THE MOBILE CITY
The planning and design of the Network City from a mobility point of view.

Remon M. Rooij

Cover illustration: Iwan Kriens

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The planning and design of the Network City from a mobility point of view.

Proefschrift

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door Remon Michel ROOIJ

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Nusquam est, qui ubique est.

He who is everywhere, is nowhere.
Seneca, Epistulae Morales[1], no. 2

[1] The Latin citation here, and the Latin citations at the beginning of each chapter originate from the collection of 124 letters which the Roman philosopher Seneca wrote to his younger (imaginary) friend Luculius. Seneca lived in the first century A.D. and he was an important official at the imperial court, where he had become the educator of the emperor to be Nero, who became notorious for his cruelty. The 124 letters of Seneca are called the 'Epistulae Morales ad Lucilium'. The word 'moralis' is derived from the word 'mores' which refers to human behaviour. In his letters Seneca focuses at how people should behave and should organise their lives.

PREFACE

A long journey and an experience of a lifetime has ended: the journey towards this thesis. The *disutilities* that came with this journey on the one hand, the time spent on writing and rewriting, and the personal learning investments, and the *utilities* of this journey on the other, especially the knowledge acquired, are definitely in favor of the latter. In fact, if this was the other way around, this journey wouldn't have been finished in this way, and this book wouldn't have been written, published and defended. And indeed, also the end of this (scientific) journey feels like coming home again.
The traveling started at the end of 1997 when my MSc thesis supervisor Mart Tacken invited me to apply for the job as PhD student at the Faculty of Architecture. A large research program on multimodal travel was getting started under the wings of TRAIL research school. Lots of PhD projects were looking for lots of PhD students. The Faculty of Architecture and more specifically the Spatial Planning chair became the environment of my journey.
This thesis deals with the relation between mobility and the city, i.e. how (multimodal) transport systems influence the functioning of the city and reverse. This topic has been my interest since I started to wonder -somewhere in the early nineties- why so many people wanted to line up in the cues so badly every morning and evening during peak hours. I hypothesized then and know now, that it is a bit more complex than this simple line of reasoning.

During my stay at the Faculty of Architecture as PhD student and later on as Assistant Professor, I always felt great confidence of my thesis supervisor Paul Drewe and daily supervisor Mart Tacken, in me and in what I was doing. At difficult times, that all PhD's seem to encounter once in a while, it was this confidence that helped me through. Therefore, I owe lots of credits to these two scientists, who have become much more than just my thesis supervisors.
Along with my supervisors, it were my colleagues of the Spatial Planning chair and the department secretary, who created the pleasant working atmosphere and who supported me and my research whenever needed. I would like to thank especially my roommates Piet Guyt and Arthur van Bilsen, with whom I spend so many vivid hours in our shared office. Also a big 'thank you' for George Hotze from the Urban Design section, with whom I worked together so pleasantly on so many occasions. And finally, also TRAIL research school owes credits for their good support of their PhD's. For me, learning via TRAIL about other disciplines that also deal with transportation issues, has indeed broadened my horizon to a large extent.
For the GIS analyses of my activity-travel data, I was supported by the Dutch Advisory Board for Traffic and Transport (AVV) with their digital road map of The Netherlands (NWB, nationaal wegenbestand). I owe credits to them for this digital service.

Personally, I believe that people live on earth in order to learn about, use, explore and extend their talents given by mother nature for the benefit of improving both themselves *and* others. I therefore feel very lucky that I have had the opportunity to use my talents for doing this research and meanwhile learn a lot about [1] the fields of urbanism, transport engineering, and (activity-travel) behaviour, [2] about doing multidisciplinary research in an international context and at international platforms, and [3] about not giving in, even if something takes more than 4 years. I therefore also feel lucky that I have been raised by my parents, Frits and Adrie Rooij, who taught me that using one's talents is not something to be ashamed of, and that you always have to try to reach for the highest goals possible. I will be always thankful to them for giving me this start in life.

People who have met me and spoken to me for more than one hour, know that my personal passion is the sports of gymnastics. I cannot imagine a life without it. It was in about the same time as when my PhD journey at the Faculty of Architecture started, that I started training and coaching young talented boys in Pijnacker-Nootdorp. Also during this journey, I have already passed a number of satisfying milestones. And it are the training hours with my young gymnasts, and especially the things they say and do from their youthful perspectives, that keep me down to earth in times that my research makes me theorize too much.

Finally, I would like to thank the person who made me realize for the first time in my life that learning should be the constant of one's life, and that teaching should be done with passion: dr. Piet van Wees, my teacher Latin during my time at the Gymnasium in Brielle. He made me realize that learning and teaching would be the cornerstones of my life, because they matter most in the exploration of one's talents. Seneca's one-liners about behaviour that can be found at the beginning of each chapter are a tribute to him, Piet van Wees.

Delft/Pijnacker, December 2005
Remon M. Rooij

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PART B DESIGN

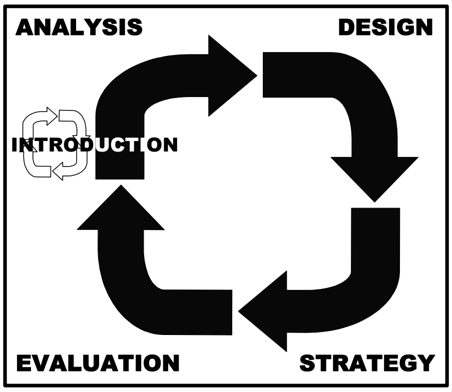
PART C STRATEGY

PART D EVALUATION

CHAPTER ONE INTRODUCTION

‘Cui ergo ista didici?’ Non est quod timeas, ne operam perdideris, si tibi didicisti.

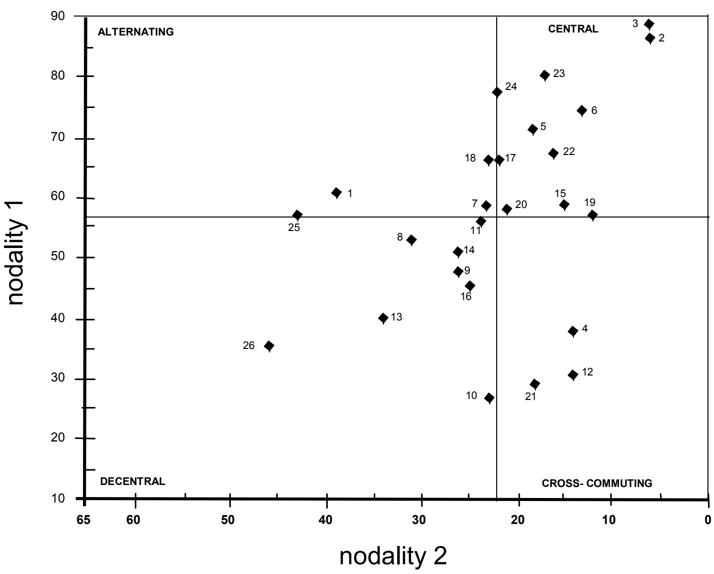
‘For whom did I learn all this?’ Don’t be afraid that you spoilt energy when you have learnt something only for yourself.
Seneca, Epistulae Morales, no. 7



This chapter introduces the topic of this thesis. The first three sections (1.1, 1.2, 1.3) describe the research context of this thesis, which can be briefly summarised as ‘spatial planning and mobility in the 21st century’. Section 1.1 gives an overview of the development of the city during the last decades, ending with the theory of the urbanism of networks as a starting point for this thesis. Section 1.2 focuses on the concept of mobility from an individual, societal, sociological, social-geographical, and technological point of view respectively. It presents the wider scope of the mobility discussion that can be found in any 21st century post-modern society and it positions the mobility debate in a future perspective; how can and should we -as designers, planners, researchers, and politicians- deal with the concept of mobility with a time horizon that goes beyond the next decade. Section 1.3 presents the main problems in today’s spatial planning. The last two sections (1.4, 1.5) focus on more scientific aspects of this introductory chapter, such as the research approach (problem definition, research aims, research hypotheses, research methodology) and the structure of this thesis.

1.1 Towards an urbanism of networks

Thinking about the future of cities and their (desirable and possible) level of mobility, the field of spatial planning is confronted with the notion of a city that has changed quite a lot over the last decades and centuries. Traditionally, a city could be defined as the concentration of buildings around one centre. However, this definition of the city – as a uni-nodal conglomerate of functions – does not fit the urban developments of the last decades.
The notion ‘urban agglomerate’ represents the reality much better, but does not enough say farewell to the centre-periphery thinking, which belongs to the traditional city. Urban activities are related in a growing spatial context. Nowadays, the city consists of several concentrations of economic, social, and/or cultural functions, activities, and facilities, which has given reasons to use the notion ‘multi-nodal city’ (Jacobs, 2000a).
Spatial concepts launched by the Dutch Ministry of Housing, Spatial Planning and Environment such as the compact city (1988) or the Dutch VINEX locations (1991) assume the dominating existence of an urban agglomeration with a central core where employment is concentrated (Drewe, 2000). An evaluation of Dutch cities has revealed that this assumption only holds for 11 out of 26 urban regions (figure 1.1.1). As far as the rest is concerned, one encounters an intensive but equal exchange of journeys-to-work between city and environs, a limited but equal exchange or decentrality with more journeys-to-work being attracted by the environs. So, the urban reality of today is rather characterised by an archipelago of bigger and smaller employment areas with various and changing centres (Martens, 2000).



1 Groningen
2 Leeuwarden
3 Zwolle
4 Enschede
5 Arnhem
6 Nijmegen
7 Utrecht
8 Amersfoort
9 Alkmaar
10 Haarlem
11 Amsterdam
12 Hilversum
13 Leiden
14 Den Haag
15 Rotterdam
16 Dordrecht
17 Breda
18 Tilburg
19 Den Bosch
20 Eindhoven
21 Sittard/Geleen
22 Heerlen
23 Maastricht
24 Venlo
25 Visburg
26 Apeldevphen

Figure **1.1.1** Commuting directions in 26 Dutch cities
Source: Martens, 2000

In his PhD thesis, Brand (2003) describes and visualises (see figure 1.1.2) the development of the city according to the phases of (the traditional) city, the stadsgewest, the polynuclear city, and the urban field. He concludes based on the research of many urban indicators that in The Netherlands an urban field with the size of the Randstad does not yet exist, but it's starting to grow.

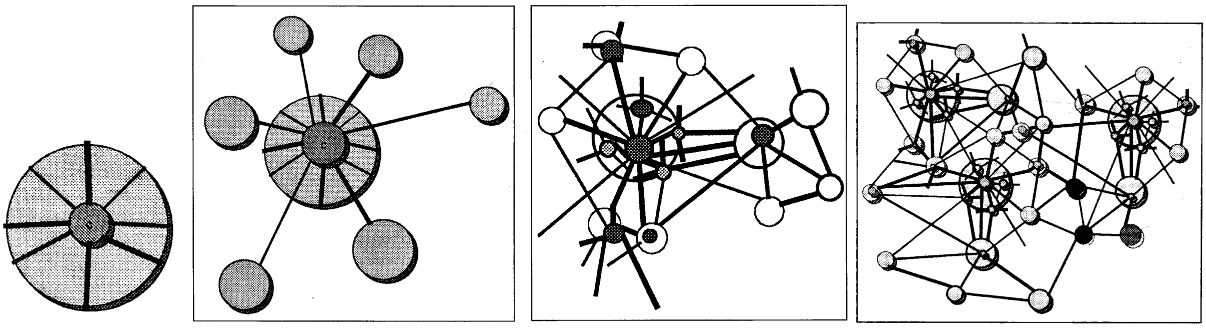


Figure **1.1.2** Development stages of the city: traditional city, stadsgewest, polynuclear, urban field
Source: Brand, 2003

1.1.1 Cities have become Network Cities in a network society

A network society can be seen as a society, in which the social, economic, and cultural structures are not determined by the shared use of certain spaces, but by the connections that an individual actor (person, company, institution) has with places, persons, or activities elsewhere. The network society does not per se produce smoothening, moral decay, and uniformisation, but it (i) changes (some of the) existing relations, where 'distance' becomes a less important factor, and (ii) creates new virtual and physical relations. And in this spatial constellation the spatial barriers are overcome by new communication and transport technologies. This is what has created the Network City.
Networks have taken their own prominent places in (daily) life and have increasingly proven their own dynamics. They determine in their own way economic, social, cultural, political, and spatial developments (Boelens, 2000). The dynamics that accompany this world-wide network society put not only the city and rural areas under pressure, but also the social-economic and social-cultural interactions (urbanity and rurality), as well as the present structure of government and governance.
Bertolini and Dijst (2003) reason that "…the lives of people are increasingly independent of urban physical and administrative boundaries…" and that "… both the spatial reach of people have increased and the diversity of activity and travel patterns." These processes have lead and still lead to "…an increasing disentangling between human activity patterns and the physical city. Each individual may increasingly create his own virtual city, which has no set physical and administrative borders, but is rather a specific, changeable combination of activity places, connected by transport networks, within definite socio-economic and behavioural constraints." The authors remind the words of Webber (1964) on the rise of 'network cities' that urban communities should be seen as 'spatially extensive, processual systems in which urbanites interact with urbanites'.

Communication and transport technologies such as the automobilisation of society have resulted in more diffuse urban transport patterns (PbIVVS, 1998a; VROM Council, 1999). Moreover, the spatial levels, on which people travel, have increased rather drastically. Also from the viewpoint of traffic and transport, one cannot think anymore of cities with their present physical and administrative boundaries. About 80% of the (personal) travel within the

Randstad (figure 1.1.3 and table 1.1.1), takes place within the 'northern and southern wings of the Randstad'; 20% of the interactions takes place between the wings, but numbers are shifting in favour of the latter (AVV, 1999; VROM Council, 1999; Ministry of Housing, Spatial Planning and Environment, 2001); a conclusion that is in line with those of Brand (2003).

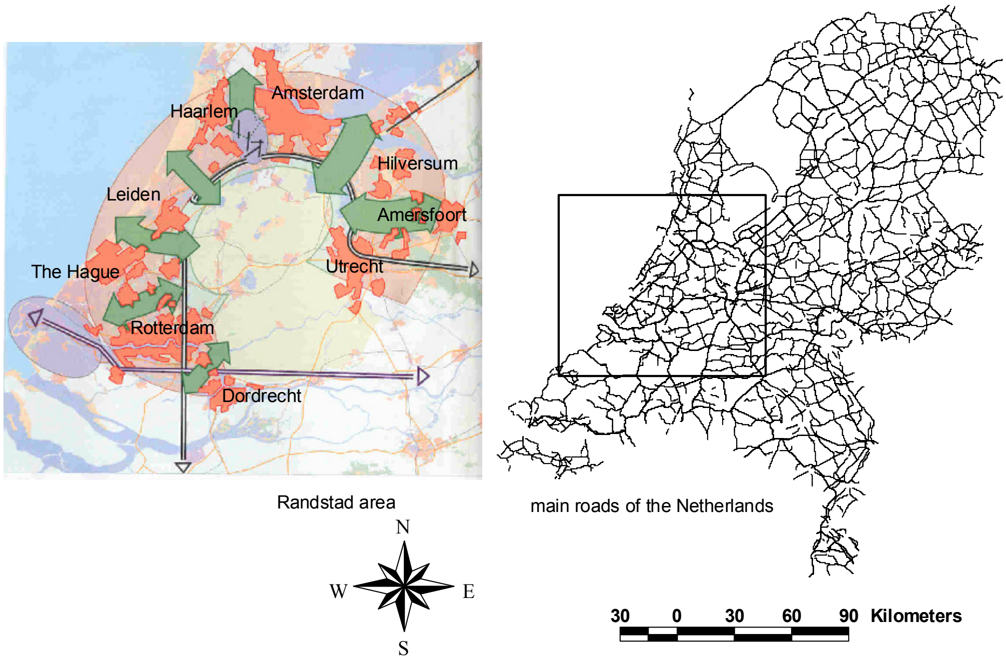


Figure **1.1.3** The Randstad area in the Netherlands
Source: Ministry of Housing, Spatial Planning, and Environment, 1996

Table **1.1.1** Share of internal trips: Northern wing and Southern wing of the Randstad, Stadsgewesten, and municipalities (1995-1997)
Source: AVV, 1999

Area	Work/ Business	other	total
Northern wing	67	83	78
Stadsgewesten Haarlem and A'dam	64	82	76
Stadsgewest A'dam	57	77	70
Municipality A'dam	42	64	56
Stadsgewest Haarlem	47	75	67
Municipality Haarlem	29	54	47
Stadsgewesten Utrecht, Hilversum, Amersfoort	52	76	68
Stadsgewest Utrecht	40	67	58
Municipality Utrecht	24	50	41
Stadsgewest Hilversum	43	72	64
Municipality Hilversum	26	50	41
Stadsgewest Amersfoort	42	70	62
Municipality Amersfoort	34	61	52

Area	Work/ business	other	total
Southern wing	72	87	82
Stadsgewesten Leiden – The Hague	63	83	77
Stadsgewest Leiden	45	70	63
Municipality Leiden	29	48	43
Stadsgewest The Hague	59	80	74
Municipality The Hague	43	66	58
Stadsgewest Rotterdam and Dordrecht	64	82	76
Stadsgewest Rotterdam	58	79	72
Municipality of Rotterdam	40	63	55
Stadsgewest Dordrecht	49	75	67
Municipality Dordrecht	34	65	55

The notion of the Network City should not be confused with the concept of *city network* or *urban network* and a *network of cities*. All these refer to the situation, in which there is a strong relation between a number of cities with respect to a functional entity such as for example trade or labour market. For example, the cities of the Hanseatic League belonged to an important network of cities based on merchandise and trade.
In the Netherlands a stream of thinkers sees the Randstad area not only as a series of complete cities, but as an urban network –may be not yet at present, but at least potentially- with all kinds of functional exchange (www.deltametropool.com). They adhere to the idea that the

economic and cultural potentials of the Randstad can increase and that the urban network can develop into a coherent urban entity, an urban field, if the mutual relation between the cities is strengthened, among others by connecting the city centres with high-speed public transport. And so, a Network City at the spatial level of the Randstad could be developed quicker under influence of modern transport infrastructures and services and communication technologies.

1.1.2 A theory of 'the urbanism of networks'

In spatial planning, networks have been often defined according to a geographical point of view (Caso, 1999). Networks of infrastructures are channels interconnecting places along lines and pathways for many purposes. Transportation networks support the mobility of people and goods, telephone networks provide people and firms with voice and (some other kinds of) data transmission.

This conception of networks is focused on a geography of places and may lead one to underestimate the centrality of the human element of networking. Indeed, networks interconnect people rather than places; infrastructures of cables, electric wires, highways, railways are planned and designed in order to serve human settlements. In this view, elements of an urbanism of networks should consider the centrality of people in networking by looking at how networks are used by people to reach (their) goals.

A theory of networks proposed by Dupuy (1991) elaborating on previous investigations (Fishman, 1990; Lloyd Wright, 1943), recognises the existence of three levels of 'operators' of networks (re)organising the urban space (see figure 1.1.4). At the first level, there are the suppliers of technical networks, such as streets, highways, cables, wires, sewerage, and so on. They are in charge of providing the physical elements of the networks (infrastructure management) and the services on the networks (exploiting the infrastructure). At the second level there are the suppliers of functional networks. They use the level immediately below to provide services -production, consumption, distribution- to the upper level. At this third level the operators are people in their daily life. They make use of the first two levels to create their personal networks by interpreting possibilities and linking activity places, spaces, services, desires and needs in a single personal (or household) behaviour. In this way, people create their own virtual[1] cities. As the first two levels are still characterised by a certain degree of 'objectivity', the third level is mainly a 'subjective' environment where personal, household, or company choices are made, even if conditioned by the lower two levels.

This distinction in levels reflects the articulation in physical, functional, social, and personal components that is inherent to the Network City. If we try to understand the city as a technology (Zeleny, 1987) we can identify these components with the hardware, the software, and the brainware of the Network City. The relationships between the software and the brainware can be expressed in terms of activities. Activities are the way in which people (third level) make use of services or interact with other persons (second level). The relationships between the hardware and the software can be expressed in terms of programme. The programme defines the requirements for the realisation or adaptation of the physical environment (first level) in relation to a certain set of objectives, while in turn the physical environment conditions the range of possibilities regarding its availability for functional or social uses (second level).

It is evident that planned spatial actions cannot be placed in the third level, but in the first and second levels. However, knowledge of the characteristics of the third level is very important in order to better shape a respondent environment supporting a real possibility of choice for people.

[1] Virtual = being functionally or effectively but not formally of its kind (Webster's)

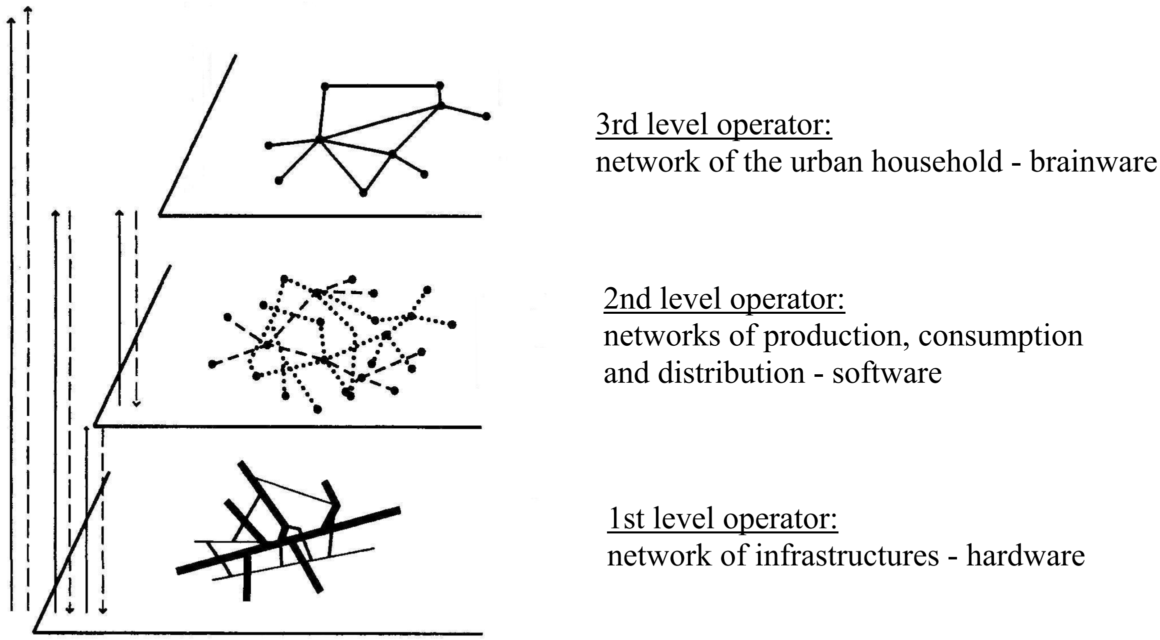


Figure **1.1.4** Urbanism of networks
Source: Dupuy, 1991

1.2 Moveo, ergo sum. Movemus, ergo sumus.

I travel, so I am. We travel, so we are.

'In our society, the notion of mobility cannot be overestimated. People have to travel for their jobs, in order to go to urban facilities, for social contacts, for recreation, and so on. Mobility increases individual well-being. Mobility isn't considered to be a right such as education and health care. However, mobility is considered to be a condition for everyone in order to participate in society.'
(Ministry of Traffic and Transport et al., 1999).

With this introduction of the National Plan of Perspectives on Traffic and Transport, the Dutch Ministry of Traffic and Transport (1999), re-emphasised the importance of individual mobility and made clear why mobility in general and personal mobility specifically should be evaluated positively for a society. Mobility has for human beings an utmost important function ecologically, socially, and economic (Steg, 1996). Although mobility is not considered by the Ministry of Traffic and Transport to be a human right as such, yet the idea of a right on freedom of movement touches the deepest human feelings on freedom as a general concept. Reducing the freedom of movement is spontaneously connected by most people to dictatorial suppression.
It could be said that it should be the duty and task of the government to guarantee (i) a reasonable degree of availability in time and space of transport alternatives for every civilian, and (ii) a reasonable degree of accessibility in time and space of urban and rural areas. This latter task of the government could be especially true if the activity places are closely bound to the execution of (socially) acknowledged human rights, such as education (schools) and health care (hospitals). With respect to this topic, ex-minister of Justice Hirsch-Ballin once referred to mobility as a 'verwerkelijkingsgrondrecht'. However, it seems to be more fruitful to avoid the notion of 'right' in the discussion about mobility (Achterhuis, 1998). It seems better to speak of a socially acknowledged need for mobility.

Living creatures indeed have to travel in order to survive: they have to collect food, to protect oneself, to breed, and to fulfil their needs of exploration. Not all trips actually made by people are necessary from an ecological point of view. The necessity of a trip depends on the necessity of the activity, in which one wants to participate and the needs one wants to fulfil with that trip. The most important needs on an *ecological* level are of direct importance to survive: the needs for food, drinking, protection, and breeding (Maslov, 1954).
At a *social* level, mobility offers people the opportunity to make and maintain social contacts, to relax, and to develop. Already in the First Dutch National Scheme for Traffic and Transport (Ministry of Traffic and Transport, 1981), it was stated that 'travelling offers important possibilities for the development of people, and the participation of people in social activities.' Therefore, mobility was considered to be of 'vital importance for the well being of man.' Many trips with motives such as visiting friends and family, going out, education, and sports are made in order to fulfil the social needs. In 2001, about 43% of all kilometres travelled within the Netherlands, about 80 billion kilometres, were made for these social needs (CBS, 2002).
At the *economic* level mobility is closely related to the employment and the national income. In 2001, 38% of the total distance travelled within the Netherlands was related to commuting and business trips: 71 billion kilometres in total (13.1 kilometres per person per day). For shopping, although shopping is not only taking place at the economic level but also on the ecological (buying food) and social (funshopping) level, attracted 10% of all kilometres travelled, about 18 billion kilometres.

The growth of (individual motorised) mobility of the last decades is strongly related to our mobility culture. In the next subsection, we elaborate on some philosophical aspects of our mobility culture.

1.2.1 Mobility culture

Culture can be defined as the set of hidden presuppositions (De Jong, 1998). Or: the collection of collective concepts which have become expressive as conditions of life in the human habitat (De Jong, 1992; De Jong et al., 1998). Mobility culture can thus be defined as the set of hidden presuppositions with respect to mobility. The notion of travelling has changed a lot since earlier days. The traveller has evolved from *homo viator*, someone who travels on his own, into (i) a *homo transportandus*, someone who is transported (mechanically), and (ii) a *homo transportans*, someone who transports (goods, information, data, etc.).
In today's culture, it goes without saying that there is scarcity in all kinds of societal fields. So, not only economics is dominated by the rules of scarcity, but also fields such as spatial planning. More general, it can be said that for human beings time and space have become significant scarce entities. But -how interesting- scarcity doesn't only result from the experienced (personal) needs, but also from the material-technological organisation of our society. So, with respect to mobility, technology plays an essential role. Let us take the example of the car.
This piece of technology promised (at first) large profits of time for those who could afford a car. The total automobilisation however levels out the head start of the early birds on the one hand, and increases the total speed and mobility of a society drastically on the other hand. The profit of time (compared to others) is nullified, and time scarcity has increased.

The actual mobility – expressed in numbers of trips, kilometres travelled, and modal split- is a quantitative expression of our mobility culture, which is presented in (inter)national statistics.

In the Netherlands in the year 2001, people on average travelled 34.5 kilometres per person per day: 18.4 km as car driver, 7.1 kilometres as car passenger, 3.2 kilometres by train, 1.5 kilometres by bus/tram/metro, 0.2 kilometres by moped, 2.5 kilometres by bike, 0.6 kilometres walking, and 0.9 kilometres by other modes (CBS, 2002).
During the last century, economic and social developments have brought the industrialised countries new norms and values with respect to mobility. Many people have adopted these norms and values as personal axioms (Baggen, 1994): it is useful and pleasant to travel large distances, individually, where and when one wants, as fast, cheap, comfortable, safe, reliable and flexible as possible, and most favourably with some show of personal style.
Mobility in general and especially car mobility have been stimulated strongly by several technological, economic, spatial, social-cultural, demographic and political developments in our society (Steg 1996; AVV, 1997). The government has always stimulated this growth, for example by constructing new roads and other large scale infrastructures. After all, transport and traffic have been seen and are seen as important instruments to improve the quality of life of every civilian.
But, are we –poor and rich- in fact getting happier with more mobility? In the theory of happiness it is questioned how happy people are and due to which factors (Van Wee, 1999; Verhoef and Van Wee, 2001). At a national level, an increase in income results in an increase of happiness, but the law of diminishing returns rules here and there is a certain saturation level. How come?
In order to explain the level of saturation, one has to distinguish between absolute and relative needs. Absolute needs concern things such as clothing, eating, drinking, and a decent place to live. Relative needs result from the fact that we want to distinguish ourselves from others (status). It could be true due to the spatial organisation of society, that nowadays the car satisfies also absolute needs, besides the relative needs. If a spatially dispersed urban area is compared to another urban area (less spatially dispersed), then the same level of mobility would result in a lower level of happiness, and a higher level of mobility is required in order to get the same level of happiness (figure 1.2.1).
Owning and using cars by the inhabitants of the countryside from the Dutch rural province of Drenthe will most probably have more to do with absolute mobility needs than owning and using cars by the Amsterdam city centre inhabitants. If absolute car oriented mobility needs indeed exist –for example because of the spatial dispersal- it isn’t hard to imagine people revolting against policy measures such as carpool lanes and congestion pricing.
Whether people get happy or unhappy by travelling, most transportation experts have adopted the view that both the absolute and the relative needs of people to travel originate from the human need of performing activities (Jones, 1979; Ettema and Timmermans, 1997). It is said in this activity-based approach that travel doesn’t take place on its own. There is always a reason, a motive, an origin, and a destination, on which the travelling is based. Besides, not all activities can take place at the same location.
So, transport can be considered to be a derivative of societal and economic activities. The relation between the mobility of people, the societal and economic activities, and the spatial organisation of those activities, clearly show symbiotic features. Travel patterns represent the societal activities, but the transport system structures the societal organisation at the same time. The increase of the societal and economic activities will lead to a larger demand for communication and transport. On the other hand the growth of these activities is conditioned by the mobility of people – i.e. the possibilities of people to transport oneself and/or goods (Bach and Van der Hoeven, 1994).

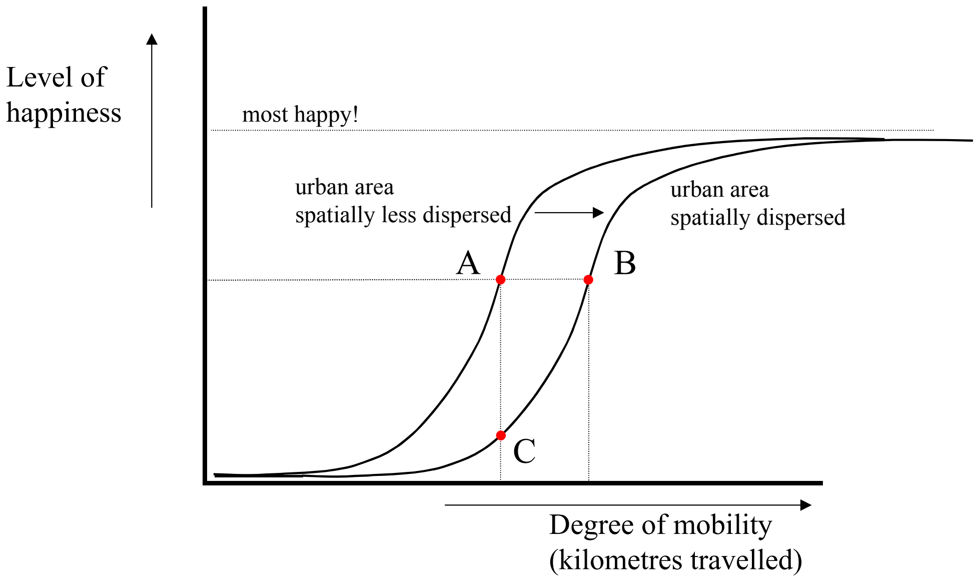


Figure **1.2.1** Level of happiness and degree of mobility for different urban areas

1.2.2 Mobility: problems and solutions, now and in the future

The present and expected developments of personal transport do not only imply blessings. It is good to remember the many positive sides of the increased and increasing mobility of people, but the many negative repercussions shouldn't be forgotten: the deteriorated accessibility, liveability (among others the use of space and the traffic safety), and environment quality. The increased mobility in general and the large increase of individual motorised transport specifically has lead to large (social) problems of different nature. We -as both individually and collectively motorised travellers- have taken a growing claim to the physical and social environment.

Damage is caused on an ecological, social, and economic level (Steg, 1996). Ecological damage takes place by the emission of damaging, toxic, and unpleasant chemicals, that contribute to the green house effect, smog, and acid rain. Most of the time, vehicles use scarce sources of energy, and the traffic contributes to the waste problem. Moreover, the increase of the vehicle fleet and the extension of infrastructures leads to the disturbing and fragmenting of scenic areas.

At the social level, the negative effects of mobility affect the liveability of urban areas: the pressure on public space, local air pollution, noise, stench, and traffic safety. At the economic level the traffic has negative consequences, because the accessibility of economic important destinations is endangered more and more, and with that the distribution function of the Netherlands. Furthermore, a large share of the (external) costs is passed on to the society by the travellers, such as environmental costs and the costs of maintaining a certain level of traffic safety.

Traffic has caused problems in the past, causes problems nowadays, and will cause increasing problems in the future: technological efforts in order to 'clean' the traffic have been nullified by the growth of traffic in absolute numbers in the past (Van Wee and Van den Brink, 1999). There is a strong contrast between the direct individual advantages for many, and the indirect, most of the time long-term disadvantages for the society as a whole. This contrast makes transport and traffic management a so-called social dilemma (Vlek, 1996, 1999b). According to Steg (1996), this social dilemma of mobility can only be solved if the next conditions are satisfied:

1. collective problem consciousness;
2. a proper balance of the collective disadvantages and the individual advantages against each other;
3. the availability of suitable behaviour alternatives;
4. effective strategies for changes in human behaviour.

A reduction of the mobility of people seems to be both socially improbable and impossible in the near future. It even can be socially undesirable. It seems that in most societies it is determined culturally that economic growth, whether sustainable or not, is at the top of the lists of priorities. And the past has shown the irreversibility of the positive relation between economic growth and the growth of mobility[2]. As long as the collective concepts on economic growth are imbedded in our society, the fields of transport planning, spatial planning, and urban design are (only) confronted with the problem of facilitating and accommodating the increasing demand for mobility as sustainable as possible. So, to manage and control mobility instead of reducing it. Moreover, it has been shown by research (see for example: Dupuy, 1995, 1999) that the positive external effects are underestimated when the pros en cons of (individual motorised) mobility are discussed.

Mobility as a challenge for technological innovation

It should be made clear that mobility does not exist only because of the need for travel, but also because of the presence of possibilities to travel. Therefore, transport technology has an important function for accommodating the increasing demand for mobility. With regard to the pursuit of solutions to the mobility problems society is faced with, Geerlings (1999) presents different views which divide into two extremes.

The first direction, eco-centrism places the eco-system at the centre. This approach sets the preservation of ecological systems as the highest goal. However, for mankind, the strict implementation of this view would mean a return to a primitive society. At the other extreme is the anthropocentric school of thinking. This takes an optimistic view of the role of technology as part of the solution to the problems. Along with this approach goes, among other things, a limitless confidence in man being able to solve the environmental problems with highly sophisticated technology. However, experience indicates that the complete implementation of the solutions proposed by this school of thought would not lead to the required results either.

In view of the shortcomings of a complete dependence on technology, a third school of thinkers arises. This is embodied in the concept of sustainability, which is discussed in chapter two in more detail, and can be considered as a hybrid of eco-centrism and anthropocentrism. It entails the deliberate selection and implementation of a certain direction of technological development which is deemed preferable from the standpoint of sustainability (Cramer, 1992).

Mobility in the future

The exploration of the relation between new ways of transport, the travel behaviour of people, and the spatial planning is future oriented. As spatial planners in the first years of the 21st century, we don't have any tools available to define with enough precision future evolutions. Therefore, an important question is how we can get grip on these uncertainties. First of all, an ordering of our thinking about the future is needed.

