   automated vehicles   automated road-trains

Figure 25-2:   Different options to improve road transport efficiency

Today, road infrastructure is often free accessible. Infrastructure use is not planned or regulated by government bodies or other regulators. Everybody may at any time start with a journey, only risking congestion once being on the road. This is in contrast with for example railway or air traffic systems in which a journey may start only when a free path is guaranteed. Theoretically, regulation leads to a more efficient use of infrastructure and eventually also to predictable delays. Road infrastructure management should copy some of the ideas of rail-like management: advanced systems regulate the inflow of traffic on a certain part of the infrastructure. Only if the quality is guaranteed, access is permitted. Other options limit the accessibility of infrastructure to those who use the infrastructure most effective (see Koolstra, 1998).

25.2.3 Secondary and urban road infrastructures

Secondary (and especially urban) road infrastructures pose limitations to the usability of road vehicles for urban goods distribution. Evidence shows (Boerkamps et al., 2000) that limitations of infrastructure access strongly influence vehicle type choice and (therefore) even have an impact on the physical distribution process. A clear illustration of the fact that the layer scheme (see Part II, Chapter 8) not only can be used top-down, but also bottom-up. Secondary road infrastructures in urban areas are less likely to be dedicated to freight transport than main infrastructure, simply because there is already a shortage of available space and the expected freight transport densities are generally too low. Nevertheless, some specific corridors, possibly using underground sections (see Section 25.4) may strongly improve the freight transport flows (see Borkens, 1997). For public passenger transport (busses and taxis) in some urban areas dedicated infrastructures already exist. If traffic intensities allow for extended use, goods distribution vehicles may be allowed to use these dedicated infrastructures. At the start of the year 2000, the city of Groningen (The Netherlands) started a test allowing urban distribution vehicles to use dedicated public transport infrastructures (PSD, 2000).

25.3   Rail infrastructure

25.3.1 Introduction
Goods transport by rail infrastructure is seldom applied for urban goods distribution. New logistic concepts however, bring application of these systems within reach. In intermodal concepts, also the use of inner urban light rail systems can be envisaged.

25.3.2 Urban (light) rail infrastructure
Urban rail infrastructures are already intensively (and exclusively) used for passenger transport. In the 1970s, in Germany some studies have been conducted to scan the possibilities of operating goods transport trams and metros in urban areas (Heckler, 1977). Although the systems seemed to be technically feasible, the economic feasibility could be questioned. More recent studies show interest in the application of light rail transport for urban distribution (CargoTram), for example in German cities (Roggenkamp and Rien, 1995) and Paris (Martinet et al., 1999). In the German city of Dresden, a pilot project is launched (Verkeerskunde, 2000). These schemes require special infrastructure provisions at load/unload points.

25.3.3 Heavy rail infrastructure
As explained in Section 23.3.3, there are different options to combine goods transport with passenger transport within trains – this combined transport especially requires adaptation of terminals or passenger stations, but does not need specific line-infrastructure alterations.

Dedicated freight train systems implicitly require capacity enhancement. New developed systems like CargoSprinters[®] (Deutsche Bahn, 1996b & 1996c; Kreutzberger, 1999), do not need substantial alterations on the infrastructure. Automated systems may require special control devices, but do not need special tracks or other infrastructure provisions.

Mixing traditional cargo train with passenger train services reduces the track capacity (or strictly: limits the maximum intensity) due to the lower speeds of traditional cargo trains (80 km/h) in comparison with passenger trains (120 - 140 km/h). New cargo train concepts, like CargoSprinter[®], therefore operate at higher speeds. Alternatively, specific (dedicated) rail infrastructures can be created like the Dutch Betuwe goods transport railway line and initiatives for such lines in Germany (see Ludewig, 1999).

25.4   Underground infrastructure

Underground goods transport for urban areas is another potential way to overcome negative external effects and to improve the quality of the distribution system.

In general, advantages of underground systems include:

- (Easy to realise) autonomous infrastructure with respect to other types of traffic (enables undisturbed traffic flows and allows transport automation);
- Weather-independent transport systems;
- Less space-utilisation;
- Fewer or no local environmental effects, such as noise, air pollution, physical inconvenience, and separation.

Underground systems pose environmental and logistical advantages. Underground systems will offer higher (operational) speeds, higher reliability and fewer emissions and energy-use. There are also, well known, disadvantages such as investment costs and system safety (if an accident occurs, the consequence can be enormous).

In essence, all known transport systems can be used in tunnels. In practice, there are some restrictions on propulsion and guidance that are related to tunnel characteristics. In fact, most of the requirements lead to advanced automated transport systems, which have little in common with traditional road vehicles as they are used today.

A main characteristic of tunnels, with respect to the usability by vehicles, are the (internal) dimensions – or, if the tunnel has a circular cross-section, the tunnel diameter. Larger tunnel diameters allow the application of larger vehicles – tunnel diameters of about five metres for example enable the use of traditional road vehicles. Smaller tunnel diameters obviously only allow smaller vehicles, which may have far-reaching consequences for the physical distribution process (see also Section 26.2.3). Larger tunnel diameters are more expensive to build than small diameter tunnels – the investment costs raise quadratic with an increase in tunnel diameter. For goods distribution in urban areas we distinguish four underground concepts, see also Figure 25-3.
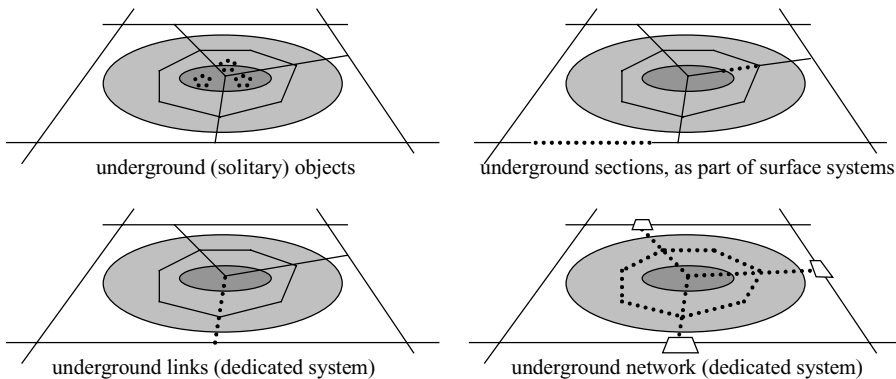
Figure 25-3:   Underground network concepts

Underground solitary objects can be distribution points that serve local addressees and function on their own. They are typically local solutions that make no part of an underground (distribution) system.

Underground sections are in fact traditional infrastructures (road, rail) that partially run underground to overcome (surface) spatial or nuisance problems.

Underground links interconnect important activity centres directly, without interference by other (transport) activities and can be dedicated underground transport systems (this in contrast to an underground section). Underground links underpass congested areas, such as inner city areas. Because links can provide direct connections, specialised transport systems can be used: only through transhipments there is an interaction with traditional transport facilities. Though specific underground vehicles can be used, another option is to use vehicles that can

both be used on surface (traditional infrastructure) as at the underground link[25] (see for example Borkens, 1997; Yamada et al., (1995).

Table 25-1:   Comparison of surface and underground operation of vehicles

	Surface operation		Underground operation	
	*Requirements for vehicles**	*Requirements for infrastructure**	*Adaptations on vehicles*	*Adaptations on infrastructure*
Traditional vehicle (surface)	nil	nil	nil	larger diameter lighting air conditioning safety measures
Multi purpose vehicle	(drivers' cabin) (combustion engine)	nil	guidance system; electric drive	guidance system
Dedicated vehicle (underground)			guidance system; electric drive	guidance system
* when compared to traditional road vehicles or road infrastructure				

Full underground networks interconnect multiple urban activity centres. Like underground links, a full underground network provides an independent (autonomous) service that is not hindered by other traffic. The full autonomy again allows the use of dedicated vehicles, although multi-purpose vehicles can be used as well. As long as underground systems only exist within urban areas, the main access points to the underground system will act as transfer centres. It will seldom be feasible to connect all buildings in an existing situation to an underground goods transport system. Therefore, distribution systems at surface level must perform the real final stage of the distribution process.

There are many initiatives for interlocal, regional or even national and international underground systems for freight transport (see Clarke and Wright, 1993; Binsbergen et al., 1995a; Visser and Van Binsbergen 1997). However, only very few initiatives have ever been realised.

Advantages of underground systems are the autonomous traffic flows, weather-independency, an efficient space-utilisation and a reduction of local environmental effects like noise, air pollution, physical hindrance, and separation to almost zero. Well-known disadvantages include investment costs and system-safety.

In essence, all known transport systems can be used in tunnels. In practice, there are some restrictions on propulsion and guidance, which are related to tunnel characteristics.

In underground infrastructures, zero-emission vehicles are preferred because this reduces the need for air-cleaning and conditioning devices. Nowadays, all specially designed underground

---

[25]   Such a concept is developed in Japan and named 'Dual Mode Truck', referring to both the propulsion system used (hybrid electric) as the type of infrastructure and guidance system (with and without a driver), see Koshi, 1992;

systems (metro) therefore are equipped with electric engines or external propulsion systems (air pressure, cables etc.).

Lateral vehicle movements of large amplitudes require large tunnel diameters, therefore most specially designed underground systems make use of guided systems to limit the lateral movements. For safety reasons rigid, physical guidance systems are preferred above electronic guidance systems.

The consequences of accidents in tunnels can be enormous: the accessibility to tunnels for rescue workers is restricted, as is the manoeuvrability of helping appliances. Therefore, much attention should be given to prevent accidents happening at all.

25.5   Additional functions of infrastructure

25.5.1 Introduction

Next to carrying and (physically) guiding vehicles, infrastructures can be used for other purposes, such as energy provision (power supply). Further more, infrastructures can be the carrier for (dynamic) traffic information systems - both for data collection (detection systems) as for information provision (signalling).

25.5.2 Power supply by infrastructures

For rail transport, external power supply by special provisions at the infrastructure is common. For road transport this is not the case: there are only few examples of electric passenger transport busses that use an external power supply system (trolley busses; using overhead wires). An external supply of electric energy to electric road vehicles eliminates the necessity of batteries or fuel tanks. Next to overhead wires, 'live rail' systems and induction-loop systems could be used for energy transfer. Overhead wires pose some dangers in combination with high vehicles and also pose visual intrusion, but render a relatively large freedom in lateral position of the vehicles (so they can by-pass other vehicles).

Live-rail systems are used by track-bound systems that run either on steel wheels/steel track or on rubber tyres and steel or concrete track. The first system is widely used in Great Britain, the second system is used for example in the Paris metro and the VAL in Lille (all passenger transport only). Also the pilot project of CombiRoad (CTT, 1996) and Dual Mode trucks (Koshi, 1992) make use of live rail systems for energy supply when the vehicles drive on the dedicated tracks. The rigid live rail system poses complications with level crossings, and pose safety risks as the live rail is fairly easily accessible. The system is best used in combination with autonomous, dedicated infrastructures.

Electromagnetic induction can also be a means of transferring electric power from the road (infrastructure) to vehicles (Calspan 1994). In the PATH (Partners for Advanced Transit and Highways) programme, this roadway powered electric vehicle concept (RPEV) is being tested.

Electromagnetic induction, live rail systems and also overhead wires will not be available on all routes. This means that these technologies can only provide electric energy on restricted parts of the road network. The systems can be used for charging batteries or for vehicles that are also equipped with internal combustion engines. The first option would not eliminate the need for on-board batteries but will probably decrease the size of the needed battery packs.

25.5.3 Traffic flow management systems

Substantial stretches of high-intensity highways are equipped with traffic flow monitoring systems. These systems range from (inductive) counter loops to cameras and are able to detect the intensity and composition of the traffic flow. The collected data can be used to gain an overview of the current intensities and can be used to generate (short-term) predictions of the traffic conditions. By means of information systems, the information can be fed back to the road system users. The ongoing developments in *dynamic traffic management systems* enable specific information exchange with specific user groups, for instance freight transporting vehicles. The management systems can be used to streamline freight traffic flows in relation to urban areas. The secondary road networks are thus far not widely equipped with monitoring systems that collect data for central processing[26]. For streamlining urban distribution, such systems should be welcome. In the Netherlands, the so RegioLab project tries to integrate existing (local) data collection systems with newly built local monitoring systems, to enable dynamic traffic management on secondary roads. Also for rail traffic, advanced information systems are being realised, to be able to track and trace trains and to enable swift reactions on incidents and accidents.

25.6   Costs of infrastructures

The costs of dedicated goods transport infrastructures relate to the (estimated, future) use of these infrastructures. This use will normally be expressed in numbers of vehicles during a certain span of time (intensity). The maximum intensity is equal to the capacity of the infrastructure and depends on infrastructure characteristics (width, angles, curves), vehicle characteristics (size, acceleration/deceleration rates), traffic flow characteristics (speed, intermediate distances) and, for example, weather conditions. The vehicle flow intensities eventually determine the payload transport capacity. The infrastructure costs relate to the infrastructure occupation, that can be expressed in occupied space in time. The initial costs of making infrastructure capacity available, are usually very high.

Capacity enhancements by traffic management systems are sometimes applicable, for example by introducing advanced safety systems. These enhancements increase the infrastructure capacity without constructing new physical infrastructures.
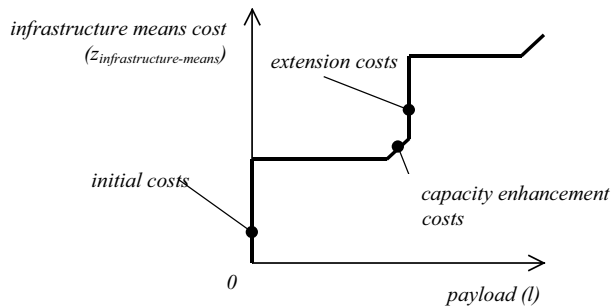

Figure 25-4:   Infrastructure-means cost to payload relationship (example)

---

[26]   However, local systems are used to tune traffic light installations.

The costs of (dedicated) infrastructure *use*, if these apply, might reflect these relationships, resulting in a function like:

$$Z^a_{(inframeans,m),\hat{K}} = \sum_{k=1}^{K}\left(\alpha^a_k \bullet s_{(inframeans,m),k}\right) \qquad with \qquad s_{(inframeans,m),k} = f(d,t,l,q) \qquad \textbf{(25-1)}$$

With:

$Z^a_{(inframeans,m),\hat{K}}$:   total (subjective) disutility over all cost-categories of set $\hat{K}$ of 'using infrastructure for mode *m*'; as perceived by actor *a*;

$s_{(inframeans,m),k}$:   objective partial disutility (cost category) *k* of 'using infrastructure for mode *m*';

α^a_k: subjective weighting of cost category *k* by actor *a*;

f(...):   is a function of ...

    d: infrastructure length;

    t: infrastructure time-use;

    l: transported load (payload);

    q: the (type of) physical infrastructures.

It is difficult to sketch an overall picture of the *tariffs* of infrastructure use. Within the European Community, the following types of tariffs apply:

- For road transport, all countries have some kind of 'fixed' taxation for infrastructure use; in most countries there are specific tolled infrastructures; all countries use some kind of user-taxation that is included in the fuel prices.
- For railway infrastructures, in countries with liberalised (deregulated) railways, tariffs must be paid.
- Main inland waterway links are 'tax-free' (Mannheim agreement), for minor waterways tariffs for locks and bridges may apply.

Note that there are only few examples of dedicated goods transport infrastructures. So in most situations, infrastructure costs must be allotted to user types and there are various ways of doing that.

25.7   Infrastructure management strategies

25.7.1 Introduction

Road, rail and inland waterway networks are largely provided by the government – infrastructure is mostly seen as public good. New views on the role of the government, especially in relation to new additional infrastructures or infrastructure networks, position infrastructure as an economical good. Such infrastructures should be 'managed', and for that different strategies with different objectives can be used. In this section, we highlight five typical network management strategies and we discuss the consequences for the use and effectivity with respect to efficiency improvement of urban goods distribution processes.

In fact, the transport system management strategies may apply to all elements in the 'layer scheme' (see Part II, Chapter 8), however, here we concentrate on the management of infrastructures.

Assuming a business-like approach, operators want to optimise their operations in one way or another. Different types of operators may have different objectives and will therefore use different operating strategies. In practice, operators will have different objectives at the same time and will therefore follow a quite complex strategy.

Here, five basic objectives are distinguished:

1. Non intervention.
2. Maximise revenues or yield (revenue or yield management).
3. Maximise use of capital goods (throughput maximisation).
4. Optimise societal allocation.
5. Optimise service level.

Basically, these objectives can be used for all operational tasks. Here we focus, as an example, on infrastructure operations.

Non-intervention strategy

In the non-intervention strategy, there are no operational limits for the users to access the services (nevertheless, a predefined user group may be granted the right of exclusive use of the infrastructure).

Maximised revenues by revenue management

In the struggle for maximised revenues, by way of revenue management, different market niches can be defined, and for each niche, a specific price/quantity equilibrium will be established. Compared to a free market situation, where mostly only one price/quantity equilibrium is established, by means of revenue management, the operator gains a part of the consumer surplus. Revenue management can only be applied if market segments are distinguishable and can be separated (at lower costs than the yield), a reservation system is in use, and the capacity of the transport system is separable and assignable (see also Edelson, 1971). Note that in revenue management tariffs may differ, but that the product is essentially the same. For transport systems this means that there are no differences in service quality. The total available capacity is subdivided into smaller parts. These parts are sold sequentially, starting with a high price and ending with bargain prices (see De Wit and Van Gent, 1996; Blauwens et al, 1995). The transport capacity of vehicles can fairly easy be subdivided into marketable capacity units. For infrastructure capacity, slots must be introduced. These slots are reservations in time and space and 'move' along the infrastructure[27]. The revenue management system is widely used in passenger air transport and sometimes also in passenger rail transport (high-speed trains). Here, different prices are asked for bulk-users (travel organisations), ad-hoc travellers, last minute travellers etc., while the actual product stays the same. There are no examples of revenue management in combination with slot allocation on road infrastructures yet. An important consequence of revenue management is that it does not require a full booked capacity or – to put it in another way – available capacity is not necessarily fully used.

Maximised use of capital goods or throughput maximisation

The maximum throughput strategy can be used to achieve some non-monetary form of maximum return on investment. The strategy is applicable when there are no direct monetary reve-

---

[27] Comparable with slots in airway traffic.

nues related to the actual use, for example, if the users pay a lump-sum tariff or no user tariff at all. The strategy can also be used for revenue maximisation if price differentiation or revenue management is not applicable (flat rates).

In throughput maximisation, normally the *first in – first out* strategy for users is applied, there are no preferred users. In case the capacity is expected to be exceeded, the inflow is reduced or stopped, irrespective of consumer demands at that moment. This action is taken because congestion reduces (maximum) throughput. Monetary measures (user charges) may be used to distribute demand over time, thus preventing excessive demands that can cause congestion. The tariffs can be time-related and implicitly assure a minimum quality of service. Nevertheless, a higher tariff does not guarantee a higher level of service. The tariffs are not necessarily intended to generate profits or maximum revenues.

Optimised service level

The optimised service level strategy aims at the users. As much as possible, user demands are met. If there are conflicting user demands, preferred users must be defined. Such preferred user groups can be distinguished on the basis of size of the vehicle, urgency, willingness to pay (representing the value of time) or other criteria (see for example Verhoef & Small, 2000). If for a certain service capacity overloads are to be expected, either capacity will be extended or the size of the most preferred group(s) must be reduced. The latter can be effectuated by redefining or tightening the criteria that are the basis for distinguishing the user groups.

Optimised societal allocation

The above mentioned strategies address direct actors only, thus suppliers and users of transport services. Now, the very existence and the use of transport systems have an impact on society and the environment, and there can be reasons to take these effects into account when designing an operational strategy for transport service operations. As the effects can be both positive and negative, the applied strategy can be aimed at stimulating or limiting the use of the service.

If the use of the service has important (net) positive effects, irrespectively of the type of user, a maximum throughput type of strategy with respect to the transport service will be applied, maybe supported by additional measures to boost the use. The strategy may lead to (and in fact aims at) a maximum, balanced, use of the available capacity.

If the use of the service results in important negative effects for society but infrastructure use is still important for some (specific) users, a kind of balanced-use strategy must be followed: it must be possible to use the service, but limits must be set to prevent an excessive use, not from the point of view of service-capacity, but from the point of view of societal capacity (see Visser, 1992 and De Wit and Van Gent, 1996). Because the non-intervention strategy does not result in an optimal allocation of scarce resources (Roth, 1996), alternative strategies must be applied. Depending on the exact societal demands, prioritised user groups may be defined and possibly user tariffs must be introduced. Alternative capacity assignment strategies, such as slot allocation, are feasible as well (Koolstra, 1998), and can also be beneficial for goods distribution.

25.7.2 Comparison

The main consequences of the different strategies with respect to the use of transport systems are displayed in Table 25-2.

Table 25-2: Comparison of operational strategies

Aspect↓	Non-intervention	Revenue man-agement	Maximised throughput	Optimised level of service[2]	Societal optimisation
Access[1]	***	*	**	**	**
	not limited	tolling & slot allocation	limited access	limited access	limited access
Capacity use	**	*	***	**	**
	congestion occurs	restricted access	max. intensies no congestion	restricted access	restricted access
Monetary return on invest-ment[3]	*	***	**	**	*/**
	congestion, low tariffs	differentiated high tariffs	low tariffs, but optimised use	differentiated high tariffs, restricted access	low tariffs? restricted access
Level of service	* / ***	***	**	***	**
	changeable: no reduced max. speed; conges-tion may occur	no congestion	no congestion reduced max speed	no congestion	no congestion

[1]	for average user	*	worst
[2]	slot allocation may be applicable	**	average
[3]	tolling assumed in all systems	***	best

The non-intervention strategy does not differentiate between types of users and provides free access to the sub-system. Congestion may occur, and this introduces some inefficiency in the use of available capacity. In the revenue-management strategy, users that are able to pay most (highest willingness to pay) are served first. The system-capacity may not be fully used. The maximum throughput strategy makes no distinction, but regulates the traffic inflow to prevent congestion.

In the strategy that optimises the service level, the most urgent demand (probably, but not necessarily the highest paying one) is processed with priority. To prevent a drop in the level of service, the incoming traffic flows may be limited to a level well below the capacity[28]. Societal optimisation can have different goals, but often some limitations in infrastructure-use will be applied. Then, capacity may not be fully used.

Note that in all strategies except non-intervention and possibly societal optimisation, congestion within the sub-system is banned. Nevertheless, outside the sub-system borders, at the entrances points or terminals, cues may occur. The guaranteed travel time or reliability (optimised level of service) and a maximum throughput can in some cases only be achieved by 'buffering' users at these entering points.

Note also that the different objectives may lead to different physical infrastructures.

---

[28] At capacity level, speeds are generally lower than in a free flow situation.

When there are no access limitations and a high service level is required, an extensive, dense, high quality network will be necessary. If restrictions apply, this may alter the market and, for example, may alter the geographical target area for the infrastructure (because different types of activities are not evenly spread). Where free accessible infrastructure aims at connecting cities and large industrial and logistic areas, a dedicated freight transport system may aim at optimising freight transport and has only to connect industrial and logistic centres. Furthermore, if restrictions in infrastructure accessibility apply, smaller[29] transport flows can be expected. This can result in a network design that consolidates flows rather than offers direct linkages. Therefore, the chosen strategies have an impact on the network design.

25.8   Conclusions

From the above we may conclude that new infrastructure developments can be expected in the fields of underground transport (links and nodes), of automated road transport (again links and nodes) and of rail transport (especially nodes).

In road transport, an evolutionary development from reserved lanes to reserved carriageways can be envisaged, applicable to main (trunk) lines. These reserved carriageways are in fact dedicated roads that can be used by special vehicles, for instance road trains or automated vehicles.

Within urban areas, free lanes for public transport (busses, taxis) can in some cases be made accessible for freight distribution activities as well, as long as there are no stringent capacity restrictions. Some pilot studies indicate that the application of light rail systems for goods transport is technologically feasible, although the practical and economical feasibility is not yet proven. Also, the inherent limited density, and thus service area, of these kinds of infrastructures must be taken into account. This implies that such subsystems can only be applied as part of an intermodal context.

Dedicated heavy rail infrastructures that are especially intended for urban distribution, will seldom be feasible. Only ready available dedicated (goods transport) rail infrastructures can efficiently be used for the trunk-line (long haul) segment of urban distribution processes.

Underground infrastructures, both links and networks, may pose new opportunities for efficiency improvements in urban distribution, again in an intermodal context. The heavy investments imply that applications will only be economically feasible in very dense areas. Socially feasible applications can also be found in severely hindered urban areas.

An additional function of infrastructure is external power supply that is used by most (urban) rail systems and can be applied in underground transport and dedicated road infrastructures. External power supply enables the use of electric driven vehicles without having to deal with carrying batteries, fuel cells or other electric power generating devices.

Other infrastructure provisions can be used to collect traffic information data and to distribute traffic information. These functions can help dynamic traffic management systems that streamline traffic flows, possibly exclusively optimised for urban freight transport.

---

[29]   Smaller flows than compare with freely accessible infrastructures.

26. Integrated goods transport systems

26.1 Introduction

The previous chapters introduced a wide variety of transport means, traffic means and line infrastructures, each with their specific advantages and disadvantages with respect to urban goods distribution. To maximise the efficiency of the (logistic) operations and to minimise negative external effects, we have to aim for an optimal use of the physical transport means. We must thereby account for the demands of the physical distribution processes and the preconditions set by the environment where the physical transport system must function. We will therefore link the findings of Part III with those of the previous chapters.

For direct distribution of full vehicle load shipments, unimodal road transport is the most appropriate physical transport system. Technological developments must help to reduce negative external effects as much as possible. In indirect distribution, multimodal transport can be applicable. By using multimodal transport concepts full advantage can be taken of use of the most appropriate (sub) modes in specific environments. The newly developed logistic concepts for urban distribution enable us to make full use of the multimodal concept.

Below, we propose urban physical transport systems for intra city transport and for transport outside urban areas. Furthermore, we give specific attention to intermodality.

26.2   Intra city transport

26.2.1 Introduction

As long as the logistic systems that concern urban distribution activities are organised along the more traditional lines, efficiency improvements for intra city transport must be based upon further technological developments of (existing) vehicle technologies.

In advanced logistic systems however, there is an opportunity to optimise the inner urban distribution systems separately from those functioning outside the cities. This may eventually result in an intermodal distribution system for urban goods distribution.

26.2.2 Developments in inner city road transport

For inner city goods distribution at surface level, special distribution trucks or vans should be developed. These vehicles must be versatile and highly manoeuvrable, must cause minimal emissions and noise and must be safe to operate. Ideally, electric drive should be applied, because these types of engines produce least (local) external effects. The power source of these electric propulsion systems can be either batteries, IC-engines (hybrids) or – in the future possibly – fuel cells.

Urban freight transport vehicles use common road infrastructures and share these infrastructures with other traffic. This is mostly other motorised (passenger) transport. Only in specific situations, goods vehicles are temporarily allowed in access-restricted areas such as pedestrian areas. Some ideas have been proposed to create dedicated infrastructure for freight vehicles on a permanent or on a temporal base. The latter means, that specific infrastructures can be assigned to freight traffic only during certain periods in a day. Other ideas include the joint use of free lanes for public transport (see: PSD, 2000), but especially in peak hours this poses serious operational problems. One can also think of dedicated infrastructure, such as special lanes for trucks. Adapted (light) trucks can provide automated transport on these dedicated infrastructures. For example, the Japanese have developed the Dual Mode Truck for this purpose (Koshi, 1992), while the Dutch have developed the CombiRoad concept (CTT, 1996). The advantage of these systems is that the vehicles can be both operated by a driver (in mixed traffic conditions) as well as unmanned (on dedicated exclusive infrastructures[30]) without the need for transhipments[31].

Ideas for dedicated underground systems have been developed in Japan (for instance the New Distribution System), in the USA (SubTrans), in the UK (Metro-Freight) and in The Netherlands (several cities, airport Schiphol). In most urban areas, an underground system would probably act as a local intermodal system - see also the next section).

---

[30]   As long as dedicated exclusive infrastructures are needed to operate automated systems.

[31]   Although for economical reasons, in CombiRoad a change of trucks is recommended.

26.2.3 Inner city underground transport

Underground freight transport is a potential alternative for short distance road transport in situations where combinations of accessibility problems, lack of space, and environmental problems occur, and some concentration of transport flows take place. The distribution of goods within urban areas is identified as a possible fields of application, in addition to some well defined 'point-to-point' relations (such as in the Schiphol Airport area between the airport, the flower auction Aalsmeer and a rail-terminal).

Both areas have in common that they deal with transport of general cargo, which are or can be transported in relative small volumes in standardised load-units, for instance on pallets or in roll cages. The Schiphol area is one of the first locations in The Netherlands where the use of a local underground freight transport system is studied. This Underground Logistic System Schiphol will probably be the test case for underground transport systems in the Netherlands (see Van Binsbergen & Visser, 2000).

Underground freight transport for urban areas concerns palletised or containerised consumer goods that are transported automatically through a new network of tunnels or tubes underground. Such an underground system has important societal benefits, for instance less nuisance, less energy consumption, less local air pollution and a more efficient use of space. Other benefits are fewer congestion problems at surface level, more reliable transport services, and reduced operational costs (if infrastructure costs are excluded).

On the other hand a new expensive infrastructure has to be built, often in dense build-up areas (see for an example Figure 26-1). Therefore, feasibility of such systems is questionable, unless the systems can be constructed as part of a urban reconstruction (redevelopment) project. Of course, such systems can also be realised in 'new towns'.
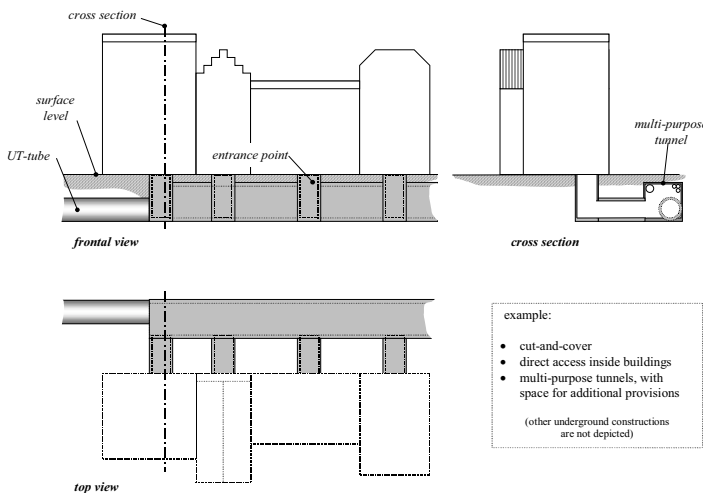

Figure 26-1:   Example of a direct-access section of the underground system

In the design phase of an underground goods distribution system, an optimal tunnel diameter must be determined. Given a fixed budget, a larger tunnel diameter results in coarse networks, while a small diameter results in a dense network (see also Section 25.4). The tunnel diameter

determines the (maximum) size of the transport means and therefore the maximum size of the used load-units. This influences the handling procedures, for example at the Local/Regional Transfer Point (see Figure 26-2).
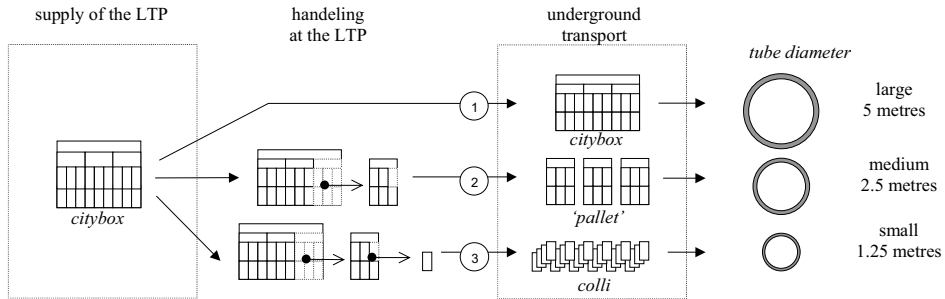

Figure 26-2: *Necessary types of handling on a Local Transfer Point (LTP) for an underground transport system with different tube diameters*

The underground network will not be able to serve all buildings (within the service are). Therefore, an underground distribution network in urban areas should include 'local terminals' from where goods can be further distributed at surface level. The distribution system that must perform the final distribution (delivery) task is not well-defined yet. Preferably, this system should be automated, to limit the operational costs. This is however no easy task because the systems should operate in mixed traffic conditions (at least there will be pedestrians around). This is one of the important issues has to be solved. For a part of the buildings (and in some specific cases, for all buildings), there will be direct-access terminals (see Figure 26-2). These terminals do not need additional (surface) distribution systems. See for some examples on underground goods distribution initiatives Visser & Van Binsbergen (1996) and Buck Consultants et al.(1999).

26.3   Transport outside urban areas

With respect to transport related to urban goods distribution activities outside urban areas, a distinction must be made in the origins of the goods. If these origins are nearby the destination area, there is almost no other choice than to use road transport. For longer-distance transport, other modes can be appropriate, especially if new logistic systems like *Network Logistics* are applied.

For traditional, short distance road transport, most attention must be given to further optimise the modes by introducing silent, less polluting and less fuel consuming engines. In notorious congestion areas, some specific infrastructure provisions (such as free lanes or carriage ways) can be appropriate. Access to Local Transfer Points (LTP, see also Part V, Chapter 30) must be provided to enable the use of City Logistics concepts. For longer distance transport, for example within the framework of *Network Logistics* (see Part III, Section 18.5) , revolutionary technological developments must be stimulated. This is necessary to make long-distance transport highly efficient (see also Section 21.4). Therefore, attention must be given to trans-

port automation and enlargement of scale, resulting in the development of automated road vehicles (like CombiRoad), and (automated) road trains. These new types of road transport can be seen as sub-modes of road transport.

The logistics concepts that include transfers at the fringes of the city stimulate intermodal transport and make rail transport a feasible alternative for long-haul road transport for urban goods distribution.

For real long-distance (international) transport, goods distribution by high-speed trains (TGV-Fret, ICE-Fracht) can ensure the international interconnection of logistic activity centres. There is, however, no direct link with urban distribution. As is explained in Section 23.3.3, urban freight distribution needs smaller scale railway transport, but shorter traditional trains would increase costs and limit infrastructure capacity. Therefore, specially designed trains must be used. Van Binsbergen and Visser (1997) describe a Dutch national rail distribution system (Rail Distribution in the Netherlands, RDN) that uses relative short trains to be loaded with standardised load-units. At Regional Transfer Points, these load-units can be transferred to road vehicles that perform the final stage of the urban distribution process. For these rail concepts, no fundamental technological changes in rail infrastructures are necessary. However, main developments must take place at interchange points (terminals and stations in case CombiTrains are used). In the future, further developed automated, higher speed train concepts, like the automated CargoSprinter, can be applied. For these automation developments, infrastructural changes with respect to the safety and the positioning system might be necessary.

Specially adapted or designed ships could possibly be used for specific transports that relate to urban distribution. For this goal, new or adapted inland waterway terminals will be necessary. However, there is no need for further adaptations to the inland waterway network.

Extra urban underground transport is attractive because traffic using these infrastructures will hardly be interrupted. Therefore, also at the interregional level, underground transport should be an attractive alternative. Thus far, no such underground systems exist: all infrastructures must yet be built, if such systems are regarded to be economically viable.

26.4   Intermodal goods transport for urban areas

Although for a long time road transport seemed to be almost omni-potent (as schematically depicted in the graph in Figure 26-3) and omnipresent, even road transport has its own, restricted or most appropriate field of application.
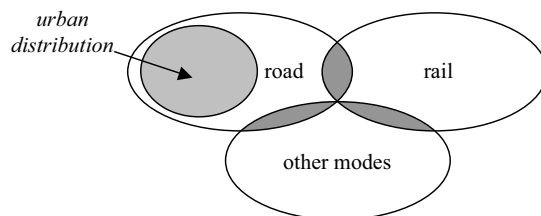

Figure 26-3:   *Unimodal view on urban distribution*

Increased congestion problems, and increased limitations to (large) road vehicle use in cities, have split the road transport mode into submodes such as urban appropriate (vans, small trucks) , and other vehicles (e.g. articulated trucks); see Figure 26-4.
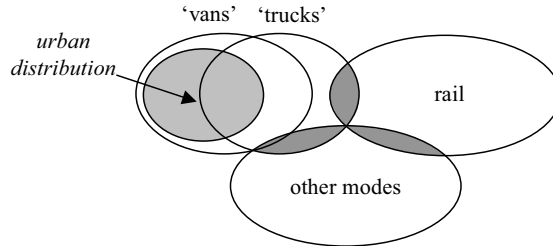

Figure 26-4:   Sub-modes in road transport

Adaptations on long-haul transport systems, new transport systems for urban areas, and new physical distribution concepts can only be applied if intermodal transport for urban distribution is introduced (see Figure 26-5).
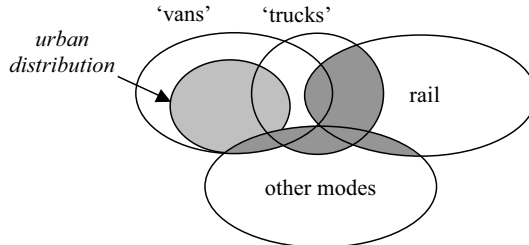
Figure 26-5:   Intermodal urban distribution

To reduce transhipment times and costs, automated transhipment systems are preferable. These automated systems can operate most efficient if standardised load-units are applied. The introduction of these units is therefore a very important prerequisite for efficient intermodal transport.

New transport modes, including underground transport, will become available in time and can even penetrate in urban areas, and will thus become an alternative for road distribution.
Intermodality asks for hierarchical intermodal networks where at the local level specific transport modes for urban distribution are used, and on the connecting trunk lines specific modes for line-haul transport (see Figure 26-6).

Figure 26-6: **Modes combined in an intermodal system**

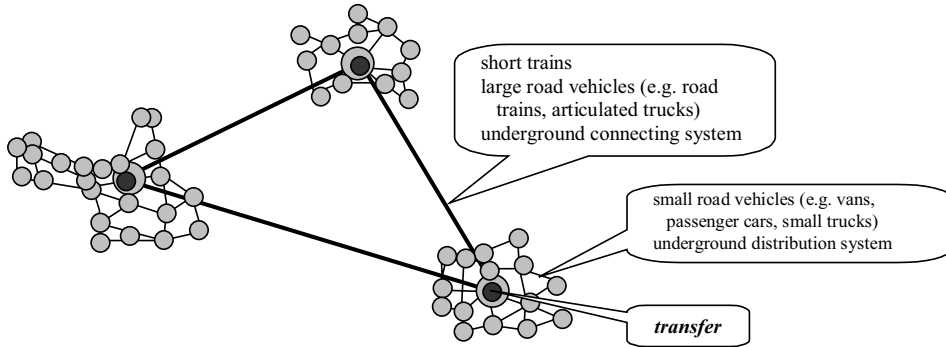Different transport modes have different characteristics that make them especially suitable for performing a certain transport task. This task can be expressed in distance, transport volume (weight and or cubic metres) and transport environment (notably needed infrastructure). The suitability depends on characteristics as maximum and operational speed, maximum load capacity, range, vehicle size and type of infrastructure use. Given the developments in road, rail and underground transport technology, the following modes (and sub-modes) should be distinguished (Table 26-1, states characteristics such as maximum speed, vehicle size, the type of infrastructure, and the typical field of application).

Table 26-1: **Modes and sub-modes for inland transport**

Mode	Submode	Main technological characteristics				Typical field of application*
		Speed (max)	Size (length)	Size (width)	Infra-structure	
		[km/h]	[m], net	[m]	[]	
Road	road trains	80	2 à 3 x 13.6	2.5	road [1]	I
	automated guided trucks	80-100	13.6 – 15.7	2.5	road [1]	I (U)
	articulated trucks	80-100	13.6 – 15.7	2.5	road	I (U)
	small trucks/large vans	80-100	ca. 10	1.8	road	I, U
	small (electric) vans	50-100	ca. 5	1.5	road	U
Rail	traditional container train	80-100	20 à 30 x 21,0	2.6	rail	I
	'Cargo Sprinter' train	80-160	3 à 5 x 21,0	2.6	rail	I
	automated wagons	80-100	21,0	2.6	rail	I
UT	large tube (4,8 m) vehicle	50-80	ca. 10	1,5	tube	I
	medium tube (2,4 m) veh.	30-50	ca. 2	1,5	tube	I/U
	small tube (1,2 m) vehicle	20-30	ca. 2	1,0	tube	U
*	I = inter city; U = urban (inner city)					
[1]	Separate, autonomous infrastructure might be necessary					
UT	Underground Transport					

To determine the typical use for the different modes, characteristics of modes must be fit the characteristics of transport demands.

Some of the mentioned transport modes differ in load-capacity. If large vehicles must be used in combination with small vehicles, consolidation (combining flows) or deconsolidation (splitting flows) must take place. Table 26-2 shows that (indeed) most transport modes operate effectively in a limited area only (see Brunn, 1991; CTT, 1996).

Table 26-2:   Modes and sub-modes for inland transport

Submode	Typical use
road trains	medium range, consolidation transport
automated guided trucks	short and medium range, consolidation point-to-point transport
articulated trucks	short and medium range, consolidation and distribution transport
small trucks/large vans	short and medium range transport *
small (*electric*) vans	short range, distribution transport *
traditional container train	medium and long range consolidation transport
'Cargo Sprinter' train	medium range consolidation transport
automated wagons	short and medium range, consolidation point-to-point transport
large tube (4,8 m) vehicle	medium range, point-to-point transport *
medium tube (2,4 m) vehicle	short and medium range, point-to-point transport *
small tube (1,2 m) vehicle	short range, restricted network transport *
- submodes printed in *italics* represent newly developed or future transport alternatives; - * denotes that transhipment is necessary, but that consolidation can be omitted.	

26.5   Conclusions

In this chapter, we used the building blocks of transport means, traffic means and infrastructures to develop physical urban distribution systems. Within urban areas, the primary focus lay on road transport. It is important to improve trucks that already perform optimised physical distribution services (direct distribution) but still cause high emissions, noise and danger. Adapted combustion engines and the use of advanced traffic control systems must help to limit the negative external effects of these vehicles. In specific circumstances, the vehicles may use dedicated lanes or carriageways or lanes that are also used by public transport means.

For indirect physical distribution schemes, such as City Logistics and Network Logistics, advanced urban distribution trucks must be developed that are versatile and cause the least hindrance. For these trucks, electric drive is the preferred propulsion system.

Light rail systems can, to a certain extent, be used for goods transport, although they do not provide door-to-door distribution. Underground goods transport is an alternative to surface urban distribution. Although underground systems cause the least external pollution and enhance efficiency, they are quite expensive and door-to-door distribution will only be feasible in a restricted number of cases. Underground links or networks can efficiently improve the distribution process in dense built-up areas.

For inter-city distribution on short distances, road transport will stay very important. Here also, improving existing technologies creates the best opportunities to decrease negative external effects. For long-haul transport, there are opportunities to significantly improve the

efficiency of road and rail transport and there are even opportunities to introduce new transport modes. The improved efficiency of existing modes relates especially to the enlargement of the scale of vehicles, the provision of dedicated (road) infrastructures and the introduction of new railway concepts such as CombiRail and CargoSprinter. The improved efficiency of new modes (underground transport and CombiRoad) is especially related to automation.

We conclude that most improvements can be only fully used if intermodal concepts are introduced. Intermodality requires swift and cheap transfers and therefore need load-units to operate efficiently. On the basis of our calculations, we have shown that the new combinations of systems may indeed improve efficiency and reduce external effects.

27. Summary and conclusions of Part IV

27.1   Efficiency improvement of goods distribution by transport systems

To achieve efficiency improvements in urban goods distribution, changes in the physical transport system are necessary, together with organisational changes.

Developments such as transport automation, the introduction of dedicated infrastructures and the use of advanced traffic control systems could induce higher transport efficiency. The transport quality could increase when transport times decrease and reliability rises.

Infrastructure and engine technology developments reduce the negative external effects of goods distribution. We have shown that the developments in transport means, traffic means and infrastructures can be used to their full extent if intermodal transport concepts are implemented. By introducing intermodality, inner urban goods distribution activities can (technically) be optimised separately from outside urban activities. Physical transfers of goods provide the physical links between the sub-systems, while load-units ease the transfer of goods between the modes. Optimised physical distribution schemes (as described in Part III) ensure a smooth logistics operation. In an intermodal concept, for inner urban distribution advanced (urban distribution) road vehicles can be operated that use the existing road infrastructure. In some specific cases, these road vehicles can also use dedicated public passenger transport links. For inner distribution, more advanced systems like automated underground transport could also be introduced. The inner urban distribution systems are linked with outside urban distribution systems by means of transfer points. Local Transfer Points (LTPs) accommodate local goods transport flows, Regional Transfer Points (RTPs) accommodate regional, interregional and even international goods transport flows (see also Part V, Chapter 30).

For extra-urban distribution activities, road transport will continue to play an important role. An increase in the carrying capacity and further improvements on engines make the road

transport system more efficient. In terms of long-haul transport, alternatives for road transport can be envisaged, including urban-distribution tuned railway systems, automated road transport systems, inland shipping and eventually automated underground transport systems.

It is clear that most of the proposed technological innovations can only be applied successfully, if advanced logistic systems support the use of these innovations.

27.2   Transport system management strategies and urban distribution

The newly developed transport systems that make use of dedicated infrastructures, are bound to be managed differently from traditional systems that use non-dedicated infrastructures. Focusing on the management of the infrastructure itself, we have shown that different (commercial) strategies result in significant potential differences in service quality and effective use. We have shown that some strategies might actually interfere with general policy objectives, and we also showed that different operating strategies may ask for different network designs.

27.3   Line infrastructures for urban distribution

For inner urban distribution processes, generally existing road infrastructures will be used. We have shown that the limitations of these infrastructures require and induce the development and use of dedicated vehicles.

Dedicated infrastructures so far used by public (passenger) transport, can under strict conditions also be used for urban goods distribution. This is especially true for road infrastructures (bus and taxi lanes), but also applies for light rail infrastructures (for CargoTram applications). Because space in urban areas is already scarce, we do not envisage the introduction of an extensive network of dedicated and exclusive urban goods distribution infrastructures at surface level. Underground transport infrastructures, however, are a possible alternative for surface distribution. Underground infrastructures are expensive, but could also pose important advantages over surface systems. Underground systems shield the environment from negative local external effects and enable undisturbed traffic flows that enhances efficiency and reliability. For extra-urban distribution, road transport will stay the most important mode, especially for short distance transport. However, for long haul transport, alternatives will become available. First of all, the existing rail infrastructure network can be used for urban distribution by operating dedicated short trains. To a lesser extent, (adapted) inland shipping may become appropriate. In the further future, dedicated goods transport systems may be developed. Alternatives include automated road transport (such as CombiRoad), railway transport or underground transport. The systems are not necessarily meant exclusively for urban goods distribution, but can certainly fulfil an important role in the long-haul segment of the urban distribution process. For the interchange of goods between the inner and extra-urban distribution systems, Local and Regional Transfer Points (LTP, RTP) must be introduced.

27.4   Traffic means for urban distribution

Developments on traffic means that contribute to higher efficiencies in urban distribution mainly relate to transport automation and propulsion technology. Transport automation should limit operational costs, because there is less need for drivers. Furthermore, automation enables continuous use of vehicles and implies greater reliability. In the near future, we expect that transport automation will only be feasible on dedicated infrastructures. In road transport, we can think of transport within secured areas (like distribution centres) or indeed at dedicated line-infrastructures. Automated Guided container carrying Vehicles and automated people movers are already commercially used, the CombiRoad and Dual Mode Truck concepts are in the experimental phase. For rail transport, automated locomotives are already in use on shunting yards and industrial areas, but the use can fairly easily (from a technological perspective) been extended to line-infrastructures. The CargoSprinter concept may eventually become an automated train system. Underground traffic means will also be automated.

Within the field of propulsion systems, first a further development in combustion engine technology is very important, because most urban goods distribution is and will continue to be performed by road vehicles. Advanced combustion engines will cause less noise and emissions and will use less fuel. Especially for inner urban road distribution and for transport on dedicated (underground) infrastructures, electric engines are a promising alternative. Vehicles that use electric engines produce (almost) no local emissions and only little noise. The drawbacks of electric driven vehicles relate to the voluminous and heavy power supply systems (batteries, fuel cells with fuel tanks, hybrid systems) or the dependency on external power supply systems (like overhead wires).

27.5   Transport means for urban distribution

Developments in transport means especially aim at tuning transport mode capacity to the specific demands of urban goods distribution.

In unimodal urban goods distribution by road, a compromise must be found between the vehicle limitations posed by the urban infrastructures at the one hand and scale efficiency on the long hauls at the other. Intermodal alternatives enable a (technologically) detached optimisation. Then, for inner urban transport, relative small transport means can be used while outside urban areas enlarged road vehicles become appropriate. This enlargement especially relates to road vehicle length.

For the railway and inland shipping modes, urban goods distribution asks for a decrease in scale (downscaling): traditional trains and inland vessels are often too large. In railway transport, downscaling of the transport means can be achieved by operating shorter trains, but this is only efficient if the *traffic* means can operate cheaply (for example by automation). An alternative is to combine passenger with goods transport within the same trains (CombiTrain).

Underground transport means can be compared with road or rail transport means, dependent on the technology used. An important difference lies in the maximum size of the cargo holds.

27.6   Load-units for urban distribution

Intermodal transport concepts show all the signs of being very appropriate in improving the efficiency of urban goods distribution. However, intermodality asks for transhipments that are normally expensive and time consuming, and introduce uncertainties in the logistics process. To overcome these disadvantages, transfers ideally should be automated.

Automated transfer processes work best with standardised units. Therefore, the introduction of standardised load-units for urban distribution would be welcome. We proposed a set of modular load-units that range from small collo-sized boxes to large swapbodies and continental containers. The modularity ensures a neat fit of most smaller units into larger ones. The small units are necessary to optimise processes within outlets and other destinations, the larger units make transhipment and transport procedures more efficient.

27.7   Application of concepts

In Part IV, we have used the layer scheme extensively to show the mutual relationships between load-units, transport means, traffic means and infrastructures, and also logistic (physical distribution) services. We have widely applied the concept of consolidation: to support the conception of a modular set of load-units, to comprehend the scale efficiencies of larger transport means and to understand the way infrastructure networks are formed. We have used the concept of intermodality to a large extent, because intermodality enables the (technologically) detached optimisation of transport processes inside and outside urban areas. The intermodality concept shows the importance of efficient transhipment processes (for which standardised load-units are essential).

27.8   Building blocks for 'spatial networks for urban goods distribution'

Part IV provides us with the technological building blocks for transport systems and especially for infrastructure networks. These infrastructure networks interlink urban areas and links these urban areas with concentration areas of (relevant) industrial activities and distribution activities. The line infrastructures that form the backbone (inter-city) networks can consist of (advanced) road, rail or even underground links, connected by transhipment nodes such as Local or Regional Transfer Points. The infrastructures that are needed require space: line infrastructures can be concentrated into corridors, transfer points should be embedded in logistic parks. Both spatial elements will be addressed in the following Part V.

References

AHSRA (1999), *Basic research for Automated Highway Systems requirements* (in Japanese), Tokyo (AHSRA).

AutoWeb (1998), Honda - The LEV Leader, in: *Autoweb/Automative news/Honda*, 15 October 1998, AutoWeb & Web Publications [http://www.autoweb.com.au/id_HON/ doc_hnd9810153/article.html].

Binsbergen, A.J. van, Th.J.H. Schoemaker & C.D. van Goeverden (1995a) *Ondergrondse transportmogelijkheden doorgrond, een systematische verkenning* (in Dutch), Delft/Den Haag (TRAIL Onderzoekschool/Projectbureau Integrale Verkeers- en Vervoerstudies)

Binsbergen A. van & J. Visser (1995b) Distributie in stedelijke gebieden ondergronds?, in: H.J. Meurs en E.J. Verroen (red.), 1995, *Colloquium Vervoersplanologisch Speurwerk - 1995 - Decentralisatie van beleid: implicaties voor kennis en onderzoek*, Delft (CVS), pp. 425-444.

Binsbergen A.J. van, A. Erkens, & B. Hamel (1994), *Long-term energy efficiency improvement for transport, technology assessment,* Delft (Delft University of Technology).

Binsbergen A.J. van, A.J. Klein Breteler, J.W. Konings, J. Rijsenbrij, J. Katgerman & D. Piebenga (1998), *Continental loading units for intermodal transport*, Schiedam (TRAIL/RUPS/CTT/ Ministry of Transport, Public Works and Water Management).

Binsbergen A.J. van, J.W. Konings & T. Klein Breteler (1999), Load Units for Urban Freight Distribution, in: E. Taniguchi and R.G. Thompson (eds.), *City Logistics I*, Kyoto (Institute for Systems Science Research).

Binsbergen A.J. van & Th.J.H. Schoemaker (1993a), *Morgen Bezorgen: goederen distributie in steden van morgen* (in Dutch), Delft, (Delft University of Technology).

Binsbergen A.J. van & Th.J.H. Schoemaker (1993b), *Grondvervoer op de rails* (in Dutch), Delft (Delft University of Technology).

Binsbergen A.J. van & Th.J.H. Schoemaker (1996), *Gedachtevorming rond Groene Heavy Duty Stroken netwerk* (in Dutch), Delft (Delft University of Technology).

Binsbergen, A.J. van & J.G.S.N. Visser (1997) *Ladingdragers en transporteenheden*, Delft (TRAIL Research School).

Binsbergen, A.J. van. (1999), New urban goods distribution systems, in: *Urban Transport Systems Conference*, Lund.

Binsbergen, A.J., van & J.G.S.N. Visser (2000) Kansrijke alternatieven voor intelligente en ondergronse logistieke systemen (ILS/OLS), Delft (TRAIL Onderzoekschool).

Blauwens G., P. De Baere, & E. Van de Voorde (1995), *Vervoerseconomie* (in Dutch), Antwerpen (MIM).

Boerkamps J.H.K., W. Brouwer & M. Overmulder (2000), *Stedelijke distributie Gelderland* (in Dutch), Amersfoort (DHV).

Boomers R. (1999) *CombiRailCar, een innovatief rijtuig voor gecombineerd personen- en goederenvervoer* (in Dutch), Delft (Delft University of Technology)

Borkens E. (1997), *Een goederenvervoercorridor in de stad - case Den Haag* (in Dutch), Delft (Delft University of Technology).

Bourgeois, G. (1988), *Le Guide de l'Entrepot*, Paris (Editions Nathan Communication).

Brouwer, W, Lierop, W.E. van, Erens, G.A.A., Carlebur, A.F.C. & Visser, J.G.S.N. (1997), *Buisleidingentransport voor stedelijk goederenvervoer*, deel A/B, DTO werkdocument M9/M10 (in Dutch), Delft (DTO).

Brunn, G.E. (1991), Cargo 2000 – Ein neues Behälter-Transportsystem für Teilladungen, in: *Die Bundesbahn 6/1991,* Darmstadt (Hestra).

Buck Consultants / TRAIL Onderzoekschool / RUPS Adviseurs (1999) *Gaat Leiden Ondergronds, hoofdrapport*, Rotterdam (RUPS Adviseurs).

Button, K. (1993) *Transport Economics*, Aldershot (Edward Elger).

Calspan (1994), *AHS Alternative Propulsion System Impact, Final Report,* Report number FHWA-RD-95-133, McLean, Virginia (Calspan Corporation Advanced Technology Center / Federal Highway Administration, U.S. Department of Transportation).

Clarke M. & D. Wright (1993), *Metro Freight, a new direction for transport*, Bedfordshire, (Cranfield School of Management).

Crainic, T.G. (1999) Long-haul freight transportation, in: R.W. Hall, *Handbook of transportation science*, Dordrecht (Kluwer).

CTT (1996), *Combi-Road Eindrapport* (in Dutch), CTT Publicatiereeks 12, , Krimpen a.d. IJssel (Centrum Transport Technologie/Projectbureau Combi-Road).

DB (1996a), *Project "Selbsttatiges Signalgeführtes Triebfahrzeug (SST)"*, München (Deutsche Bahn).

DB (1996b), *Der CargoSprinter, Flexibel, Schnell, Direkt*, (leaflet), , München (Deutsche Bahn).

DB (1996c), *Neue Technik, neue Konzeption: Der CargoSprinter*, DBAG news 07.10.96, (Deutsche Bahn Online).

Edelson, N.E. (1971), Congestion tolls under monopoly in: *The American Economic Review 61 (5),* American Economic Association, Princeton, pp. 872-882, cited in: Verhoef and Small (2000).

Green (1999), Britse regering kijkt naar invoering vrachtstroken (in Dutch), in*: Nieuwsblad Transport*, 9 maart 1999, Rotterdam (Transportuitgave), p. 5.

Groβmann G. & A. Schwertner (1996), Neue Umslagkonzepte für Laderaum- und Zeitgewinn, in: *VDI Berichte nr. 1274*, Düsseldorf (VDI-Verlag), pp. 121-136.

Heckler, W. (1977), *Der Einsatz von Stadtschnellbahnen für die Abwicklung des innerstädtischen Güterverkehrs*, Aachen (Fakultät für Bouwesen, TH Aachen).

Honda (1997), *Honda Develops Gasoline Engine with "Zero-Level Emissions"*, Honda Press News, October 20, (American Honda Motor Co.) [http://www.honda2000.com/news/press.html?y=1997&r=164].

Jaspers I.L.L. (2000), *Gecombineerd railvervoer van reizigers en goederen* (in Dutch), Delft, (Delft University of Technology/RUPS).

Koolstra K. (1998) Slottoedeling: het ontwerp van klasse-specifieke verkeersnetwerken. In: *Colloquium Vervoerplanologisch Speurwerk 1998: Sturen met structuren*, Deel 4 (in Dutch), Delft (CVS), pp. 1543–1562.

Koshi M. (1992), An automated underground tube network for urban goods transport, in *IATSS research 16, no2.,* Tokyo (IATSS), pp. 50-56.

Kreutzberger E. (1999), Train Coupling Sharing/Cargo Sprinter, in: Y.M. Bontekoning and E. Kreutzberger (eds.) *Concepts of new-generation terminal and terminal nodes*, Delft (TRAIL Research School), pp. 60-63.

Ludewig (1999), Aparte vrachtsporen tussen Duitse steden (in Dutch), in: *Nieuwsblad Transport*, 9 maart 1999, Rotterdam (Transportuitgave), p. 5.

Martinet C., N. Bourgis & J.P. Balensi (1999), *Étude sur réutilisation de la petite ceinture de Paris par un système ferroviaire léger*, rapport final, Paris (SYSTRA).

Minderhout, M.M. (1999), *Supported Driving: impacts on motorway traffic flow*, TRAIL Thesis SeriesT99/4, Delft (Delft University Press).

Mitsubishi (1998), Global standard Eco-engine, Mitsubishi Gasoline Direct Injection Engine, in: *Mitsubishi Automagic Technology*, (Mitsubishi Motors Corporation), February 1998 [http://web1.mitsubishi-motors.co.jp/GDI2000/].

NIPO (1997), *Trends Bezit en Gebruik van bestelauto's*, Amsterdam (NIPO).

NT (1998), Road Trains, in: *Nieuwsblad Transport*, 30 July 1998, Rotterdam (Transportuitgave), p. 3.

NT (1999), River Hopper, in: *Nieuwsblad Transport*, 23 November 1999, Rotterdam (Transportuitgave), p. 5.

Ooishi R. & E. Taniguchi (1999), Effects and profitability of constructing the new underground freight transport system, in: *City Logistics I*; ed.: E. Taniguchi and R.G. Thompson, Kyoto (Institute of Systems Science Research).

Pielage B.A. (2000), Design approach and prototyping of automated underground freight transportation systems in the Netherlands, in: *Underground Freight Transportation by Capsule Pipelines and Other Tube/Tunnel Systems*; ed.: P.H.L. Bovy et al., Delft (TRAIL Research School).

Post A. (2000), *Bouwstenen voor een Logistiek StadsPark* (in Dutch), Delft (Delft University of Technology).

PSD (2000), *Project Groningen, van stadsdistributie naar stedelijke distributie* (in Dutch); [http://www.psd-online.nl/start.htm].

Pusey P.S. & K Wreghitt (1970), *Modular/intermodal container parametric study*, Springfield (NTIS).

Railway Systems and Components (1995), Tokyo waterfront new transit, in: *Japanese Railway Information 65*, Tokyo (Japanese Railways, JR).

Road Bureau (1996), *New Freight Transport System, Transportation of people and freight on separate roadways*, Tokyo (Ministry of Construction Public Works/Japan Institute of Constructing Engineering/ Highway Industry Development Organisation).

Roggenkamp, M. & W. Rien (1995), Can trams carry cargo? New logistics for urban areas. In: *World Transport Policy and Practice*, Part 1/1995, Bradford (MCB University Press), p. 32.

Roth G. (1996), *Roads in a market economy,* Aldershot (Avebury); cited in: Runhaar (2000).

Runhaar, H. (2000), Efficient pricing in transport; the gap between theory and practice, in: *Proceedings NECTAR Conference 1999*, Delft (TRAIL Research School).

Rutten B.J.C.M. (1995), *On medium distance intermodal rail transport*, Delft (Delft University of Technology).

Schuttevaer (1998), Fulton Hemiksem bouwt drie schepen van Jowi-generatie, in: *Schuttevaer*, 4 September 1998, Deventer (Kluwer).

Sonntag, H. & Tullius, K. (1998), REFORM - Research on Freight Platforms and Freight Organization, (not published, see:) World Conference on Transport Research, Antwerp, 12-17 July*, Book of Abstracts*, Antwerp (WCTR), p. 88.