A way of managing uncertainties makes a distinction between three different futures: desirable, probable, and possible futures (de Jong, 1998, 1992). This distinction reflects the three fundamental categories with which we relate to the future. Respectively: what we would

[2] Chapter four on the development of individual action spaces goes in detail on this specific topic.

like it to be; what we know it will be; what it can or could be. The relationship between these three futures is reported in figure 1.2.2. Only some of the possible futures are probable, which is the domain of the predictions. At the same time probable futures are not always desirable, which results in problems: this is the domain of politics. Those possible futures that cannot be predicted must be designed. With respect to these futures of the possible, it should be taken into account that there are technological solutions available, which are not feasible economic. Moreover, there are also technical and economic feasible futures that are not implemented for social, societal, and/or political reasons.
Also, a comment is required about the evolutionary character of figure 1.2.2. What is not desirable, probable, or possible at the present moment may become desirable, probable, or possible in the future due to evolution in socio-economic and technical developments. Design as an investigating methodology could be very relevant in this concern, since it may help to explore the frontiers of the possible.

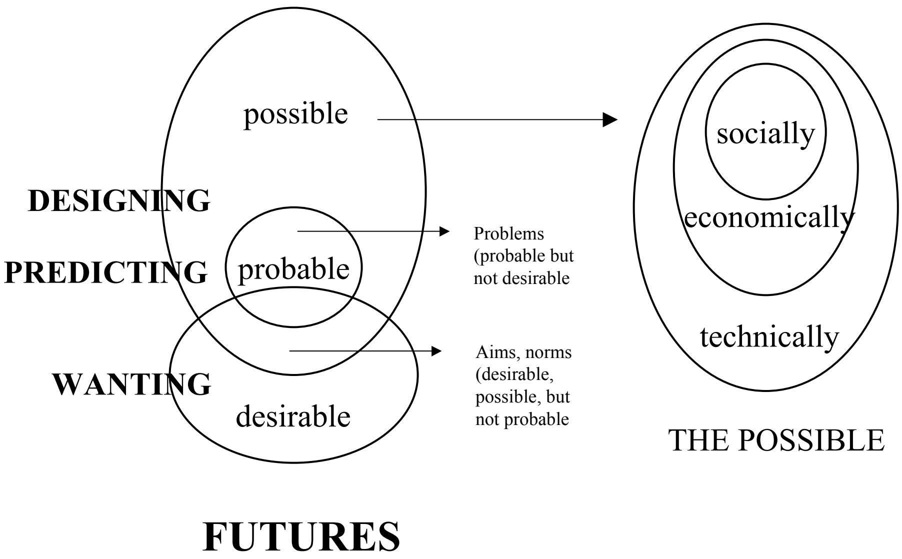


Figure **1.2.2** Future thinking
Source: De Jong, 1998

Desirable mobility futures
Desirable futures refer to what people consider the best development for themselves and the environment in which they live. They are the goals that people want to reach and for which a set of initiatives must be undertaken. Therefore, desirable futures are a matter of politics in the sense that goals must be identified, choices and tools have to be discussed and agreed on, and an equilibrium between the different interests of individuals and groups must be found.
What is now a desirable mobility future? Every person will have his or her own thoughts about what is desirable for him or her self. Within the research program Seamless Multimodal Mobility (SMM), TRAIL Research School pointed out its vision on a desirable mobility future (TRAIL, 1999).

‘Seamless multimodal trip chaining at a regional scale can be an answer to growing restrictions on the use of cars for personal travel. Sophisticated information and communication technologies as well as real-time transport process control will offer the means for effective and efficient multimodal travel services exhibiting an unprecedented high level of quality that can compete with that of the car.
The future multimodal trip chain is achieved by employing a broad gamma of individual (walk, bicycle, car) and public transport modes (bus, train, ferry, aeroplane), offered by private or public suppliers, and organised as a combination of fixed (time-tabled) and flexible (demand-responsive) services.
The future multimodal transport system will be an integrated, mixed, flexible, and multi-layered network of various types of travel services which are linked in intermodal transfer nodes. This service network is supported by physical infrastructure

links and nodes, and extensive information and communication networks for travellers, service providers, vehicle drivers, and public transport operators. A key role will be played by the Personal Intelligent Travel Assistant (PITA): a pocket-sized multimedia computer integrated with a mobile telephone that provides ubiquitous communication between travellers and service providers at any time before or during the trip.
The traveller may choose his way through the multimodal services supply by himself, or he may use the assistance of a professional trip chain organiser, the integrator. The first will most probably apply to routine trips, but for the growing share of incidental trips the Personal Travel Service offered by an integrator will result in multimodal services perfectly adapted to the individual needs and preferences of the traveller.

The research program for multimodal personal transport is motivated by the growing sensitivity of the conventional modes of transport to disturbances and to stochastic fluctuations in demand and supply. Today's mass transport services are neither attractive for the public, nor are they efficiently operated. Car use cannot grow further as was the case in the past because of excessive space consumption, increasing congestion and severe environmental impacts.
In the future, car access to the city centres as well as to freeways will most probably be restricted. Increasing diffusion of travel demands in space and time and growing variability in consumer preferences will make conventional unimodal transport systems less attractive and inefficient at a regional scale.
A lot can be gained in combining the strong points of individual and mass transport systems, and from both private and public forms of operation. This is the more true since new technologies in microelectronics and advanced information systems offer opportunities to operate more complex and nevertheless highly reliable travel services. Currently, about 8% of person trips in the Netherlands are performed as a multimodal chain, accounting for about 15% of travelled kilometres. Its seems feasible to at least double these figures, thereby reducing car use accordingly.
By using the modern information and communication system capabilities, a significant higher level of service regarding dynamic traveller information as well as traffic control can be achieved. The future multimodal personal transport system will offer the following values:

- highly reliable personal travel services;
- synchronised multimodal travel services;
- well designed multimodal travel services networks;
- omnipresent information about travel times, costs and actual traffic conditions, on behalf of travellers, integrators and transport operators;
- advanced traffic and operation control systems;
- high performance vehicles and infrastructure facilities, especially the intermodal transfer points.

The direct beneficiaries are the general public to which these services become available. These services will enrich personal mobility to the benefit of a higher participation in economic, social and cultural activities of the population, and will decrease the need to use the car for all kinds of trips. Being embedded in these multimodal chains, public transport can improve its service quality drastically and will attract much larger shares of travel demand.
Especially the existing difficulties in the transfer process (unreliability, bad comfort, delays) between separate legs of the chain (modes or lines) will be removed. Travellers will make use of the hand-held multi media pocket computers in order to get dynamic travel information about individual mode, route, time and cost alternatives. Transport integrators and operators will monitor automatically the actual travel demands and traffic flows, which helps to optimise the transport supply and intermodal connections, and helps to minimise delays.
In addition, there are beneficiaries on the supply side as well: the travel service providers, transport companies, and public authorities. Improved process control and information exchange will lead to a much higher degree of safety and efficiency of operation. It will lead to a much better utilisation of resources such as vehicle fleet and infrastructure capacities while reducing the number of road accidents drastically.'

Probable mobility futures

The probability of a certain future is a matter of prediction, which in turn depends on the knowledge already built up about the phenomenon at issue or on comparable phenomena, which permitted the construction of a theory. It is, therefore, a job for the scientist who can, on the basis of existing theories and observing current tendencies, assess with a certain precision how probable a given future is. Nevertheless, even in these cases predictions should be handled with care: the history of evolution is full of wrong predictions.
Many transport scientists have investigated probable mobility futures extensively. One of the most interesting studies on the past and future of global mobility has been done by Victor and Schafer (1997, 1998) (see figure 1.2.3 and 1.2.4). They cope with questions such as 'how much will people travel in the future?', 'which mode of transport will they use?', and 'where will traffic be most intense?'. They conclude that in high-income regions (North America, Western Europe) the share of traffic volume supplied by buses and automobiles will decline as high-speed transport rises sharply. In developing countries the strongest increase is to be anticipated for buses and later for automobiles. In all regions in the world, the share of low-speed rail transport will probably continue its strongly evident decline.

Despite the sharply rising share of air travel (and high speed train), other types of vehicles, including automobiles, will remain crucial parts of the transportation system. Even in North America, where the relative decline of automobile is expected to be the steepest, it is estimated that the absolute traffic volume supplied by cars will decline only after peaking at 22,000 passenger-kilometres per person in 2010. By 2050, automobiles will still supply 14,000 passenger-kilometres per person, which means that North Americans will be driving as much as they did in 1970.
In North America, it is expected that the very large demand for air travel (or high speed rail travel) that will be manifest in 2050 works out to only 12 minutes per person per day; a little time goes a long way in the air. So, no matter how important air travel becomes, buses, automobiles and even low-speed trains (and trams and metros) will surely go on serving vital niches. Average people will continue to spend most of their travel time on the ground.

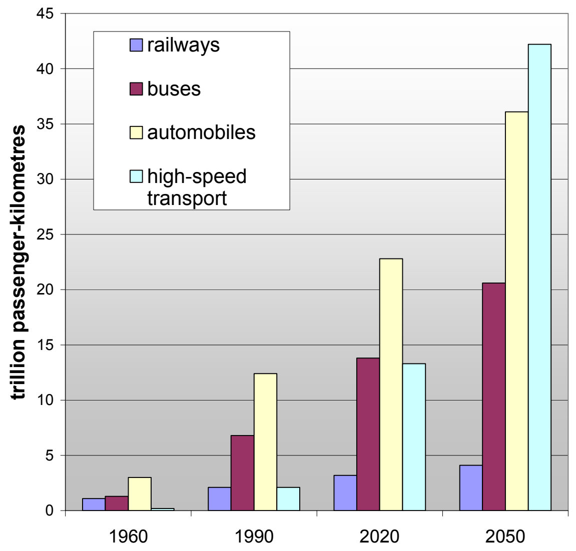


Figure **1.2.3** World traffic volume, measured in passenger-kilometres
Source: Victor and Schafer (1997)

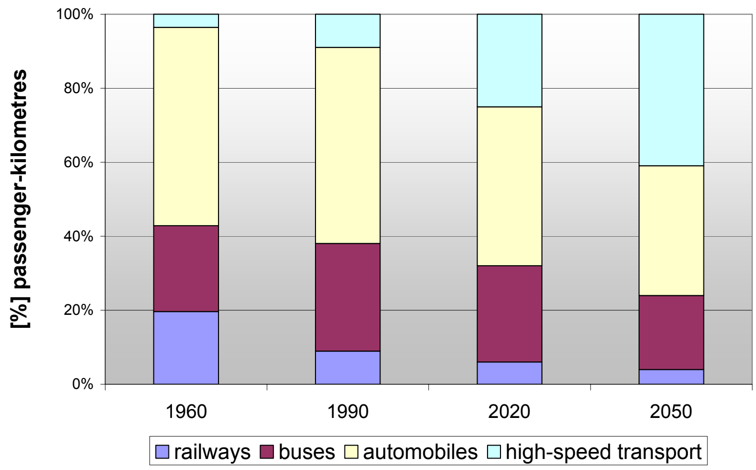


Figure **1.2.4** World traffic volume, measured in passenger-kilometres in percentages
Source: Victor and Schafer (1997)

Possible mobility futures

Possible futures are the domain of design. In this domain, different futures can be sketched as having reference to the conditions for which they are technically, economically, and socially possible (figure 1.2.2 on the futures refers). The investigation of the possible is often related to the desired futures, since design is a goal-oriented activity. This thesis deals with the issue how to plan and design the Network City from a (seamless multimodal) mobility point of view. Within the context of the total SMM research program, all kinds of researchers and designers from all kinds of research fields have been working on the feasibility of the desired seamless multimodal transport system (figure 1.2.5). One SMM project consists of several researchers and several individual sub-projects[3].

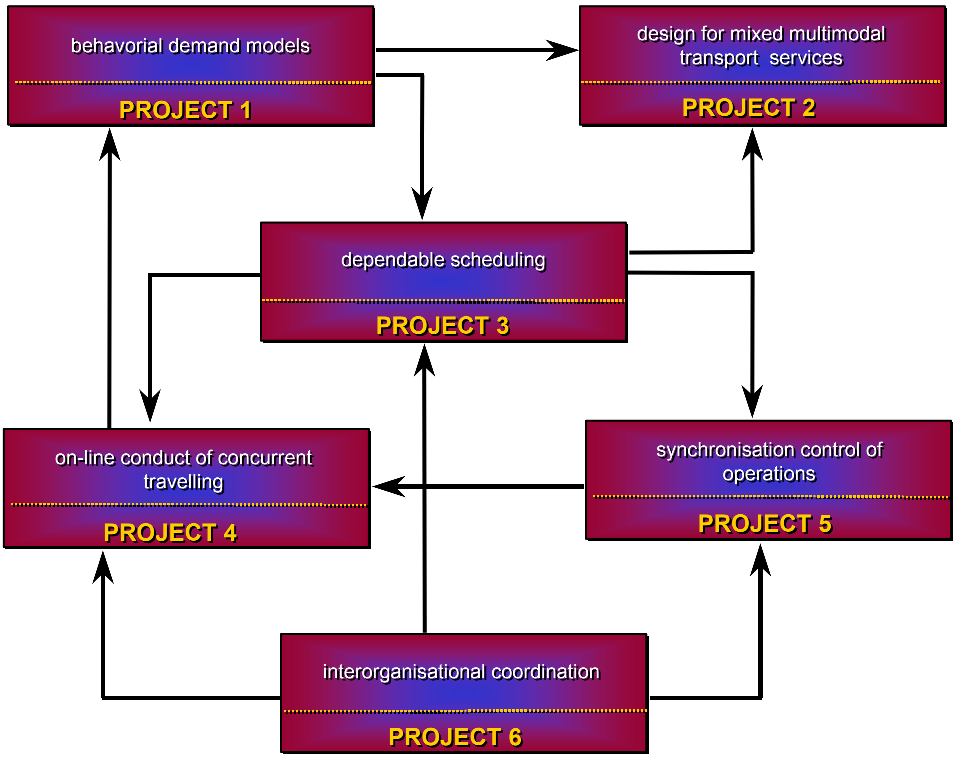


Figure **1.2.5** SMM research program and the six SMM projects
Source: TRAIL, 1999

1.2.3 Consumer approach

In order to come to recommendations for the planning and design of the Network City from a mobility's point of view, this thesis (among others) focuses on the changes of individual travel behaviour both in time and space due to the introduction of seamless multimodal transport. In terms of the urbanism of networks: how do changes in the levels of the technical networks (infrastructure, vehicles, transfer points, etc.) and functional networks (travel, transport and traffic services) influence the third level of individual (consumer) use? Table 1.2.1 points out how SMM can be adapted to Dupuy's network scheme.

[3] This PhD project is part of PROJECT 2 on the design for mixed multimodal transport services.

Network level	Multimodal transport aspects
1st level network: 'hardware'	• physical infrastructures • vehicles • transport nodes and transfer points
2nd level network: 'software'	• travel, transport, traffic services • mobility consumption patterns
3rd level network: 'brainware'	• individual or household travelling: action space

Table **1.2.1** Seamless Multimodal Mobility and the urbanism of networks

With respect to individual travellers and households, the possible influence of the time-space budget offers attractive possibilities for research (Drewe, 1996). Certain out-of-the-home activities, or certain locations that used to be inaccessible, now might become within the reach of an individual due to the increased possibilities of the seamless multimodal mobility system to travel. The travelling involved has of course to be looked at within the context of both the total time-space budget of an individual and the budgets of the other household members. With this time-space budget approach, the perspective of spatial planning shifts from the accessibility of activity places towards the individual reach of activity places, in other words the action space of persons and/or households. Here, distance has to be considered as the function of time, that is the (digital) travel speed.

1.3 Problems in spatial planning

With the increase of motorised mobility, the action space of people has increased enormously during the last centuries in general and especially during the last decades. This process has taken place under influence of economic growth and development -whether sustainable or not. The daily action space of people has grown to an extent that exceeds the size of the traditional city to a large extent.

However, people of the 21st century don't travel longer distances, because they like travelling much more than in earlier days. No, for centuries, the time spent on travelling by people has been about 1 to 1½ hours a day, independent of culture and place on earth. People nowadays travel longer distances, because they have more opportunities (in time and space, and financially) and more sophisticated transport technologies (accessibility, travel speed) to go to more remote activity places.

In order to explain this phenomenon of increased travel distances, people could be considered to be *utility maximisers*. A person addresses a positive *utility* towards an activity *a* (with all its characteristics) at an activity place *A* (with all its characteristics). On the other side a *disutility* is addressed to each trip that is necessary for the activity *a* (costs, travel time, etc.). A trip will be made if the (subjective) benefits of the activity *a* at location *A* outweigh the (subjective) costs. So, a trip will be made if the balance of utilities is positive. A traveller chooses the alternative that offers him the highest utility (subjective utility maximisation) under the conditions of time and money budget. It simply depends on the subjective (dis)utilities that a person addresses to an activity, its location, and its trip whether people will go to more or less remote places.

The multi-nodal and hierarchical infrastructure network has to accommodate the movements of personal transport. From the viewpoint of the spatial planner, this accommodation process should always take into account and strive for the *vitality of urbanised areas*, the core business of spatial (urban) planners and designers, and a key notion for successful cities

(Salingaros, 1999b). Based on a wide variety of urban and transport research, the author holds the view that this vitality is endangered most by:

[i] the *space consumption of infrastructure and vehicles*;

[ii] the decrease of the *accessibility of urban areas*;

[iii] the absence of *coherence between the hierarchical levels* in the urban web.

These three issues should be seen as the largest problem fields to tackle for the urban professionalists in the next decades and they are dealt with in this thesis. The next three sections elaborate on these three problem fields.

1.3.1 Space consumption of infrastructure and vehicles

From 1985 to 2002 the road infrastructure (hardened roads: paved, asphalted, etc.) in The Netherlands has grown with about 20% to 120,000 kilometres (CBS, statline). The length of motorways grew only a few percent to about 2,900 kilometres in 2002. The number of (private) cars grew however in this time from 4.6 million to 6.7 million, an increase of over 30%. The increase of car kilometres travelled (as driver), is with 29% about the same: in 1985 63.9 billion kilometres and in 2001 90.2 billion kilometres.
In the Dutch provinces of Zuid-Holland and Noord-Holland, the most dense provinces of the Netherlands with about 1,000 inhabitants per square kilometre, about 5% of the land is used for transport facilities. So, although only 5% of the total landuse of this part of the Netherlands is for transport infrastructure, the indirect impacts on society as a whole are very large as we know from the daily news about parking problems in city centres, congestion on the motorways, the intersecting of greenstructures and the introduction of barriers due to the construction of new rail and road infrastructures, etc.

1.3.2 Decrease of accessibility of urban areas

The accessibility of urban areas has been a hot issue in the political discussion on mobility for decades. The Ministries of Transport and Spatial Planning have formulated the improvement of the accessibility in the Netherlands as one of the core businesses (Ministry of Traffic and Transport, 2000; Ministry of Housing, Spatial Planning, and Environment, 2001). Many studies on accessibility have seen the daylight lately (Van Wee et al., 2001; Dijst, 1995; Connekt, 2000; Hakkesteegt, 1994; Scheele, 1993; Visser and Binsbergen, 1995; and many others), which has resulted in many definitions for the notion of accessibility.
Accessibility nowadays is not only seen as an infrastructural notion, but also as a geographical notion. So, an activity place has a good accessibility if a traveller needs relatively little efforts to get to that specific activity place: good feeder lines (infrastructure), good transport services. But the accessibility of an activity place gets also better if more people can reach this activity place within a certain amount of time. Sometimes a low level of accessibility can be preferred above a high level of accessibility. For a wildlife reservation a certain level of inaccessibility could be most desirable. The socially desired level of accessibility thus depends on the specific situation and (most of the time) political preferences.

1.3.3 Absence of coherence between the hierarchical levels in the urban network

The fields of architecture and urban design and planning have so far resisted describing the city in a scientific formulation, in part because of the underlying complexity (Salingaros, 1999a). Yet, this is exactly what human being implicitly do when they try to understand complex interacting systems. A central component of the human intellect is the ability to establish connections, to see and superimpose patterns and structure: the fundamental

difference between mankind and animals. The ability to establish connections applies both to tangent and visual, and less obvious, more abstract processes.
The urban web is a complex organising structure that exists primarily in the space between buildings. Each building encloses and shelters one or more human activity nodes. Coupling elements such as infrastructure and public space link the activity nodes: streets, pedestrian zones, plazas, bicycle paths, highways, etc. Many urbanists consider the public space as the principal domain of the urban designer, and the infrastructure that of the civil engineer (Heeling, 1998). Calabrese (2004) shows in her research the (negative) consequences for urban and regional planning and design of this segregated approach. This topic of inter- and/or multidisciplinarity is also debated thoroughly in this thesis.
A city without complexity is called 'dead'. Too much complexity without any organisation, without any structure, becomes 'chaotic' and 'unliveable'. Raising the degree of organised complexity appears as one of mankind's fundamental drives throughout the ages (Salingaros, 1999a). One of the principal ideas underlying the city-complexity theory is that a city mimics human thought processes, in that both depend on establishing connections, patterns, and structure.
Salingaros (1999b) clarifies his 'rules' of the composition of complex interacting systems as follows: *'The development of complex interacting systems in time defines an underlying causality. The smaller scales need to be defined before the larger scales: their elements must couple in a stable manner before the higher-order groups can begin to form and interact. Elements on the smallest scale, and their couplings, are thus the foundations of the entire structure. Requiring a hierarchy of nested scales means that not even one scale can be missing, otherwise the whole system is unstable. Connective rules determine whether a system is coherent or not. These general rules assess the stability or effectiveness of a complex system independently of what that system is supposed to do.'*

1.3.4 Towards a city full of vitality

It should be the focus of every city planner and/or designer to generate a successful urban environment, creating an efficient and liveable, psychologically positive human environment. The city should be used intensively both in time and space! Already from ancient times the city has been -and most certainly will be in the future- a place of gathering and encounter. The urban fabric should stimulate, facilitate, and accommodate these gatherings and encounters best as possible. In order to do so, the urban fabric has certain means, the urban components: streets, shops, offices, houses, pedestrian zones, station buildings, green spaces, plazas, parking lots, etc. Successful cities -in terms of efficiency, vitality, and liveability- meet both the physical and psychological needs of the human scale with their physical structures and surroundings. Successful cities provide *spatial quality*.
Spatial quality criteria are widely discussed among urban experts (Ministry of Housing, Spatial Planning, and Environment, 2001; Jacobs, 2000b). A stream of Dutch urban thinkers conclude that the (Dutch) post-war urban extensions including the recent Vinex residential zones look and feel inhuman and lack vitality. Large monofunctional residential areas, and office, business and commercial zones pop up all over the country. The preceding argument leads to a frightening conclusion: that the contemporary city is simple a collection of *disconnected* parts on all kinds of scales. And paradoxically, our civilisation now is trying to connect cities electronically, after having taken them apart geometrically. What's wrong? Can't we do any better? (Old) City centres however prove the difference. Within their ancient and durable structures, they can adopt new construction projects successfully. Connecting and disconnecting are keywords here. And the coherence of spatial levels in the urban web

(transport networks included) that connects city districts, urban zones, business areas, etc., seems to be crucial for a vital, and thus successful Network City.

1.4 Research approach

1.4.1 Problem definition, research objective, main research questions

The previous section described the main problems in spatial planning, all starting from the notion that the concept of a city has changed, from monocentric city to a Network City in a network society. It is widely agreed among urban experts that the new urban technologies, among others transport technologies, play a major role in (the development and transformation of) today's socio-spatial environment. But it is still quite *unclear* **how** these new technologies **should be interpreted** in terms of the planning and design of the (network) city. The **main objective** of this thesis is to generate those kinds of guidelines and recommendations for the planning and design of the Network City, all from a mobility point of view.

In this project, as part of the TRAIL SMM research programme, seamless multimodal transport is considered to be among the possible solutions for the three spatial planning problem fields identified. Therefore, the main research questions, to which this thesis addresses, concentrate on the relation between the planning of the Network City, the transport system, and the activity-travel behaviour of people:

[i] How can a seamless multimodal mobility system 'help' to let cities function successfully?

[ii] How does the action space of people change with the introduction (and finally the adoption) of a Seamless Multimodal Mobility System?

[iii] How does the spatial planner/designer choose the best locations for the intermodal transfer points in the multimodal network within the Network City?

These three research questions explicitly refer to the problem fields of spatial planning on space consumption, accessibility, and urban network coherence. So, this research project discusses the influence of multimodal travelling on the activity-travel behaviour of people and the planning of the transfer nodes in the Network City. Therefore, the aim of this research project is also to provide:

[i] a conceptual model that describes the impact of seamless multimodal travelling on the activity-travel behaviour of people;

[ii] knowledge about how the introduction and adoption of the demand-responsive transport system -as important feature of the SMM system of the future- influence the action space of its users, mainly older and disabled people;

[iii] a set of guidelines for the planning of the location of transfer points, considering both the configuration of the Network City and the activity-travel behaviour of people.

1.4.2 Research hypotheses

In the research for this thesis, several hypotheses have been leading for the research direction of the project. In this subsection, we introduce the hypotheses briefly, whereas chapter eleven with the conclusions deals with them extensively. The hypotheses contain the several topics this thesis focuses on to integrate: the Network City, its (multimodal) transport system, and the activity-travel behaviour of people. More specifically, the hypotheses deal with two important aspects of the multimodal transport system: the location of transfer points and demand-responsive personal transport.

The functioning and vitality of the Network City is closely related to the hierarchy and structure of its transport system. The design of the Network City and its transport system thus is a multidisciplinary task.
The relation between transport systems and land use has been discussed on many occasions (see for overview: Van Wee, 2000). Here, it is suggested that both the city and the hierarchy and the structure of its transport system should be designed[4] simultaneously in order to lay the fundaments of a vital and sustainable city. Within the context of this research project, this hypothesis is tested in a research by design workshop environment and is reflected at in chapters eight, nine, and ten of this thesis.

The location of transfer points within the Network City is one of the key success factors for multimodal transport, and together with the architectural lay-out, the urban environment, and the transport function of transfer points, it plays a crucial role in establishing the (desired) hierarchy and structure of a transport system of the Network City.
Transfer points are the connectors between the different networks of different spatial levels. They are thus of vital importance for the functioning of the transport system as a whole. Here, it is suggested that the location of these transfer points have a large impact on the functioning of the urban network.
Furthermore, it is looked at if a better choice process for the location of transfer point, which includes (i) analysing and interpreting data on actual activity-travel behaviour of people and (ii) a multidisciplinary discussion between urban designers and planners, transport planners, and transport behavioural scientists about the basic design principles (problem definition, aims, targets), results in better locations for transfer points within the Network City.

Demand-responsive personal transport systems have a (theoretical) potential to play an important role in the total multimodal transport system of the Network City, although nowadays their role in practice is marginal.
Demand-responsive services refer to explicit transport demands of travellers. It seems therefore, that these kinds of systems have the potential to handle diffuse travel patterns (in both time and space) within a Network City that is also characterised more and more by urban sprawl, very well. Furthermore, demand-responsive services within cities have the potential to act as feeder systems to higher order transport networks.

The introduction of demand-responsive personal transport systems results in new and/or other activity-travel choices of the travellers and thus in changing activity-travel behavioural patterns of these travellers, although there will be many differences in use according to the spatial setting in which the system functions (urban users, suburban users, and rural users) and the level of service characteristics.
The introduction of a new transport system results in people reconsidering their present activity-travel choices only if the new system has become part of the (renewed) choice set of the traveller. Here, it is suggested that people who live in different spatial settings will adopt and use the new transport system differently (for example expressed in differences in distance behaviour).
In today's generation of Dutch demand-responsive shared taxi systems, the level of service characteristics (travel time, costs, comfort) favours the vulnerable travellers best over other user groups. In the Netherlands, there are quite a number of demand-responsive shared taxi systems in operation. It is suggested here, that for many travellers these kinds of systems do not have the ideal characteristics in order to compete with other travel modes (car, bicycle,

[4] Here 'design' stands for both new designs for new cities / city districts and for urban transformations in existing urban areas; in fact, most urban design and planning projects deal with these urban transformations nowadays.

traditional collective public transport). The systems' characteristics only fit the wishes and demands of the more vulnerable user groups (older people and older women especially, disabled people).

1.4.3 Planning cycle

The planning cycle is the research approach that is used for the research project and is at the same time also the thread of this thesis (figure 1.4.1). In spatial planning practice the cycle consists of the steps **program-design-construction-management (and monitoring)**, where a 'design' is made according to a certain design 'program', 'construction' refers to the situation that a design is actually built, and the management and evaluation of a construction project may lead (after some time) to a new design program (Hulsbergen and Kriens, 2000).

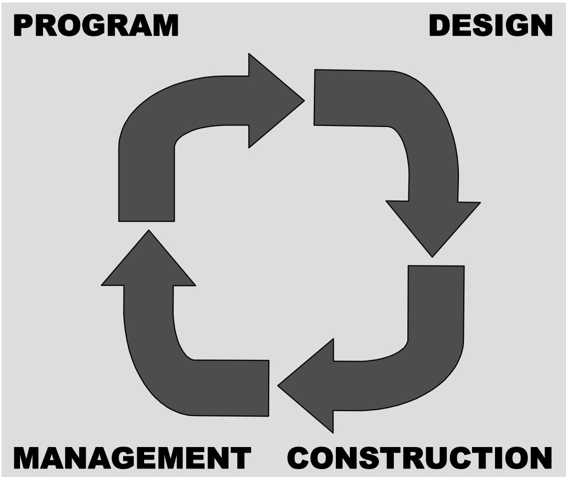


Figure **1.4.1** Planning cycle in practice

However, an important task of spatial planning consists of the development of a design instead of realising one. For this research project the planning cycle steps therefore can be formulated according to figure 1.4.2: **analysis – design – strategy – evaluation**. The phase of analysis consists of literature studies and empirical research. In the design and strategy phases, this thesis provides basic principles and conditions for the planning and design of the Network City in general and the location of transfer points specifically. Design alternatives for the locations of transfer points in the region and city of Maastricht are presented as (strategic) examples of how these design and planning principles can be implemented. The evaluation phase focuses on the reflection at the basic assumptions, the aims and the hypotheses of this research project with respect to the Network City and its transport system.

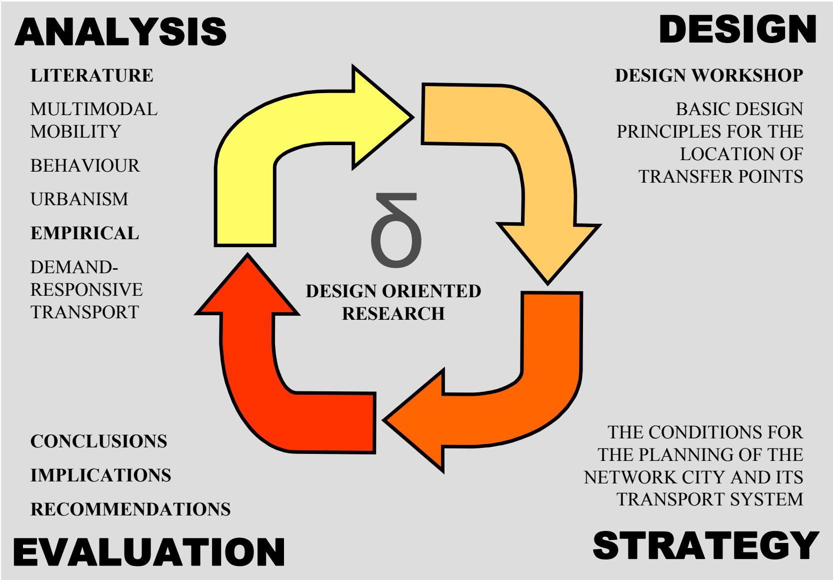


Figure **1.4.2** Planning cycle in thesis context

1.4.4 Research methodology

This thesis is built up out of theoretical (literature) research, empirical research, and research by design. The *theoretical* part of the thesis focuses on literature with respect to (i) sustainable mobility and multimodal transport, (ii) the activity-travel behaviour of people and the concept of action space specifically, and (iii) the Network City. It refers to the first aim of this thesis, as identified in the previous subsection: a conceptual framework for the introduction and adoption of seamless multimodal transport.

The *empirical research* focuses on the introduction of a new demand-responsive transport system in the city of Maastricht, the Netherlands and the role this system plays in the activity-travel behaviour of its users, and so addresses the second aim of this thesis. A Geographical Information System is used in order to analyse and visualise travel patterns of the users of the demand-responsive system.

Finally, the *research by design* part focuses on the location choice process of intermodal transfer points, the third aim of the thesis. Within an expert design workshop context, this design problem has been handled according to the spatial planning cycle. This thesis reflects on the design processes of the workshop, and filters out the most important lessons for this location choice process.

The surplus value of the research methodology applied can be found in the multidimensional way that knowledge can be acquired for recommendations for planning and design. Furthermore, it shows that all kinds of research methods can have a place within the broader research approach of the planning cycle.

1.4.5 Case studies

Two large case studies are presented in this thesis in order to illustrate and verify the hypotheses mentioned earlier above: (1) demand-responsive transport, and (2) the location choice of transfer points. For both case studies the region of Maastricht (figure 1.4.3) is chosen as the research area for both scientific and practical reasons.

Scientifically, the urban planner is given a broader scope looking at the same location from two different perspectives. Moreover and more important, the design process itself gains in

strength by looking from two different perspectives. Thirdly, Maastricht is interesting for its geographical location within the Maastricht - Hasselt - Aachen - Liège (MHAL) region at a rather large distance from the Randstad area. This is especially true for the second case study of the location choice of transfer points: Maastricht is located near two High Speed Train stations (Liège and Aachen), a national motorway crosses the city at street level (A2), and the (historical) city centre suffers quite a lot from the traffic by tourists and other visitors. Also the long distance connection (for both the individual and collective means of transport) to the Randstad area can be discussed.
Practically, a lot of data could relatively easy be acquired from this region. In an early stage of the PhD project, contacts were made with the transport provider of the Maastricht demand-responsive transport system called 'Tailor-Made Maastricht' (TMT). TMT trip data of almost one year was acquired and analysed for the project in the year 2000. In the years 2000 and 2001 the PhD project got also involved in the European research programme MOBILATE[5], which focuses on the outdoor mobility of older people. One of the main topics of the MOBILATE programme is the activity-travel behaviour of the older people from the city of Maastricht and the municipality of Margraten (rural area), the role of the TMT system within their behaviour and the attitudes of people towards this system. The empirical analyses are the focus of the sixth chapter of this thesis. The usefulness and limitations of the case studies are discussed in the introductions of the specific chapters that focus on the case studies.

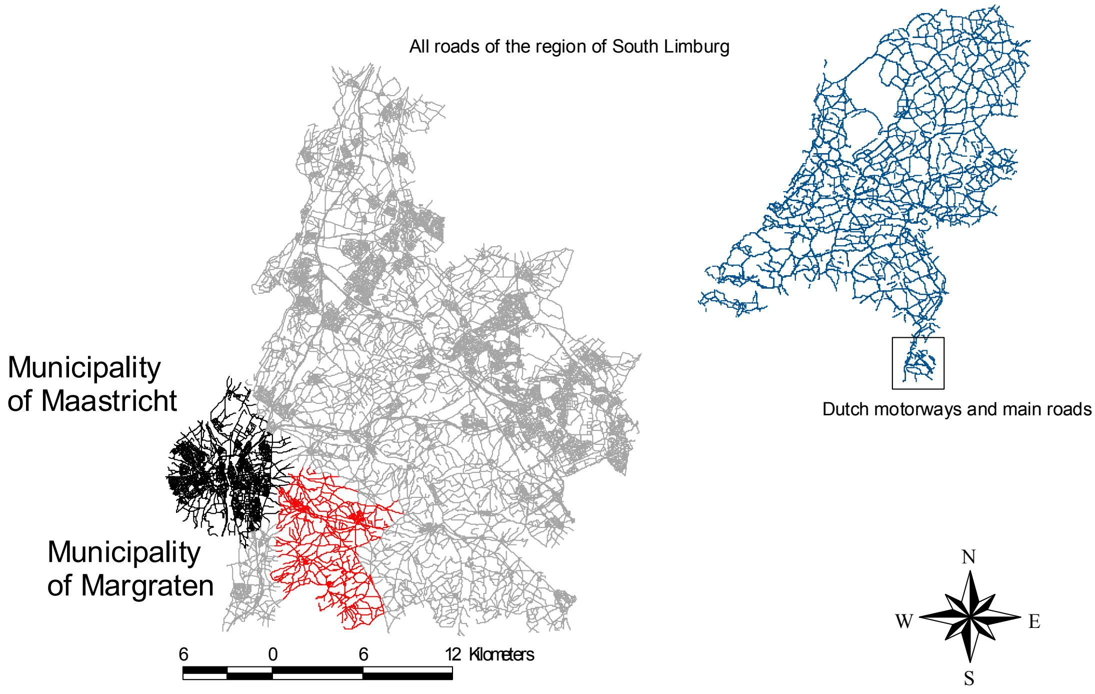


Figure **1.4.3** Maastricht, South-Limburg, the Netherlands

1.4.6 Research claim

Urbanism is a culturally bound profession to a large extent. However, the problems that most cities in developed countries are confronted with, are comparable. Cities are complex interacting systems. So, the problems in cities are by definition complex of nature. Solutions have to be found in (more) integral planning and design approaches. This research looks at the

[5] MOBILATE; this project is sponsored by the European Commission, Project QLRT - 1999- 02236

development and transformation of today's and tomorrow's city from three perspectives (figure 1.4.4):

- **urbanism**: spatial planning and urban design;
- **transport planning**: seamless multimodal mobility;
- **human behaviour**: activity-travel behaviour from a sociological, social-geographical and psychological point of view.

The future can hardly be predicted. But it can be explored by discussing possible futures. Urbanism has a perspective of action (design an planning documents) and therefore this research is δ-oriented, i.e. focusing on design and planning recommendations. With the in-depth, three dimensional, integral perspective and the δ-orientation, this thesis contributes to the domain of urbanism from a point of view that hasn't yet been explored a lot.

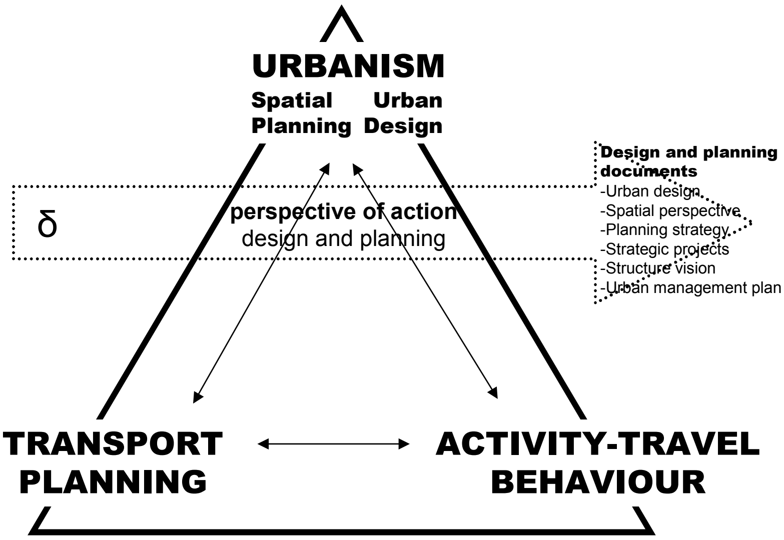
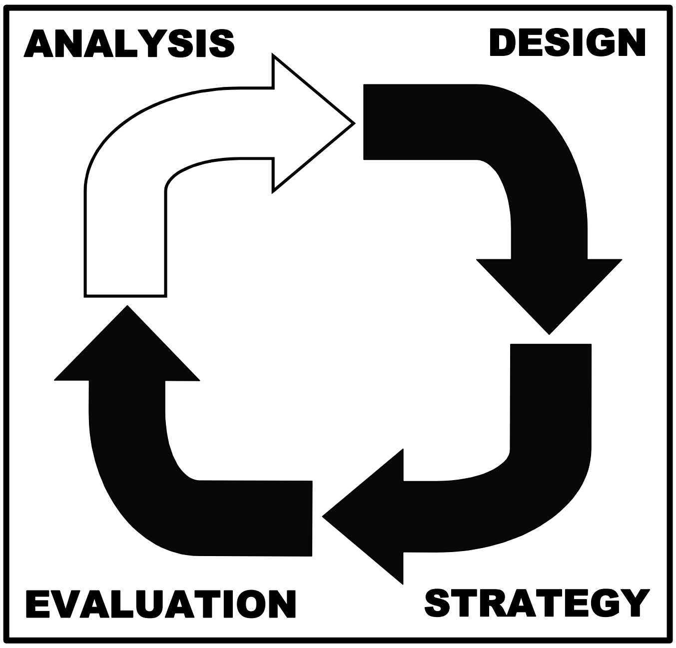


Figure **1.4.4** Research claim

1.5 What follows

The structure of this thesis follows the steps of the spatial planning cycle: analysis-design-strategy-evaluation. Chapters two to eight represent the phase of Analysis: part A. The theoretical oriented chapters of part A focus on *Sustainable transport and chain mobility* (chapter two), *Activity-travel behaviour theories* (chapter three), *Action space* (chapter four), and *The planning of the Network City* (chapter five). Chapter six introduces the location of the case studies, *The city and region of Maastricht*. The empirical oriented chapter seven focuses on *Collective demand-responsive personal transport and the activity-travel behaviour of its users: the elderly*. Chapter eight, the final chapter of the phase of analysis introduces the topic of the planning of the location of transfer points based on literature research.
Chapter nine (Part B) can be seen as the phase of Design. It focuses on *The design workshop* that was organised in order to formulate problems and aims with respect to multimodal transport and the location of transfer points in an interdisciplinary design environment.
Part C, the phase of Strategy, consists of chapter ten *Towards the conditions for the planning and design of The Network City*.
Finally, chapters eleven and twelve *Summary and Conclusions* (chapter twelve in Dutch: *Samenvatting en Conclusies*) can be considered as the phase of Evaluation (part D). Here, we summarise the lessons learned.

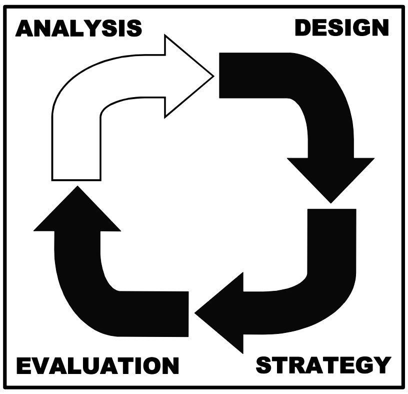
PART A
ANALYSIS



CHAPTER TWO SUSTAINABLE TRANSPORT AND PASSENGER CHAIN MOBILITY

Vitam in peregrinatone exigentibus hoc evenit, ut multa hospitia habeant, nullas amicitias.

You will have a lot of hosts in a lot of places, when you travel all the time and all around the world, but you will not have a lot of friends.
Seneca, Epistulae Morales, no. 2



The previous chapter described the research context and made clear that this PhD thesis balances between the fields of spatial planning, urban design, transport engineering, sociology, and social geography. The objective of this chapter 'Sustainable transport and passenger chain mobility' as a first part of the analysis phase of the planning cycle, is to present what mobility is about and how we can look (from several perspectives) towards the concept of mobility in our society.
Section 2.1 starts with discussing the concept of mobility from its basic definitions, and it ends with presenting how mobility has found its place in our post-modern (Dutch) society and in our (Dutch) system of politics. Section 2.2 broadens the concept of mobility into the concept of sustainable mobility. The third and largest section of this chapter presents the subject of chain mobility for passenger transport, which has attracted quite some political and scientific attention lately in the Netherlands. Finally, this chapter summarises the findings of this chapter briefly.

2.1 Mobility

"…People walk, cycle, drive, go by boat, fly, and they choose between the large supply of travel possibilities time after time. At the beginning of the 21st century, we are more mobile than ever and the growth of mobility has not stopped yet and will not stop for some more time. Besides many advantages, there are also disadvantages. Mobility and transport have large impact on safety and liveability. Just like mobility, safety and liveability contribute to welfare and wellbeing…"
(Ministry of Traffic and Transport, 2000)

"…Our society is characterised by growth. The increasing demand for mobility of persons and goods is part of our social-economic system. And this social-economic system is expanding. Our attitude towards mobility has changed during the last decades. Nowadays, we accept mobility as a part of our existence…"
(Advisory Council for Transport, Infrastructure, and Water Management, 2000)

2.1.1 The notion of mobility

The notion of mobility plays an essential role in several forms of planning. Without any doubt, this notion of mobility can be assigned to the prevailing cultural meaning about processes of change and transition: our (post-)industrial and commercial capitalism is undoubtedly related to the thinking in terms of growth (whether sustainable or not). Up-scaling, differentiation, and specialisation cannot be thought of without the mobilisation of people and environment. In our western culture growth, change, and mobility have become interdependent notions. This strongly anchored pattern of norms and values is shown in the Dutch saying "stilstand is achteruitgang" ("standing still is going backwards").
Bak (1986) identifies five separate forms of mobility: social mobility, economic mobility, spatial mobility, psychological mobility, and informative mobility. Bak argues that spatial mobility is of great significance for spatial planning, because it can be seen as the realisation of all kinds of other types of mobility. But it is not only a one way relation. Spatial mobility has also impact on the development of the other forms of mobility. Therefore, it can be said that these five types of mobility do not have any form of hierarchy, but are interrelated to a large extent. These five notions of mobility are:

Psychological mobility	concerns the human capacity to project oneself in another situation, or to evaluate situations, in which one didn't participate physically.
Informative mobility	concerns the participation in (remote) situations and processes mentally by means of information media such as radio, television, telephone, and Internet, etc.
Social mobility	concerns the processes of changes in distance between the hierarchical levels of profession, education, function, income, and status in a cultural system.
Economic mobility	concerns the optimisation of the relation between utilities and disutilities by means of the re-allocation of the means of production.
Spatial mobility	concerns the change of location physically and the means of changing locations physically of persons, goods, and institutions.

Bak summarises the relations between the five forms of mobility again in five basic notions: substitution, sequence, aggregation, contradiction, and indifference.

Substitution	refers to the substitution of one form of mobility by another. For example, informative mobility can substitute spatial mobility to a certain extent. The use of the Internet for teleworking, teleshopping, teleconferencing, etc. shows how certain physical trips can be substituted.
Sequence	refers to the causal interdependence between two types of mobility. For example, the increase of the informative mobility may result into an increase of the spatial mobility. Easy accessible information about certain (remote) activity places may lead to actual visits.
Aggregation	refers to the strengthening influence of more types of mobility on each other. For example, the increase of the spatial mobility because of the growth of a city, resulting in an increase of the economic and social mobility.
Contradiction	refers to the incompatibility between two or more types of mobility. For example, social mobility could contradict spatial mobility if a person desires a job promotion, but doesn't want to commute farther than before (which would be unavoidable for the new job).
Indifference	refers to the absence of a demonstrable relation between the different types of mobility.

What could be added as sixth notion to this list of relations is the notion of *Generation*, which refers to the process of new and extra mobility. Van Reisen (1997) for example shows in his PhD work how teleworking both substitutes and generates mobility. Time that is not spent on commuting on teleworking days, is used for (i) other travel (other purposes, other motives) on those teleworking days than commuting, and (ii) for larger commuting distances.

Time after time, history has shown that the spatial mobility has to deal with an unsteady equilibrium between travel, transport and traffic needs and travel, transport, and traffic possibilities. This is what the urban planner and designer experiences every day, because (s)he is confronted in one way or another with spatial mobility as a condition for the urban plan or design. Unexpected side-effects will follow if these spatial mobility conditions are not taken into account. Section 2.1.3 will elaborate some more on these conditions, considering mobility as a market system.

When this book refers to mobility as a notion, it implicitly refers to spatial mobility. However, the other forms of mobility and the relations between them always play a role in the background.

2.1.2 Mobility in a post-modern society

A number of philosophers have been discussing the notion of mobility lately and more specific the notion that could be called 'post-modern forms of mobility' (Baaijens et al., 1997). One of the main themes discussed is the separation of time and space due to world-wide transport, computer, information and communication networks, such as the Internet. Well-known geographical notions such as the centre and the periphery are not that significant and meaningful anymore as they used to be. No longer the linear movement from A to B is important, but the -more or less- permanent participation of people in extensive networks of

movements. In this context Castells (1991) refers to the transition of a *sense of place* towards a *sense of flow*.
Also the perception of time seems to alienate from the linear concept. The necessity of the tuning of a growing number of occasions more accurate and over longer distances, have resulted in something that could be called the *condensing of time* (Baaijens, et al., 1997).
Couclelis (1999) situates the time-space developments mentioned in a time-space matrix (table 2.1.1). She shows that in earlier times most activities were bound to one place and one point of time. Some activities are still under these strict conditions of time and space, but many other are not any more. A growing number of activities have become, are becoming, or will be becoming more *footloose* and/or *timeloose*.
Therefore, Couclelis comes to the conclusion that 'It is not distance that is dead. It is activity that is disintegrating'. Her hypotheses about the reasons of the ever lasting growing demand for travel and transport lies in this *fragmentation of activity*. She says that 'the goal of transportation therefore has changed from meeting *mobility demands* into meeting *accessibility demands*. And with respect to sustainability, the goal of transportation has changed or should change into meeting *reasonable* accessibility demands.' Who will decide on what should be considered to be reasonable, has become and/or will become the big question for the post-modern governments and societies that strive for sustainability (see also section 2.2).

Table **2.1.1** Time-space matrix

TIME LOCATION	One time	Alternate	Sequential	Fragmented	Any time
Localised					
Alternate					
Linear sequence					
Distributed					
Ubiquitous					

source: Couclelis, 2000

2.1.3 Mobility seen as three different markets

Following Van de Riet (1997, 1998a, 1998b) the transport system can be considered to be a market: a system with dynamic interaction between demand and supply. In this interaction, implicit and explicit choices are made on both the demand side and the supply side. These choices interact. The result of the interaction is three-fold: a realised supply, a realised demand, and an allocation of the demand to the supply. Three submarkets can be distinguished in the transport system: *a movement market*, *a transport market*, and *a traffic market*. Each subsystem has its own supply and demand sides (figure 2.1.1 refers).
In the movement market, the demand side consists of the activities to be performed about which the locations and points of time are unknown. The supply side consists of the (perceived) spatial and temporal distribution of the locations where the activities could be performed, and the movements associated with these activities. The outcome of this market consists of a set of movement patterns: an allocation of the activities to time and location.
In the transport market, the demand side consists of the demand for vehicles in order to transport people and goods: the movement patterns. The supply side consists of the (perceived) available supply of vehicles and services to accommodate these movements (specified according to place and time). The output of this market consists of a set of transport patterns: an allocation of the movements to the transport vehicles and services.
In the traffic market, the demand side consists of the demand for infrastructure to accommodate the vehicles and services: the transport patterns. The supply side of the traffic market consists of the (perceived) available infrastructure and its attributes. The output of the

traffic market consists of a set of realised traffic patterns: an allocation of the transport vehicles and services to the infrastructure.

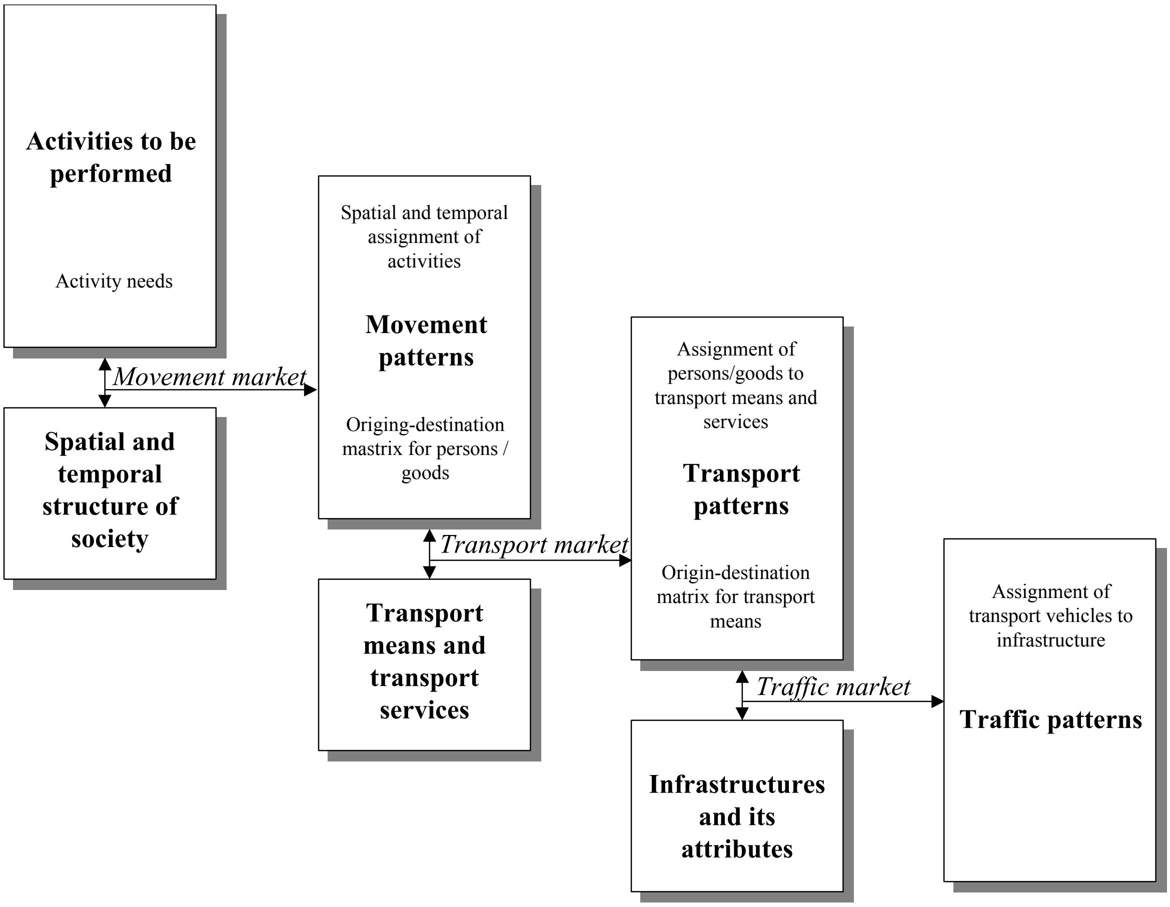


Figure **2.1.1** Mobility and its markets
Source: Van de Riet, 1998a

The power of the scheme presented and discussed here is the overall framework related to mobility in its broadest sense, which can give each mobility sub-item a position within the whole. The last decades, policy issues in the (Dutch) field of spatial and transport planning have become so broadly oriented, diversified, and complex, that there was an increasing need for such a shared framework of reference. An integral system description of the policy field of transport that could integrate the currently dispersed ways of thinking, and that can be used to show the links and differences among new transport concepts and policy options. The next subsection discusses some of those policy options, the main lines of Dutch mobility politics.

2.1.4 Mobility policies in the Netherlands

Policies on mobility are the main concern of the spatial tripod of Dutch politics: the Ministry of Transport, the Ministry of Housing, Spatial Planning, and Environment, and the Ministry of Economic Affairs. At the end of the 20th and the beginning of the 21st century these three Ministries all have produced national policy documents related to spatial planning and mobility. Furthermore, European mobility politics more and more condition national politics. We will discuss a few important (inter)national policy documents and the reactions of society towards the policy documents in more detail.

From A to Better: National Traffic and Transport Plan 2001-2020

In 2000, the Ministry of Transport published the National Traffic and Transport Plan 2001-2020 (part 1, Policy intention), the new follow-up of the Structure scheme Traffic and Transport II (SVVII, 1990). The main focus of this new document is on accessibility, safety, liveability, and technology and innovation. With respect to accessibility the Ministry aims at accommodating the needs for mobility and transport by investments in infrastructure, mobility management, and public transport. With respect to safety the Ministry aims at reducing the traffic casualties with 25% in 2010. As liveability is concerned, the Ministry wants the Netherlands to be the top in the world in the fields of ecology and environment. Finally, technology and innovation are seen as facilitators for the realisation of the many ambitions within the field of traffic and transport.

The advisory Council for Transport, Infrastructure, and Water Management (2000) concludes in its advise on the National Traffic and Transport Plan that the policy document lacks a clear integral spatial picture. It recommends the Ministry to (i) focus more on integrality and cohesion in (all kinds of) spatial policies, (ii) improve the managerial and political organisation of traffic and transport (decentralisation), and (iii) embed the forces of the market more consequently in the traffic and transport system. Discussing the integral spatial policies, the Council refers to the 5th National Policy Document on Spatial Planning, with which the National Traffic and Transport Plan should have many links.

5th National Policy Document on Spatial Planning

In 2001, the Ministry of Housing, Spatial Planning, and Environment published the 5th Document on Spatial Planning (part 1, Policy intention), the follow up of both the Fourth Document (1988) and the Fourth Document Extra (1991) on Spatial Planning.

At an earlier stage, the advisory Council for Housing, Spatial Planning, and Environment published a document on mobility in 1999, in which the Council reflects on the possible contributions of the traffic and transport sector towards the fields of ecology and spatial planning. One of the most important recommendations of the Council argues that "the spatial planning policies should no longer be held and made responsible for the national traffic and transport aims for quantity reductions, such as the diminishing of national emissions, and a modal shift on a national level." It is said that "…in the past, general spatial planning concepts such as the compact city have had insufficient effect on these kinds of targets...". However, it is also noted that "…spatial planning policies do have significant meaning for improving the liveability and accessibility at a regional and local level…". Moreover, this Council also gives clear recommendations for a strong cohesion between the 5th National Policy Document on Spatial Planning and the National Traffic and Transport Plan.

With respect to personal transport the 5th National Policy Document on Spatial Planning focuses at so-called "urban networks". Urban networks are defined here as "…strongly urbanised zones that consist of a network of larger and smaller compact cities that each have an own character and profile within this network…". The main political aim is to manage the processes of the urban networks in such a way that the urbanised areas grow into a number of highly connected, yet clearly distinghuisable urban nodes, with open spaces in between.

The 5th Document takes into account "…that the mobility of people will increase", but it wants to "…reduce negative effects." Furthermore the 5th Document argues that "…within cities and in between, public transport plays a significant role in the modal split. The regional level (of urban networks) offers opportunities to increase the role of public transport. New and existing public transport systems of different spatial levels will be connected. The improvement of the quality of public transport has priority. Furthermore, we also aim for a good (external) accessibility by car and better transfer possibilities between car and public transport."

National Spatial-Economic Politics. Dynamics in networks.

In 1999, the Ministry of Economic Affairs published the National Document on Spatial-Economic Politics. The main focus of the document is that for an active economic policy with great challenges for the future, co-operation is needed in order to establish excellent business location characteristics. In relation to mobility, the main focus is on spatial economic networks. It is said that "…some economic activities concentrate in cities. Other economic activities however, move to city edges or to the economic development axes between cities. This spatial dynamics has resulted in a spatial-economic network of economic nodes, such as cities and mainports…". "…At a regional level this development results in network cities…". One of the most essential business characteristics is the physical and virtual accessibility of the nodes in the spatial economic networks.

EU transport policies

This subsection has dealt so far with national mobility policies. However, it has become clear that European mobility policies will be increasingly important for the individual European nations and their national transport policies. In the White Paper of the Commission of the European Communities (2001) it is stated that "a large number of political measures and instruments will be needed to launch the process which, over the next 30 years, will lead to the kind of sustainable transport system we might hope to achieve." Furthermore, it is said that this common transport policy to the requirements of sustainable development cannot be adapted unless a number of problems can be rapidly resolved, among others:

- an adequate funding of the infrastructure needed to eliminate bottlenecks and to link the Community's outlying regions to its central regions. Creation of the Trans European Network remains one of the preconditions for the rebalancing of transport modes. That is why it is fundamentally important that external costs, and in particular environmental costs, be internalised into the infrastructure charges that all users will have to pay.
- Satisfying the needs of users who, in return for the increasingly high costs of mobility, are entitled to expect a quality service and full respect for their rights, irrespective of whether the service is provided by public enterprises or by private companies; this will make it possible to place the user at the heart of transport organisation.

In all national policy documents and the EU White Paper both the positive and negative (direct and indirect) aspects of mobility are discussed intensively. The discussions on the physical aspects concentrate on the themes *networks*, *(multimodal) accessibility*, and *liveability*. One of the most important assumptions for the national policy documents is that sustainable growth –but growth!- is necessary in order to improve the spatial quality of the Netherlands. The next section elaborates on this issue of sustainability, and more specifically on sustainable mobility.

The procedures of national documents in order to become national policy consist of four steps: [1] policy intention, [2] advise, [3] cabinet standpoint, [4] planning decision. Each step needs the agreement of the Parliament. Both the National Traffic and Transport Plan 2001-2020 and the 5th National Policy Document on Spatial Planning have met procedure problems; certain steps of the plans were not accepted by the Parliament, resulting in a standstill that delays policy implementation drastically. In 2004 both ministries present new policy documents; National Policy Document on Space ('nota Ruimte') and National Policy Document on Mobility ('nota Mobiliteit'). The most important changes relate to the shift from conditional planning (green and red contours) towards *development planning* (actor involvement at lowest spatial levels), as far as the spatial planning document is concerned. For the mobility policy, the main focus is directed at the *reliability* of the transport system, from door-to-door and within the societal conditions with respect to safety and the quality of the environment.

2.2 Sustainable mobility

The notion of sustainability was brought under world-wide attention in 1987 by the United Nations report 'Our common future' that was issued by a special UN commission. This commission consisted of individuals from both 'developed' and 'third world' countries. 'Our common future' is also often referred to as the 'Brundtland report' after the commission's chairwoman, the former Prime Minister of Norway, Mrs. Gro Harlem Brundtland. The Brundtland commission defined a sustainable development as *a development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs* (WCED, 1987).
In the Dutch context, the national policies are aimed at a sustainable economic growth (Ministry of Economic Affairs, et al., 1997): an absolute disconnection of environmental pressure and economic growth. Economic growth, both the improvement of the competitive power within the international field and the increase of employment, should be joined by (i) a better management of space, nature, and biodiversity, (ii) the diminishing of environmental pressure, and (iii) a reasonable reduction of the use of fossil fuels and non-renewable stocks.

The notion of sustainable development doesn't have an unambiguous and clear cut meaning, because it stands for a *process of change*. A process that harmonises the exploiting of resources, the direction of investments, the orientation of technological developments, and institutional changes. Moreover, it stands for fulfilling and enlarging the needs and aspirations of both present and future generations. Therefore, it can be said that a sustainable development refers to the interactions between the ecological, the economic, and the social-cultural system, the three dimensions of sustainability (RMNO, 1990).

2.2.1 Sustainable transport in a spatial perspective

Baggen (1994) states in his PhD research that we can talk about sustainable transport, if the mobility developments meet the same conditions as sustainable developments in general, that is the fulfilment of mobility needs and aspirations of the present generation without jeopardising the fulfilment of mobility needs and aspirations of future generations. However, in a *spatial* context a sustainable development should not only be related to mobility issues; it should at least also concern the urban structure and the ecological structure. It is important that a sustainable mobility policy is weighed against and most favourably in line with sustainability policies in other fields than mobility. Mobility stands at the crossing point of two areas of tension:

- the area of tension between liveability and accessibility (more general: between ecology and economy); and
- the area of tension between the interaction between spatial developments, development in transport systems, and the developments in the activity-travel patterns of people.

Liveability and accessibility: ecology and economy

Mobility is both a result and a condition for social-economic developments, but it is at the same time a threat for those developments. Mobility is in the centre of conflicts between the two fields of ecology and economy: the economy has its (accessibility) *demands* for the mobility system that is inextricably linked to that same economic system, while on the other hand the ecological system directly experiences the (liveability) *consequences* of mobility.

Spatial developments, developments in transport systems, and developments in activity-travel patterns

Following Binsbergen and Bovy (1996), figure 2.2.1 shows the relations between the spatial structure, the transport system, and the activity-travel patterns of people. Economic growth (external factor) increases the demand for interaction between people and thus influences the activity patterns of people. How this desire for interaction is fulfilled -virtually or physically- is expressed in the desired/actual travel pattern. Transport providers will 'listen' to this demand of transport and possibly change their transport services. On the other hand, (new) transport systems open up the scope for new or other travel patterns, which might result into changed or changing spatial structures.

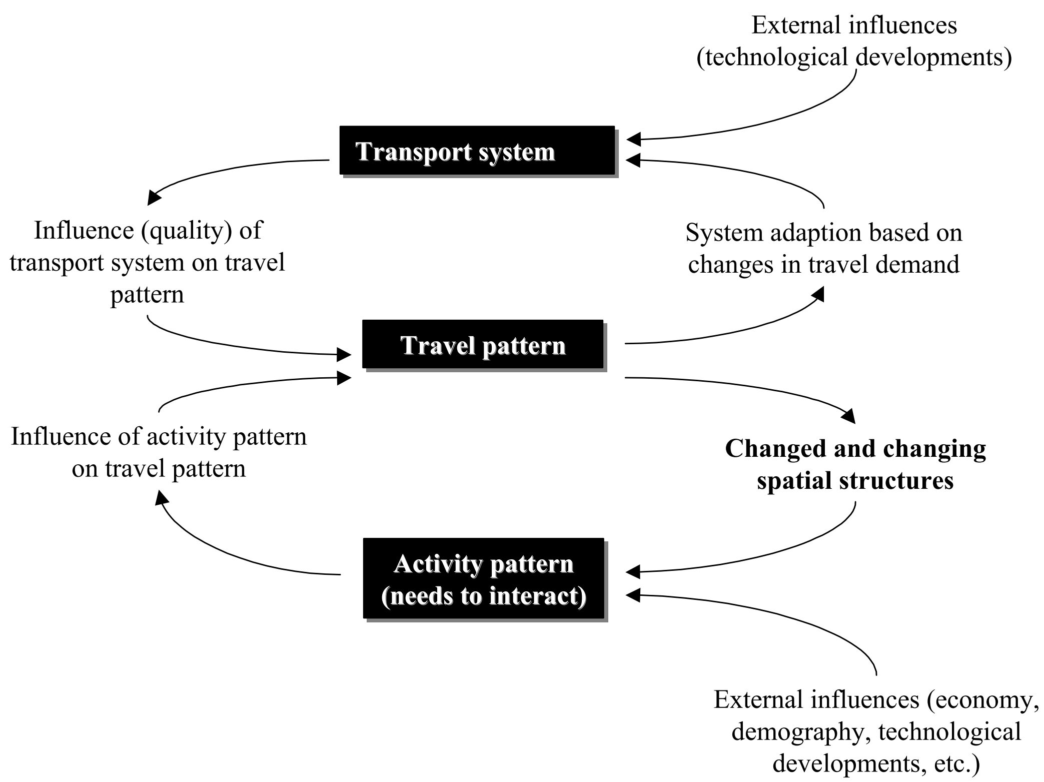


Figure **2.2.1** Spatial structure, transport system, and activity-travel patterns of people

The example of the rise of the car as territorial adapter (Dupuy, 1995) illustrates these processes precisely. The car system opened up the possibilities for criss-cross travel patterns and can thus be seen as conditioning and structuring for the processes of suburbanisation. A specific spatial structure with a specific allocation of urban functions at (geographical) locations may lead to alternative options for people in order to participate in activities at different locations.

2.2.2 Mobility freedom and mobility equity as sustainable guideline

Sustainable development is for spatial planning what preventive medicines are for one's health: an approach that rather likes to anticipate than to react. A sustainable development takes into account the freedom and equity of options in different generations. But a sustainable development also takes into account the freedom and equity of option within a certain generation (Litman, 1999). In the Dutch Fourth National Document on the Spatial Planning (1988) it was already said that '…citizens and government should take care that (…) certain groups will not get spatially isolated in our society involuntarily.'
Some groups in our society like older people and disabled people do not have had such an increase of mobility the last decades as other groups in society. This problem of the so called 'mobility disadvantaged' raises the question about the importance of the equity aims in transport policies (Louw, et al., 1991). Whether and to what extent a certain degree of manipulation of mobility patterns is desirable depends on the vision on humans and society. After all, it depends all on how one evaluates the essence of spatial mobility for the societal organisation and the human self-realisation.

2.2.3 Sustainability and seamless multimodal mobility

The societal debate on sustainable mobility in the Netherlands is aimed at issues such as energy consumption, emissions, noise, stench, accessibility, congestion, the price of mobility, space consumption of infrastructure and vehicles, traffic safety, and technology and innovation (Ministry of Transport, 2000). All issues have an ecological, economic, and a social-cultural component.
Seamless Multimodal Mobility (SMM) is considered to be a possible solution for some of those problem fields (Bovy, 2002; Van Wee, 2002). First of all, it is discussed as a congestion and space consumption mitigation strategy, and as a strategy to increase the liveability of cities and city centres, and to increase the multimodal accessibility of activity places. Furthermore, a proper hierarchy in the multimodal network with seamless (in both time and space) transfer points might result in optimal conditions for a vital city (Rooij, 1999). It is suggested in the TRAIL research program that '…seamless multimodal trip chaining at regional scale could be the answer to growing restrictions in using the car for personal travel. Sophisticated information and communication technologies as well as real-time transport process control could offer the means for effective and efficient multimodal transport services exhibiting an unprecedented high level of quality able to compete with the car…' (TRAIL, 1999).

2.3 Passenger chain mobility

In contrast to *unimodal transport*, which refers to trips made with one mode of transport, the term *chain mobility* or *multimodal transport* is a concept that refers to the combination of several (collective and/or individual) transport modes in order to travel from an origin (activity place A) to a destination (activity place B) (TRAIL, 1999, Ministry of Traffic and Transport, 1998). Therefore, a multimodal trip is defined as a trip, in which different transport modes (or services) are used resulting in a physical transfer during the trip.
Supported by high-tech information and communication technologies, the traveller can compose and direct his own trips by combining several separate transport modes within one trip. On the other hand, the traveller may also order a multimodal door-to-door trip. In this concept a chain conductor could be responsible for the perfect connection between trains, buses, taxis, automated guided vehicles etc.

The Dutch Advisory Council for Traffic and Transport (2002) conducted a research programme on today's (and the future) market for multimodal transport. Interesting conclusions were drawn with respect to the following topics:

- **The present market of multimodal transport**: about 3% of all trips can be considered multimodal. The most important main modes of transport in multimodal trips are the train (59%), bus/tram/metro (21%), and the car (14%). The most important access and egress modes of transport are the bicycle and the bus. Although the number of taxi trips is relatively limited, the taxi is used quite a lot as access/egress mode: 19% of all taxi rides have their origin or destination at a railways station. In most national travel behaviour statistics, walking is not separately considered as an access or egress mode, rightly or wrongly.
- **The multimodal traveller**: most multimodal trips have the motive work or education (53%). For all trips (both unimodal and multimodal) this is 22%. People between 15 and 25 travel multimodally quite a lot: 39% of all multimodal trips are made by this group, compared to 16% for all trips. Partly this can be explained by the fact that this group has relatively often no car available as alternative.
- **Time and space**: multimodal travelling takes places mainly during the peak hours and on working days, over distances longer than 10 kilometres and between (large) urban areas; 38% of all multimodal trips in The Netherlands have their origins in one of the four largest cities (Amsterdam, Rotterdam, The Hague, Utrecht).

When could multimodal transport be attractive?

Unimodal transport has always been and most probably will be attractive for short-distance trips or for trips where origins and/or destinations are not located near any intermodal transfer points. Table 2.3.1 presents the average number of trips per person per day of the Dutch population in 2001 (100% = 3,07 trips per person per day) and shows that on average 60% of all trips are shorter than 5 kilometres, and 75% shorter than 10 kilometres. The slow modes bike/moped and walking attract 45% of all trips made. 80% of the public transport trips are longer than 5 kilometres.