Smit, A. & P. Poppink (1999) Nieuwe emissienormen voor vrachtauto's eindelijk bekend, in: *Transport en Logistiek, nr. 48*, 2 December 1999, Zoetermeer (TLN), p. 13.

Verhoef E.T. & K.A. Small (2000), Product differentiation on roads; Second-best congestion pricing with heterogeneity under public and private ownership, in: *Proceedings NECTAR Conference 1999*, Delft. (TRAIL Research School).

Verkeerskunde (2000), Goederentram stadscentrum Dresden (in Dutch) in: *Verkeerskunde 6*, The Hague (ANWB), p. 8.

Visser, J.G.S.N. (1992) *Toltunnels in de Randstad*, Infrastructuur, Transport en Logistiek 16, Delft (Delftse Universitaire Pers).

Visser, J.G.S.N. & A.J. van Binsbergen (1997) Underground Networks for Freight Transport: A Dedicated Infrastructure for Intermodal Short-Distance Freight Transport, in: *3rd TRAIL Year Congress 1997 "Transport, Infrastructure and Logistics, New times and innovative solutions offered"*, 30 oktober 1997, Delft (TRAIL Research School).

Visser, J.G.S.N. & A.J. van Binsbergen, 1996, Ondergronds goederentransport: Fictie wordt werkelijkheid, in: A.M.T. Mouwen, N. Kalfs & B. Govers (red.) (1996) *Colloquium Vervoersplanologische Speurwerk - 1996 - Beheersbare Mobiliteit: een utopie?*, Delft (CVS), blz. 1251-1270.

Visser, J.G.S.N., A.J.M. Vermunt, & A.J. van Binsbergen (1998), *Ruimtelijke concepten ondergronds transport* (in Dutch), Delft/Hoeven (TRAIL Research School).

Wit J. de & H. van Gent (1996), *Economie en transport* (in Dutch), Utrecht (Lemma).

Yamada, H., S. Ueda, T. Kono, Y. Tanaka (1995?) *Development of the dual mode truck control technology for the new freight transport system*, Tokyo (Public Works Research Institute, Ministry of Construction).

Zürcher, V. (1999) *CargoSprinter Eckdaten: Zugseinheit mit 10 Container*, (leaflet) AD-tranz/ABB Daimler-Benz Transportation (Schweiz) AG.

PART V
Spatial networks for urban goods distribution

CONTENTS OF PART V

28. Introduction to spatial networks for urban goods distribution

28.1 Introduction

Part V focuses on the spatial conditions required to improve the efficiency of urban goods distribution. In Part V, 'Spatial networks for urban goods distribution', we will address the second research objective of the thesis:

> *Analyse and develop possible solutions for the problems related to urban goods distribution, and develop an integrated concept for an efficient goods distribution process for urban areas.*

The role of the spatial network is to create certain *spatial and infrastructural conditions for consolidation by co-operation and bundling of efforts* from private and public organisations in the field of urban goods distribution. The spatial and infrastructural conditions consist of the development of *logistic parks, as well as logistic sub-locations* and *corridors*. Logistic parks and logistic sublocations are the locations for concentrating regional and local transfer points. These locations must be well connected through adequate traffic networks (preferably multimodal), both to each other and to key (retail) destinations in the city centres; furthermore, locations must be bundled in corridors to maximise efficiency.

Logistic parks and corridors are the nodes and links of the spatial network for urban goods distribution. This concept supports economic, traffic and transport policy objectives of a national or regional nature, as well as environmental and spatial objectives.
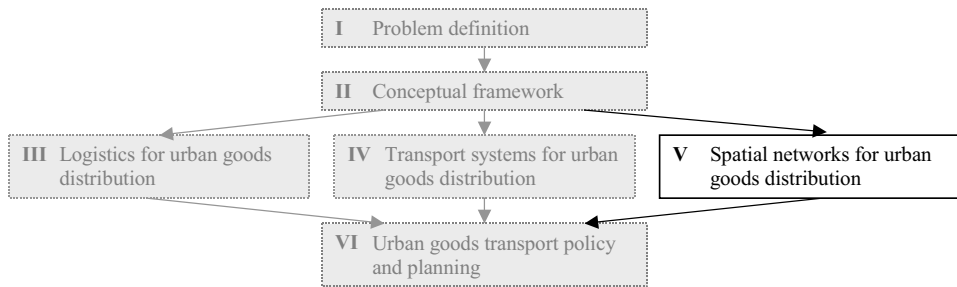
Figure 28-1: *Part V related to the other parts of the thesis*

Part IV dealt with the physical component of the urban distribution system and provided the elements that are required to physically implement the logistics concepts elaborated in Part III. The consolidation of flows and the full utilisation of the benefits of consolidation were the incentive for logistic networks and transport networks. The third element in network development, as outlined in the layer-scheme for urban goods distribution (see Part II), is the spatial network; it will be introduced in Part V. These three network concepts, at different levels in the layer scheme, are the building blocks for the policy-making process that will be developed in Part VI.

From this research objective, we derived, in Part I, the following research question:

> *Which conditions (infrastructural, spatial, and technological) could support the implementation of these logistical concepts?*

Part V formulates the spatial conditions for an efficient urban goods distribution system. The logistic concepts, as developed in Part III, use *local* or *regional transfer points* (LTPs; RTPs) near urban areas, in which transport flows are consolidated or de-consolidated for local collection and distribution and interregional or long distance transport and/or are transferred between transport modes. Spatial concentration of these transfer activities with other, relevant, logistic activities[1], promotes consolidation. The spatial aspects and the role of spatial planning in contributing to an efficient urban goods distribution system must therefore be understood. Based on theoretical notions, the contribution of the spatial planning options to the solution will be shown.

28.2   Contents of Part V

In Part V, we present a number of new insights and applications, which we specify below, and that we will then use to expand on, in spatial terms, the logistics concepts as introduced in Part III, and the physical components as introduced in Part IV.

---

[1]   Such as distribution centres operated by logistic service providers, suppliers or retailers.

Zoning is a spatial planning tool to concentrate economic and logistic activities as nodes within a spatial network
From an accessibility point of view, a zoning system can be set up for retail businesses that depend strongly on the accessibility for freight traffic. Within urban areas, there are large differences in accessibility between shopping areas. Regulation can be used to avoid mismatches between the level of accessibility that can be provided in an area and the demand for accessibility by the businesses in that area.

Logistic parks supports consolidation and the use of intermodal transport
The development of spatial concentrations of logistic activities is a major condition for consolidation of goods flows towards urban areas. A logistic park facilitates logistic and traffic-intensive activities by providing space and transport services. These transport services are provided on the basis of co-operation and outsourcing to consolidate goods flows.

Distri-regions
Distri-regions or distribution regions are geographic areas where freight traffic is optimised through the development of spatial concentrations of logistical and traffic-intensive activities. The location of these concentrations, called logistic parks, has to be planned on both a regional and national level.

Horizontal and vertical integration
The integration of logistic activities at logistic parks can occur through both horizontal and vertical integration. Horizontal integration concerns the movement and concentration of existing logistic activities to logistic parks. Horizontal integration is made possible by integrators, outsourcing to logistic service providers or urban distribution centre companies or by co-operation between transport companies. Vertical integration is based on the outsourcing of logistic activities to logistic service providers.

Network design
In network design, spatial demand patterns are coupled with geological conditions. The physical network shape depends strongly on consolidation/deconsolidation principles. In the functional network design, we deliberately introduce the design of an integrated (coherent) hierarchical network that consists of subnetworks especially fit to fulfil a dedicated task and that together can provide for the entire door-to-door goods distribution process.

Corridors
Combinations of infrastructure networks form multimodal corridors. Corridors can be defined at the international, national and at the local/regional level. Freight Corridors have a spatial dimension. The space is reserved for transport of freight. In order to provide different services, these corridors should be multimodal.

This chapter will show the interrelations between Part V and the other parts of the thesis. Chapter 29 will discuss two relevant aspects of spatial planning, namely zoning and corridors. Zoning is a major spatial planning tool, and concerns location planning. It can be used to

influence the location of logistic and commercial activities related to urban goods distribution. Corridors can be considered both from a location planning perspective and from an infrastructure perspective. Both aspects will be discussed.

Chapter 30 will focus on logistic parks as a location planning tool. Logistic parks already exist. They operate as nodes within a spatial network. A classification of types will be presented. Spatial concentration of logistic activities, such as storage and transhipment at a logistic park, contributes to efficiency improvement. This aspect will be discussed, and theoretical insights will be used as argumentation.

Chapter 31 will deal with corridors. Corridors are the spatial dimension of infrastructure networks that form the (spatial) links between the nodes, defined here as logistic parks. Aspects of network design will be discussed. For instance, different network configurations will be presented and the relevant aspects, such as consolidation and intermodality, will be considered. We make a distinction between corridors at a national level and at a local or regional level. Both levels will be discussed and applied to urban goods distribution.
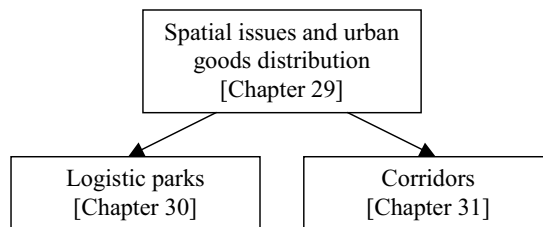
Figure 28-2: Structure of Part V: Spatial networks for urban goods distribution

28.3   Spatial networks for urban goods distribution

Figure 28-3 shows the primary services, roles and actors related to the spatial network for urban goods distribution. The spatial network for urban goods distribution consists of:
- Logistic parks and logistic sublocations;
- Interregional corridors;
- Local corridors.

These elements are the nodes and links of the spatial network. The layer scheme, as depicted in Figure 28-3 and in Figure 28-4, shows the typical position of these spatial elements within the layer scheme. The spatial location of the economic activities and the integrated logistic services determine the origins and destinations of the goods movement. Actors in their primary role as shipper, receiver or integrated service provider are the 'users' of the location. On the other side, providers, such as governments and some public/private organisations, provide the space for these activities. They provide and regulate the use of the available space.

PRIMARY SERVICES	PRIMARY ROLES	ACTORS

Economic Activities

Integrated Logistic Services → Shipper (Conseignor), Receiver (Conseignee) → producers, consumers, retailers

Load Unit Services → Integrated Service Providers → logistic service provider, integrators

Load Unit Operators → carriers
Load Unit Providers → container leasing companies

Transport (Means) Services → Transport means Operators → carriers
Transport means Providers → transport means leasing companies

Traffic (Means) Services → Vehicle (Traction) Operators → traction providers, carriers
Vehicle (Traction) Providers → traffic means leasing companies

Infrastructure Services → Infrastructure Operators → traffic managers & regulators (government)
Infrastructure Providers → infrastructure owners (private, government)

✱

Resource Management → Resource Managers → regulators (government)
Resource Providers → exploration/mining companies

✱   resources relate to all 'means'

Figure 28-3:   Primary services, roles and actors related to spatial networks

PRIMARY SERVICES	PRIMARY MEANS	DIMENSIONS

Economic Activities

Integrated Logistic Services ← Goods/Products → weight, mass [tonnes]; volume [m^3]

Load Unit Services ← Cargo → weight, mass [tonnes]; volume [m^3]

Transport (Means) Services ← Load Units (containers) → units [#]; unit-kilometres [km]

Transport Means (trailers, carriages, barges) → transport performance [tonnekm]

Traffic (Means) Services ← Traffic Means (trucks, locomotives, pushboats) → traffic performance [veh.km] trips, stops [#]

Infrastructure Services ← Infrastructure Means (roads, tracks, waterways, nodes) → traffic intensities [veh/hr]

✱

Resource Management ← Resources (space, energy, 'air') → space utilisation [m^2] emissions [kg], energy use [J]

tonne = metric tonne (1000 kg)

= number (no dimension)

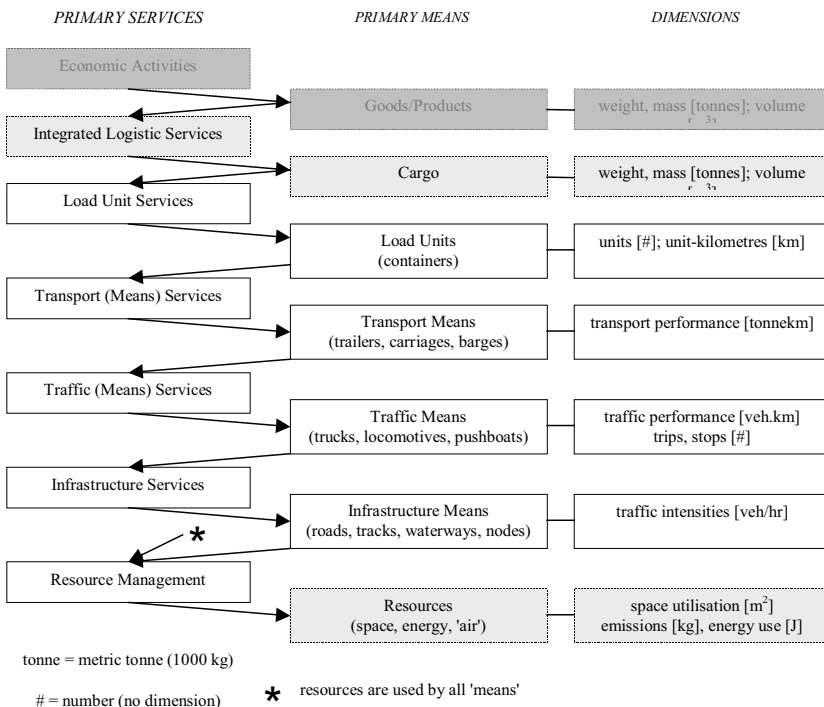✱   resources are used by all 'means'

Figure 28-4:   Primary services and means, related to spatial networks

29. Spatial issues and urban goods distribution

29.1 Introduction

The principal physical elements of advanced urban goods distribution concepts are terminals (*local or regional transfer points*) and dedicated infrastructures. These physical elements require space and also need to be located at the right location to enable an optimal operation. Therefore, land use planning considers the localisation of these facilities.

The facilities will perform even better when they are truly embedded in the physical context of goods distribution, as the physical proximity of the other distribution facilities eases co-operation. Therefore, the spatial planning should include the localisation of all these goods distribution related facilities.

In the Netherlands, a stringent land-use policy is applied, and this type of policy enables the creation of a well-structured spatial network of goods distribution facilities, including line infrastructures, terminals and associated facilities. The policies have been based on concepts such as the *spatial zoning* and the *ABC location policy*, and the *compact city* (explained below); in the future, they will be based upon the concepts of the *spatial corridor* and the *network city*. The resulting policy plans, many of which have been implemented, include:

- Urban renewal;
- Revitalisation of cities;
- Development of large shopping malls;
- Development of large-scale housing locations.

We will use and in some cases adapt these concepts for urban goods distribution process, and will elaborate on them in Chapters 30 and 31.

29.2 Spatial zoning and the compact city

29.2.1 Introduction
In the Netherlands, two important spatial planning concepts have been developed that fit very well with the concepts we developed for urban goods distribution: the *compact city*, and the *ABC location policy*. With help of these spatial planning concepts, we are able to concentrate goods distribution related activities with the aim of achieving synergistic effects, so that various goods distribution related activities support each other and can use shared facilities. The *ABC location policy* aims at placing the right activities at the right site (allocation), while the *compact city location policy* aims at concentrating activities so as to limit space utilisation. Although both policies were originally developed with the aim of reducing passenger traffic, these concepts can also be adapted for goods transport.

29.2.2 The ABC location concept
Spatial zoning is a well-known tool in land-use policy, used to physically and spatially separate conflicting activity types see (VROM, 1989; 1993). This is usually done to mitigate the negative external effects of activities, especially hazards, noise and other types of hindrance (e.g., the emissions of exhaust gasses of processing industries).

In addition to these zoning activities, in the Netherlands and some Scandinavian countries, spatial zoning concepts have been formulated and implemented on the basis of 'traffic attraction'. In the Netherlands, this resulted in the so-called 'ABC location policy' concept. In this concept, (urban) areas are classified using accessibility indicators. The original concept aims at passenger transport:

- A-locations are easily accessed by high-quality public transport and have only limited accessibility for passenger cars, including a restricted number of parking places;
- B-locations are easily accessed by both public transport and passenger cars, and
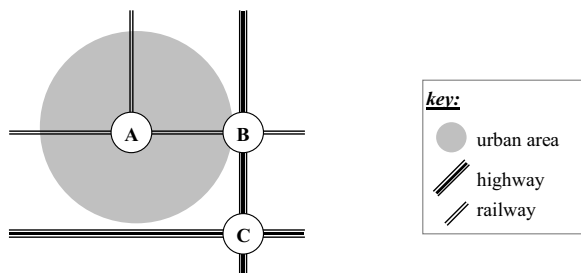- C-locations easily accessed by passenger cars, but not easily accessed by public transport.

Figure 29-1:   ABC-locations in an urban region

It became evident even in the first publications that this clear and straightforward categorisation has become somewhat diluted because additional features of an A-location were included: an A-location should be a high-quality inner city location as well.

The ABC categorisation is used to allocate different types of activities to specific locations:

- A-locations are reserved for high-density activities that generate a great deal of passenger traffic, such as large office buildings.
- B-locations are reserved for medium-density activities that still attract much passenger traffic (visitors as well as workers) such as shopping malls.
- C-locations are reserved for road-to-traffic oriented activities, such as production and distribution.

For goods transport, an analogous system could also be developed; intermodal accessibility may - in time - be of importance. The current ABC policy aims only at passenger transport, and locates all distribution activities at C-locations. The policy sets requirements for the accessibility for road transport, but does not set accessibility requirements for rail or inland waterways.

29.2.3 The Compact Cities

The concept of *compact cities* was based on the idea that cities, with a relatively small surface area and high density, could provide the necessary variety of urban functions (employment, shopping facilities, recreation, etc…) within or in close proximity to residential areas. The concept aimed especially at reducing the strong increase in passenger car traffic, and supported the notion that dense urban areas with a wide variety of activities are essential for society. Urban renewal and revitalisation projects were started to encourage both companies and residents to stay in, or return, to urban areas. This policy was introduced because employment and economic growth in larger cities were lower than the national average in the Netherlands, as in other countries. In an effort to remedy the situation, attempts were made at stimulating economic activities in these cities. This increase in economic activity in urban areas naturally leads to a higher demand for goods, and thus to more traffic.

On the other hand, the urban renewal policies in the Netherlands have significantly decreased the volume of goods traffic, in particular the heavy goods traffic in the urban areas. Unlike other countries, industrial activities within urban areas in the Netherlands have been reduced by an active outplacement policy of local authorities. These industrial activities have been moved to more accessible industrial locations at the edge of the urban areas. In practice, the concept of *compact cities* did not meet all the needs and desires of inhabitants and businesses; therefore, additional plans have been developed for housing, the retail sector, and goods traffic-intensive activities.

In order to keep up with population growth, as well as consumer demand for single-family dwellings, large-scale (VINEX) housing locations are under development. The development of these housing locations, in the period from 1995-2005, in and close to the city, will influence to a large extent the location where these consumers spend their income . It is possible that the development of these locations, each with their own shopping facilities, will lead to a further geographic spread of consumer spending, although the development of each VINEX location is supposed to support the compact city policy.

29.2.4 Spatial zoning for goods traffic-intensive activities

In Part IV, we introduced the concept of *local and regional transfer points* (LTP and RTP) that are used to transfer goods from the regional or national to the local goods transport

systems. To limit transport distances and to integrate these transfer points as well as possible within the logistics concepts of businesses, these transfer points should ideally be located near (main) distribution facilities of businesses. We therefore developed the concept of *logistic parks*, areas in which various goods distribution activities, including Local or Regional Transfer Points, are combined (see Chapter 30 for an elaboration).

The development of these logistic parks requires a spatial zoning policy for goods traffic-intensive businesses as well as for the retail industry. The opportunities of spatial zoning on a local or regional level for freight traffic-intensive businesses have already been discussed by RIGO (1995) and Heidemij (1994). Heidemij developed a simple zoning system for the optimal location of freight traffic intensive business establishments, but did not consider the benefits of spatial concentration of logistic activities. RIGO concludes that freight transport is not a major location factor, that companies are becoming increasingly footloose, and that the location factors vary greatly between companies. They are very reluctant to recommend government intervention and control in the location of companies, in particular because they fear a lack of success. RIGO, however, considers the problem mainly in terms of production. In our study, the spatial zoning issue is related to the location of transport-related activities, including distribution centres, transhipment centres, and retail establishments. Logistic parks cannot be developed when there is no policy for developing logistic parks, or at least for defining which criteria need to be fulfilled to develop logistic parks; furthermore, there is no active support for such a policy, and no active prevention to keep businesses from choosing the wrong locations.

One concept of logistic parks, named *distri-parks*, received local and regional policy attention in the nineteen-eighties (BRO Adviseurs, 1995). The focus of these distri-parks was mainly on international transport, and did not lead to a broad implementation, largely due to a lack of co-operation and high land prices at these locations. Although the price of land is still an issue, the situation has changed a great deal.

29.2.5 Spatial zoning for the retail industry

Although spatial zoning is already common practice in locating shopping facilities (see part I: shopping facilities), hardly any attention is paid to accessibility issues. There is little information available to regulate transport-intensive retail activities, such as supermarkets, in areas that are difficult to access. This is normally considered the entrepreneur's own responsibility. However, measures such as traffic calming zones and the new access regimes (see part II) that have been introduced in Amsterdam and other cities in the Netherlands, have decreased the accessibility of certain areas.

Guidelines already exist for shopping centres outside the inner city. For large-scale retailers such as home-furnishings, do-it-yourself retailers, and car retailers, specific legislation has been developed. Furthermore, specific regulation has also been developed for allowing large-scale *shopping mall* developments outside city centres, but within the large conurbations (to avoid solitary shopping malls). Slowly however, the concept of solitary shopping malls, supermarkets and factory outlets is also being introduced in the Netherlands (as already happened in France and Belgium).

29.3   Corridors and network cities

29.3.1 Introduction

In the follow-up to the ABC location policy, attention has shifted from urban areas to 'inter-urban areas'. These inter-urban areas should be used to locate less dense activities, and should also provide transport interconnections between the urban areas. Therefore, the *corridor* concept has been developed by the ministry of Economic Affairs and Transport, Public Works and Water Management. We will examine corridors both in terms of land-use policy and transport functionality. In the Netherlands, the concept of corridors can also refer to economic development axes (Ministerie van Economische Zaken, 1997). We will consider this a corridor from a unique land-use perspective.

29.3.2 Corridors from a land-use perspective

The *compact city* concept was, for a long period, one of the main components of spatial planning in the Netherlands. In due time, individual and commercial preferences showed that less-dense concentrations of activities could also be quite attractive. These lower-density activities cannot be placed within the compact cities, therefore, additional space should be found. In the 'Ruimpad' (broad-way) and 'Netherlands 2030' spatial studies, the spatial *corridor* concept is introduced. In this view, corridors are 'rectangular' areas, interconnecting dense urban areas, which supply space for less-dense activities such as housing, recreation, distribution, and light industry.
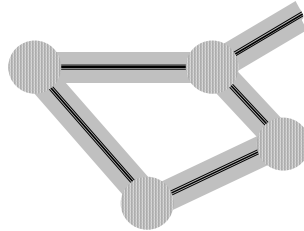
Figure 29-2: Corridor from 'land-use planning perspective': space around line-infrastructures

These corridors are defined on the basis of a central transport axis, usually highways and/or railroads. Different models have been developed to match the spatial structure of the corridor with the structure of these central axes (see Figure 29-3). All models locate the densest areas around the public transport (rail) axis; the lower density areas are directly accessible by road. These areas are also appropriate for urban logistics activities.

One major issue is the interconnection of road and rail transport, for both freight and passenger transport. In the 'alternating axes' model, intersections of the modes are explicitly introduced, creating opportunities for setting up intermodal facilities. Of course, such facilities can also be set up to accommodate intermodal urban goods transport.

Whatever the final model will be, there will always be conflicting claims with respect to locations: an intersection of highways and railways is highly attractive for various activities (offices, shopping malls, interchange points for passenger transport, and interchange points for goods transport) and these claims cannot easily be matched. Therefore, innovative

concepts must be developed to fulfil as many demands as possible, by taking into account both the local interests and regional and interregional interests that relate to intermodal transport.
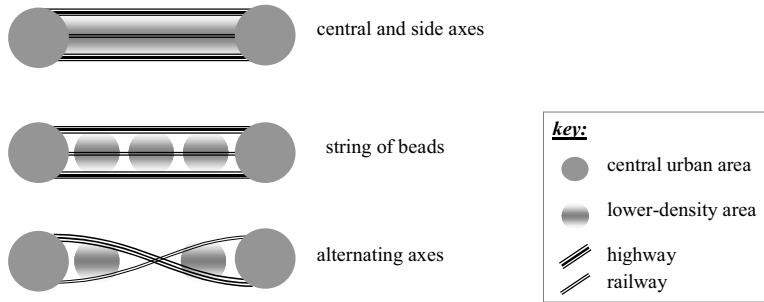
Figure 29-3:   Alternative models for corridors

29.3.3 Corridors from an infrastructural perspective

From an *instrumental*, or functional perspective, we can look to the transport function of the corridor. In relation to urban goods distribution, corridors hold the backbone network and therefore ensure the interconnection between the nodes (urban areas, distribution areas, production areas).
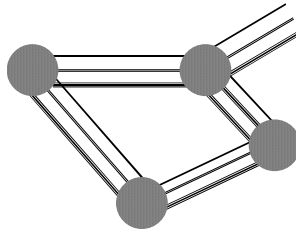
Figure 29-4:   Corridor from 'infrastructure perspective': bundle of infrastructures

From this perspective, only the function of the corridor is relevant. This function depends on the types of transport systems that are available and on the quality of these systems.

Corridors are usually multimodal: they bundle different transport options that enable the interrelations. The different modes can be used in parallel (competitive or complementary), sequentially, or as a combination; see Figure 29-5.
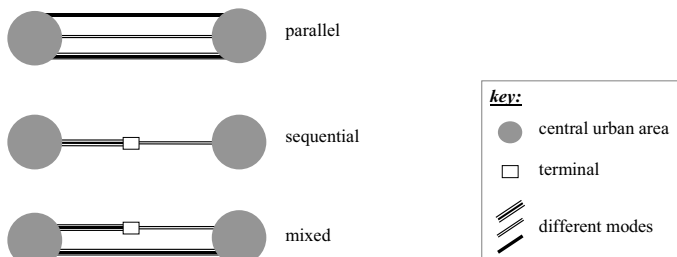
Figure 29-5:   Alternative combinations of transport modes within corridors

29.3.4 Network cities

As a further development, in the preparation for the forthcoming 'Fifth Spatial Planning Memorandum', the Dutch government has introduced the concept of *network cities* (VROM, 1999), an integration of the compact city and corridor approaches. In the network city concept, medium-sized urban areas are interconnected, and activity centres are distributed among them. One city may hold a large shopping area, another a major industrial area, and a third, the most important cultural activities. For urban distribution activities, this development will probably have no important consequences in comparison with current policy: important shopping areas will still be located in or very near city centres. In this concept, corridors are still required to connect the city with different transport systems. Corridors are, in this concept, the spatial reservations for the different infrastructures for goods transport and passenger transport. It concerns the land directly used by the required infrastructure, and future reservations; the zone is influenced by the infrastructure, and therefore has limited use for other purposes.

29.4   Conclusions

The spatial dimension of urban goods distribution consists of a spatial network built of nodes and links. The nodes are developed by spatial zoning, in this case the zoning of the retail industry as the destination of urban goods flows, and the zoning of freight traffic-intensive businesses and logistic activities at logistic parks. Corridors build up the spatial network by connecting these nodes. Corridors can be considered both from a land-use and an infrastructural perspective. The corridors can be multimodal, and thus can contain more than one infrastructure network. The bundling of infrastructure can be parallel, sequential or mixed. In the end, corridors relate both to spatial planning and to infrastructure planning.

30. Logistic parks

30.1 Introduction

Advanced urban distribution systems, as proposed in Part III and IV, function best within a larger system that connects different urban and industrial areas. Therefore, an interregional or national system must also be designed. The total area should be sub-divided into regions, or service areas of logistic parks, known as *distribution regions* or *distri--regions*. Each service area should consist of one main intermodal logistic park (comprising a *regional transfer point*, as defined in Part III) as well as several other intermodal or unimodal logistic parks to cover the rest of the region ('sub-location' logistic parks, each comprising a *local transfer point*, as defined in Part III). These logistic parks will form the nodes within the spatial network.

This section defines the concept of logistic parks and presents a classification of types. Two main categories will be defined: logistic parks and freight centres. The contribution of logistic parks to the efficiency improvement of urban goods distribution will be discussed in theoretical terms. Because logistic parks are developed by location planning, aspects of location planning will also be discussed. This section will also explain the role of logistic parks within logistic chains.

30.2 Logistic parks for urban goods distribution

The logistic concepts described earlier are based on regional transfer points near urban areas, in which transport flows are consolidated or split up for either local collection and distribution

or interregional and long distance transport, and/or are transferred from one mode to the other. These transfer points, called logistic parks, can be either private or public; but in either case, the spatial concentration of these activities promotes consolidation. By concentrating businesses, co-operation and outsourcing in the areas of transport and logistics will be promoted. Co-operation and outsourcing is the basis for consolidation of transport loads. Concentration will also support the development of special transport facilities, such as facilities for intermodal transport.

The concept of logistic parks is based on existing, or soon to be developed, industrial areas; they can be part of a larger area with mixed industries, or may have to be developed from scratch. The location for logistic parks has to be selected carefully in order to have access both to interregional infrastructure and to urban areas. They have to be the right size in order to be efficiently used, to limit competition with other locations, and to guarantee a proper level of service in each part of the urban area.

A *logistic park* is an area of specialised industries in a distribution region that fosters both logistical and traffic-intensive activities, while also serving as the transfer point for regional collection and distribution. Public and private transfer points (defined in Part III) are located there. It serves as a collection area for logistical activities such as storage, sorting, and redistribution. These activities are concentrated around one or more transfer points of different transport modalities. Because the location of these activities coincides with the transhipment site for intermodal transport in the logistic parks, there is no longer a need for an extra link in the logistical intermodal chain anymore.

These logistic parks are attractive locations with facilities for transport companies, distribution centres, warehouses (of wholesale or retail organisations or import companies), trade centres, auction houses, post distribution centres, and *value added logistics* (VAL) activities. Logistic parks also offer opportunities for the location of pick-up centres for certain resale concepts.

A logistic park is part of a nation-wide network of logistic parks that are connected by different modalities. This nation-wide network is thus better equipped for flexible time patterns (off-peak use of the road network, night transport, etc…), changing demands for transport, and providing different transport services, than it would be without multimodal connections.

Besides a logistic park, a region may also contain *logistic sub-locations*. A logistic sub-location is comparable to a logistic park, but is subordinate to a logistic park, rather than autonomous, and runs on a smaller scale. Logistic sub-locations may be required due to the size of a region, or because of an advantage of location. Thus, there is no optimal location for one logistic park. Both logistic parks and logistic sub-locations have two functions:

- to *facilitate* logistic and traffic-intensive activities by providing space and transport services;
- to *support* bundling and consolidation of streams of goods by the development of certain (collective) transport services.

Through the concentration of volumes, the bundling of efforts and the spatial concentration of logistical and transport generating activities offers the possibility of using modalities other than road transport for short-distance freight traffic. At the logistic parks, collective and private transport services can be set up. These transport services concern the following:

- City logistics or urban distribution, (the collection and distribution of goods within the urban area).
- Regional logistics (the collection and distribution of goods within the region).
- Interregional or international transport services by rail, road or inland shipping.
- Reverse logistics(the collection and consolidated disposal of waste).

These services may be supported by information and communication systems.

In certain cases, the service areas of logistic parks will overlap in the border areas. Such an overlap will be required in order to provide a proper service in the border areas.

Some of the logistic parks will also be connected to the Trans-European Networks (TEN) and/or be a part of the network of European transport centres (Europlatforms EEIG).

The concept of logistic parks has been already developed in other countries, for a number of different purposes. Section 30.3 shows a classification of logistic parks and freight centres[2], and describes what we can learn from logistic parks elsewhere. We will then deal with the following aspects:

- The number of logistic parks in the Netherlands. This must be determined by maximising the level of use and maximising the quality level of service.
- The location of logistic parks within a national network, based on connections and transport system performance.
- The location of logistic parks within a given region. Relevant aspects include: access to interregional transport networks, and location in relation to service (*consumers*) areas.
- The layout of logistic parks, including factors such as size, facilities and local issues.

30.3   Freight centres and logistic parks

The development of freight centres and logistic parks is the outgrowth of national policies regarding freight transport. The term *freight centres* is used here as a generic name for public or private transhipment terminals, and *logistic parks* for spatial concentrations of distribution or other transport-related activities with a terminal facility for transhipment. The original concept of a freight centre referred to a terminal building for transhipment activities, or a transfer point between long-distance and short-distance transport, (such as a regional transfer point, as discussed in Part III). A logistic park is a spatial concentration of transfer points (such as a distribution centre and home base for third-party logistic service providers). The reasons for developing freight centres and logistic parks are twofold: to facilitate logistic activities with location, space and transport facilities, and to consolidate goods flows by developing particular transport services. Freight centres and logistic parks come in different forms and under different names, such as Freight Villages, Güterverkehrszentren (GVZ), Tradeports, Interporti, Platformes Logistique, Distribution Business Areas, or logistic centres. Windborne International Group (1994) uses the following definition for freight centres, which is also applicable to logistic parks:

---

[2]   Freight centres are a concept that is, to some extent, comparable with logistic parks.

Freight centres form intersections of at least two different transport modes at which independent companies from the distribution sector and other transport-intensive business (e.g. component manufacturers) are located in a designated area.

The aim is to enhance co-operation between transport modes and to improve the supply of distribution services in a region. A freight centre also implies an organisational element, in that individual forms co-operate or share the use of on-site facilities (for example through information systems) and may therefore benefit from significant synergetic effects. Freight centres are intended to improve urban goods traffic, to boost the regional economy and to enhance international trade.

The definition suggests that freight centres are inherently multimodal. Many freight centres are only transfer points between long-distance and short-distance road transport. Long-distance and short distance road transport can, for this purpose, go together with different transport modes.

Table 30-1: *Classification of freight centres and logistic parks (Source: Sonntag and Tullius, 1998; adapted by authors)*

	Terminal development: freight centres			Area development: logistic parks			
	Private terminal		Public terminal	Transport oriented	Transport + other	Industrial + some transport	Port related
	Forwarder DC	Transport company DC	Urban consolidation terminal	Freight Village	Industrial and logistic park	Business Grouping Developments	Special logistic area
Transport modes	Road-road Road-rail	Road-road Road-rail	Road-road	Road-road Road-rail-(barge)	Road-road Road-rail	Road-road	Road-sea/air Road-rail-sea/air
Main aims	Optimisation logistic operation	Optimisation transport operation	Traffic reduction in cities	Modal shift and urban traffic reduction	Regional economic growth and modal shift	Revitalising small- and medium-sized businesses	Regional economic growth
Operator (typically)	Large forwarder, retailer or transport company	Transport company	Transport company and an authority	Operating company (public influence)	local government and/or private company	Development by local government and transfer to private businesses	Airport or harbour authorities
Company structure	Large forwarder or retailer or company	Huge transport company or co-operating companies	Local transport company or co-operating companies	Mostly small companies	Large industrial companies and transport companies	Wholesalers and transport companies	International oriented companies
Land use	Small areas in urban areas or in the outskirts	Small areas in urban areas or in the outskirts	Small areas in urban areas or in the outskirts	Large areas in the outskirts of urban areas	Large areas in the outskirts or at old industrial areas	Large areas in the outskirts of urban area	Near airports and harbours
Orientation	Urban area	Urban area	Urban area	Urban and regional	Regional and international	Urban area and regional	International

Note: There are many different types and many different names. This is an attempt to classify and to name them.

Types of freight centres

In the REFORM project (Sonntag and Tullius, 1998), a classification of freight centres has been suggested. Table 30-1 is based on that classification, with some adjustments. The main function of the terminal-type freight centre is the distribution of freight from long-distance trucks to small city delivery trucks. Freight centres can be divided into two types: private

terminals, operated by a forwarder or transport company, and public terminals. In the case of a public terminal, its service is open to other transport companies.

Types of logistic parks

Logistic parks are based on area development and can have a different orientation. For this reason, logistic parks are divided into four types; transport oriented, transport + other, industrial + some transport, and port related.

- *Transport oriented logistic parks*, also called 'freight villages', have a transhipment terminal. A freight village is defined as an area within which all activities relating to transport, logistics and the distribution of goods, both for national and international transit are carried out by various operators. Service providers are established on site. A freight village is preferably served by a multiplicity of transport modes (road, rail, inland waterway, air), including open-access transhipment facilities. Freight villages are found in Germany and Italy, where they are known as Güterverkehrszentren, and Interporti respectively. In Europe, there are about 45 freight villages, according to Europlatform, the European interest group of freight villages. Although the focus is on the national and international transit of goods, they are relevant for city logistics purposes.
- *Industrial and logistic parks* not only fulfil transport functions but are also industrial and service areas.
- *Business grouping developments* are primarily set up to group businesses. When in such areas also grouping of transhipment, storage and transport activities occur, they operate like a freight centre.
- *Special logistic areas,* such as cargo centres and seaports, provide an interface for additional transport modes.

The public sector plays a major role in the development, but in some cases, also acts in the operation of these freight centres and logistic parks. In some countries, it is a regional authority or the private sector that set up freight centres or logistic parks.

30.4   Contribution to efficiency improvement

30.4.1 Introduction

Logistic parks contribute in different ways to the reduction of the problems mentioned in Part I. First, the concentration of goods distribution related activities can reduce vehicle movements, and thus mileage, because depot and route consolidation will become much easier. Secondly, the use of intermodal transport, especially the use of modes such as rail and waterway links, and sub-modes such as large road vehicles, will be stimulated, thus reducing congestion on roadways. Reduction in vehicle movements by depot and route consolidation

The main reason for promoting logistic parks is that by concentrating businesses, co-operation and outsourcing in the areas of transport and logistics will be promoted. Co-operation and outsourcing is the basis for consolidation of goods flows. Concentration will also support the development of special transport facilities, such as facilities for intermodal transport. Consolidation thus leads to greater efficiency. The contribution of concentration, or the clustering of transfer points at logistic parks, to efficiency improvement is explained by RIGO

(1995) with an example. We have changed this example somewhat, so that it fits within this context.

Example of alternative urban goods distribution schemes (RIGO, 1995)
Suppose that two transport companies decide to work together in city logistics. In this hypothetical situation, transport company P distributes the shipments with its own truck to four receivers (A to D). One round trip occurs daily, from the distribution centre to these customers. Transport company Q does the same, but to receivers B to E. P and Q decide to start an independent city logistics company, R.

There are two alternative situations. In the first situation, company P and Q are located at different locations. Company R has to pick up the shipments at both distribution centres before they can be distributed to the receivers. In the second situation, company P and Q are located at a logistic park. In this second situation, the city logistic company R and transport companies P and Q will be close to each other. In this example, it can easily be demonstrated that the consolidation of goods with city logistics will lead to an efficiency improvement. The example also will show that in the second situation, the efficiency improves even more than in the first situation.

| original situation | alternative 1 | alternative 2 |
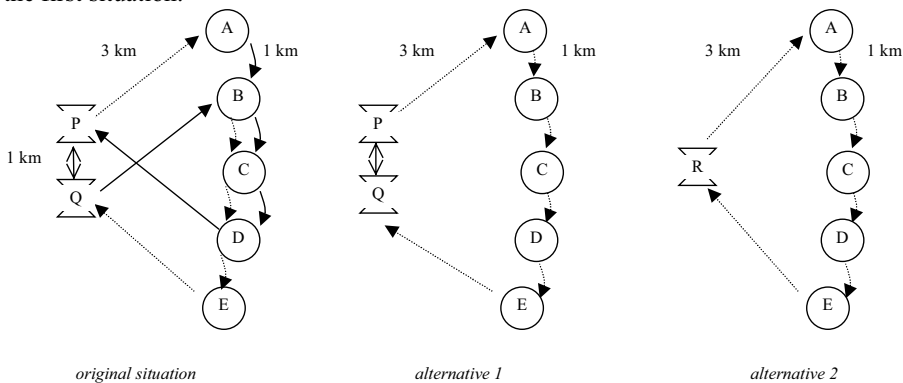
Figure 30-1:   *Example of alternative urban goods distribution schemes (Source: RIGO (1995), adapted by the authors)*

P and Q are located 1 kilometre from each other. The average distance between A, B, C, D and E is about 1 kilometre. The average distance between the distribution centres P and Q and the first address is about 3 kilometres; also, the average distance between the distribution centres and their last addressee is 3 kilometres. The length of a round trip for distributor P is 3+1+1+1+3=9 kilometres, which is also the trip length for distributor Q. Together, this makes 18 kilometres.

In alternative situation 1: City logistics company R starts at the distribution centre Q, collects the goods and then distributes them. The roundtrip is 1+3+1+1+1+1+1+3=12 kilometres.

In alternative situation 2: Companies P and Q are located at the same place. In that case, the roundtrip is 3+1+1+1+1+1+3=11 kilometres.

Table 30-2:   ***The reduction of vehicle kilometres with consolidation and a joint location at a logistic park***

	Starting situation	*Alternative One*	*Alternative Two*
Trip Length	9 km	12 km	11 km
Number of Trips	2	1	1
Total Vehicle Kilometres	18 km	12 km	11 km

Further examination of this example shows that the savings on vehicle kilometres depend very much on the average distance to the destinations and the distance between the distribution centres. The number of destinations that both transport companies have in common in order to combine shipments is also relevant. However, even if they do not have destinations in common, savings in vehicle kilometres will occur because the average distance between destinations will decrease. This can also be illustrated with an example.

We assume a rectangular region S with the size of A_S square kilometres and N destinations. In such situation, the average distance d between destinations can be calculated:

$$A_s = d^2 N \Leftrightarrow \sqrt{A_s} = d\sqrt{N} \Leftrightarrow d = \frac{\sqrt{A_s}}{\sqrt{N}} \qquad\qquad \textbf{(30-1)}$$

With:
  A_S = size of the region in square kilometres
  d = average distance between destinations in kilometres
  N = number of destinations

It is obvious that the average distance between destinations depends on the square root of the total number of destinations. In a situation similar to the current situation, as described above, but with joint destinations, the average distance is a factor $\sqrt{2}$ smaller than in a single trip.

30.4.2 Stimulating intermodal transport
The concentration of logistical and transport generating activities will also support the development of special transport facilities, such as facilities for intermodal transport.

As described in Part IV, the total costs of an intermodal door-to-door transport alternative $\hat{G}$ (using M 'sub-modes) as perceived by actor a (taking into account the weighting set $\hat{K}$, although this symbol is omitted in the expressions) can be expressed as follows:

$$Z_{\hat{G}}^a = Z_{(load,1)}^a + \sum_{m=1}^{M}\left(Z_{(transport,m)}^a + Z_{(transfer,[m,m+1])}^a\right) + Z_{(unload,M)}^a \qquad \textbf{(30-2)}$$

Under the condition:
  $Z_{(transfer,[m,m+1])}^a = 0$ for $m=M$

And with:
  $Z_{(transport,m)}^a = Z_{(transportmeans,m)}^a + Z_{(trafficmeans,m)}^a + Z_{(inframeans,m)}^a$

Intermodal transport is most attractive if the costs for this alternative ($Z_{intermodal}^a$) are lower than the costs of the unimodal alternative ($Z_{unimodal}^a$).

Thus: if $Z_{unimodal}^{a} \geq Z_{intermodal}^{a}$, intermodal transport is attractive.

In intermodal transport, the transfer costs ($Z_{(transfer,[m,m+1])}^{a}$) play a major role.

Through concentration near multimodal transfer points, transfer activities in themselves can be made more efficient through efficiencies of scale and by avoiding unnecessary prehaulage and endhaulage. Furthermore, by concentrating various logistic activities, part of the transfer activities already occur. For example: a transfer requires goods being unloaded from one (sub) mode and being loaded onto another. If other logistic activities performed on the goods already require an unloading of goods, the costs of this activity are distributed.

This can also make a difference for longer moves; such as transport moves within the Randstad or transport moves between the Randstad and the border regions of the Netherlands. As we will explain below, intermodal transport is generally more attractive when transport distances increase (see section 30.5.2). For this reason, in certain distri-regions, both multimodal logistic parks and road-based sub-location logistic parks will be required. Within each region, it must be considered if one or more side-location logistic parks will need to be added to the multimodal logistic park. These sub-locations will probably be not multimodal, but rather, will act as an intermediary between interregional road transport and local or regional distribution. The number of sub-locations depends upon the number and spread of urban areas, industrial areas, and logistic centres in a region, and the available infrastructure network.

30.5   Transport volume via logistic parks

30.5.1 Introduction

This section presents a theoretical framework for a more thorough investigation of the size of the service areas of logistic parks. The size of a service area is a key factor in determining the number of logistic parks and sub-locations within a region. Therefore, we must consider the transfer points at a logistic park as intermodal terminals. The service area for a transfer point should meet two criteria: the maximum size of a service area, and the minimum size of a region, based on the minimum potential volume of freight, which is required to operate the intermodal facilities commercially.

30.5.2 The service area of a logistic park

The theory behind applying the location-allocation model to determine the number of intermodal terminals is already described by Maat (1997) and Van Binsbergen and Visser (1997). We will refer to this literature. The theoretical aspects of determining the size of the service areas of terminals require further clarification. The assumption, as used in the location-allocation model by Maat (1997), that the size of the catchment areas should be less than 50 kilometres, is arbitrary. The actual size should be based on a cost (with cost-critical goods) and/or time (with time-critical goods) comparison between intermodal transport and direct delivery. There is a simple rule of thumb method that can be used in this.

As noted in Part IV (sections 21.4 and 21.5) and section 30.4.2, the costs for unimodal and multimodal transports, can be expressed as follows in the expressions 30-3 and 30-4, respectively (using the example of Figure 30-2):
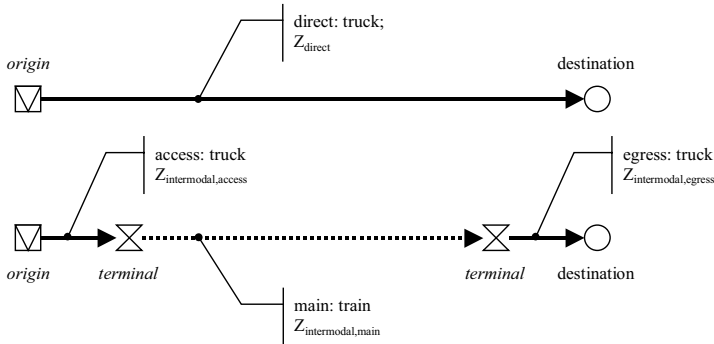

Figure 30-2:   Example: comparison direct (unimodal) and intermodal transport

Here, for direct (unimodal) transport, the costs are:

$$Z_{direct}^{a} = Z_{(load,road)}^{a} + Z_{(transport,road)}^{a} + Z_{(unload,road)}^{a} \qquad\qquad (30\text{-}3)$$

And for the intermodal alternative:

$$Z_{intermodal}^{a} = Z_{(load,access.road)}^{a} + Z_{(transport,access.road)}^{a} + Z_{(transfer,[acccess.road,train])}^{a} +$$

$$+ Z_{(transport,main.train)}^{a} + Z_{(transfer,[train,egress.road])}^{a} +$$

$$+ Z_{(transport,egress.road)}^{a} + Z_{(unload,egress.road)}^{a} \qquad\qquad (30\text{-}4)$$

As is also explained in Part IV (section 21.5), $Z_{transport,m}^{a}$ relates to a variety of cost factors: $Z_{transport,m}^{a} = f(d,t,l,p,q)$. Transport distance d is one of them.

Thus, for the first leg of the intermodal chain ($Z_{(transport,access.road)}^{a}$; access transport) distance also plays a role. If the distance of this transport from the origin to the (first) terminal T is r, then: $Z_{(transport,access.road)}^{a} = f(r,\cdots)$.

We define the border b of the service area S of a terminal as the distance from that terminal, at which the costs of direct delivery ('unimodal') are equal to the costs with intermodal transport. Therefore, by definition:

$$b = r \quad \text{if} \quad Z_{unimodal}^{a} = Z_{intermodal}^{a}$$

Now, we will show that this distance b is dependent of the quality and the length of the main transport leg (backbone) of the intermodal alternative. We use the example, shown in Figure 30-2.

If we take the direct transport alternative as the reference, we can interpret the value $Z^a_{unimodal}$ as being a 'budget': intermodal transport is most[3] attractive if $Z^a_{unimodal} \geq Z^a_{intermodal}$.

Now we introduce a constant value $Z^a_{constant}$ so that:

$$Z^a_{constant} \stackrel{def}{=} Z^a_{unimodal} - Z^a_{intermodal}$$

When the loading and transfer costs can be considered independent from the transport distance d, we can add these costs to a new constant value $Z^a_{constant.new}$:

$$Z^a_{constant.new} = Z^a_{constant} + Z^a_{(load,unimodal.road)} + Z^a_{(unload,unimodal.road)}$$
$$- (Z^a_{(load,access.road)} + Z^a_{(transfer,[access.road,train])} + Z^a_{(transfer,[train,egress.road])} + Z^a_{(unload,egress.road)})$$

Then:

$$Z^a_{constant.new} \geq Z^a_{(transport,unimodal.road)} - (Z^a_{(transport,access.road)} + Z^a_{(transport,egress.road)} + Z^a_{(transport,train)})$$

Or:

$$Z^a_{constant.new} \geq \left(Z^a_{(transport,unimodal.road)} - Z^a_{(transport,train)} \right) - \left(Z^a_{(transport,access.road)} + Z^a_{(transport,egress.road)} \right)$$

If we assume that $Z^a_{constant.new}$ is indeed constant, we can see that if we can manage to increase the cost difference between $Z^a_{(transport,unimodal.road)}$ and $Z^a_{(transport,train)}$ the access and egress costs may also increase. This is the usual case for longer distances. As explained in Part II (section 9.5.6) and Part IV (section 21.5), intermodal transport is more attractive at longer overall transport distances, as long as $Z^a_{road.unimodal} >> Z^a_{(transport,train)}$. Therefore, long-distance intermodal transport must have larger services areas than short-distance intermodal transport, because of $Z^a_{(transport,access.road)} = f(r, \cdots)$ and $Z^a_{(transport,egress.road)} = f(r, \cdots)$, where r represents the distance to the terminal.

This also implies that with 'cheaper' transport at the main link, longer access and egress distances are feasible. Therefore, 'cheap' main link transport results in larger service areas.

This simple formula shows that the size of the service area is strongly related to the costs of the intermodal main transport, and thus to the main transport distance. This simple formula shows that the size of the service area is strongly related to the costs of the intermodal main transport, and thus to the main transport distance. This indicates a correlation between the size of service area and the transport distance for logistic parks; short-distance logistic parks, such as local transfer points, serve a much smaller area than long-distance ones, such as intermodal freight terminals.

We may also conclude that the use of more cost-efficient transport systems in an intermodal system allows for larger service areas[4].

---

[3]   Because not all choice criteria are deterministic, so even if $Z^a_{unimodal} > Z^a_{intermodal}$, some actors will prefer unimodal transport.

[4]   We have used a neutral formalisation Z for the total weighted costs, as perceived by an actor. Cost-efficiency can, therefore, be defined in terms of financial costs, time costs, or social costs.

30.5.3 The potential transport volume via a logistic park

Intermodal facilities can only be viable if they attract sufficient transport volumes to enable the use of efficient transhipment (and other) equipment. Thus, in practice the intermodal facilities at a logistic park require a critical mass of transport flows in order to be financially profitable. This requires a minimum size of service area for a logistic park. If this minimum size exceeds the upper limit for the service area of intermodal logistic parks, then the intermodal facilities at the logistic park will not be feasible.

The following example shows how the minimum size of a service area can be determined when the critical volume of an intermodal terminal is given. The following constraint must be satisfied:

$$V_{critical} < V_{T_c} \qquad\qquad\qquad\qquad (30\text{-}5)$$

With:

$V_{critical}$ = Critical mass in terms of volume (tonnes or cubic metres per year)

V_{T_c} = Potential volume for an intermodal terminal (tonnes or cubic metres per year)

The potential volume V_{T_c} can now be determined, when we are able to determined how many businesses are located within the service area and how many potential transported volume, they generate.

Let us assume a circular service area around an intermodal terminal T with a given business density $\vartheta_{N,S}(x)$, in which x is the distance from the central terminal.

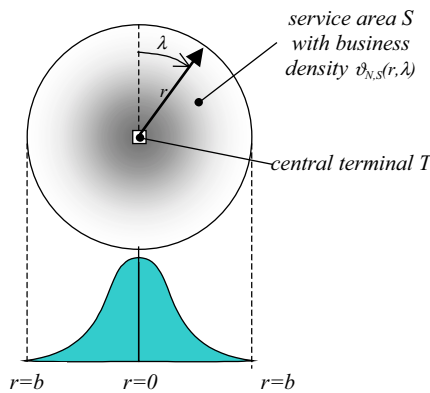Figure 30-3:   *Service area S with a business density $\vartheta_{N,S}(r,\lambda)$.*

The number of businesses N within a region with border $r=b$ is calculated with the following formula:

$$N_S = \int\limits_0^b \int\limits_0^{2\pi} \vartheta_{N,S}(r,\lambda)\,drd\lambda \qquad\qquad\qquad\qquad (30\text{-}6)$$

With

N_S =   number of business in the circular service area S;

$\vartheta_{N,S}(r,\lambda)$ =   density of business in service area S as a function of the distance r

                               from the centre of the service area (for a terminal T) and with angle λ;

   b =   border of the service area as measured from the centre with $0 \le r \le b$

Now, for the volume of transported goods to the region we assume:

$$V_{S,T} = \overline{v}_{N,T} \bullet N_s = \overline{v}_{N,T} \bullet \int_0^b \int_0^{2\pi} \vartheta_{N,S}(r,\lambda)dxd\lambda \qquad\qquad \textbf{\textit{(30-7)}}$$

$V_{S,T}$ =   volume of transported goods in service area S per time period T;

$\overline{v}_{N,T}$ =   average volume of transported goods per business per time period T;

With this formula, we are able to calculate the potential volume, as required to determine the minimum size of a service area. There are, however, a few complications. If we assume a constant density of businesses ($\varphi_{N,S}(r,\lambda)=\varphi$), then the number of businesses can increase rapidly by enlarging the service area (r). However, it is questionable whether it is possible to maintain a constant average volume of transported goods per business. We can also assume that the potential volume is related to the distance to the terminal. In that case, the probability that goods are transported intermodally decreases when businesses are more remote from the terminal. To elaborate, we provide the following example:

Above, the border b of the service area S is defined. This border has a certain practical value, because it indicates the size of the service area. If all cost components are really included in the Z_G^a functions, all goods within the service area would be shipped via the modality that uses terminal T, while all goods outside that area would be shipped via alternative modes. In practice, there will not be such an 'all-or-nothing' situation: the relative quality (or costs) of the alternative modes will have an impact on the mode choice, but will not be able to fully describe the choice processes of all relevant actors.

Therefore, we introduce a 'probability': $\mathrm{P}_{T_G} = f\left(Z_G \middle| Z_1 \cdots Z_{G'}\right)$

This is the probability that goods will be transported using a given logistic park (or terminal T_G). This probability depends on the relative quality of the transport system G that uses the specific terminal, compared with the transport quality of all other alternative transport systems G', from the perspective of *all* actors.

Thus the volume of transported goods that would be shipped by terminal T becomes:

$$V_{T_G} = \mathrm{P}_{T_G} * V_s$$

If we, for instance, apply the 'logit' choice formulation, this would result in:

$$V_{T_G} = \left(e^{Z_g} \middle/ \sum_{i=1}^{G'} e^{Zi}\right) * V_s \qquad\qquad \textbf{\textit{(30-8)}}$$

Note that both $V_{S,T} = f(r,\cdots)$ and $Z_G = f(r,\ldots)$.

When the distance to the terminal increases, the probability that goods shipped via the modality that uses terminal T decreases. Therefore, larger service areas do not, necessarily lead to a greater potential volume.

A more fruitful approach is to concentrate businesses near a terminal at a logistic park. If the density is constant [$\varphi_{N,S}(r,\lambda)=\varphi$] then it is easily to demonstrate with this formula that, for instance only 1 percent of the freight volume will be within 1/10th of the distance to the border of the service area and only 25 percent within 50 percent of the distance to the border. Applying these formulas will show that increasing the density of businesses near a terminal will increase the potential volume for intermodal transport. The Freight Village 2000 study (1998) demonstrated this with figures.

The theoretical argumentation presented above proves that:

- The number of businesses increases with the distance to a logistic park (considering a circular area with a fixed density),
- The probability that goods will be transported using a given logistic park decreases with the distance to that park;

The combination of both factors leads to the conclusion that the concentration of businesses near transfer points, such as intermodal terminals, is necessary to generate enough potential volume for intermodal transport to make intermodal concepts competitive.

30.5.4 Conclusions

This section presented a theoretical framework for an investigation of the size of the service areas of logistic parks. The size of a service area is critical to determining the number of logistic parks within a region. Therefore, we have considered the transfer points at a logistic park as intermodal terminals. A service area should meet two criteria: the maximum and minimum size of a service area.

The first criterion, the maximum size of a service area, depends upon the differences (in transport quality and cost) between the unimodal road transport mode and the main transport mode of the intermodal concept. This indicates a correlation between the size of service area and the transport distance for logistic parks; short-distance logistic parks, such as local transfer points, serve a much smaller area than long-distance ones, such as intermodal freight terminals.

The second criterion is the minimum size of a service area, based on the minimum potential volume of freight required to operate the intermodal facilities commercially. If this minimum size exceeds the upper limit for the service area of intermodal logistic parks, then the intermodal facilities at the logistic park will not be feasible.

In this section, both constraints have been operationalised through the use of mathematical formulae, and can be used to determine the size of the service areas. With this information, it is possible to determine the number of logistic parks and logistic sub-locations.

We have also concluded that the concentration of businesses near transfer points, such as intermodal terminals, is necessary to generate enough potential volume for intermodal transport to make intermodal concepts competitive.

30.6   Location planning

30.6.1 Introduction

In recent projects (see Visser and Van Binsbergen, 1998), attention has been paid to network design and the location of related logistic parks. The location of logistic parks must be carefully determined. While geographical and environmental conditions are important, the geographical aspects of production and consumption are also key to the characteristics of the interregional and regional networks and transport systems.

30.6.2 Location planning and distribution regions

Advanced urban distribution systems (as proposed in Parts III, Chapter 18 and IV, Chapter 26), function best within a larger system that connects different urban and industrial areas. Therefore, an interregional or national[5] system must be designed. The total area should be sub-divided into regions, or service areas of logistic parks, also called *distribution regions* or *distri-regions*. Each service area will consist of one main intermodal logistic park (comprising a *regional transfer point*) and several other intermodal or unimodal logistic parks, that is, *sub-location* logistic parks (each comprising a *local transfer point*) to cover the rest of the region. We include the definition of *distri-region* as follows:

> A geographic area where freight traffic is optimised through the development
> of spatial concentrations of logistical and traffic-intensive activities. A
> distribution region contains the area where locations for these concentrations
> (also known as logistic parks) may be found. The objective is to develop a
> functional nation-wide division into regions.

In a study for the interdepartmental project-team Underground Transport (IPOT) network (see Visser, Vermunt and Van Binsbergen, 1998), in which designs are made for a combined intermodal-underground freight transport system, the concept of logistic parks has been applied to the Dutch situation. The selection of the location of the logistic parks was based upon two criteria:

- The most important locations of existing distribution centres in the Netherlands.
- The key location for regional distribution near large urban areas.

The location and number of main intermodal logistic parks, and thus the number of distri-regions, is determined by applying a location-allocation model using the rail network as the national backbone network, and road for collection and distribution transport (see Maat, 1997).

The task of determining the number of intermodal logistic parks required and then selecting the right locations, is crucial for an efficient operation. There are two opposing forces that influence the optimal number of intermodal logistic parks. On the one hand, cost control calls for minimising the number of intermodal terminal facilities. The investment outlays and operating costs are inversely proportionate to the number of terminals. On the other hand, the optimal service provision and the reduction of pre- and endhaulage by road call for maximising the number of terminals.

---

[5]   National in case of a small country as, for instance, the Netherlands.

The task is thus to determine the optimal number of intermodal terminals and their optimal locations. At the same time, certain principles should be taken into account, as used in the study by Maat (1997):

- An optimal balance should be found between minimising the number of terminals, minimising the amount of kilometres driven in road transport, and maximising the number of users to be served.
- The service areas, served by the terminals, should together cover the entire country.
- The prospective sites for the terminals should be tied to the locations of existing terminals and stations.
- The service radius of a terminal is limited to 50 km.

The methodological aspects are elaborated by Van Binsbergen and Visser (1997) for rail-to-transport and by Taniguchi et al. (1999) and Castro et al. (1999) for road transport. For the Dutch situation, the concept of logistic parks is worked out in more detail (see Visser and Van Binsbergen, 1998).

For the Netherlands' situation, Maat (1997) shows that with 10 logistic parks with multimodal terminals (RTPs) 91 percent of the Netherlands is covered. Each time a terminal is added, the coverage increases by a mere one percent at most. With 14 multimodal logistic parks, one can attain complete coverage (see also Figure 30-4).