Table **2.3.1** Average number of trips per person per day in percentages

	Car	Public Transport	Bike/moped	Walking	Total
0.0 – 0.5 km	0.3%	0.0%	1.3%	6.2%	7.8%
0.5 – 1.0 km	1.6%	0.0%	3.6%	6.2%	11.4%
1.0 – 2.5 km	8.1%	0.3%	11.4%	5.2%	25.0%
2.5 – 5.0 km	8.5%	0.6%	5.2%	1.0%	15.3%
> 5.0 km	30.0%	4.0%	5.2%	0.3%	39.5%
total	1.49 48.5%	0.15 4.9%	0.82 26.7%	0.57 18.6%	3.07 100% (other included)

Source: CBS, 2002

In general, transferring from one mode of transport to another is only attractive if the trip travel time, the trip travel costs, and/or the service (during the trip) outweigh the loss of time and comfort that takes place during the process of the transfer. Multimodal transport has especially potential for success in the long-distance trips between urban conurbations. From research in the Netherlands (Advisory Council for Traffic and Transport, 2003; Goeverden and Van Nes, 2000) we know that nowadays multimodal transport has a small share of all trips, nearly 3%. This share increases if typical trip types are considered, for instance, 20% of all interurban trips to the main cities in the Netherlands, or 80% of all train trips (tables 2.3.2 and 2.3.3).

Table **2.3.2** Percentage unimodal and multimodal trips

Main transport mode	1985 - 1987		1995 - 1997	
	Unimodal	Multimodal	Unimodal	Multimodal
Car driver	34.0	0.1	36.0	0.2
Car passenger	13.6	0.2	12.9	0.2
Train	0.3	1.1	0.4	1.7
Tram/metro	0.7	0.2	0.7	0.2
Bus	2.0	0.4	1.6	0.4
Bike	27.3	0.0	27.5	0.0
Walking	17.5	0.1	15.9	0.1
Other	2.2	0.0	2.1	0.0
All transport modes	97.7	2.3	97.1	2.9

source: Goeverden and Van Nes, 2000

Table **2.3.3** Distribution type of relation of multimodal trips in percentages

	1985 - 1987		1995 - 1997	
	Share of type of relation	Share multimodal per type	Share of type of relation	Share multimodal per type
Total	100.0	2.3	100.0	2.9
To 4 large cities	14.4	5.6	13.5	6.6
Interurban	28.1	6.3	31.2	7.9
Interurban and towards large cities	2.8	16.8	3.2	20.5

source: Goeverden en Van Nes, 2000

The research shown here refers to national oriented numbers based on the Dutch National Travel Survey. Of course, multimodal travelling can be and certainly is very competitive at the international and intercontinental spatial level. Unfortunately, there is little in depth research available about internationally oriented activity-travel behaviour. It can however be expected that in the future travelling at those larger distances will take place more frequently than today and that (thus) the share of multimodal travelling (train-airplane-taxi, or car-airplane-rented car, etc.) will grow because of the globalisation of activity patterns.
The total (multimodal) transport system is built up out of all kinds of subsystems and services. The next five subsections discuss the main elements of the multimodal system briefly: the collective transport systems, the individual transport systems, the slow travel modes, demand-responsive systems, and the intermodal transfer points. They also refer to literature that goes into more detail on these specific topics.

2.3.1 Collective transport systems

Collective ways of transport are characterised by the bundling of travel demand (Egeter et al., 1990). The supply of transport doesn't cover every thinkable travel need, but meets 'the common denominator'. Bundling can take place at three levels:

- bundling of access or egress points: the stops;
- bundling of transport relations: the lines;

☞ bundling in time: the timetable or travel planning.

The principle of bundling implies that the networks of the collective modes of transport are aimed at concentrations of living areas, working areas, and/or urban facilities. Collective means of transport can only produce sufficient quality if there is coherence between the spatial structure and the network structure.

The networks of collective public transport are traditionally oriented radially. Collective (public) transport is thus very appropriate for trips from centre to centre. Nowadays, tangential relations are also very important besides the centrally oriented relations, because in the last decades a large number of activities have moved from the centre to the edges of the city: the suburbanisation of housing and working. The public transport system has been unable to cope with this spatial trend sufficiently.

When the quality of public transport is looked at, several aspects have to be distinguished (table 2.3.4) (Stoelinga, 1998). It should not be forgotten that it is impossible to optimise all quality aspects in one transport subsystem, because of the fact that the combination of some aspects results in contradictory design demands.

In the collective public transport system we can differentiate between the availability of transport supply. We can identify (i) a basic system, that offers everyone a certain level of travel possibilities (always and everywhere), and (ii) additional services that are aimed at specific target groups (the availability depends on the characteristics of that target group).

Table **2.3.4** Quality aspects of public transport

Aspect	
Travel speed	Depends on driving time, distance, waiting time, transfer time, egress time, and excess time.
Reliability	Objective and subjective.
Availability in place	Walking distances towards transfer points and walking distances within a transfer point.
Availability in time	Frequency.
Comfort	In the vehicle and within the transfer point.
Fare system	Multimobility credit card or cash?
Information provision	Multimodal, up-to-date, dynamic, omni-present
Accessibility	For the less mobile. For a faster traffic flow.
Safety	Objective and subjective.
Image	Public transport should be internalised in daily life.

Source: Stoelinga, 1998

Connecting and feeder systems

Two quality aspects that cannot be realised in the same subsystem are availability in time and availability in space. A good availability in space results in a network with a high stop density, and thus offers lower travel speeds, especially on larger distances.

For connecting systems, high travel speeds have priority. These subsystems are primarily focused on the bridging of distances. Stop and transfer point densities are determined by the speed function. Routes have a stretched character. The location of stops / transfer points are determined by the concentrations of housing, working, and facilities.

For feeder systems, the most dominant quality aspect is the availability in space. These kinds of subsystems focus on the opening up of an area. Stop and transfer point densities are determined by the criterion of walking distances, which results in relatively low travel speeds.

Spatial level

The transport market distinguishes transport subsystems that each operate on their own spatial level (table 2.3.5) (Advisory Council for Transport, Infrastructure, and Water Management, 1996). The average speed and the transfer point or stop distance determine the travel distances for which the specific transport subsystem comes into consideration. However, a specific subsystem that is ideal for a certain distance class, could also fulfil travel needs for somewhat shorter and somewhat longer distances. This means that for certain travel distances, there are two appropriate systems (figure 2.3.1). We can speak about competitive subsystems.

Table **2.3.5** Collective transport and spatial level

	Travel distance	Stop distance	Travel speed
Intercontinental	1,000 + km	450+ km	180+ km/h
International Plane, high-speed train	300 – 1,000 km	150 km	150 km/h
National Intercity train	100 – 300 km	50 km	120 km/h
Interregional Fast train	30 – 100 km	15 km	90 km/h
Regional Stoptrain, light rail	10 – 30 km	2 km	60 km/h
Agglomeration Metro, fast tram	3 – 10 km	800 – 1,000 m	30 km/h
Local Bus, tram	1 – 3 km	300 m	20 km/h

Source: Advisory Council for Transport, Infrastructure, and Water Management, 1996

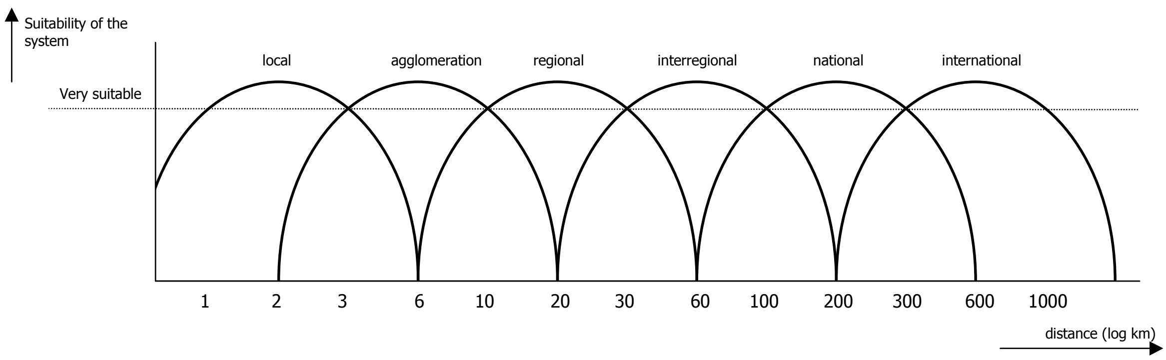


Figure **2.3.1** Overlap collective transport systems
Source: Brand-Van Tuijn and Govers

2.3.2 Individual transport systems

There is a fundamental difference between collective transport and individual transport. When a transport operator plans a collective transport system, he plans both the infrastructure and the vehicles. For individual transport systems, the planning is only focused at the infrastructure: the urban street and road network, the motorway network, the bicycle network, etc. It is beyond the scope and range of influence of the planner of traffic facilities how these individual networks are actually used by individual vehicles and travellers.

The second difference is related to the difference in network structure. Individual systems perform best if travel flows are spread. This -in combination with the necessity to avoid interlocal traffic travelling through urban areas- has lead to a tangential structure of the main road network in the Netherlands. The motorways and other interlocal main roads do not go from city centre to city centre, but go along the edges of urban areas. In this way, only car traffic that has its origin and/or destination within a city, travels on urban road networks.
Looking at the differences of the structure of the collective transport networks and the structure of individual transport networks, it is not hard to understand that spatial planning has been directed at the network structure of the car system, with an increasing importance of and dependence on the car. This resulted into the development of many residential areas and business areas at locations that are not suited very well for public transport.
The structure of the road network can be considered to be good, if the location of a road is derived from the function of that road (De Jong and Paasman, 1998). This functional classification leads to a hierarchical structure of the roads with an increasing feeder function and a decreasing connector function (table 2.3.6).

Table **2.3.6** Car system and spatial level

Hierarchy	Density [km/km2]	Ramp every
National motorway	0.02	30 km
Regional motorway	0.07	10 km
Local motorway	0.20	3 km
City (district)road	0.70	1 km
Neighbourhood road	2.00	300 m
Street	7.00	100m

Source: De Jong and Paasman (1998)

2.3.3 Slow travel modes

Slow travel modes play an important role in the Netherlands for the short travel distances (figure 2.3.2, table 2.3.1). About one out of three to four trips are made by bike or moped (CBS, 2002), which results in 14.4 billion biked travel kilometres by the Dutch population in 2001. The number of walking kilometres has been rather stable the last decades: about 3.5 billion kilometres in 2001. By the way, when we speak of a trip, walking as access and/or egress mode is not considered to be a separate travel mode. Therefore, the Dutch pedestrian union rightly claims much more walking kilometres in the national travel statistics than presented by the Central Bureau for Statistics. In national statistics, trips such as walking-car-walking, or walking-bus-walking are referred to as unimodal.

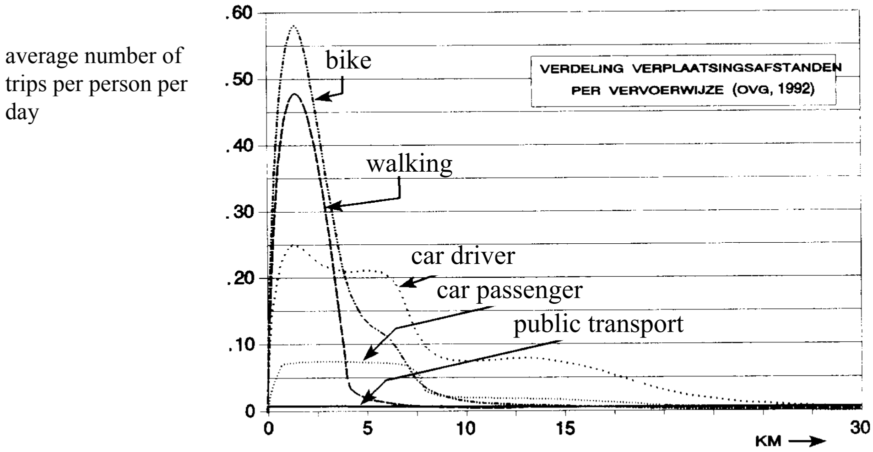


Figure **2.3.2** Distribution of travel distances per travel mode (National Travel Survey, 1992) Source: Bovy, 1995

Slow travel modes mean proximity

In order to understand the position of the slow travel modes in the Dutch situation, we should always keep in mind the ratio of slow mode kilometres travelled, car kilometres travelled, and public transport kilometres travelled. There is an evident relation between travel distance and travel mode. In general, faster modes of transport are used when distance increase. However, it is worth notifying that the car is used a lot for all distance classes, even for trips shorter than 2.5 kilometres (almost half of all trips made is shorter than 2.5 kilometres) (see table 2.3.1).

In a study, specifically aimed at the use of the bicycle, the Project Bureau for Integral Traffic and Transport Studies (1998b) concludes from their data that for distances up to 2.5 kilometres, the bicycle is used twice as often as the car (table 2.3.7). For distances between 2.5 and 5.0 kilometres, the bike and car are used about the same. For distances between 5.0 and 7.5 kilometres, the car is used twice as often as the bike. For distances over 7.5 kilometres, the share of bike trips is getting marginal. Public transport comes into the picture at distances over 7.5 kilometres.

The distances of 5.0 and 7.5 kilometres can thus be seen as a reasonable limit for cycling. So, there is still a large potential for the bicycle in the present travel pattern, when we consider the fact that most trips take place at distances shorter than 5.0 kilometres and that the car is used quite intensively for this distance class.

Table **2.3.7** Distribution of number of trips per person per day (in percentages) for the main means of transport and in distance classes

Travel distance	Car	Public transport	Bicycle	Walking	Total
0.0 – 2.5 km	22	1	40	37	100 = 45%
2.5 – 5.0 km	50	3	40	7	100 = 16%
5.0 – 7.5 km	64	5	26	5	100 = 11%
> 7.5 km	75	11	7	0	100 = 28%
Total	46%	5%	29%	18%	100%

Source: PbIVVS, 1998b

2.3.4 Demand-responsive transport systems

In the description of the desired SMM system (TRAIL, 1999) a lot of attention is given to demand-responsive transport systems and services. Theoretically, demand-responsive travel

services can be distinguished from private travel services and fixed travel services (figure 2.3.3). In the set of private services no market system is involved. When –for example- a group of neighbours decide to travel together or to share the use of a car, the trips made can be identified as private services between the neighbours. When one person fulfils his desire for travel by making a trip all alone in a private vehicle it is said that ‘the traveller provides himself with a travel service’.
A person can also look at the transport market for an external service provider, who can fulfil his travel demand. Collective means of transport search for an optimum service level that is related to *implicit* travel demands. The explicit travel desire from an individual traveller (‘I want to travel from origin A to destination B at a particular point of time X’) is only known by the traveller himself; certainly not by the collective transport provider. These kinds of services are fixed during a rather long period of time. Long before a traveller has decided to look at the transport market for a service provider, these kinds of services have already been decided on (stops, network, time-schedule, route, vehicle, etc.).
The second kind of commercial services, the demand-responsive services, refer to *explicit* travel demands and have a certain degree of time-space flexibility. This service is a tailor-made product and takes into account the (personal) wishes of the client. Flexibility can be found in the type of used equipment, the routes, the stops, and the point of travel time. Therefore, a ***demand-responsive travel service can be defined as the commercial supply of a travel service directly referring to an explicit demand of a client, the traveller.***

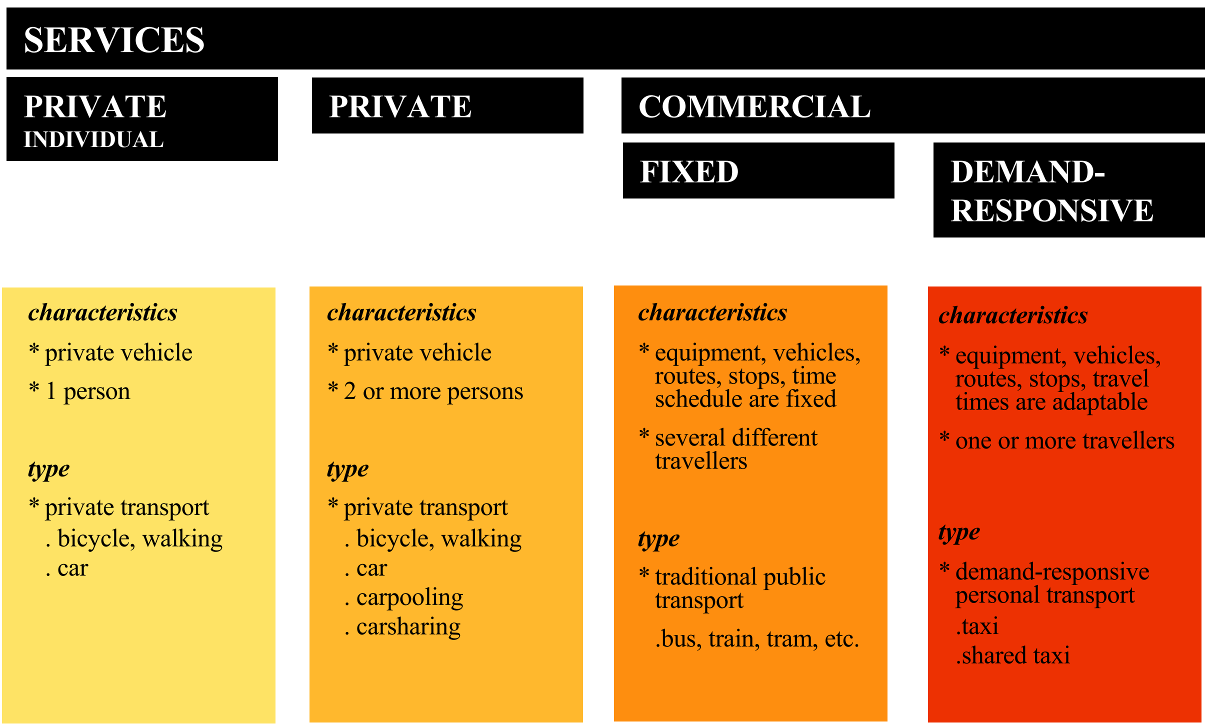


Figure **2.3.3** Travel services

In chapter seven, this thesis focuses on (i) the collective demand-responsive personal transport system of the city of Maastricht in the Netherlands and (ii) the role it plays within the travel behaviour of its users, mainly older people. The role these kinds of shared taxi systems, but also demand-responsive transport systems more generally, should and could play within the multimodal transport system as a whole, is still discussed among many transport experts (AVV, 2000a; Diepens, 1999; Van Nes, 1999):

- demand-responsive shared taxi systems as feeder systems of higher order transport systems such as the train;
- demand-responsive shared taxi systems purely as closed systems, only for certain user groups (disabled, elderly) in order to improve their integration in society;
- demand-responsive transport as a system that could easily adopt the criss-cross travel patterns;
- demand-responsive transport as a system with a high degree of flexibility for accessing the transport network both in time and space.

By analysing the Maastricht demand-responsive transport system from a users' point of view, this thesis gives a scientific contribution to this specific discussion on these potential and/or actual characteristics of demand-responsive transport.

2.3.5 Access points and transfer points

In a transport system, not only the subsystems are of importance, but also the access points to the subsystems and the transfer points between the subsystems. In describing the kinds of access points and transfer points, we elaborate on the definitions of Connekt (1999).

Access points and transfer points offer possibilities to access a certain subsystem and to transfer between the subsystems. In principal, a traveller reaches his first access point by foot. At an access point, a traveller enters the territory of an other subsystem, which results in transferring and/or adapting to the new subsystem (Connekt, 1999). For individual transport subsystems, the definition of access points is derived from the transition of territories, so from the type of infrastructure. For the collective transport subsystems, this is self-evident.

We can distinguish four kinds of access points (figure 2.3.4):

(i) **Connection point**: an access point that connects individual networks of different spatial levels (I< or >I);

(ii) **Collective transfer point**: an access point that connects collective networks of different spatial levels (C< or >C);

(iii) **Transferium**: an access point that connects a collective network with an individual network of an equal or higher spatial level (I >= C);

(iv) **Stop / P & R**: an access point that connects a collective network with an individual network of a lower spatial level (also pedestrians) (C > I).

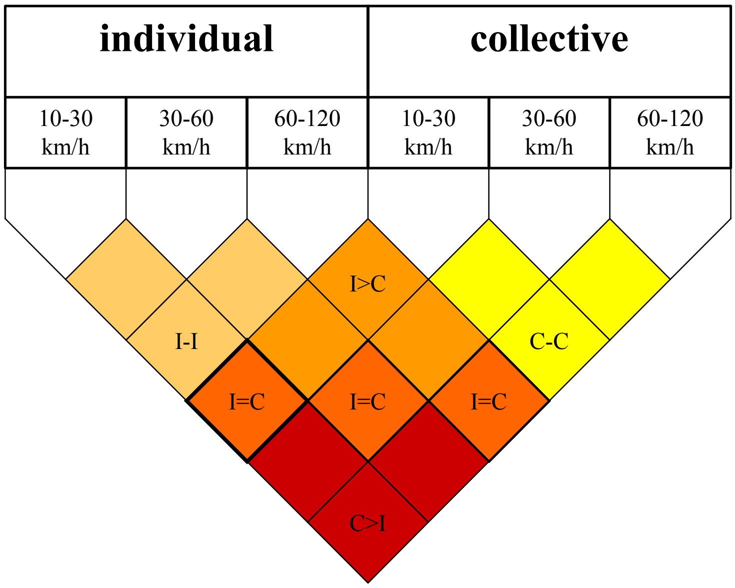


Figure **2.3.4** Four categories of access points
Derived from: Connekt, 1999

At an access point, a physical transfer can take place between the two modes of transport, or the same vehicle can go from one type of infrastructure to another type of infrastructure (without a physical transfer). In the current situation, the exchange between two collective subsystems is associated with a physical transfer (for example the transfer from tram to train). Most of the time, this is not the case for the exchange between two individual systems (for example the transition from the urban road network to the motorway). However this is not self-evident: light rail (change from the tram network to the train network) and the transfer from car to bike at the National Park 'Hoge Veluwe' prove the difference.
There are locations where several kinds of access points are combined, where transfers are possible between many different individual and collective subsystems at different spatial levels. For a good functioning of the transport system as a whole, it is essential to bear in mind the location of the access points in combination with the nature of the access points (typology). Chapter eight and nine go into more detail on this specific topic.

2.3.6 Scale thinking

One of the most important issues in the discussion about a multimodal transport system, transfer points, and the Network City is the spatial level to which these notions (can) refer. Therefore, this section discusses the theory of the scale articulation approach that has been developed at the Faculty of Architecture of the Delft University of Technology (De Jong, 1978; De Jong and Paasman, 1998) in order to be able to estimate the value of the spatial level discussion properly. Furthermore, we discuss the results of research by Barabasi (2002) on the form and structure of complex interacting systems.

The scale articulation theory of De Jong is based on the fact that scale falsification is possible, if one adopts a line of reasoning that is true for another spatial level than to which the discussion refers ((dis)aggregation mistakes). Besides, scale articulation opens up possibilities to clearly understand paradoxical design notions such as 'concentrated deconcentration'.
Figure 2.3.5 shows a spatial pattern that allows different, contradictory conclusions at different spatial levels (scope). If we look at one circle and its close surroundings, then we can

see ‘difference’. On the other hand, if we look at groups of seven circles as one unit and their surroundings, then we see ‘equality’. This figure also shows that such a confusion of tongues is already possible with a difference in spatial level with a scale factor three. This has been the reason to design so called urban categories based on this scale factor three.

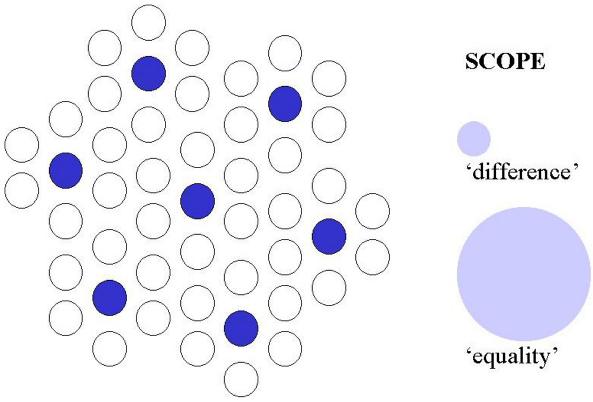


Figure **2.3.5** Scale falsification
Source: De Jong and Paasman, 1998

One element of the almost logarithmic urban series {0,3, 1, 3, 10, … km}is the name (nominal value) of an ‘elastic’ urban category that reaches to the next category on both sides (figure 2.3.6). The name-giving nominal radius R=10 km then is the median of the distribution of the probability densities of the logarithm of radiuses between (rounded) r=3 km and r=30 km, with a standard deviation of 0,15.
The theory has chosen for a series of radiuses (and not diameters), because an area with a radius of {0,3, 1, 3 km} corresponds with the terminology of {neighbourhood, city quarter, city (district)}[1] or {hamlet, village, town}[2]. This terminology is however only used here to indicate the size of an area and has no functional meaning as such. It only presents the potentials for functions. Besides, the tolerances are so large, that an area with a 3 km radius can be referred to as a town, but also as a very large village. One can speak of a large village from the nominal value up to the crossing point of the r=3 km curve with the r=10 km curve. Beyond that point, one can speak of a very large village, or a (small) city (table 2.3.8).

[1] In Dutch: {buurt, wijk, stadsdeel}
[2] in Dutch: {gehucht, dorp, stad}

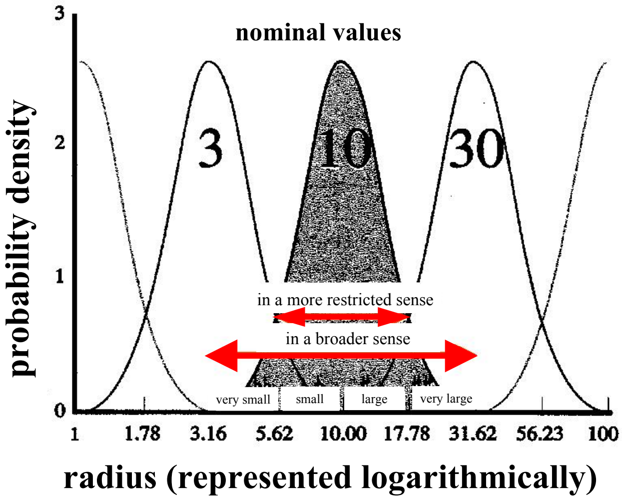


Figure **2.3.6** Names and boundaries of urban categories
Source: De Jong and Paasman, 1998

Table **2.3.8** Urban categories

Radius [m]	Area [m2]	Inhabitants	Name (morphological)
30 000	3 000 000 000	10 000 000	Metropolis
10 000	300 000 000	1 000 000	Agglomeration
3 000	30 000 000	100 000	Town / City (district)
1 000	3 000 000	10 000	Village / City quarter
300	300 000	1 000	Hamlet / neighbourhood

Source: De Jong and Paasman, 1998

Not only urban areas, but also connections in the transport network can be interpreted in the terminology of this semi-logarithmic series (table 2.3.9 refers).

Table **2.3.9** Transport network categories

Name (non-functional)	National highway	Regional highway	Local highway	City road	Road	Street
Density [km/km2]	0.02	0.07	0.2	0.7	2	7
Connection every	30 km	10 km	3 km	1 km	300 m	100 m
Function	National highway, Interliner, fast train	Regional highway, fast bus, stop train	Local highway, light rail, metro	Light rail, tram, bus	Neigh-bourhood road	Neighbour-hood street

Source: De Jong and Paasman, 1998

This theoretical framework is applied here as an example to the region of Zuid-Limbug and the city of Maastricht, resulting in the pattern shown in figure 2.3.7. The figure clearly shows the agglomerations of Maastricht, Heerlen-Kerkrade, and Sittard-Geleen (r=10 km), the city of Maastricht (r=3 km), and the Maastricht city districts (r=1 km).

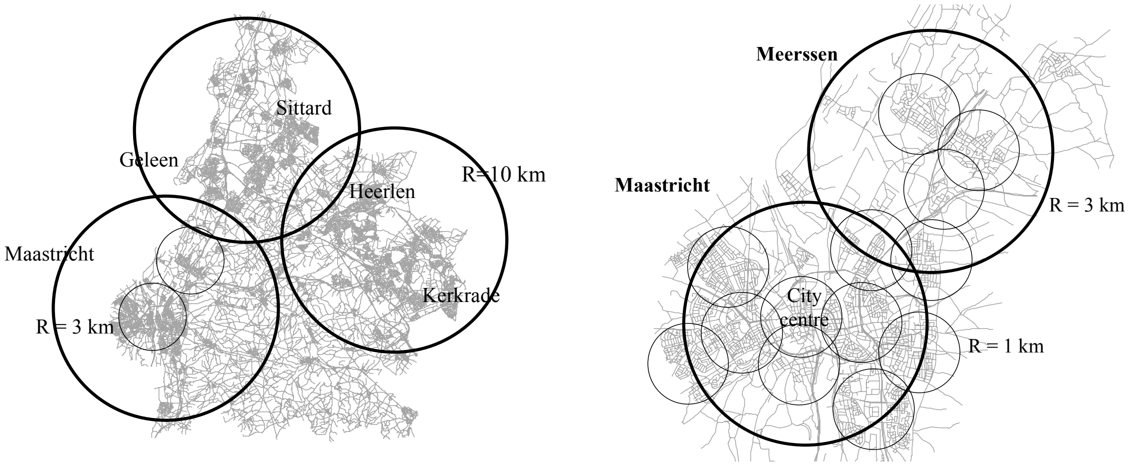


Figure **2.3.7** Urban categories: R=10 km, R=3 km, R=1 km; Zuid-Limburg, Maastricht

Rules of hierarchy in complex networks have been studied by physicist Barabasi (2002). He shows that (good functioning) complex networks are in fact so called *scale-free* networks, in which the power-law rules (figure 2.3.8).

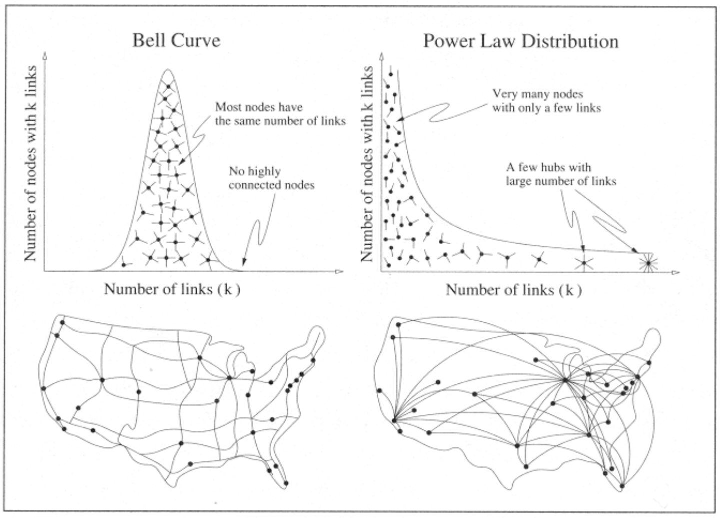


Figure 6.1 Random and Scale-Free Networks. *The degree distribution of a random network follows a bell curve, telling us that most nodes have the same number of links, and nodes with a very large number of links don't exist (top left). Thus a random network is similar to a national highway network, in which the nodes are the cities, and the links are the major highways connecting them. Indeed, most cities are served by roughly the same number of highways (bottom left). In contrast, the power law degree distribution of a scale-free network predicts that most nodes have only a few links, held together by a few highly connected hubs (top right). Visually this is very similar to the air traffic system, in which a large number of small airports are connected to each other via a few major hubs (bottom right).*

Figure **2.3.8** Power-law distribution[3]
Source: Barabasi (2002)

[3] Note that there is an important qualitative difference between a power law and a bell curve when it comes to the tail of the distribution. Bell curves have an exponentially decaying tail, which is a much faster decrease than that displayed by a power law. This exponential tail is responsible for the absence of the hubs. In comparison, power laws decay far more slowly, allowing for 'rare events' such as hubs.

He discusses that the power law distribution forces us to abandon the idea of a scale, or a characteristic node. The largest node (best connected) is closely followed by two or three somewhat smaller hubs, followed by dozens that are even smaller, and so on, eventually arriving at the numerous tiny nodes. There is no intrinsic scale in these kinds of networks. This is why these networks are referred to as scale-free.

Furthermore, he argues that the scale-free topology is a natural consequence of the ever expanding nature of real networks. Starting from two connecting nodes (figure 2.3.9), in each panel a new node (shown as an empty circle) is added to the network. When deciding where to link, new nodes prefer to attach to the more connected nodes (the rich-get-richer concept). Thanks to growth and preferential attachment, a few highly connected hubs emerge.

But there is more. In a competitive environment, new nodes with a high level of attractiveness or ‘fitness’ are linked to relatively frequently. So, preferential attachment is driven by both fitness and connectivity. Between two nodes with the same number of links, the fitter one acquires links more quickly. And if two nodes have the same fitness, the older one still has an advantage (the fit-get-richer concept).

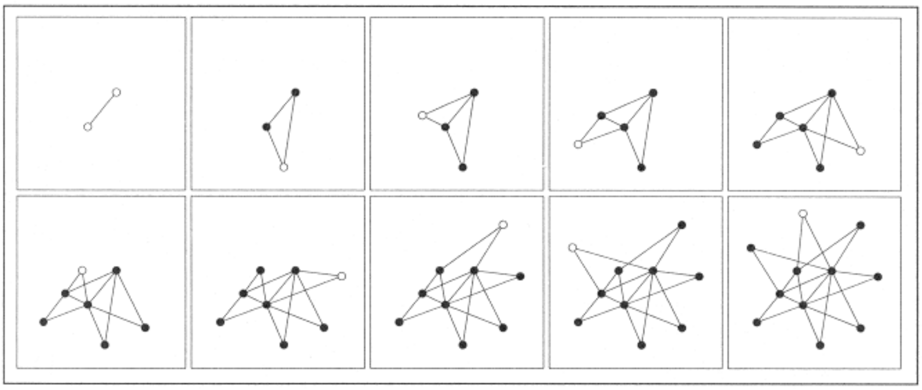


Figure **2.3.9** Growth of networks
Source: Barabasi (2002)

2.4 Summary and conclusions

This chapter focused on (passenger) mobility in a societal context: the first thesis chapter in the phase of analysis of the planning cycle. By many people, the mobility of people is considered to be an (self-)acquired right, and should be evaluated positively, for it has contributed to both individual well-fare and well-being, and societal well-fare and well-being to a large extent. During history, the increase of the mobility of people has opened up possibilities for people to participate in new and/or other activities on all kinds of (remote) locations. But nowadays, the negative impacts of the increased mobility are felt as hard as ever.

In the past the mobility discussion used to be simple and one way directed: linear orientated. Clear distinctions could be made between the centre of a city and its periphery and most travelling took place during specific hours of the day. However, the paradigm of travelling and communication has changed during the last decades in a way that can be characterised by the transition from the *sense of places* towards the *sense of flows*. The (ongoing) rise of individual motorised mobility, the (ongoing) spreading of activities, and the (ongoing) rise of information and communication technologies result in people participating in extensive

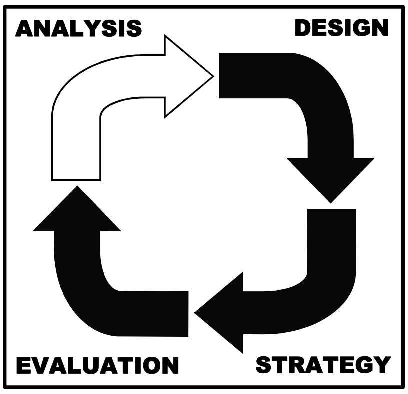
networks of movements and communication with diffuse and long-distance travel and communication patterns accordingly.
But the physical world encounters boundaries. The decrease of the accessibility of locations – which can be defined as the time, money and efforts, it costs to reach that specific activity location – (at specific times) is a good example of such a problem where those boundaries are met.

Sustainability is a concept that optimises societal problems, such as most mobility problems, from three perspectives: an ecological perspective, an economic perspective, and a social-cultural perspective. Chain mobility for passenger transport is considered by many to be a possible solution for quite a number of mobility problems and has the potential to bring balance in the three perspectives mentioned above for the field of mobility. It is the task of the fields of urban, environmental and transport planning to create a (knowledgde-based) vision about the city and its transport system.
The adoption of the body of thoughts on sustainability starts with (changes in) the behaviour of people. And with respect to the mobility of people, we are interested in the activity-travel behaviour of people. The next chapter therefore explicitly focuses on activity-travel behaviour theories and ends with a conceptual model of the introduction and adoption of seamless multimodal mobility.