Each addition of an extra terminal results in a roughly five percent decrease in traffic performance (kilometres). This percentage declines after 16 terminals, at which point the addition of terminals more is no longer acceptable. With 16 to 17 terminals, one hundred percent of the demand is covered by the logistic parks. This figure was used to define the distri-regions for the Netherlands (see also Visser and Van Binsbergen, 1998).

The assumption that the terminals are tied to the locations of existing rail terminals and railway stations was made in order to let the algorithm work. It is likely that in certain regions, new intermodal terminals would be required.
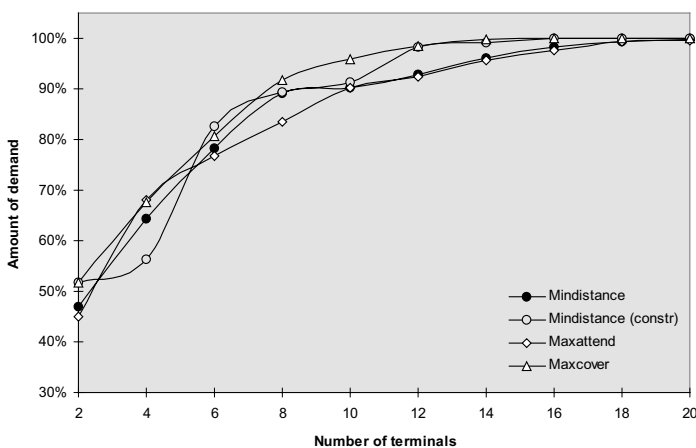

Figure 30-4:   *Assigned demand as a function of the number of terminals with four types of location-allocation models (Source: Maat, 1997)*

Table 30-3 shows the regions covered by the intermodal logistic parks. Each region is named after the main urban area in that region. The intermodal logistic parks form a network of logistic parks. Three levels, based on the development of the network, can be defined. The first level contains the regions Amsterdam, Den Bosch, Rotterdam and Zwolle. These regions are the most important ones from a goods distribution perspective. Level two, or phase two is based on making the network more densely. Level three contains the logistic parks that are required for full coverage of the Netherlands. The regions are also depicted in Figure 30-5.

Figure 30-5: *The Netherlands sub-divided in seventeen areas for intermodal logistic parks (source: Visser and Van Binsbergen, not published).*

Table 30-3: *Hierarchical network of intermodal logistic parks*

First level	Second level	Third level	Other possible locations*	
Amsterdam	Arnhem/	Alkmaar	Amersfoort	Hoorn
Den Bosch	Nijmegen	Apeldoorn	Assen	Roermond
Rotterdam	Breda	Groningen	Den Helder	Roosendaal
Zwolle	Eindhoven	Leeuwarden	Doetinchem	Tiel
	Haaglanden	Maastricht/Heerlen	Drachten	Uden
	Utrecht	Middelburg/	Emmen	Venlo
		Vlissingen	Gouda	Weert
		Tilburg	Heerenveen	Winschoten
		Twente	Hoogeveen	
*	locations as mentioned by NEA/INRO-TNO (1989)			

NEA/INRO-TNO (1989) studied this aspect from an urban distribution centre point of view. They considered three different configurations (with 17, 24 or 34 centres). The study considered a network of distribution centres between which freight is transported by road.

30.6.3 Location planning from a network perspective

The location of the logistic parks should be optimal for the interregional/national network, and the location should make a sufficiently high level of collection and/or distribution services possible in each part of the urban service area, as required. Both optimisations may lead to different locations. With respect to the *backbone network* the logistic park location should be situated as close to the infrastructure corridor of the backbone network as possible, and if possible near one or more of the nodes within that network ('C' in Figure 30-6). The optimal location with respect to the *service area* is normally the centre of that area ('A' in Figure 30-6), and if that is not feasible for land-use planning reasons, as near to that area as possible ('B' in Figure 30-6). Therefore, a compromise must be reached. The best possible location will be found as an optimum between the following factors:

- Extra costs, both fixed and variable, of a detour-connection from the backbone network;
- Extra costs of the connection to the service area;
- Differences in land price and land-use planning requirements;
- Environmental costs of the location;
- Extra operational costs of transport.

Location planning is a typical example of a planning issue where both private and public dimensions are at stake, and where different actors, with different preferences, each play a role.
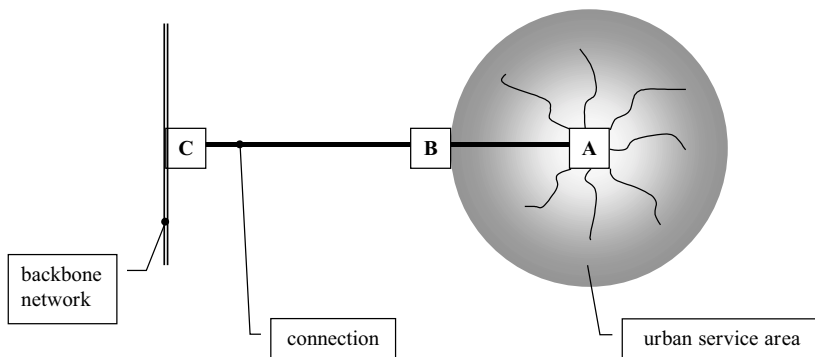

Figure 30-6:   Locations for a logistic park

The alternative locations in Figure 30-6 can be characterised as follows:

- Location A is an example of an optimal location in terms of city logistics when not considering land price costs and environmental costs.
- Location B is an optimal location in terms of city logistics when land price costs and environmental costs are also considered.
- Location C is an optimal location in terms of the backbone network.

In the case of the Dutch urban distribution concept when shipments are consolidated in an urban distribution centre, the optimal location was found in location B (Visser 1992). With new transport and transhipment technology, such as underground logistic systems, it also might be worth developing both location C and location A, and then interconnecting them, for instance by underground transport, as suggested in the study of OLS Leiden (Buck Consultants et al., 1999).

The type 'C' logistic park requires a location that complies with the following requirements, in no particular order:

- Connected to the highway system or (to be realised) backbone road network for freight.
- Connected to the (freight) railway network.
- Connected to the inland waterways network.
- A concentration of transport-intensive industries or the possibility of same.
- Spatial expansion possibilities.
- If possible connected to the Trans-European Networks (TENs).

The preferred starting point for a logistic park is an existing industrial area that is already connected to the national road, rail and/or water network. Potential locations will have to be selected. It is also likely that new locations will still have to be developed.

These intermodal logistic parks include *regional transfer points*. These transfer points connect inner city physical transport systems with transport systems that transport goods outside the urban areas. The long-haul transport systems use centralised, regional transfer points within a fairly large service area. This ensures a sufficient consolidation of transport flows and also ensures a sufficient transport quality (because the total number of transfer points is limited, the operational speeds can be high). RTPs will be intermodal centres because at the trunk lines next to road transport (that interconnect the RTPs), alternative transport modes will be used.

There will be more urban concentrations than regional transfer points because too great a density of these RTPs will reduce the effectiveness of the network. Therefore, some urban concentrations will not be directly served by a RTP, and thus local freight traffic will not be able to efficiently use such a centre. In addition to this, for large urban concentrations served by a (single) RTP, the centre will always be peculiar to the service area (it is, after all, preferably located at the frames of the urban area). Therefore, additional local transfer points, located at logistic sub-locations (see section 30.2), are necessary. These LTPs can be part of the type 'B' logistic parks, in the direct vicinity of the urban areas. These parks will require:

- A connection to the regional or local (main) road network;
- A concentration of transport-intensive industries.
- Spatial expansion possibilities, possibly limited.

LTPs can be either unimodal (road-to-road transfer) or intermodal (road-to-underground system) centres.

Figure 30-7 presents a sketch of an integrated system of one RTP and two LTPs for a large urban area.
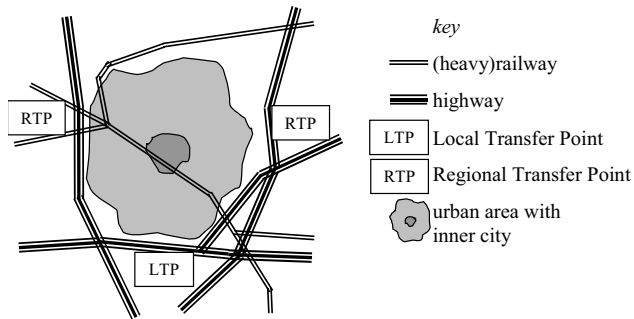
Figure 30-7:   *Regional Transfer Point (RTP) with additional Local Transfer Points (LTP) in a large urban area*

30.7   Logistic activities on a logistic park

30.7.1 Introduction

Outsourcing and specialisation in the field of logistics led to new concepts of warehousing and logistic centres in the 1980s/early 1990s. The development of European distribution centres is one example. The trend in these years was up-scaling of logistic activities which led to an increase of the average distance between final destination and distribution centre. Logistic parks are based on the integration of logistic activities near consumer areas, for instance for the purpose of forward storaging. Forward storaging means bringing the storage closer to the consumer.

It is possible to integrate several logistic activities into one location (i.e., by of outsourcing to a third-party logistic service provider – a.k.a., vertical integration). Freight centres, such as the urban distribution centre, are one example. It is also possible to move existing distribution activities to regional locations for distribution activities (horizontal integration). This means that only the geographic location of the distribution centres changes. Both strategies benefit from the fact that no extra handling activities are introduced in the logistic chain when shifting to intermodal transport, and thus, no extra costs are generated. Both strategies could lead to consolidation on the condition that co-operation, outsourcing and specialisation in certain logistic services occur.
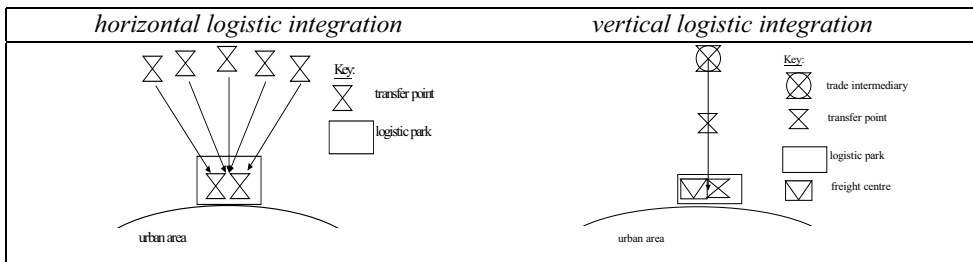

Figure 30-8:   *Development of a transfer point by logistic integration*

The principal logistic activity at a logistic park is the transhipment of goods. In the study of underground freight transport in urban areas, the following types of distribution concepts are defined. The logistic activities are different and thus, so are the facilities required.

Table 30-4:   ***Transport flows through a logistic park per distribution concept (Source:*** ***Brouwer, 1997a and 1997b)***

	incoming flows	*reverse flows*
cross-docking	dedicated packages: medicine deliveries parcel post delivery non-food retail	disposable packing
direct distribution	fresh products household products with a high throughput	garbage
rolling stock	beverage deep freeze products canned food small household products	glass paper textile metals and plastics

Moving existing distribution activities to these regional locations will support the use of intermodal transport, but it can also lead to horizontal or vertical integration of logistic activities.

30.7.2 Horizontal integration at a logistic park

Horizontal integration can occur by:
- An integrator;
- Outsourcing to a logistic service provider or urban distribution centre company;
- Co-operation between transport companies, e.g., city logistics.

The second strategy, in which one company supplies regional distribution services to a group of shippers, has been adopted by large transport companies and logistic service suppliers in certain specific transport market segments; this is referred to as *organisational consolidation*. In certain market segments, such as clothing and electronic equipment, transport companies supply regional distribution services to a group of shippers; in this way, consolidation is occurring. Usually, it is the transport company or the logistic service provider who, for commercial reasons, takes the initiative to combine services. There are examples, however, which demonstrate that forwarders or receivers can also take initiatives to bundle loads. Although this strategy is successful, this process of consolidation is reaching its limits.

City logistics is an example of the third strategy. City logistics is based on co-operation between companies, which pool their distribution trips on a voluntary basis.

30.7.3 Vertical integration at a logistic park

Vertical integration can also be described as the physical shortening of the logistic chain (Heidemij, 1994). Vermunt (Vermunt and Olsthoorn, 1995) and Ogden (1992) distinguish the following logistic utilities:

- Translation or place utility: change of goods in space.
- Stabilisation or time utility: change of goods over time.
- Transformation or form utility: change of goods in form or quality.
- Decomposition utility: change in the composition of a shipment.
- Commercial utility: change of ownership.

Transfer points within a logistic chain combine two or more of these utilities. The following figure shows the development of logistic transfer points by combinations of different utilities from a historical perspective.
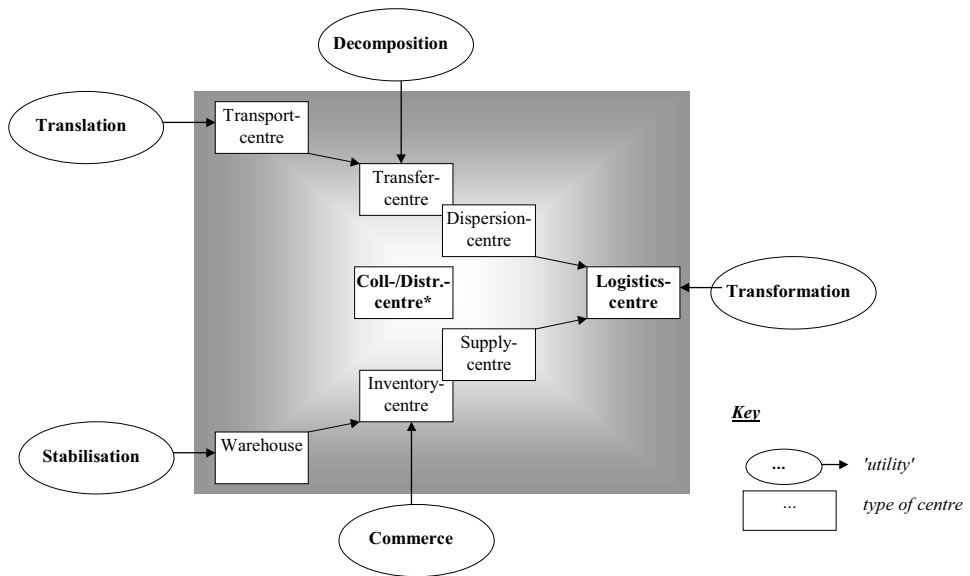
Figure 30-9:   Types of distribution centres in a logistic park (Source: Vermunt and Olsthoorn, 1995)

Location production

Production, logistic and commercial activities, which are related to these utilities, are certainly not entirely independent. Production factors such as capital, knowledge and labour are often restricted to certain areas, while economies of scale are a driving force for spatial concentration of the same activity. On the other hand, for certain product-groups the vicinity or the accessibility of consumer areas has always been a major location factor. This is particularly the case when products need to be customised to regional preferences. A trend towards situating production activities near consumer areas supports the development of logistic integration in regional transfer points.

Outsourcing of storage activities

From the shipper's point of view, one can also combine activities by outsourcing storage activities from the shop location to a location in a transfer point. Outsourcing storage activities has certain benefits. High-cost retail floor space can be used entirely for sales purposes, while storage can take place at relatively cheap locations, possibly through a specialised logistic service provider.

There are several options:

- *Neighbourhood centre or street depot*. A storage depot for a shopping street or neighbourhood centre. This depot can be set up by a group of shopkeepers or by the owner of a shopping mall.
- *Mini-storage*. In this concept, shopkeepers hire a garage or warehouse with storage boxes for storage purposes at the logistic park.
- *Public warehousing.* A logistic service provider takes care of storage and delivery of goods on request.
- *Pick-up centre*. For resale concepts that use showrooms to display products but hand over the bought goods at a separate location, goods can be stored at a logistic park and be picked by customers or delivered at home by a dedicated transport service.

The option of public warehousing is most common. In almost every country, one will find examples of these kinds of services, also related to some type of urban distribution system.

30.8   Spatial characteristics of a logistic park

30.8.1 Introduction

The size and layout of logistic parks are important spatial characteristics; they are determined by the type of activities that occur there. First, we must discuss the layout of a typical logistic park. Then, we will examine ways to determine the size of a logistic park.

30.8.2   Logistic park layout

There is no single blueprint available for logistic parks, as the layout depends on local factors, such as area size and access to rail, road and/or inland waterway.

A logistic park must have a minimum of high quality road access by road. Access routes, via special freight lanes or a combination of public transport and freight lanes to and within urban areas is also critical. Finally, it requires rail connections and a rail terminal, and where appropriate, a barge-terminal for waterborne transport.

The layout of a logistic park is adjusted to the implementation of separate internal lanes to and from the intermodal terminals.

At a logistic park, all kinds of activities must be situated. The following overview is partly based on the Nordic Transport Centre in Aalborg, Denmark (Bentzen, 1999).

Logistic parks host the following elementary logistic activities:

- Private warehouses for general goods, dry goods, refrigerated (chilled)/frozen goods and classified goods.
- Public warehouses, such as warehouse hotels and public bounded warehouses.
- City distribution centre.
- Transhipment facilities for road, rail and if required waterborne.
- Offices and parking lots for transport companies.

Activities that are related or associated to the elementary activities of a logistic park include:

- Retail or wholesale distribution centres.
- Storage facilities for retailers.
- Pick-up centres for customers.
- Production companies related to value added logistics (VAL).

Furthermore, the parks require supporting facilities, including:

- Administration, bank, post, and customs clearance facilities, as well as training and research facilities.
- Service stations for vehicle maintenance, washing and fuel, secured areas for parking and container depots.
- Facilities for internal and external data communication and information.
- Centralised waste disposal.
- Security services.
- Parking lots for private cars and public transport service.
- Catering, hotel facilities and so on.

In addition, in other countries, plans exist to develop facilities within logistic parks for data-communication systems between companies to exchange information on transport services and traffic information.

From examples in Germany and France, some general rules for the layout can be derived. Most of these areas are divided in four or five zones.

Table 30-5:   *Layout of a logistic park*

Location aspects	Situated activities
direct access to road:	Transport companies and distribution centres (dedicated or public)
direct access to rail:	Rail terminal
central located facilities:	Supporting facilities: catering, service stations and administration
peripheral located facilities:	Parking and container depot facilities
associated activities:	Production companies
(direct access to road)	Wholesale, e.g. fresh food centre
	Large scale retail activities

The development of logistic parks demands high investment. However, spatial concentration virtually guarantees an efficient use of facilities, and creates a critical mass for special investments in for instance a rail terminal.

Two remarks must be made in this respect:

- A major proportion of these investments would normally be already made. The main difference is that the investment will be done in a structured way and carefully attuned to other investments.
- The commercial use and the expected improved utilisation of these investments will probably lead to a faster cost recovery and a higher return on investments.

30.8.3 Logistic park size

The facilities known as *freight centres* differ in size. According to German standards, a freight centre should cover an area of at least 30 hectares. In Germany, a rule of thumb is used that 26.6 square metre is required per tonne transhipped per day. More precise the formula is as follows (Windborne, 1994):

$$A_{LP} = \alpha * V_{in} + \beta * V_{in+out} + \gamma \qquad\qquad (30\text{-}9)$$

With

A_{LP}	=	area size of a logistic park (LP) [m^2]
V_{in}	=	volume of goods arrived [tonne]
V_{in+out}	=	volume of goods arrived + volume of goods departed [tonne]
α	=	multiplication factor for arriving goods = 26.6 [m^2/tonne]
β	=	multiplication factor for all goods (arriving + departing) = 33.9 [m^2/tonne]
γ	=	fixed value; range = 37 950 m^2 to 88 550 m^2

The input is the expected tonnage to be transhipped in a given region.

This formula is based on traditional transhipment from rail to road. It is likely that in the future more efficient use of facilities and land use will occur. A reduction of the average number of square meter per tonne transhipped is therefore likely. There is currently no information available to adjust the formula.

The FV2000 Consortium (1998) provides some information on net floor productivity. This information can be used to calculate the total covered warehouse surface. The floor productivity at a freight village, one type of logistic park, is 13.4 tonnes/m^2 (covered warehouse surface), while a freight village with a rail terminal has a floor productivity of about 6.0 tonnes/m^2. If the volume of freight flows is known, then the warehouse surface can be calculated.

VUA and Arcadis (2000) developed a methodology to estimate the size of logistic parks. The method is based on data for four existing distribution centres and has not been validated.

$$Q_I = \frac{V\,week}{F\,week} \qquad\qquad (30\text{-}10)$$

with

Q_I	=	storage size [m^3]
V_{week}	=	transport volume per week [m^3]
F_{week}	=	delivery frequency per week [#]

$$A_W = \delta * Q_I \quad \text{with} \quad \delta \quad = \quad 2.9\ [m^{-1}] \qquad\qquad (30\text{-}11)$$

with

V_W =   covered warehouse surface [m^2]

Q_I =   storage size [m^3]

$$A_{LP} = \varphi * A_W, \text{ so: } A_{LP} = \delta * \varphi * \frac{V_{week}}{F_{week}}$$

(30-12)

with:

A_{LP} =   area size of a logistic park (LP) [m^2]

V_W =   covered warehouse surface [m^2]

Because the average delivery frequency was unknown, they used a minimum value of one delivery per week and a maximum of five deliveries per week.

A logistic park or a side location logistic park has a minimum size of 15 hectares and about a quarter or half the area is built up. This minimum size is really the bottom-line for the size of a logistic park. In Germany, the limit is about 40 hectares, while in Japan, a size of 160 hectares is considered normal.

BRO (1995) investigated for different types of transport & distribution companies the average area size and the number of personnel.

Table 30-6:   ***The average size of Transport & distribution companies (Source: BRO Adviseurs, 1995)***

Type of T&D-company	Personnel*	Area size**	Built area***
Small transport & distribution company	6 (60%)	3000 m^2 (500m^2/emp., 1000m^2/t.u.)	20% (5%)
Medium size transport & distribution company	25 (75%)	7000 m^2 (300m^2/emp., 400m^2/t.u.)	30% (5%)
Large transport & distribution company	150 (70%)	15000 m^2 (100m^2/emp., 150m^2/t.u.)	25% (10%)
Expedition/distribution company	30 (50%)	7000 m^2 (200m^2/emp., 400m^2/t.u.)	40% (10%)
emp.	employee		
t.u.	transport unit		
*	in parenthesis the share of driving personnel		
**	area size as average area size, in square metres per employee and in square metres per transport unit		
***	average share of the area that are buildings. In parenthesis the share of office buildings of the built area		

30.9   Conclusions

Logistic parks and freight centres are two different concentrations of logistic activities. We have defined a logistic park as an area of specialised industries in the field of logistics and traffic-intensive businesses, which is also the central location for regional collection and distribution. Logistic parks are the transfer points between the interregional backbone network and local distribution networks (from a logistic and a physical network perspective).

The location choice for a logistic park must be considered both in terms of the optimal location as a node in the backbone network and in terms of the optimal location with the service area. Both optimisations do not necessarily lead to a single optimal solution. Indeed, in most cases, it will lead to different optimal locations. As a node in a backbone network, the location should be situated as close to the infrastructure of the backbone network as possible, and if possible, also near the internal nodes of the network. The optimal location within a service area is normally the (weighted) centre of the area.

In cases where a compromise must be reached, the optimal location can still be found:

- As a balance between the extra (fixed and variable) costs of a detour from the backbone network, that is, the extra costs of the connection to the service area and land price differences;
- As a balance in the environmental costs of the location and the extra transport.

The difference in the degree of consolidation in backbone transport and in city logistics plays a major role in defining the optimal location.

The Netherlands can be divided into 17 distri-regions, based on rail transport. Each region is a service area for one or more logistic parks (including logistic sub-locations). Each distri-region is, at the same time, the service area for the intermodal facilities at a multimodal logistic park. Besides a multimodal logistic park, regions will also require sub-location logistic parks in order to provide proper transport service everywhere in the region.

This section also presents a theoretical framework for a more thorough investigation of the size of the distri-regions. The service area for a transfer point should meet two criteria: the maximum size of a service area, and the minimum size of a region, based on the minimum potential volume of freight required to operate the intermodal facilities commercially.

We may also conclude that the concentration of businesses near transfer points, such as intermodal terminals, is necessary to generate enough potential volume for intermodal transport to make intermodal concepts competitive.

Logistic parks are, therefore, not only the home base for regional transfer points but also a location for freight traffic intensive businesses and logistic-related activities.

31. Networks and corridors

31.1 Introduction

The network elements and characteristics of transport systems, as portrayed in Part IV, must be combined into physical networks to interconnect the Regional and Local Transfer Points and associated logistic parks. In this chapter, we will investigate the fundamentals of networks, and will conclude by introducing the concept of corridors.

Networks comprise both the links and nodes and of a transport system, that is, spatial nodes such as logistic parts, and links such as corridors. A network increases the attractiveness and effectiveness of both local and regional distribution. The importance of a network between regional transfer points for local or regional distribution in the Netherlands has been discussed by RIGO (1995). Despite the focus of RIGO on road transport and urban distribution centres as transfer points, their conclusions are even more valid when we consider intermodal transport as a possible option for domestic freight transport.

Corridors are the linking spaces required to make networks function smoothly. By reserving space for the infrastructure of the different modalities in close physical proximity, we can ensure that the important origins and destinations for freight transport are connected (e.g., spatial nodes such as logistic parks). The importance of corridors for transport networks has been analysed by Maiorana (1994).

31.2 Physical networks

Transport systems, such as the urban goods distribution system, operate in functional networks. These functional networks are the combination of physical distribution service

networks and physical networks. These networks coincide with certain layers in the transport layer scheme for urban goods distribution (elaborated in Part II). The physical distribution networks were introduced in Part III. These physical distribution service networks use physical networks to distribute goods. The physical networks consist of physical links and nodes. Physical links or connections and nodes refer to the infrastructure networks, as well as the spatial reservations required for these infrastructure networks. The services each network provides can be unimodal or intermodal.

Important characteristics of this functional network include:

- Access point density, which indicates the necessary access and egress transport distances to the system.
- Network density and shape, which indicates the average detours and thus the average distance and its distribution.
- Network quality, which includes average travel times, the distribution of travel times and related costs.

The urban goods distribution system (and transport in general) can be regarded as one intermodal network consisting of multiple subsystems (highway network, rail network etc), mutually connected by transfer points.

31.3 Physical network design

31.3.1 Introduction

For the design of service networks, a design path can be followed as shown in Figure 31-1 (based on Van Binsbergen et al., 1997).
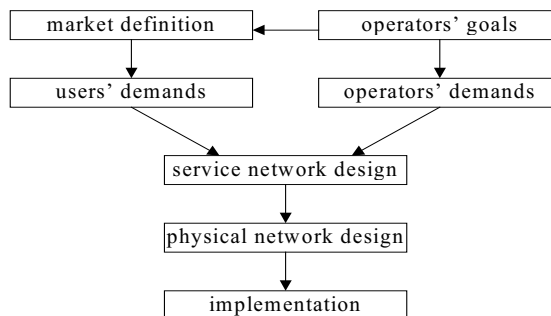

Figure 31-1: Stages in a network design process

The operators' goals determine both the market definition (and thus the potential market size) and the operator demands (this is, for example, reflected in the transport volume through a terminal at the logistic park, as elaborated in Section 30.5.3)[6]. These demands form the

---

[6]   Note that in this approach, the supplier predefines the market niche at which he wants to aim his services. Although this is common practice (a railway operator will initially try to extend his railway services and will generally not be interested in operating prehaulage and endhaulage road services), this first step is easily overlooked in theoretical studies.

preconditions from the supply side of the design process. They include technological, operational and legal issues. Then, of course, users will have their demands that the service supplier tries to fulfil. User demands may conflict with operator demands and even within the user and operator demands there will be discrepancies. The main task of the service designer is to find points of common interest and to design a balanced system. Although we will not go through this process step by step in this thesis, we will draw some conclusions on the shape of the physical network for urban goods distribution.

31.3.2 Physical network principles
The ideal[7] structure of the physical network that interconnects the access points (or transfer points) depends on the expected traffic volumes and the location of the access points. Figure 31-2 depicts a situation where between four origins and four destinations 16 direct links exist. There is no form of consolidation (neither in infrastructure use, nor in vehicle use).
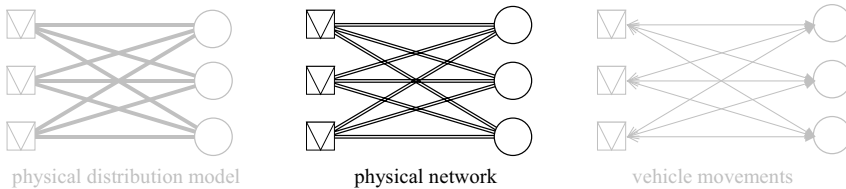

physical distribution model   physical network   vehicle movements

Figure 31-2:   Direct connections

Direct connections are efficient where large goods or traffic flows are moving between specific origins and destinations, but in most cases, network consolidation must occur. This means that thin traffic flows are combined with dense flows on a limited number of links or different infrastructure links are bundled together.

This results in access/egress or branch-like sub-networks that feed the consolidation network (trunk network). In a unimodal system, vehicles are consolidated on a few physical links, but there is no load consolidation. Vehicles simply drive from access or collector roads to the main roads and then move from there to egress or distributor roads – without transhipments. The quality of the main route must counter-balance the 'costs' of consolidation, being the effect of the detour (see Figure 31-3).

physical distribution model   physical network   vehicle movements
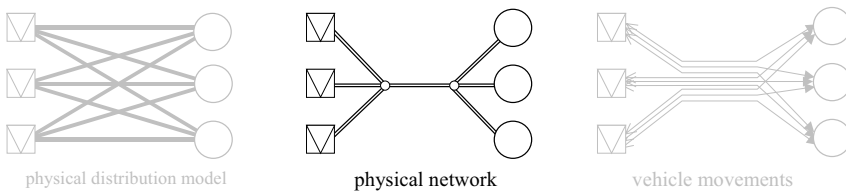
Figure 31-3:   Access/egress/consolidation network

These networks greatly resemble the logistical or organisational collection/distribution networks and, in essence, fulfil the same role.

However, one major difference is that in logistic collection/distribution networks cargo may be transferred in the collection/distribution points. In logistic chains, the disadvantages of the collection/distribution system are the transhipments and the detours (compared to the direct link). These disadvantages must be counterbalanced by the efficiency advantages that can be gained through consolidated links.

In the logistical consolidation/deconsolidation of multi-modal networks (see Figure 31-4), load is consolidated into vehicles and – using the appropriate physical network – vehicles are consolidated on the networks. The consolidation on a vehicle level requires the introduction of transfer points. However, this type of consolidation reduces the number of vehicles used.
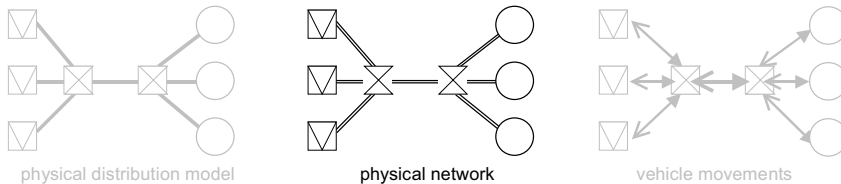

physical distribution model   physical network   vehicle movements

Figure 31-4:   Consolidation/deconsolidation logistic network

Theoretically, the logistic hub-and-spoke type of network can also be used for designing infrastructure networks. We distinguish two types of hub-and-spoke networks. In the first type (see Figure 31-5), both the access and egress links to and from the 'hub' consolidate traffic flows. However, unlike logistic networks, the hub itself has no additional value for the transport process. Worse, the high traffic densities in the central node may even be counter-productive. The hub simply operates as a traffic junction.
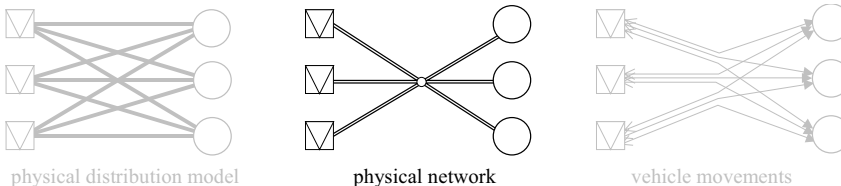

physical distribution model   physical network   vehicle movements

Figure 31-5:   Theoretical hub-and-spoke network

The logistical hub-and-spoke concept (see Figure 31-6) uses the cargo densities in the hub to optimise the cross-docking and vehicle-consolidation process. Of course, this process requires some type of transfer point, where cargo can be transhipped from one vehicle to another, allowing the number of traffic moves to be reduced. In this case, in theory, different modalities can be used for different directions.

---

7   In reality, network structure is influenced by a multitude of external factors such as existing infrastructures, built-up areas and geographical conditions.
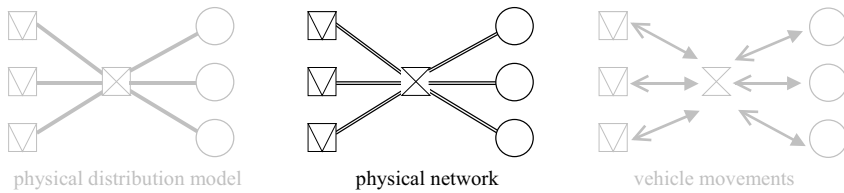
Figure 31-6:   Hub-and-spoke logistic network

In cases where different subsystems or modalities are used, a hierarchical network design is appropriate. A hierarchical network is designed as a combination of a local hub-and-spoke logistic network (see Figure 31-4) and an interregional consolidation/deconsolidation logistic network (see Figure 31-6). Therefore, for our purposes, we propose to use a hierarchical network. Corridors for an interregional consolidation/deconsolidation logistic network will be elaborated in section 31.5. The local corridors for local hub-and-spoke logistic networks will be elaborated in section 31.6.

31.4   Physical network shapes

31.4.1 Introduction

The above-mentioned network principles are used to design the definitive network shape, especially the shape of the trunk-network. First, there are some basic network shapes from which the most appropriate can be chosen. Then, the definitive network shape must be adapted to the physical circumstances.

31.4.2 Basic physical network shapes

Physical networks come in few basic shapes, each with specific advantages and disadvantages (see Figure 31-7 and (Bolt, 1983)). Except for the line-shaped network, the basic shapes include:

- Star or radial shaped networks concentrate flows in a central area; this results in large detours and require relative low investment costs;
- Circular networks result in even distributed utilisation of links; this results in large detours and also require relative low investment costs;
- Grid networks result in fairly low utilisation and medium detours but require relative high investments;
- Triangular networks also result in low utilisation of links, have limited detours and require high investments.

Although the different shapes result in substantial differences in utilisation, detours and investment costs, the designer does not have complete freedom of choice, as the physical configuration of the nodes influences the applicable network design.
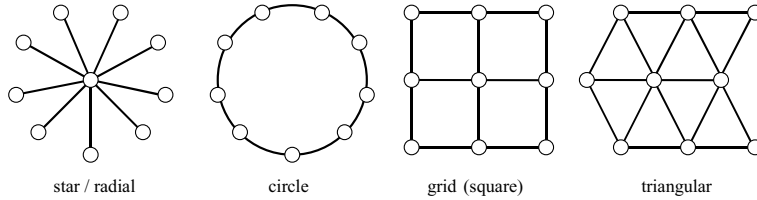
star / radial	circle	grid (square)	triangular

Figure 31-7: ***Basic physical network shapes (derived from Bolt, 1983)***

In practice, the 'ideal' physical network shapes must of course be adapted to the real-life circumstances. In short notice, these circumstances include:

- The actual location of 'activity concentrations' (see section 31.3.1).
- The location of existing infrastructure.
- The location of existing built-up areas and buildings that should be avoided.
- The location of other objects and areas that should be avoided.
- Geographical and other natural circumstances.

The location of existing infrastructures plays a role, because these infrastructures should either be avoided or be 'used'. The latter indicates that existing infrastructures already claim space and new infrastructures may use (part of) this space -all this in order to limit total space utilisation (this concept is referred to as spatial bundling, see Willems, 1997).

Valuable (built-up) areas and buildings should be avoided as well, by introducing bypasses[8]. Mountain ranges, rivers, and for example the composition of the soil also determine the definitive shape of the physical infrastructure network. These limitations not only apply to surface infrastructures, but also to underground infrastructures. The foundations of buildings may not be disturbed. Underground constructions should be avoided and geomorphological conditions must be taken into account as well.

31.4.3 Characteristics of physical networks

Networks can be categorised based on:

- Type of network use (mixed or dedicated use).
- Network length, an indicator of network density.
- An indicator for the quality, for instance link speed.
- Typical detour factors.

Consolidation enables the introduction of high quality networks such as a highway system. On these relatively coarse networks, traffic is bundled; the relative detours are compensated by higher average speeds. Although the network length is limited, highways account for a very large share of the total traffic performance. The typical network shape of highways (in the Netherlands and many other countries) is a mixture of a triangular and a grid network.

Ideally, several layers of underlying road networks (performing at regional and agglomerate and local/urban level) support high-level highway networks. However, in practice lower level networks are often eradicated, or replaced by higher-level networks. This—almost irreversible—development results in local and regional use of 'national' infrastructures, reducing the level of quality of these networks.

---

[8]   This can also be an underground section, an 'underpass' so to speak.

The Dutch (heavy) rail network also has both triangular and grid network characteristics. The density is low (indicated by a total network length of about 2600 kilometres).

New national networks (CombiRoad, underground systems) will at first only link the most important activity centres. For one specific Dutch situation (four main cities within the Randstad area and some twelve medium sized cities and activity centres outside this area), a ring-shaped network within the 'Randstad' area, with some added main links is an appropriate base trunk line network.

Local networks do not so much connect individual activity centres but must serve continuous areas. New networks in existing urban areas could be designed as underground networks. Given a fixed budget for underground infrastructure investments, the tube diameter determines the network lengths: large tube diameters are more expensive than small ones, so that large diameter networks will be less dense than small diameter networks (see Figure 31-8). The preferred network density determines the network length, and the preferred network density depends on the investment costs and the desired maximum distance from network access points to final destinations.
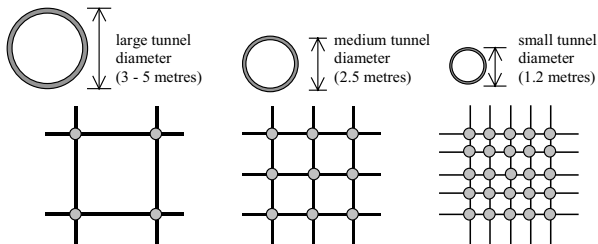

Figure 31-8:   Tunnel diameter and network density (example, based on 'equal' investment costs)

31.4.4 Intermodality

While the road transport system is virtually ubiquitous, it is not very reasonable to assume that rail, waterborne and underground systems will ever reach such a high density. The high density of the road network is the result of a very long development history, but is also attributable to the versatility of the infrastructure[9]. The inherently limited density of alternative networks (for alternative modes) forces the users of these networks to use intermodal concepts to ensure the distribution of goods from all origins to all final destinations. This implies that earlier described systems, such as heavy and light rail transport, inland navigation, CombiRoad and underground transport, can only function within an intermodal concept, except for the origin/destination relations that are directly linked by the alternative system or transport mode. Next to that, incompatibility of specific transport or traffic means with specific infrastructures (even of the same mode), may result in a multi-modal concept. For example, this is the case with road-trains: these are road vehicles but can nevertheless not use most urban road infrastructures. Even within 'traditional' road transport, there is a fundamental difference between highway and urban infrastructure networks. Large

---

[9]   The position of the road transport system, as depicted, holds for almost all current situations in Western society. However, in the past and at specific locations, waterways (canals) and to a certain extent even railways ('tramways') held a comparable position.

road vehicles that can be operated on highways can often not be used in urban networks. This forces service providers to choose smaller vehicles within the last section of the physical distribution channel (see Boerkamps et al, 2000) or to transfer the goods at a local transfer point. Especially in the latter case, this is a type of 'intermodal road concept'.

31.4.5 Conclusions

Combinations of different network shapes are possible. The network shape depends on the locations of the origins and destinations, (im)balances in goods flows and geographical circumstances. A nation-wide network for the Netherlands for urban goods distribution should lead to a combination of a circular shape in the Randstad (western part of the Netherlands), a grid or triangular shape in the middle part of the Netherlands (Noord-Brabant, Utrecht and Gelderland) and a radial shape for the rest of the Netherlands. This will be discussed in section 31.5.6.

31.5 Interregional/national corridors

31.5.1 Introduction

Corridors are the linking spaces required to make networks function smoothly. By reserving space for the infrastructure of the different modalities in close physical proximity, we can ensure that regions (or, to be more precise, the logistic parks, main ports or industrial areas, or border crossings in the regions) are connected. The importance of corridors for transport networks has been analysed by Maiorana (1994). Interregional and national corridors represent the set of available (or necessary) infrastructure links and the spatial reservations for these links that interconnect transfer points on logistic parks within regions (distri-regions). Although a corridor is defined as the interconnection between logistic parks of neighbouring distri-regions, the infrastructures that make part of the corridor, of course also accommodate transport flows between other regions.

The interregional and national corridors offer space to those links of the transport networks that are part of the national backbone network. The national backbone network is a combination of the infrastructure for domestic freight transport, international hinterland connections and feeder connections from the regions in the Netherlands to these hinterland connections. The possible options and characteristics will be discussed.

31.5.2 Road transport networks

Most road networks are designed for mixed use by passenger and freight transport. Only since the 1990s have dedicated sections and lanes for freight and public transport been constructed. Thus far, the total network length of these sections is very limited, but in time these sections can be combined into larger networks or specific 'connections'. Table 31-1 shows the characteristics of the Dutch road network system.

Table 31-1:   ***Characteristics of intercity road system (The Netherlands, 1996) (source:***
                    CBS, 1998)

	traffic type	*network length*	*characteristic speed*	
			pass.	*freight*[10]
		[km]	*[km/h]*	*[km/h]*
highways	Mixed	2.222	105-113	85
'freightlanes'	Dedicated	<20	-	85
motorways	Mixed	936	92	80
other main roads	Mixed	7.776	80	65
other roads	Mixed	44.991	64	65

31.5.3 Rail transport networks

Table 31-2 displays the main characteristics of the current Dutch rail transport network that can be used by freight trains. For rail, for instance, for the RDN (Rail Distributie Nederland) concept, we investigated what part of the rail network could be used for domestic freight transport by rail.

Table 31-2:   ***Characteristics of rail systems (The Netherlands, 1996) (source: Visser et***
                    al., 1998)

	traffic type	*network length*	*characteristic speed*[10]	
			pass.	*freight*
		[km]	*[km/h]*	*[km/h]*
rail	Mixed	2570	113	85
rail[11]	Dedicated	230	-	85

---

[10]   Indicative.

[11]   Public infrastructure, dedicated for freight (harbour areas etc.), includes 'Betuwelijn' (under construction).
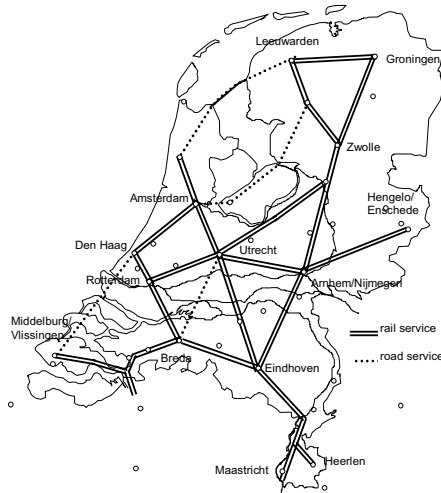
Figure 31-9:   Rail and additional road services using existing infrastructures (Source: Van Binsbergen et al., 1997)

31.5.4 Alternative transport networks

CombiRoad and underground transport networks do not yet exist. The estimated network lengths are based on preliminary studies. The CombiRoad network would be a dedicated consolidation network, aimed especially at transporting goods between areas with dense industrial, distribution and commercial activities. For trunk line networks, connecting the main logistic activity centres and urban areas in the Netherlands, a minimum network length of about 300 kilometres will suffice. The same holds for an underground trunk line network: the network length is primarily determined by the spatial configuration of the activity centres. For serving the whole of the country, a trunk network length of about 2000 kilometres would be necessary (see Figure 31-10); note that the extended trunk network is almost identical to the railway network as depicted in Figure 31-9.
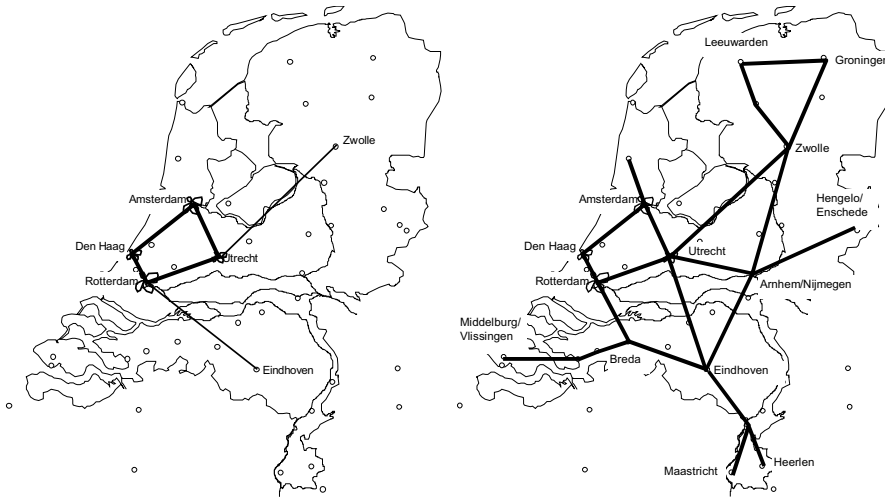
Figure 31-10:   Trunk line networks for the Netherlands (Source: Visser et al., 1998)

***Table 31-3:   Characteristics of alternative infrastructure networks (The Netherlands)
(source: Visser et al., 1998)***

	traffic type	*network length*	*characteristic speed*[10]	
			pass.	*freight*
		[km]	*[km/h]*	*[km/h]*
Combi-Road[12]	Dedicated	320 - 2100	-	50 – 80
Underground	Dedicated	320 - 2100	-	40 – 60

31.5.5 Other intercity transport alternatives

Dedicated inland shipping vessels may, in the future, conquer an—admittedly small—market share in urban distribution. The introduction of standardised load units is one factor that enables the use of inland shipping. Nevertheless, this transport mode will only be applicable for a restricted part of the total urban goods distribution flows. In the Netherlands, options are being discussed to promote intermodal transport of international and domestic freight by both water and rail. For waterborne transport, the project STIGOWA (STimuleren GOederenvervoer over WAter or "Stimulate Freight Transport by Waterborne") (STIGOWA, 1997) defined the network for waterborne freight transport, based on the existing waterways and channels in the Netherlands. In the long term, completely new transport systems may be introduced, such as automated underground systems. These systems form an extension of the earlier described inner-city systems.

31.5.6 Resulting corridors
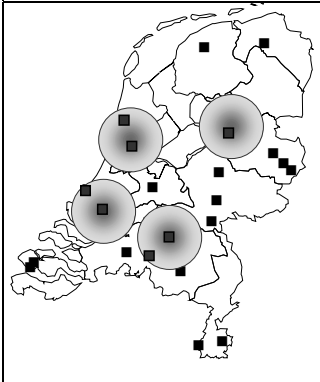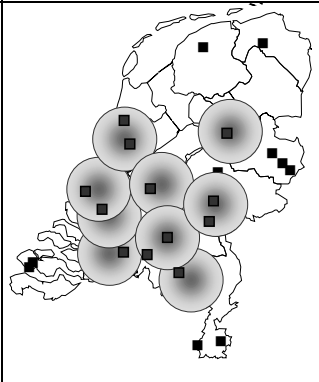
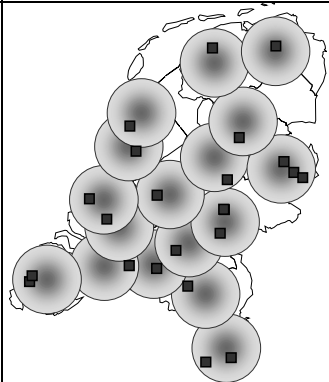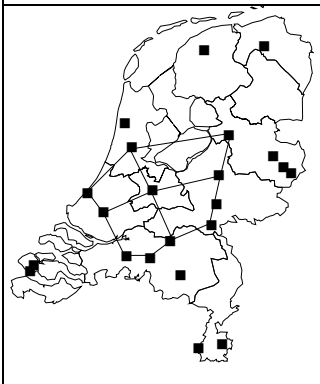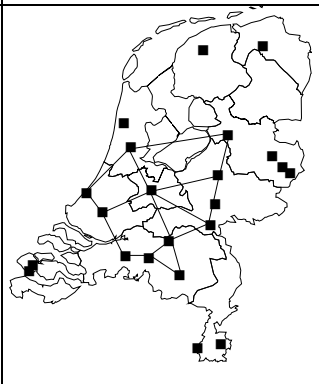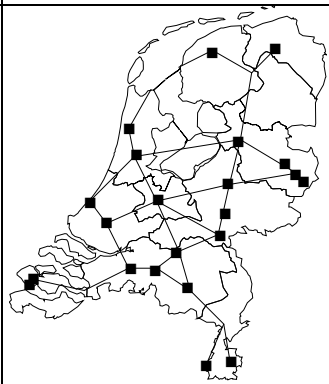The new concepts for urban distribution include road, inland waterway, and rail, as well as alternative transport modes, as possible modes for the backbone network. When we overlay the networks as depicted in Figure 31-9 and Figure 31-10 and then add the main road links

---

[12]   In pre-planning stage.

(highways) and relevant inland waterways, we get almost the same picture: bundles of infrastructures interconnecting the different urban areas. These bundles can now be assigned to being corridors; see Table 31-4 for an overview. This table is based on the design of a backbone network for underground freight transport (see Visser et al., 1998).

The concept of corridors and the theoretical notions, demonstrated in section 31.4, on network design are proper starting points for long-term strategic thinking on infrastructure for freight transportation (and passenger transport). An optimal network design could be the guideline for spatial reservations for future infrastructure. Table 31-4 demonstrates how a network of corridors can be set up in three phases.

Table 31-4:   ***Regions and corridors between these regions (based on Visser et al, 1998)***

First phase	Second phase	Third phase
Amsterdam Den Bosch Rotterdam Zwolle	Arnhem/Nijmegen Breda Eindhoven Haaglanden Utrecht	Alkmaar Apeldoorn Groningen Leeuwarden Maastricht/Heerlen Middelburg/Vlissingen Tilburg Twente

Corridors		

31.6   Intraregional/local corridors

City logistics will be capable of providing transport services when the appropriate networks are available. In Part IV and in Visser & Van Binsbergen (1998), a number of transport systems are described. In addition, on a local level, the networks will be combined into corridors, based on road transport and other available options [13].

Local corridors refer to specific routes or paths that can be designated for use by certain freight vehicles. Corresponding with interregional corridors, local corridors can be defined at different levels (routes, infrastructure, and spatial reservations). These routes may also be designated only for specific classes of vehicles, either temporarily (only for a certain period of time) or permanently. It is possible to combine these routes with a prohibition for freight vehicles on particular routes (route bans), or restrictions on entry to a designated local area (local or regional area ban). The routes can make use of roads for all traffic, or use dedicated lanes for special purpose traffic.

Figure 31-11:   Route signs for freight traffic in Amsterdam

The purpose of corridors is to guarantee a high level of access to certain areas and/or preserve other routes or areas from hindrance by freight traffic. The corridors should correspond with the best routes from logistic parks, or similar concentrations of logistic activities, to the relevant freight traffic destinations within urban areas, for instance shopping areas. Freight traffic makes many times round trips so it is also important to define corridors between these destinations within urban areas. Figure 31-12 shows freight routes within the city of Amsterdam. These freight routes can be considered as corridors.

---

[13]   For technological and legislative reasons, even underground infrastructures will generally be 'combined' with already existing surface space reservations for infrastructure.

Figure 31-12:   Routes within Amsterdam

Corridors can be implemented in different ways. The following table shows some technological options that can be used in these corridors.

Table 31-5:   Technological options for local corridors

Options	Automation of guidance and control	Infrastructure	Examples of application
	Guidance	*Shared links*	
A.1	signage	routes	freight traffic routes
A.2	access control & path assigning	shared or separate lanes	shared-use of bus lanes or separate freight lanes
	Control	*Separate networks*	
B.1	automated speed control	dedicated infrastructure	dedicated road network for freight
B.2	automated control	own infrastructure	underground transport systems in urban areas

Defining routes for freight, mainly for transit freight traffic, is a widespread practice in many countries. The use of access control and path assigning is becoming popular. There are some examples of a separate infrastructure for freight transport in urban areas, such as underground freight transport systems, but there is limited relevant experience.

A major factor to consider is to what extent corridors, based on dedicated infrastructures, will be used efficiently. In a study by the OECD (OECD, 1992), dedicated infrastructures showed a low socio-economic efficiency. Although this study only looked at freight lanes next to highways, and only considered traffic safety and time saving, this aspect is very important.

Within urban areas, the underground system will not serve all possible destinations, but will serve 'local distribution centres' and some specific (large) shops or streets; the latter are referred to as 'direct access links'. This results in a network such as that displayed in Figure 31-13.
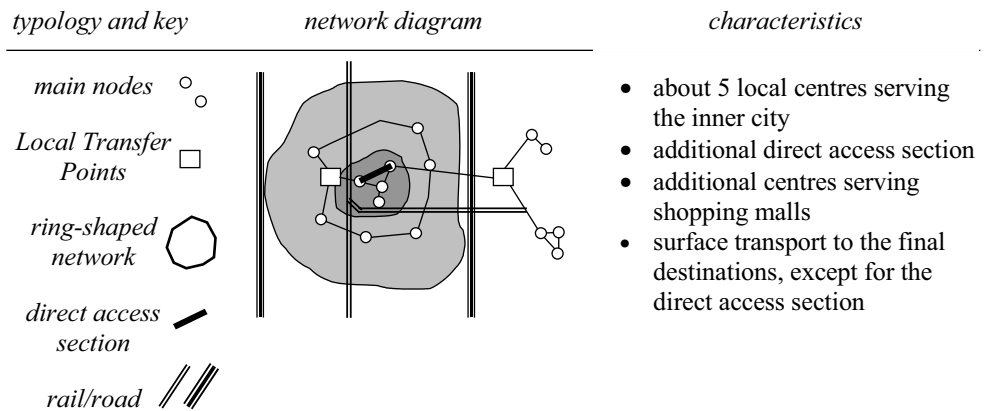

Figure 31-13: *Example of a design for an underground network (Leiden, the Netherlands) (Source: Buck Consultants et al., 1999)*

31.7   Conclusions

In this chapter, we have elaborated on the links within the spatial networks, namely the interregional and local corridors. We have investigated the fundamentals of infrastructure networks. Therefore, we have introduced a network design methodology that can be used either to design new networks, or to adapt or extend existing networks. The desired physical distribution pattern and the preferred physical network shape influence the design. We have shown that the different basic network shapes have specific advantages and disadvantages, but we have also shown that the designer has only a limited freedom of choice, as market and geographical conditions can set rigid requirements. In our case, we have integrated different subsystems or modalities. Therefore, a hierarchical network design is appropriate. A hierarchical network is designed as a combination of a local hub-and-spoke logistic network and an interregional consolidation/deconsolidation logistic network.

In practice, the physical shape of the network is influenced by a variety of circumstances, ranging from the location of other infrastructures and buildings to the geological conditions. We have noted that in underground network design these (or similar) factors must also be taken into account. We have displayed a range of network characteristics and concluded that

in the current situation, road transport is ubiquitous. This implies that the use of alternative modes and networks always requires applying an intermodal concept. We also found that the physical infrastructure characteristics of urban road networks have an impact on the vehicle choice within the distribution process, especially in the final stage. This may result in an intermodal use of the different road networks (large vehicles used on highways, small vehicles used on urban infrastructures). We concluded that combinations of different network shapes are possible. The network shape depends on the locations of the origins and destinations, (im)balances in goods flows, and geographical circumstances.

A nation-wide network for the Netherlands for urban goods distribution should logically lead to a combination of a circular shape in the Randstad (western part of the Netherlands), a grid or triangular shape in the middle part of the Netherlands (Noord-Brabant, Utrecht and Gelderland) and a radial shape for the rest of the Netherlands. We considered different kinds of road, rail and alternative networks.

We then examined the concept of corridors as combinations of multimodal infrastructure links between local and regional transfer points at a national and a regional level. For the corridors between regions at the national level, we have distinguished three phases. The first phase only connects the four main regions for collection and distribution of consumer goods in the Netherlands (Amsterdam, Den Bosch, Rotterdam and Zwolle). The second phase is expanded with five other important regions (Arnhem, Nijmegen, Breda, Eindhoven, Haaglanden and Utrecht). The third completes the network by connecting the more remote regions (Alkmaar, Apeldoorn, Groningen, Leeuwarden, Maastricht/Heerlen, Middelburg/ Vlissingen and Twente) and by increasing the density of the network (Tilburg).

At the local level, local corridors can also be defined. Existing local corridors should be based on road transport. However, in the future underground connections may also be possible. Local corridors refer to specific routes or paths that can be designated for use by certain freight vehicles. The local corridors should correspond to the optimal routes between destinations such as shopping areas and logistic parks. Corridors between shopping areas are also important, because freight traffic can be used to make round trips. Different options for corridors are possible. These options are based on differences in the automation of guidance and control of the traffic and the available infrastructure. The options include: freight traffic routes, shared-use of bus lanes or separate freight lanes, a dedicated road network for freight and an underground transport system. These options can be considered as phases in the development of local freight corridors within urban areas.

32. Summary and conclusions of Part V

The spatial dimension of urban goods distribution consists of a spatial network, composed of nodes and links. The nodes are developed by spatial zoning, in this case the zoning of the retail industry as the destination of urban goods flows, and the zoning of transfer points, freight traffic intensive businesses, and other logistic activities at logistic parks.

Corridors build up the spatial network by connecting these nodes. Corridors can be considered both from a land-use and an infrastructural perspective. The corridors must be multimodal, meaning that they must contain more than one infrastructure network. The bundling of infrastructure can be parallel, sequential or mixed.

Logistic parks are spatial concentrations of logistic activities. We defined logistic park as an area of specialised industries in the field of logistics and traffic-intensive businesses, while also acting as the central location for regional collection and distribution. Logistic parks are the transfer points between the interregional backbone network and local distribution networks (from a logistic and a physical network perspective).

The location choice for a logistic park must be considered in terms of the optimal location as a node in the backbone network and the optimal location with the service area. Both optimisations do not necessary lead to the same optimal solution; in most cases, each will lead to different optimal locations. As a node in a backbone network the location, should be situated as close to the infrastructure of the backbone network as possible, and if possible near one or more of the nodes within that network.

We have shown that the Netherlands can be divided into 17 distri-regions, based on rail transport. Each region is a service area for one or more logistic parks. Each distri-region is, at the same time, the service area for the intermodal facilities at a multimodal logistic park. Besides a multimodal logistic park, regions will also require side-location logistic parks in order to provide proper transport service throughout the region. We also presented a theoretical framework for a more thorough investigation of the size of the distri-regions. The

service area for a transfer point should meet two criteria: the maximum size of a service area, and the minimum size of a region, based on the minimum potential volume of freight required to operate the intermodal facilities commercially.

In this part, we investigated the fundamentals of infrastructure networks. We introduced a network design methodology that can be used to design new networks or to adapt or extend existing networks. The desired physical distribution pattern and the preferred basic physical network shape will influence the final design.

The physical network shape is in practice influenced by a variety of circumstances, ranging from the location of other infrastructures and buildings to the geological conditions. We noted that in underground network design these and other similar factors must also be taken into account. We displayed a range of network characteristics, and concluded that in the current situation, road transport is ubiquitous. This implies that the use of alternative modes and networks will always require the application of an intermodal concept. We also found that the physical infrastructure characteristics of urban road networks have an impact on the vehicle choice within the distribution process, especially the final stage. This may result in an intermodal use of the different road networks (large vehicles used on highways, small vehicles used on urban infrastructures). We will use this knowledge to design and evaluate physical urban networks, especially underground networks, as well as networks for inter-city rail and dedicated road transport (trunk lines).

Finally, we used the concept of corridors as combinations of multimodal infrastructure links between local and regional transfer points at a national and a regional level. For the corridors between regions at the national level, three phases were distinguished. The first phase will only connect the four main regions for collection and distribution of consumer goods in the Netherlands (Amsterdam, Den Bosch, Rotterdam and Zwolle). The second phase will be expanded with five other important regions (Arnhem, Nijmegen, Breda, Eindhoven, Haaglanden and Utrecht). The third will complete the network by connecting the more remote regions (Alkmaar, Apeldoorn, Groningen, Leeuwarden, Maastricht/Heerlen, Middelburg/Vlissingen. and Twente) and by increasing the density of the network (Tilburg).

At the local level, local corridors can also be defined. Existing local corridors are based on road transport. However, in the future underground connections may also be possible. Local corridors refer to specific routes or paths that can be designated for use by certain freight vehicles. The local corridors should correspond with the optimal routes between destinations, such as shopping areas, and logistic parks. Corridors between shopping areas are important as well, because freight traffic can be used to make round trips. Different options for corridors are possible. These options are based on differences in the automation of guidance and control of the traffic and the available infrastructure. The options include: freight traffic routes, shared-use of bus lanes or separate freight lanes, a dedicated road network for freight, and an underground transport system. These options can be considered as phases in the development of local freight corridors within urban areas.

The following Part contains the implementation strategy for the integrated concept. The key elements of the integrated approach are presented in Parts III, IV and V. Part V contains the spatial dimension of the physical network elements that were presented in part III. The spatial dimension turned out to be a spatial network with nodes, the logistic parks, and links, the corridors. These are critical elements of the integrated approach and play an important role in the implementation strategy.

References

Bentzen, K. (1999) *Nordic Transport centre Aalborg Denmark*, Aalborg (NTU).

Binsbergen, A.J. van & Th.J.H. Schoemaker (1996), *Gedachtevorming rond Groene Heavy Duty Stroken netwerk* (in Dutch), Delft (TU-Delft).

Binsbergen, A.J. van, J.G.S.N. Visser & C. Maat (1997) *Lokatiekeuze terminals en netwerkvorming* (in Dutch), Delft (TRAIL).

Bolt, D. (1983) *Urban form and energy for transportation*, Delft (Planologisch Studiecentrum).

Bontekoning, Y.M. & E. Kreutzberger (eds.) (1999), *Concepts of new-generation terminal and terminal nodes*, TRAIL Research School, (Delft University Press).

Borkens, E. (1997), *Een goederenvervoercorridor in de stad - case Den Haag* (in Dutch), Delft (Delft University of Technology).

BRO Adviseurs (1995) *Ruimtelijke problemen in de Transport- en Distributiesector* (in Dutch), Vught (BRO).

Brouwer, W, W.E. van Lierop, G.A.A. Erens, A.F.C Carlebur & J.G.S.N. Visser (1997), *Buisleidingentransport voor stedelijk goederenvervoer* (in Dutch), deel A/B, DTO werkdocument M9/M10 (in Dutch), Delft (DTO).

Buck Consultants/ TRAIL Onderzoekschool/ RUPS Adviseurs (1999), *Gaat Leiden Ondergronds, hoofdrapport* (in Dutch), Rotterdam (RUPS Adviseurs).

Castro, J.T., H. Kuse & M. Kubo (1999) Study on location planning of distribution facilities, in: E. Taniguchi and R.G. Thompson, 1999, *City Logistics I*, Kyoto (Institute for Systems Science Research).

CBS (1998) *Statistisch jaarboek 1998* (in Dutch), Voorburg/Heerlen (CBS).

CTT (1996), *Combi-Road Eindrapport* (in Dutch), CTT Publicatiereeks 12, Krimpen a.d. IJssel (Centrum Transport Technologie/Projectbureau Combi-Road).

FV2000 Consortium (1998) *Freight Village 2000: Increasing the attractiveness of intermodal Transport*, Bologna (Europlatform).

Green, D. (1999), Britse regering kijkt naar invoering vrachtstroken (in Dutch), in: *Nieuwsblad Transport*, 9 maart 1999, Rotterdam (Transportuitgave), p. 5.

Heidemij Advies (1994) *Ruimtelijke dimensies van het goederenvervoer* (in Dutch), Arnhem.

Koshi, M. (1992), An automated underground tube network for urban goods transport, in: *IATSS research 16*, no2. Tokyo (IATSS), pp. 50-56.

Ludewig, J. (1999) 'Aparte vrachtsporen tussen Duitse steden' (in Dutch), in: *Nieuwsblad Transport*, 9 maart 1999, Rotterdam (Transportuitgave), p. 5.

Maat, C. (1997) Optimisation of Rail Terminal Locations using Network Models, in: *Vervoerslogistieke Werkdagen 1997*, Rotterdam (VLW).

Maiorana, J.J. (1994) *Corridor Preservation, A synthesis of highway practice*, NCHRP Synthesis 197, Washington (National Academy Press).

Ministerie van Economische Zaken (1997) *Ruimte voor Economische Dynamiek; Een verkennende analyse van ruimtelijk-economische ontwikkelingen tot 2020*, Den Haag (Ministerie van Economische Zaken).

Ministerie van Volkshuisvesting Ruimtelijke Ordening en Milieu (VROM) (1993) *Vierde Nota voor de Ruimtelijke Ordening - Extra*, Den Haag (SDU).

Ministerie van Volkshuisvesting Ruimtelijke Ordening en Milieu (VROM) (1999) *De ruimte van Nederland, Startnota Ruimtelijke Ordening 1999*, Den Haag (SDU).

Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieu (VROM), Economische Zaken (EZ) Landbouw, Natuurbeheer en Visserij (LNV) and Verkeer en Waterstaat (V en W), (1989) *Vierde Nota Ruimtelijke Ordening*, Den Haag (SDU).

NEA/INRO-TNO (1989) *Een vervoersysteem van standaardeenheden in het interstedelijk verkeer* (in Dutch), Rijswijk (TNO).

OECD (1992) *Cargo routes: truck roads and networks*, Paris (OECD).

Ogden, K.W. (1992) *Urban Goods Movement: A guide to Policy and Planning*, Aldershot (Ashgate).

RIGO (1995) *Goederenvervoer en de ruimtelijke structuur van bedrijvigheid, een verkenning* (in Dutch), Amsterdam (RIGO).

Rutten, B.J.C.M. (1995), *On medium distance intermodal rail transport*, Delft (Delft University of Technology).

Schoemaker Th.J.H. & A.J. van Binsbergen (1993) *Trendbreukscenario Goederenvervoer: het Groen Transport Scenario* (in Dutch), Delft (Delft University of Technology).

Sonntag, H. & K. Tullius (1998), *REFORM - Research on Freight Platforms and Freight Organization*, (not published, see:) Book of Abstracts World Conference on Transport research, Antwerp (WCTR), p. 88.

STIGOWA (1997) *"Nat overslaan!"* (in Dutch), Den Haag (IPO).

Taniguchi. E., M. Noritake, T. Yamada & T. Izumitani (1999) Optimal size and location planning of public logistics terminals, in: *Transportation Research Part E: Logistics and Transportation Review, volume 35*, September 1999, p. 207-222, (Elsevier Science Ltd).

Vermunt, A.J. & F.M.C. Olsthoorn (1995) Verschijningsvormen van logistieke knooppunten, in: *Praktijk Magazijnen/Distributiecentra* (in Dutch), (Kluwer bedrijfswetenschappen).

Visser, J.G.S.N. (1992) *Effectiviteit van het beleid inzake stedelijk goederenverkeer, Toetsingsmethode voor het stadsdistributiecentrumconcept* (in Dutch), OTB-werkdocument 92-10, Delft (Delftse Universitaire Pers).

Visser J.G.S.N. & A.J. van Binsbergen (1997), Underground Networks for Freight Transport, A dedicated infrastructure for intermodal short-distance freight transport, in: *3rd TRAIL Year Congress 1997 "Transport, Infrastructure and Logistics, New times and innovative solutions offered"*, Delft (TRAIL Research School).

Visser, J.G.S.N. & A.J. van Binsbergen (1998) Intermodal short distance freight transport concepts: regional transfer points, in: *TRAIL conferences proceedings, 4th Annual Congress 1998, part 2*, Den Haag (TRAIL Research School).

Visser, J.G.S.N., A.J.M. Vermunt, & A.J. van Binsbergen (1998), *Ruimtelijke concepten ondergronds transport* (in Dutch), Delft/Hoeven (TRAIL Research School).

Willems, J. (1997), Design of converged infrastructure and transport corridors, 3rd TRAIL Year Congress 1997 "Transport, Infrastructure and Logistics, New times and innovative solutions offered", Delft (TRAIL Research School).

Windborne International Group (1994) *Intermodal freight centres in Europe*, Stockholm.

PART VI
Urban goods transport policy and planning

CONTENTS OF PART VI

33. Introduction to urban goods transport policy and planning

33.1 Introduction

In Part VI, 'Urban goods transport policy and planning', we address the third research objective of this thesis:

> *Develop a comprehensive policy plan for implementing effective policy measures, aiming at improving the efficiency of the goods distribution process for urban areas.*

This Part results in an integrated design of a goods distribution concept for urban areas, including the related policy plan. The policy plan consists of the needed institutional framework and implementation plan. This part focuses on the design of a comprehensive concept for the distribution of goods for urban areas. Within this comprehensive policy plan, the distinct actors, their roles, and the timing of actions should be defined. We will examine both the public as the private sector; however, the final emphasis will be on public policy-making in the field of urban goods distribution.
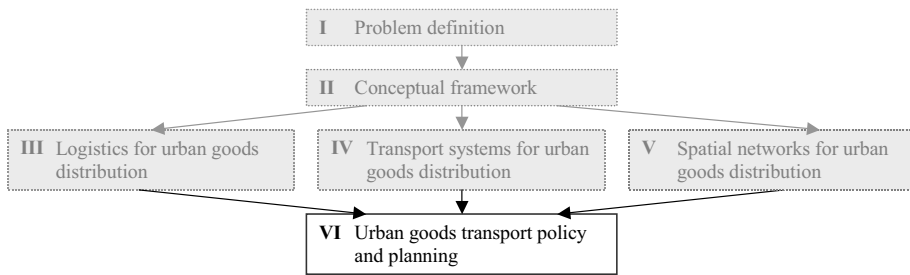
Figure 33-1:   *Part VI related to the other parts of this thesis*

This Part is based on insights and tools developed in previous parts of this thesis. It is, in essence, the synthesis of all other parts. The logistic concepts for urban distribution, namely 'network logistics' and 'city logistics', must be merged with appropriate transport systems and must then be fit into the spatial environment. These concepts are elaborated in Part III - Chapter 18, in Part IV - Chapter 26, and Part V, respectively. Because private actors alone are not able to set up such an integrated and complex distribution system, a public-private implementation strategy must be developed.

From this research objective we derived, in Part I, the following research questions:

(1) How does and how should public policy-making and planning for urban goods distribution occur?

In other words, we must develop an institutional framework, which provides tools to develop and implement public policy in the field of urban goods distribution. In this institutional framework, we will look at the actors who play a role in the urban goods distribution process and their interests in urban goods distribution. Because these actors play important but different roles, we will discuss the appropriate public policy-making process in the field of urban goods distribution and the range of available public policy and planning options. In addition, we will look at the policy objectives and policy measures in urban goods distribution policies in different countries to evaluate the progress made in policy-making. The theoretical notions behind policy-making by public actors are the same as laid out in Part II, regarding micro-economic utility theory, choice behaviour of actors and systems optimisation.

(2) How could the urban goods distribution system be designed in order to improve the efficiency of urban goods distribution in the future?

This research question indicates that we must develop an integrated concept for urban goods distribution, leading to a more efficient urban goods distribution system. In this Part, we will complete the integrated concepts for urban goods distribution by integrating the different elements, presented in Parts III, IV, and V, into one integrated concept for urban goods distribution.

(3) In order to implement these innovations in the urban goods distribution system, how should a consistent and integrated set of policy measures be structured, which public policy actions can be defined, who should perform these actions and in what order should these actions occur?

In other words, we must develop an implementation strategy for the implementation of the integrated concept for urban goods distribution. The approach to developing implementation strategies for urban goods distribution will be defined in the institutional framework. It will then be applied to the implementation of the integrated concept for urban goods distribution, in Chapter 37.

(4) Does the integrated concept for urban goods distribution lead to the required level of efficiency improvement, and is the implementation of the concept feasible?

This research question requires an evaluation of the integrated concept for urban goods distribution and of each step in the implementation strategy in terms of efficiency improvement and feasibility. In Part VI, we will apply the principles of system optimisation and efficiency, as defined in Part II (Section 7.2). We will evaluate the integrated concept on its social and economic efficiency. We will also consider the strengths, weaknesses, opportunities, and risks in implementing the proposed innovations and policy actions in urban goods distribution.

The research questions will be further elaborated in the following chapters. The next section briefly outlines the contents of Part VI.

33.2   Contents of Part VI

In this Part, we will develop and apply an institutional framework bridging the gap between theory and practice in the policy-making process, with reference to the participation of actors. We will also define the role of analysis and modelling as a tool in the policy-making process. We will apply the notion of 'concerted actions' by public and private parties within the field of urban goods distribution. We will contribute, in this way, to traditional systems analysis (see for instance Miser & Quade, 1985). We will also contribute to the network approach as a public policy and planning concept (see for instance Glasbergen, 1989) in the sense that we combine it with elements of systems analysis. Thus, we will contribute to innovations in public policy and planning.

Consultative planning
The strong involvement of private actors in the urban goods distribution process requires a public planning style in which governments can act as facilitators: they can present a window of opportunity and encourage public participation. This we call consultative planning. This type of planning requires a synchronised process of consultation and concerted action, as well as a synchronised process of analysis and modelling during the public policy making process.

Levels of intervention
By applying the transport layer scheme, we can distinguish six levels of intervention in the urban goods distribution process. These levels are demand control and transport prevention, logistic optimisation, transport optimisation, traffic optimisation, infrastructure provision, spatial structuring, and environmental costs reduction. Policy options can be defined at each level.

Integrated design
We propose the implementation of new advanced physical distribution concepts that are based on the *consolidation* of flows and the full utilisation of the benefits of consolidation (*efficiency improvement* and a *better logistic performance*). These concepts will be made possible by re-arranging the base activities within the *spatial* and *organisational* logistic chains, relating to spatial relocation and the relocation of an activity between logistic units, respectively. Improvements in the transport system and changes in land use will support these new concepts.

Integration of networks
The integrated design for urban goods distribution is based on the integration of networks at different levels, namely: logistic networks, transport networks, and the spatial network. These networks are supported and facilitated by underlying networks. Overall efficiency improvements are possible only when each network in the system is attuned to the other networks in the system. Nodes and links within these networks will have to correspond. The physical elements of the networks are the urban transport network, the national backbone network, and the logistic nodes.

Implementation strategy
We apply a seven-step approach to developing an implementation strategy for urban goods distribution. The implementation strategy is divided into three stages: short-term, medium-term and long-term. Within each stage, we will discuss possible options and propose public policy measures.

Conditions for efficiency improvements
We evaluate the integrated design by defining the conditions under which efficiency improvements will occur.

The contents of Part VI are as follows. Chapters 34, 35 and 36 elaborate on the first research question, how does and how should public policy-making and planning on urban goods distribution occur. Therefore, Chapter 34 introduces the institutional framework for urban goods distribution, clarifying and defining the roles of the various actors within the implementation strategy. Chapter 35 proceeds with an overview of public policy and planning options. This is followed by an overview of the current state of public policy-making in different countries (Chapter 36).

The second and third research questions are related to the design of the integrated concept and the required implementation of innovations, and will be addressed in Chapter 37. Chapter 37

presents the main elements of the integrated concept and develops an implementation strategy.

The evaluation of the integrated concept, as required for research question 4, is performed in Chapter 38. This chapter will explain the contribution to efficiency improvement made by the integrated concept. Further, we will elaborate on the strengths and weaknesses of the integrated concept and the risks and opportunities in implementation.

In Chapter 39, we will draw conclusions regarding the implementation strategy, and recommendations will be formulated. The structure of the chapters in this part is shown in Figure 33-2.
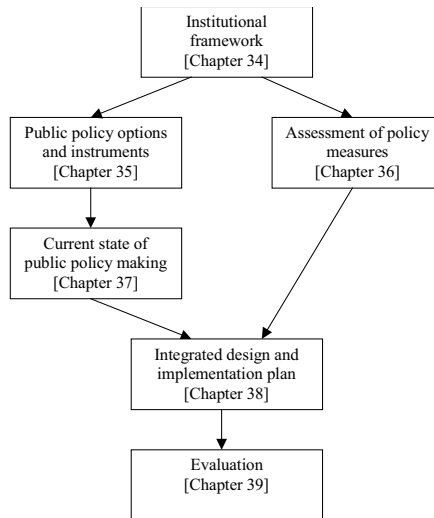
Figure 33-2:   The structure of part VI

34. Institutional framework

34.1 Introduction

The objective of this chapter is to establish an institutional framework which defines the roles of different actors, in particular the role of the public sector in the optimisation the urban goods distribution process. The implementation of a new integrated concept for urban goods distribution must be based on both private and public involvement, and must therefore include the actions of public and private actors. Therefore, we will adopt the concept of consultative planning as a public policy and planning instrument, suitable for this purpose. Finally, in this chapter, we will define the steps in the development of implementation strategies and apply it to urban goods distribution.

The institutional framework identifies the public and private actors within the field of urban distribution and defines their roles. The combination of actions, which actors perform to achieve a certain goal or objective, is referred to as a *policy*: the ambition to reach certain goals with certain instruments and by a succession of policy actions in time as a *policy strategy* (based on Hoogerwerf, 1985). In the situation with a multitude of actors, policy can be defined as: "a complex of decisions and herewith coherent actions (or absence of actions) by an actor towards a problem or target group" (based on Bukkems, 1989).

In general, policy-making starts when problems are anticipated, challenges occur, objectives have to be set and met, or guidelines or rules are needed. Most often, it is a combination of these factors. For instance, in urban goods distribution, the problems related to the environment and accessibility act as starting points for policy-making in that area.

The institutional framework also includes a 'format' for policy-making processes. Here, the following aspects of policy-making in urban goods distribution are pertinent:

- Policy-making is simultaneously a continuous process of policy preparation, implementation, and enforcement, rather than a linear process, starting with problem formulation and ending with the implementation. This dynamic and interactive method of policy-making requires a more permanent basis for monitoring, controlling, consultation, and decision-making.
- Modern policy-making not only consists of the active participation of public and private organisations at different levels of consultation, but should also include a proper analytical base for evaluation and monitoring of policy measures.
- There are different levels of intervention in the urban goods distribution system, represented by the layer scheme (see Part II, Chapter 8).

The policy process in the field of urban goods distribution is unique in the sense that many public and private actors are involved in different ways and that the problems are multidimensional.

In this chapter, we will analyse the planning process and implementation aspects with respect to urban goods distribution.

34.2   Policy actors and their interests

In the operation of the transport system for urban goods distribution, many actors and regulators (public and private) are involved. It is a public-private operation of the transport system. The term *actor* is a general term for individuals, groups, or organisations that have an interest (stakeholder) or are active within a particular area, in this case urban goods distribution. Actors can be divided into groups. The representation of urban goods distribution as a multi-layer scheme (described in Part II, Chapter 8) is a base for a classification of actors (Figure 34-1).

Governments have limited control over the system. In order to meet their goals, they need support in terms of commitment or participation from the private actors, regulators or other stakeholders. This influences to a large extent:

- The public policy objectives, in terms of considering the interests of the actors involved;
- The public planning process, in terms of the steps to be taken for analysis, communication and consultation;
- The type of public policy actions (measures).

Figure 34-1 displays the different actors and the roles they play within the process of urban goods distribution. The figure does not explicitly differentiate between public and private actors because in practice these roles can shift between these actors.

PRIMARY SERVICES   PRIMARY ROLES   ACTORS

Economic Activities	
	Shipper (conseignor), Receiver (Conseignee) — producers, consumers, retailers
Integrated Logistic Services	
	Integrated Service Providers — logistic service provider, integrators
Load Unit Services	
	Load Unit Operators — carriers
	Load Unit Providers — container leasing companies
Transport (means) Services	
	Transport means Operators — carriers
	Transport means Providers — transport means leasing companies
Traffic (means) Services	
	Vehicle (Traction) Operators — traction providers, carriers
	Vehicle (Traction) Providers — traffic means leasing companies
Infrastructure Services	
	Infrastructure Operators — traffic managers & regulators (government)
	Infrastructure Providers — infrastructure owners (private, government)
Resource Management	
	Resource Managers — regulators (government)
	Resource Providers — exploration/mining companies,

* resources relate to all 'means'

Figure 34-1:   Primary roles and actors related to the service levels in the goods transport layer scheme (see Part II, Chapter 8)

The various actors have specific interests as Figure 34-2 shows, and play distinct roles within the process of urban goods distribution (Figure 34-1). Therefore, these actors involved, have different objectives and use different weighing sets for the costs and benefits (or, in other words: utilities and disutilities, as defined in Part II, Chapter 7) related to goods distribution. For instance, consignors or consignees in the role of shippers tend to maximise their level of sales service, including costs, pickup and delivery times, and reliability, while freight carriers try to meet the level of service required by the shippers (external goal), and try at the same time to minimise the costs of delivering and collecting goods (internal goal). Residents and visitors have a different focus from most other stakeholders; they use the urban environment for their own activities. They do not welcome traffic, and would like to minimise the difficulties caused by traffic, but at the same time profit from the supply of goods to the urban areas. Their interests conflict with the interests of actors which depend on the delivery of goods in urban areas, such as carriers and retailers.

Residents and visitors are not direct participants in the urban distribution process, with the exception of the significant distribution of goods from outlets to the homes. They are not direct participants, but they are stakeholders. Because they can not guard their interests very well, their role must be played by public agents. Public actors care for the 'general' interest of the society.

Public actors function at different levels (local, regional, national and international) each with their respective roles. In urban areas, the local governments are the most directly involved. The scheme in Figure 34-2 depicts the various actors and their—sometimes conflicting—interests.
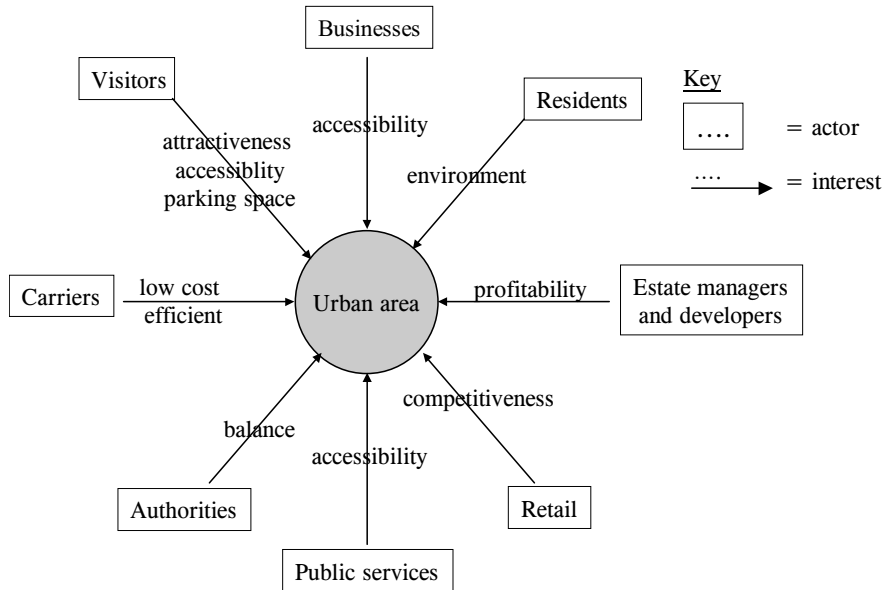
Figure 34-2: ***Urban goods distribution in inner cities influences interests of various actors***

34.3 The public policy-making process

34.3.1 Introduction

Planning styles are a key element of the policy-making process. The type of planning style depends very much on the role of the government. There are different classifications of planning styles to be found in the literature, for instance in Geurts (1995), Orthùzar and Willumsen (1990) or Simonis (1983).

We propose the following typology of planning styles:

- Traditional planning, in which governments act as doctors: they try to control processes and try to solve problems with public measures. This leads in general to a typical top-down approach. Top-down approaches in urban freight transport generally concern policies, initiated by the public sector, in particular the national government.
- Progressive planning, in which governments act as educators: providing information to the relevant actors and try to let them solve the problems. This bottom-up approach is recognised by the active role of the private sector
- Consultative planning, in which governments act as facilitators: They present a window of opportunity and encourage public participation. This method of planning is a combination of bottom-up and top-down.

The types of associated roles by public actors are 'dictatorial', 'stimulating', and 'co-operative' respectively, added with the 'demand responsive' approach (see also Part II, Section 10.2).

Consultative planning offers opportunities to combine elements of the top-down approach with elements of the bottom-up approach, as illustrated in Figure 34-3. The role of the public sector as facilitator is similar to the role of the public sector in urban goods distribution. Therefore, we suggest the adoption of this planning style.
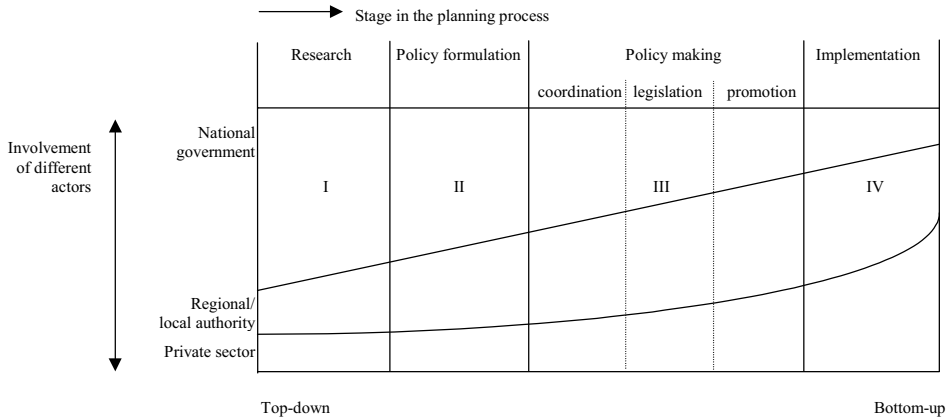
Figure 34-3: *A combined top-down and bottom-up policy-making (see Visser & Van Binsbergen, 1999b)*

Guidelines for the planning process are essential for a successful implementation of policies. The following terms of reference for policy-making are based on the consultative planning style (Geurts, 1995):

- Policy-making is a rational process. Decisions are the results of series of identifiable steps. These steps do not have to be linear in time.
- One can speak of a poly-actor model. The policy-making and implementation occur by many public actors with their own values, interests, responsibilities, and rationalities. However, during the policy-making process, it is necessary to a multitude of actors with overlapping and/or unclear authorisation and responsibility, but limited numbers of representatives.
- The policy making process must be well-structured; offering space and a framework for policy enforcement and adjustment. At the same time, the policy process may not show (organisational, in time and in contents) an unreliable behaviour. Related to time, this means: the use of milestones. Organisational: the use of fixed phases and places, in which at is clear who will be involved. In contents: use of benchmarks, consideration of existing policies and earlier agreements.
- Objectives must be defined clearly and should be made operational for evaluation purposes. This means no vague, unclear, or ambiguous objectives, but certainly no over-specification and detailing of objectives.
- Consensus on policy objectives and instruments is not, by definition, necessary. Policy-making is a process of consultation and negotiation, in which frequent compromises are

made. The public actors are not necessarily in hierarchical relation to each other. Although, a historical developed and institutionalised network of policy management exists between the public actors.

- The policy itself must be supported by sufficient means to realise the objectives.
- The policy making process requires optimal communication and information processes.
- Evaluation of policies should be possible during the policy-making and implementation. It concerns the degree of achieving objectives (effectiveness), the use of resources (efficiency) and coherency.
- Involvement and commitment of the relevant actors during the implementation. Avoid resistance by these actors (for instance, guarantee sufficient freedom of acting on the implementation level).

This type of policy-making means that relevant information will be needed in order to develop a policy vision, an agreement with the involved actors and an implementation strategy. In this respect, objectives need to be explicitly formulated, constraints and boundaries need to be set, and the solution area must be defined. This means that the policy-making process should be expanded with a synchronised process of consultation and a synchronised process of analysis and modelling, as shown in Figure 34-4:
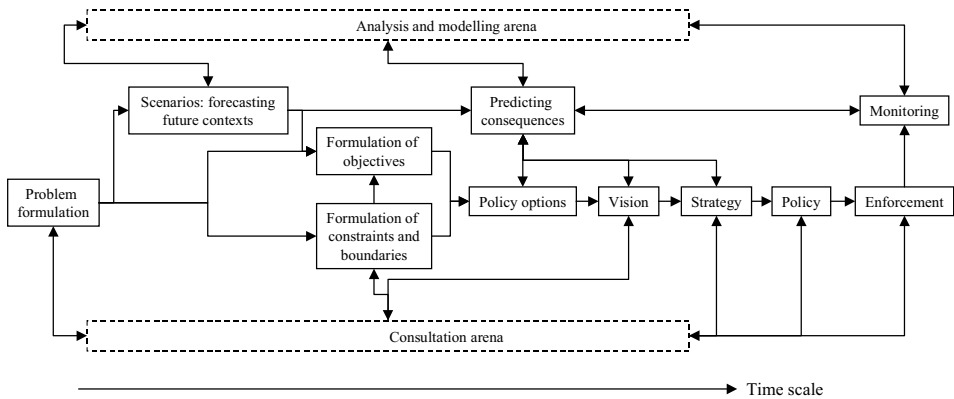
Figure 34-4: The process of policy-making (based on Miser & Quade, 1985)

The next sections will discuss the role of consultation and the role of analysis and modelling in the planning process.

34.3.2 Consultation as part of the policy-making process

Consultation can be positioned in between the horizontal and vertical co-ordination by governmental bodies and market self-regulation by the private sector (see Figure 34-5). Consultation, as a method of public-private co-ordination, has several objectives that especially hold true for urban goods distribution policy:

- To strengthen commitment (thematic or territorial) in order to
  - improve the social acceptance of policies, especially if benefits of measures are not 'visible' (i.e., environmental issues);
  - develop consensus among actors and to co-ordinate public and private policies to prevent future actions being counter-productive;
- To appeal to or activate additional knowledge, information and means from private actors;
- To improve the quality of the policy and the planning process, resulting in:
  - speeding up of the decision-making and implementation
  - an efficient distribution of costs, benefits and risks over public and private actors.

The result of the consultation process is a commitment to the final policy by the actors involved.

Different levels of participation of private actors in the consultation process can be distinguished, namely hearings, consultations and concerted action (see the participation ladder in: De Lange, 1999). Here, we will only consider consultation and concerted action.
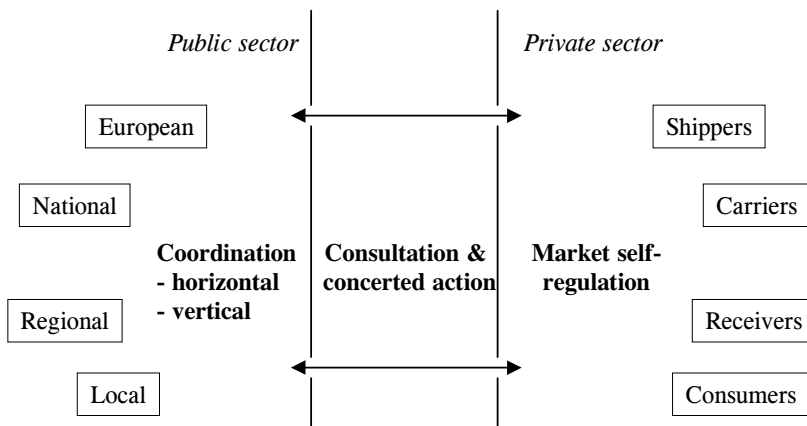
Figure 34-5:   *The position of consultation related to governmental co-ordination and market self-regulation*

Consultation occurs with the group of decision-makers (actors and regulators) active in the urban goods distribution system, and stakeholders. The decision-makers are in control of the urban goods distribution system. Stakeholders have interests but normally no active, decision-making role. In certain situations, the participation of stakeholders in the policy-making process is also relevant. The Vroom-Yetton model (see Figure 34-6) shows when a broad public participation is necessary (Daniels et al., 1996). It depends upon: 1) the quality requirements, 2) the available information, 3) the problem structure, 4) public acceptance, 5)

the decision makers' competence to make a decision, 6) the objectives, 7) the conflict to be expected, if public participation must be considered.
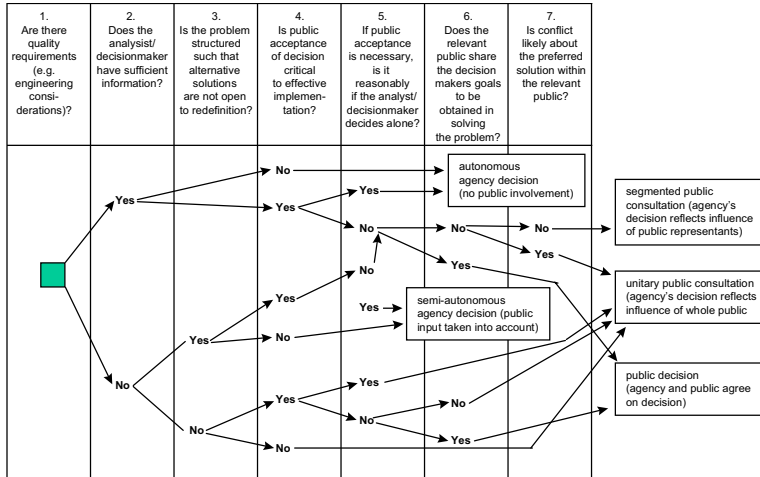
Figure 34-6: *Vroom-Yetton model to decide what kind of public participation is needed in during the policy-making process (Source: Beroggi, 1999 based on Daniels et al., 1996)*

Consultation is needed in different stages of the policy development and implementation process, as illustrated by Figure 34-7. During the policy-making process, it is necessary, particularly in the area of urban goods distribution, that the level of public participation increase. This is shown in Figure 34-7.
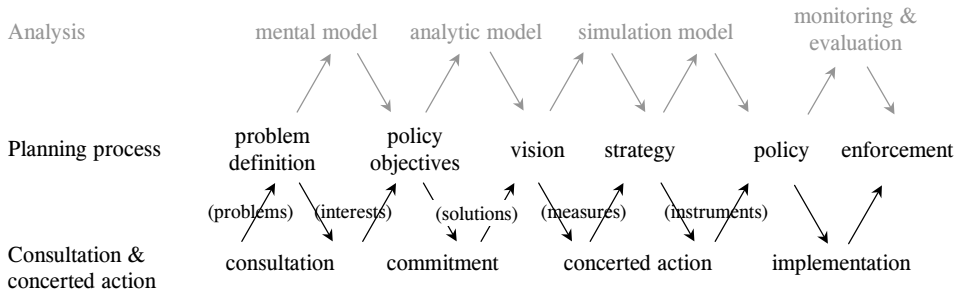
Figure 34-7: *Consultation with an increasing level of public participation during the policy-making process*

With respect to the different phases of the planning process (Figure 34-7), the different methods of consultation within the field of urban goods distribution can include:

- Consultation:
    - Identification of problems, encountered by the different stakeholders and shareholders;
    - Evaluation (ex ante) of the support for future policy actions;
    - Evaluation (ex post) of the effects of policy plans.
- 'Generation' of commitment: convincing actors to become actively involved, to support the policy, and to spend time in preparing the decision-making and implementation.
- Concerted action: persuading the actors to adopt the policy.
- Involvement in implementation: spending resources on the implementation of the policy by these actors.

During the policy-making process, the level of participation of private actors must increase for a successful implementation. The consultation must make clear what the interests and objectives of the actors are, and what the level of ambition of the policy will be. During the process, the actors will be consulted about the problems, possible solutions, and the choice of a policy. The participation will then grow from making a commitment, to making the policy a concerted action until the implementation of the policy.

In the Netherlands, the PSD (Platform Stedelijke Distributie –or, in English, Urban Distribution Platform) fulfils the role of a national consultation program in the field of urban goods distribution. Transport companies, retailers (consignors, consignees), logistic service providers, and public parties are involved in this PSD. Amsterdam was one of the first cities where a local program was enacted. The city of Leiden followed that example in 1999.

Consultation is a key element of the policy-making process. In the consultative planning approach, the participation of private actors in the planning process is essential for a successful implementation. Therefore, the level of participation must increase from consultation to implementation during the policy-making process.

34.3.3 Modelling as part of the policy-making process

The second element of the policy-making process is the role of analysis and modelling in providing relevant information for the policy-making process. Policy management literature in general, pays little attention to the role analysis and modelling can play. Although in this thesis we will not elaborate on the modelling of urban goods distribution (see Visser & Van Binsbergen (1999b) for more information on modelling), we want to stress the importance of analysis and modelling for providing the right information.

Transport models are traditionally used to estimate future travel demands and impacts. The use of models is an essential part of the analysis in the policy-making process. It must provide relevant information for the policy-making process. Marshall and Oliver (1995) make it clear that models play a significant role in the process of understanding a problem, in finding solutions, in supporting the decision-making process, and finally in monitoring and controlling the implementation process. The results of models can be used in the discussion with the public or actors involved. Although modelling is significant in the decision making process, it should be noted that models are seldom used in more than one phase of the planning process.

During the different stages of the planning process, the required tools for analysis and modelling will shift successively from a mental model, to an analytical model, to a simulation model, and finally to a monitoring and evaluation tool. This sequence is illustrated in Figure 34-8.
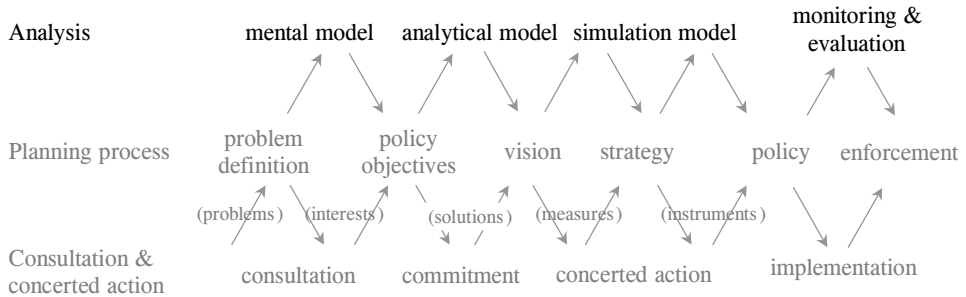
Figure 34-8:   ***The need for analysis and modelling in the different phases of the policy-making process***

When the policy measures are taken, the impacts of the measures must be monitored and evaluated (ex post evaluation). One can then compare the expected results with the real impacts. To perform such an evaluation, modelling tools are required. These tools should simulate the reactions of (other) actors to the proposed policy measures. Thus, the influence of proposed measures can be projected.

Marshall and Oliver observe an integration of forecasting and decision making and the use of graphical aids in the formulation and design of mathematical models and in the presentation of results to decision makers. They see the following as essential ingredients for an integrated forecasting and planning process:

- The development of a clear understanding of how uncertainty is to be handled, with a logical framework in which to discuss and analyse rational courses of action.
- A clear identification of the sources of uncertainty, identifying the effects of new sources of information and new forecasts and making it clear if the decision-maker and forecaster are one and the same or different people or institutions.
- A careful and thoughtful problem formulation, including who makes decisions, which factors are known, which ones are uncertain, which ones directly influence decisions, and the timing of information and decisions.
- Identification of the objectives of the decision maker(s) and the decision-making environment --it is important to understand how objectives have different effects on strategies, and how objectives depend on the client(s).
- Recognition of multiple attributes, and understanding the extent to which there may be trade-offs among them.
- Emphasis on sensitivity analysis, recognising that models are not just crude approximations of results and insights to decision-makers.

If we use this as a term of reference, we must admit that often not enough attention is paid to elements such as identification of the sources of uncertainty, and sensitivity analysis. An

integrated approach could not only lead to a more efficient decision-making process, but also to better planning practices.

There is not yet a common practice in urban goods distribution modelling. Some examples can be found in the literature. Ogden (1992) and Button & Pierman (1981) discuss earlier experiences with urban freight transport modelling. Oppenheim (1993), for instance, presents an overview of modelling approaches. More recent examples of urban freight transport models in France and Germany are discussed in the COST 321-report (COST 321 Action, 1998). The drawbacks of the current models are discussed by Visser & Van Binsbergen (1999b) and Taylor & Button (1999). The current models only offer choices at the traffic level (such as route-choice). The GoodTrip model (see Boerkamps & Van Binsbergen, 1999) is developed according to the multi-layer scheme for urban goods distribution (see Part II) and models logistic choices. Thus, urban distribution models, such as the GoodTrip model, provide relevant policy information.

34.4   Policy-making: implementation strategy development

34.4.1 Introduction
In this section, we will analyse the different steps of developing an implementation strategy as part of the policy-making process for urban goods distribution. An implementation strategy is an integrated and balanced set of policy measures put into a time frame. The strategy includes successive and related policy actions that guarantee a successful introduction of a complex and comprehensive policy plan. The implementation strategy ensures that:
- short-term and medium-term measures comply with long-term measures;
- measures are mutually supportive and complementary .

Related to the policy-making process, as shown in Figure 34-4, we propose the following seven-steps approach:
1. Identifying time-stages;
2. Formulation of objectives;
3. Inventory of policy options (*solutions area*);
4. Vision: formulating an optimum scheme (*soll*);
5. Analysing the state of affairs (*ist*);
6. Identifying the discrepancies;
7. Strategy: developing the implementation strategy.

In this section, we now focus on each step of the planning process towards an efficient goods distribution systems for urban areas (see Section 34.4.2 to 34.4.6).

34.4.2 Stages in time
The urban goods distribution system is in constant flux; at every moment, changes occur, 'new' concepts are introduced and 'old fashioned' concepts are set aside. To enable the design of a clear implementation strategy and a related policy plan, different time stages must be defined that differ in available (private and public) policy options. Some policy options require a longer time span to be introduced. For instance, the planning and construction of infrastructure can take a period of more than ten years.

Nevertheless, we can make an arbitrary segmentation based on 'short-term', 'medium-term' and 'long-term', taken from earlier studies on urban distribution schemes and underground urban distribution systems (See Van Binsbergen & Visser, 1997a), where short-term is regarded as 'within five years', medium-term as 'within 10 years' and long-term as '10 years or longer'.

34.4.3 Formulation of objectives

Formulation of targets is part of the operationalisation of policy objectives, as is explained in Part II (Section 10.5). The formal approach is:

- Problem formulation and analysis;
- Formulating policy objectives;
- Identification of gaps.

Indicators are used to quantify policy objectives in order to be useful for evaluation purposes. These indicators are used as criteria in the evaluation phase. In general, criteria will be related to the utilities and disutilities of the options to be evaluated.

There is a strong relationship between the problems of urban goods distribution, analysed in Part I and policy objectives. Literature (i.e., Ogden, 1992) provides us with a full set of policy objectives. The categorisation of policy objectives is shown in Figure 34-9.
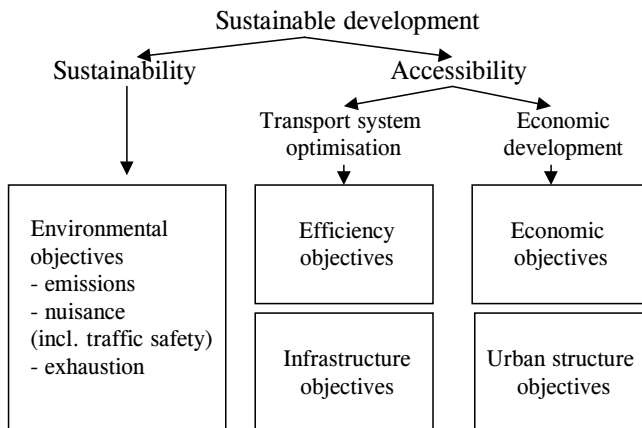
Figure 34-9:   *Policy objectives for urban goods distribution (based on Visser et al., 1999)*

The policy objective of 'sustainable development' can be considered as an overall policy objective. Two other groups of policy objectives, 'sustainability' and 'accessibility', support the concept of sustainable development. Accessibility objectives deal with transport system optimisation objectives and, therefore, with economic development objectives.

The policy objective of 'transport system optimisation' correlates strongly with economic development as well as with environmental objectives, in the sense that it supports both. The level of support depends on the valuation of both the economic and environmental costs and benefits of the transport system.

In this context, sustainability deals with environmental objectives. The environmental objectives refer, obviously, to the environmental disutilities or costs of transportation. The

transport system optimisation objectives (the efficiency objectives and infrastructure objectives) refer to economic costs or disutilities as well as to utilities, related to the performance of the transport system, expressed in transport costs, time, reliability and safety. The third group, economic development objectives, refers to the indirect economic benefits of transportation, and can be expressed, to some extent, in economic costs as well.

In practice, the relevance of policy objectives is quite situation specific and can differ between local and national levels. It can also be different for each urban area or country. This will be demonstrated in Chapter 36.

In Part II, the objective of the public sector is defined as an optimisation: minimising the costs or disutilities of urban goods distribution (or any other activity), given a set of public weights for each of the costs or disutilities involved (see Part II, Chapter 9) under the condition that the level of service or performance (or amount of utilities) stays equal or improves.

34.4.4 Inventory of options and formulating an optimum feasible scheme
The basis for constructing an integrated urban distribution concept and the related implementation strategy was developed in Part II (Chapter 10) of this thesis. In Part II (Chapter 8), we also explained that the transport system functions as a multi-layer system. Underlying layers facilitate the layers above. Overall efficiency improvements are possible only when each layer in the system is attuned to the other layers in the system.

The integrated design for the distribution of consumer goods consists of three main layers:
- Logistic systems, developed in Part III (Chapter 18), 'Logistics for urban goods distribution';
- Transport systems, developed in Part IV (Chapter 26), 'Transport systems for urban goods distribution';
- Spatial systems, developed in Part V (Chapters 30, 31), 'Spatial networks'.

The ultimate efficiency improvements are reached by a combination of these levels, which we call the *integrated* logistic concept for goods distribution. The main elements of the integrated logistic concept for goods distribution have already been presented in parts III, IV, and V.

The key element in the integrated concept is that the logistics systems are facilitated by corresponding transport systems and these, in turn, by the appropriate spatial system.

For each stage in the implementation strategy, an inventory of options in terms of logistics, transport system and spatial system must be made. A key criterion is the feasibility of the option in that stage: the likeliness that an option can be introduced in that stage at acceptable costs, or in other words, the costs for introducing the option may not have a (net) negative impact on the functioning of the system (the demand may not be significantly affected).

The feasibility should be regarded from technological, economical, practical, and juridical perspective; the option must be:

- Technologically available (not in a development or testing phase);
- Economical: the costs of introduction and use must be comparable with existing alternatives or the costs must outbalance the benefits of the option;
- Useable and applicable: there must be no need for excessive additional measures to enable the use (unless these measures are itself feasible);
- Juridically supported: there are no legal obstacles for use.

The feasibility issue affects the stage in which an option becomes available.

Generally, improvements on existing systems ('evolutionary developments') are easier to implement and are more easily accepted than completely new systems ('revolutionary developments'), especially when developments ask for widespread investments. Even if long-term benefits are eventually envisaged, this is no guarantee for positive investment decisions. Long-term developments also need to be supported by short-term developments. Short-term developments should prepare for the implementation of long-term developments.

An 'optimal' feasible scheme is a combination of available options, such that the market demands are fulfilled at least at the level of autonomous development, but if possible at a higher level, while the negative side effects are within the targets set. The optimum should be a societal optimum, and should thus include private and public optimisation. The optimal future scenario, in this case, is a goods distribution system, optimised in an economic and environmental sense. Efficiency improvements are reached by a better *utilisation* of the transport system and by using efficient means (*conservation*) (see Part II, Section 7.2.4). Consolidation, (as developed in Part II, Section 9.5), is the main step towards utilisation and conservation. Thus, both groups of policy objectives, defined earlier, can be met.

Because it is difficult to formulate targets in a general sense, the most practical general approach is to design a scheme, complying with the following conditions:

- Does not interfere with the demand side of urban goods distribution;
- Tries not to increase the relative cost levels for distribution (relative to the distribution costs of non-urban areas), unless striking improvements can be achieved ('utility');
- Tries to minimise any negative side effects, as much as possible.

34.4.5 Analysing the state of affairs and identifying the discrepancies

In the analysis of the state of affairs at each relevant stage, we have to establish what developments would occur autonomously, or without urban goods distribution policy-related incentives. The state of affairs is a description and analysis of the current situation (regarding urban goods distribution) or a projected situation, with no change in policy intervention. This is also referred to as the reference situation or "null" alternative. This 'policy free' state of affairs is difficult to establish, because autonomous developments also react to the conditions in urban goods distribution. After the state of affairs is established, any discrepancies can be identified and these discrepancies then form the basis for the development of the implementation strategy.

The problem definition in Part I establishes the state of affairs for urban goods distribution. The problem definition analyses which exogenous developments influence the demand for urban goods distribution and how they will develop in the future.

34.4.6 Developing the implementation strategy

The implementation strategy is a plan which shows the consecutive steps (measures) that must be taken from the 'current' state of affairs to the envisaged optimum feasible scheme. The strategy provides an outline of the actions and measures required to implement the scheme, and then relates these actions and measures to a timeline. The strategy aims at remedying any discrepancies identified in the previous step.

The implementation of the integrated design as presented in parts III, IV and V is not limited to technical and logistic changes. In addition, spatial, economic, organisational, and social changes have to occur. Furthermore, public policy and regulation must support or even enforce these developments if there are important societal benefits but not as many private benefits[1]. All these elements are part of the implementation strategy.

The approach chosen to set out a public planning policy for goods distribution in urban areas is based on the back-casting method, described in Part II (Section 10.3), and will be used in Chapter 37 of Part VI.

34.5   Conclusions

This chapter presented the first part of the institutional framework for the design and implementation strategy for efficient goods distribution systems in urban areas. In this part of the institutional framework, we looked at the actors who play a role in the urban goods distribution process and their interests in urban goods distribution. We discussed the appropriate public policy-making process in the field of urban goods distribution and concluded that the following aspects of policy-making in urban goods distribution are relevant:

- Policy-making is a continuous and virtually concurrent process of policy preparation, implementation, and enforcement.
- Modern policy-making not only consists of active participation of public and private organisations by means of different levels of consultation, but also includes a proper analytical base for evaluation and monitoring of policy measures.
- This dynamic and interactive method of policy-making requires a more permanent basis for monitoring, controlling, consultation, and decision-making.
- There are different levels of intervention in the urban goods distribution system, as represented by the layer scheme.

The implementation of a new integrated concept for urban goods distribution must be based on both private and public involvement, and must therefore include the actions of both public and private actors. The involvement of private actors is based on their interest in urban goods distribution or in the problems it can cause. This strong involvement implies a public planning style in which governments act as facilitators. Therefore, we have adopted the concept of consultative planning as a public policy and planning concept, suitable for this purpose. This method of planning combines top-down long-term vision with bottom-up implementation.

---

[1]   Or in the case private parties find themselves locked in a 'prisoners dilemma' situation, from which no singular firm can escape although if all firms should co-operate, a better situation should emerge; public action can force the private parties out of this lock-in situation.

Consultation is an important part of the policy-making process. In the consultative planning approach, as suggested here, the participation of the private actors in the planning process is essential for a successful implementation. Therefore, the level of participation increases from consultation to concerted action and implementation during the policy-making process.

The second element of the policy-making process is the role of analysis and modelling in providing relevant information for the policy-making process. For example, analysis and modelling are needed to provide relevant information for decision making and monitoring. There is no common practice in urban goods distribution modelling. A new generation of models, such as the GoodTrip model, should be developed according to the multi-layer scheme for urban goods distribution. Thus, urban goods distribution models provide relevant policy information.

We analysed the different steps for developing an implementation strategy as part of the policy-making process for urban goods distribution. An implementation strategy is an integrated and balanced set of policy measures put in a time frame. The policy-making process is tailored for our purpose through a seven-step approach for implementation strategy development:

1. Identifying time-stages;
2. Formulation of objectives;
3. Inventory of policy options (*solutions area*);
4. Vision: formulating an optimum scheme (*soll*);
5. Analysing the state of affairs (*ist*);
6. Identifying the discrepancies;
7. Strategy: developing the implementation strategy.

This approach will be used for the design and implementation strategy for efficient goods distribution systems in urban areas in Chapter 37 of Part VI.

35. Public policy options and instruments

35.1   Introduction

This chapter continues with the development of an institutional framework for urban goods distribution policies and deals with the policy and planning options, as explained in Section 33.1. These options or policy measures define the area for possible changes and solutions in the urban goods distribution system. It is important to survey the full range of policy options, as is elaborated in Section 34.4. The scope of options will be presented here. A policy option, or policy measure, is defined as *a government action based on governmental instruments*. For this purpose, seven levels of interventions in the urban goods distribution system are distinguished and will be presented in Section 35.2. At each level, the possible policy options will be discussed. Next, a typology of policy instruments will be presented. Governmental instruments or policy instruments are instruments or actions, which a government is entitled to use in order to carry out a policy. They are the tools of governments during the policy-making process. With the typology, it is possible to define the role of public policy-making in the implementation strategy, as discussed in Chapter 37.

35.2   Policy options

Levels of intervention
In the area of domestic freight transport, several classifications of policy options have been developed in order to present the scope of possible policy options (Bakkenist, 1998; B&A Groep, 1998; Cost 321 (European Commission Directorate General Transport, 1998)). In our opinion, these classifications are inappropriate for our purposes, as they are incomplete and

tend to overlap. We have used the systems methodology (see Part II, Chapter 8) to identify starting points for policy options. Usually, policy options are more effective when they relate to 'high' levels in the scheme. For example, influencing production and consumption has more impact than promoting energy-efficient trucks. On the other hand, it is usually easier to take measures in the 'lower' levels of the scheme because fewer actors are involved. A well-balanced long-term policy strategy integrates measures at different levels. By fine-tuning the policies at different levels, there will be fewer inconsistencies and policy measures will not counteract each other.

The different levels are shown in Figure 35-1.
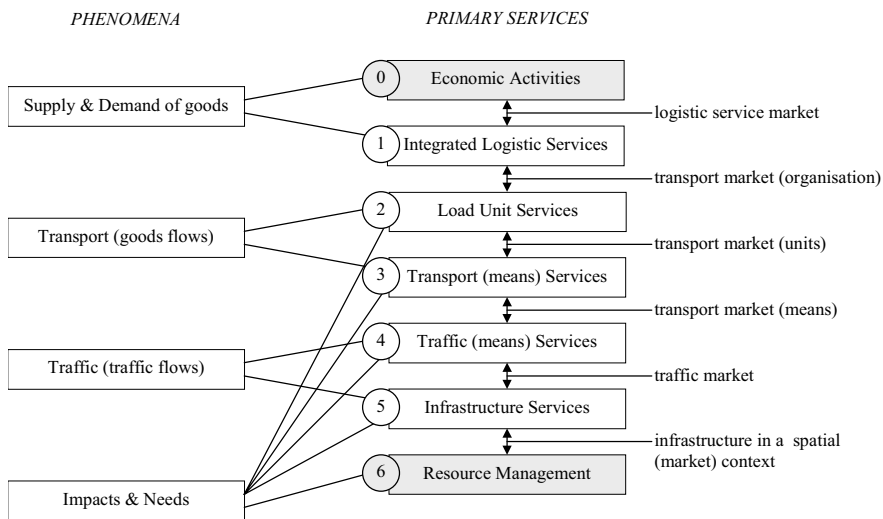
Figure 35-1:   *'Phenomena', service layers, and markets in the goods transport system*

Level 0: Demand control and transport prevention or avoidance (primary service: economic activities)

The need for freight transport is basically caused by our consumption patterns. The consumer decides which goods to consume and where to get them. Although measures to control the demand are not within the scope of transport policies, they should be mentioned. From a societal point of view, demand control is generally considered unacceptable.

Transport prevention or transport avoidance is a relatively new issue in this area (see, for instance, Bakkenist, 1998). It concerns the control of volume and distance in the movements of goods. The following strategies are recognised:

- Transformation from goods to electronic information;
- Reduction of weight or volume of goods;
- Reduction of packaging material;
- Local production (stream assembly down or up);
- Consolidation of production (brandless assembly);
- Regional suppliers.

The main focus of these strategies is to reduce the size and weight of goods to be transported and to reduce physical distances by relocating production activities closer to the customer, or closer to the resources.

Level 1: Logistic optimisation (primary service: integrated logistic services)
Logistic chain optimisation concerns the reorganisation of the logistic chain. Consolidation, with or without a modal shift, leads to a more efficient use of the transport system. The following strategies have been defined:
- Chain optimisation and consolidation (instead of partial optimisation);
- Virtualisation of the logistic chain, (i.e., by using logistic information systems, either in-company or between companies);
- Consolidation of the logistic chain by co-operation or outsourcing;
- Consolidation within transport means or modal shift (intermodality);
- Shifting of distribution activities in time (night distribution) or space (dispersal).

Part III deals with these optimisation strategies (for examples, see Section 13.4 and Chapter 18).

Levels 2 and 3: Transport optimisation (primary services: load units and transport means services)
There is a strong relationship between logistics optimisation and transport optimisation. The following strategies are, however, typical transport optimisation strategies:
- Optimising vehicle utilisation;
- Enabling the use of large-scale transport means (inter-modality).

Part IV deals with these optimisation strategies (see, for example, Chapters 22 and 23).

Level 4: Traffic optimisation (primary service: traffic means service)
Regarding traffic optimisation, it is relevant to consider the target group, whether freight traffic, car traffic, cyclists, or all traffic. The following strategies for traffic optimisation in urban freight transport policy and planning can be mentioned:
- Infrastructure-use licensing and regulation (entrance times, dedicated routes, emission restrictions);
- Dynamic route-planning;
- Parking or loading strategies. There are different types of facilities for parking, loading and unloading: curb-side use, off-street facilities and truck parking facilities;
- Road pricing.

These strategies are discussed in a study for the city of Delft (see Van Binsbergen & Visser, 1997a), and also in Part IV (Chapters 24 and 25). In Section 35.3.5, licensing and regulation will be elaborated.

Level 5: Infrastructure provisioning (primary service: infrastructure services)
With respect to infrastructure provisioning, policy options include:
- Improvement of load/unload facilities;
- Introduction of dedicated infrastructures.

The improvement of load/unload facilities is a well-established policy option. However, the introduction of dedicated infrastructures is new and innovative, and is discussed in Part IV (Chapter 25).

Level 6: Spatial structuring and environmental costs reduction (primary service: resource management)

Resource management refers to both the improvement of the use of space by means of spatial structuring, and the reduction of environmental costs. One strategy for spatial structuring for optimisation (see Part V, Chapter 29) is:

- Location and zoning of land use. For instance, spatial concentrations of transport generating or attracting activities near freight transport facilities.

The use of resources is quite strongly related to environmental costs, related to different kinds of pollution, in particular air pollution and noise, and to the use of natural resources, such as fossil fuels.

Strategies to reduce environmental costs are related to:

- Cleaner fuels;
- Catalysts;
- Noise reduction;
- Energy-efficient engines
- Silent road surfaces.

European standards for vehicle emissions, as introduced since 1988, have led to significant reductions of emissions. Proposed new standards will further reduce these emissions.
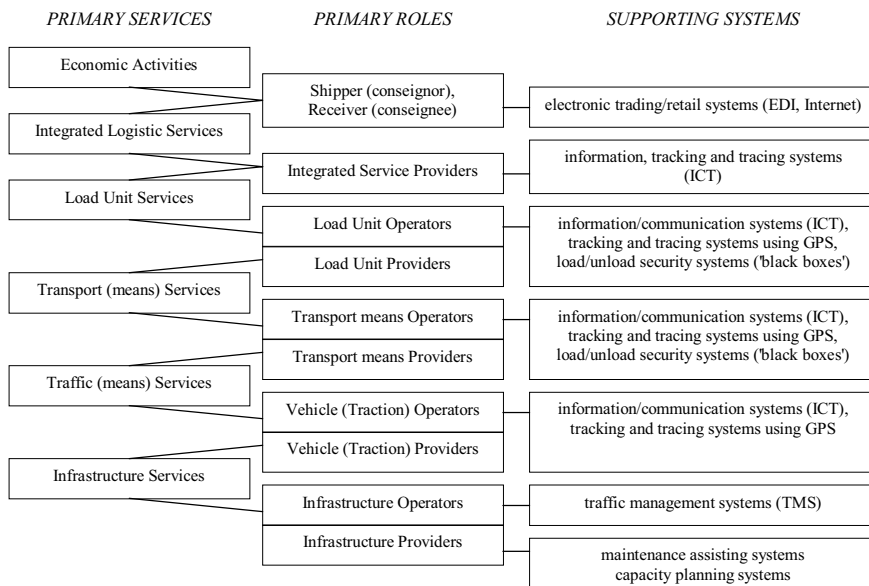
Figure 35-2:   *Support systems in urban freight transport*

As demonstrated in Figure 35-1, each level represents a service in a specific market situation. Markets depend strongly on information exchange. Thus, information is required to monitor market processes. Information systems can improve these market situations. Therefore, for each level, information systems can be distinguished to support that service. Because they are not related to a specific level, we present them separately, but we will not discuss them here. Figure 35-2 shows what kind of support systems can be defined in the field of urban goods distribution.

At the level of resource management (not presented in Figure 35-2), information support systems, such as local pollution warning systems, can also play a significant role.

35.3   Policy instruments

35.3.1 Introduction
In this section, we deal with the instruments that a government is entitled to use in order to carry out a policy. Policy instruments can be categorised in different ways (see Bruijn and Hufen (1992) and Louw, Nijkamp and Priemus (1991)). The following typology of policy instruments is proposed:
- Active involvement as a:
  - Developer;
  - Provider;
  - Operator;
- Planning instruments concerning:
  - Infrastructure planning;
  - Spatial planning;
- Financial instruments dealing with:
  - Taxes and pricing;
  - Financial support;
- Legislative instruments (licensing and regulation);
- Communication and consultation instruments;
- Agreements and covenants.

The typology of policy instruments is quite general and is applicable to different layers in the urban goods distribution system as defined in part II. The policy options presented at each level in Section 35.2 can be supported by these policy instruments.

35.3.2 Active involvement
Active involvement by the public sector can have three roles:
- Developer: The public sector can play this role in different ways, for instance as developer of technology or the infrastructure.
- Provider: The public sector can provide the financial means.
- Operator: The public sector can operate the systems.

Besides active involvement, there are also more passive ways of involvement. This way of involvement refers to the other instruments discussed in this section.

Active involvement of governments can occur at different levels of the urban goods distribution system. In the urban goods distribution layer scheme, presented in Part II, governments can, in theory, play any of the 'primary roles' defined at each service level. For instance, the public sector plays an 'active' role in the provisioning of the infrastructure. SDC Leiden is an example of an active involvement of the local government in urban distribution.

35.3.3 Planning instruments

The use of planning instruments is a more passive means of involvement for governments. Urban goods distribution land-use and infrastructure are a significant issue in planning. The public sector has responsibilities regarding the planning of infrastructure and land-use planning.