CHAPTER THREE ACTIVITY-TRAVEL BEHAVIOUR THEORY

Necessaria metitur utilitas: supervacua quo redigis?

Utility is the measure of what is necessary; but how can one measure abundancy?
Seneca, Epistula Morales, no. 39



In the previous chapter we investigated the transportation issues mobility, sustainable mobility, and passenger chain mobility. The objective of this second chapter of the analysis phase, called 'Activity-travel behaviour theory', is to present [i] 'human theories' from the fields of sociology, economy, geography, and psychology about how mobility originates, and [ii] the behavioural consequences of the introduction of SMM. This chapter builds on section 1.2 where mobility as a derivative of human activities and needs has already been discussed briefly.
Section 3.1 shows the most important streams of the activity-travel behaviour theory. Section 3.2 deepens the discussion presenting the hierarchy of activity-travel choices. Section 3.3 focuses on a specific aspect of the activity-travel behaviour theory, namely the process of activity-travel scheduling. Having discussed all these scientific activity-travel behaviour models, section 3.4 comes up with a conceptual model of the adoption of seamless multimodal travelling. It presents the key concepts and the decision context, in which the introduction of SMM takes place, and it shows the potential impact of the introduction and eventual adoption of SMM on the activity-travel (scheduling) behaviour of people. Section 3.5 summarises decades of travel behaviour research in the' laws of activity-travel behaviour'. Finally, section 3.6 presents in brief the main findings and conclusions of this chapter.

3.1 Theoretical streams

For decades, all kinds of researchers with different scientific backgrounds have come up with theories about activity-travel behaviour: transport experts, economists, geographers, and social scientists. The next three subsections discuss several activity-travel theories that originated from these different scientific fields. Most theories of recent date are specifically characterised by their integral approaches, which is not hard to understand as we look at the political field in which nowadays decisions have to be made about the physical planning of countries and cities. Many local, provincial, and national governments are confronted with complex spatial planning problems: economic costs and benefits have to be weighed against societal and environmental costs and benefits.

3.1.1 Trip-based versus activity-based approach

Over the last couple of years, the so-called *activity-based approach* has received increasing attention among transport researchers (see for an overview of activity-based approaches to travel analysis: Ettema and Timmermans, 1997). Researchers have specifically relied on activity-based approaches in order to overcome the shortcomings of the disaggregate travel demand models of the sixties and seventies. First, the activity-based approach has been used to provide a better theoretical fundament of activity-travel behaviour research as it refers to the questions *why* people travel and *how decisions* regarding trips *are made*. The activity-based approach assumes that travel is not a demand on its own right, but a demand which is derived from the combination of the utilities of (i) activity participation, and (ii) performing activities at a different locations. It states that a trip, defined as the travelling from one activity place to another with a specific transport mode or combination of transport modes, will only be made if the subjective benefits that belong to that specific activity at that specific location outweigh the subjective costs that belong to that specific activity and the travelling to that specific location (see also frame 3.1.1). The activity-based approach therefore implies that travel is best understood in the broader context of individual (household) activity patterns.

The disaggregate travel demand models of the sixties and seventies are known as the *trip-based approach*. This approach uses the single trip as the basis of analysis. Trips are clustered in motives (work, shopping, recreational), and analysed both separately and independently. As a rule, points of time are not analysed, except for the peak hours (Jones, 1983). No relations are made with the activities the travellers perform, nor with the activity-travel behaviour of other people. Central issue in the trip-based approach is that trip making is the result of choices that individuals or groups of individuals make (Jones, 1979). The results of the trip-based approach were somewhat disappointing, although it has the advantages of its simplicity and its relatively cheap methods (Clarke, 1986). The most important drawback of the trip-based approach is that trips are studied isolated. This approach denies the mutual interdependence between trips, between trips and activities, and between people. It does insufficiently recognise the fact that people do not derive utility from the travelling itself, but from the specific activity and the specific location of activity. The activity-based approach takes this criticism as a starting point.

Trip making can be seen as the result of individual choice behaviour. An individual chooses, whether he will participate in one or more out-of-the-home activities, at which location, with which mode of transport, etc. Very often, the micro-economic utility theory is used in order to understand the travel behaviour of individual travellers (Bovy et al., 1993). Let's consider the choice whether or not to participate in out of the home activity j.

Theoretical assumptions

1. Three utility components play an important role when the decision is made in order to make a trip.
   - ☞ The utility Ni of staying at the origin i
   - ☞ The utility Nj of performing an activity at a destination j
   - ☞ The disutility Zij of the trip from the origin i to the destination j

   A trip will only be made if the balance of these utility components is positive.

   $$Nj - Ni - Zij > o$$

   The utility scale for the activity is chosen in such a way that Ni=0.
2. The individual addresses a positive utility towards each activity j. This utility depends on the nature of the activity and all its characteristics g. The total activity utility results from the sum of the separate utilities that belong to the separate characteristics of the activity. Each individual values each activity (and its characteristics) in his own way.

   $$Nj = \Sigma Ngj$$
3. A disutility Zij is addressed to each trip that is necessary for the activity. This disutility depends on the characteristics of the trip (travel time, travel mode, costs). The total trip disutility results from the sum of the separate disutilities h that belong to the separate characteristics of the trip. Each individual values each trip (and its characteristics) in his own way.

   $$Zij = \Sigma Zh$$
4. A trip is only made if the (subjective) benefits of the activity (and the trip) outweigh the (subjective) costs. So, a trip will only be made, if the balance of utilities is positive.

   $$Uj = (Nj-Zij) > 0$$
5. An individual cannot participate in all activities because of constraints concerning time, space, and money.
6. The traveller chooses that alternative j that offers him the highest utility (subjective utility maximisation) under the conditions of time and money budget. When the chosen alternative is indicated with c, then:

   $$Uc = \max Ui \text{ (for all i)}$$

   This process of maximisation is conditioned by the -per definition- limited knowledge of the traveller about the activity-travel environment. A stream of scientific thinkers (see: Van den Bergh and Fetchenhauer, 2001) therefore raise doubts about the processes of the supposed rationality of human behaviour and suggest research models based on so called *bounded rationality*. Bounded rationality is a reaction to the surplus of possibly available information and to the restricted capacity of human senses and brains to digest information.

Frame **3.1.1** Travel behaviour and utility maximisation

Jones (et al., 1983) has formulated the fundamentals of the activity-based approach into 5 assumptions. The first assumption made -as has already mentioned above- is that travel is a *derived demand*. That is to say, in most cases travel is not an independent demand, but takes place in order to participate in activities that take place at different destinations. As a consequence, characteristics of activities and locations will strongly influence individual activity-travel behaviour.
A second important assumption of the activity-based approach is that activity performance depends on the availability in both time and space of *specific facilities*, which sets limitations to the possibilities of performing activities. For example for shopping one is limited by the actual shopping locations in the city, and the opening hours of the shops. Furthermore, limitations may also arise from appointments made by household members; for example when household members have decided to travel to work together. These kinds of limitations are termed time-space constraints, which are the focus of Hägerstrand's (1970) space-time geography (subsection 3.1.2).
A third assumption is the emphasis on the *household as the decision-making unit*. As most households consist of multiple persons, interpersonal linkages influence activity patterns to a large extent. The fourth assumption is that travel should be regarded in the *context of activity patterns*, consisting of multiple activities and trips. This implies that interdependencies (space-time linkages) exist between independent events throughout the day. For the larger part this is due to the limited time budget of people: 24 hours a day. If more time is spent on one activity at one site, less time is available for others.
The last assumption is that travel and activities should be considered as the *outcome of a scheduling process*. One of the key questions in the activity-based approach is how individuals and households make and adapt their activity-travel decisions. These include decisions about which activities to perform, where, at what time, with what duration, with whom, coupled with which mode(s) of transport, and route choice. The planning and execution of these decisions over time define the activity scheduling process (Doherty and Axhausen, 1998) (section 3.3).

Within the research studies of the activity-based analysis, a behavioural and a non-behavioural approach can be identified. The behavioural approach is based on analyses of actual activity-travel behaviour. The perceptions and attitudes of the people involved are considered to be the main explaining variables of the behaviour. The non-behavioural approach are explicitly aimed at the possibilities of behaviour, which offer constraints, options, and norms (Vidacovic, 1988). The next section will focus on the theory of the founding fathers of the behavioural (Chapin) and non-behavioural approach (Hägerstrand).

3.1.2 Behavioural versus non behavioural approach

One of the first researchers to recognise the importance of time and space in urban planning was Chapin (1974). He emphasised the importance of activity patterns as the building blocks of the use of time and urban space. According to Chapin, the daily activity pattern consists of necessary (biologically determined), obligatory (more socially than biologically determined), and discretionary activities. To answer the question how individuals decide about the activities to perform, Chapin distinguishes between four driving forces by which activities are determined: propensity, opportunity, appropriate situation, and the environmental context.
With respect to *propensity*, Chapin distinguishes motivational and constraining factors. The motivational factors are related to the Maslow hierarchy of needs (1954): physiological protection, safety, affective relationships, self-esteem, and self-fulfilment. However, the preferences for certain activities cannot be separated from the cultural and social context of

people. These constraints concern personal characteristics such as gender, stage in life cycle, role in the household, and health status.
Opportunity is associated with physical and spatial variables affecting the probability of choosing an activity. It principally reflects the availability and spatial location of facilities needed to perform specific activities. Besides, Chapin stresses that the *individually perceived* availability and spatial location might be as important as the *actual* availability and spatial location of facilities.
A third factor in activity performance is the *appropriateness of timing and circumstances*. The timing of an activity may for instance depend on if one has been engaged in the activity before, or commitments one has made for other activities.
Finally, activities are influenced by the *environmental context* that provides facilities and opportunities. The environmental context encompasses all non-physiological factors (technological, economic, cultural, and political developments) affecting the individual's activities, including a person's own behaviour from the past.
Chapin's theory can be considered a milestone in urban planning, as it is the first to relate activities, time and space in urban planning in a single coherent theory.

Chapin's behavioural approach stresses that the revealed activity-travel behaviour of people is an outcome of personal attitudes, motives, and choices. Although the emphasis is on the individual choices, Chapin did not overlook the constraining aspects of activity-travel behaviour. However, Chapin's approach is often referred to as a 'choice-approach', in contrast with the 'constraint-approach' of the non-behaviourists, such as Hägerstrand. The non-behavioural researchers are less interested in the revealed daily activity-travel behaviour of people. The non-behavioural theory says that the actual behaviour of people has already been adapted to the specific characteristics of the environment. Therefore, the non-behavioural approach focuses on the time-space constraints on behaviour alternatives. It looks for those constraints that pester certain behaviour alternatives.

The founding father of the 'constraint-approach' is Hägerstrand (1970) with his time-space geography. He systematically explores the opportunity to unfold activity patterns in a specific temporal-spatio environment. He assumes that time and space are scarce goods and that, consequently, daily activity patterns are largely determined by space-time constraints. He states that an activity can be described in terms of a certain duration and location. A sequence of activities then implies an individual path through space and time (figure 3.1.1). This activity path consists of stations where activities take place, and transport chains between the activities. Obviously, not all paths through space and time are feasible in everyday life. Hägerstrand identifies three basic types of constraints to which activity patterns are subject.
The first of these are the *capability constraints*, referring to physical limitations. An important limitation is the need to spend a considerable amount of time of the day sleeping and eating. Furthermore, individual indivisibility and limits to the maximum speeds of different transport modes imply that activities that are too remote in space cannot be part of one's time-space path.
Hägerstrand also distinguishes *coupling constraints*, which basically define 'where, when, and for how long the individual has to join other individuals, tools and materials in order to produce, consume and transact (Hägerstrand, 1970). The synchronisation of activities makes strict arrangements necessary about point of time, duration, and location.
Authority constraints belong to the third category of constraints, which prohibit the use of facilities (activities, transport modes, etc.) at certain times. Examples are: a driving license, opening hours of shops, entrance tickets, etc.

Hägerstrand's theory opens the opportunity to theoretically assess the activity patterns that an individual can perform, given the locations at which he or she can perform certain activities, the transport facilities available to him or her, and the current coupling and authority constraints. The relevancy of Hägerstrand's theory for transportation thus lies in its opportunity of integrating both spatial and temporal aspects which determine individuals' travel patterns (Ettema, 1996).

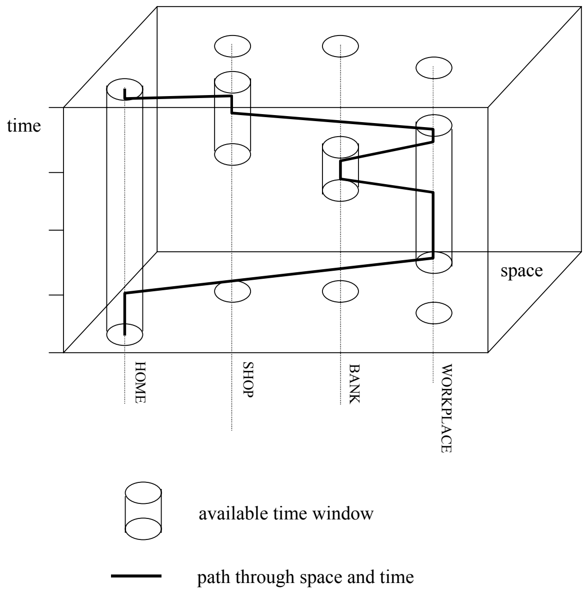


Figure **3.1.1** Space-time path of Hägerstrand
Source: Ettema, 1996

3.1.3 Psychological theories

The last decade sociologists and psychologists have also joined the discussion of activity-travel behaviour theory. The focus has mainly been on the short-term choices of the activity-travel behaviour (Vlek, 1999a, Rothengatter and Carbonell Vaya, 1997): predominantly driving behaviour and choice behaviour of transport mode. In contrast to the past, even the Dutch ministry of transport -that for a long time had been focused only on the hardware, the infrastructure- has adopted a sociological and psychological view in its policy (AVV, 1998a, 1998b; SCP/AVV, 2000).

Psychologists define 'behaviour' as the things that a person does, thinks, feels, and finds in relation to his or her physical environment, other people, and/or him or herself (Vlek, 1999a). The following overall scheme is discussed in the behavioural study of the Dutch Ministry of Transport about whether car use can be influenced and directed (AVV, 1998a).

One of the most important conclusions of the behavioural study of the Ministry of Transport is that travel behaviour in general is mainly *habitual behaviour*: activity-travel choices that have once been made are only seldom reconsidered. Only the so-called *catastrophes* have true impact on the reconsideration process (for example the doubling of gasoline prices, the doubling of the frequency of public transport, or a change in household composition). But catastrophes aren't easy to create and don't take place that often. Therefore, it is more important to promote those travel alternatives that are in line with the collectively desired habitual mobility behaviour. In this minefield, the 'soft' factors play a major role: the *attitudes* of people. The individual attitudes (for example towards a specific transport system) will for the larger part determine the behaviour of that person.

The most effective way to change individual attitudes is to change (ironically enough) the behaviour of people, if need be with a powerful *measure* (catastrophe). The attitude of people will adapt to the behaviour thanks to the human mechanism of *the reduction of cognitive dissonance*. It is in the human nature to reduce the gap between attitudes and behaviour.
Another background factor that plays a role is the fact that a lot of people (want to) believe that their behaviour is better -e.g. more environment friendly- than that of others. Research has shown that the average car driver thinks that his driving behaviour is better than most others (AVV, 1998a).

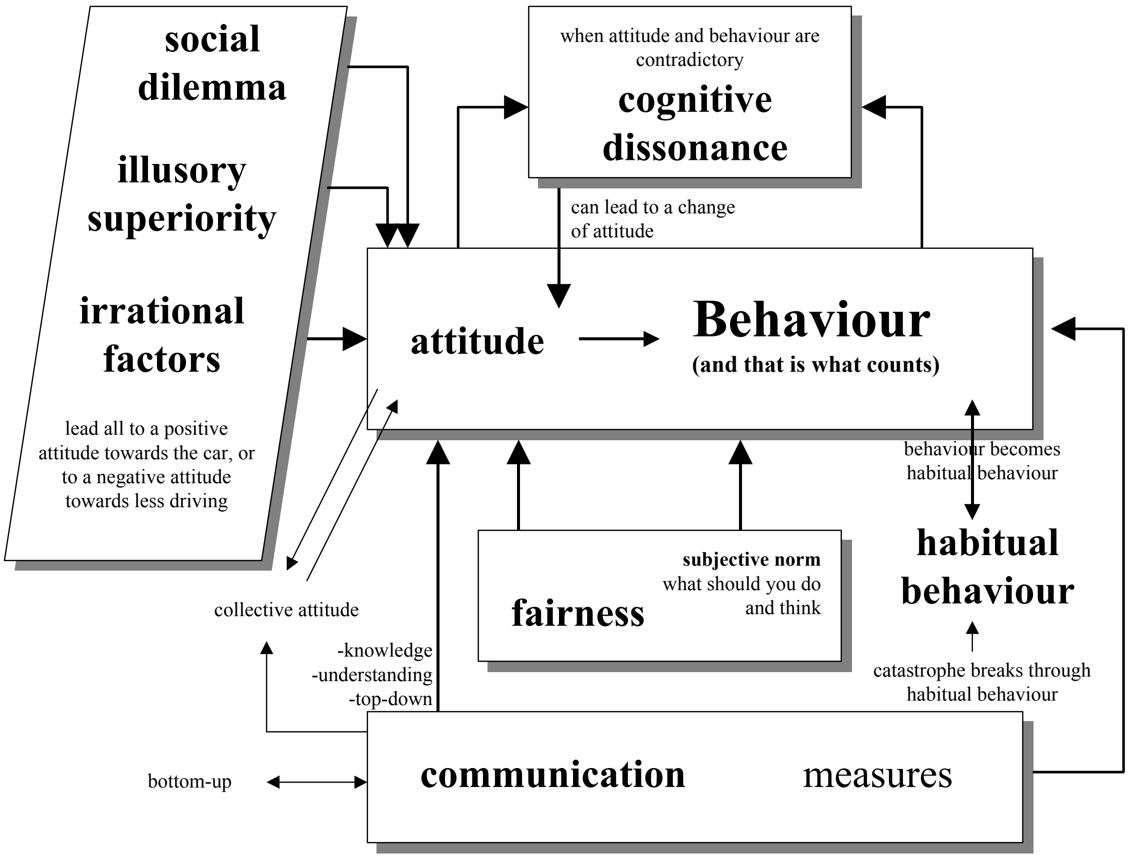


Figure **3.1.2** Conceptual scheme Can the use of the car be steered?
source: AVV, 1998a

It is hard to convince people of the long-term and collective effects of their individual behaviour, often referred to as a social dilemma or commons dilemma (Vlek, 1996). People have to be shown that their behaviour *does* matter in the aggregate. In order to do so, *communication* becomes a key word. However communication should not be seen as the solution but as an aid to change attitudes, and as a means to show that you as a government pursue a *fair* policy.

The prediction of individual behaviour from knowledge of attitudes has been investigated for quite some time now (Forward, 1997). However, in addition to the attitude component that should explain behaviour, the Theory of Planned Behaviour (Azjen, 1985; 1987) states that besides attitudes towards the act and the subjective norm, perceived behavioural control affects behaviour indirectly via intentions. Behaviour refers to an observable act and intentions as a willingness to try (Forward, 1997). Attitudes are the individual's evaluation of performing a particular behaviour. The subjective norm describes the perception of other people's beliefs; do they approve or disapprove of a certain kind of behaviour? Perceived behavioural control refers to a person's perception about his own capability to perform an act.

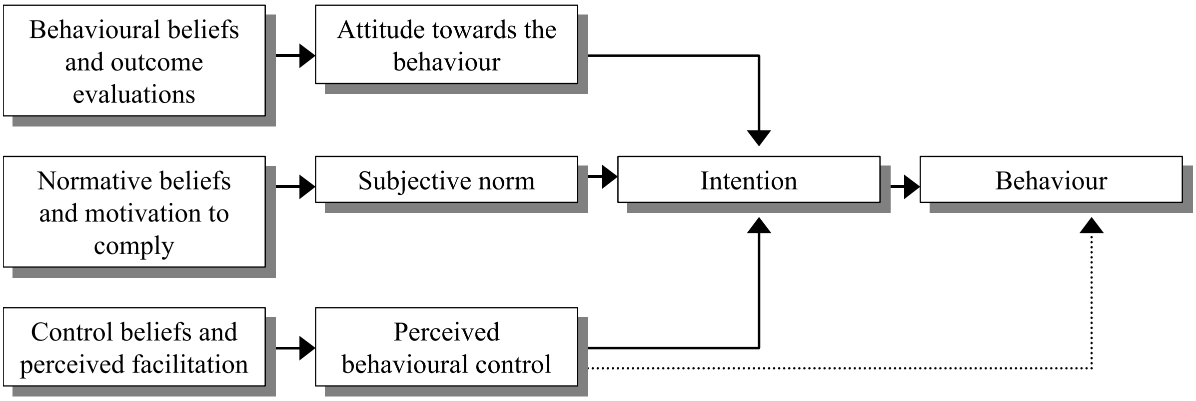


Figure **3.1.3** Theory of Planned Behaviour
source: Forward, 1997

The broken arrow between perceived behavioural control and behaviour implies that the effect on behaviour can be both direct and indirect. Perceived behavioural control is a significant predictor of behaviour when the control over the behaviour is low. At the most basic level, behaviour is a function of salient beliefs. Three kinds of antecedents, or salient beliefs, are distinguished: (i) behavioural beliefs, normative beliefs, and control beliefs. Since people's beliefs represent the information (be it correct or incorrect) they have about themselves and about the world around them, it follows that their behaviour is ultimately determined by this information.
An obstacle to predicting behaviour from intention is that much behaviour is habitual. Engaging in a habitual or impulsive behaviour is perhaps not preceded by the formation of an intention. Gärling et al. (1998, 2003) suggest that a classification of behaviour as planned, habitual, or impulsive provides a key to improving predictive validity of stated intentions. Whether or not an intention is formed, and if it is formed, how much the behaviour is subsequently planned, are conceived of as important distinguishing factors (table 3.1.1)

Table **3.1.1** Planned, habitual, and impulsive behaviour

	No or little planning	Much planning
No intention formed	Habitual behaviour	-
Intention formed	Impulsive behaviour	Planned behaviour

source: Gärling et al., 1998

Another psychological theory -the NOA-model, that is used at the University of Groningen[1] - focuses on both the individual circumstances and the environment circumstances in which the activity-travel behaviour takes place. The NOA-model (Vlek, 1999b) that has mainly been applied to car use, but can also be discussed in a broader activity-travel perspective, says that changes in behaviour are based on changes in the individual determinants of behaviour. It therefore says that the (actual) behaviour at the micro level can be explained by (i) the personal *motivation* of a specific kind of behaviour and (ii) the *feasibility* of that behaviour

[1] At the Centre for Environmental and Traffic psychology (Centrum voor Omgevings- en Verkeerspsychologie - COV).

(Figure 3.1.4). The *needs* and the *opportunities* that a certain person has, explain the motivational part for a specific kind of behaviour. The *opportunities* and the *abilities* that a certain person has, explain the feasibility part of a specific kind of behaviour.
Needs are individual or societal motives that are coupled with reaching more or less essential goals (as described by Maslow, 1954). It is an interesting question to what kind of needs personal mobility should be counted (subsection 3.2.3). Opportunities are (physical or social) situations that promote or restrict a specific kind of behaviour. Abilities refer to the knowledge, experience, and skills in order to be able to execute a specific kind of behaviour. If a person doesn't have the opportunity and/or ability, a desired kind of behaviour will most probably not be executed.
The norms, opportunities, and needs (meso level) are strongly influenced by more societal developments (macro level). These factors can be categorised in the so-called TEDIC-complex of implicit and explicit influences: the technological, economic, demographic, institutional, and cultural developments. The influence of the TEDIC-factors on the mobility culture of Western societies has been enormous during the last decades (AVV, 1997) (see also section 4.3, action space from a historical point of view).

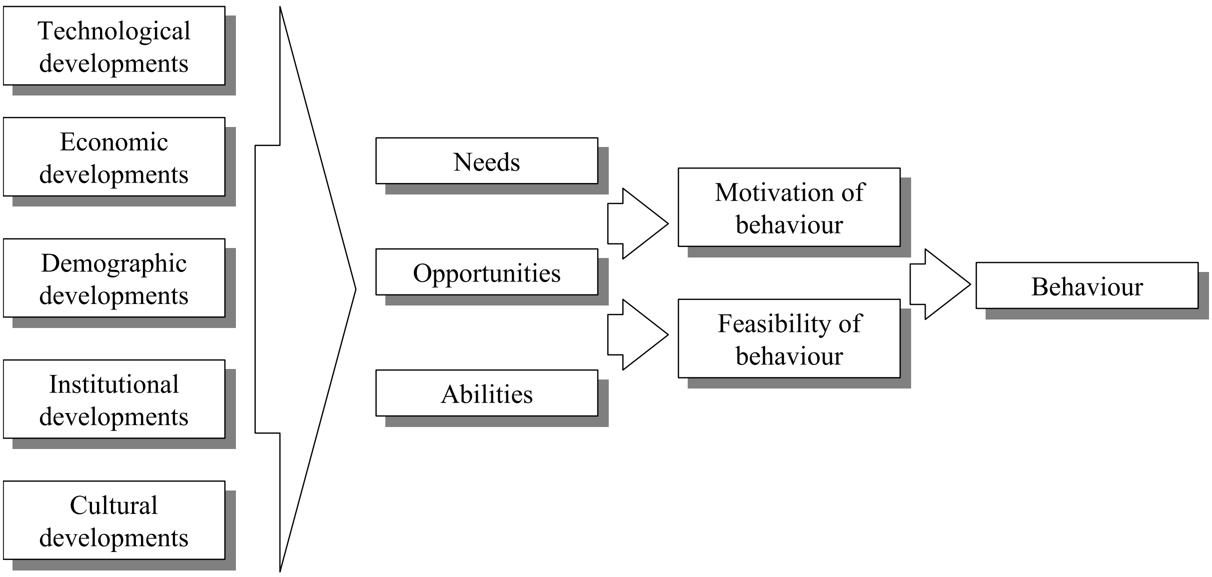


Figure **3.1.4** NOA-model
source: Vlek, 1999b

3.2 Hierarchy of activity-travel choices

For the planning and execution of the activity-travel behaviour travellers make all kinds of activity-travel choices in relation to their activity and trip patterns. These interdependent activity-travel choices can be divided into 4 main categories (figure 3.2.1) (Bovy, et al., 1993):
1. activity choices;
2. location choices;
3. mobility choices;
4. trip choices.

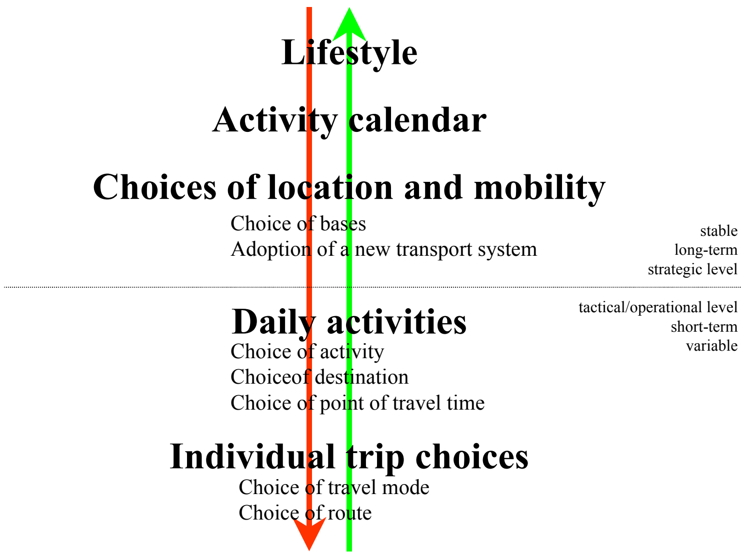


Figure **3.2.1** Activity-travel choices

In the theory of the hierarchy of activity-travel choices it is assumed that every individual pursues a certain kind of *lifestyle* that offers him or her the most individual satisfaction: lifestyle therefore determines the choices of life such as education and profession. In order to satisfy the individual lifestyle, a person develops his own *activity calendar*, an individually composed entity of all kinds of activities: work, education, sports activities, social and recreational activities, holiday travelling, etc. Lifestyle and additional activity patterns are considered to be very stable characteristics of person that will not change many times during an individual lifetime. They are the framework of the behavioural patterns that will change more often, such as the location choices and the mobility choices.

Location choices concern among others the choice about the place of residence (city/village, neighbourhood), the situation of a dwelling, the location of the work place, school, and for example the school of your children. On the one hand, the needs for activities -and thus the travel demands- are decisive for location choices. But on the other hand, the choices of locations are rigorously constrained by the individual (household) travel possibilities and the spatial supply of facilities. Choices of location are rather stable and can be considered as the spatio-temporal framework for the daily activities and the actual trip making.

Mobility choices focus on getting a driving license, the purchase of a vehicle, the purchase of a season ticket for public transport, etc. Because of the rather high investments involved, they determine the behaviour for a rather long period of time, and therefore can be characterised as of strategic significance for the activity-travel behaviour.

The *daily activity-travel choices* are important because they actually fulfil the needs of an individual. Some activities have a rather stable pattern (in time and/or space), like working and going to school. Other activities might have a more variable pattern (in time and/or space), such as visiting friends. A trip is often considered to be a derivative of the needs to participate in activities. However, it should not be forgotten that choices of activities also depend on the possibilities for a person to travel. These possibilities for the larger part depend on the long-term activity-travel choices.

Individual trip choices concern the daily short-term decisions about mode of travelling, point of time, travel route, etc. These trip choices are conditioned by the activity pattern to be executed, the pattern of locations, and the personal mobility situation. Therefore the individual trip choices belong at the bottom of the hierarchy of activity-travel choices.

In the context of a research project about traffic congestion and behavioural reactions, Stern, Bovy, and Tacken (1998) argue that, as congestion being a stochastic process, behavioural reactions towards congestion should be considered to be dynamic. Based on this notion, the researchers assume that the frequency of decision making with regard to each of the possible reactions towards traffic congestion is related to the type of behavioural response.
Figure 3.2.2 shows an overview of the possible reactions of both individual travellers (i.e. consumers) and authorities (i.e. providers). A hierarchical order is assumed to exist between the frequency of behavioural responses and the type of behaviour. For the individual traveller, the least practised responses are changes in lifestyle and location, and the most frequently practised responses are changes in driving and daily-travel behaviour.

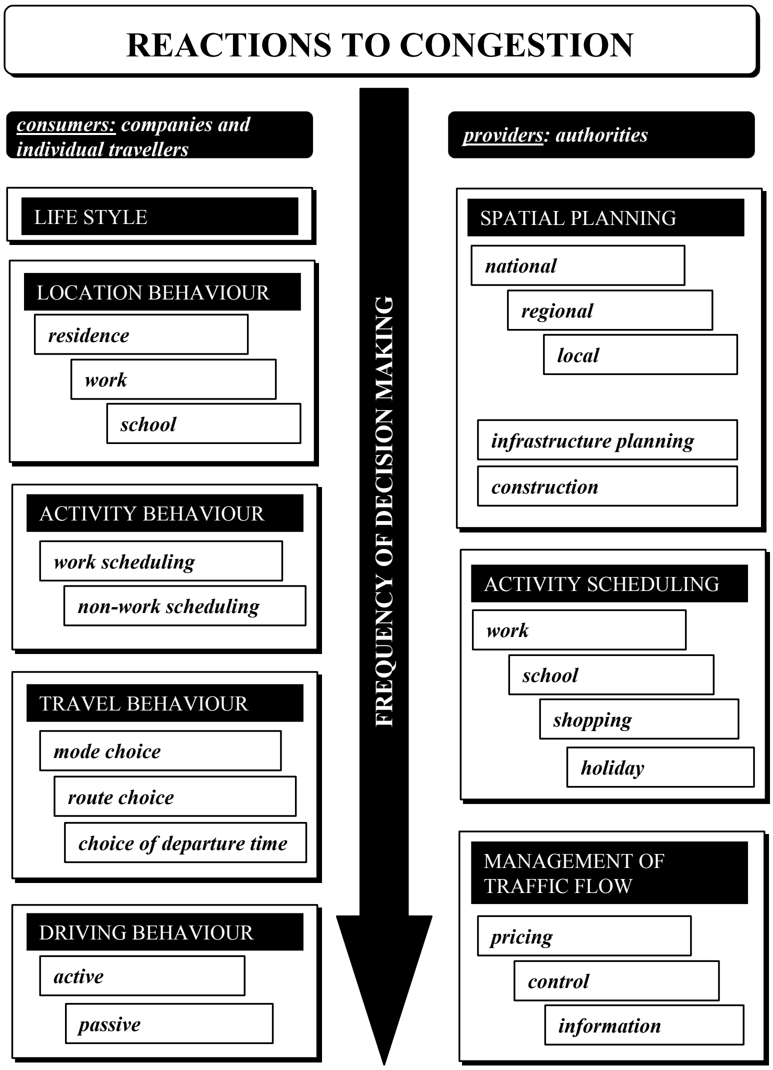


Figure **3.2.2** Hierarchy of reactions towards congestion by frequency of decision making source: Stern, Bovy and Tacken, 1998

The next two subsections will discuss the long-term, medium-term, and short-term activity-travel choices in more detail. The third subsection will focus on reserved mobility lifestyles as a consequence of the desire for a sustainable society and sustainable transport, as was discussed in chapter two.

3.2.1 Long-term choices

The basic explanatory variable of mobility patterns and mobility decisions can be considered to be an individual’s lifestyle. According to the model of Havens (1981), travel is a derived demand aiming at the fulfilment of certain needs. These needs are clustered into a smaller number of groups, which can be defined as roles. Havens defines a lifestyle as a combination of roles held by a single household member.

An important implication of the role and lifestyle concept is the temporal stability of activity programs. That is, once an activity is part of a lifestyle it tends to remain part of it (Ettema, 1996). So, lifestyle choices are important factors that determine the activity-travel behaviour for a relatively long time. Lifestyle decisions have a large impact on the so called long-term activity calendar (Ettema, 1996, see also section 3.3). This personal calendar contains general information about the activities in which a person regularly participates. Lately, the notion of lifestyle is more often connected in traffic and transport research to developments in activity and travel patterns of people (Ministry of Economic Affairs, 1993; Werkgroep ‘2duizend; 1997, Driessen, 1993). It is stated that choices for a certain lifestyle directly influence the needs of travelling. In the report of the Social and Cultural Planning Bureau ‘Lifestyles in the Netherlands’ (Ganzenboom, 1988), an outline is given of the determinants that together distinguishes lifestyles. These are (Ganzenboom, 1988):

- money budget;
- time budget;
- cognitive skills;
- considerations of status.

Besides, the report mentions three dimensions that can be used in order to discriminate people in terms of lifestyle. These are (Ganzenboom, 1988):

- economics;
- culture;
- stage of life (determined demographically, but also a matter of choice).

Bourdieu (1979) looks at lifestyle as a consequence of the first two dimensions, the two most important resources in society: money, income, and possession on the one hand, and knowledge and education on the other hand. According to Bourdieu two kinds of hierarchies can be identified in society: a economic class and a cultural class. The elite of the cultural class consists of scientists, academics, teachers, artists, and high-ranking officials, while the elite of the economic class consists of mangers of the business community and business owners. At the basis, these two dimensions coincide: the poor and unskilled. At the top, the two dimensions differentiate: cultural and high income versus non-cultural and very high income.

Driessen (1993) used Bourdieu’s two societal classes in order to describe the activity-travel behaviour of people, and especially the role of the car and public transport within the activity-travel behaviour. Driessen shows that the chance for having a driving licence, owning a car, and having a season ticket for public transport (Dutch Railways) increases with increasing education and increasing income. Driessen also shows that the manifestation of cultural and economic behaviour is not limited to the elite groups of society: about half of the population shows behaviour that can be characterised as cultural or economic.

Respondents with an economic lifestyle are very mobile. Most of the time, they have a driving licence and own a car. They travel many kilometres as a car driver. On the other hand, it is hard to find people within this group of respondents that have a season ticket for public transport. Therefore, this group can be characterised as “car drivers”.