Infrastructural measures
The planning of the physical infrastructure relates to the location, capacity, and purpose of the infrastructure.

Spatial measures
Land-use planning is an instrument to quantitatively and qualitatively control the supply of land or space. Thus, some control over the location of economic or logistic activities is possible, for example, the ABC-location planning (see Part I and also Part V).

35.3.4 Financial instruments

Traditionally, financial instruments are classified into two groups; supportive instruments, and punitive instruments. Financial instruments can be used to support developments (subsidies) or to slow down developments (adding external costs through taxes and pricing). Therefore, we distinguish between taxes and pricing instruments, and instruments for financial support.

Taxes and pricing
Taxes and pricing are widely used policy instruments. There are a large variety of taxes and pricing instruments, such as road pricing. We will not discuss these in detail, but we must mention that the levels of intervention can range between price regulation, which can be imposed in order to fix rates or prices, and methods of taxation such as on-the-spot fines.

Financial support
Financial support can vary in the level of subsidisation between, including such instruments as:
- Financing;
- Subsidies;
- Credit loans;
- Acting as a guarantor for financing.

For instance, financial support may be used for the development or market introduction of services or technologies.

Financial instruments can be applied to urban goods distribution in many ways. At almost all levels of the urban goods distribution layer scheme, financial instruments can be applied.

35.3.5 Licensing and regulations

Licensing and regulation can be applied to every market situation; thus, licensing and regulation can be applied to all the levels of the urban goods distribution scheme. In practice, licensing and regulation is applied at the infrastructure service level of the urban goods distribution scheme, in terms of traffic and vehicle regulation.

Ogden (1992) describes several types of traffic and vehicle regulations. Some of these, such as time windows and vehicle restrictions, have been broadly implemented in various countries. Experience with time windows shows that time windows that are too tight, or cover too broad an area, can cause accessibility problems and extra traffic during peak periods. This shows the importance of co-ordinated time-windows. Experience with vehicle restrictions shows that standardisation is a critical factor for success.

Traffic calming measures

When required, sections of the city can be made unattractive for cars (and therefore also for trucks); indeed, their use can even be completely forbidden. These techniques are known as eco-zones, car-sheltered areas, and pedestrian areas.

The following types of entry restriction can be applied to freight traffic:

- The period during which one may enter (time windows);
- Dimensions and/or surface areas of vehicles;
- Axle load and/or vehicle weight;
- Emissions;
- Noise;
- Target group and/or urgency;
- Load factor;
- Any combination of the above.

Restrictions based on dimensions and/or surface areas of vehicles (such as those applied in Paris and other urban areas) are primarily intended to limit the physical hindrance of freight traffic. Smaller vehicles are easier to manoeuvre in the urban environment, and the driver's control of the vehicle is usually better. In many municipalities, the maximum length used is ten metres.

Restrictions based on axle load and/or vehicle weight are meant to limit the physical damage that freight vehicles inflict on the infrastructure and its surroundings. The infrastructure at risk of damaged may be located either under or beside the road surface. A frequently-used restriction on axle load is a maximum of 2.4 metric tonnes.

Emission restrictions are aimed at the air quality, which in urban areas is already under assault because of the concentration of activities. Emissions with 'local effects', such as carbon particles (aerosols), volatile hydrocarbons (PAK, including benzene), and smog-causing substances (such as NO_x and SO_2), play a role here. Noise restrictions are also aimed at the local living environment in the city. Traffic is often the main source of noise pollution, and freight traffic, again, plays a significant role here. The system of 'eco-zones', used in Germany, utilises 'emission' criteria: traffic in a particular area is admitted only as long as it does not lead to higher levels of polluting substances than is permitted. In practice, standards are applied to emissions and traffic volume, and with that, the total level of emissions is controlled. For freight traffic, it essentially means that only vehicles that conform to strict

environmental standards may enter the areas concerned. In 1996, three cities in Sweden introduced environmental zones. Within these zones, trucks are only admitted if they satisfy certain criteria. This type of policy is the subject of discussion as these zones can disturb competition.

Admission rules based on the criteria of 'target group' and 'urgency' are another form of restrictive policies that may be used. For instance, it is possible to aim, for a higher degree of loading by providing only a limited number of concessions, as is done in Amsterdam.

It is possible to regulate admission by means of physical criteria, but licenses or exemptions can also be applied or used in combination; licenses may be linked to the type of freight traffic, the emission level of the vehicle, or the dimensions of the vehicle. Everyone who satisfies the criteria then gets a license.

It is also possible to apply a point system, such as the 'eko-point' system for international freight traffic in Switzerland. Whoever has used too many points will no longer be allowed into the city.

Making the inner cities more attractive by means of traffic limiting measures often happens in combination with time windows for the provisioning freight traffic. It is expected that in many municipalities, the extent of the 'car-protected' zones will increase. However, an overview of plans for new 'car-protected' zones is currently lacking.

Narrowing time windows

The institution of time windows belongs to the category of traffic limiting measures. It serves primarily to keep designated streets or areas completely free of freight traffic during specific periods. Outside of the time window, the inconvenience is non-existing, but during the window times, there is a concentration of traffic.

Time windows usually start between 06:00 and 08:00 hours, and end between 10:00 and 12:00 hours; the majority are from 07:00 to 12:00 hours. A time window lasting four hours is usually sufficient; in some cases, it lasts only two hours. In certain cases, there may also be time windows during the evening.

In many municipalities, the time windows are on the agenda; it is possible that time windows will be introduced in some cities or made more severe in others.

A new development in regulation is the certification of transport companies in combination with the introduction of permits (i.e., green sticker). Certification means that transport companies, organisations, or vehicles, meeting a set of criteria, such as size, weight, emissions, and/or average load factor, receive a permit. With this permit, the company can make use of certain routes, may enter certain areas or may use certain public unload facilities. The load factor can be used as a criterion because it is an indicator for an efficient use of vehicles.

Enforcement is always an important issue in the application of regulation. Experience shows that a lack of control can make a policy less effective. In recent years, all kinds of tools have been developed to support the enforcement of regulations, including the use of electronic identification, automatic (video-) cameras, and non-permanent roadblocks (such as rising pyramids or rising steps).

35.3.6 Communication and consultation instruments

The public sector can use communication and consultation instruments to stimulate the desired behaviour of actors or to support certain ideas. In the area of urban distribution, these instruments are used to support voluntary co-operation.

The main purpose of voluntary co-operation is to achieve an efficiency improvement by consolidation, in terms of cost reduction or quality improvement. City logistics is defined in some countries as a service based on co-operation between companies that pool their distribution trips on a voluntary basis. Transhipment terminals are, therefore, quite significant for city logistics. In 1978, in the Central Business District (CBD) of Fukuoka City (Japan), 29 trucking companies started to work together to set up a collective delivery and pick-up service to and from this congested Central Business District. Compared to what it would have been if the 29 companies operated separately, this service reduced the volume of truck traffic by 60 percent (Nemoto, 1997). Other examples can be found in Europe, for instance in Germany.

Other methods of consolidation, and the role of co-operation, are described in Part III (Section 16.2 and Chapter 17). In the examples of co-operation that we found, communication and consultation by the local, regional or national government played an essential role in the implementation process.

35.3.7 Agreements and covenants

Agreements and. covenants allow both public and private actors to commit to change. It is possible, but not necessary, that this instrument be used in combination with another policy instrument. Examples can be found in the area of disposable packaging material. The participants in local, regional and national programs can commit themselves to certain policies, agreed upon within such a program.

35.4   Conclusions

In this second part of the institutional framework, we have presented the scope of public policy options. In order to improve the knowledge of the range of possible options, we applied the systems approach methodology to identify starting points for policy options. For this purpose, six levels of interventions have been identified. These levels refer to the layers of the urban goods distribution layer scheme, presented in Part II. At each level, the possible policy options are briefly discussed.

- Demand control and transport prevention or avoidance
- Logistic optimisation
- Transport optimisation
- Traffic optimisation
- Infrastructure provision
- Spatial structuring and environmental costs reduction

It proved to be possible to identify the scope of options with the use of the urban goods distribution layer scheme. The knowledge developed here will be used in the design of the integrated concept, in Chapter 37.

A typology of policy instruments was then discussed. Policy instruments are the means a public authority has to carry out its policies. We have classified policy instruments as follows:

- Active involvement. Three types of active involvement are described: as developer, provider, or operator.
- Planning instruments. Infrastructure planning and spatial planning are the relevant planning instruments;
- Financial instruments. Financial instruments can be divided into:
  - Taxes and pricing; and
  - Financial support.
- Legislative instruments. Licensing and regulation refers to the introduction of restrictions based on criteria, such as time windows, dimensions or weight of vehicles, emissions, load factor and so on.
- Communication and consultation instruments. These instruments are used in urban goods distribution to promote co-operation.
- Agreements and covenants. Agreements and covenants are used to commit (public and private) actors to certain action. This instrument is often used with other planning instruments

This classification of policy instruments will be used in Chapter 37 to define the role of public policy-making in the implementation strategy of the integrated concept.

36. Current state of policy-making

36.1 Introduction

Here, we will continue with the institutional framework. In this chapter, we will look at the policy objectives and policy measures in urban goods distribution policies in different countries to evaluate the progress made in policy-making. The purpose is to investigate what kind of public policy-making occurs in several countries, in order to learn from it, but in the meantime, to define a state of affairs (see Section 34.4.6).

Policies for freight transport in urban areas have been studied for quite some time now. Many reference materials provide us with useful information. Among them, Button and Pearman (1981), and Ogden (1992) provide an interesting overview of policies and policy measures. The reports from the three Round Table Meetings on urban freight transport, organised by the European Conference of Ministers of Transport (ECMT, 1976; ECMT, 1984 and ECMT, 1999) present interesting overviews. In Europe, research was carried out for the European Commission in the period 1994-1998, in close co-operation with research in some member-states, such as France and Germany (European Commission, 1998). Relevant information is also provided by Taniguchi and Thompson (1999). Other sources of relevant information are the national studies on urban freight transport. In Japan, the Japan Society of Civil Engineers formed a research task force on urban freight transport policies, which published a report titled 'Urban Freight Transport System as Social Infrastructure' (1994). In the Netherlands, 'Platform Stedelijke Distributie' regularly publishes reports on urban goods distribution (1997a and 1997b).

In this chapter, we will start with a short historical overview of urban freight transport policy in general and in the Netherlands. Then we will discuss developments in Germany, France, and Japan. We consider these countries to be representative, or examples for other developed countries. In this chapter, we only consider the policies of governments (local, regional or national). We will draw conclusions on similarities and differences between the policies in these countries in terms of policy objectives and introduced policy measures.

36.2   History of public policies for urban goods distribution

Policies related to urban freight transport are almost as old as urbanisation itself. Even old Rome took measures to control freight traffic entering the city (and for similar reasons as we do nowadays). In the late 19th century and the beginning of the 20th century, urban traffic congestion induced the proposal and introduction of some innovative transport systems, such as underground pneumatic capsule pipelines (for postal services in Paris 1866-1984, Marseille, Budapest; Visser and Loos, 1995), the MailRail system in London (still in operation, see Bliss, 2000) and the Chicago underground goods transport system (operated from around 1900 to 1941 (Havers 1966; Moffat, 1992)).

Dufour and Patier (1997), start their historical overview in the nineteen-seventies, because at that time, motorised traffic, in particular freight traffic, started to cause congestion and environmental problems in urban areas. In the early 1970s, small-scale research on measures to limit freight traffic in dense urban areas was performed in France and other developed countries (Dufour and Patier, 1997). At that time, the first experiments, for instance in the UK (Button and Pearman, 1981) started with the concept of urban distribution centres (a public consolidation terminal at the border of an urban area to consolidate the in going flow of goods). This was the first revival of a relatively old concept, which was abandoned at the time freight trucks began to be used in freight transport on a large scale. However, no large-scale implementation took place. Instead, freight and other traffic was constrained by vehicle and time restrictions, such as time windows. These measures accelerated the relocation of transhipment activities to the outskirts of urban areas.

During the late 1980s and early 1990s, rapid and far-reaching changes occurred in logistics and in the area of city planning. In the logistics sector, the factors most affecting cities were the rapid growth of road transport, the spread of hub and spoke networks and a growing demand for speed, flexibility, reliability, and variety in logistics services. The key factors in urban areas were rapid growth, even faster growth of road traffic, the building of ring roads and bypasses and rising city property prices. According to Dufour and Patier (1997), the combination of both sets of factors had varying consequences, including: growth in commercial vehicle movements; business relocations and restructuring in both the production and distribution sectors, causing growth in truck traffic in certain areas; development of private distribution centres, and a worrying loss of vitality in some inner cities. All these changes occurred in climate of reduced space for (freight) traffic reduced due to congestion, concerns about the environmental quality, and budget restrictions. The result was a growing concern on the part of both the freight transport sector and city authorities. In the early 1990s, national programs were set up both in France and in the Netherlands, to find long-term solutions to the problems, which were roughly defined as environmental and accessibility

problems. In the Netherlands, the concept of urban distribution centres again received attention. The urban distribution centre concept, a solution which has now been studied, practised and discussed for a long time (see for instance Ogden, 1992), is now found in many forms. Besides the traditional public terminal concept, there is also co-operation between companies in local distribution, known as city logistics. In many countries, national and local governments have tried to implement one or two of these concepts with many failures and some successes. Bottlenecks were the commercial incentive to operate such a terminal or service, the lack of co-operation between different actors and the effectiveness to solve societal problems.

In order to be able to focus on the underlying problems, policy objectives and public policy measures, we will analyse these aspects for different countries. We would like to start with the Netherlands.

36.3   Urban goods distribution policies in the Netherlands

The history of public policies with respect to urban goods distribution is displayed in Figure 36-1. The introduction of urban distribution centres (see Dablanc & Massé, 1996) on the national transport policy agenda (to solve the accessibility and environmental problems of freight transport in cities) occurred in the Netherlands between 1990 and 1995. The introduction of urban distribution centres (UDCs) was one of the measures mentioned in SVV II (Second Dutch National Transport Plan) (Ministerie van Verkeer en Waterstaat, 1990). For this reason, the Ministry of Transport, Public Works and Water Management initiated a research project on the feasibility of urban distribution centres (Coopers & Lybrand, 1991a and 1991b). The Ministry considered the introduction of a UDC in the city of Maastricht as a pilot project.

early seventies	local - UDC ideas
early eighties	local - vehicle & time restrictions
eighties	local - pedestrian zones
1991	SVV II - urban distribution centres
1991-1995	local - UDC initiatives (Maastricht, Groningen, Utrecht)
1995	National Platform Urban Distribution - support market initiatives such as consolidation upstream
1996	local - UDC initiatives (Amsterdam, Leiden)
1997	National Platform Underground Transport and Pipe Lines
1998	Western provinces: Daldistributie Randstad (DADIRA)

Figure 36-1:   Policy developments on urban goods distribution in the Netherlands

A few attempts were made to start up urban distribution centres elsewhere. The first UDCs were not operational before 1993. At this moment, (mid 2000) these UDCs are not proving to be commercially successful and are not very effective in solving problems. Other projects started in 1996 in Amsterdam and Leiden. The UDC in Leiden made use of special electric vehicles, but this did not turn out to be successful. The UDC faced problems with its location and did not receive support from other transport companies. In 2000, this UDC was closed down. The Amsterdam project looks quite promising, and many cities in Netherlands are likely to copy the 'Amsterdam' model.

In April 1995, the Urban Distribution Program ('Platform Stedelijke Distributie') was installed. This national program is associated with the Ministry of Transport, Public Works and Water Management and supports initiatives from local authorities or private enterprises that will lead to a more efficient urban freight transport. Different interest groups, such as shippers, wholesale companies, retail organisations, transport companies and local and provincial governments are represented in the program. The role of the program is to initiate and stimulate new projects, to guide and support projects and to publish the results. At least five projects are supported by the Platform: co-operation between retail fashion chains for upstream consolidation purposes, reduction of own account transport by fashion shop owners, collective delivery of goods for one street, selective accessibility in the city of 's-Hertogenbosch, and urban distribution in Amsterdam.[2] The program also prepared a set of guidelines for the evaluation and monitoring of urban freight transport projects. One of the most recent actions of the Platform is to support the concept of the urban distribution truck. In 1999, the national government proposed, as an environmental target, that in the year 2010 between thirty and sixty percent of the vehicles within inner cities must use liquid propane gas (LPG) or liquid natural gas (LNG) as fuel. The introduction of the urban distribution truck based on LPG or LNG could support that policy.

In 1999, the Platform produced an overview of all existing measures for freight traffic in 290 Dutch cities and existing projects related to urban freight traffic in the 40 largest Dutch cities. This overview demonstrates the diversity of local regulations.

One of the issues confronted in local policies is how to control freight vehicle movements, and how to enforce regulations about time and size restrictions in different parts of cities. Although there are strict regulations concerning which trucks may, or may not, enter the city and when, it is quite difficult to enforce these regulations and to maintain control. For the moment, in most cities, parking guards are in charge of this function. In some cities, an electronic system has been proposed, which would control access to some areas.

To this end, the Platform adopted, in October 1999, the Vehicle Access Matrix (see Table 36-1). The Vehicle Access Matrix was developed as a guideline for vehicle restrictions in

---

[2] One such project is a recent action by the Platform is to support the concept of the urban distribution truck. In 1999, the national government proposed, as an environmental target, that in the year 2010 between thirty and sixty percent of the vehicles within inner cities must use liquid propane gas (LPG) or liquid natural gas (LNG) as fuel. The introduction of the urban distribution truck based on LPG or LNG could support that policy.

urban areas. It describes, for four types of trucks with a weight more than 3.5 tonnes, to what extent they have access to certain types of areas, and under what conditions (loading factor, emission standards). Four types of area are distinguished: main routes, the inner city, 7.5 tonne (total truck weight) restricted areas, and pedestrian zones. This Vehicle Access Matrix was proposed by the transport interest groups EVO, TLN, and KNV, in order to promote standardisation of the vehicle restrictions regimes in the Netherlands.

Table 36-1:   ***Vehicle Access Matrix (Source: Platform Stedelijke Distributie, 1999)***

Category One vehicles		Access regime		
Type: Truck *Weight:* 3.5-7.5 tonnes *Wheel base:* < 4.5 m *Length:* max. 7.5 m *Width:* max. 2.3 m *Height:* max. 3.2 m	*Load factor* Not applicable *Emission standard* Euro-2, hybrid, LPG or other clean technology	*Zone* 1 Main routes 2 Inner city 3 7.5 tonnes area 4 pedestrian zone	*Time of delivery* 24 hours per day 24 hours per day 24 hours per day 06:00 - 12:00	*Permit needed* No No No No, else custom made
Category Two vehicles		Access regime		
Type: Truck *Weight:* 7.5-18 tonnes *Wheel base:* < 5.5 m *Length:* max. 10 m *Width:* max 2.55/2.6 m *Height:* max. 3.6 m	*Load factor* 80% or more *Emission standard* Euro-2, hybrid, LPG or other clean technology	*Zone* 1 Main routes 2 Inner city 3 7.5 tonnes area 4 pedestrian zone	*Time of delivery* 24 hours per day 24 hours per day 24 hours per day 06:00 - 12:00	*Permit needed* No No Yes, custom made No, else custom made
Category Three vehicles		Access regime		
Type: Solo-truck *Weight:* > 18 tonnes *Wheel base:* > 5.5 m *Length:* max. 12 m *Width:* max 2.55/2.6 m *Height:* max. 4 m	*Load factor* 80% or more *Emission standard* Euro-2, hybrid, LPG or other clean technology	*Zone* 1 Main routes 2 Inner city 3 7.5 tonnes area 4 pedestrian zone	*Time of delivery* 24 hours per day 24 hours per day 24 hours per day 06:00 - 12:00	*Permit needed* No Yes, custom made Yes, custom made Yes, custom made
Type: Tractor-trailer *Weight:* < 40 tonnes *Wheel base*: too divers *Length*: max 16.5 m *Width*: max 2.55/2.6 m *Height*: max. 4 m	*Load factor* 80% or more *Emission standard* Euro-2, hybrid, LPG or other clean technology	*Zone* 1 Main routes 2 Inner city 3 7.5 tonnes area 4 pedestrian zone	*Time of delivery* 24 hours per day 24 hours per day 24 hours per day 06:00 - 12:00	*Permit needed* No Yes, custom made Yes, custom made Yes, custom made
Type: Articulated truck *Weight*: < 40 tonnes *Wheel base*: too divers *Length*: max. 18.75 m *Width*: max 2.55/2.6 m *Height*: max. 4 m	*Load factor* 80% or more *Emission standard* Euro-2, hybrid, LPG or other clean technology	*Zone* 1 Main routes 2 Inner city 3 7.5 tonnes area 4 pedestrian zone	*Time of delivery* 24 hours per day 24 hours per day 24 hours per day 06:00 - 12:00	*Permit needed* No Yes, custom made Yes, custom made Yes, custom made
Category Four vehicles		Access regime		
Type: Special transport *Weight*: > 40 tonnes *Wheel base*: - *Length*: - *Width*: - *Height*: -	*Load factor* Not applicable *Emission standard* Euro-2	*Zone* 1 Main routes 2 Inner city 3 7.5 tonnes area 4 pedestrian zone	*Time of delivery* 24 hours per day 24 hours per day 24 hours per day 24 hours per day	Permit needed No Yes, custom made Yes, custom made Yes, custom made

The provinces in the western part of the Netherlands (Zuid-Holland, Noord-Holland and Utrecht) initiated a policy program called GOVERA (Freight Traffic Randstad). This program focuses on communal research and demonstration projects on consolidation by voluntary co-operation, and the use of intermodal freight transport by interest groups in freight transport. One project deals with consolidation of regional transport flows (Leidra) and another with consolidation of inter-regional transport flows (Dadira). GOVERA is also examining the

implementation of intermodal services within the Randstad, the western part of the Netherlands.

Another long-term project is the development of underground transport systems for freight. The feasibility and desirability of an underground freight transport system in cities is being studied in different projects initiated by the national government, such as DTO (Haccoû et al, 1996; Brouwer et al, 1997a end 1997b).

In October 2000, the national government introduced a new national transport plan, which will also focuses attention on urban goods distribution. This policy will contain further research of the aforementioned initiatives in the field of urban freight transport.

36.4   Urban goods distribution policies in Germany

The public policies in Germany are quite different from those in the Netherlands. There is no national policy directly related to urban goods distribution, as in the Netherlands, but there are two developments in Germany that are particularly significant for urban goods distribution. The development of GVZs (Güterverkehrszentrums or Cargo Traffic Centres), and the introduction of City–Logistik, have, in recent years, been an important element in the modernisation of the transport system. Whereas *GVZ*s, aim at the creation of inter-regional networks between conurbations, City-Logistik intends to organise the delivery of goods within urban areas.

The introduction of GVZs is an initiative by the national government. They have been developing the GVZ master plans in Germany since the beginning of the 1990s. Their objective is the creation of 30 GVZ locations to shift traffic from roads to rail and ship. Besides the GVZ Bremen, GVZs have been implemented at Augsburg, Dörpen, Dortmund, Hannover, Leipzig, München, Nürnberg, Rostock, and Trier.

Briefly described, *City-Logistik* refers to a joint service for delivering goods to urban areas by different transport companies. The Bremen City logistics Company set up such a service in June of 1994. The associates of this company are the GVZ development company and nine forwarding agents. This company uses 13 'ecological' trucks. In 1996, 1,500 tons were distributed monthly (this is equivalent to 5,000 consignments or 4,000 delivery-stops); this led to a reduction in traffic of about 100 stops a day. In other German cities, City-Logistik projects have also started (for an overview, see COWI/NTU, 1996). Although the presence of a GVZ is not a pre-condition for City-Logistik, both concepts benefit from this combination. Although at the start the projects looked promising, a significant number of these projects have now ended, in Germany. In the period 1995-1999, transport companies withdrew their participation in City-Logistik projects, mainly for commercial reasons, but also because of a lack of support by public policy.

The German federal government investigated, within the framework of the EU-Cost 321 program, twenty different policy measures for urban goods distribution with data from nine cities, namely Augsburg, München, Nürnberg, Cottbus, Bremen, Hannover, Bielefeld, Dortmund, and Düsseldorf. The results can be found in the Cost 321 final report (European

Commission Directorate General Transport, 1998). The results are not used in any national policy document in Germany. Germany has no national consultation program for urban goods distribution. However, in some cities, for example, in Hannover and Düsseldorf, local consultation programs are active, called "Güterverkehrsrunde". These programs are installed to develop and introduce local initiatives to solve the problems related to freight traffic in these cities (see Sustrate, 1999).

36.5   Urban goods distribution policies in France

France started, almost from the beginning, with a national approach. Both the freight transport sector and city authorities were concerned, in particular by a lack of data, methods or references for constructing a policy framework. Therefore, the Transport Ministry (MELTT) and the environmental and energy agency ADEME launched a national experimental and research program on urban goods transport in France was established because program in 1993. The research focused on freight transport surveys in urban areas, modelling, starting pilot projects, and making policy recommendations. The program aimed at providing useful information to several groups of stakeholders, such as planners, infrastructure managers, governmental organisations and the transport sector.

In the first phase (1993-1996) of the program, relevant quantitative information on urban goods flows was collected. An in-depth survey in Bordeaux was carried out. Information was gathered about the different stakeholders' views on urban freight transport, their main concerns, and their strategies. Other activities in this phase of the program were a critical review of the legislative, regulatory, and institutional framework, an analysis of the cost structure of the urban sections of logistic chains and a review of experiences in neighbouring countries. In the second phase of the program, experiments were performed. In December 1996[3], cities of more than 100,000 inhabitants were given two years time to draw up "urban movement plans" (in French: "Plan de Déplacements Urbains" (DPU)). These plans necessarily include urban freight transport. One of the intentions during this phase was to provide cities with information about flows, and with an urban freight transport model. Pilot experiments for urban freight management were also planned. One of the ideas was to create a permanent urban freight transport monitoring system.

Generally speaking, few practical experiments are yet in place in France, except in Monaco, where a public terminal for urban freight transport is operational. It consists of a dispatching platform for delivering goods , in order to prevent trucks larger than 8.5 tonnes from entering into the inner city.

---

[3] This occurred as the result of the 1996 Clean Air Act in France.

Some other experiments are also of note:
- A project has been launched in the area of Lille – Douai – Arras.
- The new program of Castelnau d'Estrétefonds (near Toulouse), which is promoted by the region.
- La Rochelle has performed out a feasibility study for a public terminal where electric vehicles will be used. This public terminal will be opened soon.
- Rouen, with Le Havre, is involved in the 'Sustainable urban and regional freight flow' project (SURFF). The aim of this project is to create an intelligent freight program with processing and exchange of information about the freight logistic chain.
- Strasbourg is experimenting with deliveries of urban goods according to a 'park and ride' concept.

Much research has been carried out but there is no extensive practice. This is probably caused by the fact that private companies manage their own freight problems, and do not rely on public intervention.

It must be mentioned that France has a long tradition of developing freight centres, such as Garonor and Rungis in the Paris region (see Part V). These areas have been built up by private developers. In 1993, there were about 150 freight centres in France. The three largest private developers are Garonor, Sogaris and Pan Euro Log.

In France, GART, a network of 150 French cities and metropolitan authorities (which does not include Paris), operates as a national consultation program for local public authorities in the area of urban goods distribution. GART promotes the concept of a national consultation program, where public and private representatives meet, as in the Netherlands (see Section 36.3). They also promote the installation of local consultation programs. Such programs are needed because of the absence of harmonisation in regulation. For example, regulations in municipalities in the Paris region use at least thirty different definitions of a truck.

36.6   Urban goods distribution policies in Japan

Urban areas in Japan face severe congestion problems. The high share of trucks in the total vehicle fleet in Japan is, at 36.4 percent, remarkable. Correspondingly, freight traffic has a high share in road use in urban areas. The share of trucks is quite high compared to that of other advanced countries (i.e., Germany, which has about 5%). This may be due to the use of Just-In-Time (JIT) concepts and the high share of own-transport by shippers and shopkeepers. In this respect, urban goods distribution contributes very much to local environmental and congestion problems.

Not coincidentally, the environmental problems in Japan are quite serious. In seventy percent of the metropolitan areas in Japan, the environmental standards regarding air pollution are exceeded. Measures that were implemented before 1997 are:

- Subsidies for electric vans;
- Research on new transport systems (Dual Mode Truck);
- Development of terminals;
- Support to co-operation;
- Traffic control;
- Deregulation of transport;
- Advanced information systems;
- Vehicle restriction in certain areas and on certain routes[4];

In Japan, about 280 freight centres and logistic parks were developed under the guidance of several ministries in 1960s and 1970s. About 230 of these were projects with the purpose of grouping small and medium-sized wholesalers and to make them competitive (business grouping developments). Twenty-five freight centres, called Common Truck Terminals, were built in order to increase the efficiency of truck transport. The freight centres that are expected to solve urban problems are called Distribution Business Areas. There are 22 Distribution Business Areas in Tokyo, and 14 in other cities.

Until 1997, Japan did not have a national policy on freight transport. In 1997, however, the Japanese national government authorised a set of policies on freight transport, titled 'Comprehensive Program of Logistics Policies'. This program covers not only urban freight transport but also inter-city and international freight transport, from economic, environmental, and social viewpoints. The government also decided to periodically review the program's outcomes, and published the first and second follow-up reports in 1998 and 1999. The objectives of the program are:

- To be able to offer one of the most convenient and attractive logistics services in the Asian-Pacific Region;
- To be able to provide logistics services at a reasonable cost so that they will not disturb competitiveness in inviting new enterprises to set up their business bases;
- To cope with energy problems, environmental issues, and traffic safety issues that are related to logistics.

One of the most significant concerns behind the program was the strengthening of the international competitiveness of Japanese businesses. Improvements in logistics should support such a strategy.

---

[4]   For instance in Tokyo and Osaka, restrictions on the use of older (and therefore more polluting) vehicles were implemented.

The following policy measures to improve urban freight transport are mentioned to be implemented:

- Investments in improving the infrastructure to reduce the time and cost for goods transportation based on the principle that beneficiaries should pay for part of the capital;
- Further support to private enterprises by providing subsidies to logistics-related facilities/equipment;
- Promoting improvement and strengthening the functions of the logistics business in urban areas and joint collection and delivery points where the sorting of goods for final consumers in metropolitan areas is performed;
- Developing logistics facilities in the vicinity of major highway interchanges, industrial areas, and seaside industrial zones;
- Voluntary co-operation, such as:
  - Joint collection and delivery points in urban areas;
  - Facilities for disposal of goods towards buildings in metropolitan areas;
  - Facilities for joint collection and delivery in business district;
  - Stopping facilities for on-road collection and delivery;
  - Setting up delivery boxes;
- Supporting the development of an advanced logistics system;
- The development and standardisation of the Intelligent Transport System (ITS);
- Providing road traffic information by bringing the Vehicle Information Communication System (VICS) into nation-wide use;
- Introduction of Electronic Toll Collection (ETC) system at tollgates;
- A shift from own-transport by private companies towards transport by professional carriers.

It is important to know that a large traffic survey is held every ten years in Japanese cities for planning purposes. The collected data offers opportunities for research in the field of freight transport.

36.7   Conclusions

Based on these country reports, we can draw some conclusions about the underlying objectives, the measures considered, and the types of policies applied.
There is a clear distinction in the phase of development of urban freight transport policies between the different countries. For instance, in France there is a strong emphasis on research and analysis, while the Netherlands is in a more experimental phase. Both countries focus more on investigating urban freight transport than on promoting and implementing a national policy. Earlier experiences have probably made them more cautious. Germany has gone beyond the experimental phase and has now tried to implement measures related to regulation, inter-modal terminals, and city logistics. However, as far as we know, they have no long-term public policy in place; rather, their policy can best be described as 'learning by doing'. Japan has been in an implementation phase since the authorisation of the 'Comprehensive Program of Logistics Policies' in 1997, which gives priority to logistics in the national budget.

In all four countries, the private sector has shown that it takes an interest in public policies.
Another aspect worth examining is the definition of the urban goods distribution problem itself. Surprisingly, current policies seem to deal only with current conditions. While questions about qualitative and quantitative aspects of the existing problems should be easily answered by reports that deal with urban freight transport, most urban freight transport policies only deal with the current situation; no attempts have been made to make forecasts for future developments, when the situation might deteriorate. It would be logical to assume that urban freight transport will follow trends that are occurring in other fields of transportation. However, the underlying problems are also not always well defined, and the correlation with the proposed measures is sometimes missing, as are the objectives.

The main policy objectives for each country are quite different. Although the reduction of local traffic and the reduction of emissions are important in all countries, there is a difference in emphasis. For instance, while Japan focuses quite strongly on economic objectives, the Netherlands emphasises the reduction of local pollution, including noise.

Table 36-2 presents a comparison of measures in the four countries. A distinction is made here between attempts, experimentation, and implementation of measures. Time windows and weight restrictions seem to be popular measures, but time-windows are found mainly in the European countries. New types of restrictions may also be noted, for instance, eco-zoning. Eco-zoning means that only low-emission vehicles are permitted to enter a specific zone. The temporary measure to close cities in France can also be viewed as an interim form of eco-zoning.

The concept of freight centres is expressed quite differently in each country. In the Netherlands, the concept of consolidation terminals ("Urban Distribution Centres") has been promoted, while the other countries focused on area-type freight centres, such as freight villages.

There are some experiments with freight routes but the reason for these routes is mainly a desire to avoid freight traffic on other routes, rather than improving the quality of the route for freight.

Collective co-operation, especially city logistics, receives attention in most countries but its implementation is not easy. A few successful cases exist in Germany and Japan.

In all four countries, programs have been established for the discussion of problems and measures with representatives of the private sector, but with some significant differences. For instance, in Germany local programs have been established, while in Japan and the Netherlands national programs exist.

The policies currently in place focus quite strongly on short-term problems and solutions. Little or no attention is paid to long-term problems, particularly long-term policy options. While consolidation is considered an important tool for solving problems, it is mainly considered a matter of private actors; little attention is paid to the principles of facilitation or accommodation.

Table 36-2:   ***Differences in policies between the selected countries***

	Germany	France	The Netherlands	Japan
Two main policy objectives	• Efficiency improvement • Reduction of hindrance	• Reduction of freight traffic and shopping trips • Reduction of local emissions	• Reduction of local emissions • Accessibility improvement	• Efficiency improvement • Reduction of energy consumption and emissions
Underlying problems	• Transport inefficiency • Heavy duty trucks in urban areas	• Urban structure enforcement • Congestion • Environmental problems	• Environmental problems • Accessibility problems	• High transport costs • Congestion
Licensing and regulations	• Implementation of time windows and weight restrictions • Experiments with low-emission zones	• Implementation of time windows, weight and volume restrictions • Experimenting with temporary closing when emission limits are exceeded	• Implementation of time windows, weight and size restrictions • Experiments with permits (green sticker)	• Implementation of weight restrictions • Implementation of permits to enter shopping malls
Freight centres	• Implementation of (multimodal) freight centres (GVZ)	• Implementation of freight villages	• Experiments with consolidation terminals	• Implementation of different types of freight centres
Freight routes	• Experiments with freight routes • Intercity freight trains	• No special routes	• Attempt to use bus routes • Experiments with freight routes near industrial areas	• Truck ban in outer lanes of some routes at night
City logistics	• Implementation of co-operation in city logistics, but ending	• No city logistics experience	• Attempt, but failed • No experiments	• A few cases of implementation • Governmental promotion
Low-emission vehicles	• Experiments with electric and CNG-trucks	• Experiments with electric trucks	• Experiments with electric/ hybrid and LNG-trucks	• Subsidising of electric vehicles
Consultation	Local consultation programs	Local consultation programs	National consultation program	National consultation program
Policy level	Local	National	National	National

Note: We include here the definitions for attempts, implementation, and experiments. Experiments are defined as small-scale implementation in one or two cities on an experimental basis. Implementation is defined as a well-established practice or policy. Attempts are defined as attempted, but unsuccessful, implementations.

With respect to urban freight transport, little attention is paid to transport outside urban areas, but it must be noted that in many cases, urban freight transport is directly related to transport outside urban areas. In many cases, the goods come from another region or even from another country. With the combination of GVZs and City Logistik, this means that inter-regional networks between conurbations and the delivery of goods within urban areas, are considered quite promising, not only within Germany but also in other countries.

With this overview of policy developments in other countries, we close this triptych on the institutional framework. Chapter 34 proposed recommendations for the policy-making process of public policy-making for urban goods distribution. Chapter 35 presented an overview of the range of policy options and the public policy instruments that can be used.

Chapter 36 analysed the current state of public policy-making. The main conclusion from this chapter is that a long-term policy is required to develop further consolidation and to accommodate in urban goods distribution. For this, the policy scope must shift from local problems and solutions to a more integrated and long-term approach on a broader (national or even international) level. In the next chapter, we will develop such a long-term 'vision', and a strategy to implement it. This 'vision' integrates developments that have already taken place, and adds new elements to it, as developed in Parts III, IV and V. One of the challenges is to bridge the gap between this research-based long-term vision and short-term public policies. Therefore, we will develop an implementation strategy for urban goods distribution.

37. Integrated design and implementation strategy for urban goods distribution

37.1 Introduction

In this chapter, we will develop an integrated concept for urban goods distribution, leading to a more efficient urban goods distribution system. In this Part, we will complete the integrated concepts for urban goods distribution by incorporating the different elements, presented in Parts III, IV, and V, into a single seamless concept for urban goods distribution. The elements of the urban goods distribution systems will be elaborated in Section 37.2. In Section 37.3, we will analyse the stages in which the implementation will occur, and how it can be supported by public policy instruments. Three time stages will be distinguished, namely the long-term (longer than ten years),the medium-term (five to ten years), and the short-term (within five years).

37.2 Elements of the integrated concept

37.2.1 Introduction: The integrated design

In Part III, Chapter 26, we developed a set of advanced physical distribution concepts. In the long term, these new concepts will be introduced next to existing distribution concepts and in some cases, replace them. These distribution concepts are based on the *consolidation* of flows and the full utilisation of the benefits of consolidation (*efficiency improvement* and a *better logistic performance*) as described in Part II (Section 9.5) and elaborated in Part III. These concepts will be realised by re-arranging base activities within the *spatial* and *organisational*

logistic chains[5]. Improvements in the transport system (see Part IV) and changes in land use (see Part V) will support these new concepts. The analyses in Parts III, IV, and V show that networks on different levels can be defined as follows:

- Logistic networks, described in Part III, 'Logistics for urban goods distribution';
- Transport networks, described in Part IV, 'Transport systems for urban goods distribution';
- Spatial network, described in Part V, 'Spatial networks'.

Underlying networks assist the networks listed above with a variety of services. Comprehensive efficiency improvements can only be possible when each network in the system is attuned to the other networks in the system. Nodes and links within these networks will therefore have to coincide.

The following elements of the integrated design are physical representations of these networks:

- Urban transport network. The urban transport network for the urban distribution of goods can be based on road transport or on underground transportation. This means that two groups of urban transport networks are relevant:
  - City logistics systems, based on surface transport;
  - Underground logistic systems (ULS), based on underground freight transport;
- National backbone network. The backbone network provides interregional transport services. This network is physically represented by the infrastructure available for this backbone network.
- Logistic nodes. Transfer points which have individual locations with facilities. They can serve a regional, local, or sub-local (e.g., neighbourhood or shopping centre) area. Depending on the functionality and the size of the service area, three types of logistic nodes can be distinguished:
  - Regional logistic parks, location for regional transfer points;
  - Local logistic parks or logistic sub-locations, location for urban transfer points;
  - Local dispersion facilities, location for local transfer points.

Figure 37-1 shows all elements of the integrated design for urban goods distribution. These concepts are elaborated and applied in different configurations to one or more situations in the Netherlands (see Brouwer, 1997a and b; Visser et al., 1998, Buck et al., 1999; TNO Inro, 1999). These physical elements of the integrated concept will be discussed in this chapter.

---

[5] That is, through relocation of activity both spatially and between logistic units, for instance, through the consolidation of activities in a single business park, or through outsourcing of certain business functions.
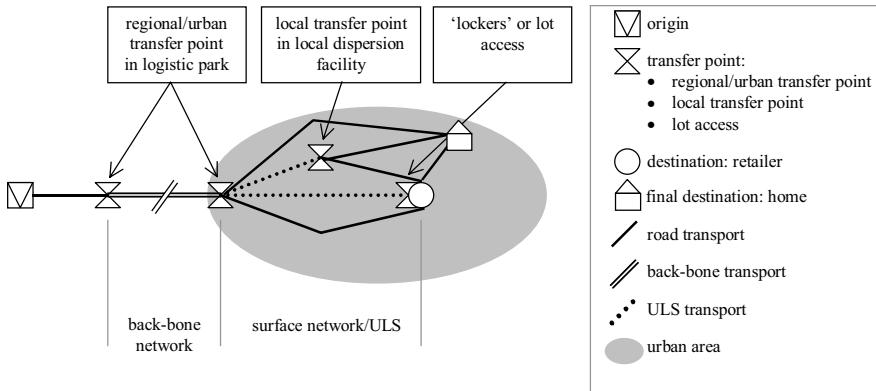
Figure 37-1: Elements of the integrated concept for urban goods distribution

37.2.2 City logistic system

The concept of city logistics and related network logistics is defined in Part III (Sections 18.4 and 18.5). These logistic concepts are based on consolidation of urban goods distribution near urban areas. The city logistic system is based on traditional road transport by advanced road transport vehicles, such as the urban distribution truck (see Part IV, Section 27.4). City logistics uses local corridors (see Part V, Section 31.6). Local corridors can be based on special routes for freight vehicles, shared lanes for freight and public transport, or separate and dedicated freight lanes. The local corridors connect relevant destinations (e.g., shopping areas to logistic parks and major exit points of the highway system).

The services provided by city logistics or network logistics are (see Visser, 2000a):

- Delivery to retail shops;
- Delivery of goods at home;
- On-demand delivery in combination with storage services;
- Reverse logistics;
- On demand collection at a retail shop or a central storage location;
- On demand delivery at home;
- On demand delivery at a pick-up location (local dispersion facility).

Within the city logistics services, it is the use that can be made of a pick-up point (local dispersion facility) for customers to pick up the bought goods. These pick-up points can also play a role in the distribution of goods to shopping areas. Another possibility is the introduction of 'lockers' outside shops and homes. Distribution of goods to shops and home-deliveries has become more difficult, because deliveries occur more frequently at times when the shopkeeper is not present, or consumers are not at home (i.e. 'night-distribution'). Lockers outside shops or at homes can offer a solution to this problem.
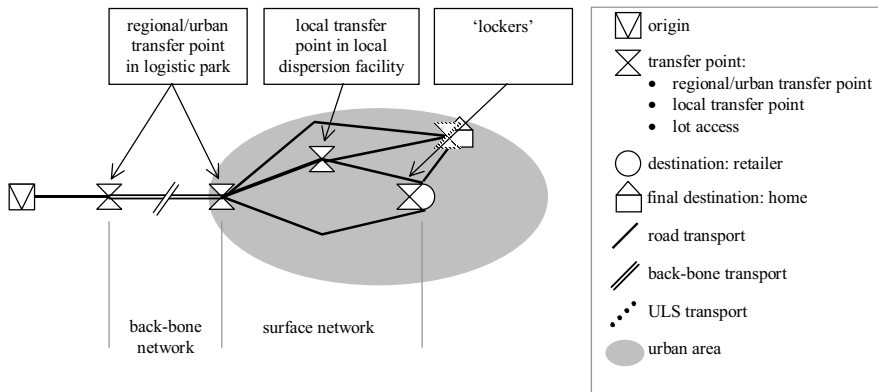
Figure 37-2:   Elements of city logistics system

From a logistic point of view, city logistics can be implemented within a relatively short term. Facilitating city logistics with a dedicated infrastructure within urban areas is more complicated, and will thus become available in the medium-term.

37.2.3 Underground logistic system for urban areas

City logistics or network logistics can also be based on underground logistic systems. Underground logistic systems offer opportunities to use logistic concepts, which are not feasible with surface transport (see Visser, 2000b; Visser & Van Binsbergen, 2000a).

The essence of an underground logistic system (ULS) is that goods that have to enter the city are delivered to a transfer point in a Logistic Park, where, after eventual storage or handling, they are transferred into the ULS transport system (see Figure 37-3). Goods are then moved by automatic vehicles through an underground network and delivered in the city, either directly at the destination address, or at a Local Terminal (possibly at a local dispersion facility). In the latter case, they are distributed further by vehicles, possibly electric, on the road to their final destination. The system has provisions that make temporary storage, transhipment, and additional activities possible.

The ULS concept may look like an underground form of urban freight distribution, but there are significant differences. There are great expenses and loss of time that occur in urban distribution due to transhipment and roundtrips with a great number of stops. These are avoided in a ULS by the automation of transport and transhipment, while the shipments are directly delivered to the destination without stops in between. Because the whole process occurs in a closed and controlled environment, the system can be completely managed. This provides opportunities for all kinds of JIT services.

The introduction of nationally functioning ULS systems will lead to profound changes in the logistic chains (see Visser et al., 1998). This might even be a condition for a ULS: the chances for a ULS system in the city improve if it is connected to a national network. The starting point for a national system is that transport flows be bundled as much as possible to create advantages of scale (both economic and social). The national network would look after the connections between the Logistic Parks.

In a ULS system, automated guided electric vehicles move load units of the size of a pallet at a speed of approximately 4.5 m/s through an underground network to their destination. The destination is an inner city Local Terminal where the load unit in question (i.e., a pallet) is automatically unloaded and then delivered, by end-haulage at surface level, to the destination. Alternatively, the destination may be a Lot Access, where the destination, such as a large supermarket has its own connection. The advantage of a Lot Access is that no end-haulage is needed.

Three types of ULS systems can be distinguished in principle:
- Colli system. A small tube with a diameter of approximately 1.5 metres, used for the transport of small load units of 0.60 (l) x 0.40 (w) x 0.60 (h) m, named "Colli". This system is suitable for the transport of boxes and parcels.
- Pallet system. A medium tube with a diameter of between 2 and 3 metres, used for the transport of pallets of up to 1.25 (l) x 1.25 (w) x 1.80 (h) m. This system is suitable for the transport of pallets, roll-containers, and pallet-boxes.
- Citybox system. A large tube with a diameter of about 5 metres, used for the transport of large units such as the Citybox.

The Local Terminals contain an underground section for loading and unloading the ULS vehicles, and a surface section for aboveground dispatch. A Local Terminal functions as a "service desk" for the ULS on its assigned service area. Different kinds of terminals can be distinguished on the basis of the type of network and, to a certain extent, the type of vehicle. These types of terminals are listed here in order of increasing size:

- Lot-accessing terminals:
    - Individual lot: small store, catering establishment, office;
    - Dual access (two adjoining lots);
    - Large store, catering establishment, office;
    - Shopping centre, multipurpose business building;
- Street-access terminal;
- District terminal;
- City-section terminal.

If the Local Terminal is directly connected to a shopping complex, the terminal is identified as a "Lot Access". The characteristic feature of a "Lot Access" terminal is that it provides access to either a store, catering establishment or office (so that no after-transport needs to occur), or to a closed complex. In the latter case, there is still end-haulage, but it occurs in a protected environment (for example, indoors, where it can be closed off to the public during certain hours); this is indicated as internal transport. The other types of terminals may all require some sort of end-haulage, probably by road. A Local Terminal consists of the following elements:

- An underground platform for loading and unloading the tube vehicles;
- A vertical transport system (e.g., an elevator);
- Intake and outtake areas (at the surface and partly underground);

- Storage facilities;
- A surface loading and unloading facility for after-transport vehicles.

For internal and after-transport it will be necessary to provide (depending on the type of load units used):

- An (electric) cart or trolley (Colli system);
- A pallet-truck (Pallet system);
- A small road vehicle (Citybox system).
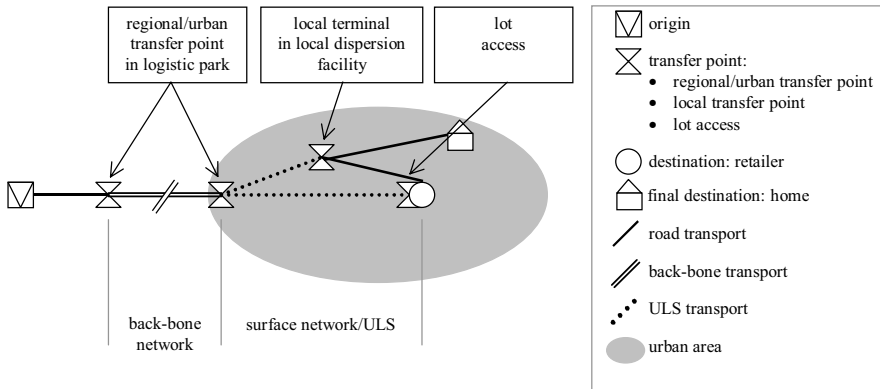
Figure 37-3:   Elements of the Underground Logistic System

The introduction of Underground Logistic Systems within urban areas is most likely a long-term development. A possible reason is the lack of experience with the organisation, construction and operations of underground logistic systems, in particular in complex areas such as urban areas. From a logistic point of view, Underground Logistic Systems will be introduced when there is experience with similar, operating city logistics concepts.

37.2.4 Backbone network

The backbone network is a network from a logistic (Part III), transport (Part IV) and spatial (Part V) point of view. The backbone network is needed to connect the local or regional collection and distribution of urban goods in order to provide a door-to-door service.

The backbone network consists of links (see Part V, Section 31.5) between the major local and regional transfer points, such as Logistic Parks, and consists of parallel or additional transport systems. Part IV discusses rail, waterborne, road and underground transport as possible options. The purpose of the backbone network is to consolidate inter-urban goods flows in relation to urban goods distribution on infrastructure corridors, as described in Part V. The backbone network provides:

- Inter-regional or
- International transport services

These services can be dedicated to certain distribution channels, (see for instance Buck Consultants International (2000)). The services are provided by different carriers in a private, dedicated or public manner (see Part III, Chapter 17).

Although the backbone network already exists to a certain extent, and corridors for freight are already recognised for hinterland transport, the logistics organisation, the transport system, and the infrastructure for a 'real' backbone network for urban goods distribution still need to be developed. In particular, the introduction of a dedicated infrastructure for freight, based on rail but also road, can be considered as a long-term development. For rail, it may even be more complicated, because the required rail materials (trains, load units) do not yet exist.

37.2.5 Logistic nodes

Logistic nodes encompass all logistic transfer points, such as regional and local logistic parks, logistic sub-locations, and local dispersion facilities. They act as focal points for transhipment, storage, and distribution.

Logistic parks

The concept of Logistic Parks is discussed in Part V (Chapter 30). The function of Logistic parks within networks is threefold. They represent:

- A node within logistic networks, in particular in network and city logistics.
- A node within transport networks, by means of transhipment terminals (unimodal or intermodal) at the location.
- A node within the spatial network by means of spatial concentration of logistic activities.

Regional Logistic Parks are locations for regional transfer points. They are also major nodes within the backbone network, while the local Logistic Park or logistic sub-location is simply a location for urban transfer points. This distinction between regional and local Logistic Parks is made to indicate that within a given region, a limited number of logistic parks will have an intermodal connection with the backbone network, while at the same time, other logistic parks will be required to locate logistic activities and to provide city logistics services.

A Logistic Park operates as a transhipment terminal for city logistics and the ULS for road, rail, and inland navigation, but also concentrates distribution centres and transport-intensive activities. It plays a significant role in the consolidation of urban goods distribution.

The following services can be performed from the Logistic Parks:

- City logistics by road;
- Underground logistics by ULS;
- Regional collection and distribution;
- Inter-regional transport.

At the logistic park, the following storage services should be provided:

- Individual stock management for retailers;
- Joint stock management for retailers, shippers and logistic service providers;
- Production/whole stock management by production companies and wholesalers or retail organisations.

The transfer points at a Logistic Park can be operated in a private, dedicated or public manner. This depends on the type of logistic service that is provided. The development of transfer points is, in principle, a private initiative.

The development of logistic parks is, as other countries show, a public-private development. Within urban areas, land use planning is the responsibility of local governments. However, with respect to logistic parks, national governments have a responsibility in developing a

long-term vision regarding the number and the location within a country[6]. From a logistics perspective, regional transfer points already exist. From a spatial planning perspective, concentrations of transfer points and other logistic activities, need to be developed for logistic parks. The planning of logistic parks can occur within the short term. However, the actual realisation and implementation will be medium and long-term developments. In particular, the development of intermodal facilities will require long-term development

Local dispersion facilities
Within urban areas, facilities will be needed for pick-up and delivery points for retailers and customers when goods do not have to, or cannot, be delivered to the door. Temporary storage facilities will be needed. The concept of local dispersion facilities (also referred to as "WijkDistributieWinkel") is described in Brouwer at al. (1997) These facilities can be located near shopping areas or shopping centres, in particular near parking facilities (see also Visser, 2000b). The pick-up and delivery services can be combined with other services (for example, the post office services in the Netherlands). These facilities can accommodate terminal activities when Underground Logistic systems are introduced in an urban area. The development of local dispersion facilities depends very much on private initiatives and the development of city logistics.

37.2.6 Implementation strategy of the integrated design
The integrated design, as briefly outlined, in this section can be considered as a guideline or 'blue-print' for the long-term future. This design has integrated current developments and added new elements to it, as developed in Parts III, IV, and V. The integrated design will require a plan or strategy for implementation. Some elements can already be put into operation in the short-term. Others will require a long-term strategy. In order to develop an implementation strategy, it must be clear which elements of the integrated design can be realised within what time frame (short-term, medium-term or long-term) and what kind of policy instruments are needed to support the implementation.
In Sections 37.3, 37.4 and 37.5, the implementation strategies for the short, medium and long term will be defined. We will compare projected developments (the state of affairs within that particular time frame) with the 'ideal situation', based on possible options (in the area of logistics, transport systems and spatial planning) within the same time frame. The discrepancies between them are the basis for the definition of the relevant policy instruments. Following the back-casting method, as described in Part II, we will first discuss the long-term improvements, then the medium-term and, finally, the short-term improvements.

37.3   Long-term improvements in urban goods distribution

37.3.1 Introduction
Long-term has been defined, for our purposes, as a period of time greater than ten years. Our starting-point is that the integrated design, as outlined earlier, has to be realised within that time frame. In this section, the long-term options in logistic, transport systems and spatial

---

[6]   This is discussed in depth in: Van Binsbergen & Visser, 1998.

planning will be discussed. In the long term, the full range of options will be available. Even options based on new transport systems are relevant.

The long-term implementation strategy aims at reaching the following situation, as developed in Section 37.1:

- Operation of an integrated city logistics system that co-ordinates urban goods distribution movements in an urban area (but allows competition in operations);
- Application of dedicated urban distribution vehicles making (shared) use of dedicated infrastructures and underground infrastructures where appropriate;
- Operation of a multimodal backbone logistics system for interregional movements of urban goods outside urban areas;
- Application of high-capacity and environmentally sound transport means outside urban areas.

To achieve this, additional aims include:

- Application of intermodal transport, that requires:
  - Transfer points;
  - Standardised load units;
- Application of a restricted number of logistic parks.

At the end of the long-term stage, the integrated design as presented in Section 37.1 should be realised.

37.3.2 Projected long-term developments in demand

The demand for transport is expected to increase because of economic growth and population growth, despite dematerialization trends (see Part III, Section 15.2). In the long term, the increase in the use of new marketing channels, in particular e-commerce, increases the need for flexible and reliable transport within urban areas. For reasons of efficiency and customers service, pick-up points, called local dispersion facilities, will be introduced within urban areas.

Consumer demand with respect to the accuracy and reliability of logistics services will be quite high, but at the same time, environmental concerns and limited space will further limit the movements of freight vehicles in urban areas. This means that an increased level of service in the distribution of goods has to be provided with fewer freight vehicle movements, although vehicle movements already generate less pollution and fewer problems.

37.3.3 Long-term options in logistics

In the long term, we may expect logistic network development to occur by an intensification of co-operation, especially in the field of co-ordination, but also to some extent also in operations. Like retailers and producers, providers of all kinds of logistic services (carriers, logistic service providers) will merge to become international operating companies that offer a wide variety of logistic services.

The longer term allows for fundamental changes within logistics. Different types of shifts are possible:

- Shift from specialisation in type of goods (or shippers) to specialisation in type of service area and type of services; from 'national' services to dedicated 'long haul' (backbone logistics services) and 'end-distribution' services (city logistics services);
- Organisational co-ordination of logistics specialists;
- Integrated logistic systems with differentiated services (compare with 'split & combine distribution', Part III, Section 17.5.5).

Logistics organisations will make full use of newly available communication and planning technologies to optimise logistics processes.

For logistic service providers, the need for labour cost reductions will force them to look for options that reduce the use for labour in other parts of the logistics channel, and thus different kinds of automation.

37.3.4 Long-term options in transport systems

Intra-City

In the long term, advanced road transport vehicles will be available for intra-city distribution. Although internal combustion engine vehicles will still dominate road transport, functionally acceptable hybrid and electric drive alternatives will also be available.

In the long term, infrastructural alternatives for (surface) road transport will also become available. For instance, light rail and waterborne transport (specifically for cities with canals) goods transport technology will be available, although these systems will not provide door-to-door distribution (see Van Binsbergen & Visser, 2000a). Underground systems will also become technically feasible[7]. Underground transport is another alternative to surface urban distribution. Underground transport systems can be adjusted to the requirements of city logistics and network logistics because of their dedicated infrastructure and the options for full automation of the transport and transhipment process. Underground links or networks can efficiently improve the distribution process in dense built-up areas.

Significant shifts include:

- Shared use of dedicated 'public transport' infrastructures and dedicated goods transport infrastructures;
- Application of dedicated urban distribution vehicles;
- Development of underground infrastructures.

Inter-city

In indirect distribution methods, such as network logistics, multi-modal transport is an excellent technique. By using inter-modal transport concepts, full advantage can be taken of use of the most appropriate modes in specific environments. Newly developed urban distribution concepts enable us to make full use of the multi-modal concept. In Part IV, we proposed urban physical transport systems for intra city transport (Section 26.2) and backbone physical transport systems for transport outside urban areas (Section 26.3). Both sets of

---

[7] This is elaborated in several studies like Visser, Vermunt & Van Binsbergen (1998); Visser & Van Binsbergen (1999a).

systems need to be compatible from different viewpoints (expressed in policy terms like interconnectivity, interoperability and intermodality), mainly to build complex networks.

In the wider future, dedicated goods transport systems may be developed. Alternatives included are automated road transport (e.g., CombiRoad), railway transport, or underground transport. The improved efficiency of new modes depends especially on automation and a dedicated (rail or road) infrastructure. The systems will be able to fulfil a significant role in the long-haul segment of the urban distribution.

Therefore, for the backbone networks, alternative modes will have to be available. Although these alternatives 'compete', they also can provide one, integrated and co-ordinated system. Significant shifts and developments within the transport system include:

- Focus on intermodal transport instead of unimodal transport;
- Development of an intermodal interregional long-haul (backbone) network, and within that network:
  - Application of 'short-distance' intermodal, and 'downscaled' rail transport;
  - Advanced, 'upscaled' road transport;
  - Application of 'short distance' intermodal 'downscaled' inland navigation;
  - Underground systems;
  - Application of standardised load units.
- Development of automated systems.

37.3.5 Long-term options in spatial options

The third element in the integrated approach is related to the spatial system. Network logistics and intermodal transport concepts, discussed earlier, require a spatial structure. Network logistics make use of regional transfer points. Consolidation and de-consolidation activities occur at these transfer points. Base activities will be located close to these transfer points. Network logistics make use of the multi-modal networks. Therefore, the multimodal nodes (terminals) and regional transfer points should coincide for efficient operation. These locations are defined as logistic parks (see Part V, Chapter 30). A nation-wide network of interregional corridors, as laid out in Part V (Section 31.5), third phase of network development, could be realised.

Significant shifts and developments include:

- Necessity of developing locations for local and regional transfer points to support network logistics and city logistics;
- Development of logistic parks that bundle logistic (transport) activities with the transfer points.
- Development of a nation-wide network of corridors as a spatial reservation for multimodal backbone network.

37.3.6 Integrated long-term scheme and projected discrepancies

In the long term, all the 'ingredients' are available to apply the combined *network logistics*/*city logistics* systems. These concepts combine optimal logistic services for the movement of goods within urban areas (*city logistics*), with inter-urban distribution schemes (*network logistics/backbone logistics*) for the movement of goods outside urban distribution areas.

All technological means will be available to apply an efficient and environmental sound goods distribution system.

The 'autonomous' state of affairs in the long term is difficult to determine, because problems related to urban goods distribution already require policy actions on short notice. Nevertheless, we can try to 'extend' current experience and this way indicate the main expected discrepancies between the 'ideal' situation and the long-term state of affairs:

- Insufficient co-operation between logistic service providers to eliminate unnecessary capacity use;
- Lack of drives to develop new intermodal concepts and to implement inter-modal transport at full scale (especially if external effects are not 'internalised');
- Insufficient incentives to build underground networks within urban areas (investment costs are perceived as being too high);
- Insufficient incentives to build dedicated (underground) networks outside urban areas, except for specific projects that also (or mainly) serve other goals (hinterland connection[8]);
- The legislative framework may not support the needed developments, especially at the spatial level and at the level of local entrance limitation measures.

37.3.7 Consequences for long-term implementation strategy

The policies of both public authorities and private parties should be aligned. Section 34.3 explains that 'policy co-ordination' between the public and private sector is essential. If we assume that this co-ordination is a success, then necessary private policies will include:

- Desire to co-operate, whilst maintaining a competing position;
- Desire to implement inter-modal transport and the network logistics and city logistics concept in the own logistic activities;
- Concentration of distribution activities in logistic parks;
- Operation of appropriate vehicles;
- Operation of appropriate terminals.