Respondents with a cultural lifestyle are a little bit more mobile than the average respondent. They travel less kilometres by car, but more kilometres by public transport. Car ownership is

relatively low, and many persons within this cultural group have a seasonal ticket for public transport. The cultural group can be characterised as “public transport travellers”.
Peak hour travelling has also been investigated in this research project. It can be concluded that people with an economic lifestyle travel for a large part in the peak-hours, while on the other hand the people with a cultural lifestyle travel more often in off peak-hours.
There is also an interesting difference in travel motive between the cultural and economic people. Respondents with a cultural lifestyle very often travel by public transport in their spare time. This is especially true for the captives, but also for the non-captives.

Batenburg and Knulst (1993) describe that the growth of mobility of the Dutch population can be attributed to 4 societal trends: reduction of household size, emancipation, the combination of tasks, and the diversification of spare time behaviour. The authors conclude that the combination of tasks has influenced the growth of mobility most. Besides, the growth of the group of people that have a large repertoire of spare time activities has also contributed to the absolute number of individual trips, but to some what lesser extent.
In the seventies, the mobility of the adults, who are younger than 50 years of age and belong to a one or two person household, hardly differ from the average mobility of any other adult in the Netherlands. In the nineties, this group that exists of a lot more well-to-do’s than forty years before, shows an extremely higher rate of mobility and a more intensive use of the car than any other adult. The increase of the absolute number of the one and two person households can and should be seen as a main explaining variable for the general increase in this rate of mobility.
However, the increase in the rate of mobility and specifically the use of the car can only be attributed to the lifestyles mentioned to a limited extent. One has to say that (car) trips over longer distances have become generally adopted at a very large scale in the western (post-)modern societies. This can also be concluded from the fact that that part of the population that is not involved in obligatory out-of-the-home activities, has caught up in the car usage with a more than average increase.

With a future perspective, Werkgroep 2’duizend (1997) formulates in the report ‘Trends in consumer preferences’ five different lifestyles that are constructed (table 3.2.1) from eight societal trends. These trends are:

1. HOME AS BASIS: the home is used for many functions and its interior design is both functional/practical and comfortable. Being at home should equal enjoying. Home is always a good place to return to after any out-of-the-home activity.
2. MIRACLES OF TECHNOLOGY: consumers will use technology more and more often. Technology is seen as a chance, as a challenge.
3. THE MULTIFUNCTIONAL CONSUMERS: a person will allocate his time available over more and more activities.
4. HEALTH: people stay active till a high age.
5. MILD-SCHIZOFRENE CONSUMERS: individuals sometimes buy expensive things/services, sometimes very cheap things/services. Therefore it is hard to predict the actual consumer behaviour.
6. ESCAPE: by means of television, cyberspace, and gossip journals, people seek for an escape out of reality.
7. LIVE LIFE TO THE MAX: the consumer looks for excitement and danger in his spare time.
8. I as the CENTER OF THE UNIVERSE: people look for more individual quality of life. The focus is on inner growth and self realisation.

Table **3.2.1** Lifestyles

Societal trend	Lifestyle
I as the center of the universe Home as basis	Caring and working together (the part-time carers)
Miracles of technology Live life to the max	Click and kick (the techno youngsters)
Multifunctional consumer Mild-schizofrene consumer	Combining task and taste (the task combiners)
Health	Health (vital older people)
Escape Miracles of technology	Escape on demand (the escapers)

Source: Werkgroep 2'duizend, 1997

The report then gives an overview (table 3.2.2) of the distribution of the Dutch population over these lifestyles in order to give some insight about the share of these households in the total (societal) mobility. The report is not clear about what kind of mobility is meant: the number of trips, kilometres travelled, or time spent. It is made clear however that especially the lifestyles Caring and working together and Combining task and taste have a relatively large impact on the total transport system in strong contrast with the lifestyle Click and Kick.

Table **3.2.2** Lifestyle and influence on transport system

	Distribution of people over lifestyles	The share of lifestyle in the transport system
Caring and working together	11%	18%
Click and kick	20%	8%
Combining task and taste	11%	25%
Health	25%	22%
Escape on demand	33%	27%
Total	100%	100%

Source: Werkgroep 2'duizend, 1997

Werkgroep 2'duizend concludes –based on this lifestyle research- that the transport system of the future will be and has to be adapted more than today to specific target groups. Both individual and collective ways of travelling will be more differentiated and thus target group oriented. There is also a large emphasis on traffic guidance in order to use transport capacity best as possible. Besides, an important role is dedicated to information and communication technologies.

3.2.2 Medium-term and short-term choices

Based on Bhat and Koppelman (1993), Stoppelenburg and Tacken (1995) present a conceptual activity choice model that shows the factors, which the planning of activities (medium-term). The planning of activities concerns the choice whether or not to participate in any activity, chosen from a list of alternatives. Important factors that condition these kinds of choices are the frequency with which an activity is performed, the duration of the activity, the location of the activity, and the means of transport towards the activity location. The *planning* of activities, i.e. the creation of an *activity program*, should be distinguished from the *scheduling* of activities. An *activity schedule* results from this *activity program* and will be discussed in the next section (3.3) in more detail, as well as the relation between the activity program and activity schedule.

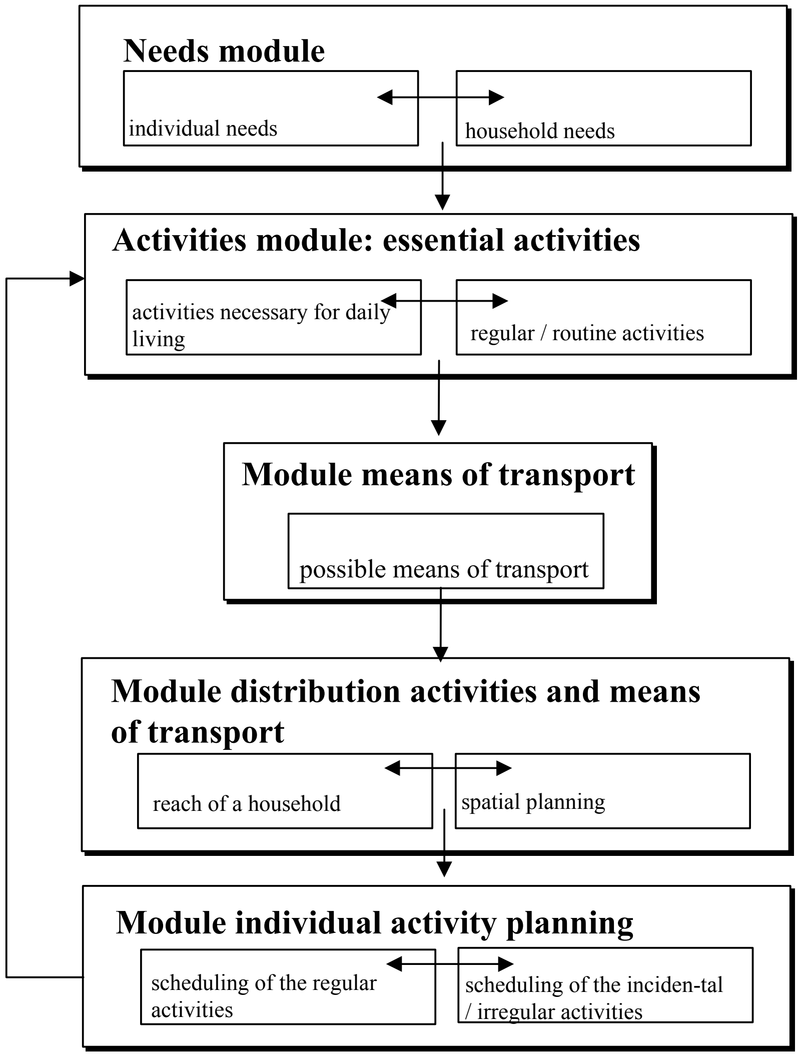


Figure **3.2.3** The planning of activities
source: Stoppelenburg and Tacken, 1995

The model identifies five different modules -the needs module, the activities module, the means of transport module, the distribution module, and the individual activity planning module- which will be discussed briefly. The needs module and activities module focus on the difference in flexibility and priority of activities: some activities have to be done (eating, drinking, sleeping), or have a very high priority (working, going to school, shopping, etc.). Factors that primarily condition these two modules are the lifestyle of the adults in a household, the attitude towards consumption, the number of people within the household, the income of a household, and the social and cultural norms of the society.
The means of transport module is conditioned by factors such as the availability (within a household) of certain transport modalities (car, bicycle, etc.), the availability of certain transport licenses (driving license, season ticket for public transport, etc.), the location of the residential area of the household in relation to activity locations, the attitude of the household members towards travel alternatives, and the number of household members. The way in which the means of transport and the activities are distributed among the household members, results in a different reach and potential action space for each of the household members.

Finally, each of the activities of all individual household members has to be placed in individual schedules. The next section will go into detail.
The research on the medium-term activity-travel choices and the short-term activity-travel choices is quite extensive (Bovy and Stern, 1989; 1990; Steg, 1996; Rothengarther and Carbonell Vaya; 1997, Stern, Bovy and Tacken, 1998; Van Reisen, 1997; Timmermans and Van der Waerden, 1998, and many, many others). It is beyond the scope of this thesis to list all available research knowledge about the medium-term and short-term activity-travel choices.
However, we will shortly discuss some of the results of an interesting comparative study of Dutch and California time use data by Kitamura et al. (1992a, 1992b): a research project about the medium-term activity-travel choices. The primary objective of this study was to gain a more fundamental understanding of activity-travel behaviour by examining individuals' time use and comparing time use patterns across individuals who reside in these two different travel environments. The data used in this study includes data of a nation-wide US sample of 3,047 respondents, a random Dutch sample of 2,964 respondents and a Californian sample of 1,564 individuals. Some interesting results are shown in table 3.2.3.

Table **3.2.3** Average time spent per day for paid work, domestic work, and travelling in minutes

		Weekdays			Weekends		
		NL	California	USA	NL	California	USA
Paid work		167	247	230	28	95	89
Female	Working	350	439	438	278	325	368
Male	Working	469	453	463	287	419	369
Domestic work		160	110	112	136	124	125
Female	Working	136	73	82	119	97	84
	Not working	244	195	163	166	165	148
Male	Working	49	38	58	62	45	58
	Not working	138	146	132	106	114	135
Travel		69	96	85	64	107	90
Female	Working	71	90	90	57	106	96
	Not working	56	70	73	59	100	86
Male	Working	89	125	94	72	116	98
	Not working	67	95	85	71	111	89

source: Kitamura et al, 1992

First of all, it can be said from the table that the average total time expenditure on paid work by males on weekdays is virtually identical for all three data sets (about 8 hours). Females expend less time on paid work than males (especially during weekdays), and the differences between the Netherlands and the USA are quite significant. The lesser amount of time spent on paid work by Dutch females is compensated by larger amounts of time on domestic work during the week.
Californians spend a higher amount of time travelling than the average American or Dutchman. Dutch respondents overall spent less time travelling on weekend days than on weekdays, while both the California data and the US data show greater overall average time expenditures on weekend days, with the only exception of working Californian males. This tendency suggests the presence of significantly different weekend time use patterns between the Netherlands and the United States. It reflects the institutional factor of more restrictive opening store hours in the Netherlands in the weekends, but it also indicates the higher labour force participation of women in the United States, which tends to push domestic work and other activities to the weekend leading to more travel on weekend days.

3.2.3 A reserved mobility lifestyle as a cultural challenge

The increase in mobility in general and specifically the large increase of individually motorised transport has lead to many significant (societal) problems of different nature. People have taken an increased claim on the physical and social environment (Vlek, 1999a). This individually increased claim on the environment has gradually become a socially accepted fact. In the scientific field of traffic and transport research (Van Wee, 1999), more and more questions arise about the negative consequences of today's societal rate of mobility, and the degree of mobility a society as a whole should look for: where does the optimum lie between (societal) costs and benefits of mobility?

It is interesting to discuss whether mobility needs should be considered as relative or absolute needs (Van Wee, 1999). Absolute needs are things such as a place to live, clothing, food and drink. Relative needs come from the fact that people want to distinguish themselves in a group (status etc.). Nowadays, the car satisfies for many people absolute needs besides relative needs. By the way, car ownership and car use of someone who lives in a rural area will most probably be more oriented at the absolute needs than of the inhabitants of a metropolis. If there are indeed absolute car needs in our society –for example because of the spatial organisation- it is not hard to understand that people or specific interest groups arise against governmental measures such as congestion pricing.

In recent history, social scientists (Ministry of Economic Affairs, 1997) have focused in a slightly different context on (i) groups that showed reserved consumption patterns, (ii) the way this reservation diffused in society, and (iii) the conditions under which this diffusion could take place. An important starting point is the social stratification of the population of consumers. Most of the time, it is the rich –the groups of high status- that are in the (financial) position to use most goods and services, and thus also to pollute most. At the same time, this is the group that has the possibilities and possibly the motives to be reserved in their consumption behaviour. Those who are affluent, indeed have the choice to cut down on consumption.

Behavioural standards can diffuse in society in different ways. According to Bourdieu (1979) the success of reserved behaviour is the presence of a so-called cultural elite. The cultural elite determines 'good taste' (via the trickling down principle). However, other researchers (Blumberg, 1974) have shown that the diffusion of trends can also take place from the lower layers of society upwards (via the percolating up principle). Many things in society –for example fashion- is determined by the youth.

A second condition of success for reserved behaviour is the fact that people who have to change their behaviour are dependent on people who want to change their behaviour. A third condition is that the reserved behaviour somehow offers advantages for people who have to change. And finally the reservation should not contradict governmental policies.

The reduction of the mobility of people at the short term can be considered both improbable and impossible: it seems that in most societies in the world it is culturally determined that economic growth –whether sustainable or not- is at the top of the priority list of governments (Ministry of Housing, Physical Planning, and Environment, et al., 1997). History has shown that the relation between the growth of mobility and the growth of the economy is evident (Schafer and David, 1997; Schafer, 1998). As long as these collective concepts about the growth of the economy exist in the governmental policies, it is the duty for the designers of our physical society -the urban planners and designers, and the traffic and transport engineers- to accommodate and facilitate the growing demand for transport as sustainable as possible. Besides, there is no cultural elite: the possession of a car still gives status, and the people are not dependent on the public campaign makers of for example the reduction of car use. The car industry and its commercials in fact run a campaign against reserved mobility behaviour.

Finally, the collective disadvantages of mobility do not lie in the scope of most people, but they do experience the individual advantages. This contradiction can be considered to be a so-called commons dilemma (Vlek, 1999a).

3.3 Activity-travel scheduling

The previous section showed the hierarchy of activity-travel choices. The aim of this section is to describe in greater detail *how* individuals make decisions regarding their activity-travel behaviour: the activity-travel scheduling process. The problem of activity-travel scheduling and implementing daily activities represents a complex decision making problem in which individuals have to develop a strategy for realising their needs and preferences within a particular space-time and institutional setting (Timmermans and Van der Waerden, 1998).

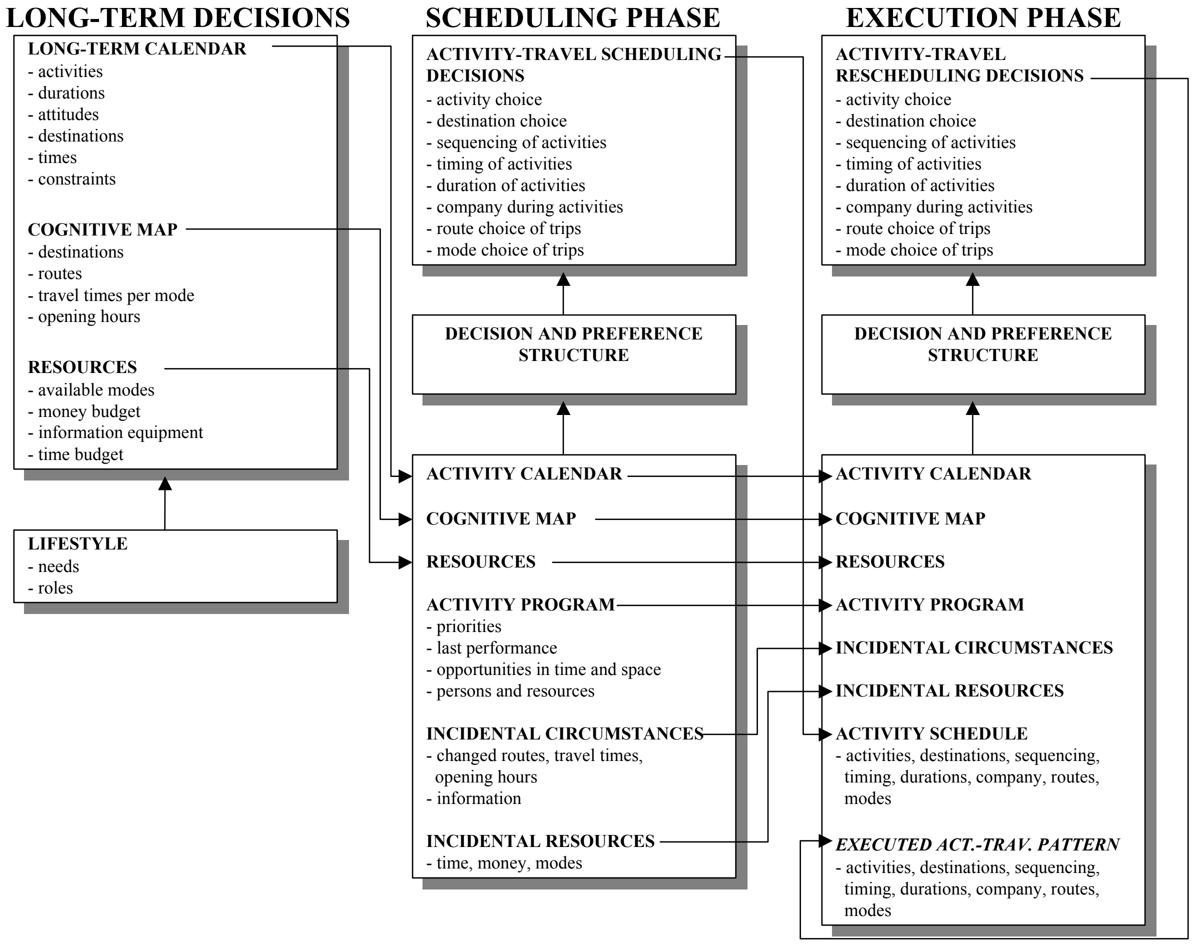


Figure **3.3.1** A theory of activity-travel scheduling behaviour and activity-travel patterns source: Ettema, 1996

Activity-travel patterns therefore can be considered as the outcome of the interplay between individual preferences, and the opportunities and constraints induced by specific spatio-temporal settings within the institutional context. In order to give an extensive overview of the activity-travel scheduling process, a scheme (figure 3.3.1) created by Ettema (1996, page 14) is discussed in the next three subsections. Long-term decisions, the scheduling phase, and the execution phase are described successively.

3.3.1 Long-term decisions

Lifestyle decisions influence the activity and travel behaviour of an individual over a long period of time. They particularly influence someone's *long-term activity calendar*, which contains general information regarding activities that an individual performs with certain regularity. Information can be stored about for instance the average duration of an activity, the attitude towards an activity, the frequency at which an activity is performed, the available destinations and times at which an activity can be performed. Also constraints (see section 3.1.2 about Hägerstrand's constraints) can be incorporated in the calendar. Calendars are household specific to allow for the fact that depending upon household composition, lifestyle and possible other variables, different individuals and households will be involved in different sets of activities.

As the executed activity-travel behaviour patterns are induced by specific spatio-temporal settings, it is relevant to define the cognitive environment. Based on limited and perhaps imperfect information, individuals will not necessarily be completely familiar with the spatio-temporal settings, for example the opening hours of a shop, all possible destinations to perform a certain activity, all available routes, etc. Knowledge about the environment is stored in a *cognitive map*, a memory representation that individuals have from their environment.

As a third, long-term lifestyle decisions affect a household's *resources*, which enable a person to perform in any activity. With the increasing developments in ICT, information has become also a resource. Hence, whether or not to buy a computer with Internet connection or TV can also be considered as a long-term mobility decision.

3.3.2 Scheduling phase

With respect to the factors affecting the activity-travel scheduling process, we distinguish between general conditions that remain stable over long periods (long-term calendar, cognitive map, and resources), and conditions that hold specifically for the day for which the schedule is made.

The calendar of activities defines the set of household and individual activities that need to be executed within a particular time horizon. Daily activities will be drawn from this calendar. This can be defined as *the activity program*. It consists of all those activities that are planned to be executed during a particular day, and their attributes that refer to this specific day. *Priorities* may differ from day to day, *special opportunities* may occur. Circumstances that differ from the average circumstances (congestion due to traffic incident, breakdowns in the public transport system, etc.) are termed *incidental circumstances*. It should be noted that information equipment plays an important role in acquiring information about incidental circumstances (radio, tv, Internet). Finally, it should be noted that *resources* might change from day to day. If no vehicle, money, or time is available, it will be hard to make a trip.

One particular aspect of an activity program –or that results from a activity program- concerns the *activity schedule*. The activity schedule concerns the sequencing and timing of the activities of the activity program. It should be remembered that individuals might also be involved in unplanned activities. The actual set of activities that is implement may differ from the program and schedule. The actual, realised activities are referred to as the *(executed) activity-travel pattern*.

3.3.3 Execution phase

An activity schedule that has been planned, has of course to be executed in reality. During this execution phase, an individual continuously has to decide whether to execute the activities as scheduled or to adjust and reschedule them in response to unforeseen and unexpected circumstances. Decisions to adjust the schedule are termed *activity-travel rescheduling decisions*. Similarly to activity-travel scheduling decisions, activity-travel rescheduling decisions are made subject to the same factors, such as the long-term calendar, the cognitive map, the available general and incidental resources, the activity program, and the incidental circumstances. However, the performance of activities and the decision whether to reschedule also depend on the outcome of the scheduling phase, that is, the activity schedule. For instance, someone working on a tight schedule may need to reschedule more than someone working on a less tight schedule.

There are several possible reasons why individuals may decide to divert from their original schedule. First, the experienced outcome of scheduled activities and trips may give rise to changes in the scheduled next activities (for example if an activity takes longer than expected). Secondly, (new) outside information regarding changes in the travel and activity environment or the activity program may change plans: information about congestion on the road network may lead to new scheduling choices. Thirdly, a person's motivation and attitude may have changed internally: when it starts raining, a person may decide to do not leave his house at all. Finally, one's physical condition may be a reason to adjust the schedule: getting a sudden headache may prevent one from going out.

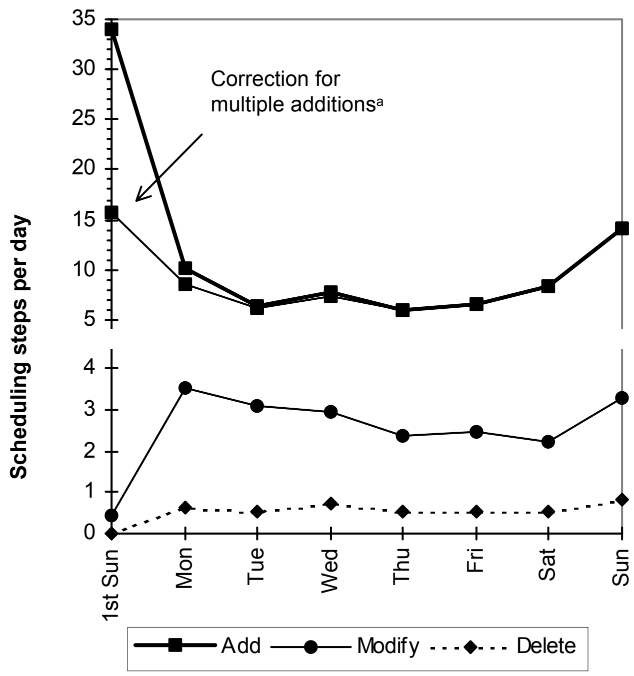
It should be noted that the rescheduling phase is a part of the scheduling process as a whole, representing continued modification to an ongoing schedule. Once a schedule is changed, this will result in a *revised schedule*, which in turn is subject to the same monitoring process and may be further adjusted. What results in the end is a *revealed activity-travel pattern of executed activities and trips* which may be different from the one that was originally planned. The impact of an SMM system on the (re)scheduling possibilities of an individual traveller will be point of discussion in section 3.4.

3.3.4 CHASE survey

In line with other research about activity-travel scheduling -for example the Household Activity-Travel Survey (HATS) of Jones et al. (1983)- Doherty (1997, 1998) has researched how households schedule, reschedule, and execute their activity programs in the period of one week (from Sunday to Sunday). He used the so-called Computerised Household Activity SchEduling survey (CHASE). Doherty says: "Household activity scheduling has become a topic of considerable interest for travel behaviour researchers. Activity scheduling embodies the interdependent decisions made about which activities to participate in, when, where, for what duration, with whom, and by what mode and route. Past research has mainly focused on the modelling of each of these aspects in isolation, while more recent efforts have attempted to harmonise these decisions into more comprehensive modelling frameworks. Despite the need, very little fundamental research has been conducted into the underlying scheduling process in support of these models. The CHASE survey approach attempts to fill this gap. The CHASE program is unique in that it runs on a laptop computer within a household for a week long period during which time all adult household members login daily to record their scheduling decisions as they occur (including choices to add, modify, and delete activities)."

Figure 3.3.2 shows that after the First Sunday, adults make about 8 additions, 2 modifications, and 1 deletion per day during the execution of their schedule over the course of the week.

These steps were taken to complete their schedules, which include an average of 12.4 activities and 4.9 trips per adult per day.



Note the difference in scale at the break.
[a] Multi-day activity additions (e.g. add work Monday-Friday) considered as single addition decisions.

Figure **3.3.2** Scheduling steps per adult per day, by entry day
source: Doherty and Axhausen, 1998

Figure 3.3.3 shows that the scheduling decisions applicable to each day are made on various time horizons. Outside of the routine activity additions made on the first Sunday (38% overall), a substantial proportion of additions are scheduled impulsively just before execution (28% overall), on the same day (20% overall), or are planned one or more days in advance (15% overall). The amount of pre-planning differs by day of the week. Most notably, more impulsive additions decisions occur on Saturdays, whereas more "day of" decisions are made on Sundays.

Modification decisions exhibit a significantly different pattern from additions. The vast majority tend to be made impulsively (62% overall), compared to on the same day (24% overall) and planned more than a day in advance (14% overall). This pattern is fairly consistent across the days of the week, as shown in Figure 3.3.2. Compared to modifications, more advanced thought appears to be put into deletions as a higher proportion are made on the same day (38% overall) and a lower proportion made impulsively (41% overall).

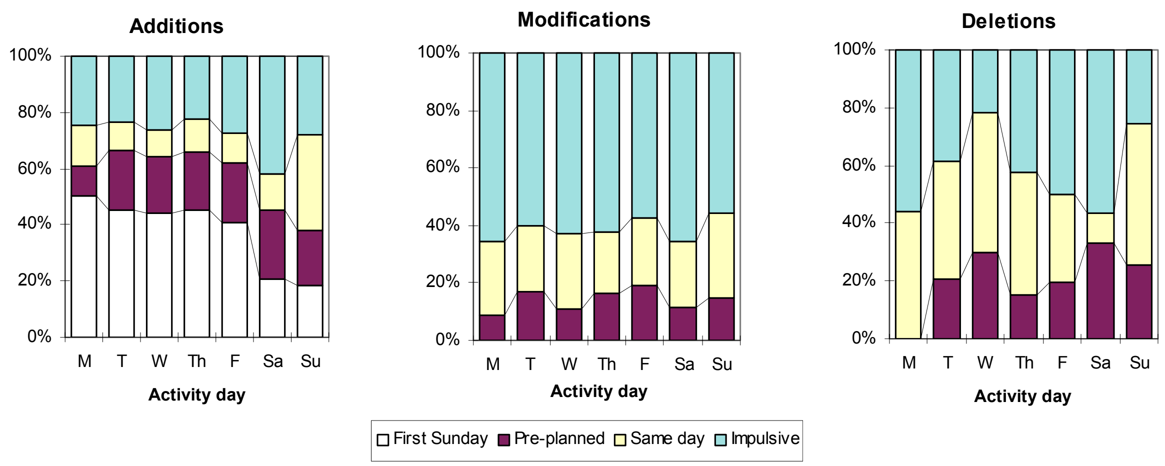


Figure **3.3.3** The proportion of additions modifications, and deletions made for each day, by when they were planned
Source: Doherty and Axhausen, 1998

Figure 3.3.4 shows in three dimensions the distribution of activity additions planned on one day, by the activity day they are planning for (exclusive the first Sunday, which is shown in Figure 3.3.2). It clearly shows that in addition to pre-planning for the next day (62% overall) people also reach out and make additions on future days as the week progresses (38% overall), in an opportunistic fashion.

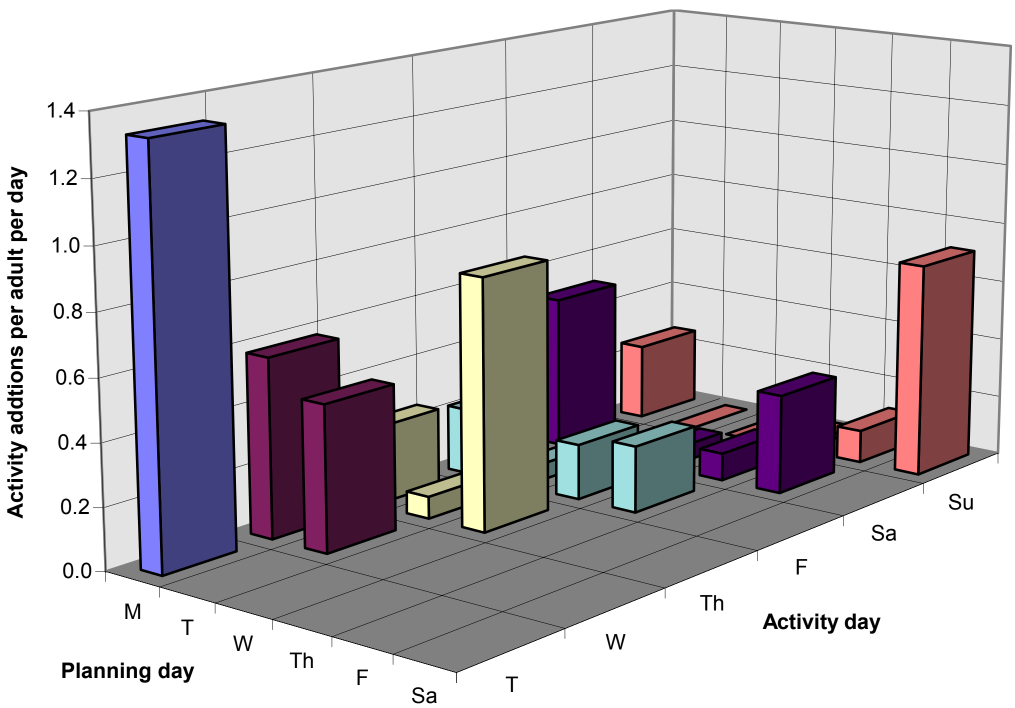


Figure **3.3.4** Pre-planned activities (exclusive of first Sunday) by planning day and activity day
Source: S.T. Doherty, et al., 1998

This evidence strongly suggests that activity scheduling is a dynamic process reflecting continued addition and revisions to a schedule over time. Scheduling represents a mix of routine followed by continued pre-planning and impulsive decisions made over the course of the week. This differs substantially from the notion that activities are planned and carried out in sequence all at once. Thus, if the goal is to develop a behaviourally sound model, then a dynamic model is needed - one that can simulate the fundamentally different types of decisions that occur over time.' (Doherty and Axhausen, 1998)

3.4 Conceptual model of the adoption of seamless multimodal travelling

The previous three sections focused on the fundamentals of activity-travel behaviour research. This section conceptualises the adoption of seamless multimodal travelling. Seamless multimodal travelling is gaining acceptance for a variety of reasons. In particular, it is being discussed as a congestion and space consumption mitigation strategy (Ministry of Transport, 1998; TRAIL, 1999). An important question for transport planners and policy-makers is: given that seamless multimodal travelling appears to have positive impact on the decrease of space consumption and congestion, how will people adopt SMM in their activity-travel behaviour? This section conceptualises this specific adoption process. At the end of this section some consequences of an SMM system are discussed in relation to the activity-travel (scheduling) behaviour.

3.4.1 Key concepts

The proposed conceptual model about the traveller's choice whether or not to adopt seamless multimodal travelling is presented in the next section. Now, it is useful to give a brief description of the choice context, including a discussion of some of the basic terms used in the model. First, a distinction is made between two types of factors in the individual choice process: facilitators or constraints, and drives (Mokhtarian, 1995).
A *facilitator* is a factor which allows or enables a (change in a) specific kind of behaviour, or makes the (change in the) specific kind of behaviour easier or more effective. A *constraint* is a factor that hinders or prevents a specific kind of behaviour or change in behaviour. The same factor may be either a facilitator or a constraint, depending whether it is present in a positive sense or a negative.
A *motivator* or drive is a factor that actually motivates a person to consider a specific kind of behaviour or a change of it. Note that these terms apply to many types of behaviour or changes in behaviour; the particular behaviour we are interested in here is the decision with respect to the adoption of seamless multimodal travelling.
The presence of facilitators increases the probability of adoption, given the initial drive to consider it. Without that drive, facilitators are assumed to have no effect. The presence of constraints decreases the likelihood of adoption.

The motivators for a seamless multimodal mobility system can be divided into two aspects: the 'multimodal-aspect' and the 'seamless-aspect'. The 'multimodal-motivator' should be seen as space consumption, pollution, and congestion mitigation strategy. A better connectivity and synchronisation of both collective and individual means of transport can lead to a more effective and efficient use of the vehicle fleet.
The 'seamless-motivator' should be seen as a strategy to give an answer to the growing diffusion of travel demand and consumer preferences of individual travellers. For example, demand-responsive transport systems - defined as the commercial supply of a travel service directly referring to an explicit demand of a client, the traveller (Rooij and Tacken, 1999) - can cope directly with these individual demands. Moreover, information and communication

technology will offer the traveller the opportunity to obtain real-time, dynamic multimodal travel information about delays, travel alternatives, transfer possibilities, and costs.
The most important group of facilitators (and at the same time constraints) for the SMM system are the present individual and collective transport subsystems. At the moment, the car system offers the traveller the possibility of a very convenient door-to-door trip, without a transfer at windy stations and without long waiting times. But it is a system with increasing congestion and with increasing car access restrictions for both city centres and freeways.
The public transport system offers mass transit services which, quite often, do not cope with the individual needs of the traveller. There are few possibilities for the traveller to influence his/her destination, route, or what so ever during the trip.

Why is it important to distinguish between motivators, facilitators, and constraints? One reason is: to the extent that multimodal travel is considered a useful transport strategy, policies supporting seamless multimodal travelling are being and will continue to be developed. These policies likely include measures to remove or reduce external constraints, and/or to enhance facilitators. If it is (falsely) assumed that the presence of constraints (or the lack of facilitators) is the only thing preventing people from adopting seamless multimodal travelling, then the effect of removing those constraints (or providing those facilitators) will be overestimated. That is, having no binding constraints is only a necessary, not a sufficient, condition for seamless multimodal travelling. Secondly, most people are driven by a combination of factors to behave the way they behave. However, those factors will be weighted differently for different people.

3.4.2 Decision context

As an approach to understand the decision process of the adoption of SMM, the following structure is suggested (based on Salomon, 1997) (figure 3.4.1). An individual is exposed to an environment which defines the context within which one can act (perform activities and travel to activity places) and which includes facilitators and motivators. The environment includes technological, economic, cultural, and political facets. The individual is also subject to numerous constraints, some of which are long-term or permanent and others may be temporary. Within this environment and these constraints, the individual, shown as the black box, can make his choices.

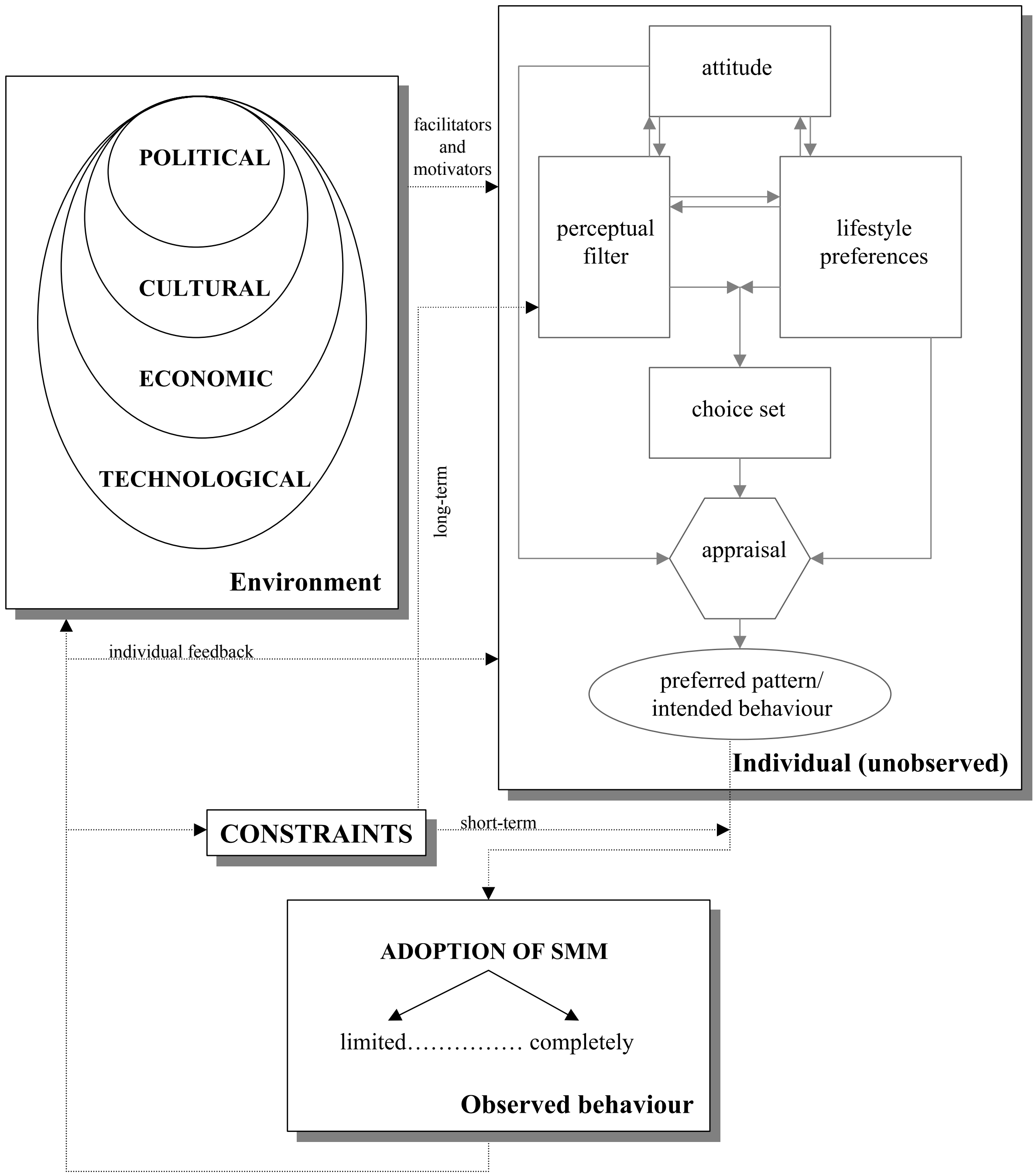


Figure **3.4.1** A schematic model of the seamless multimodal travelling decision context

There is a dynamic aspect to this structure, as indicated by the dashed arrows in the figure. Actual behaviour provides experience and new information that may lead to an alternative choice when the situation arises again. The feedback mechanism acts on all elements described above. The changes in many individuals' behaviour may change the environment. And the changes may alter the constraints and they may affect the individual's perception of the choices.

A major objective is to penetrate the black box and suggest a plausible explanation for the process occurring there. The black box, it is hypothesised, consists of five relevant entities, shown schematically in the figure 3.4.1. For the sake of simplicity the underlying dependence among perception, attitudes and lifestyle preferences, which are shown in the next figure (3.4.2), have been omitted. Below each of the five components is discussed.

An *attitude* has been defined as the individual's long-term evaluation of performing a particular behaviour. Attitude therefore is an inward oriented characteristic of a person, related to his or her own norms and values. Two types of attitudes can be identified: cognitive and affective. Cognitive attitudes are 'facts', as viewed by the individual.

Travel time, for example, registered in one's cognitive map is a product of information received from the environment, and the cognitive attitude. Affective attitudes express the individual's (dis)liking. For example, two persons who are travelling by train will differ in their feelings towards this modality of transport: one may value the train system positive, because of the possibility it offers for working and reading, while another will value it negative because of the lack of privacy.

The *perceptual filter* acts on the information received from the environment. The filter may block some information, or may distort information that is entered. The output of the filter is a cognitive map of the environment, in terms of facilitators, constraints, and views, which may or may not correspond with the 'objective environment': a subjective view at the reliability, availability, and suitability of the main characteristics of the SMM system.

Important characteristics of the SMM system are among others (door-to-door) travel time (reliability), the transfer (spatial and functional organisation), the transfer time and the frequency of transport services (temporal connectivity between networks), car access of transfer points (spatial connectivity different networks), the location of transfer points in the city (suitability), actual and precise information for the traveller and the way in which this information is communicated towards the traveller (technology availability), and the safety of the SMM system as a whole (suitability). The perception of the traveller of these characteristics are essential to get SMM into the choice set of the traveller.

Lifestyle preference is, as we have already seen in the previous sections, the long-term, strategic preference towards travelling an individual has formed. A lifestyle that an individual aspires to maintain can be viewed as a policy which guides his short-term decisions. The actual choices may depart from the lifestyle policy, due to short-term constraints or other short-term contextual factors. But in general coherence between the short-term and long-term choices can be expected. In contrast with personal attitudes, lifestyle drives can be seen as an outward oriented characteristic of a person. Talking about lifestyles we have to make clear that the diversity and variety of lifestyles nowadays is larger than ever and more transient than ever, which makes it very hard for scientific research to cope with.

The *choice set* comprises those options recognised by the individual as possible, not necessarily desired, courses of action. It is a subset of the 'universal set' of travel alternatives.

The *intended behavioural patterns* are a set of patterns that remain at the end of the screening by the previous elements. In the absence of constraints (or impulsive responses), the actual observed behaviour will be identical to these preferred behavioural patterns.

An SMM system has a lot of system characteristics that are quite different from today's transport systems. Therefore, SMM has the potential to change existing trip and travel patterns of people drastically. The next section discusses the impact an SMM system can have on the activity-travel scheduling possibilities of people.

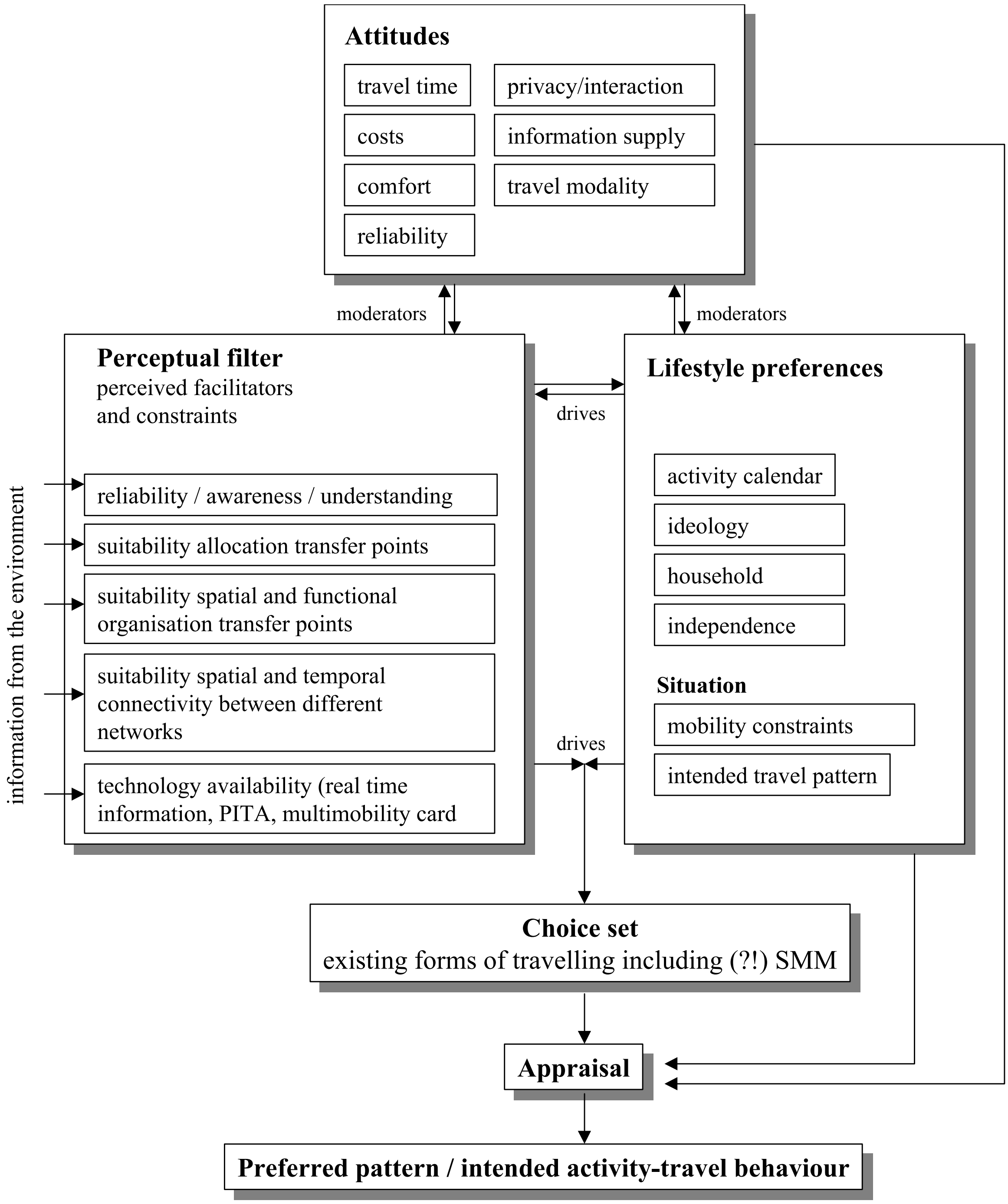


Figure **3.4.2** A schematic model of the internal decision making process

3.4.3 SMM: impact on activity-travel (scheduling) behaviour

Seamless multimodal travelling has the potential to gain acceptance widely because it combines the 'good' characteristics of the different transport modalities, both individual and collective, within a ubiquitous information environment. SMM increases the number of possible activity-travel choices and (re)scheduling options for the individual traveller, and therefore the flexibility of the transport system as a whole. Thanks to actual and dynamic transport network information about travel times, delays, costs, congestion, etc., the individual traveller has the opportunity to know exactly which travel alternative applies best to his personal demand. And the best travel alternative for a specific trip today, can be different from the best alternative for the same trip tomorrow. And the individual traveller can know! In potential, changes in the individual's activity agenda could be adapted quite easily, because of the time-space flexibility the transport system offers.

Future research will have to give answers to questions like whether (i) the travellers will really make use of these expanded (real-time) information services that increase their potential scheduling flexibility, and (ii) to what extent. It can be imagined that, when travellers can acquire all kinds of (relevant and/or irrelevant) information, they will find themselves in an information overflow and therefore will not use any information at all.

SMM perception

Whether SMM will have or gain a strong position within the (mental) choice set of the individual traveller will depend strongly on how the system is perceived - its reliability, its suitability, and its availability (figure 3.4.2 refers) - in both time and space. The individual perception about the suitability of SMM predominantly concerns (i) the allocation of transfer points within the urban field and along the transport network (see chapters 7,8, and 9), (ii) the spatial and functional organisation of transfer points (architectural layout) (Van der Spek, 1998; Daamen, 1999), and (iii) the spatial and temporal connectivity between the different networks (Van der Spek, 1998; Goverde, 1999; Soto Y Koelemeijer, 1999; Van Egmond, 1999). Secondly, the perception of the technology availability plays a major role in whether SMM will become part of an individual choice set, especially the actual, dynamic information about all travel alternatives (Van der Vark, 1999).

The perception of the reliability of a transport system will be discussed in a little bit more detail. To explain the relationship between the transport system's reliability and the travel behaviour of individuals, distinction has to be made between different kinds of 'reliabilities' (Rooijers, 1997).

- ☞ **objective reliability**
  the chance that a trip can be made with the travel time, costs, and level of comfort, that were (contractually) promised by the transport provider.
- ☞ **subjective reliability**
  the perceived chance that a trip can be made with the travel time, costs, and level of comfort, that the traveller expects.

The relation between the objective and subjective reliability, and the individual travel behaviour is quite clear. When a traveller expects - objectively or subjectively - to get a certain type of product (read: trip), it will be a disappointment when the actual product doesn't meet his or her expectations. Next time, there is a chance that he or she might go searching for other travel alternatives. The transport alternative that couldn't meet the traveller's expectations might be excluded from the choice set.

- ☞ **image reliability**
  A certain modality of transport can have a reliable or unreliable image (ignoring the degree of objective/subjective reliability for a specific trip). A transport modality might be excluded from an individual traveller's choice set because of such an unreliable image.

☞ **experience reliability**
If there is little variation in performance[2] of a transport system or modality, then the traveller will value such a travel alternative as highly reliable: he or she *knows the quality of the product*.

If there is large variation in performance, but the predictability of that variation is large as well, then the traveller will value such an alternative also as reliable: he or she *can predict the quality of the product* precisely.
If there is large variation of performance and the predictability of that variation is low, the traveller will value the system as unreliable: he or she *won't be able to predict the quality of the product*. There is a great chance that the traveller will exclude such a transport alternative from his or her choice set.

SMM Network City

SMM adds a new kind of (i) physical network design with intermodal transfer points and (ii) an organisation, information, and financial service network that links the existing (separate) collective and individual transport modalities both physically (intermodal transfer points) and virtually (information, organisation and financial services) to the network city. Seen from an angle of urban technology, an 'urbanism of networks' seems to be the right avenue of search for the impact of the SMM system on (i) changes in the time-space behaviour of travellers and (ii) on new spatial planning concepts (Section 1.7 and Chapter 5 refer).
SMM will be of relevance for the patterns of all three networks. However, central focus in the project 'Design of personal travel services' will be on changes at the third level, the personal level, the level of the patterns of use of the individual travellers/households. Therefore, the empirical part of this thesis efforts will be directed at the (i) changes of time-space behaviour (action space, activity and trip patterns) of users of SMM systems 'avant la lettre' and (ii) action spaces with a high potential for multimodality.

Present and future activity-travel behaviour

Figure 3.4.3 shows a picture how the role of an SMM system should be interpreted within the activity-travel behaviour of people. It says that the changes in future activity-travel behaviour originate from three main factors.
the present main variables and main spatio-temporal conditions that explain the present activity-travel behaviour of people will be different in the future (e.g. the demographic, institutional, political context) and may change due to the introduction and eventual adoption of SMM;
the demand side of the activity-travel behaviour of people, i.e. the desired activity program and activity calendar, will be different in the future (e.g. the technological, economic, cultural, political context) and may change due to the introduction and eventual adoption of SMM;
the supply side of the activity-travel behaviour of people, i.e. infrastructure, travel services, transport modalities, Information and Communication Technologies, etc. will be different in the future and may change due to the introduction and eventual adoption of SMM.

[2] Performance: for example travel time, level of comfort, cost-quality ratio, etc.

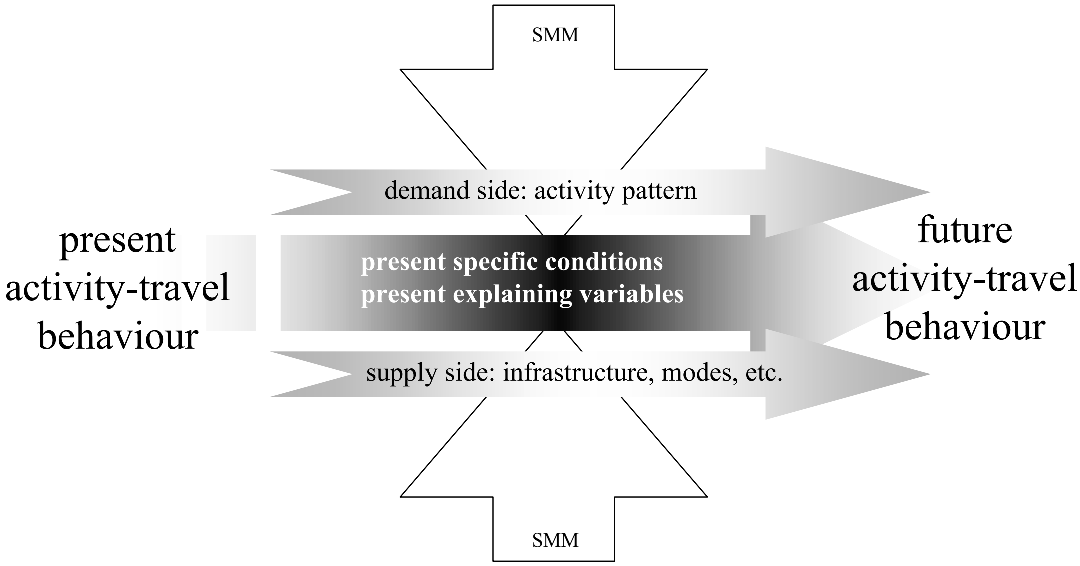


Figure **3.4.3** The impact of SMM on the future activity-travel behaviour of people

For human beings it is impossible to predict the future. So, the same applies for the prediction of future activity-travel behaviour of people. However, desirable, possible and probable futures can be constructed. It should be noticed that the three factors mentioned are interrelated to a large extent. In the prediction of the future activity-travel behaviour, the influential capacity of one factor on the other two cannot and should not be forgotten: developments of one factor will directly influence the development of the two others.

3.5 The laws of activity-travel behaviour

The essence of the 'theory of planned behaviour' and 'the NOA-model' as described in section 3.1 is that behaviour should be seen as the result of reasoned choices of people. However, activity-travel behavioural research has shown us that policies that are made from the viewpoint of these kinds of theories have only limited success (Tertoolen en Weggemans, 1998). As a final input for this chapter, we will discuss 10 lessons of activity-behavioural research defined by Tertoolen and Weggemans.

Lesson one

People have the tendency to maintain present behaviour that is well known, that they trust, and that is satisfactory.
For many people this is the easiest and most efficient way to organise daily life. People trivialise the negative aspects of their own present behaviour, and they judge behaviour alternatives worse than they objectively should en could be doing. Behaviour becomes habitual behaviour if the behaviour lacks certain reasoning and planning (Garling, 1998). Habitual behaviour develops when a specific kind of behaviour is repeated often and is experienced as pleasant.

Lesson two

Attitudes can change behaviour, as behaviour can change attitudes.
People cannot only change their behaviour according to their attitudes, but are also capable of adapt their attitudes towards their behaviour. It is in the human nature to reduce the gap between attitudes and behaviour: the so-called reduction of cognitive dissonance (AVV,

1998I). If people are tempted to try a new kind of behaviour and this kind of behaviour is satisfactory, then the attitude of people towards this behaviour will most probably change in a positive way.

Lesson three

People can come up with many reasons why knowledge that they possess does not and should not necessarily lead to changes in their behaviour.
People are capable of strengthening their self-image, without any changes in their behaviour, via mechanisms of -for example- self-justification (Steg, 1996), reduction of cognitive dissonance, and transferring responsibilities to others (Van Lange, 1991).

Lesson four

The behaviour of people is part of a behavioural pattern.
Both attitudes and behaviour of people are part of individual lifestyles. Behaviour nor attitudes can be changed very easily (Ettema, 1996, Jones et al, 1983, Batenburg and Knulst, 1993).

Lesson five

People pay attention to what their environment tells them.
Social networks and social norms influence individual opinions, attitudes, and thus the behaviour of people to a large extent. People adapt their behaviour to what is considered to be ‘normal’.

Lesson six

People listen selectively.
People neglect messages, when a specific message does not lie in line with the individual world of thinking, or contradicts personal interests (Steg, 1991).

Lesson seven

If people consider a measure to be unjustified, they are capable of using this measure as a reason to maintain their present behaviour (Tertoolen, 1994).

Lesson eight

In general, people have a positive opinion about their own behaviour.
People estimate that their own behaviour is better (more environment friendly, more reasonable for others, etc.) than average. AVV (1998I) speaks from illusory superiority. As a consequence, ‘others’ have to change their behaviour first, according to most individuals.

Lesson nine

People should have the feeling that they are capable of performing desired behaviour.
This is especially a subjective feeling about the own individual capacities. People have to believe that they can change their behaviour and that this change is relevant.

Lesson ten

People have central and less central attitudes.
This has to do with the individual and internal hierachy of norm and values of a person. The most central attitude will win, when a specific kind of behaviour is desired by the one attitude, and not desired by another attitude.

3.6 Summary and conclusions

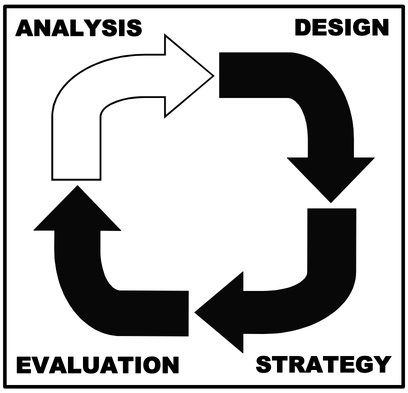
As a second part of the analysis phase of the planning cycle, this chapter added insights in the background of reasons why people travel as they do. From the theories of activity-travel behaviour we can learn that the perception of individuals is one of the most important, maybe thé most important factor that determines if, how, and when people travel. Therefore, multimodal passenger transport will only gain acceptance widely if both the objective performance (travel time, costs, reliability, safety, etc.) and the subjective performance (image, social safety, etc.) are perceived positively.
The conceptual model of the adoption of Seamless Multimodal Travelling presented in this chapter interrelate the perceptual filter of a person, his or her attitudes, and his or her lifestyle preferences. What results is a (activity-travel) choice set that leads to a preferred or intended activity-travel behaviour.
What also becomes clear from behaviour research is that the mobile person is to a large extent 'an habitual animal'. If a certain kind of (activity-travel) behaviour satisfies, there needs to be a so-called 'disaster' to have him or here change this specific behaviour. A lot of activity-travel behaviour is simply not reasoned.

There are several ways to put into operation, to analyse, and to visualise activity-travel behaviour patterns. The next chapter elaborates extensively on the 'action space' way of thinking, as already briefly referred to in section 1.2.3.

CHAPTER FOUR ACTION SPACE

Patet omnibus veritas.

The truth is accessible for everybody.
Seneca, Epistula Morales, no. 33



The previous chapter discussed several activity-behaviour theories from different fields of interest. The objective of this third chapter of the analysis phase is [i] to present the social-geographical theory of action space, and [ii] to discuss the impact of SMM on the action space of people. The action space theory has its foundations in the activity-based research school, and approaches activity-travel behaviour integral from the viewpoint of both the individual traveller and the environment, in which he or she travels. The name **action space** *resembles exactly what the theory stands for. On the one hand,* **action** *refers to (i) performing activities and (ii) the action of travelling. On the other,* **space** *refers to the context, the spatial environment, in which the performing of activities and the travelling takes place.*
Before discussing the concept of action space and the action space model in section 4.2, section 4.1 starts with introducing the concepts of reach and accessibility, which we will need in order to understand what the action space model offers and especially does not offer. Section 4.3 dives into the history of the activity-travel behaviour of people and shows how action spaces have grown and have had the opportunities to grow during the last centuries in general, and especially during the last decades. Section 4.4 looks into the future and discusses how ongoing developments in transport (SMM) and communications (ICT) have the potential to influence the action space of people in the coming years. Finally, this chapter ends with a short summary and the main conclusions of this chapter.

4.1 Reach and accessibility

The possibilities to visit out of the home activity places, can be described in two ways: from the point of view of persons and from the point of view of activity places, which respectively refer to the *reach of people* and the *accessibility of places* (Dijst, 1995b). Dijst defines the notions of reach and accessibility as follows:

☞ **Reach** is a personal characteristic. It refers to the area, within which a number of activity places is located, which a certain person can choose as destination, against acceptable (time) costs.

☞ **Accessibility** is a characteristic of an activity place. It refers to the area, within which a number of persons is situated, who can choose that specific activity place as destination, against acceptable (time) costs.

The definition of reach by Dijst focuses on the size of the area. This results in his conclusion that the reach of person A is the same as the reach of person B, and that the reach of person A and B is larger than reach of person C (figure 4.1.1). It should be notified that others (e.g. Hakkesteegt, 1993) have defined reach according to the number of activity places within reach, and (thus) not according to the seize of the area (then the reach of person A would be larger than the reach of person B, and the reach of person B would be the same as the reach of person C). Dijst however focuses on the *possibilities to travel* and to participate in activities. These possibilities are influenced by the time-space characteristics of the activity-travel patterns of people and their environment. So, the boarder of the physical space, where to someone is able to travel, marks the reach of a person.

The author here would suggest that both the seize of the area and the number of activity places define the reach of people, for people have both an interest in (1) the distance travelled and time spent on travelling this distance, and (2) the number of opportunities they have for fulfilling their demand within their time and money budget. So, if time budgets are the same, the reach of person A is larger than that of person B, and the reach of person B is larger than that of person C (figure 4.1.1).

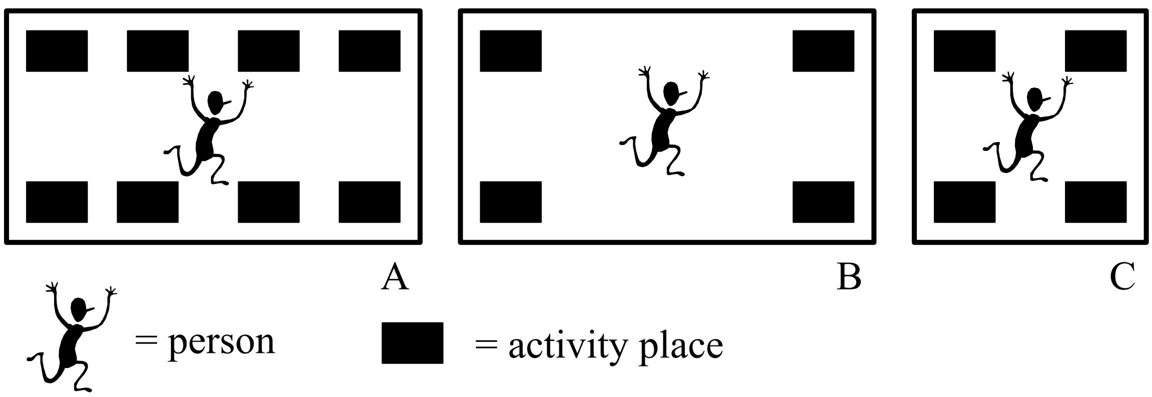


Figure **4.1.1** The reach of person A, B, and C
Source: Dijst, 1995b

4.2 Action space model

It is desirable to use an integral approach of (i) the reach of people and (ii) the use of activity places, when the activity-travel behaviour of people is looked at and analysed. Such an approach incorporates not only the characteristics of the time-space context, but also the structural characteristics of activity and travel patterns. The action space model offers such an approach.

In discussing the action space of people, Dijst (1995b) distinguishes *actual action spaces* and *potential action spaces*. An actual action space refers to the area which does include the activity places which an individual or a group of individuals *have visited* during a certain period of time. A potential action space refers to the area which could include the activity places which an individual or a group of individuals *might visit* during a certain period of time.

The concept of potential action spaces primarily is the operationalisation of the concept of reach as has been defined in the previous section. From a theoretical viewpoint, using the concept of potential action spaces is more favourable than using the concept of reach. The term *action space* comes very close linguistically to the meaning of the activity-based research approach. The name action space resembles exactly what this theory stands for. On the one hand, *action* refers to (i) performing activities and (ii) the action of travelling. On the other, *space* refers to the context in which the performing of activities and the travelling takes place. Furthermore, by adding *actual* or *potential*, the realised spatial behaviour can be distinguished from the potentially possible spatial behaviour systematically.

The choice for the time scale and the spatial level of an action space can be adapted to 'more or less' natural borders that are important in the life of a person. An action space can thus be limited for example to an evening, a day, a week, etc. and also to a city, a region, a country, etc. respectively. The limitation of the spatial level of an action space is determined among others by the *fixed* (in both time and space) origins and destinations and the travel speed, with which a person travels.

$$\frac{(x - \frac{1}{2} L)^2}{\left(\frac{(\tau [T - L/V] + L/V) V}{2}\right)^2} + \frac{y^2}{\left(\frac{(\tau [T - L/V] + L/V) V}{2}\right)^2 - (\frac{1}{2} L)^2} <= 1$$

where:

T	=	available time interval
V	=	travel speed
L	=	distance between the bases
τ	=	travel time ratio
x,y	=	co-ordinates of points on or within the ellipse

Figure **4.2.1** Elliptical function of the action space model
Source: Dijst, 1995b

The four main determinants of the action space of people are (i) the basis locations of a person, (ii) the available time intervals for performing activities and travelling, (iii) the travel time ratio, and (iv) the travel speed. They are the focus of the next subsections. The general form of an action space is an ellipse (figure 4.2.1) (Dijst, 1995b; Dijst and Vidakovic, 2000; Newsome et al., 1998). When there are two bases (see subsection 4.2.1), the four variables mentioned delimit the area which is reachable within the boundaries of an ellipse whose long axis has the length of TV/2:

4.2.1 Activity bases

How people function in society is directly related to their possibilities to use activity places for their activities. The number and the nature of activity places that can be visited depend to a large extent on the degree of fixedness in both space and time of those activity places. With respect to this time-space fixation, (at least) two kinds of activity places can be distinguished.

- ☞ **independent activity places** (bases) – for these kinds of activity places decisions with respect to location, travel time, stay time are made isolated from other activity places.
- ☞ **dependent activity places** – for these kinds of activity places the point of time of a visit, the duration of the visit, and location of the visit depend on the visiting of independent activity places.

The main criteria for selecting an activity place as a basis location depends on:

- ☞ the frequency with which an activity place is visited;
- ☞ the stay time at the specific activity place;
- ☞ the fixedness in space of an activity place over a long period of time.

If an activity place is visited often and the duration of the visits are long, and if the location of the activity place is fixed in space over a long period of time, it can be considered as a basis location. Dijst (1995b) does not give any numbers or measures for high or low frequencies, a long or short duration, and when we can call an activity places 'fixed in time and space'. He makes clear that there are only a very limited number of activity places that qualify for basis locations. Traditional basis location are the home of a person and (sometimes) the working location of a person (Dijst, 1995b).

The basis locations are very important for using and visiting other (independent) activity places, because '…activities to which the individual is strongly committed and which are both space and time fixed, tend to act as pegs, around which the ordering of other activities is arranged and shuffled according to their flexibility ratings (Cullen and Godson, 1975). Time arrangements and activities at the basis location(s) structure the day of a person to a large extent. These time arrangements at the bases divide the day in time intervals.
Bases are not only important for the distinction of time intervals, bus also for their in-between distance. If there is only one basis location, then the distance between the bases is zero. The function of the ellipse (figure 4.2.1) automatically changes into the function of a circle. In these circle action spaces all time intervals available can be spent on travelling to and staying at non-basis locations. Ellipse and line action spaces have two bases. A large distance between the two bases results in large amounts of time spent on travelling between the bases. This reduces the time to be spent on other activities. In the case of line action spaces the whole time interval available is dedicated to the travelling between the two bases.

4.2.2 Available time interval

Available time intervals are important because of their length. A larger available time interval means a larger choice set for the spending of time and might result in visiting more activity places or in visiting more remote activity places. The length and point of time of available time intervals are also of significance for the nature of the activity places to be visited. People are less willing to spend long travel times on daily shopping than on for example visiting a (unique) museum.

4.2.3 Travel time ratio

When the travel time increases due to increasing distance, the available time for staying at one or more activity places decreases. At the border of the potential action space, the individual has no stay time left. The relation between travel time and the sum of travel and stay time is called the travel time ratio (Dijst, 1995b; Dijst and Vidakovic, 2000). The relation between travel and stay time depends among others on the nature of the activity places and the number of activity places that a person wants to visit in a certain available time interval.

$$\tau = T_t / (T_t + T_s)$$

where:
τ = the travel time ratio
T_t = the travel time
T_s = the stay time

4.2.4 Travel speed

The travel speed influences the size of the action space in two ways (Dijst, 1995b). The speed determines first of all the travel time needed to bridge the distance between the two bases (if there are two bases, of course). This indirectly influences the time available for any travelling different form the travel between the basis locations. So, secondly the speed also determines the distance that can be travelled within these specific time windows.

4.2.5 A typology of action spaces

Based on Dijst (1995b) and De Jong and Paasman (1998), we theoretically distinguish 15 different action spaces (table 4.2.1) along two dimensions: the shape of action spaces and the spatial level (= the size) of action spaces. On beforehand, it can be estimated that line and ellipse action spaces at the neighbourhood level will be vary rare. This is not hard to understand when we look at the spatial level of these two action spaces that should include two basis locations.

It is also worthwhile notifying that the personal characteristics of a(n group) of individuals and or (a) household(s) could be of significant influence in the exclusion of certain activity spaces on beforehand. When we consider older people who are not active anymore on the labour market, it will be harder to find line and ellipse action spaces than for a 40-hour-per-week working husband with children. Chapter six addresses to this specific topic of action spaces of older people in more detail.

Table **4.2.1** Typology of action spaces

Spatial level Shape	0-1km neighbour-hood	1-3 km city (district)	3-10 agglomeration	10-30 region / metropolis	30-100 national
Circle					
Line	*				
Ellipse	*				

* = not relevant

Based on a data set of 650 work related activity chains (filtered from a 12,300 trip data set conducted in Charlotte, North Carolina in 1985) Newsome et al. (1998) have elaborated on the concept of elliptical activity spaces, which they refer to as the graphical representation of the space within which a group of activities are carried out for an individual or a household. They show that …'the ellipse, while offering an appealing way to visualise the activity space concepts, it also provides several appropriate measures for quantification and comparability to allow further analysis of travellers' activity spaces.'

One measure is the ratio of the minor to the major axis that can be seen as an indicator of the (relative) degree of 'fullness or thickness' of the ellipse representing the relative extent to which the traveller is willing, able, or required to deviate form the main travel route (the line between the tow basis locations). The second measure is the area of the ellipse, which provides an expression of the extent of the activity space. The area of an ellipse is given by:

$$\textbf{Area} = \pi \, \mathbf{a} \, \mathbf{b}$$

where: a = ½ major axis
b = ½ minor axis

Figure 4.2.2 illustrates the way in which the opportunities of which people avail themselves by travelling are typically distributed over space. It also illustrates the fact - incorporated in all models of travel behaviour - that the frequency with which people make journeys has an extremely strong tendency to decrease as journey length increases (Adams, 1997). When the journeys made by a number of people are plotted on a graph as though they had a common origin, and with the position of each dot indicating the length and compass direction of each journey, a clear distance decay effect emerges. The density of the dots increases with distance from the centre, permitting the generalisation of the pattern as a domed 'mobility surface'.