Developments in consumer demand will initially increase the demand for personnel, and will thus drive logistic service providers to look for options to automate tasks, for example, in transport (automated underground transport) and transhipments (automated terminals).

As is outlined in Section 35.3, the public sector can use different policy instruments to ensure that they reach the above-mentioned goals. The public sector's role is to create the right conditions for changes in the logistics system; they cannot therefore be actively involved in the operation of the logistics system. However, the public sector can be more actively involved in the development of infrastructure. The public sector can also use planning instruments, pricing measures and provide some financial support to private sector in terms of the development and introduction of new environmentally efficient technologies.

---

[8] This 'hinterland connection' is typical for the Netherlands: it connects the harbour areas with the German hinterland. However, in other countries such projects might also be identified.

Active involvement
- Infrastructure financing and construction of dedicated (underground) infrastructure for freight within urban areas;
- Infrastructure financing and construction of dedicated infrastructure (road, rail, underground) for the backbone network.

Local infrastructure is primarily the responsibility of local governments. The role of the national government is to support local governments and to harmonise local infrastructure development. Interregional or national infrastructure, such as the infrastructure for the backbone network, is the responsibility of a national government. Therefore, the national government is involved.

Planning instruments
- Land use planning in terms of logistic parks;
- Infrastructure planning, local corridors;
- Infrastructure and spatial planning, national freight networks (road, rail, waterborne).

Within urban areas, land use planning is the responsibility of local governments.

Pricing (taxation)
- Land-use pricing (taxation) to support land use planning;
- Road-pricing, taxation on the use of non-dedicated distribution vehicles ('internalising external effects').

Pricing is an instrument that can stimulate certain behaviour in private actors. In this case, land-use pricing can be used to concentrate logistic activities at a logistic park and road pricing can be used to improve the efficiency of infrastructure use.

Financial support
- Subsidies for setting up distribution activities at the dedicated sites;
- Subsidies for using dedicated vehicles, intermodal transport and the application of load-units;
- Subsidies for building dedicated infrastructures and networks;
- Subsidies for operating dedicated infrastructures and terminals.

Financial support can be used, mainly by national governments, to support the implementation of new technologies or for the operation of infrastructure.

Licensing and regulation
- A licensing system that controls the type and movements of vehicles within urban areas:
  - Demanding standards for minimum load-factors;
  - Demanding standards for maximum noise-emissions;
  - Demanding standards for maximum exhaust emissions;
  - Setting maximum dimensions and load standards;
  - Implementing entrance time regulations;
- Allocating space for urban distribution activities; restricting allocation of these activities on other locations.

This regulation refers mainly to the use of local infrastructure. Principally, local governments will be involved. The national government is responsible for the harmonisation of the regulation.

Communication and consultation instruments
• Communication of a long-term vision for urban goods distribution.
This is typically a role for national governments

Agreements and covenants
• Agreements or covenants to develop dedicated infrastructure for freight.
This depends on who is the owner of the infrastructure.

37.4   Medium-term improvements in urban goods distribution

37.4.1 Introduction
The medium term has been defined, for our purposes, as a period of five to ten years. The medium-term implementation strategy will aim at reaching the following situation:
• Introduction of dedicated urban distribution vehicles;
• Full application of *city logistics* concepts;
• Application of larger road vehicles outside urban areas.
This should be supported by:
• Application of 'intermodal' road transport, with local transfer points.
Furthermore, the long-term perspective already demands some actions:
• First tests with advanced rail and inland shipping transport modes;
• Spatial reservation for real intermodal transfer points and logistic parks.
The medium-term stage should prepare for the introduction of the long-term improvements, as described in Section 37.3.

37.4.2 Projected medium-term developments in demand
In the medium term, on the demand side, e-commerce as a marketing channel will be in full development. However, the overall share of goods sold via the e-commerce channel will still be limited, compared to the share of traditional marketing channels. The majority of sales will be 'traditional', but the 'e-commerce' principles will trickle through. Higher demands will emerge with respect to logistic service quality and reliability. There will be pressure from local governments to use more energy-efficient and quieter, safer, and cleaner vehicles within urban areas.

37.4.3 Medium-term options in logistics
Logistics concepts can change fairly easy and fast because they require relatively low investments (especially when 'hardware' such as warehouses and transport equipment are hired and not owned). Therefore, even in the medium term, fairly profound changes in logistics activities are feasible. We expect an intensification of co-operation of logistic service providers at the regional and interregional scale, so that they can operate door-to-door

services. Voluntary 'city logistics' will be feasible, driven by incentives from local governments (see Section 37.4.7). The enlargements in scale of retail-operations (also as a result of mergers) will strengthen the interregional nature of end-distribution.
This means:

- A shift of focus from local and regional towards city logistics;
- Co-ordination of regional logistic service providers, so that they can perform 'door-to-door' distribution.

37.4.4 Medium-term options in transport systems
Intra-city
Advanced urban distribution trucks must be developed; they must be both versatile and cause the least disturbance. For these trucks, the preferred propulsion system is electric drive. With these characteristics, the urban distribution trucks will be able make use of a dense road network (although still with some limitations in 'sensitive' areas). The first steps in implementing these advanced technologies will occur in the medium term. There will be no real alternatives for inner city road transport. Dedicated surface infrastructures may become available.

Inter-city
First of all, the existing rail infrastructure network can be used by operating dedicated trains. To a lesser extent, adapted inland shipping may also be appropriate.
For long-haul transport, there are opportunities to significantly improve the efficiency of road and rail transport. These opportunities relate especially to the enlargement of the scale of vehicles (road trains in road transport and the introduction of new railway concepts, such as CombiRail and CargoSprinter) using existing tracks.
For compatibility reasons, load units should be standardised in order to be used in the proposed intermodal concepts. Inter-modality requires transhipments that are normally expensive and time consuming, and can introduce uncertainties in the logistics process. To overcome these disadvantages, transfers should ideally be automated; automated transfer processes work best with standardised units. We propose a set of modular load units that range from small collo-sized boxes to large swap-bodies and continental containers. The modularity ensures a neat fit of smaller units into larger ones. The small units can be used in different transport systems and are necessary to optimise processes within outlets and other destinations, while the larger units will make transhipment and transport procedures more efficient.

37.4.5 Medium-term options in spatial options
In the medium term, space for urban logistic parks can be set aside, and local transfer points can already be introduced as local dispersion facilities. These local transfer points support the city logistics systems. Other logistic activities can be encouraged to use the logistic parks and local dispersion facilities.
The second phase of the introduction of interregional corridors (see Part V) could be started to develop a multimodal backbone network.

37.4.6 Integrated medium-term scheme and discrepancies

In the medium term, enough ingredients are available to introduce efficient *City logistics* concepts that make use of adapted logistics systems and make use of dedicated road vehicles for inner city distribution. The introduction of Local Transfer Points (LTPs) enables the use of 'intermodal' road transport: applying large road-vehicles outside urban areas and dedicated distribution vehicles inside these areas. This is also the first stage in the development of *network logistics* for the longer term.

The discrepancies that may be expected between the ideal situation and the current state of affairs in the medium term include:

- Lack of co-operation between logistic service providers within the field of city logistics;
- Dispersed location of (warehouses) of logistic service providers and shippers;
- Limited use of dedicated vehicles for urban goods distribution;
- Limited use of 'intermodal' road concepts (large vehicles outside, distribution vehicles inside urban areas).

There are no technological barriers to introducing advanced vehicles, but there may be financial barriers (the new technologies will be relatively expensive).

37.4.7 Consequences for medium-term implementation strategy

It the medium term, there is no immediate need for great efforts in infrastructure. Therefore, the active involvement of the public sector is limited to the realisation of the first logistic parks, and to making intermodal transport from the logistic parks possible by connecting it to the main infrastructure. In this stage, it is quite important to financially support the development of new technologies.

Active involvement

- Construction of logistic parks;
- Construction of infrastructure to connect logistic parks to main infrastructure (different modalities);
- R & D pilot projects for underground freight transport.

Although these are mainly local initiatives, some active involvement of national government will be required.

Planning instruments

- Land use planning aimed at space reservation for local transfer points (operational in the medium term), regional transfer points/logistic parks, and dedicated infrastructures (anticipating the long-term strategy).
- Spatial planning of logistic parks.
- Spatial planning of interregional corridors.

Logistics parks need to be part of regional or local spatial plans.

Pricing (taxation)

- Pricing could possibly be used as an incentive to achieve more efficient logistics schemes (i.e., load/unload tariffs).

Pricing within urban areas is a very difficult policy instrument. The introduction of a pricing system for loading and unloading is one way to start. It is a typical local policy instrument.

Financial support
- Development and introduction of urban distribution vehicles;
- Development and tests on railway alternatives;
- Development of organisational aspects and physical means for short-distance intermodal transport.

These developments are of national interest. Therefore, the national government has a responsibility to support these developments financially.

Licensing and regulation
- Stringent entrance requirements or limitations, including:
  - Load factors;
  - Vehicle size;
  - Entrance times;

This regulation refers mainly to the use of infrastructure, provided by local governments.

Communication and consultation instruments
- Communication of the relevance of logistic parks.

Communication and consultation regarding logistic parks is the responsibility of both regional and national governments.

Agreements and covenants
- Covenants for public-private development of logistic parks.

This is a local responsibility.

37.5   Short-term improvements in urban goods distribution

37.5.1 Introduction

The short term has been defined, for our purposes, as a period of five years. In the short term, there are limited possibilities for changing the urban goods distribution process. However, some steps could easily be taken. These steps should aim at stimulating the actors to use more efficient goods distribution systems and to anticipate medium and long-term plans with respect to city logistics and network logistics.

In the short term, it would be appropriate to strive for:
- Co-ordinated urban distribution processes;
- Increasing average load factors;
- An efficient use of urban infrastructures.

37.5.2 Projected short-term developments in demand

As explained in Part III, marketing channels will change quite rapidly. Even in the short term, new marketing channels will arise, particularly due to the influence of e-commerce technology. Complex networks of marketing channels will also be built. These new marketing channels will require different sets of physical distribution concepts.

37.5.3 Short-term options in logistics

In the short term, current developments in logistics will be intensified. There will be more co-operation and mergers between retailers and between carriers, and pressure to decrease the costs for the distribution process. At the same time, demands for services such as *just in time* deliveries will encourage logistic service providers to offer dedicated services. Because the costs for distribution activities are relatively low and there is fierce competition, transport is a 'demand market'. This may, in the short term, lead to *less* efficient services. The technological means and knowledge are available to operate very efficient services, however, the incentives to operate these services efficiently (and, for example, accept higher storage or other costs) are missing.

37.5.4 Short-term options in transport systems

Intra-city

Within urban areas, the optimisation of the transport system aims at adjusting the transport system to its distribution function and adjusting the transport system to the conditions of the urban (specifically the inner-city) environment. This means an improved logistic performance and reduction of the social costs of goods distribution. Specific conditions within urban areas relate to the limited (transport, environmental and spatial) capacity for freight traffic movements of the road-only infrastructure. In the short term, the emphasis will lie entirely on road transport. It is important to improve trucks that already perform optimised physical distribution services but still cause high emissions, noise, and hazards. Adapted combustion engines and the use of advanced traffic control systems must help to limit the negative external effects of these vehicles.

Inter-city

The conditions outside urban areas are quite different from those within urban areas. The optimisation of the transport system aims at adjusting the transport system to its transport function and making it more efficient. Conditions outside urban areas relate to the limited transport capacity for freight traffic movements of the mainly-road based infrastructure, but there are some options in the area of load and vehicle consolidation, as described in Part IV (Section 21.3), that are applicable. The average load factors can be increased, and larger vehicles may be operated. In a first stage, the average size of vehicles must increase (with more large vehicles, fewer small vehicles should be operated); in a second stage, the size of large vehicles may be extended – but this will require adapted legislation.

37.5.5 Short-term spatial options

In the short term, we may expect a further 'exodus' of distribution-related[9] and retail-related[10] activities from urban (built-up) areas to low-density areas. Thus far, there is no real integrated policy approach to guide this development. However, in the medium term and long term a

---

[9]   In the past, nearly all distribution-related activities left the urban areas. Only a very few stayed behind. These few will also move to peripheral locations.

[10] The first wave of retail-related activities, which depends very much on the accessibility for freight traffic, left inner cities during the last ten years.

concentration of this type of activities is desired. The first phase of interregional corridor development can occur (see Part V, Chapter 31)).

37.5.6 Integrated short-term scheme and short-term discrepancies

In the short term, there are not many readily available technologies that can replace traditional (road vehicle) technologies. However, evolutionary developments in engine technology will lead to significant improvements. With respect to logistics organisation, all knowledge and all necessary technical means are available, but the application is not yet attractive. With respect to land-use planning, there is a fairly uncontrolled exodus of distribution related activities from urban and built-up areas.

In an ideal situation, in the short term, logistics co-operation can be strengthened and the first steps to an integrated city logistics system can be set.

However, in the current state of affairs we encounter:

- A lack of co-operation and even a lack of willingness to co-operate;
- A lack of willingness to make goods distribution more efficient (because higher levels of service may prevail over reducing transport costs).

37.5.7 Consequences for short-term implementation strategy

This would require the following measures:

Active involvement

- R & D on behalf of the development of the urban distribution truck.

Active involvement is limited to a further development of a prototype for the urban distribution truck of the future. This is very much the role of a national government.

Planning instruments

- Planning of logistic parks.
- First steps in land-use planning: reserving space for logistic parks and developing a strategy to streamline the re-allocation of distribution activities outside urban areas.

The development of logistic parks is, as other countries have shown, a public-private development. Within urban areas, land-use planning is the responsibility of local governments. However, in particular with respect to logistic parks, the national government has a responsibility in developing a long-term vision regarding the number and locations within a country.

Pricing (taxation)

- Pricing measures in the short term are not very likely, only in very specific situations one can start with probes for load/unload tariffs.

Financial support

National governments can provide financial support, under very strict conditions, to pioneers of new technology or organisational concepts, including:

- The first users of advance logistics systems;
- The first users of logistic parks;
- The first users of advanced technological means;
- Development of technologies for transport automation.

Licensing and regulation

- Entrance requirements (limitations) that may be bypassed if there are viable reasons; the requirements would refer to:
  - load factors;
  - vehicle size;
  - entrance times;
- Legislation to make larger road vehicles outside urban areas possible.

This refers to the use of local infrastructure and is, thus, a matter of local governments.

Communication and consultation instruments

- Supporting co-operation;
- Stimulating urban distribution trucks;
- Installing regional consultation programs.

The installation of regional consultation programs is a regional matter. Regional governments should therefore take responsibility.

Agreements and covenants

- Co-operation agreements;
- Covenants on regulation of access in urban areas.

Co-operation agreements are a private matter, but it is possible that local governments play a role in this. This is particularly the case when preferential treatment is given to co-operative private companies with respect to access to urban areas.

37.6   Conclusions

37.6.1 Introduction
This section presented the integrated design and implementation strategy for urban goods distribution in the future. First, the key elements of the integrated design were described. Then, the implementation was developed, based on an estimate of when the options will become available, from logistic, transport and spatial standpoints and what kind of policy instruments are needed. This approach leads to an implementation strategy that defines the necessary development and policy instruments for each period of time (short-term, medium-term or long-term).

37.6.2 Conclusions regarding the integrated design
The design of efficient goods distribution systems for urban areas is based on the integration of networks at different levels, namely logistic networks (elaborated in Part III), transport networks (elaborated in Part IV), and the spatial network (elaborated in Part V). The main principle is that underlying networks facilitate the networks above with a variety of services, as demonstrated in the transport layers scheme. Overall efficiency improvements can only be possible when each network in the system is attuned to the other networks in the system. Nodes and links within these networks will have to correspond. The following elements of the integrated design are, therefore, physical representations of these networks:
- Urban transport network, based on local corridors, consists of:
  - city logistics systems, based on surface transport;
  - underground logistic systems (ULS), based on underground freight transport;
- National backbone network, based on interregional corridors. The backbone network provides interregional transport services.
- Logistic nodes. Transfer points have specific locations with facilities. Depending on the functionality and the size of the service area, three types of logistic nodes can be distinguished:
  - Regional logistic parks, location for regional transfer points;
  - Local logistic parks or logistic sub-locations, location for urban transfer points;
  - Local dispersion facilities, location for local transfer points.

The integrated design, as shown here, represents the 'ideal' situation for the long term. The integrated design will need a plan or strategy for implementation.

37.6.3 Conclusions regarding the implementation strategy
For each stage in the implementation strategy, the conclusions will be summarised.

Short-term stage
In the short term, there are limited possibilities for changing the urban goods distribution process. Actions within this stage should aim at stimulating the actors to use more efficient goods distribution systems, and to anticipate medium-term and long-term plans with respect to city logistics and network logistics. Within urban areas it is important to improve trucks

that already perform optimised physical distribution services (direct distribution). Adapted combustion engines and the use of advanced traffic control systems must help to limit the negative external effects of these vehicles. Outside urban areas, the average size of vehicles must increase (with more large vehicles, fewer small vehicles should be operated). Later, the size of large vehicles may be extended – this will require adapted legislation.

Public actions in this stage include:

- R & D on behalf of the development of the urban distribution truck;
- Planning and reservation of space for logistic parks;
- Stimulation of the development and first use of new advanced logistic systems, logistic parks and advanced transport and transhipment technologies;
- Agreement on entrance restrictions for urban areas;
- Legislation for larger road vehicles outside urban areas;
- Supporting co-operation with covenants.
- Installing regional consultation programs.

Medium-term stage

The medium-term implementation strategy aims at a full application of city logistics concepts, the introduction of dedicated urban distribution vehicles within urban areas, and the application of larger road vehicles outside urban areas. In this period, the development of advanced rail and inland shipping transport means for urban goods distribution has to occur. Logistic Parks should be connected with rail and waterborne infrastructure. Thus, standardisation of load units will be needed. In this stage, the implementation of intermodal transport by rail and waterborne will be prepared.

Public actions in this stage include:

- Covenants for public-private development of logistic parks;
- Construction of logistic parks;
- Pricing could possibly be used as an incentive to achieve more efficient logistics schemes (i.e., load/unload tariffs);
- Development and tests on railway alternatives;
- R & D pilot projects for underground freight transport.

Long-term stage

The long-term implementation strategy aims at full implementation of the integrated design. Within urban areas, we will see full operation of an integrated city logistics system and application of dedicated urban distribution vehicles making shared use of dedicated infrastructures and underground infrastructures. Outside urban areas, it would mean full operation of a multimodal backbone logistics system for interregional movements of urban goods with the application of road, rail or waterborne transport systems based on dedicated infrastructure.

Within urban areas, underground systems will become technically feasible.
Public actions in this stage include:

- Infrastructure planning, financing and construction of dedicated (underground) infrastructure for freight within urban areas;
- Applying a licensing system that controls the type and movements of vehicles within urban areas in combination with road-pricing, taxation on the use of non-dedicated distribution vehicles;
- Infrastructure planning, financing and construction of dedicated infrastructure (road, rail, underground) for the backbone network;
- Land use planning for logistic parks and land-use pricing (taxation) to support land use planning;
- Financial support for the implementation of new technologies or for the operation of dedicated infrastructure.

37.6.4 Conclusions regarding logistic services and intermodality
In terms of efficiency improvement, the development of new logistic services (with respect to consolidation) and the development of intermodality (with respect to the use of efficient transport means) are pertinent. These two aspects will be discussed below.

Logistic services
The services for the integrated concept will be developed in stages. As ***Figure 37-4*** shows, real network logistics services will become available after the introduction of city logistics services and backbone logistics services, which means, in the long-term.
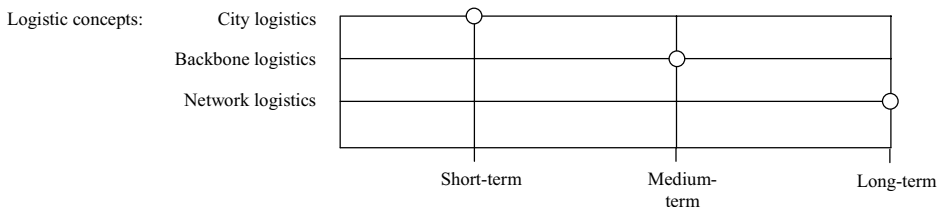
Figure 37-4: ***The development of city logistics, backbone, and network logistics services within a time frame.***

Intermodality
In terms of efficiency improvement in urban goods distribution, the development of intermodality is quite significant. The implementation of intermodal transport for urban goods distribution depends strongly on the availability of facilities for intermodal transport. The urban network, the backbone network, and the logistic nodes provide the facilities for intermodality in urban goods distribution. The implementation strategy shows that these facilities will become available in stages.

Within urban areas, the road network will be the transport mode. In the medium term, a dedicated infrastructure for freight may become available but the ULS network that has to facilitate network logistics will only become available in the long term. In the meanwhile, city

logistics has to make use of surface road transport. In the medium term, a dedicated road infrastructure comes available.
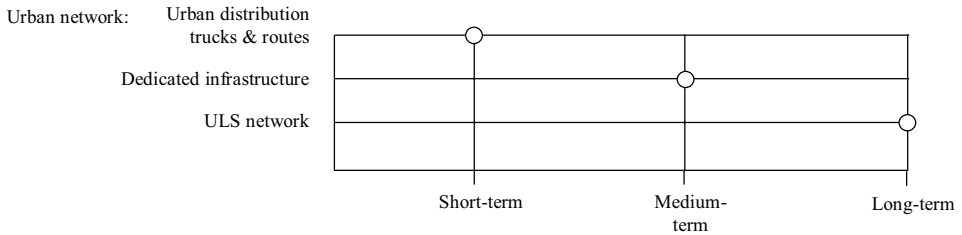
Figure 37-5: ***The implementation of the urban network for urban goods distribution***

Although the services for backbone logistics are expected in the medium term, the current road infrastructure can already act as the carrier for backbone networks. Although a dedicated road network for freight will not immediately be available, this can still be realised in the short term. The development of a backbone rail network depends not only on the availability of rail capacity of the existing infrastructure, but on the right material being developed. This means that a backbone rail network can only become available in the long term.
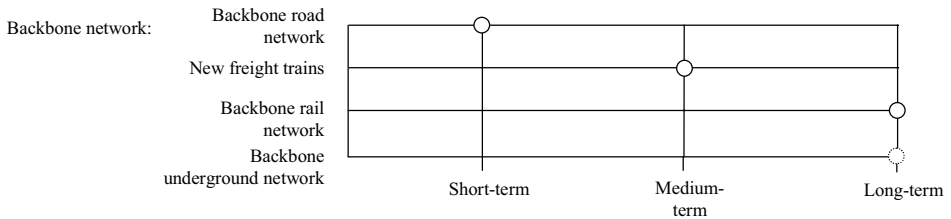
Figure 37-6: ***The implementation of a backbone network for urban goods distribution***

Logistic parks develop in stages. In the short term, space can be reserved for regional and urban transfer points. In the medium term, further spatial concentration can be promoted. In the long term, a backbone railway network will become available. At that moment, multimodal terminal facilities will be required.
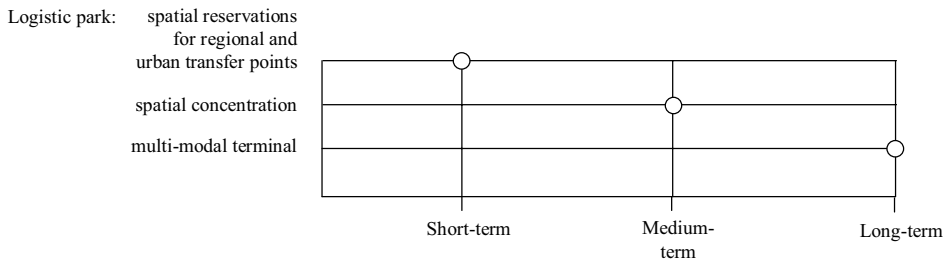
Figure 37-7: ***The implementation of logistic parks for urban goods distribution***

Intermodality based on road-road concepts will become available in the medium term. True intermodality, such as rail-road or rail-ULS, depends on the progress that has to be made in the implementation of the urban network, the backbone network and the multimodal terminals at the logistic park and will, therefore, become available in the long term.

38. Evaluation

38.1 Introduction

In this section, we will perform an evaluation of the integrated concept. We will demonstrate that the integrated concept leads to efficiency improvements in urban goods distribution. We will then focus on the strengths and weaknesses of the concept, as well as the opportunities and risks in terms of implementation, in order to estimate the chances for implementation.

The evaluation has to demonstrate, first, that the integrated concept performs at a higher level of efficiency than the current system for the distribution of goods in urban areas. It also has to demonstrate that the integrated concept shows a better performance than each of its elements does separately. Finally, for the sake of implementation, it has to be demonstrated that each element of the integrated concept contributes to the improvement of the overall efficiency.

To demonstrate the advantages of the new proposed integrated urban distribution concepts, we will follow a qualitative and a quantitative approach. The qualitative approach is based on theoretical argumentation, which is in fact the basis for this thesis. The methodological framework, presented in Part II and used throughout this thesis, supports the theoretical argumentation. By applying micro-economic utility theory, we try to understand the reasoning of actors and the decisions they take; this modelling can result both in qualitative analysis and in quantitative analysis.

The quantitative approach results in well-defined results, but requires explicit assumptions that therefore influence the final results. Quantitative analysis is difficult in this instance, due to the lack of proper data regarding urban goods distribution. Some quantitative analysis and results are presented in this thesis. The quantitative analysis is based on our own research and on other sources.

38.2   Theoretical argumentation

38.2.1 Introduction
As is explained in Part II, efficiency is defined as the ratio of normative costs for achieving given results and the real costs for the process. Related to the optimisation of the urban goods distribution, this means that the implementation of the integrated concept should reduce the costs (in the 'broadest' sense) to the publicly accepted (normative) level, or in mathematical terms:

$$Z_{G,K}^{society,real} \cong Z_{G,K}^{society,norm}$$

Part I describes which costs or disutilities are relevant from a societal point of view. It concerns societal costs related to:

- Local environmental problems and nuisance, the most relevant ones being:
  - Local air pollution,
  - Traffic noise,
  - Traffic safety,
  - Use of space.
- Global environmental problems related to climate change and acidification,
- Exhaustion of fossil fuels,
- Exhaustion of materials.

Economic costs factors related to accessibility problems are also involved. The economic costs refer to transport costs and cost factors, such as travel time, flexibility, and reliability of urban goods distribution, which have an effect on logistic costs.

In Part I, for each type of cost, the normative costs are established by analysing policy targets in that particular area. With respect to emissions, nuisance and exhaustion, targets are formulated to give some indication of the normative societal costs. With respect to economic costs, no targets are formulated. Therefore, there is no clear indication for the normative economic costs.

38.2.2 Main principles
The integrated concept is based on the optimal bundling of the movements of goods ("consolidation") in time as well as in space, through logistic services such as city logistics, backbone logistics, and network logistics. These logistic services are based on consolidation achieved by co-operation between actors acting at the same level (horizontal co-ordination) and the integration of activities of actors at different levels (vertical co-ordination). The new distribution concepts provide alternatives for existing less-than-Trail Load (LTL) vehicle movements. Full vehicle load distribution (point-to-point) is already optimised and is quite difficult to replace by other distribution concepts.

The purpose of consolidation is:

- To improve the utilisation of the transport system to generate economies of scale and scope;
- To decrease the use of various means, and thus, costs;
- To provide a level of critical mass for more efficient transport systems, such as rail or waterborne transport.

Consolidation requires a breakdown of a given goods movement into two parts: a collection/distribution movement, and a *long*-distance transport move. This generates two advantages:

Goods flows going in different directions can be bundled within the collection/distribution movement and/or within the transport movement. Collection and distribution coincides with the movement within urban areas, while the *long*-distance transport movement occurs interregionally, outside urban areas.

With the separation between the local distribution movement within urban areas and the transport movement outside urban areas, it is possible to optimise both movements separately. Because the circumstances are quite different within urban areas and outside urban areas, this means that the optimisation will be different. This means, small, quiet and zero-emission vehicles, or underground freight transport in the urban areas and large volume vehicles, such as trucks or trains, in inter-regional or long-distance transport. Consolidation should lead to higher load factors, thus more efficient use of these transport systems.

Dedicated infrastructure, within urban areas and outside urban areas should make the operation smoother (a guaranteed capacity with undisturbed vehicle movements) and improve the efficiency.

Within urban areas, it becomes possible to use small, quiet, zero-emission vehicles, based on alternative propulsion technology, because:

* The circumstances within urban areas require small and highly manoeuvrable vehicles;
* The goods flows are relatively small;
* The short transport distance and the light vehicles make it feasible to use battery-powered or other "green" vehicles.

Underground Logistic Systems within urban areas combine the benefits of transport automation with the benefits from a dedicated, undisturbed, and underground infrastructure. This means low variable and exploitation costs and relatively low investment costs because of the use of small size vehicles, attuned to the average consignment size (pallet or roll-box) and the small diameter underground infrastructure. It also means energy-savings and a low (local) environmental burden, resulting in the reduction of noise, visual pollution, and emissions.

Outside urban areas, consolidating as much as possible becomes the most attractive option. This means the use of large road vehicles, and even rail and waterborne vehicles because:

* Circumstances make it possible to use large vehicles;
* At an interregional level, bundling leads to large volume freight flows;
* *Long*-distance transport is more efficient with high load capacity vehicles with a high load factor.

The integrated concept is therefore based on intermodality. Intermodality requires transfer points; in this case, regional and urban transfer points. To avoid extra transport moves, and to promote co-operation, these transfer points should be located in a central location near intermodal transhipment facilities, in a logistic park (see Part V, Chapter 30).

Finally, city logistics and network logistics make it possible to reorganise existing logistic chains, by which efficiency gains can be reached elsewhere in the chain, (e.g. storage and production, in fact all S-, P-, I-, T-, S-activities, see Part III, Chapters 13 and 14).

38.2.3 Theoretical argumentation for efficiency improvement

Although we can argue that the advanced logistic systems can result in efficiency improvements, it is difficult to prove this in general terms. However, we can prove it by stating some preconditions.

We find two basically distinct routes in efficiency optimisation. The first is the introduction of *inter-modality* that allows the use of dedicated transport modes for specific areas.

The second is integral chain optimisation that includes transport and storage.

Intermodality

In Part IV (Section 21.5), the total perceived costs by an actor *a* of a door-to-door transport that consists of multiple stages (parts), defined as a set $\overset{1}{G}$ of stages *g* is determined as follows:

$$Z_{G,\overset{1}{K}}^{q} = \sum_{g=1}^{G}\left(Z_{g,\overset{1}{K}}^{a}\right)$$

Here, $\overset{1}{K}$ represents the set of relevant cost-characteristics (or types of disutilities if societal costs are included) as perceived by actor *a* (or *society*). The total costs or disutilities of intermodal door-to-door transport (using *M* modes) as perceived by actor *a* is expressed as follows:

$$Z_{\overset{1}{G}}^{q} = \sum_{g=1}^{G}\left(Z_{g}^{a}\right) = Z_{(load,1)}^{a} + \sum_{m=1}^{M}\left(Z_{(transport,m)}^{a} + Z_{transfer,[m,m+1])}^{a}\right) + Z_{(unload,M)}^{a}$$

Now, if $\overset{1}{G}$ represents the original situation and $\overset{1}{G}'$ represents the new situation (new logistics concept), will be attractive for actor *a* if:

$$Z_{G',\overset{1}{K}}^{a} < Z_{G,\overset{1}{K}}^{q}$$

Possible costs or disutility reductions are related to *reduced transport costs* or *reduced costs of other logistic activities* within that logistic chain, or reduced *disutilities* (including societal costs). Thus, the total chain costs (or disutilities) of $\overset{1}{G}'$ must be lower than the total chain costs (or disutilities) of $\overset{1}{G}$, even if the 'chain' of $\overset{1}{G}$ is unimodal (as is usually the case in current goods distribution for urban areas).

Reduction of transport costs or disutilities occurs when the following conditions are met:

- Consolidation leads to economies of scale, scope, and density that will be used for reduction of the transport disutilities; this must therefore lead to lower values for $Z_{(transport,m)}^{a}$ for the transport alternative.

- The increase of 'transfer' disutilities $Z_{(transfer,[m,m+1])}^{a}$ may not exceed the total reduction of the transport disutilities that result if alternative modes (in $\overset{1}{G}'$) are used.

When these conditions are met for all costs or disutilities, then such an intermodal system can lead to efficiency improvements. It is possible that these conditions only are met for certain costs or disutilities, such as environmental costs. In that case, it depends on the actors' weighing set of costs (see Part II, Section 7.2), whether or not a system is considered more efficient from the actor's point of view. When an intermodal system cannot fulfil these conditions for all costs or disutilities, it is quite unlikely that this system will be more efficient.

Integral chain optimisation

As was already explained in Part III (Chapter 13), total logistics chain optimisation is aimed at decreasing overall logistic costs; however, higher costs for some parts of the chain (due to the trade-offs), can be accepted, if necessary. For instance, large-scale transportation may reduce transport costs but may increase storage costs; in total chain optimisation, an optimal balance is sought after.

Here, again we can define a set $\overset{1}{G}$ of activities that were originally performed; the chain costs will be composed of the component parts as represented by the basic logistic activities:

$$Z_G^q = \sum_{g=1}^{G}\left(Z_g^a\right)= Z_{(transport)}^a + Z_{(ass.composition)}^a + Z_{(storage)}^a$$

A set $\overset{1}{G}'$ represents a new, optimised, situation with an analogue cost structure. Again, $\overset{1}{G}'$ will be attractive for actor *a* if:

$$Z_{G',K}^q < Z_{G,K}^q$$

From Vermunt (Visser at al., 1998) we learn that consolidated flows of homogeneous flows – one result of the newly proposed logistic systems – can indeed lower transportation costs (per unit).

This would mean that $Z_{G',K}^{q\,1} < Z_{G,K}^{q\,1}$ if:

$$Z_G^{q\,1} > Z_{(transport)'}^a + Z_{(ass.composition)'}^a + Z_{(storage)'}^a$$

and this would require that

$$Z_{(transport)}^a - Z_{(transport)'}^a > (Z_{(ass.composition)'}^a + Z_{(storage)'}^a) - (Z_{(ass.composition)}^a + Z_{(storage)}^a)$$

or: the benefits of operating new types of transport (organisation) must be larger than the extra costs of applying (the related) new storage and assortment composition strategies.

Efficient transport means

Costs or disutility reductions in alternative modes will have to be found in improved efficiencies of activities within logistic chains, because:

$$Z_{(activity),K}^{a\,1} = f\!\left(\varepsilon_{K,S}^q, s_{(activity)}^a, v_S\right)$$

The variable *s* represents the service that is provided by that activity. The variable *v* represents the volume or quantity of the required service.

Economies of scale, scope, and density influence the cost effectiveness ( ) of an activity.

$$\varepsilon_{K,S}^q = f\!\left(v_S\right)$$

For transport the costs-function looks like this:

$$Z_{(transport,m),K}^{a\,1} = f(\varepsilon_K^q, d_m^a, v_m^a)$$

Variable *d* represents *distance* as a service provided.

If such a relationship does not exist, consolidation does not lead to any cost reduction.
Possible cost reduction options, due to economies of scope, or density include:

(1) $Z_{(transport,new.mode)}^a \le Z_{(transport,road)}^a$

(2) $Z^a_{(load,new.mode)} \leq Z^a_{(load,road)}$

(3) $Z^a_{(transfer,[new.mode,alt.mode])} \leq Z^a_{(transfer,[road,alt.mode])}$

(4) $Z^a_{(unload,new.mode)} \leq Z^a_{(unload,road)}$

Efficiency improvements can be based on combinations of these options.

A special remark must be made regarding alternative transport systems. The introduction of other transport systems that cannot provide door-to-door transport in itself will add extra stages to the transport chain (pre and end haulage transport) and thus, extra costs or disutilities. Spatial location planning can, to some extent, avoid these extra stages by means of:

- Strategic localisation of transhipment points (terminals);
- Strategic localisation of the logistic activities (transfer points) near these terminals.

Proximity to multimodal terminals reduce, and spatial concentration avoids, extra stages related to pre and end haulage or at least reduces distances.

38.2.4 Energy use

In the new urban distribution concepts, there are three main methods that should reduce the energy use of the system:

- Consolidation by new logistic services (transport distance reductions and increasing load factors);
- Traffic calming measures and dedicated infrastructures;
- Engine efficiency measures and new types of engines (without changing the mode of transport);
- Alternative transport modes (intermodality).

The fuel consumption of internal combustion road vehicles is well-documented. For larger road vehicles like trucks, Rijkeboer (in: Schoemaker and Van Binsbergen, 1993) developed the following calculation method for fuel consumption that is partially based on theory and partly on empirical data[11]:

$$FU = \alpha \left\{ \bullet\, \beta_r \bullet M + \beta_a \bullet A \bullet \left(\frac{25}{v} + \frac{v^2}{1000} \right) + \beta_k \bullet M \bullet \left(1 - \frac{v}{100} \right) + \beta_{kr} \bullet M_b \bullet \left(\frac{v}{100} - 1 \right) + \beta_e \bullet \left(\frac{M_b + 10}{v} \right) \right\}$$

With variables
FU =   fuel use [kg/km];
v =   speed [km/h];
M =   mass of the vehicle as it (really) is when driving [metric tonne];
M_b =   vehicles own mass plus the load capacity (so: maximum gross vehicle mass) [metric tonne];
A =   frontal surface of the vehicle [m^2] (if the vehicle is fully loaded, then M = M$_b$).

And coefficients (values for the 1990 vehicle fleet):
α =   efficiency factor: 0.925;

---

[11] The formula must be regarded as a 'rule of thumb' because the units do not match.

β_r =   coefficient for rolling resistance: 3.90;

β_a =   coefficient for air drag: 0.91;

β_k =   coefficient for the kinetic energy of the vehicle: 9.71;

β_{kr} =   coefficient for the kinetic energy of the rotating parts of the engine and transmission: 0.24;

β_e =   coefficient for the internal losses of the rotating parts of the engine and transmission: 42.97.

This formula can be used to discuss efficiency improvements in energy use in urban goods distribution.

Consolidation by new logistic services

In the formula, we recognise the obvious fact that higher gross vehicle masses and higher speeds lead to an increase in fuel consumption.

The formula also shows that deadheading and low load-factors are quite uneconomical because the vehicle's own weight plays a significant role in total energy consumption.

Experience shows that increased load capacities (maximum loads) in weight require heavier vehicles, but experience also shows that this increase in vehicle weight is somewhat limited due to the advantages in scale of vehicle construction. The formula shows that larger (high load capacity vehicles) result in lower energy use per transported tonne than smaller vehicles. This fact is also recognised by Cooper (1991).

Therefore, from the formula it may be concluded that:

- Higher load factors indeed are economical from an energy-use perspective;
- High-capacity vehicles are also more economical from an energy-use perspective than smaller vehicles.

Cooper (1991) also proves that decentralised warehousing (one element of 'network logistics') decreases transport distances and therefore decreases energy-use.

Traffic calming measures and dedicated infrastructure

The fuel-consumption formula also shows that lower speeds lead to lower energy use; this is also proved by Den Tonkelaar (1991).

The latter can be specified more accurately for inner city transport. As Rietveld et al (1998), based on Van Binsbergen et al (1995) suggest, urban 'stop-and-go' traffic can be modelled by assuming an 'ideal speed' and a 'stopping distance' that together result in an average speed that we can monitor in practice.

Physics theory shows that accelerating is quite energy-intensive. Therefore an average continuous speed of, say, 30 km/h is far more energy-efficient than 'stop-and-go' traffic that results in an average speed of 30 km/h. Therefore, measures that lead to a stable traffic flow (for example traffic on dedicated infrastructures) significantly reduce energy use.

Engine efficiency improvement and alternative propulsion systems

By improving internal combustion engines, significant decreases in energy use can be achieved. However, the tendency to increase the vehicle power may counteract these gains (see Delsey, 1991). The proposed urban goods distribution concepts allow an adjustment of the vehicle capacities (including the vehicle power) to the operating environment and of course allow improvements in engine efficiency.

The chain efficiency for battery powered or externally power-supplied vehicles is not much better than that of advanced internal combustion engine vehicles (see Van Binsbergen et al, 1994). Therefore, electric traction will not result in significant reductions in energy use.

Alternative modes and intermodality
Another significant energy consumer is the rolling resistance of road vehicles. By applying steel wheels on steel tracks (railways), this rolling resistance is strongly reduced. This would theoretically mean that railway transport is more energy-efficient than road transport. However, for operational (shunting) and security reasons, rolling equipment is mostly quite heavy. For heavy and bulk transport (ores, sand, steel), this is not a significant problem, but as Rutten (1995) states, the transportation of lightweight goods by rail is less attractive, unless the railway equipment can be made significantly lighter. In new railway concepts (such as CargoSprinter and CombiCars), these weight reductions may be implemented. Meanwhile, advanced safety systems will reduce the risk of accidents, and other operational schemes will eliminate the necessity for shunting operations. Both developments could permit the introduction of less robust, lightweight equipment. The proposed urban distribution systems accommodate the application of intermodality at the interregional backbone network (*network logistics* and the introduction of *urban and regional transfer points*).

For urban distribution, the above proves that:
- An exact fit of the vehicles to the task they have to perform reduces the overall energy use because load factors will be high, and no 'over dimensioning' of vehicles is necessary – this advantage can be achieved if co-operative distribution schemes are applied where various vehicles make up the distribution fleet;
- High load factors are economical from an energy-use point of view, and high load factors can be achieved by the advanced logistics systems we propose;
- Stable traffic fleets are significantly more energy-efficient; this situation can be achieved by applying dedicated infrastructures (such as underground transport) or other traffic regulating measures.

There are however also some negative aspects to the newly developed concepts. Most concepts make use of transfers that also use energy. Furthermore, consolidated flows (goods transport with larger vehicles) sometimes imply detours. These aspects may reduce the positive effects of the new concepts, and therefore limit the applicability. From an energy-use point of view, application thresholds can be defined: goods transport over too-short distances and transport that is already quite efficient should be excluded from the new concepts.

38.2.5 Emissions
As is explained in Part IV (Section 24.3) of this thesis, the types of local emissions that are caused by the transportation system principally relate to the applied propulsion system. The quantity also depends on the type of propulsion system and also of the state of the art of the applied technology.
Our integrated concepts explicitly enable the use of dedicated vehicles for inner city distribution. These vehicles can be equipped with electric engines or advanced internal combustion engines, and fit exactly the needs of urban distribution.

CO_2-emissions are directly related to the energy use of internal combustion engines: the emissions of CO_2 per used kilogram of fuel are constant. At the same time, most other emissions are directly related to the energy use, but the relations are not always linear. NO_x-emissions per kilogram of fuel can even increase when engines run at high temperatures, such as is the case while running at high speeds and also is the case in are fuel-efficient engines (higher efficiency engines operate with higher temperatures that generate more NO_x; see for example, NEA 1993);

Thus, most measures that limit the energy use also limit emissions, except for certain measures that aim at increasing the engine efficiency itself, because such measures may cause (somewhat) higher emissions of NO_x.

The use of battery powered and external power supplied electric vehicles reduces local emissions to zero. If fuel cells are applied, there are only emissions of CO_2 and water (Van Binsbergen et al, 1994).

The explicit distinction between inner city and inter city transport also enables the use of specific *long haul* distribution vehicles outside the urban areas. The specifications of the applied vehicles can be exactly tuned to their use (running on long stretches of infrastructure at a relative high speed), resulting in lower emissions compared with *all-round* vehicles. If the vehicles are used on dedicated infrastructures, also electric propulsion systems (now powered by external power sources) can be applied. This reduces local emissions to zero. Advanced internal combustion engines that are optimised to the long-haul transportation process, limit emissions in comparison with all-round vehicles.

38.2.6 Noise
Noise pollution is a typical local environmental problem. The total noise pollution in an area is an accumulation of noise produced by different sources. The noise pollution cannot be calculated by a simple summation, but must be established by complex methods that take into account the human perception of noise levels (logarithmic), noise frequencies (weighting set) and factors that influence the propagation of noise (buildings, kinds of surfaces, vegetation etc). With respect to the traffic-intensities, relatively most traffic-related noise pollution is caused by high-pitched sources (mopeds) and by goods transport vehicles. In actual operation, large goods transport vehicles produce up to 10 dB(A) higher noise emissions than vans or passenger cars, which means that one passing large truck produces as much as noise emission as approximately ten vans passing simultaneously (Gorißen, 1991).
New technologies will help to reduce the noise produced by (goods transport) vehicles, however some negative effects on energy use may be the result: some measures that aim at reducing engine noise, will increase vehicle weight or cannot be combined with high-efficient engine technologies (see Broome and Morrison, 1991). It is also important to pay attention to the noise caused by the tyre-road surface interaction (although this source is especially significant for higher speeds; Filippi, 1991)
Because the new logistic concepts will reduce the overall goods transport vehicle intensities, they will also contribute to lowering noise pollution.
Electric powered vehicles produce significant less noise than their internal combustion engine counterparts do; in fact, the low noise production can even pose some traffic safety problems

(see below). Advanced internal combustion engines can be made more silent (however, some negative effects with respect to the fuel consumption may arise), but the low levels of electric engines cannot be achieved. Because our concepts explicitly allow the use of dedicated vehicles, these vehicles can also be optimised to (low) noise emissions.

Specially designed load units can reduce the noise of load/unload activities.

The noise production of vehicles that run on inner city trips can be reduced as well, although there are fewer noise pollution problems outside urban areas.

38.2.7 Safety issues

Transport safety is related to the size of vehicles, their speed and the ability of drivers to monitor the traffic situation (which is related to the vehicle size and construction).

Generally, small vehicles cause fewer accidents per vehicle kilometre and the effects of the accidents are less severe. Because our concepts allow the use of dedicated (small) vehicles for inner-city distribution, this would decrease the number and severity of accidents.

Dedicated infrastructures limit the change of accidents (because the number of interactions with other traffic is reduced), especially in the case of underground infrastructures.

38.2.8 Accessibility

With respect to accessibility, we have to distinguish the accessibility of urban areas for goods transport and for visitors (for instance customers) respectively. The accessibility for goods distribution processes ('goods accessibility') relates to the costs and quality of the logistics system, the accessibility for persons ('personal accessibility') influences the attractiveness of an urban area.

The level of accessibility improvement depends quite strongly on to what extent cost reductions can occur and to what extent time savings are possible due to more efficient logistic processes. Not only related to transport costs, consolidation can generate economies of scale, scope and density, related to time consolidation can lead to more frequent transport services and in this way to time-savings.

The advanced logistics systems monitor the distribution process in detail; this in itself improves 'goods accessibility' to a limited extent. Advanced traffic regulation systems may have a larger impact, for instance, they limit the occurrence of choosing fault routes – a major reason for delays in logistics processes. Dedicated goods-transport infrastructure provisions will of course improve 'goods accessibility' the most: for instance, underground infrastructures will ensure undisturbed transport flows to the connected users.

Applying the advanced logistics concepts can increase load factors for inner city goods transport, which reduces the number of goods transport vehicles in the urban area and therefore reduces total traffic volumes, if only slightly. Therefore, advanced logistics systems will improve 'personal accessibility'.

38.3   Quantitative evaluation

38.3.1 Introduction

Elements of the integrated concept, as developed in this thesis, are investigated in different research projects. Although these studies did not focus on the integrated concept in its entirety, the results from quantitative analyses within these studies can be used for this evaluation. Four research projects are, in this case, relevant:

- *A road transport service for standardised load units (pallets) for intercity freight traffic within the Netherlands* (NOVEM), a feasibility study, performed by NEA/INRO-TNO (1989). This study focussed on reductions in traffic volume, energy use, and emissions, with different levels of consolidation. All domestic goods flows transportable in standardised load-units were considered.
- *Rail Distribution Netherlands* (NS Cargo). In this study, a combination of city logistics by road within urban areas and a backbone network, based on rail is considered (Van Binsbergen and Visser, 1997b). No evaluation of this concept has taken place.
- *A logistic vision for the Randstad* (GOVERA). This study (GOVERA, 1997) discusses the relevance of three new logistic services, based on the existing road network, rail network, and waterborne network for all freight transport within the Randstad (the western part of the Netherlands). No quantification was performed.
- *A national network for freight transport with underground transport by pipeline* (IPOT). In the IPOT-research program, research was performed to design and evaluate alternatives of local Underground Logistic Systems within urban areas with different types of multimodal national backbone networks for urban goods distribution. In different phases of the program, quantitative evaluation has been performed (see Visser et al. (1998) and TNO (1999)).

Other projects, such as 'Long-term efficiency improvement for transport' (Van Binsbergen et al., 1994) considered the effectiveness of energy-efficiency improvements by implementing new transport technologies.

38.3.2 Potential market share

In the IPOT-study, performed by TNO (1999), an estimate of the potential market share for the final phase of the integrated concept, in which Underground Logistic Systems are operational, was performed. The domestic goods flows are divided into three generations (TNO, 1999):

- Generation 1: product groups which are currently suitable for underground transportation, (i.e. products transported in units as pallets or boxes, such as food and clothes).
- Generation 2: product groups which are not currently palletised, but which can be moved in such a unit package in the near future, such as semi-finished products.
- Generation 3: product groups which will probably never be suitable for unit transportation in pallets or boxes, such as bulk products, high-volume goods, and hazardous goods.

Data from CBS is used to quantify the share of its generation in the total transport volume (see Figure 38-1). About nine percent of the goods are physically suited for the integrated concept. Another nine percent can become so with some logistic changes. The other eighty-two percent are bulk products. They hardly have any relationship to urban goods distribution.
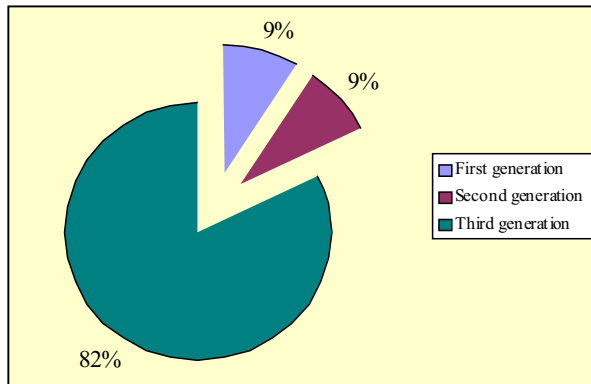
Figure 38-1: Potential market share of the integrated concept (TNO, 1999)

38.3.3 Intermodality, based on road/road systems

The results from the NOVEM-study give an indication of the efficiency improvements with consolidation concepts. Although, in this study, concepts such as city logistics or network logistics are not discussed, we assume that these logistic concepts can be considered as the basis for consolidation in that study.

NEA/TNO (1989) evaluated the concept, based on a backbone road network and urban distribution by road. Full consolidation occurs at the backbone network. Different levels of consolidation are assumed within urban areas.

The evaluation considered:

- Reduction in traffic volume, expressed in vehicle kilometres;
- Reduction of energy use;
- Reduction of emissions (carbon monoxide, hydrocarbons, nitrogen and aerosols);
- Reduction in transport costs.

In this evaluation, three options for backbone networks were considered, namely networks consisting of 17, 24, or 37 nodes. The calculation was performed by assuming full consolidation on the backbone network and different degrees of consolidation in collection and distribution.

Reduction in traffic volume

Table 38-1 presents the reduction in traffic volume with three network configurations. One hundred percent consolidation in the backbone network and no consolidation in collection and distribution leads to a reduction in traffic volume with seventeen nodes of twelve percent, while a network with twenty-four nodes or thirty-seven nodes lead to a reduction of fourteen or seventeen percent, respectively. A partial explanation is that the network configurations differ in the volume of transported goods. It is interesting to note that one hundred percent of consolidation in collection and distribution leads to a reduction of about 40 percent in three network configurations.

Table 38-1: ***Reduction in traffic volume with different levels of consolidation in collection and distribution of goods (NEA/INRO-TNO, 1989)***

Traffic volume in conventional road transport	Low variant (17 nodes)	Medium variant (24 nodes)	High variant (37 nodes)
[million veh.kms/year]	539	588	637
Degree of consolidation in collection and distribution of goods [%]	change in traffic volume [%]		
	Low variant (17 nodes)	Medium variant (24 nodes)	High variant (37 nodes)
0	-12	-14	-17
25	-19	-21	-23
50	-25	-27	-29
75	-32	-33	-35
100	-39	-40	-41

Reduction of energy use.

Due to the reduction in traffic volume, reductions in energy use also occur with consolidation (see Figure 38-2). As explained in Section 38.2.4, higher load factors also lead to more energy use per driven vehicle-kilometre. Therefore, the reduction of energy consumption is little less than the reduction in vehicle kilometres. The differences in energy use between the network configurations in terms of energy use are limited.

Here, the energy use of conventional road vehicles is used. The use of more energy-efficient vehicles is not considered. Thus, applying new technologies may increase the reduction of energy use even further.
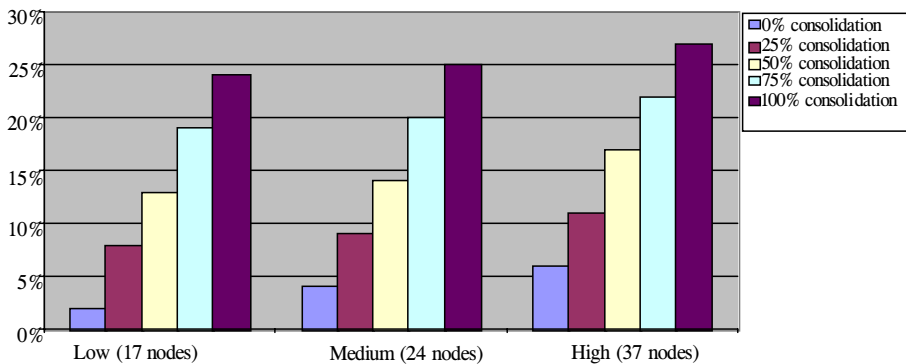
Figure 38-2: ***Reductions in energy use with different levels of consolidation in collection and distribution of goods (NEA/INRO-TNO, 1989)***

Reduction of emissions (carbon monoxide, hydrocarbons, nitrogen and aerosols)

Consolidation also reduces emissions, as is illustrated in Figure 38-3. This figure shows that there are some differences between emissions. For instance, the reduction of nitrogen is much less compared to the reduction of carbon monoxide. With a network of 13 nodes, there is even an increase of nitrogen emission. These differences depend very much on the differences in emission per vehicle-kilometre.

Here, the emission factors of conventional road vehicles are used. The use of low-emission vehicles is not considered. Thus, new technologies may further increase the reduction of emissions.
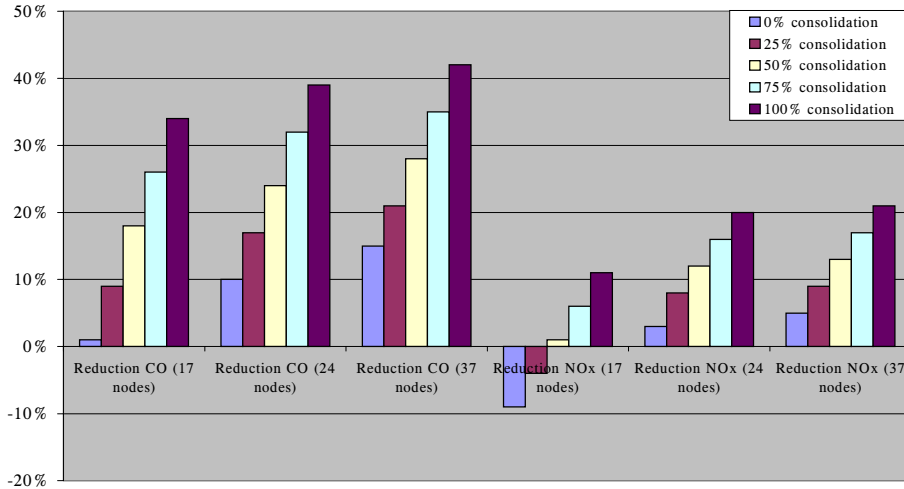
Figure 38-3:   *Reductions of carbon monoxide and nitrogen with different levels of consolidation in collection and distribution of goods (NEA/INRO-TNO, 1989)*

Reduction in transport costs

Finally, the NOVEM study also examined the reduction in transport costs. Figure 38-4 shows that consolidation leads to transport costs reduction.

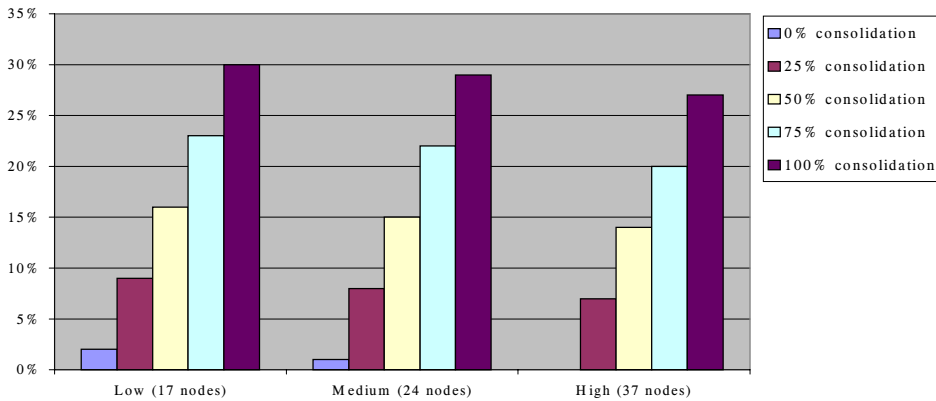*Figure 38-4:*   *Savings in transport costs with different levels of consolidation in collection and distribution of goods (NEA/INRO-TNO, 1989)*

There are hardly any costs savings when there is no consolidation in collection and distribution. Nevertheless, there are significant cost savings to be gained when consolidation occurs in collection and distribution. This demonstrates that collection and distribution are

relevant cost factors. There is, however, a reduction in costs savings when the number of nodes within a network increases. The costs savings are probably reduced by the extra investments required for transhipment facilities.

Conclusions

The NOVEM-study demonstrates that consolidation is able to reduce costs and disutilities significantly. It must be noted, that these calculations are based on assumptions and simple relationships. In reality, a one hundred percent degree of consolidation is hard to achieve. Therefore, these results must be considered as indicative.

38.3.4 Intermodality based on different modalities

The IPOT studies focussed on an integrated design, based on local Underground Logistic Systems within urban areas, with different types of multimodal national backbone networks for urban goods distribution.

Quantitative evaluation of intermodal concepts is difficult because only the costs factors of existing rail and waterborne systems are available. Current rail systems hardly show any efficiency improvements regarding energy use and emissions. This means that few efficiency gains can be introduced with existing intermodal concepts. Therefore, the integrated concept is based on new technologies for rail, new automated guided vehicles for long distance surface transport (compared to CombiRoad) and underground freight transport.

Energy use

For the IPOT project on underground transport, CE (2000) has estimated the direct and indirect energy use of different transport systems. It shows that in terms of direct energy use the ULS concept comes close to the overall energy efficiency of a future truck (see Table 38-2 and Table 38-3). However, it must be taken into account that these figures are just indicative. First, in urban areas, the energy-use of trucks per driven kilometre is much higher than the presented average figures, due to the 'stop-and-go' traffic characteristics. Because ULS doesn't suffer from this kind of traffic, the direct energy use of ULS will be significantly lower. Second, the figures presented for the ULS-systems are speculative, because these systems do not exist yet. The figures are estimates, figures from practice can both be better or worse (especially dependent from the actual traffic conditions in the underground system).

Compared to trucks, vans are in general not very energy efficient because of their limited carrying capacity. It is expected that in 2020 more energy efficient vans will become available. For city-logistics these new types of vans, and also new energy efficient trucks will be interesting.

Table 38-2:   ***Direct energy-use of different road vehicles in different years (CE, 2000)***

[MJ/tonnekm]	*1996*	*2005*	*2020*
Van	5.61	5.27	4.7
Truck	1.58	1.35	0.97

Table 38-3:   ***Direct energy of electric vans, ULS, rail, waterborne and Combi-road (CE, 2000)***

[MJ/tonnekm]	*Direct energy use*

Electric van (battery)	2.0 (in 2020) and 3.5 (in 1996)
ULS	0.7-1.4
Rail	0.7
Waterborne	0.4
Combi-road	1.3

Table 38-3 provides some indication of the direct energy use by the modalities within the integrated concept.

CE (2000) has also calculated the indirect energy use. These calculations show that the indirect energy use (the energy used to construct the transport system, including the infrastructure) of ULS is, compared to road transport, significantly high (see Table 38-4). This can be explained by the fact that a new infrastructure, dedicated for freight-purposes with a moderate level of occupancy, must be built. Again, these figures are indicative, but they make it clear that dedicated infrastructures have, in general, a high share of indirect energy use.

Table 38-4:   *Indirect energy use in MJ/tonnekm and share in total energy use (CE, 2000)*

	Indirect energy use [MJ/tonnekm]	*Indirect energy use as share of total (direct and indirect) energy use [%]*
Road transport	0.47	18%
Rail	0.30	45%
Waterborne	0.27	60%
ULS in urban areas	13.0-16.0	94%
ULS as backbone	3.7	78%

Reduction of emissions

TNO (1999) has estimated the reduction of emissions by ULS. A set of absolute reductions of carbon dioxide, carbon monoxide, nitrogen, particulates, and hydrocarbons are presented in Table 38-5). According to this study, the reduction of these emissions by ULS has little impact on the *total* emissions by traffic, because of the limited modal share of ULS. However, the local effects will be significant, because ULS, like most other electric systems, does not emit emissions locally.

Table 38-5:   *Emission reductions by implementing a national backbone network based on ULS (TNO, 1999)*

Emission	*Maximum reduction [million kilograms]*	*Emission*	*Maximum reduction [million kilograms]*
CO_2	1692.1	NO_x	24.1
CO	12.4	Particulates	1.7
VOS	5.9	SO_2	2.1

Note: no information was presented on total emissions

Noise
According to TNO (1998), the implementation of an intermodal system based on Underground Logistics Systems in the Netherlands can lead to a reduction of the number of houses with noise pollution higher than 55 dB(A), with about 36.000 houses (indicative).

Traffic safety
TNO (1998) estimates that the number of accidents will be reduced by a maximum of 12 percent by implementing an intermodal system based on Underground Logistics Systems.

Accessibility
Intermodal concepts are not, in general, very efficient due to time lost by extra transfer movements, and correspondingly increased waiting times. Figure 38-5 presents a comparison of lead times between intermodal concepts with collection and distribution by ULS and four types of backbone networks (road, CombiRoad, Rail and ULS). The results are derived from a simple simulation model (Visser et al., 1998) but provide some indication of possible differences in lead times. In this comparison, it is assumed that the four backbone network modalities use a dedicated infrastructure, and, in case of rail, new and innovative technologies.
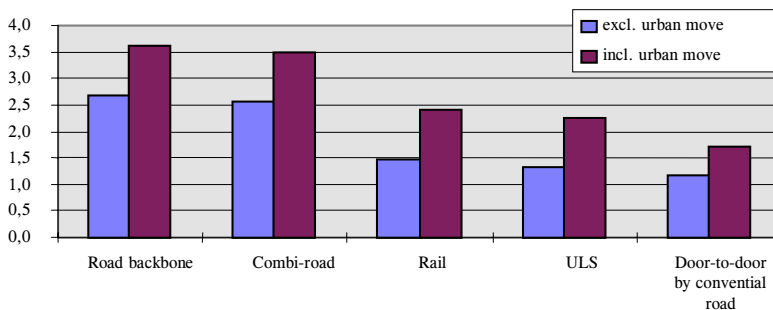
Figure 38-5: ***Indication of lead times (in hours) with ULS in urban areas and four types of backbone networks (road, CombiRoad, Rail and ULS) compared to direct delivery by road (Visser et al., 1998)***

From Vermunt (Visser at al., 1998) we learn that the consolidated flow of homogeneous flows – one result of the newly proposed logistic systems– does indeed lower transportation costs per unit. In Figure 38-6, a cost-comparison is carried out between the costs of traditional distribution of commodities and the costs incurred when a change in logistic concept occurs, whether by introducing city logistics or network logistics (example taken from Visser et al., 1998). In this case, producers deliver product to distribution centres at logistic parks instead of delivering it to the national distribution centre of a retail organisation. The situation for specialities remains the same, but can be improved by further consolidation (not calculated in this figure). The calculation is based on road transport.

Figure 38-6:   *Applying network logistics for commodities leads to costs reduction for commodities (source: Visser et al., 1998)*

The transport costs of new intermodal concepts are influenced by costs of investment in new infrastructure. In particular, in the case of ULS, a new infrastructure must be constructed solely for freight transport. Therefore, the same reasoning as with indirect energy use can be applied here. TNO (1999) notes that the expected rise of transport costs for existing road transport due to accessibility problems will make ULS more competitive. With respect to conventional road transport, new intermodal concepts could see more efficiency improvements in the future.

38.4   Strengths, weakness, opportunities and threats (SWOT)

38.4.1 Introduction

In this section, we discuss the strengths and weaknesses of the integrated design for urban goods distribution. Further, we will discuss the opportunities and risks for the implementation of the integrated design. This is called a SWOT-analysis. The strengths, weaknesses of and the opportunities and risks (or, in short: SWOT) for logistic parks are discussed by Van Binsbergen and Visser (1998). Another aspect of the integrated design, namely underground Logistics Systems in urban areas, also has its strengths and weaknesses. These aspects, as well as the opportunities and threats, are discussed in Visser and Van Binsbergen (2000).

38.4.2 Strengths

Strengths, in general, deal with the competitiveness and feasibility of the proposed solution, in terms of meeting certain goals. It concerns the competition between existing and alternative solutions, systems, or methods.

When we consider the strengths of the integrated concept, we must conclude that the concept is based on improved transport technologies that fit within new logistic concepts, and therefore offer an alternative to existing ways of transportation. The introduction of new logistic concepts, in combination with new transport technologies, has the potential to lead to better and new logistic services in terms of a better, faster and more reliable transport and/or lower costs.

Another strong point is that the concept integrates different processes and developments in the area of logistics, transportation, technology and spatial structure, as elaborated in Part VI, with the emphasis on an overall efficiency improvement of urban goods distribution in environmental and in economic terms. This means that it serves social, as well as economic objectives and thus also public and private interests. The integrated design is based on the synergies between these developments that are to some extent already occurring and converging. Thus, it fits within current trends and does not necessarily need to be considered as a breach in trends.

Another strength is that the implementation can occur, stepwise and in a flexible way, attuned to local or regional circumstances. The financial risk can be divided in time, place and between public and private actors.

38.4.3 Weaknesses

In general, weaknesses relate to uncertainties in the mechanisms of the proposed solution, the question is, normally, raised: "will it work?". In our case, uncertainties are related to the mechanisms of implementing the integrated design and uncertainties in achieving the efficiency improvements that we expect.

The combination of different developments is a strong point of the concept, but can also be considered as a weakness. A weakness is that the success in terms of final implementation and efficiency improvement, depends on the implementation of all elements. A chain is as strong as its weakest link. This means that the introduction of underground logistics systems in urban areas, for instance, depends on the development of at least city logistics, backbone logistic and logistic parks. This mutually interdependence can be considered as a weakness of the integrated design. Therefore, the implementation strategy is explicitly set up in stages.

Other weaknesses are the long time-span of the implementation and the financial risks that are involved. In particular, when large investments in infrastructure are involved, the time difference between the period these investments occur and the period of gaining the benefits, involves financial risks. Regarding the national backbone network and underground logistics systems in urban areas, new, dedicated, infrastructures are proposed. Such infrastructure requires a long period of development and only operates optimal at the level of a completed network. Another weakness is that these dedicated transport systems are technological and organisation innovative, and were never tested at such a scale. Uncertainties can lead to reluctance to implementation.

With respect to logistic parks, despite the large investments, the financial risks can be limited (see Van Binsbergen & Visser, 1998) by spreading the risk between public and private partners, and by stepwise development. It must be noted that it concerns a shift from investments in new industrial areas to new investments in these logistic parks. Investments in infrastructure for underground logistic systems indeed involve financial risks because uncertainties still exist.

The adaptation of logistic innovations is an uncertain factor. The integrated design requires logistic changes in urban goods distribution. Although it is expected that these logistic changes will occur, it is uncertain that they will occur on the scale that is expected and as far as is required for some of the elements of the integrated design, such as underground logistics systems.

The integrated design is based on public-private and private-private co-operation. This kind of co-operation is difficult to establish in certain situations, in particular when there is no direct urgency. One can consider this a weakness.

Uncertainties in achieving the expected efficiency improvements depend quite strongly on the degree in which consolidation will occur in urban goods distribution. When no consolidation takes place, for instance, when deliveries are not combined, hardly any efficiency improvements can be expected. A second condition is that economies of scale, scope, and density towards costs (environmental and economic) should occur. Without such economies, consolidation will not lead to efficiency improvements. Both, consolidation and economies of scale, scope, and density are not guaranteed for certain.

38.4.4 Opportunities

Opportunities deal with conditions that are favourable for the implementation of the proposed solution.

The demand for transport in the area of urban goods distribution will still increase. This means that this a growing market. The current urban goods distribution is about to find its limits in environmental and in economic terms. This means that there is a growing need for innovations in the urban goods distribution to perform better, quantitatively and qualitatively, and at the same time reduce the burden on resources and the environment. However, the technological innovations in the transport system can only be properly implemented when there will be a division in the urban and interurban goods movement, as proposed in the integrated concept.

The proposed logistic concepts are based on ongoing developments in logistics, namely professionalisation (from transport on own account to professional transport; more advanced

logistic systems) and centralisation of production and logistic facilities (even internationally). Shippers and receivers become accustomed to the fact that goods flows are handled and organised by third parties. They experience that it is still possible to monitor (track and trace) and control these flows and that the reliability is at an acceptable level.

Increased attention to accessibility and environmental problems has raised interest, both in finding new ways for urban distribution, and in short-distance (national) goods transport. Although a necessary 'faith' in market forces to optimise logistics remains, several governmental organisations begin to see the necessity of stronger incentives. They no longer rely only on market initiatives, but are also looking to the policy options, as they themselves have to direct developments in a desired direction.

38.4.5 Threats

Threats or deal with conditions that are unfavourable for the implementation of the proposed solution.

The integrated solution leans quite strongly on the belief that inefficiencies in economic and environmental terms must be taken seriously and that solutions for them should be found. In practice, society is often willing to accept these inefficiencies, or believes that the reduction of these inefficiencies requires too much effort or resources from the actors involved. It is also possible that other matters receive much more public attention. We can refer to these cases as the 'business-as-usual'-scenario. This scenario can be considered as a sort of risk.

Among the most significant participants in the field of urban goods distribution are probably the transport companies, the logistic service providers and especially the retailers. Although some of these companies support ideas of city and network logistics (especially larger logistic service providers), often there is a lack of support with these companies for profound changes in logistics.

This can be partly related to the sometimes quite 'ad-hoc' based way goods transport occurs – especially small companies are hardly accustomed to apply advanced logistic systems. Shop owners rely on their (direct) relations with suppliers and/or transport companies. Many small transport companies have a rather limited scope with regard to logistic operations. These groups are generally not in favour of new logistic concepts.

This also applies to very large retail chains – these companies already use highly advanced logistic systems and often make use of dedicated distribution facilities and specialised transport equipment. They have optimised their processes quite well, that is, within their own organisations. In addition, these large companies are reluctant to participate in urban distribution concepts although participation in larger scale (national) distribution concepts may be an option.

The urban distribution concepts developed are all based on the premises that urban areas of rather high densities exist and that it is possible to concentrate transport flows spatially. Both premises can be put in question if some autonomous developments are taken into account.

One can argue that in the case of spatial dispersion of urban activities, there may be less need for advanced logistic concepts that are based on consolidation. Even worse, it will be almost impossible to bundle the (tiny) flows into consolidated flows of reasonable size to use the new concepts efficiently. This argumentation is valid – if spatial dispersion occurs and there is no drive for concentration, then it makes less sense and it will be more difficult to use logistic

systems that are based on the concept of consolidation. Nevertheless, due to other policy goals – namely accessibility of various facilities by 'slow' transport modes and public transport – we assume that unlimited spatial dispersion will not be accepted by (Western European) policy makers.

Nowadays 'privatisation' and the blessings of the free market interfere with notions that policy makers should intervene in urban logistic processes. Transport companies, shippers and receivers should be free to find their own solutions, only the government can stimulate and facilitate those private initiatives and can set some limitations.

38.5   Conclusions

The evaluation demonstrated that the integrated concept performs under certain conditions at a higher level of efficiency than the current system for the distribution of goods in urban areas. To demonstrate the advantages of the new proposed integrated urban distribution concepts, we followed a qualitative and a quantitative approach.

The integrated concept is based on optimal bundling of the movements of goods ("consolidation") in time as well as in space by providing logistic services, such as city logistics, backbone logistics, and network logistics. These logistic services are based on co-operation for optimal consolidation. In order to be able to bundle goods flows going into different directions. Consolidation requires breaking down a goods movement into a collection/distribution movement and a *long*-distance transport movement. The separation between the local distribution movement within urban areas and the transport movement outside urban areas makes it possible to optimise both movements separately. This means small, quiet and zero-emission vehicles, or underground freight transport in the urban areas and large volume vehicles, such as trucks or trains, in inter-regional or long-distance transport. The integrated concept is therefore based on intermodality. A dedicated infrastructure within and outside urban areas, should make the operation smoother (a guaranteed capacity with undisturbed vehicle movements) and improve the efficiency.

The theoretical argumentation demonstrates that the integrated concept will lead to efficiency improvement when certain conditions are met. Reduction of transport costs or disutilities occurs when the following conditions are met:
- Consolidation should lead to economies of scale, scope, and density that will be used for reduction of the transport disutilities.
- The increase of 'transfer' disutilities may not exceed the total reduction of the transport disutilities that result if alternative modes are used.

Costs or disutility reductions in alternative modes will have to be found in improved efficiencies of activities within logistic chains. If economies of scale, scope, or density do not exist, consolidation does not lead to any cost reduction.

The introduction of new transport systems that cannot provide door-to-door transport will, in itself, add extra stages to the transport chain (pre and end haulage transport), and thus extra costs or disutilities. Proximity to multimodal terminals reduce and spatial concentration should avoid extra stages related to pre and end haulage or at least reduces distances. When

these conditions are met for all costs or disutilities then such an intermodal system can lead to efficiency improvements.

Some quantitative evidence can be found in studies performed by NOVEM and IPOT. TNO (1999) estimates, based on physical and logistic characteristics of goods flows, that the potential market shares between nine and eighteen percent of all domestic goods flows. This means that the integrated concept does not provide an overall solution for the problems related to traffic and freight traffic specific. The NOVEM study shows that consolidation in an intermodal road/road system leads to significant reductions in energy use, emissions, and transport costs. The level of efficiency improvement depends on the degree of consolidation, in particular the degree of consolidation in collection and distribution.

The IPOT studies demonstrate that intermodal systems, based on new concepts have the potential for further efficiency improvements. The use of new advanced road vehicles and ULS within urban areas and new rail systems as a backbone is able to further reduce energy use, emissions, noise problems and safety hazards. A comparison of the indirect energy use shows that dedicated systems, in particular Underground Logistic Systems, have a very high share of indirect energy use. This can be explained by the fact that a new infrastructure, dedicated to freight-purposes with a moderate level of occupancy must be built. When the indirect energy use is taken into account, then ULS might be less energy-efficient than conventional transport systems.

The construction of new infrastructure will probably also affect the level of costs-savings of new intermodal systems. The expected rise of transport costs of existing road transport, due to accessibility problems, will make new intermodal system such as ULS more competitive.

We discussed the strengths and weaknesses of the integrated design for urban goods distribution and the opportunities and threats for the implementation of the integrated design.

The strength of the integrated concept is that it offers an alternative for existing ways of transportation. The introduction of new logistic concepts in combination with new transport technologies leads to better and new logistic services, in terms of a better, faster, and more reliable transport and/or lower costs. It also serves social, as well as economic, objectives and thus also both public and private interests. The concept also fits within current trends and does not necessarily need to be considered as a breach in trends.

Weaknesses or risks are the uncertainties in achieving the expected efficiency improvements, including the long time-span of the implementation and the financial risks involved. The integrated concept is based on public-private and private-private co-operation. This kind of co-operation is difficult to establish in some situations, particularly when there is no direct urgency.

One opportunity is that urban goods distribution is a growing market. There is a growing need for innovations in services and efficiency improvement. Thus, the public will focus attention on accessibility and environmental problems in urban areas. *Business-as-usual* and *conservative* behaviour of the actors involved can be seen as risks.

Based on this SWOT-analysis, we conclude that the integrated concept is 'implementable' but that it is still difficult to draw a final conclusion about the likelihood of it becoming fully implemented. Although many of the developments of processes are already occurring, the full implementation of the integrated concept depends strongly on the attitude of the actors

involved and the success of public-private co-operation. Current conditions in this respect look favourable. For instance, consultation platforms, such as Platform Stedelijke Distributie in the Netherlands, are becoming increasingly effective in developing public-private co-operation and initiating innovations in urban goods distribution.

39. Summary and conclusions of Part VI

The proposed integrated logistics concept for urban goods distribution is based on the optimal bundling of the movements of goods (*consolidation*) in time as well as in place. This should be done by providing logistic services, such as city logistics, backbone logistics and network logistics, in close harmony with appropriate technological means, such as advanced vehicle technologies, advanced infrastructures, and other supportive systems. Logistic services are achieved by co-operation between actors acting at the same level (horizontal co-ordination) and the integration of the activities of actors at different levels (vertical co-ordination).

Consolidation requires the breakdown of a given goods movement into two parts: a collection/distribution movement, and a long-distance transport movement. The separation between the local distribution movement for urban areas, and the transport movement outside urban areas, allows the optimisation of both movements. This means small, quiet, zero-emission vehicles and/or ULS can be used in the urban areas, while large-volume vehicles, such as trucks or trains, can be used for inter-regional or long-distance transport. Dedicated infrastructure within and without urban areas should make the operation smoother and improve the efficiency. The integrated concepts are based on the application of different transport systems in different areas: that is, the concept is based on intermodality.

Introducing such a complex, integrated goods distribution system, will require a long string of co-ordinated actions from a wide variety of public and private actors. This necessitates the development and application of an implementation strategy that includes all the necessary actions. The implementation strategy is based on back-casting methodology, which first sketches the envisaged 'ideal' system, and then back-traces the necessary actions of the different actors involved.

With the help of an institutional framework, the different actors and the roles they should play can be identified. The implementation should be based on both private and public

involvement. The involvement of private actors is based on either their direct interests in urban goods distribution ('shareholders') or their being indirectly involved or affected by the goods distribution process ('stakeholders', often represented by public factions). This strong involvement implies a public planning style in which governments act as facilitators and allow strong involvement of private actors. This method of planning combines a top-down long-term vision with a bottom-up implementation. Consultation is a significant part of such a planning process. Finally, analysis is needed to provide relevant information for decision-making and monitoring.

For the development of the implementation strategy, we propose a seven-step approach:
1. Identifying time-stages (short-term, medium-term, long-term);
2. Formulation of objectives (private and public objectives);
3. Inventory of options in each time-stage ('solutions area');
4. Formulating an optimum scheme for each time-stage ('soll');
5. Analysing the state of affairs at each time-stage ('ist');
6. Identifying the discrepancies between 'ist' and 'soll' for each time-stage and developing a public-private policy to overcome these gaps;
7. Developing the implementation strategy by connecting the different public-private policy actions.

For the public portion of the actions, the following policy instruments can be defined:
•   Active involvement (subdivided into three types: developer, provider or operator).
•   Planning instruments (infrastructure planning and spatial planning are most relevant for urban goods distribution);
•   Financial instruments, to be subdivided into:
    •   Taxes and pricing, and
    •   Financial support (subsidies).
•   Legislative instruments. These include instruments such as restrictions on entrance times, vehicles weight, dimensions, or emissions, and requirements with respect to load factors.
•   Communication and consultation instruments; instruments that can be used to promote co-operation.
•   Agreements and covenants that are used to commit (public and private) actors to specific actions.

An evaluation of public policies in German, Japan, France, and the Netherlands shows that a wide range of measures has been taken. There is a clear distinction between urban freight transport policies between the different countries. For instance, in Germany local programs have been established, while in Japan and the Netherlands national programs exist. On a practical level, in France, there is a strong emphasis on research and analysis, while in the Netherlands there is more experimentation. Germany has gone beyond the experimental phase and is trying to implement measures related to regulation, inter-modal terminals, and city logistics, but has not established a long-term public policy. Japan has been in an implementation phase since 1997, and has been giving budget priority to logistics.

The evaluation shows that significant developments are taking place, but that public policies are not very well co-ordinated and pay little attention to integrated and long-term planning. The focus is very strongly on the short term, while policies are quite pragmatic.

The implementation strategy to develop and implement the envisaged integrated logistics system is divided into three stages: short-term, medium-term and long-term. These strategies are designed in such a way that in each of the time-stages, positive results can be seen. In each stage, an inventory of the remaining problems should be made. On basis of this analysis, policy makers will have to decide whether to go on with the strategy or to keep the system the way it is at that moment. The implementation strategy is designed in such a way that even when the strategy is 'aborted', the existing situation will still function.

Short-term stage

In the short term, there are limited possibilities for changing the urban goods distribution process. Actions within this stage should aim at stimulating the actors to use more efficient goods distribution systems, and to anticipate medium-term and long-term plans with respect to city logistics and network logistics. Within urban areas it is important to improve trucks that already perform optimised physical distribution services (direct distribution). Adapted combustion engines and the use of advanced traffic control systems must help to limit the negative external effects of these vehicles. Outside urban areas, the average size of vehicles must increase (with more large vehicles, fewer small vehicles should be operated). Later, the size of large vehicles may be extended, but this will require changes in legislation.

Public actions in this stage include:

- R & D on the urban distribution truck;
- Planning and reservation of space for logistic parks;
- Stimulation of the development and first use of new advanced logistic systems, logistic parks and advanced transport and transhipment technologies;
- Agreement on entrance restrictions for urban areas;
- Legislation for larger road vehicles outside urban areas;
- Supporting co-operation with covenants.
- Installing regional consultation programs.

Medium-term stage

The medium-term implementation strategy aims at a full application of city logistics concepts, the introduction of dedicated urban distribution vehicles within urban areas, and the application of larger road vehicles outside urban areas. The medium-term implementation strategy aims at a full application of city logistics concepts, the introduction of dedicated urban distribution vehicles within urban areas, and the application of larger road vehicles outside urban areas. Logistic parks should be connected with rail and waterborne infrastructure. In this stage, the implementation of intermodal transport by rail and waterborne will be prepared. Finally, standardisation of load units will be required in this stage.

Public actions in this stage include:

- Covenants for public-private development of logistic parks;
- Construction of logistic parks;
- Pricing used as an incentive to achieve more efficient logistics schemes (i.e., load/unload tariffs);
- Development and tests on railway alternatives;
- R & D of pilot projects for underground freight transport.

Long-term stage

The long-term implementation strategy aims at full implementation of the integrated design. Within urban areas, we will see full operation of an integrated city logistics system and application of dedicated urban distribution vehicles making shared use of dedicated infrastructures and underground infrastructures. Outside urban areas, it would mean full operation of a multimodal backbone logistics system for interregional movements of urban goods with the application of road, rail or waterborne transport systems based on dedicated infrastructure.

Within urban areas, underground systems will become technically feasible.

Public actions in this stage include:

- Infrastructure planning, financing and construction of dedicated (underground) infrastructure for freight within urban areas;
- Applying a licensing system that controls the type and movements of vehicles within urban areas in combination with road-pricing, taxation on the use of non-dedicated distribution vehicles;
- Infrastructure planning, financing and construction of dedicated infrastructure (road, rail, underground) for the backbone network;
- Land use planning towards logistic parks and land-use pricing (taxation) to support land use planning;
- Financial support for the implementation of new technologies, or for the operation of dedicated infrastructure.

The evaluation demonstrated that the integrated concept performs under certain conditions at a higher level of efficiency than the current system for the distribution of goods in urban areas. To demonstrate the advantages of the new proposed integrated urban distribution concepts, we followed a qualitative and a quantitative approach.

The theoretical argumentation demonstrates that the integrated concept will lead to efficiency improvement when certain conditions are met. Reduction of transport costs or disutilities occurs when the following conditions are met:

- Consolidation should lead to economies of scale, scope, and density that will be used for reduction of the transport disutilities.
- The increase of 'transfer' disutilities may not exceed the total reduction of the transport disutilities that result if alternative modes are used.

Costs or disutility reductions in alternative modes will have to be found in improved efficiencies of activities within logistic chains. If economies of scale, scope, or density do not exist, consolidation does not lead to any cost reduction.

The introduction of new transport systems that cannot provide door-to-door transport will, in itself, add extra stages to the transport chain (pre and end haulage transport), and thus extra costs or disutilities. Proximity to multimodal terminals and reduced spatial concentration should avoid extra stages related to pre and end haulage, or at least reduce distances. When these conditions are met for all costs or disutilities, then such an intermodal system can lead to efficiency improvements.

Some quantitative evidence can be found in studies performed by NOVEM and IPOT. TNO (1999) estimates, based on the physical and logistic characteristics of goods flows, a potential market share of between nine and eighteen percent of all domestic goods flows. This means that the integrated concept does not provide a comprehensive solution for all problems related to traffic generally, and to freight traffic specifically. The NOVEM-study shows that consolidation in an intermodal road/road system does lead to significant reductions in energy-use, emissions, and transport costs. The level of efficiency improvement depends very much on the degree of consolidation, in particular the degree of consolidation in collection and distribution.

The IPOT studies demonstrate that intermodal systems based on new concepts have the potential for further efficiency improvements. The use of advanced road vehicles and ULS within urban areas, coupled with new rail systems as a backbone can further reduce energy use, emissions, noise problems, and safety hazards. At the same time, a comparison of indirect energy use shows that dedicated systems, in particular Underground Logistic Systems, have quite a high share of indirect energy use. This can be explained by the fact that a new infrastructure, dedicated to freight-purposes with a moderate level of occupancy, must first be built. When the indirect energy use is taken into account, then ULS might be less energy-efficient than conventional transport systems. The construction of new infrastructure will probably also affect the level of costs-savings of new intermodal systems.

The general conclusions from Part VI are as follows:

- A systematic and integrated approach is essential because of the organisational complexity of the urban goods distribution, the strong interactions with other systems in society and the multi-dimensional nature of the problem.
- A long-term implementation strategy is required to achieve fundamental changes, because substantial and long-term interventions are required in different and successive stages.
- Each implementation stage should be consistent within itself and should, at the same time, be part of the long-term strategy.
- The strategy combines a top-down approach (development of a long-term vision) with bottom-up approaches (realisation and operation of the system) in a public-private environment. Consultation, participation, and commitment of private actors are essential in the implementation strategy.

40. Recommendations for further research

This thesis outlines the development and implementation of an integrated concept for goods distribution in urban areas. Attention is paid to design and evaluation of the concept. We like to propose some recommendations to further elaborate this concept.

The thesis presents an approach to an integrated design of the concept. In this design, it is essential to determine the optimal combination of transportation systems and services within and outside urban areas, and to determine the shape and dimensions of the network on all levels (national, regional and local). This is elaborated in broad lines.

The optimisation method, proposed in the conceptual framework (Part II), is only applied to a limited extent. No definite solutions could therefore be found for the optimal dimensions of the distri-regions, the number of logistic parks, the density and shape of the national backbone network and the local networks, and the required transport and transhipment technologies.

These aspects are strongly interrelated. Because it concerns a hierarchical multi-modal network, the problem of network optimisation problem is too complex to find a satisfying solution.

The thesis begins to evaluate the proposed concept. The results of the evaluation, based on a qualitative and quantitative method of approach are, however, not satisfactory for definitive judgement of the commercial and social viability, and of the level of efficiency improvement that would result from a stepwise implementation (which was one of the objectives of the research performed).

Lack of data was one of the major problems. As concluded in Part I, a reliable, detailed and extensive database on the practice of goods distribution in urban areas is missing. The current information databases offer few possibilities to accurately and reliably determine the

influence of new logistic concepts, or the influence of new marketing concepts, like E-commerce on the distribution of goods.

In Part III, new ways of road transport, rail transport, waterborne and underground freight transport, as well as transhipment technologies are discussed. Research has already been carried out in these areas, but this has not yet resulted in adequate insights into their performance in terms of quality, travel time, and environmental costs. In particular, further research is needed to find out under what conditions to determine in how far these innovations lead to efficiency improvement. Because desk research will not provide sufficient information, actual testing (laboratory, field or other ways) will be required.

With the resulting insights it will be possible to determine the potential social costs and benefits, the business economical cost savings and the spatial economic potentials. Such an evaluation requires:

- The implementation of a data base, including the collection of data, on goods distribution;
- Analysis of the dimensions and the composition of the goods flows;
- Research at the current locations of logistic activities and transport generating businesses;
- Research into the use of space of these businesses, and their environmental impacts;
- Determination of criteria for admission into logistics parks and other logistic locations;
- Costs-benefits calculations and comparisons;
- Scan of logistic and economic changes by this concept;
- Modal shift analyses.

The implementation of the proposed innovations requires huge technological and logistic adaptations in the management of companies active in the distribution of goods. Financial, organisational and legal obstacles might slow down, or even prevent, the implementation of these innovations. In this thesis, these barriers are dealt with to a limited extent. However, these barriers should not be neglected, and deserve therefore careful attention. To determine public acceptance and/or support, further research into the following areas is needed:

- The obstacles to co-operation between companies, such as between retail organisations, shippers and transport companies;
- The patterns of co-operation between shippers operating within a region or in a network;
- The social acceptance among market players;
- The goodness of fit within logistic strategies of companies;
- The ways of bundling of local initiatives;
- The distribution of tasks and means between public and private players.

These recommendations for further research are of social, and also partly of scientific, relevance. We hope that, with these recommendations, the tradition of relevant scientific and social research in the area of goods distribution in urban areas will be continued.

References

B&A Groep (1998) *Startnotitie beleidsrealisatie korte afstandsgoederenvervoer, kansen en belemmeringen* (in Dutch), Den Haag.

Bakkenist Management Consultants (1998) *Transportpreventie: Een nieuw concept in logistiek Nederland* (in Dutch), Amsterdam (Bakkenist Management Consultants).

Beroggi, G.E.G. (1999) *Safety concepts in land use engineering*, Delft (Delft University Press).

Binsbergen A.J. van, A. Erkens & B. Hamel (1994) *Long-term energy efficiency improvement for transport: technology assessments*, Delft, (Delft University of Technology).

Binsbergen A.J. van, Th.J.H. Schoemaker, C.D. van Goeverden & G.G.M.M. Vermijs (1995) *Berekening van maatschappelijke kosten en baten van snelheidsverlaging voor het personenautoverkeer* (in Dutch), Delft (Delft University of Technology).

Binsbergen, A.J. van & J.G.S.N. Visser (1997a) *Haalbaarheidsstudie stadsdistributiecentrum Delft, transferpunt voor goederen met een binnenstedelijke bestemming* (in Dutch), Delft (TRAIL Onderzoekschool).

Binsbergen, A.J. van & J.G.S.N. Visser (1997b) *Ladingdragers en transporteenheden, lokatiekeuze terminals en netwerkvorming, hoofdrapport* (in Dutch), Delft (TRAIL).

Binsbergen, A.J. van & J.G.S.N. Visser (1998) *Distributieregio's en concentraties van logistieke bedrijvigheid: de oplossing voor het korte-afstandsgoederenvervoer*, Delft (TRAIL).

Bliss, D. (2000) MailRail – 70 years of automated underground freight transport, in: Visser, J.G.S.N. & A.J. van Binsbergen (ed.) (2000) *Proceedings 2nd International Symposium Underground Freight Transportation by Capsule Pipelines and Other Tube/Tunnel Systems (ISUFT 2000)*, TRAIL Conference Proceedings Series no. P2000/2, Delft (TRAIL Research School).

Boerkamps, J. & A. van Binsbergen (1999) GoodTrip – A New Approach for Modelling and Evaluation of Urban Goods, in: Taniguchi, E. et al. (1999) *City Logistics I*, *proceedings*

of The First International Conference on City Logistics, Kyoto (Institute for Systems Science Research).

Broome D. & D. Morrison (1991) Truck noise and exhaust emissions control, optimal technology, in: *Freight transport and the environment*, ed. K.M. Gwilliam, Paris (ECMT), pp. 89-98

Brouwer, W., W.E. van Lierop, G.A.A. Erens, A.F.C. Carlebur, & J.G.S.N. Visser (ed.) (1997a), *Buisleidingtransport (BLT) voor Stedelijk Goederenvervoer, deel A* (in Dutch), DTO-werkdocument M9. Delft (DTO).

Brouwer, W., W.E. van Lierop, G.A.A. Erens, A.F.C. Carlebur, & J.G.S.N. Visser (ed.) (1997b) *Buisleidingtransport (BLT) voor Stedelijk Goederenvervoer, deel B* (in Dutch), DTO-werkdocument M10. Delft (DTO).

Bruijn, J.A. & J.A.M. Hufen, 1992, Instrumenten van de overheid, in: *Beleidswetenschap, nr. 2, jrg 6* (in Dutch), blz. 69-92, Alphen aan den Rijn (Samson H.D. Tjeenk Willink).

Buck Consultants International (2000) *Naar een Netwerk van netwerken; visie-ontwikkeling ten behoeve van de 5ᵉ Nota Ruimtelijke Ordening*, Den Haag.

Buck Consultants/TRAIL Onderzoekschool/ RUPS Adviseurs (1999) *Gaat Leiden Ondergronds, hoofdrapport* (in Dutch), Rotterdam (RUPS Adviseurs).

Bukkems, G. (1989) *Doorwerking van het in het nationale ruimtelijke plannen verwoorde beleid, in het bijzonder de Vierde nota over de Ruimtelijke Ordening* (in Dutch), Nijmeegse Cahiers 30, Nijmegen (Katholieke Universiteit Nijmegen).

Button, K.J. & Pearman A.D. (1981) *The economics of Urban Freight Transport*, London (Macmillan).

Centrum voor energiebesparing en schone technologie (CE, 2000) *Maatschappelijke baten van ondergronds logistieke systemen*, Delft (CE).

Cooper J. (1991) Innovation in logistics: the impact on transport and the environment, in: *Freight transport and the environment*, ed.: M. Kroon, R. Smit and J. van Ham, Amsterdam, (Elsevier Science Publishers), pp. 235 - 253.

Coopers & Lybrand Management Consultants (1991a) *Plaatsen van stadsdistributiecentra: definitiestudie* (in Dutch), Rotterdam.

Coopers & Lybrand Management Consultants (1991b) *Plaatsen van stadsdistributiecentra: naar een bereikbare en leefbare binnenstad van Maastricht, plan van aanpak*, Rotterdam.

COWI/NTU (1996) *Rationalisation of Urban Goods Transport*, Lynby/Aalborg.

CPB (1992) *Scanning the future; a long-term scenario study of the world economy 1990 - 2015*, Den Haag (SDU Publishers).

Dablanc, L. & F. Massé (1996) Les centres de distribution urbaine: un tableau comparatif, in: *Transport Urbains* no 91, Avril-June 1996, France.

Daniels, S.E., Lawrence R.L., & Alig R.J. (1996) Decision-making and ecosystem-based management: applying the Vroom-Yetton model to public participation strategy, in: *Environmental Impact Assessment Review 16*, blz. 13-30.

Delsey J. (1991) Growth of vehicle power and environmental consequences, in: K.M. Gwilliam (ed.) *Freight transport and the environment*, Paris (ECMT), pp. 77-88.

Dufour, J.G. & D. Patier (1997) Introduction to the discussion based on the experience of the French experimental and research programme, *Round Table 108 Freight Transport and the City*, Paris (ECMT).

European Commission Directorate General Transport (1998) *COST 321 Urban Goods Transport, final report*, Brussels (European Commission).

European Conference of Ministers of Transport (ECMT, 1976) *Round Table 31 Freight Collection and Delivery in Urban Areas*, Paris (OECD).

European Conference of Ministers of Transport (ECMT, 1984) *Round Table 61 Goods Distribution Systems in Urban Areas*, Paris (OECD).

European Conference of Ministers of Transport (ECMT, 1999) *Round Table 109 Freight transport and the city*, Paris (OECD).

Filippi F. (1991) Prospects for the reduction of noise from heavy duty diesel vehicles, in: M. Kroon, R. Smit and J. van Ham (eds.) *Freight transport and the environment*, Amsterdam (Elsevier Science Publishers), pp. 119-130.

Geurts, K.T. (1995) *Milieu-effecten van verkeers- en vervoersbeleid aan de voordeur*, Bilthoven (RIVM).

Glasbergen, P. (1989) *Milieubeleid, Theorie en praktijk*, Den Haag (VUGA).

Gorißen N. (1991) Measures for more environment-friendly freight traffic, in: K.M. Gwilliam *Freight transport and the environment*, Paris (ECMT), pp. 141-147.

GOVERA (1997) *Naar een logistieke visie voor de Randstad*, discussienota, Den Haag (GOVERA).

Haccoû, H.A., J.G.S.N. Visser & R.L. Elting (1996) *Buisleidingen voor goederentransport, definitiestudie* (in Dutch), DTO werkdocument M2. Interdepartementaal Onderzoeksprogramma DTO, Delft (DTO).

Havers H.C.P. (1966) Underground railways of the world - their history and development, London.

Hoogerwerf (1985) *Overheidsbeleid* (in Dutch), Alpen aan den Rijn (Samson Uitgeverij).

Japan Society of Civil Engineers (JSCE, 1994) *Urban Freight Transport System as Social Infrastructure* (in Japanese), Tokyo (JSCE).

Lange, M. de (1999) Procesmetselaars, in: *Stedebouw & Ruimtelijke Ordening, thema Procesmetselaars, no. 5*, 1999, Den Haag (NIROV), p. 5-7.

Louw, E., P. Nijkamp & H. Priemus (1991) *Sturingssystemen voor infrastructuur en mobiliteit, naar een onderzoeksagenda* (in Dutch), Infrastructuur, Transport en Logistiek nr. 9, Delft (Delftse Universitaire Pers).

Ministerie van Verkeer en Waterstaat (1990) *Tweede Structuurschema Verkeer en Vervoer; deel d: regeringsbeslissing* (in Dutch), Tweede Kamer 1989-1990, 20922 nrs. 15-16, Den Haag (SDU).

Miser, H.J. & E.S. Quade (1985) *Handbook of systems analysis, overview of uses, procedures, applications, and practice*, Chichester (John Wiley & Sons).

Moffat B. (1982) *Forty feet below: the story of Chicago's freight tunnels*, Interurbans Special 82, Glendale (Interurban Press).

NEA (1993) Trendbreukscenario Goederenvervoer: vervoer, verkeer en milieu in de werkscenario's en het Trendbreukscenario (in Dutch), Rijswijk (NEA).

NEA/INRO-TNO (1989) *Een vervoersysteem van standaardeenheden in het interstedelijk verkeer* (in Dutch), Rijswijk.

Nemoto, T. (1997) Area-wide inter-carrier consolidation of freight in urban areas, Transport Logistics, Vol 1, No 2.

Ogden, K.W. (1992) *Urban Goods Movement: A guide to Policy and Planning*, Aldershot (Ashgate).

Oppenheim, N.A (1993) Combined, equilibrium model of urban person travel and goods movements, in: *Transportation Science, vol. 27, No. 2*, may 1993.

Ortúzar, J. de Dios & L.G. Willumsen (1996) *Modelling Transport*, Chichester (John Wiley & Sons).

Platform Stedelijke Distributie (1997a) *Gemeenten en Goederenvervoer, Tipper 1* (in Dutch), Den Haag (PSD).

Platform Stedelijke Distributie (1997b) *PSD Projecten Programma, PPP 1* (in Dutch), Den Haag (PSD).

Platform Stedelijke Distributie (1999) *De vitale stad, bereikbaar in drie stappen, Tipper 2*, Den Haag (PSD).

Rietveld P., A. van Binsbergen, T. Schoemaker & P. Peeters (1998) Optimal speed limits for various types of roads: a social cost-benefit analysis for the Netherlands, in R. Roson and K.A. Small (eds.) *Environment and transport in economic modelling*, Dordrecht/Boston/London (Kluwer Academic Publishers), pp. 206-225.

Rutten B.J.C.M. (1995) *On medium distance intermodal rail transport*, Delft (Delft University of Technology).

Schoemaker Th.J.H. & A.J. van Binsbergen (1993) *Trendbreukscenario Goederenvervoer: het Groen Transport Scenario* (in Dutch), Delft (Delft University of Technology).

Simonis, J.B.D. (1983) *Uitvoering van beleid als een probleem* (in Dutch), Amsterdam (Uitgeverij Kobra).

Sustrate, V. (1999) Economic transport in the Hanover area, in: European Conference of Ministers of Transport *Round Table 109 Freight transport and the city*, Paris (ECMT).

Taniguchi, E., R.G. Thompson & T. Yamada (1999) Modelling City Logistics, in: E. Taniguchi & R.G. Thompson (eds.), *City Logistics I*, Kyoto (Institute for Systems Science Research).

Taylor, S. & K. Button (1999) Modelling urban freight: what works, what doesn't work? in: E. Taniguchi and R.G. Thompson (eds.) *City Logistics I*, Kyoto (Institute for Systems Science Research), pp 203-217.

Teisman, G.R. (1999) Interactieve beleidsvorming als norm, in: *Stedebouw & Ruimtelijke Ordening, nr. 5* (1999) pp. 8-11, Den Haag (NIROV).

TNO (1998), *Ondergronds transport in buizen, een integrale afweging*, Delft (TNO).TNO Inro (1999) *Naar een landelijk netwerk voor goederenvervoer met ondergronds transport per buisleiding* (in Dutch), Delft.

Tonkelaar W.A.M. den (1991) Speed limits, effects and benefits in terms of energy efficiency and reduction of emissions, in: *Freight transport and the environment*, ed.: M. Kroon, R. Smit and J. van Ham, Amsterdam (Elsevier Science Publishers), pp. 261-270.

Visser, J.G.S.N & A.J. van Binsbergen (1999a) Ondergrondse goederendistributie in Leiden; resultaten van een haalbaarheidsstudie, in: Rodenburg, R.H.J. & A.L. Kruse (eds.) *Vervoerslogistieke werkdagen 1999* (in Dutch), Delft (Connekt), pp. 409-431.

Visser, J.G.S.N. & A. Loos (1995) Heeft ondergrondse stedelijke distributie toekomst?, in: *Verkeerskunde nr. 6* (in Dutch), Delft (ANWB), blz. 33-35.

Visser, J.G.S.N. & A.J. van Binsbergen (1999b) Urban freight transport policy and the role of modelling, in: E. Taniguchi & R.G. Thompson (eds.) *City Logistics I*, Kyoto (Institute for Systems Science Research).

Visser, J.G.S.N. & A.J. Van Binsbergen (2000a) Underground Goods Distribution in the City of Leiden: The Results of a Feasibility Study, in: Liu, H. & C. Roberts (eds.) *Proceedings of the First International Symposium on Underground Freight Transportation by Capsule Pipelines & Other Tube/Tunnel Systems 1999*, Columbia, Missouri (Capsule Pipeline Research Center), p. 157-166.

Visser, J.G.S.N. & A.J. van Binsbergen (2000b) Underground Logistical Systems in cities: A visualisation of the future, in: Visser, J.G.S.N. & A.J. van Binsbergen (eds.) *Proceedings 2nd International Symposium Underground Freight Transportation by Capsule Pipelines and Other Tube/Tunnel Systems (ISUFT 2000)*, TRAIL Conference Proceedings Series no. P2000/2, Delft (TRAIL Research School).

Visser, J.G.S.N. (2000a) City Logistics and the strategic options for the future, in: Taniguchi, E. (ed.) *City Logistics 2000*, Kyoto (Institute for City Logistics).

Visser, J.G.S.N. (2000b) Underground Freight Transport in Urban Areas, in: Liu, H. & C. Roberts (eds.) *Proceedings of the First International Symposium on Underground Freight Transportation by Capsule Pipelines & Other Tube/Tunnel Systems 1999*, Columbia, Missouri (Capsule Pipeline Research Center), p. 104-115.

Visser, J.G.S.N., A.J. van Binsbergen & Toshiro Nemoto (1999) Urban Freight Transport
    Policy and Planning, in: E. Taniguchi & R.G. Thompson (eds.) *City Logistics I*, Kyoto
    (Institute for Systems Science Research).
Visser, J.G.S.N., A.J.M. Vermunt & A.J. van Binsbergen (1998) *Ruimtelijke concepten
    ondergronds transport* (in Dutch), Delft/Hoeven (TRAIL Onderzoekschool).

Appendix A Terminology

Accessibility - The attributes and features (travel costs, travel time and so on) of a transportation product or service (walking, car, public transport) that are of importance for satisfying certain determined or obvious requirements for mobility for persons and transportation for goods.

Actor – a general term for individuals, groups or organisations that have a certain interest (*stakeholders*) or are active within a particular area, in this case urban goods distribution.

Assortment - a specific selection from all available products brought together with a certain actor so that he can maximise his utility. *Demand assortment*: assortment as desired by an actor (e.g.: desired by a consumer). *Supply assortment*: assortment as provided by a supplier (e.g.: provided by a retailer).

Backbone logistics - organisation of the goods flows between regions in a way that consolidation takes place by cooperation between private organisations.

Backbone network – network (physical, logistic) that interconnects regions within the Netherlands

Basic logistic activity - single, fundamental, uniquely identifiable logistic operation performed on goods.

CargoSprinter - short (7 wagon) goods transport train with operational characteristics similar to passenger trains (maximum speed, acceleration capabilities).

Channel director - the most powerful actor in the marketing channel.

City-logistics - organisation of goods flows to consolidate of goods flows within an urban area

by cooperation between private organisations.

CombiRail - combined transportation of passengers and goods (cargo) within specialised railway carriages.

CombiRoad - concept for automated road goods transport by automated tractors towing standard semi-trailers, using dedicated infrastructure.

Commodities - products that are so 'common' (well-known, widely used) that they make part of the assortments of most retailers in a specific market niche (compare with *specialities*).

Composite distribution - combined distribution of goods that in fact have different requirements of the distribution system.

Conservation - reducing the need for resources ('costs') without changing the use of the system (generating 'benefits'). It is strongly related to *efficiency improvement*.

Consignment - see Delivery.

Consolidation - the bundling (bringing together) of the movement or flows of goods in time as well as in space.

Consultation - a way of public-private co-ordination. Consultation fills the gap between the horizontal and vertical co-ordination at the side of governmental bodies and the market self-regulation at the side of the private sector.

Cooperation - collaboration of private and/or public organisations.

Corridors - are reservations (route, infrastructure or space) at the level of a link between two points for a specific purpose, in this case freight movement. For instance, interregional corridors are the spatial reservations for (existing or new) infrastructure of different modalities, close to each other, in a way that they interconnect regions (or, to be more precise, the logistic parks, main ports, industrial areas, or border crossings in the regions). Local corridors interconnect logistic parks, or similar concentrations of logistic activities, to the relevant freight traffic destinations within urban areas, for instance shopping areas.

Delivery (consignment, sending, provisioning) - a clear, recognisable, separate, collection or quantity of goods that is transported in one trip for one consignor from one loading berth to one discharging berth for one consignee.

Delivery frequency -the number of times that a receiver at his business location is provisioned, per day or per week.

Differentiation - that the splitting up of a service into separate stages, in which each stage, is a sub-service is provided by different organisations.

Distribution region (or distri-region) - a geographic area where freight traffic is optimised through the development of spatial concentrations of logistical and traffic-intensive activities.

Direct distribution - delivery from goods directly from the supplier to the (end-) user, without trade or logistics intermediaries.

Diversification - setting up a transport service to be as robust to be as robust as possible, while delivering as many different kinds of services using (mostly) the same means.

Economies of density - implies that the demand can be 'bundled' and thus specialised means become attractive and efficient. Enables a differentiated pallet of service and allows for specialisation. Relates to service and network advantages.

Economies of scale - implies that given the same production means, a larger production volume results in lower average production costs per unit.

Economies of scope - implies that given the same production means, different (ranges of) products can be produced, so that different niche markets can be served.

Efficiency - defined as the ratio of performance and costs (including negative effects); deals in this context with economic as well as social performances and costs. We define *social efficiency improvement* as the reduction of the total social costs of transport with the same or improved ability to transport goods in the desired amount and variety to and from urban areas from the viewpoint of sustainable development. *Economic efficiency improvement* is the reduction of the total logistical costs at the same or improvement quality of transport.

Fast movers - products that are sold in large quantities (volumes, units); compare with *slow movers, specialities, and commodities.*

Final Distribution - see urban goods distribution

Fordism – Strategy emphasizing control of a large part of the logistic chain in the production column, allowing the producer he is able to tune the different basic activities – so named because when the Ford motor company operated its mass production lines, it also controlled the supply and sales segments of the logistic chain.

Freight centre - a generic name for a public or private transhipment terminal. They form intersections of at least two different transport modes, at which independent companies from the distribution sector and other transport-intensive business (e.g. component manufacturers) are located in a designated area.

Goods flow - a group of goods that is delivered by one organisation and/or collected, always in the same way (same vehicle type, conditioning and so on), to the same receiver/collection or delivery address.

Gross Vehicle Weight (GVW) - Total weight of a single vehicle, or of all vehicles in a combination, plus load. (OECD, 1992)

Horizontal Optimisation – Optimisation whereby companies can optimise their activities and use them for different channels, or co-operate to achieve economies of scale or other economies. See also Vertical Optimisation.

Institutional framework – a general framework that identifies the public and private actors within the playing field of urban distribution, defines their roles, and fulfils the role of a 'format' for policy-making processes.

Integrated design - design (of a goods distribution system) that includes logistics organisation and the required (adjusted) transport means, infrastructures and legislation.

Integration - activities that are joined together as one single action. (antonym: *differentiation*).

Intermodal - transport between an origin and a destination in which different transport modes

are used sequentially (see *multimodal*, compare with *unimodal*).

Licensing - regulatory system, in which only vehicles or transport companies that have a licence (and comply to certain legislation) may enter a certain area during a pre-determined time.

Load unit - covers a wide range of load platforms, including pallets, boxes, crates, racks and containers, all designed to hold and protect cargo.

Local terminal - a terminal at a shopping area, where goods are delivered by *ULS*.

Local Transfer points - transhipment terminals or distribution centres that connect inner city physical transport systems with transport systems for transporting goods within the local areas (see also *Regional Transfer points*).

Locker - a facility at homes or shops for carriers to deliver and store goods

Logistic chain - a sequence of logistic activities, combined into logistic units.

Logistic channel - the alternative or potentialroute that a product can use to be distributed from a supplier to a final consumer.

Logistics concept - the organisation of the movement of goods (in time as well as in space). The logistic concept is described by the physical channel that is used for the distribution of the goods.

Logistic park - is an area of specialised industries in a distribution region that allows logistical and traffic-intensive activities, while it is also the central location for regional collection and distribution. A logistic park can also be part of a larger area with mixed industries.

Logistic sub-location (or: side-location) - like a small-scale logistic park, but is dependent upon a logistic park, rather than autonomous.

Logistic unit - is a specific combination of closely related (dependent) logistic activities controlled by a single actor.

Lot access - the private connection of a house, shop, or a shopping complex to an *ULS*.

Marketing channel - the 'trade route' a product can follow from a supplier to a final consumer (compare with *physical distribution channel*).

Multimodal - transport between an origin and a destination in which different transport modes are used sequentially (see *intermodal*, compare with *unimodal*).

Network logistics - the combination of city logistics and backbone logistics.

Nighttime distribution - distribution of goods during the night (between approximately 20:00 and 07:00 hours).

Outsourcing - contracting out certain duties to a specialised organisation.

Payload (load capacity) - Maximum permitted weight of goods that can be carried. (OECD, 1992)

Physical distribution channel - (alternative) physical route a product can use to be distributed from a supplier to a final consumer (see also: *logistic channel*; compare with *marketing chan-*

nel).

Physical distribution service network - represents the total physical distribution system (performed by one or more logistic service provider), and can be used to optimise logistic processes at a tactical level.

Physical infrastructure network - represents (existing, future and projected) infrastructural links and nodes.

Physical network - consists of physical links (connections) and nodes. Physical links (connections) and nodes refer to the infrastructure networks and the spatial reservations, required for these infrastructure networks.

Pick-up point (local dispersion facility) - a facility for customers to pick-up purchased goods.

Player - see *actor*

Policy - the ambition to reach certain goals with certain instruments and by a succession of policy actions in time as a *policy strategy* (based on Hoogerwerf, 1985). In a situation with a multitude of actors, policy can be defined as: "a complex of decisions and herewith coherent actions (or absence of actions) by an actor towards a problem or target group" (based on Bukkems, 1989).

Policy option (policy measure) - a government action based on governmental instruments.

Provisioning - see Delivery.

Regional Transfer points - transhipment terminals or distribution centres that connect inner-city physical transport systems with transport systems that transport goods outside the urban areas.

Round trip - a vehicle movement from its origin and back to its origin, to make deliveries at one or more destinations in a sequential order.

Semi trailer - Trailer which has no front axle and which is coupled to the hauling vehicle in such a manner that part of the trailer rests on the tractor and that a substantial part of its weight and load it may contain is borne by the tractor. (OECD, 1992)

Sending - see Delivery.

Slow movers - products that are sold in small quantities (volumes, units) (compare with *fast movers, specialities,* and *commodities*).

Specialisation - a specific transport service, which is set up to accommodate a specific physical distribution channel.

Specialities - goods that are unique to a specific retailer (or retail group); goods that define the market position of the specific retailer (compare with *commodities*).

Split & Combine distribution - optimising strategy in goods distribution, where shipments are broken up, the parts of the shipments are transported along different routes, and the shipments is reassembled near the final destination.

S*takeholder* - term for individuals, groups or organisations that have a certain interest.

Stop - A stop in a trip to load or unload goods at the business location of a receiver.

Sustainable development - defined as "Development which meets the needs of the present, especially of the world's poor, and protecting the ability of future generations to meet their needs" (World Commission on Environment and Development (Commission Brundtland), 1987).

Tele – prefix added to traditional terms to indicate a process being performed by telephone or by Internet: i.e., a tele-retailer sells products over the Internet rather than through a store; tele-shopping can be done over the phone..

Tractor - motor vehicle designed, exclusively or primarily, to haul other vehicles. (OECD, 1992)

Trade-off – term used to describe the pairing of basic logistic activities, and the resulting balancing act in optimising the pair – for instance, the balance between optimising shipping frequency vs the need for inventory.

Traffic means - the vehicle that provides the traction and steering or guidance.

Trailer - Road vehicle designed to be drawn by a motor vehicle, supporting all of its own weight and load on its own wheels. (OECD, 1992)

Transport means - the load carrier, such as wagons or railway carriages.

Trip - movement of a vehicle from its origin to one or more destinations (may also be back to its origin --see round *trip*).

Truck (lorry) - motor vehicle designed, exclusively or primarily, to carry goods. (OECD, 1992) with a maximum total weight of more than 3500 kilograms.

Underground Logistic System (ULS) - an dedicated underground transport system for freight

Unimodal - transport between an origin and a destination in which only one transport mode is used (compare with *intermodal/multimodal*).

Urban goods distribution - Goods distribution in urban areas, covering the transport of consumer goods to, from, and within urban areas; deals with the delivery of consumer goods to shops, department stores, supermarkets, the hospitality industry, offices and directly to the homes of customers.

Utilisation - increase in the use of the system (generating 'benefits') without increasing the level of use of resources ('costs'). It is strongly related to productivity improvement.

Van - a road vehicle for the movement of freight, not longer than 5.1 metres, and with a maximum total weight of 3500 kilograms.

Vertical Optimization - Trade-offs between different basic logistic activities within a single logistic chain

Appendix B   Abbreviations

DIY	Do It Yourselves
ECR	Effective/Efficient Consumer Response
EDI	Electronic Data Interchange
FUL	Full Urban distribution vehicle Load
FTL	Full Truck Load
GDV	Grootschalige Detailhandelsvestigingen (in Dutch; large-scale shopping malls within the main urban areas)
GVW	Gross Vehicle Weight
JIT	Just In Time logistics concept
LTL	Less than (full) Truck Load
LTP	Local Transfer Point
PDV	Perifere Detailhandelsvestigingen (in Dutch; shopping malls consisting of furniture shops, DIY shops, located at the edge of a cities' CBD)
RTP	Regional Transfer Point
SPITS	Logistics theory involving Searching for consumers, Production, Inventory, Transport and Supplier (see also *Assortment* Composition)
ULS	Underground Logistics System

Samenvatting
(Summary in Dutch)

Inleiding

Een efficiënte distributie van goederen in stedelijke gebieden is van vitaal belang voor de welvaart van deze stedelijke gebieden. Niettemin, hangen verschillende problemen in steden samen met het vrachtverkeer dat met de distributie van goederen wordt voortgebracht. Bijvoorbeeld, vrachtauto's en bestelauto's veroorzaken geluidshinder, stoten verontreinigende uitlaatgassen uit, verminderen de verkeersveiligheid en veroorzaken hinder aan andere weggebruikers, zoals fietsers en bestuurders van personenauto's, trams en bussen. Daar staat tegenover dat, door de verkeersbeperkende maatregelen en door congestie, de efficiëntie van de distributie van de goederen in gevaar komt. De huidige wijze van distribueren van goederen in stedelijke gebieden is waarschijnlijk onvoldoende duurzaam en bedreigt hierdoor de aantrekkelijkheid van deze gebieden voor de huidige en toekomstige gebruikers en bewoners. De toekomstige economische ontwikkeling en de rol van steden in de samenleving kunnen hierdoor worden bedreigd. Deze problemen treden op in veel stedelijke gebieden in Europa, Amerika, Azië en Australië. In veel gevallen zijn beleidsmaatregelen ontwikkeld, voorgesteld en toegepast. Desondanks treden deze problemen nog steeds op en dreigen in omvang en ernst toe te nemen.

De verwachting is dat de distributie van consumentgoederen naar winkels, horeca-gelegenheden en consumenten in de eenentwintigste eeuw verder zal wijzigen. Door demografische, ruimtelijke en economische ontwikkelingen zal de vraag naar goederen-vervoer in stedelijke gebieden toenemen. Tegelijkertijd zullen vooral technologische ontwikkelingen de wijze waarop consumentgoederen worden gekocht en geleverd, beïnvloeden. Te denken valt bijvoorbeeld aan de toenemende mogelijkheden van tele-shoppen.

Deze dissertatie heeft dan ook als probleemstelling: *een helder inzicht ontbreekt in de aard van het toekomstige distributiesysteem voor consumentgoederen om het concept van duurzame ontwikkeling na te streven. Het is daarbij niet duidelijk hoe met de uitdagingen en kansen moet worden omgegaan om de noodzakelijke veranderingen in het distributiesysteem te implementeren*. Onderzoek dient een bijdrage te leveren tot dit inzicht.

In deze dissertatie ontwikkelen we een geïntegreerde lange-termijnvisie voor een toekomstig stedelijk distributiesysteem voor consumentgoederen, dat het concept van duurzame ontwikkeling ondersteunt, en werken we een strategie uit om de noodzakelijke veranderingen te kunnen verwezenlijken. Deze algemene doelstelling is uitgesplitst in drie onderzoeks-doelstellingen:

1. *Ontwikkel een helder begrip* omtrent het distributieproces van consumentgoederen in steden en de wijze waarop het is gerelateerd aan milieu- en bereikbaarheidsproblemen.
2. *Analyseer en ontwikkel mogelijke oplossingen* voor de problemen, gerelateerd aan de goederendistributie en ontwikkel een integraal concept voor een efficiënt distributieproces in steden.
3. *Ontwikkel een omvattend beleidsplan* voor de implementatie van effectieve beleids-maatregelen, die gericht zijn op de verbetering van de efficiëntie van het goederen-distributieproces in steden.

De dissertatie leidt tot een integraal ontwerp van een goederendistributieconcept voor stedelijke gebieden, inclusief een bijbehorend beleidsplan.

In deze onderzoeksdoelstellingen worden enkele begrippen gehanteerd, die gedefinieerd moeten worden. Onder efficiëntie wordt de verhouding verstaan tussen de genormeerde of na te streven kosten om een bepaald resultaat te bereiken en de werkelijk waargenomen kosten (inclusief negatieve effecten) van het stedelijke goederendistributieproces. In het geval van stedelijke goederendistributie gaat het om zowel de economische kosten, als de maat- schappelijke kosten. Wij gebruiken hierbij het begrip duurzame ontwikkeling, zoals dat door de commissie Brundtland is ontwikkeld. De sociale en economische efficiëntie van het distributieproces zien we dan ook als indicatoren voor de duurzaamheid van het goederendistributiesysteem.

In deze dissertatie werken we integrale logistieke concepten uit ten behoeve van de distributie van goederen in steden. Deze zijn gebaseerd op een optimale bundeling van goederenstromen ("consolidatie") in tijd, en in ruimte. Een optimale bundeling is mogelijk door het leveren van logistieke diensten, zoals city logistiek, backbone logistiek en netwerk logistiek en de toepassing van bijbehorende transportmiddelen, zoals geavanceerde voertuigtechnieken, moderne infrastructuur en overige ondersteunende systemen. Deze logistieke diensten zijn gebaseerd op samenwerking tussen actoren, werkzaam op hetzelfde terrein (horizontale coördinatie) en integratie van activiteiten op verschillende niveaus en op verschillende terreinen (verticale coördinatie).
Consolidatie vergt echter een splitsing in de goederenstroom tussen een niet- of minder geconsolideerde beweging voor de collectie of distributie van de goederen binnen de herkomst- of bestemmingsregio en een geconsolideerde beweging tussen de regio van herkomst en de regio van bestemming. De fysieke scheiding tussen het lokale distributie- traject in stedelijke gebieden en het traject buiten de stedelijke gebieden, maakt het mogelijk beide trajecten afzonderlijk te optimaliseren. Dat wil zeggen, kleine, stille en schone voer- tuigen of ondergronds goederentransport in de stedelijke gebieden en groot-volume voer- tuigen, zoals vrachtauto's (of nieuwe voertuigen, zoals roadtrains, automatische vracht- voertuigen) of treinen (aangepast voor stedelijke distributie) in het interregionale of lange afstandstransport. Een autonome infrastructuur, binnen stedelijke gebieden en daarbuiten, dienen garanties te bieden voor voldoende capaciteit en ongehinderde (of ongestoorde) voertuigbewegingen en hiermee bij te dragen tot milieu- en economische efficiëntiever- beteringen in stedelijk goederenvervoer. Omdat wordt uitgegaan van het toepassen van verschillende transportsystemen in de transportketen, zijn de nieuwe logistieke concepten gebaseerd op intermodaliteit.

Opzet van de dissertatie

De uitwerking van de onderzoeksdoelstellingen en de ontwikkeling van een integraal concept en implementatiestrategie voor de goederendistributie in steden vindt plaats in de zes delen van de dissertatie.

Deel I geeft naast de probleemstelling en de onderzoeksdoelstellingen van de dissertatie, een definitie van wat onder de distributie in steden van consumentgoederen wordt verstaan. De omvang van het huidige goederenvervoer nu en in de toekomst wordt bepaald, alsmede de omvang van de problemen die met vervoer van goederen in steden verband houden.

Deel II bevat het conceptuele kader. De theoretische en methodologische aspecten van stedelijk goederenvervoer worden uiteengezet. De micro-economische nutstheorie wordt gekoppeld aan dit type vervoer. Het concept van markten, afgeleid van de micro-economische nutstheorie, wordt gebruikt om het goederendistributiesysteem te beschrijven als een lagen-schema. Het optimaliseren van de goederendistributie in steden wordt vervolgens gedefinieerd in termen van efficiëntieverbetering

Deel III introduceert een algemene logistieke theorie die is aangepast en toegepast op de goederendistributie in steden. In dit deel worden nieuwe intermodale logistieke concepten gepresenteerd die bijdragen tot een efficiënte goederendistributie.

Deel IV beschouwt de mogelijke oplossingen op het terrein van transporttechnologie. Daarbij wordt met name gekeken naar intermodale oplossingen. De mogelijke transportsystemen buiten en binnen de steden worden apart beschouwd. Het gaat daarbij om zowel aanpassingen van bestaande systemen, als nieuwe systemen.

Deel V gaat in op het ruimtelijke aspect van de optimalisatie van de goederendistributie in steden. Een optimaal ruimtelijk netwerk voor stedelijke goederendistributie bestaat uit knooppunten, oftewel logistieke parken, en verbindingen, aangeduid als corridors. Het concept van logistieke parken wordt toegelicht en het belang ervan voor efficiënte goederendistributie vastgesteld. Tevens wordt het belang van corridors toegelicht.

Deel VI beschrijft eerst het beleidsraamwerk voor een lange-termijnbeleidsplan voor stedelijke goederendistributie. Op basis van de delen III, IV en V wordt een lange termijnvisie voor stedelijke goederendistributie neergelegd. Tevens wordt met behulp van de kennis uit het beleidsraamwerk een implementatiestrategie uitgewerkt. Een evaluatie wordt uitgevoerd met betrekking tot de mate waarin de efficiëntie van stedelijke goederendistributie zal verbeteren en wordt een sterkte-zwakte analyse uitgevoerd om de kansrijkheid te bepalen.

Deel I: Probleemdefinitie

Stedelijke goederendistributie betreft het vervoer van goederen naar en binnen stedelijke gebieden, waarbij het gaat om de einddistributie van consumentgoederen naar de detailhandel, horeca, kantoren of direct aan huis. Op basis van de definitie worden verschillende vormen van goederenvervoer, dat in of door de stad plaatsvindt, dus uitgesloten.

De omvang van de stedelijke goederendistributie is bepaald. De vraag naar vervoer wordt uitgedrukt in de dimensies: massa (tonnen), volume (kubieke meters), aantal transporteenheden (dozen, pallets, rolcontainers, rekken) of in geldwaarde. Het vervoersvolume kan worden bepaald door de vraag naar vervoer per bestemming vast te

stellen. Per bestemming zal de vraag naar vervoer sterk verschillen. In deze dissertatie onderscheiden we dertien typen bestemmingen. Binnen een type bedrijf zullen verschillen optreden, die verband houden met de grootte van het bedrijf. De grootte van de betreffende bestemming kan worden uitgedrukt in verkoop per tijdseenheid, aantal werknemers of grootte van het verkoopvloeroppervlak.

Vervolgens is een schatting gemaakt van het aandeel stedelijke goederendistributie in het totale goederenvervoer in Nederland. Deze schatting geeft enkel een grove indicatie van het jaarlijkse *vervoersvolume en vervoersprestatie* van stedelijke goederendistributie. Volgens de berekening betreft het in Nederland op jaarbasis ongeveer 106 miljoen leveringen met een totaal volume van 107 miljoen kubieke meter, oftewel 53 miljoen ton. Daarbij worden op jaarbasis 3.1 miljard voertuigkilometers afgelegd. Vergelijken we dit met het totale binnenlandse goederenvervoer, dan betreft het aandeel stedelijke goederendistributie in tonnage ongeveer tien procent en in voertuigkilometers 18 procent. Het gaat hierbij om voertuigkilometers die zowel binnen als buiten het stedelijk gebied worden afgelegd. Indien we de voorspellingen voor het binnenlandse goederenvervoer representatief achten voor het stedelijk goederenvervoer, dan zal de stedelijke goederendistributie in tonnen met zo'n 22 procent tussen 1995 en 2020 toenemen, terwijl het voertuigkilometrage zal toenemen met minimaal 64 procent en maximaal 153 procent.

Met betrekking tot stedelijke goederendistributie worden drie typen problemen onderscheiden:

1. De bijdrage van het goederenvervoer aan de *reductie van de leefbaarheid* in stedelijke gebieden, zoals luchtverontreiniging, geluidshinder, verkeersonveiligheid en ruimtegebruik.
2. De *bijdrage tot de mondiale klimaatsverandering en de verzuring* als gevolg van emissies, de uitputting van natuurlijke grondstoffen en de afvalproblematiek.
3. De *vermindering van de bereikbaarheid* van stedelijke gebieden voor het goederenvervoer van bepaalde bestemmingen op bepaalde momenten, door congestie en restrictieve maatregelen.

Deze problemen, aan te duiden als conflicten of knelpunten, dienen in samenhang te worden bekeken. Zo is de vermindering van de bereikbaarheid voor een belangrijk deel het gevolg van de lokale maatregelen om de lokale leefbaarheid te verbeteren. Er zijn drie belangrijke exogene ontwikkelingen aan te wijzen die de vraag naar goederenvervoer in stedelijk gebied beïnvloeden, namelijk de bevolkingsontwikkeling, de economische groei en de ontwikkeling van winkelvoorzieningen. Daarnaast speelt de wijze waarop het vervoer door de vervoerder wordt geregeld een belangrijke rol. Deze typen problemen kunnen worden gekwantificeerd door middel van indicatoren. Bijvoorbeeld de indicatoren voor lokale milieuverontreiniging zijn emissies koolstofdioxide, stikstofdioxide, koolwaterstoffen, aerosolen en lood. In relatie tot de leefbaarheidsproblemen blijken, met name ten aanzien van de lokale milieuproblemen duidelijke meetbare doelstellingen te zijn geformuleerd. Ten aanzien van de bijdrage aan de mondiale klimaatsverandering, verzuring, uitputting van natuurlijke grondstoffen en afvalproblematiek bestaan er weliswaar doelstellingen maar deze zijn lastig te vertalen. Daarvoor is het noodzakelijk vast te stellen welk aandeel stedelijk goederenvervoer heeft in deze problematiek en welke bijdrage deze moet leveren in het terugdringen van emissies en dergelijke. Ten aanzien van de bereikbaarheid, ontbreekt vooralsnog een algemeen

geaccepteerde meetbare doelstelling. Hierdoor is het lastig om het begrip efficiëntie met betrekking tot bereikbaarheid te operationaliseren.

Deel II: Theoretisch raamwerk

In het theoretisch raamwerk worden de basisbegrippen, -typologieën en methoden uitgewerkt, die in de volgende delen worden toegepast. De kern van het theoretisch raamwerk vormt de fundamentele beschrijving van het keuzegedrag van actoren (privaat of publiek). Goederen-distributie in steden is in de praktijk een complex spel van processen, geleid door het gedrag van vele verschillende actoren, zoals consumenten, producenten, winkeliers, transport-bedrijven en overheden. Door op stedelijke goederenvervoerprocessen de *micro-economische nutstheorie* toe te passen, zijn we in staat om het keuze-gedrag van actoren op een systematische (wiskundige) wijze te beschrijven. Deze theorie hanteert de begrippen nut (voor baten) en disnut (voor kosten) om goederen en diensten te kunnen waarderen. Het gaat daarbij om in geld te waarderen kosten en baten, maar ook om niet-monetaire kosten (en baten) die door het vervoer van goederen worden gegenereerd, zoals bijvoorbeeld luchtverontreiniging en geluidhinder. De kosten en baten van alternatieve keuzemogelijkheden worden door verschillen in belangen doorgaans verschillend gewaardeerd door actoren. Deze verschillen in waardering leiden tot verschillende voorkeuren en tot verschillende keuzen.

De micro-economische nutstheorie hanteert het begrip 'markten' om de interacties tussen actoren weer te geven. Ten aanzien van stedelijk goederendistributie zijn *markten* op verschillende niveaus te formuleren. Deze markten vormen de basis om het *transport lagenschema*, dat voor goederendistributie hier is uitgewerkt. Het transportlagenschema is een systeembeschrijving van het transport van goederen. Het transportsysteem is daarin onder-verdeeld in *diensten-lagen*. Een diensten-laag vertegenwoordigt een subsysteem binnen het transportsysteem en levert een bepaalde dienst binnen het systeem. Een diensten-laag kan worden beschreven in de volgende termen:

- *Fenomeen,* de fysieke verschijning van een subsysteem;
- *Primaire dienst*, de dienst dat door het subsysteem wordt uitgevoerd;
- *Primaire rol*, de classificatie van de betreffende actor;
- *Primaire middelen*, de fysieke middelen die in het subsysteem worden gebruikt;
- *Actoren*, de belangrijkste spelers in het subsysteem.

Een diensten-laag heeft eveneens een bepaalde *dimensie*, oftewel is uit te drukken in een meetbare grootheid, om de betreffende dienst kwantificeerbaar te maken. De vijf primaire diensten in het goederenvervoer zijn:

- *Integrale (logistieke) diensten*;
- *Laadeenheden-dienst*;
- *Transportmiddelen-dienst*;
- *Verkeersmiddelen-dienst*;
- *Infrastructuur-dienst*.

Een in de praktijk geleverde transportdienst kan worden gedefinieerd of gecategoriseerd als combinaties van een of meer primaire diensten. Omdat een primaire dienst op verschillende manieren kan worden geleverd, is het mogelijk om nieuwe alternatieve transportdiensten te genereren of primaire diensten te integreren, te splitsen (aan te duiden met het begrip

differentiatie, te specialiseren of te combineren (door middel van diversificatie). Naast deze diensten-lagen kunnen nog twee lagen in het transport-lagenschema worden toegevoegd, namelijk:

- *Vraag en aanbod*. Dit verwijst naar de economische activiteiten, zoals productie, handel en consumptie, die de vraag naar goederenvervoer genereren;
- *Effecten en behoeften*. Dit verwijst naar het gebruik van natuurlijke hulpbronnen, zoals fossiele brandstoffen en de effecten op de samenleving, bijvoorbeeld emissies.

Beide lagen vertegenwoordigen de relatie van transport met de samenleving. Problemen, gerelateerd aan transport in het algemeen en stedelijke goederendistributie in het bijzonder, kunnen tot op een zekere hoogte worden beschreven als *fricties tussen lagen*. De representatie als een lagenschema maakt het mogelijk om het systeem van goederendistributie te beschrijven en alternatieve mogelijkheden tot verbetering van het goederendistributiesysteem te ontwikkelen op een meer systematische wijze.

Het doel van de thesis is om paden te identificeren en te ontwikkelen om het goederendistributieproces in steden te optimaliseren door het efficiënter te maken (vanuit een bedrijfseconomisch en een maatschappelijk oogpunt). Optimalisatie van het goederendistributiesysteem koppelen we dus aan de introductie en operationalisatie van het theoretische begrip *efficiëntie*. Hierbij kan worden opgemerkt dat efficiëntie zowel individueel voor private partijen kan worden gedefinieerd, als uit het oogpunt van publieke partijen, als het gaat om maatschappelijke aspecten. Met behulp van de uitwerking van de micro-economische nutstheorie is nu de optimalisatie wiskundig te beschrijven als een kostenminimalisatie. Door verschillen in waardering van de kostenfactoren kan het resultaat van deze optimalisatie uit individueel oogpunt afwijken van de optimale situatie uit maatschappelijk oogpunt. Als oplossing voor een dergelijk probleem kan een gecombineerde set van kosten-waarderingen, gebaseerd op een combinatie van private en publieke doelstellingen, worden opgesteld. Op deze wijze kan op theoretische gronden een maatschappelijke optimalisatie plaatsvinden.

Er zijn verschillende vormen van inefficiënties te onderscheiden. Deze inefficiënties houden verband met de eerder genoemde fricties tussen de lagen in het transportlagenmodel. Efficiëntieverbeteringen in het distributiesysteem kunnen dus op verschillende niveaus plaatsvinden en op twee manieren, en wel door benutting en conservatie. Het begrip *benutting* houdt in een toename van de baten (door gebruik) van een systeem bij gelijkblijvende kosten. *Conservatie* betekent een reductie van de kosten bij eenzelfde baten-niveau.

Schaalvoordelen spelen een belangrijke rol bij efficiëntieverbetering. Vandaar dat het van belang is in te gaan op het begrip *schaalvoordelen*. Schaalvoordelen geven de baten weer van het combineren van activiteiten. *Consolidatie* kan leiden tot dergelijke schaalvoordelen. Consolidatie kan leiden tot schaalvoordelen maar boven een bepaald niveau zullen schaalnadelen gaan optreden. Consolidatie is feitelijk dus ook een optimalisatievraagstuk.

Met deze uitwerking is het gelukt om theoretische verbanden te leggen tussen optimalisatie van het goederendistributiesysteem en efficiëntieverbetering enerzijds en tussen efficiëntie-verbetering en consolidatie van goederenstromen, anderzijds. Een belangrijke conclusie is dan ook dat consolidatie essentieel is voor de optimalisatie van goederendistributie in stedelijk gebied.

Deel III: Logistieke systemen voor stedelijke distributie

De vervoerprocessen die plaatsvinden in stedelijke gebieden worden aangestuurd door logistieke systemen waarin verscheidene actoren trachten te komen tot een optimale afstemming van logistieke activiteiten als transporteren, opslaan (bufferen), assortimenten samenstellen of splitsen (en daarmee in het verlengde, consolidatie en deconsolidatie).

Deze logistieke basishandelingen, gezamenlijk aangeduid met het op de Engelstalige begrippen gebaseerde acroniem 'SPITS', worden in meerdere of mindere mate onderling afgestemd, afhankelijk van het type actor en de zeggenschap van de actor in de logistieke keten.

Actoren kunnen één of meer basis-activiteiten in eigen beheer uitvoeren of daaraan sturing aangeven. Wij duiden zo'n groep samenhangende logistieke basishandelingen aan als *logistieke eenheid*. Deze logistieke eenheden zijn dus in wezen activiteitengroepen die worden uitgevoerd door specifieke actoren.

De stedelijke distributie heeft vooral betrekking op de zogenaamde *einddistributie*: het verspreiden van gerede (eind-) producten onder (eind-) gebruikers. Die eindgebruikers zijn meestal consumenten, maar kunnen ook bedrijven of instellingen zijn.

Wij richten onze analyses op de zogenaamd 'georganiseerde' einddistributie, hetgeen inhoudt dat we vooral aandacht besteden aan de levering van goederen aan winkels, horeca-gelegenheden en grote afnemers. Daarmee blijft in deze dissertatie de directe einddistributie naar consumenten grotendeels buiten beschouwing (met uitzondering van directe leveringen, bijvoorbeeld als resultaat van e-commerce of teleshoppen).

Transport is uiteraard een belangrijke logistieke basisactiviteit: transport draagt primair zorg voor de verplaatsing van goederen in ruimte, van een plaats waar goederen geproduceerd of opgeslagen zijn naar een plaats waar ze verder bewerkt of gebruikt kunnen worden. Transport draagt ook altijd een tijdelement in zich, maar doorgaans wordt transporttijd niet gezien als een logistieke bijdrage (uitzonderingen, zoals 'rollende voorraad', daargelaten).

Opslag is primair te zien als een 'verplaatsing' in de tijd: van een moment dat goederen gereed of beschikbaar zijn naar het moment dat goederen nodig of bruikbaar zijn.

Gebruikers hebben een groot aantal goederen nodig om de behoeften te bevredigen. Dit samenstelsel van goederen kan worden aangeduid als *assortiment*. Om een dergelijk assortiment samen te stellen, dienen gebruikers goederen bij één of meer aanbieders te selecteren. Omgekeerd bieden aanbieders, zoals winkels, doorgaans ook assortimenten van goederen. Naarmate een 'aanbod' assortiment beter aansluit bij een 'gebruikers' assortiment, zal de aanbieder het de klant meer naar de zin kunnen maken. Wij veralgemeniseren het begrip assortiment tot een samenstelsel van goederen, die op verschillende (schaal-) niveaus bij elkaar worden gebracht: in een *samengesteld product*, op het schap in een winkel, in een winkel als geheel, in een winkelstraat/winkelcentrum en in een stedelijke omgeving.

In operationele zin kan het begrip assortimentsvorming ook worden gelezen als 'consolidatie': het om transporttechnische redenen samenvoegen van lading, zodat efficiënter kan worden vervoerd. Deze brede interpretatie van het begrip assortimentsvorming blijkt cruciaal in het denken over stedelijke goederendistributie. Het toont het belang aan van een stedelijke omgeving als winkelverzamelgebied (een *assortiment van winkels* met ieder een assortiment aan producten). Bovendien lijkt consolidatie in zekere zin ook op het samenstellen van een

assortiment: niet met als doel om de gebruiker tevreden te stellen, maar om een logistiek deelproces (vervoer) efficiënter te laten verlopen.

Logistiek draait om de *besturing van goederenstromen*; deze stromen worden aangestuurd vanuit de handelsketen: *het marketingkanaal*. Dit marketingkanaal beschrijft de successie van actoren die betrokken zijn bij het overdragen van een goed van een producent naar een eindgebruiker. Hierbij kunnen allerlei *intermediairen* betrokken zijn, zoals onder andere de groothandel. De marketingketen beïnvloedt de fysieke stroom van goederen, maar de actoren die bij de behandeling van de fysieke stromen betrokken zijn, hoeven niet dezelfden te zijn als die betrokken zijn bij het marketingkanaal. Bij de fysieke distributie zijn onder meer transportondernemingen en logistieke dienstverleners betrokken. Deze actoren zorgen ervoor dat de goederen fysiek worden verplaatst.

Ten behoeve van een efficiëntieverbetering van stedelijke distributie is een aantal nieuwe distributieconcepten ontwikkeld die alle gebaseerd zijn op de idee dat in bepaalde gevallen het samenvoegen van logistieke activiteiten als transport, opslag en assortimentvorming, kan leiden tot schaalvoordelen en efficiëntieverbetering. Bestaande logistieke concepten trachten vooral binnen logistieke activiteiten te optimaliseren (transportoptimalisering, optimalisering van productie) of te optimaliseren in reeds bestaande ketens, waarbij er vooral een sterke wisselwerking is tussen productie, opslag en transport. In de nieuw voorgestelde concepten wordt er veel meer geoptimaliseerd door verschillende bedrijven tezamen. Het samenvoegen van opslagfaciliteiten, transportactiviteiten en dergelijke, is daarvan het meest in het oog springend. *Samenwerking* kan niet alleen lokaal tot optimalisaties leiden, maar maakt het ook mogelijk op regionale of (voor Nederland) nationale schaal te optimaliseren, door tot netwerkvorming over te gaan. In deze distributienetwerken worden per regio één of meer centrale distributiecentra ontwikkeld, van waaruit de verstedelijkte gebieden worden bevoorraad. Deze distributiecentra zijn gevestigd in logistieke parken (dit wordt uitgewerkt in deel V). Verschillende, reeds elders ontwikkelde logistieke concepten, worden in de nieuwe concepten gecombineerd. Voorbeelden daarvan zijn 'composite distribution' (het gezamenlijk distribueren van sterk verschillende producten), 'pipeline-distribution' (het met beperkte middelen aanbieden van een groot palet aan vervoerdiensten) en 'stedelijke distributie' (het met betrekkelijk kleine, maar zeer efficiënt beladen voertuigen bevoorraden van stedelijke gebieden).

Deel IV: Vervoersystemen voor stedelijke distributie

Om de nieuwe logistieke concepten te kunnen toepassen, zijn in bepaalde gevallen nieuwe vervoertechnieken noodzakelijk. Veel belangrijker is echter, dat bij de introductie van de nieuwe logistieke concepten bestaande of nieuw te ontwikkelen vervoersystemen veel efficiënter gebruikt worden dan nu het geval is. Juist het concept van 'netwerklogistiek' maakt het mogelijk een technische scheiding aan te brengen tussen korte-afstand, kleinschalige distributie binnen stedelijke gebieden en langere-afstand, grootschalig transport buiten die gebieden.

Voor het binnenstedelijke vervoer kunnen dan *speciale voertuigen* worden ontwikkeld (zoals de 'distributietruck') die voldoen aan eisen als wendbaarheid en mogelijkheden voor efficiënt beladen en lossen, maar ook aan strenge eisen ten aanzien van emissies en geluidsproductie

Op de langere termijn kan daarboven gedacht worden aan bijvoorbeeld ondergrondse logistieke systemen.

Voor het vervoer buiten de stedelijke gebieden kunnen bestaande vrachtautocombinaties worden ingezet (ze hoeven toch de stad niet meer in), en in de toekomst zelfs 'roadtrains' en/of eventueel automatisch bestuurde wegvervoersystemen. Deze geautomatiseerde systemen zouden kunnen leiden tot een daling van de exploitatiekosten en zouden, onder voorwaarden, wellicht tot capaciteitswinsten kunnen leiden. Het Nederlandse CombiRoad concept en het daarmee enigszins vergelijkbare Japanse Dual Mode systeem zijn voorbeelden van dergelijke vervoerconcepten.

Ook zouden dan (aangepaste) *rail systemen* kunnen worden ingezet. Daarbij zijn te noemen nieuwe, korte goederentreinen die rijden in vaste samenstellingen met personen-trein karakteristieken (zoals bijvoorbeeld de Duitse CargoSprinter), of treinen waarin personen en goederen gezamenlijk worden vervoerd (CombiTreinen).

Op bepaalde verbindingen komt *aangepast binnenvaartvervoer* in aanmerking om specifieke typen goederen naar de regionale of lokale logistieke parken te vervoeren. Evenals bij het railsysteem, is hier vooral te denken aan schaalverkleining (zoals de 'Neo-Kemp' klasse van binnenvaartschepen).

Railvervoer en binnenvaartvervoer zijn modaliteiten waarvan toepassing voor stedelijke distributie op het moment vrijwel uitgesloten wordt geacht, maar die bij een zorgvuldig uitgedacht en opgezet bovenregionaal systeem wellicht een rol van betekenis kunnen vervullen.

Omdat er in de nieuwe logistieke systemen toch al sprake is van overslag (vanwege de tijdelijke opslagfunctie in de logistieke parken) is de overslag tussen voertuigen en tussen modaliteiten nauwelijks een extra hindernis.

Niettemin zouden de overslaghandelingen aanmerkelijk efficiënter kunnen verlopen, indien gebruik gemaakt zou worden van gestandaardiseerde laadeenheden die in en op alle relevante vervoermodaliteiten efficiënt gebruikt kunnen worden. Standaardisering van lading (door middel van laadeenheden) brengt een geautomatiseerde overslag van lading tussen modaliteiten ook binnen bereik. Ten behoeve van de stedelijke distributie is te denken aan *gestandaardiseerde laadeenheden* op verschillende niveaus met name op het gebied van (buiten-) afmetingen van de eenheden en de plaatsen van de aangrijppunten. Daarbij is te beginnen op het niveau van de verpakking, waar de in sommige sectoren (supermarktbranche) veel gebruikte collo-modulaire maten, waar algemene toepassing leidt tot een sterke efficiencieverbetering op overslag- en opslagcentra. Vervolgens zouden euro- en industriepallets de basis moeten vormen voor de *palletboxen*, waarin goederen veilig en betrouwbaar vervoerd en overgeslagen kunnen worden. Daaropvolgend kunnen de zogenaamde tribox en CityBox worden ontwikkeld die drie respectievelijk zes industriepallets kunnen dragen. De afmetingen van de CityBox zijn zodanig gekozen dat ze zowel efficiënt op grotere wegvoertuigen als op kleinere stadsdistributievoertuigen geplaatst kunnen worden. De kleinere boxen zijn vooral bedoeld voor bedrijfsinterne logistiek en bijvoorbeeld voor ondergrondse logistieke systemen.

Sommige nieuwe of vernieuwde vervoersystemen zullen gebruik moeten maken van nieuwe of ten minste aangepaste infrastructuren. Dat geldt natuurlijk vooral voor ondergrondse, volledig automatische, vervoersystemen - ondergrondse netwerkinfrastructuur voor voer-

tuigen kennen we in Nederland immers niet (en in het buitenland komt deze slechts zeer sporadisch voor).

Echter, ook voor automatische weggebonden vrachtvervoersystemen zullen waarschijnlijk tenminste aparte rijstroken en wellicht aparte rijbanen nodig zijn, zolang althans menging van geautomatiseerd met niet-geautomatiseerd wegvervoer niet haalbaar is.

Voor het railvervoer geldt dit waarschijnlijk in mindere mate: de beveiligingssystemen maken een volledig automatisch systeem waarschijnlijk relatief snel acceptabel.

Deel V: Ruimtelijke netwerken voor stedelijke goederendistributie

De voorzieningen voor stedelijke goederendistributie hebben naast een logistieke en transporttechnische ook een ruimtelijke dimensie. Deze ruimtelijke dimensie kan worden omschreven als een ruimtelijk netwerk van knooppunten en verbindingen. De rol van het ruimtelijk netwerk is het creëren van de ruimtelijke en infrastructurele condities voor het consolideren van goederenstromen via samenwerking en gezamenlijke inspanning door private en publieke organisaties op het terrein van de stedelijke goederendistributie. De knooppunten kunnen worden ontwikkeld door middel van ruimtelijke planning, bijvoorbeeld het ruimtelijk concentreren van winkelbestemmingen in winkelcentra en van overslagpunten, zoals distributiecentra, vrachtverkeersintensieve bedrijvigheid en logistieke activiteiten in logistieke parken. Corridors completeren het ruimtelijk netwerk door deze punten onderling te verbinden. Corridors zijn multi-modaal. Dit betekent dat op deze verbindingen meerdere vormen van infrastructuur worden gebundeld. Corridors kunnen daarbij zowel vanuit een ruimtelijke planningsperspectief als vanuit een infrastructuurperspectief worden bekeken.

Logistieke parken zijn ruimtelijke concentraties van logistieke activiteiten. We definiëren logistieke parken als een bedrijventerrein voor op logistiek gespecialiseerde en vrachtverkeersintensieve bedrijvigheid. Het is tegelijkertijd een centrale overslaglocatie voor regionale collectie en distributie. Logistieke parken vormen de overslagpunten tussen het interregionale (nationaal backbone-)netwerk en lokale distributienetwerken (vanuit een logistiek en een fysiek netwerk perspectief). Logistieke parken zijn daarom overslagpunten uit logistiek en infrastructureel oogpunt. Logistieke parken hebben twee belangrijke functies:

− Het *faciliteren* van logistieke en vrachtverkeersintensieve bedrijvigheid door middel van het aanbieden van ruimte en vervoersdiensten;
− Het *stimuleren* van bundeling van goederenstromen door de ontwikkeling van bepaalde collectieve vervoersdiensten.

Door het bundelen van initiatieven en de ruimtelijke concentratie van logistieke en vracht-verkeersintensieve bedrijvigheid wordt draagvlak (oftewel voldoende potentiële vervoers-volume) ontwikkeld voor nieuwe vervoersdiensten en voor het gebruik van andere modaliteiten, zoals railvervoer of nieuwe infrastructuur. De opzet van een logistiek park is dat de logistieke activiteiten, zoals op- en overslag op een logistiek park geen extra schakel in de logistieke keten vormen, zoals in het traditionele stadsdistributiecentrum-concept. In principe gaat het om het verplaatsen of vervangen van bestaande activiteiten in een keten naar een logistiek park via horizontale (het samenvoegen van verschillende logistieke ketens door

uitbesteding, samenwerking of specialisatie) en verticale integratie (het samenvoegen van schakels in een keten). Dit kan leiden tot consolidatie en dus tot efficiëntieverbetering

We komen uit op een indeling van Nederland in 17 distri-regio's. Een *distri-regio* is een zoekgebied voor één of meer logistieke parken. Een distri-regio is tevens een verzorgingsgebied voor intermodale terminalfaciliteiten op een multi-modaal logistiek park. Naast deze multimodale logistieke parken zullen, om voldoende service en ruimte te bieden, ook unimodale kleinere logistieke parken, met logistieke nevenlocaties aan te duiden, nodig zijn. De indeling in zeventien regio's is gebaseerd op korte-afstand railvervoer als dragende vervoersmodaliteit voor het nationaal back-bone netwerk en is indicatief. Voor de uitwerking van een regio-indeling is een theoretisch raamwerk opgezet om de grootte van een verzorgingsgebied te bepalen als basis voor de regio-indeling.

De locatiekeuze voor een logistiek park moet worden bekeken op basis van de optimale locatie als knooppunt in het nationaal backbone-netwerk en op basis van de optimale locatie in het betreffende verzorgingsgebied. Beide optimalisaties leiden niet noodzakelijkerwijs tot dezelfde optimale oplossing. Aan de hand van een situatieschets met drie typen locaties is dit toegelicht.

Omtrent de inrichting van een logistieke park bestaan enkele voorbeelden in het buitenland. Het gaat erom ruimte te bieden aan elementaire logistieke activiteiten (distributiecentra van logistieke dienstverleners, kantoren en parkeerruimte voor transportbedrijven, en dergelijke), activiteiten die gerelateerd zijn aan dergelijke activiteiten (distributiecentra en opslag-voorzieningen van detail- en groothandel, productie- en VAL-diensten en in de toekomst afhaalvoorzieningen voor consumenten) en ondersteunende faciliteiten (administratieve diensten, service stations voor vrachtauto's en dergelijke). De ruimtebehoefte op een logistiek park kan indicatief worden vastgesteld op basis van kengetallen (FV 2000, 1998; VUA en Arcadis, 2000). Een goede basis voor het nauwkeuriger bepalen van de ruimtebehoefte ontbreekt echter.

Corridors vormen de verbindingen binnen het ruimtelijk netwerk. Corridors kunnen worden gedefinieerd als de reserveringen (routes, infrastructuur, ruimte) tussen twee punten voor een specifiek doel, in dit geval vrachtvervoer. Feitelijk bestaat het ruimtelijk netwerk uit twee niveaus, namelijk het nationaal niveau en het regionale/lokale niveau. Corridors kunnen dan ook op twee niveaus worden gedefinieerd, namelijk op nationaal niveau als multimodale verbindingen tussen regio's (ten behoeve van een *nationaal backbone netwerk*) en regionaal als verbindingen tussen de logistieke parken en belangrijke bestemming voor stedelijk goederenvervoer, zoals winkelvoorzieningen en deze bestemmingen onderling.

De *nationale corridors* vormen de ruimtelijke reservering voor bestaande of nieuwe infrastructuur van verschillende modaliteiten, in elkaars nabijheid op een manier dat zij regio's onderling verbinden (meer precies: de logistieke parken, mainports en industriële complexen of regio-grenzen).

Lokale corridors verwijzen naar specifieke routes of paden die toegewezen kunnen worden voor het gebruik van specifieke vrachtvoertuigen (ten dienste van stedelijke distributie). Op het regionale/lokale niveau zullen de corridors dan ook worden gebaseerd op de bestaande weginfrastructuur. Op termijn zijn ook ondergrondse verbindingen mogelijk worden. De regionale/lokale corridors corresponderen met de meest optimale routes (uit maatschappelijk en economisch oogpunt) tussen bestemmingen als winkelcentra en logistieke parken.

Corridors tussen belangrijke bestemmingen, zoals winkelcentra zijn eveneens van belang, vanwege het feit dat steeds meer vrachtvoertuigen meerdere winkelcentra afgaan (rondritten maken). Verschillende opties zijn mogelijk. Deze opties verschillen in de mate van automatisering van de geleiding en besturing van het verkeer en de aanwezige infrastructuur. De mogelijke opties zijn: speciale routes, medegebruik van busbanen en aparte vrachtbanen, een eigen wegennetwerk voor vrachtverkeer tot een ondergronds netwerk voor goederentransport. Deze opties kunnen worden beschouwd als fasen in de ontwikkeling van regionale/lokale corridors voor goederendistributie binnen stedelijke gebieden.

Deel VI: Het beleid ten aanzien van goederendistributie in stedelijk gebied

In dit deel wordt allereerst een beeld geschetst van een geoptimaliseerd goederen-distributiesysteem als een mogelijke toekomstvisie. Vervolgens wordt een institutioneel raamwerk ontwikkeld voor het vaststellen van de rollen van diverse actoren, in het bijzonder de publieke sector, in het optimaliseren van het stedelijk goederendistributieproces en wordt de strategie tot implementaties vastgelegd.

Het volledige concept is op drie niveaus te beschrijven, namelijk als *logistiek netwerk*, *transport netwerk* en als een *ruimtelijk netwerk*. De volgende elementen van het integrale ontwerp vertegenwoordigen deze netwerken:

- Het stedelijk goederenvervoernetwerk. Hiervoor bestaan twee opties:
  - *City-logistiek systemen*, gebaseerd op een bovengrondse (weg-)infrastructuur met waar nodig speciale vrachtroutes of aparte banen, waarbij diensten worden aangeboden voor het afleveren van goederen aan de detailhandel, of bij een afleverpunt of thuis-bezorging, maar ook ophaaldiensten en tijdelijke opslag van consumenten of detailhandel.
  - *Ondergrondse Logistieke Systemen* (OLS), gebaseerd op toekomstige ondergrondse infrastructuur. OLS betreft een volledig geautomatiseerd systeem, waarin ongehinderd transport mogelijk is en waarbij geen rondritten worden gemaakt maar de zendingen direct bij de klant (of indirect via een terminal) worden afgeleverd.
- Het *nationaal backbone netwerk*. Dit netwerk verbindt de regio's onderling en verzorgt de interregionale transportdiensten met behulp van de interregionale weg-, rail- en vaarwegenhoofdinfrastructuur. De backbone logistieke diensten worden geleverd tussen de belangrijke logistieke parken en maken gebruik van 'concurrerende' en aanvullende bestaande en nieuwe transportsystemen. Korte-afstandsvervoer per rail is een van de potentiële mogelijkheden.
- *Logistieke knooppunten*. Dit betreft de ruimtelijke concentraties van overslagpunten, zoals terminals en distributiecentra. Hierbij onderscheiden we:
  - *Regionale logistieke parken*, locaties voor regionale overslagpunten;
  - *Stedelijke logistieke parken* ofwel *logistieke nevenlocaties*, locaties voor stedelijke overslagpunten;
  - *Lokale verdeelcentra*, dit betreft lokale verdeelpunten in een stedelijk gebied. Deze lokale verdeelpunten hebben een functie als ophaalpunt of lokaal distributiepunt voor de aflevering van goederen in een wijk of winkelcentrum of -gebied. In een OLS-systeem hebben zij tevens een terminalfunctie.

Logistieke parken zijn in deel V uitgewerkt. Zij vormen de vestigingsplaats voor regionale of stedelijke logistieke overslagpunten, en vormen intermodale knooppunten voor het nationaal backbone netwerk en het stedelijk goederenvervoernetwerk.

Om een dergelijke complexe, integrale goederendistributiesysteem is een lange reeks van gecoördineerde publieke en private acties nodig. Dit vereist de ontwikkeling en toepassing van een implementatiestrategie met alle benodigde acties. De ontwikkeling van een implementatiestrategie is gebaseerd op de backcasting-methode, zoals beschreven in deel II. Daarin wordt eerst een 'ideaal' beeld gevormd en vervolgens teruggeredeneerd welke acties van de betrokken partijen nodig zijn. Daartoe wordt in een institutioneel raamwerk de verschillende actoren en hun rol geïdentificeerd. De implementatie vereist publieke en private betrokkenheid. De sterke betrokkenheid van verschillende private en publieke actoren impliceert een overheidsbeleidstijl, waarin de overheden opereren als faciliterend en een sterke betrokkenheid van private partijen stimuleren. Deze wijze van beleidsontwikkeling, aan te duiden met *onderhandelende beleidsvorming*, combineert een top-down lange-termijnvisie met een bottom-up implementatie. *Overleg* is een belangrijk onderdeel van een dergelijk beleidsproces. Nationale of regionale platforms zijn daarvoor nodig. *Analyse en modellering* zijn noodzakelijk om de relevante informatie voor de besluitvorming en monitoring te leveren. Temeer, omdat beleidsontwikkeling in de praktijk een continuerend en interactief proces is van voorbereiding, implementatie en handhaving nagenoeg gelijktijdig in plaats van opeenvolgend. De implementatiestrategie is vervolgens in stappen ontwikkeld. De implementatiestrategie om het beoogde integrale logistieke systeem te ontwikkelen en te implementeren, bestaat uit drie fasen: korte termijn, middellange termijn en lange termijn. De strategieën zijn op een zodanige manier vormgegeven, dat in elk van de tijdsfasen resultaten worden geboekt.

Korte termijn
Op de korte termijn, zijn beperkte mogelijkheden aanwezig om het goederendistributieproces te veranderen. Maatregelen op de korte termijn richten zich op het stimuleren van actoren om efficiëntere goederendistributiesystemen te ontwikkelen en te anticiperen op middellange en lange termijn plannen met betrekking tot city logistiek en netwerk-logistiek. Binnen het stedelijk gebied is het belangrijk om vrachtvoertuigen te verbeteren, die al optimaal distribueren (zoals directe distributie). Aangepaste brandstofmotoren en het gebruik van geavanceerde verkeerscontrolesystemen moeten helpen om de negatieve externe effecten te beperken. Buiten de stedelijke gebieden, kan de gemiddelde grootte van voertuigen toenemen (om het aantal kleinere voertuigen af te laten nemen).

Middellange termijn
De middellange-termijnstrategie richt zich op volledige toepassing van city-logistiek-concepten en de introductie van aangepaste stedelijke distributievoertuigen binnen het stedelijk gebied en toepassing van grotere voertuigen buiten de stedelijke gebieden. In deze periode, vindt de ontwikkeling plaats van geavanceerde railvoertuigen en binnenvaart vaartuigen, die in het interregionale goederenvervoer ten behoeve van stedelijke distributie kunnen worden gebruikt. Logistieke parken dienen met elkaar te worden verbonden met rail- en vaarweginfrastructuur. Ten behoeve van een vlekkeloze uitwisseling tussen modaliteiten

is de ontwikkeling van standaardlaadeenheden van belang. In deze fase wordt de implementatie van intermodaal transport per rail en binnenvaart voorbereid.

Lange termijn
De lange-termijnstrategie richt zich op de volledige implementatie van het integrale ontwerp. Dit betekent dat binnen stedelijke gebieden een volledig gebruik van integrale logistieke systemen plaatsvindt en dat aangepaste stedelijke distributievoertuigen gebruik maken van een aparte infrastructuur (speciale routes, medegebruik busbanen) en mogelijk van ondergrondse infrastructuur. Buiten de stedelijke gebieden, betekent dit volledig gebruik van multimodale backbone-logistieke systemen voor interregionale vervoersbewegingen van goederen met het gebruik van weg, rail of binnenvaart, gebaseerd op een eigen infrastructuur.

Om vast te stellen in hoeverre het voorgestelde integrale concept daadwerkelijk bijdraagt tot efficiëntieverbetering van stedelijke goederendistributie heeft een evaluatie plaatsgevonden. De evaluatie demonstreert dat het integrale concept onder zekere condities op een hoger efficiëntieniveau functioneert dan het huidige systeem voor goederendistributie. Om de voordelen van de voorgestelde integrale distributieconcepten te demonstreren is een kwalitatieve en een kwantitatieve benadering gekozen.
De kwalitatieve benadering toont aan dat het integrale concept zal leiden tot efficiëntie-verbetering wanneer aan bepaalde voorwaarden wordt voldaan. Reductie van transportkosten of maatschappelijke kosten treedt op als aan de volgende condities wordt voldaan:

- Consolidatie dient te leiden tot schaalvoordelen. Deze schaalvoordelen moeten vervolgens leiden tot kostenreductie;
- De toename van de overslagkosten bij het gebruik van intermodale concepten, mogen de totale reductie van de transportkosten en overige maatschappelijke kosten niet overstijgen;

Kostenreducties in alternatieve modaliteiten dienen te worden gezocht in verbeterde efficiëntie van activiteiten binnen de logistieke ketens. Als schaalvoordelen in het intermodale transport niet bestaan, dan zal consolidatie ook niet kunnen leiden tot enige vorm van kostenreductie. Bij de introductie kunnen nieuwe transportsystemen nog geen van deur-tot-deur dienst leveren. Dit betekent dat dit als vanzelf leidt tot extra schakels in de transportketen (in de vorm van voor- en natransport) en dus tot extra kosten. Nabijheid tot multimodale terminals reduceert en ruimtelijke concentratie vermijdt zelfs extra voor- en natransport of reduceert de afstand op zijn minst. Als aan dergelijke condities wordt voldaan voor alle kosten, dan kan intermodaal transport leiden tot efficiëntieverbetering

Een kwantitatieve onderbouwing kan worden gevonden in studies uitgevoerd door NOVEM en IPOT. TNO (1999) schat, op basis van fysieke en logistieke karakteristieken van goederen-stromen dat het potentiële marktaandeel voor een integrale logistieke concepten in stedelijke goederendistributie tussen negen en achttien procent in vervoersvolume (tonnen) van alle binnenlandse goederenstromen, zal zijn. Dit betekent dat integrale concepten niet een oplossing bieden voor alle problemen met betrekking tot verkeer en vrachtverkeer in het bijzonder. De NOVEM-studie laat zien dat consolidatie in een intermodaal (weg/weg) systeem leidt tot aanzienlijke reducties in energiegebruik, emissies en transportkosten. De mate van efficiëntieverbetering hangt sterk af van de mate van consolidatie, in het bijzonder de consolidatie in de collectie en distributie van goederen.

De IPOT-studie demonstreert dat intermodaal transport, gebaseerd op nieuwe concepten, de potentie heeft tot verdere efficiëntieverbetering. Het gebruik van nieuwe geavanceerde wegvoertuigen en ondergronds goederentransport (Ondergrondse Logistieke Systemen) binnen stedelijke gebieden en nieuwe railsystemen als een verbindend (backbone) systeem is in staat om een verdere reductie van energiegebruik, emissies, geluid en veiligheid mogelijk te maken. Een kanttekening is dat aparte (dedicated) systemen, in het bijzonder ondergronds goederentransport een hoog indirect energiegebruik kennen in vergelijking met traditioneel vrachtvervoer over de weg. Dit kan worden verklaard uit het feit dat een nieuwe infrastructuur, apart voor goederenvervoer met een middelmatige bezetting dient te worden gebouwd. Wanneer het indirecte energiegebruik bij ondergronds goederentransport wordt meegenomen, is deze minder energie-efficiënt dan conventionele transportsystemen.

Aanbevelingen

In deze dissertatie is een aanzet gegeven tot een evaluatie van het voorgestelde concept. Ondanks de gekozen kwalitatieve en kwantitatieve benadering is deze evaluatie niet voldoende om een definitief commercieel en maatschappelijk oordeel te kunnen vellen over de mate van efficiëntieverbetering die zal optreden bij de stapsgewijze of volledige implementatie van het concept. Daarnaar is wel gestreefd. Een groot probleem bleek onder andere het ontbreken van de juiste informatie. Zoals in deel I is beschreven, ontbreekt een gedetailleerde informatiebasis voor onderzoek naar stedelijk goederenvervoer. De invloed van nieuwe logistieke concepten, of de invloed van nieuwe marketingconcepten, zoals e-commerce op de stedelijke distributie, is op dit moment moeilijk vast te stellen.

In deel III worden de toepassing van nieuwe wegvoertuigen, railvervoer, binnenvaart en ondergronds goederentransport besproken. Hoewel hier al onderzoek naar is verricht, is de performance in termen van vervoerskwaliteit, reistijd, kosten en milieu-aspecten nog onbekend of onvoldoende nauwkeurig bepaald. Hierdoor is het moeilijk vast te stellen in hoeverre dergelijke technieken werkelijk bijdragen tot efficiëntieverbetering. Met name kan worden onderzocht onder welke omstandigheden deze technieken wel of niet beter presteren. Desk-research zal hiervoor onvoldoende antwoord bieden; praktijkmetingen of andere vormen van testmeting zijn essentieel.

Een belangrijke vraag waarop ook geen definitief antwoord gegeven kon worden, betrof de omvang van de distri-regio's, het aantal logistieke parken, de dichtheid en vorm van het verbindende netwerk en de lokale netwerken en de toe te passen technieken. De beantwoording van deze vragen hangt onderling nauw samen. Het netwerkoptimalisatievraagstuk is met name, omdat het om een hiërarchisch multimodaal netwerk betreft, voor ons te complex om een goed antwoord te kunnen vinden op de bovenstaande vragen. Dit optimalisatie-vraagstuk vergt de inschakeling van wiskundigen.

Summary

Introduction

The distribution of goods for urban areas is vital to the prosperity of these areas. In their role as a central focus of trade and retail commerce, urban areas cannot function without an adequate goods transport system. Nevertheless, there are various problems related to the urban goods distribution process. First, goods distribution vehicles cause pollution in the form of noise and exhaust emissions, reduce traffic safety, and physically obstruct the flow of other traffic. Second, goods traffic contributes to the accessibility problems of passenger transport that affect most urban areas. Finally, the efficiency of the urban goods distribution process itself is hampered by congestion, which can be exacerbated by public policy measures that were intended to reduce other problems. The combination of environmental and accessibility problems, both for passenger transport as well as for goods distribution, endangers the sustainability of urban areas. This implies that the way goods are currently distributed seriously jeopardises the attractiveness of these vulnerable areas for their present and future users, thereby endangering their future economic development and role in society.

We argue that policies can only be effective if a comprehensive set of policy actions is implemented, addressing the problem at different geographical scales and at various functional levels of the urban goods distribution system in concert. These functional levels refer to the organisational aspects of the system, or logistics—the goods transport and goods traffic means, the infrastructures, and the spatial system in which the urban goods distribution process must function. Progressive innovation is required on all these levels to achieve an efficient urban goods distribution system, efficient both in terms of commercial interests and societal interests.

In this thesis, we developed an integrated long-term problem-solving vision of a future urban goods distribution system that supports the concept of sustainable development, and a strategy to implement the necessary changes in the goods distribution system for urban areas. This general objective consists of three research objectives:

1. Develop a clear *understanding* of the goods distribution process for urban areas and the way it is related to environmental and accessibility problems.
2. Analyse, develop possible solutions for the problems related to urban goods distribution, and establish an *integrated concept* for an efficient goods distribution process for urban areas.
3. Develop a comprehensive policy plan for implementing effective policy measures, which aims at improving the efficiency of the goods distribution process for urban areas.

The research resulted in an integrated design for a goods distribution concept for urban areas, including a related policy plan, consisting of the needed institutional framework and implementation plan.

Contents of the thesis

This thesis was structured around the three objectives, and the resulting concepts and plans.
In Part I, we elaborated the problems and the projected results of these problems. We introduced our research questions and our research approach and define the scope of the study. This part therefore resulted in a comprehensive, qualitative, and quantitative description of the problems related to goods distribution for urban areas.

Because we must first understand the urban goods distribution processes before we can design solutions, in Part II of this thesis we constructed a framework, or *layer model* with which we analysed the complex urban goods distribution system. The layer model was also useful for identifying and categorising potential problem-solving measures. In Part II, we also applied existing micro-economic theory and logistics theory to enable a thorough understanding of the urban goods distribution system. The results of Part II were then used as a conceptual framework that provides a basis for the development of an integrated and consistent set of measures that help to solve the problems related to urban goods distribution.

The various levels at which solutions can be developed are elaborated in Part III (Logistics), Part IV (Transport systems) and Part V (Spatial Networks). These parts result in a set of attuned, interrelated measures that lack only context to be meaningful. In Part VI, these measures will be assigned to potential actors, then translated into an implementation strategy, and placed within a time-frame, in the context of an institutional framework. This framework is an elaboration of the layer model approach we developed in Part II.

Conclusions

The proposed integrated logistics concept for urban goods distribution, expanded in the thesis, is based on the optimal bundling of the movements of goods (*consolidation*) in time as well as space. This should be done by providing logistic services, such as city logistics, backbone logistics and network logistics, in close harmony with appropriate technological means, such as advanced vehicle technologies, advanced infrastructures, and other supporting systems. Logistic services are achieved by co-operation between actors acting at the same level (*horizontal co-ordination*) and the integration of the activities of actors at different levels (*vertical co-ordination*).

Consolidation requires the breakdown of a given goods movement into two parts: a collection/distribution movement, and a long-distance transport movement. The separation between the local distribution movement for urban areas, and the transport movement outside urban areas, allows the optimisation of both movements. This means that small, quiet, zero-emission vehicles and/or ULS can be used in the urban areas, while large-volume vehicles, such as trucks or trains, can be used for inter-regional or long-distance transport. Dedicated infrastructure within and outside urban areas should make the operation smoother and more efficient. These integrated concepts are based on the application of different transport systems in different areas: that is, the concept is based on *intermodality*.

Introducing such a complex, integrated goods distribution system will require a long string of co-ordinated actions from a wide variety of public and private actors. This necessitates the development and application of an implementation strategy that includes all the necessary

actions. The implementation strategy is based on back-casting methodology, which first sketches the envisaged 'ideal' system, and then back-traces the necessary actions of the different actors involved.

The implementation strategy for developing and implementing the envisaged integrated logistics system is divided into three stages: short-term, medium-term and long-term. These strategies are designed in such a way that in each of the time-stages, positive results can be seen. In each stage, an inventory of the remaining problems should be made. On basis of this analysis, policy makers will have to decide whether to proceed with the strategy, or to maintain the status quo. The implementation strategy is designed in such a way that even when the strategy is 'aborted', the existing situation will still function.

Short-term stage

In the short term, there are limited possibilities for changing the urban goods distribution process. Actions within this stage should aim at stimulating the actors to use more efficient goods distribution systems, and to anticipate medium-term and long-term plans with respect to city logistics and network logistics. Within urban areas, it is important to improve the trucks that are already performing optimised physical distribution services (direct distribution). Adapted combustion engines and the use of advanced traffic control systems can help to limit the negative external effects of these vehicles. Outside urban areas, the average size of vehicles must be increased (more large vehicles should result in the operation of fewer small vehicles). Later, the size of large vehicles may be extended, but this will require changes in legislation.

Public actions in this stage include:

- R & D on the urban distribution truck;
- Planning and reservation of space for logistic parks;
- Stimulation of the development and first use of new advanced logistic systems, logistic parks and advanced transport and transhipment technologies;
- Agreement on entrance restrictions for urban areas;
- Legislation for larger road vehicles outside urban areas;
- Supporting co-operation with covenants.
- Installing regional consultation programs.

Medium-term stage

The medium-term implementation strategy aims at a full application of city logistics concepts, the introduction of dedicated urban distribution vehicles within urban areas, and the establishment of larger road vehicles outside urban areas. The medium-term implementation strategy aims at a full application of city logistics concepts, the introduction of dedicated urban distribution vehicles within urban areas, and the application of larger road vehicles outside urban areas. Logistic parks should be connected with both the rail and the waterborne infrastructure. In this stage, the implementation of intermodal transport by rail and waterborne will be prepared. Finally, standardisation of load units will be required in this stage.

Public actions in this stage include:

- Covenants for public-private development of logistic parks;
- Construction of logistic parks;

- Pricing used as an incentive to achieve more efficient logistics schemes (i.e., load/unload tariffs);
- Development and tests on railway alternatives;
- R & D for pilot projects for underground freight transport.

Long-term stage

The long-term implementation strategy aims at the full implementation of the integrated design. Within urban areas, we will see full operation of an integrated city logistics system and application of dedicated urban distribution vehicles, making shared use of dedicated infrastructures and underground infrastructures. Outside urban areas, it would mean the operation of a multimodal backbone logistics system for interregional movements of urban goods with the application of road, rail or waterborne transport systems based on dedicated infrastructure. Within urban areas, underground systems will become technically feasible.

Public actions in this stage include:

- Infrastructure planning, financing and construction of dedicated (underground) infrastructure for freight within urban areas;
- Applying a licensing system that controls the type and movements of vehicles within urban areas in combination with road-pricing, or taxation on the use of non-dedicated distribution vehicles;
- Infrastructure planning, financing and construction of dedicated infrastructure (road, rail, underground) for the backbone network;
- Land use planning for logistic parks and land-use pricing (taxation) to support land use planning;
- Financial support for the implementation of new technologies, or for the operation of dedicated infrastructure.

The evaluation demonstrated that the integrated concept performs under certain conditions at a higher level of efficiency than the current system for the distribution of goods in urban areas. To demonstrate the advantages of the new proposed integrated urban distribution concepts, we followed a qualitative and a quantitative approach.

The theoretical argumentation demonstrates that the integrated concept will lead to efficiency improvement when certain conditions are met. Reduction of transport costs or disutilities occurs when the following conditions are met:

- Consolidation should lead to economies of scale, scope, and density, which can be used for the reduction of the transport disutilities.
- The increase of 'transfer' disutilities may not exceed the total reduction of the transport disutilities that result if alternative modes are used.

Costs or disutility reductions in alternative modes will have to be found in improved efficiencies of activities within logistic chains. If economies of scale, scope, or density do not exist, consolidation does not lead to any cost reduction.

The introduction of new transport systems that cannot provide door-to-door transport will, in the end, add extra stages to the transport chain (pre and end haulage transport), and thus extra costs or disutilities. Proximity to multimodal terminals and reduced spatial concentration can avoid these extra stages related to pre and end haulage, or at least reduce distances. When

these conditions are met for all costs or disutilities, then such an intermodal system can lead to efficiency improvements.

Some quantitative evidence can be found in studies performed by NOVEM and IPOT. TNO (1999) estimates, based on the physical and logistic characteristics of goods flows, a potential market share of between nine and eighteen percent of all domestic goods flows. This implies that the integrated concept does not provide a comprehensive solution for all problems related to traffic generally, and to freight traffic specifically. The NOVEM study shows that consolidation in an intermodal road/road system does lead to significant reductions in energy-use, emissions, and transport costs. The level of efficiency improvement depends very much on the degree of consolidation, in particular the degree of consolidation in collection and distribution.

The IPOT studies demonstrate that intermodal systems based on new concepts have the potential for even more efficiency improvements. The use of advanced road vehicles and ULS within urban areas, coupled with new rail systems as a backbone, can further reduce energy use, emissions, noise problems, and safety hazards. At the same time, a comparison of indirect energy use shows that dedicated systems, in particular Underground Logistic Systems, have quite a high share of indirect energy use. This can be explained by the fact that a new infrastructure, dedicated to freight-purposes with a moderate level of occupancy, must first be built. When the indirect energy use is taken into account, then ULS might be less energy-efficient than conventional transport systems. The construction of new infrastructure will probably also affect the level of costs-savings of new intermodal systems.

The general conclusions are as follows:
- A systematic and integrated approach is essential because of the organisational complexity of the urban goods distribution, the strong interactions with other systems in society and the multi-dimensional nature of the problem.
- A long-term implementation strategy is required to achieve fundamental changes, because substantial and long-term interventions are required in different and successive stages.
- Each implementation stage should be internally consistent and should, at the same time, be part of the long-term strategy.
- The strategy combines a top-down approach (development of a long-term vision) with bottom-up approaches (realisation and operation of the system) in a public-private environment. Consultation, participation, and commitment of private actors are essential in the implementation strategy.

Finally, we make some recommendations. These recommendations for further research are of both social and scientific relevance. A reliable, detailed and extensive database on the practice of goods distribution in urban areas is required. The current databases offer few possibilities for accurately and reliably determining the influence of new logistic concepts, or the influence of new marketing concepts, such as E-commerce on the distribution of goods. In this thesis, new methods of road transport, rail transport, waterborne and underground freight transport, as well as transhipment technologies are discussed. In particular, further research is needed to determine whether and how much these innovations lead to efficiency improvement. Theoretical research will not provide enough information; actual testing (laboratory, field or other ways) is required. To end, we briefly examined the financial, organisational and legal

barriers to the implementation of the proposed innovations; we strongly feel that the significance of these barriers warrant careful attention, and should therefore not be neglected in the future. We hope that, with our thesis and these recommendations, the tradition of relevant scientific and social research in the area of goods distribution in urban areas continues.

Curricula Vitae

Curriculum Vitae - Arjan van Binsbergen

Arjan van Binsbergen was born in Naaldwijk, the Netherlands, on March $1^{st,}$ 1967. He attended secondary school in Naaldwijk, where he passed his pre-university examination in 1985. He studied civil engineering at the Delft University of Technology and graduated in 1992, after writing his Master's thesis on intermodal transfer facilities for passenger transport. In 1992, he worked briefly with the municipality of The Hague, and then became a researcher at the Transportation and Traffic Engineering Department of the faculty of Civil Engineering at the Delft University of Technology. There, he worked in the fields of intermodal passenger transport, long-term transport scenario studies, environmental effects studies (with a particular focus on goods transport), and intermodal goods transport. In 1993, he cooperated in a study on the future of urban goods distribution, a study that turned out to be the basis for his part in this thesis. From 1994 on, he collaborated with Johan Visser on various research projects within the field of urban goods distribution and underground goods distribution systems. Since 1998, he has been assistant professor and daily supervisor of several Master's students. His work resulted in a number of papers, articles and contributions to books. In 2000, he was appointed as managing director for TRAIL, the Netherlands Research School for Transport, Infrastructure and Logistics.

Curriculum Vitae - Johan Visser

Johan Visser was born on December 3rd, 1961 in Roosendaal, the Netherlands. He finished the VWO (pre-university education) at the Gertrudislyceum in Roosendaal in 1980, and then attended the Delft University of Technology to study civil engineering. He received his Master's degree in 1986, after writing a thesis on the design of broadband telecommunication networks in the Netherlands and the long-term influence of telematics on mobility patterns and the spatial structure. He followed this in 1987 with a two-year post-graduate study on policy management, and worked as a junior researcher at the OTB Research Institute. In January 1989, he joined the army for his (compulsory) military service. During his military service, he was responsible for logistics during the field operations of the OCOSD (education centre for special service officers) in Breda, the Netherlands. In 1990, he returned to OTB as a researcher, specializing in urban freight transport. Since 1994, he has been involved in studies related to underground freight transport. In these projects, he began collaborating with Arjan van Binsbergen; this led to the initiative to join forces in writing a thesis on the topic of goods distribution in urban areas. This joint research led to a number of reports and publications in proceedings of international conferences. In his spare time, he enjoys composing and playing music. During his holidays, he enjoys travel and likes to scuba dive in Zeeland and in subtropical waters.

TRAIL Thesis Series

A series of The Netherlands TRAIL Research School for theses on transport, infrastructure and logistics.

Nat, C.G.J.M., van der, *A Knowledge-based Concept Exploration Model for Submarine Design*, T99/1, March 1999, TRAIL Thesis Series, Delft University Press, The Netherlands

Westrenen, F.C., van, *The Maritime Pilot at Work*: E*valuation and Use of a Time-to-boundary Model of Mental Workload in Human-machine Systems*, T99/2, May 1999, TRAIL Thesis Series, Eburon, The Netherlands

Veenstra, A.W., *Quantitative Analysis of Shipping Markets,* T99/3, April 1999, TRAIL Thesis Series, Delft University Press, The Netherlands

Minderhoud, M.M., *Supported Driving: Impacts on Motorway Traffic Flow*, T99/4, July 1999, TRAIL Thesis Series, Delft University Press, The Netherlands

Hoogendoorn, S.P., *Multiclass Continuum Modelling of Multilane Traffic Flow*, T99/5, September 1999, TRAIL Thesis Series, Delft University Press, The Netherlands

Hoedemaeker, M., *Driving with Intelligent Vehicles: Driving Behaviour with Adaptive Cruise Control and the Acceptance by Individual Drivers*, T99/6, November 1999, TRAIL Thesis Series, Delft University Press, The Netherlands

Marchau, V.A.W.J., *Technology Assessment of Automated Vehicle Guidance - Prospects for Automated Driving Implementation*, T2000/1, January 2000, TRAIL Thesis Series, Delft University Press, The Netherlands

Subiono, *On Classes of Min-max-plus Systems and their Applications*, T2000/2, June 2000, TRAIL Thesis Series, Delft University Press, The Netherlands

Meer, J.R., van, *Operational Control of Internal Transport*, T2000/5, September 2000, TRAIL Thesis Series, Delft University Press, The Netherlands

Bliemer, M.C.J., *Analytical Dynamic Traffic Assignment with Interacting User-Classes: Theoretical Advances and Applications using a Variational Inequality Approach,* T2001/1, January 2001, TRAIL Thesis Series, Delft University Press, The Netherlands

Muilerman, G.J., *Time-based logistics: An analysis of the relevance, causes and impacts,* T2001/2, April 2001, TRAIL Thesis Series, Delft University Press, The Netherlands

Roodbergen, K.J., *Layout and Routing Methods for Warehouses*, T2001/3, May 2001, TRAIL Thesis Series, Haveka, The Netherlands

Willems, J.K.C.A.S., *Bundeling van infrastructuur, theoretische en praktische waarde van een ruimtelijk inrichtingsconcept*, T2001/4, June 2001, TRAIL Thesis Series, Delft University Press, The Netherlands

Binsbergen, A.J., van, J.G.S.N. Visser, *Innovation Steps Towards Efficient Goods Distribution Systems for Urban Areas,* T2001/5, May 2001, TRAIL Thesis Series, Delft University Press, The Netherlands