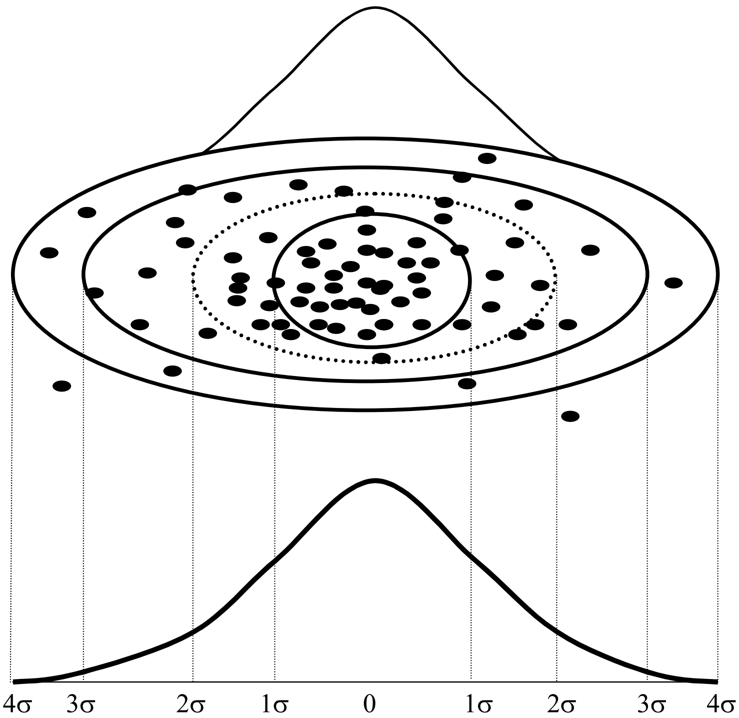


Figure **4.2.2** A centred interaction field
Source: Adams, 1997

We can think of the mobility surface as a 'time-space dome' in which people spend their lives. The height of the mobility surface at any particular point is proportionate to the amount of time that is spent at that point. The volume of the dome corresponds to the total amount of 'interaction time' that people have to spend - the number of waking hours in a day that are available for interacting with others. People and societies that do not travel far inhabit high, rigid, confining domes; those who travel far live in low, flexible, spread-out domes. But they all live in domes that have the same volume because they all have the same number of hours a day at their disposal.

Figure 4.2.3 gives an indication of the dramatic transformation that takes place in the time-space dome of a society as its level of mobility doubles and re-doubles. The high peaked dome represents the spatial activity pattern of an individual, or a group, with an average trip length of 1,25 kilometres. The other domes represent the effect of doubling and then doubling again the average trip length. The new, more remote, opportunities of which people avail themselves as they become more mobile are generally not additional to those previously enjoyed, but substitutes for opportunities previously taken closer to home, and now foregone. The figure illustrates the obvious fact that if people, in spending the time at their disposal, distribute themselves more widely over space, the amount of time they spend closer to home - and perhaps at home - must be substantially reduced.

Although the travel behaviour of people will rarely display a pattern as simple and symmetrical as that in both figures, the essential principle illustrated in the time-space dome is inescapable: if people in their travelling choose to spread themselves more widely, they must spread themselves more thinly. If the average trip length doubles, the area covered by the dome quadruples, and the average height of the dome decreases to a quarter of its previous height.

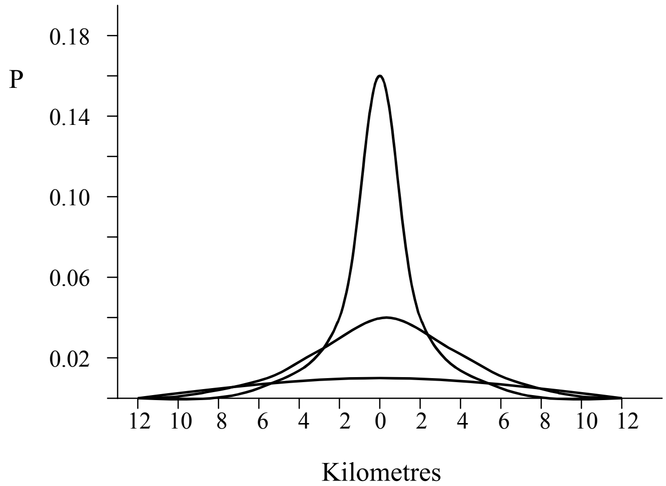


Figure **4.2.3** Effects of average trip length doubling and doubling again. P = intensity of interaction
Source: Adams, 1997

4.2.6 Perceived action space

From time-space perspective, the potential action space includes all activity places that a person can or could visit. However, knowledge about the existence of these places is needed in order to actually visit them. From research we know that people have incomplete and subjective knowledge about their spatial environment (see Chapter three) and that actual action spaces may differ from potential action spaces significantly. The perceived action space comes into play here (Dijst, 2001). In principle, it is impossible for people to know everything. Therefore, people strive for satisfying solutions instead of optimal solutions. For human behaviour, *'good is better than the best'*, very often.

How are the actual, potential, and perceived action space related to each other? All three types can be subdivided in the three ideal forms (ellipse, circle, line) as mentioned in the previous section. The actual action space falls completely within the potential and perceived action space (area I). Of course, people don't have to travel to all activity places that are perceived and potentially available (area II). But there can also be perceived action spaces that fall outside the area of potential action spaces or potential action spaces that fall outside the area of perceived action spaces. People might have wrong information in such a way that they think they can go somewhere but in fact cannot (area III). And of course, there can be locations that are potentially available, but are not known by the traveller (area IV).

Section 4.4 discusses the impact of the introduction and adoption of SMM and ICT on the three different kinds of action spaces. But first, we go into detail how actual action spaces have developed during history.

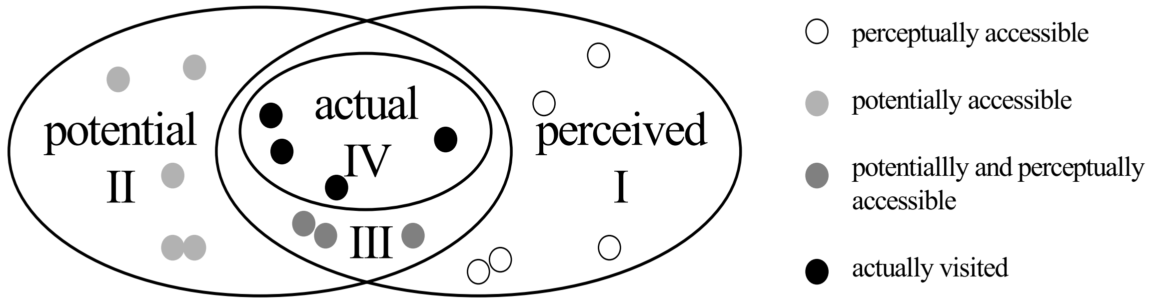


Figure **4.2.4** Potential, perceived, and actual action spaces
Source: Dijst, 2001

4.3 Action space through the ages

In history, the levels of mobility of societies have followed the level of economic welfare (figure 4.3.1) (Schafer, 1998; Victor and Schafer, 1997). The action spaces of people have increased accordingly. In order to explore and clarify this increase of action spaces,, the history of both the supply side and demand side of transport is considered in more detail in the next subsections: the developments of transport systems over time and some laws of mobility that have proved to be constant over time.

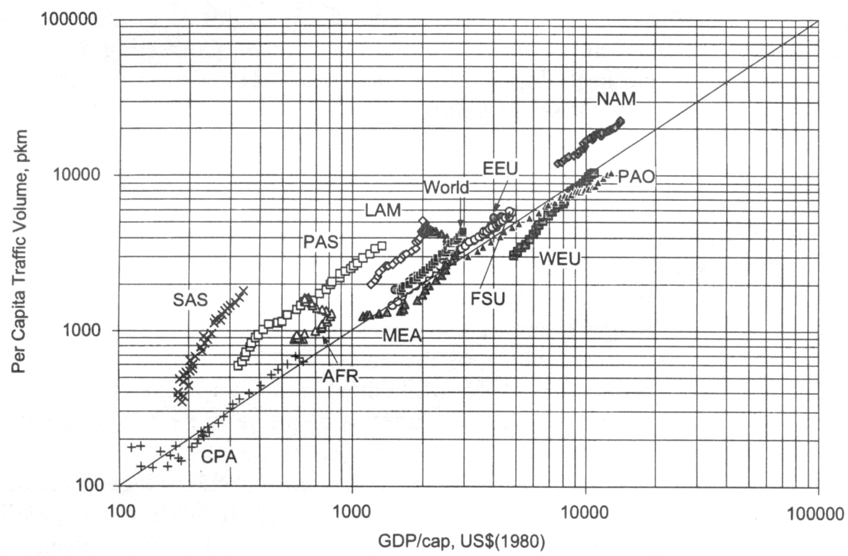


Fig. 5. Motorized mobility (car, bus, rail, and aircraft) per capita by world region vs GDP per capita between 1960 and 1990.

CPA – China and other centrally planned Asia; SAS – Bangladesh, India, Pakistan; PAS – Pacific Asia; AFR – Kenya, Nigeria, South Africa, Zimbambwe, and other Sub-Saharan Africa; FSU Former Soviet Union; PAO – Australia, Japan, New Zealand; MEA – Middle East and North Africa; EEU – Eastern Europe; LAM – Latin America and Central America; WEU – European Community, Norway, Switzerland, and Turkey; NAM – Canada and United States

Figure **4.3.1** Relation between level of mobility and economic welfare
Source: Schafer, 1998

4.3.1 Development of transport systems

A lot has changed with respect to the possibilities for people to travel and to transport goods during the last centuries. Transport systems have come and have gone, but new transport always followed a certain path of development (figure 4.3.2 and table 4.3.1): from a

pioneering phase via a phase of fast growth towards a phase of dominance. Certain transport systems never reached the phase of dominance, but never came further than the phase of pioneering or a certain growth.
Most of the time, the development of a transport system from pioneer to dominance took about 50 years. Probably, these routes of developments will be no different in the future (Filarski, 1997). When the technological changes in today's society are considered, we should seriously take into account that existing transport modes such as the car and the train will be gradually displaced by other transport modes.

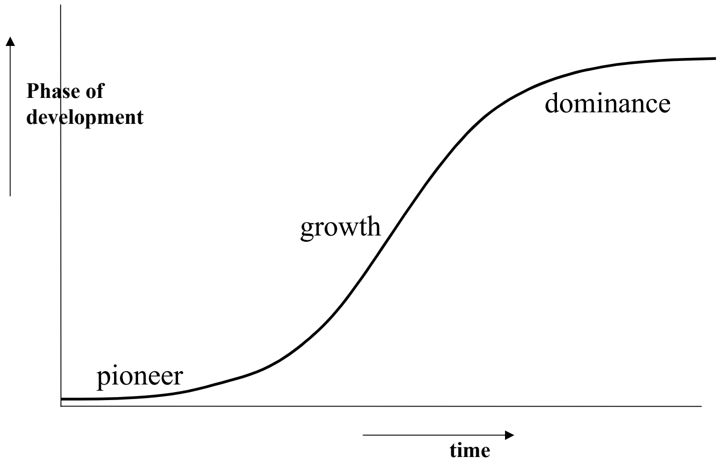


Figure **4.3.2** The development phases of transport systems
Source: Filarski, 1997

Table **4.3.1** The pioneering, growing, and dominant transport systems in history

Period	Pioneering phase	Growing phase	Phase of dominance
Till 1660	Sailing wagon	Track boat	Walking
1660-1800	Stage coach	-	Track boat
1790-1840	Train, steam boat, steam car	Stage coach	Track boat
1840-1870	Steam car, bicycle	Train, steam boat	Track boat, stage coach
1870-1910	Car	Bicycle, tram	Train
1910-1950	Airplane, airship	Car, bus	Bicycle, train, tram
1950-2000	Diverse	Airplane, high-speed rail, light rail	Car

Source: Filarski, 1997

Nowadays, we live in the era of the dominance of the car and a lot of technological innovations take place within the car system itself: the continuous evolution of (new) braking mechanisms, car-based automated vehicle guidance technology, in-car route information technology, the differentiation of car types (small city cars, space wagons, etc.), dynamic traffic management, the planning and maintenance of car infrastructures, etc. So, a lot of research and development money of the transport sector (both commercial and not-commercial) is invested to improve the functionality of the car system as a whole. At the same time, the marketing of innovations has become an important medium to have the technologies successfully introduced and adopted. It is not always the best technology that is adopted, but sometimes the technology with the best image.
Furthermore, companies in dominant industries sometimes try to fight and prevent the birth of new industrial activities, for the fact that most of the times 'the new' replaces 'the old'. In literature, this process of the established order fighting the newcomers is often referred to as

the *sailing ship effect* (Kleinknecht, 1998). In earlier days, the sailing ship industries fought the rise of the steam ship by many technological improvements of the sailing ship for decades. The dominant branches of industry are large and powerful, and have (very often) a good political lobby, which increases the chance that they will be served well politically.
The airplane, high-speed rail, and to a smaller degree light rail are today's growers. Today's group of transport systems in the pioneering phase is very diverse and only the future can tell which systems will survive.
When we look at the introduction and adoption of transport systems from a somewhat higher perspective, we can conclude that the (new) transport systems of the last decades all have to do with (i) higher speed, and/or (ii) more time-space flexibility.

4.3.2 Mobility laws

The number of trips per person per day has proved to be constant over time in all kinds of different countries. For mobile people the average number of trips per person per day is about 4. For the total population this number is about 3.6 (CBS, 2001). For older people this number is somewhat lower, about 2-3 (Tacken, 1998; Rooij and Tacken, 2001). The number of trips per person per day also differs with income and education level: it increases with increasing income and education level. A slow shift can be noticed in the direction of somewhat higher numbers due to an increase of the mobility of society as a whole: an increase of about 2% per year (Bovy, 1993).
The revealed constancy of the number of trip per person per day is mainly due to the fact that travel is a derived demand. Therefore, the out-of-the-home activity pattern of a complete population will not change very quickly and very drastically, because (i) many activities are related to the basic human needs (e.g. working, going to school, shopping), and (ii) many activities are culturally determined (e.g. visiting, sport activities). Furthermore, the time to participate in activities is limited: a day has 24 hours and the largest share is already dedicated to obligatory activities such as sleeping, eating, etc.
A second constant is related to the amount of time spent on travelling; nowadays about 1 hour and 10 minutes per person per day on average (Bovy, 1993; Schafer, 1998) (figure 4.3.3). Also here, the number increases with about 2% per year (Bovy, 1993). The relative constancy of this parameter is determined mainly by the absolute restrictions of the total time budget of people for all activities (24 hours a day), and by the little amounts of time left due to the time spent on the activities themselves.

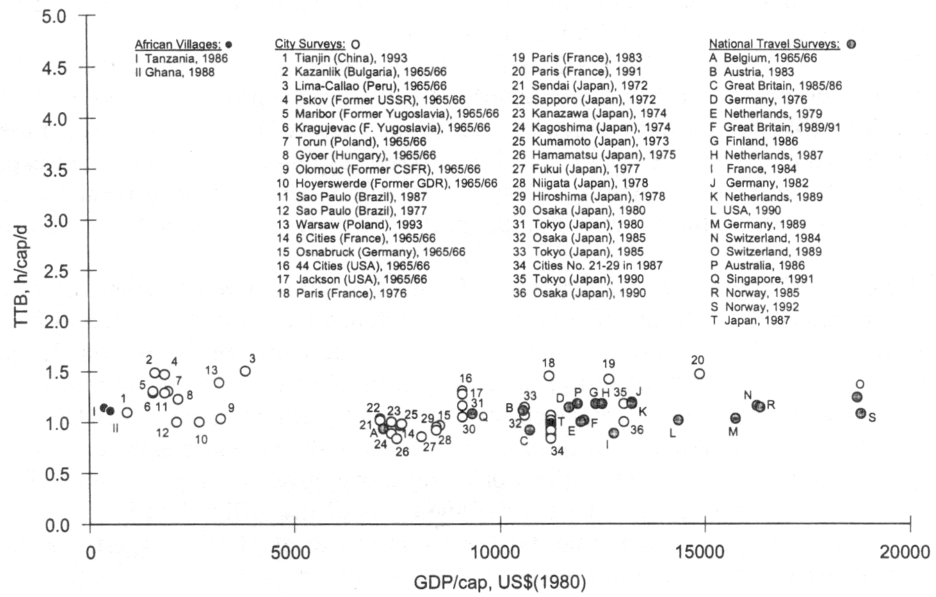


Fig. 4. Travel time budget ($h\,cap^{-1}\,day^{-1}$) in numerous cities and countries throughout the world. Sources: Kloas *et al.*, (1993); GFV, (1987, 1992); Orfeuil and Salomon, (1993); UKDOT, (1994); DMT, (1993); Szalai *et al.*, (1972); Katiyar and Ohta, (1993); USDOT, (1992); Malasek, (1995); Vibe, (1993); Riverson and Carapetis, (1991); EIDF, (1994); FORS, (1988); Metrõ, (1989); Olszewski *et al.*, (1994); Xiaojiang and Li, (1995).

Figure **4.3.3** Constant travel times
Source: Schafer, 1998

Research (Schafer, 1998) also shows that the populations of industrialised countries (except Japan) spend a fixed percentage of about 10-15% of their income on mobility (figure 4.3.4). With a time budget that stays the same (24 hours a day) and a growing wealth, it is clear that in the past people have used a large share of their wealth for buying speed. Therefore, distance parameters have proved to be the least constant parameters. Travel distances and action spaces of people have increased under influence of the rise of faster travel modes (car, high-speed rail, airplane), increased car availability and car possession, improvements in the accessibility of activity locations, and the spatial shifts of activity places (sub-urbanisation).

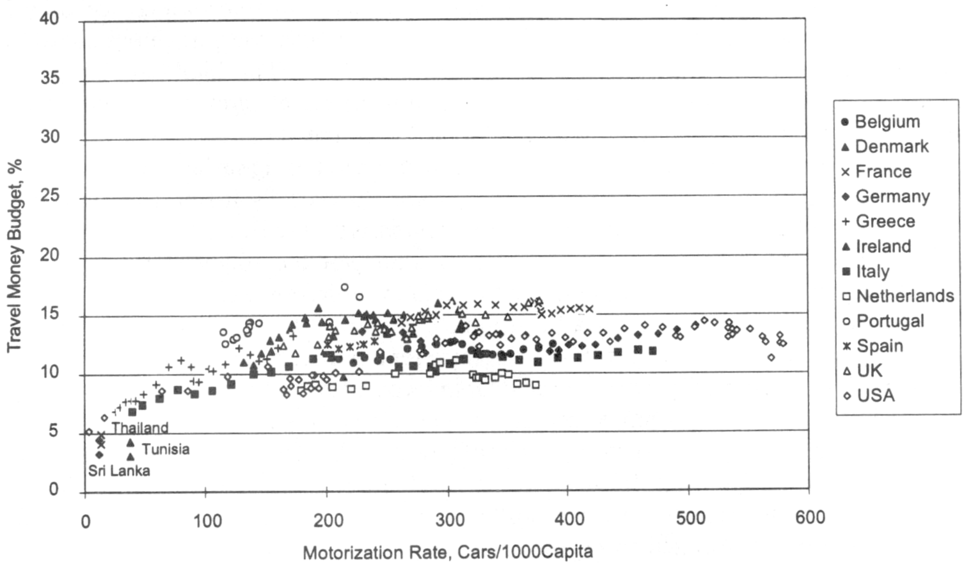


Fig. 3. Travel money budget (share of transport expenditures to total expenditures) vs car ownership rate for 12 OECD and three developing countries. The denominator of the TMB for the developing countries is total expenditure on nondurable goods and services—not total consumer expenditure, such as for the OECD data, which overrepresents the rich. Sources: Eurostat, (1994); Davis, (1994); SB, (1972, 1994); USDOC, (1975); UKCSO, (1994); UKDOT (1988); Deaton, (1985). Time period of country data: Belgium: 1970–92; France: 1970–92; Denmark: 1966–92; FRG, Greece: 1970–91; Ireland: 1970–89; Italy: 1960–92; Japan: 1970, 1975, 1979–1992; Netherlands: 1969–91; Portugal: 1977–89; Spain: 1980–85; UK: 1965–92; USA: 1909, 1914, 1919, 1921, 1923, 1925, 1927, 1929–40, 1948–92; Tunisia: 1979/80; Sri Lanka: 1980/81; and Thailand: 1975/76.

Figure **4.3.4** Percentage of money budget spent on mobility
Source: Schafer, 1998

4.4 Action space, SMM and ICT

In this section we discuss the (potential) influence of Seamless Multimodal Mobility (SMM) and Information and Communication Technologies (ICT's) on the action space of people. We should remember that the history of high-tech ICT's is relatively short and the seamlessness of multimodal transport is still in its infancy. Therefore, strict conclusions and implication are hard to give. However, hypotheses can be made and educated guesses can be generated. A lot of the outcomes are -off course- very much dependent on the psychological, socio-demographic, and spatial attributes of individuals.

Let us first summarise some interesting characteristics of ICT's.

- ICT's increase the *awareness space* of people. Because of the ICT's, people get in contact with places and people, which used to be beyond their scope (source). Accordingly ICT's will increase the perceived action space of people.
- ICT's have the potential to organise a better match between potential and perceived action spaces (Dijst, 2001). Travellers might benefit directly from omni-present, actual, and dynamic travel information. Activity-travel behaviour could be more easily adapted in favour of the wishes and demands of the traveller him- of herself.
- ICT's have the potential to result in a revaluation of time in favour of the discretionary acts of travelling over the obligatory acts of travelling (Dijst, 2001). ICT's can make life easier. It is not hard to understand that people indeed will use ICT's when these ICT's can help them with (or substitute completely) certain activities that people consider to be a burden. In this way, more time becomes available for discretionary activities.

- A full use of ICT’s can result in a better organisation of all kinds of transport processes, and multimodal transport processes especially. ICT’s have the potential to improve the functioning of the *hardware*, the *software*, and the *orgware* of transport systems[1], resulting on average in higher travel speeds and (thus) increased action spaces.

The final point above aims at the relation between ICT’s and SMM. Furthermore, SMM has also some interesting characteristics itself, directly influencing the action space of people.

- The seamlessness in both time and space in and between transport subsystems (i) and (ii) the ongoing developments in high-speed transport (sub)systems and systems with a high degree of time-space flexibility will undoubtedly result in higher travel speeds and thus increasing potential action spaces of people.
- On the other hand, locations (shopping malls, city centres, business districts, etc.) will make more explicit choices with respect to their accessibility, or are forced to do that by the (local) authorities. Their will be a growing differentiation of the level and nature of the accessibility of locations. Some locations will opt for total multimodal accessibility, the main connectors of the transport network. Other locations will opt for restricted (in time or space) accessibility. The Dutch city centres are good examples of locations that explicitly go for restricted accessibility: car free or car calm inner cities and parking restrictions.

Thus, ICT’s increase the knowledge of known and (formerly) unknown activity places and routes, and SMM offers the (physical) opportunity to get there with an on average higher travel speed than before, resulting in (i) larger potential, perceived and actual action spaces, and (ii) a better fit of perceived and potential action spaces (figure 4.4.1). Moreover, a revaluation of time can be expected: (i) obligatory actual action spaces might both decrease (for example teleshopping) and increase (for example: teleworking, increased travel distance to work, but less often), and (ii) discretionary actual action spaces will increase. It all has to do with the maximisation of utility (see section 3.1.1) between what you:

- *have to do* – minimise burden
- *want to do* – maximise profits
- *can do* – use existing potentials.

No empirical research shows that there are reasons to suggest that the developments of the number of trips per person per day or the number of visited activity places (both about 2% growth per year on average) will radically change under influence of ICT’s and SMM. There also seems no reason to suggest that the Laws of mobility will not apply anymore.

[1] Section 1.2.2 refers Zeleny’s (1987) notions of the *hardware, software, and orgware* of complex interacting systems such as a city, or a multimodal transport system. Zeleny’s terminology is in line with Dupuy’s layer scheme where the first network level refers to the hardware (infrastructures, vehicles), the second network level refers to the networks of consumption and production (transport services), and the third network level refers to individual networks of use.

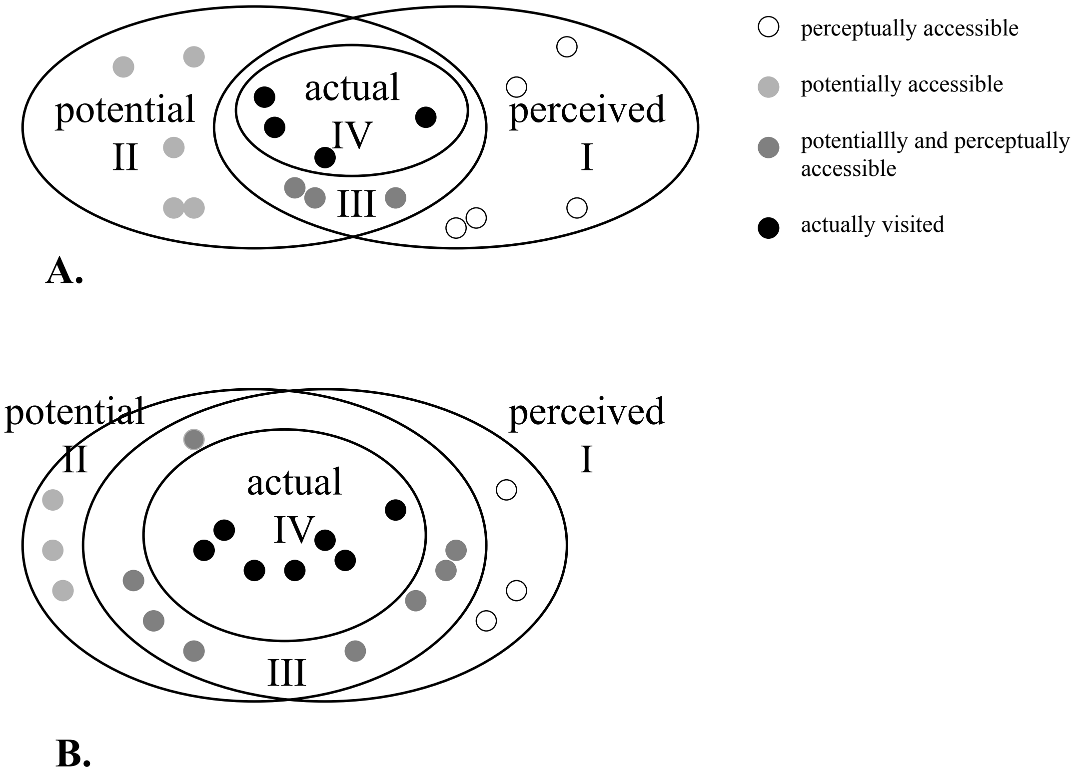


Figure **4.4.1** The change of action space of people under influence of SMM and ICT's

4.5 Summary and conclusions

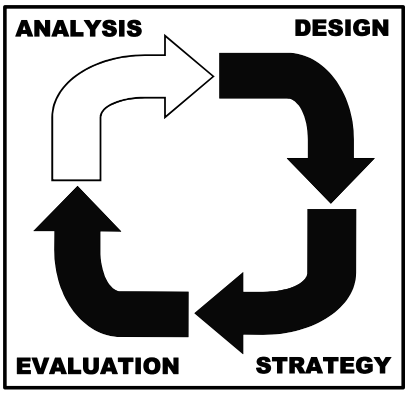
This chapter, the third chapter of the analysis phase of the planning cycle, discussed the concept of action space and some more practical matters related to this action space principle. A distinction is made between actual, potential, and perceived action spaces. The chapter also discusses the influence of Seamless Multimodal Mobility and Information and Communication Technologies on all 3 kinds of action spaces. It is stated that there are no reasons to suggest that the 'laws of mobility', (i) a constant travel time budget, (ii) a constant number of trips per person per day, and to a lesser extent (iii) a constant mobility money budget, will change under influence of SMM and ICT's and that the action spaces of people in general shall increase, and that ongoing developments in the ICT sector will result in a better match of potential and perceived action spaces. ICT's also have the potential for an individuals revaluation of time in favour of the discretionary acts of travelling over the obligatory acts of travelling.

Improved information, communication, and transport technologies do not only influence the action space of people, but also the way, in which 'the city' functions and how the 'city' is perceived, both by people in general and by urban professionals specifically. The next chapter elaborates on this specific topic: the Network City. The chapter gives a helping hand to the field of spatial planning how the future of this profession should be looked at from the perspective of the network society.

CHAPTER FIVE THE NETWORK CITY AND ITS PLANNING

Non sum uni angulo natus, patria mea totus hic mundus est.

I have not been born for somewhere in a small corner; the whole world is my fatherland.
Seneca, Epistulae Morales, no. 28



After having analysed sustainable transport and chain mobility in chapter two, activity-travel behaviour theories in chapter three, and the concept of action space in chapter four, the objective of this chapter is to present and discuss the Network City and its planning. Chapter five builds on section 1.1 'Towards an urbanism of networks' of the Introduction of this thesis, where the first theoretical foundations of the urban network theory have been given in discussing the three layer scheme of physical networks (first level), the networks of consumption and production (second level), and the individual (personal, household or company) networks (third level).
This chapter starts with section 5.1 that discusses several dimensions of the concept of the Network City and related terminology. It is said that the introduction and adoption of new information, communication, and transport technologies are among the main drives of the rise of the Network City. Transport technologies have already been discussed in chapter 2. Therefore, section 5.2 focuses on the role of Information and Communication Technologies in the Network City. Now that we know how we should interpret the notion of the Network City, section 5.3 discusses the changes that the field of spatial planning is confronted with: to what extent shall traditional spatial planning (have to) change because of the rise of the network

society? The question still stands how the Network City will look like spatially. So, section 5.4 and 5.5 present a first physical-spatial design brief and some physical-spatial consequences for the Network City of the future. Section 5.4 gives a morphological approach towards the Network City in order to describe the Network City as a complex, dynamic, interacting system. It explains why it is important to plan and design coherence in the spatial levels of the Network City. Section 5.5 describes the relation between the Network City and Sustainable Urbanism as one of the most challenging tasks of the city of the future. Finally, section 5.6 summarises and concludes the main findings of this chapter.

5.1 Network cities in a network society

"In today's 'network society' physical, social, and virtual networks have taken a prominent position. These networks do not only determine our daily life in an increasing degree, but they also determine the economic and cultural, and political and geographic relations. Therefore, the present lay out and organisation of the city is under increasing pressure. The design ideas and the instruments of a lot of today's urbanists still result from a traditionally and geographically concept of space and time. Therefore, they are hardly suitable to play along with the fundamental fleetingness and infiniteness of the network society."

From: Boelens (ed.) (2000b), The Netherlands as country of networks.

5.1.1 From city to Network City

In earlier days, the (traditional) city used to be the geographical unit, within which the daily life of an individual took place: the city as the daily urban system. Until the 1960's the city could be described as the monocentric conglomerate of functions (Advisory Council for Spatial Planning, Housing, and Environment, 2001a).
But in modern western societies, the view on and the perception of 'the city', and on what someone used to call 'his or her city', has changed drastically during the last decades. Every person has his or her own action space, both physically and electronically, his or her own territory where he or she comes and goes, and participates in activities. The city is no longer the monocentric conglomerate of functions, but it has grown into a multinodal urban field, the multinodal or polycentric city. Multinodality refers to the presence at a specified level of scale of more than one concentration of collective activities that pertain to that scale (Jacobs, 2000a).

There is quite some debate about the shape of the future city, in terms of centralisation and decentralisation. The parameters of the debate have been most thoroughly explored by Jenks et al. (1996) *The Compact City*; Graham and Marvin (1996) *Telecommunications and the City*; and Mitchell (1995) *City of Bits*; Drewe (2003) *ICT and urban form*. Roberts et al. (1999) show in their 'Network Metropolis' approach, that it is relevant to point out two divergent trends, the first towards a metropolitan renaissance and the second towards suburbanisation and specialisation. First, city centres have retained their importance as spaces for face-to-face interaction, transactions, and creativity (Bianchini and Landry, 1995). Furthermore Roberts et al. argue that the dispersal of some of the urban functions traditionally associated with the city centres, coupled with a growth of those that remain, has resulted in a more spatially specialised metropolitan lay-out. Developments on the edges of towns and cities -clearly documented by Garreau in 1991 in his masterpiece *Edge City*- and activities in the city centres seem to or have the potential to become complementary.
One of the dangers of the Network City is that places can become a series of stereotypes and everywhere can become like everywhere else. It is a paradox that '…in an age when more information is available to an ever widening group of the population and the means to exploit it in terms of movement exist, that the specific character of certain popular locations is in danger of being destroyed…' (Roberts, et al., 1999).

5.1.2 A network society

Although there are many individual differences between people, it can be said that on average the regional spatial level[1] is the area that nowadays seems to fit the daily urban system of people best (Advisory Council for Spatial Planning, Housing, and the Environment, 2001b). But more and more, the interaction behaviour of people, both physical and virtual, crosses regional, provincial, and (inter)national boundaries: the rise of the network society (Castells, 1996).

A network society is a society, in which social, economic and cultural structures are not solely determined by the shared use of a certain space, but also (primarily) by the connections that an individual actor (person, company, institution) has with places, persons, or activities elsewhere. Therefore, the network society does not produce smoothening or uniformity, but it creates alternatives and it changes existing structures in such a way that distance becomes a less important factor. So, new (additional) physical-spatial structures come to life in the network society. In this constellation, spatial barriers can be overcome by new communication and/or transport technologies.

The rise of the network society takes place under influence of processes such as the ongoing globalisation, telematisation, and individualisation, about which quite a number of social-economic and spatial studies have reported (Caso, 1999; Castells, 1996; Graham and Marvin, 1996; Mitchell, 1995; Roberts et al., 1999; Sassen, 1994, 1996; Boelens, 2000b). It can be concluded that our western booming economies undergo severe changes economically, social-culturally, and politically:

- World wide economies become interdependent;
- The ongoing individualisation and a gigantic increase of not only the number of social relations, but also of the fleetingness of those social relations;
- Local, regional, and even national governments lose control. Boundary crossing processes more and more take place outside the own territorial competencies of governments.

Consequently, spatial planning is influenced rather drastically by the processes mentioned above (section 5.3 refers). The notion of the Network City has arisen in order to refer to these processes. The body of the Network City is not (only or primarily) shaped by physical-spatial characteristics, but (primarily) by the connections and the nodes. This does not mean that the physical world is of no importance anymore. The physical world is geographically bound and strives for sustainability. The other world is boundary crossing (at all levels of scale, and both physical and virtual), (inter)national oriented and highly dynamic. Both worlds have influence on each other. Both the quality of the environment as well as the (physical and virtual) accessibility is relevant. These two worlds can coincide, but not necessarily. Thus, the *space of places* is not replaced by the *space of flows*, but the two are both part of our domain of reality.

Anderson (1999) and Roberts (2000) agree that mobility and telecommunications have indeed enabled the developments of 'open' and more fluid conceptions of community. Roberts shows that the neighbourhood is no longer valid for the definition of community. Quering of this idea has its roots in the 1960's with the work of Melvyn Webber who argued that a pattern for the future was more likely to be based on multiple communities of common interests rather than communities based on place and propinquity (Webber, 1968).

Anderson argues that although place-bound communities still exist, they are actively chosen and re-chosen by people who live in them. Rather than society suffering from a lack of community, people are suffering from an overload of it (e.g. professional community,

[1] The notion of a 'region' applies to the urban area with a mean radius of 30 kilometres. Section 2.3.6 refers.

community of birth, communities of interest, communities of residence, etc.). An increase of choice promoted by ease of communication has left people confused as to which community they should prioritise.

5.1.3 Urbs and civitas: a multi-layered Christaller scheme

Under the influence of the rise of the network society, a situation develops, in which the identity of the *urbs*, that is physical dimension of the city, and the *civitas*, that is the social dimension of the city, are no longer self-evident. The *urbs* and the *civitas* always used to go together, but that is no longer the case anymore; the *civitas* can take place anywhere: at places with a high or low density, in the train, on the Internet, etc. However, it is wrong to think that because of the separation of *urbs* and *civitas*, the historic city centres shall disappear as snow in summer. The Dutch Advisory Council for Spatial Planning, Housing, and the Environment (1999b) states that '…different forms of urbanity exist…' and that '…the importance of the form of urbanity that is based on face-to-face contact and is based on activities in an urban setting with a relatively high density, has definitely not decreased.' And, as we have seen in chapter four, both an increase and decrease of action spaces of people can take place in the future: so, both a concentration and a deconcentration of urban activities and/or the built environment can be expected, referred to in literature (Boelens, 2000b) as the *double movement*.

The technology that makes it easier to fly around the world, both physically and electronically, is also making it easier to bring the world together. That is why *glocalisation* is a good description for what is happening in the world today. It is not just making things bigger, it is also making them a lot smaller. Peace and prosperity are much more likely when we all feel part of the same neighbourhood.

So, the Network City stands for multiple options instead of one uniform spatial-functional concept for cities. Therefore, it becomes more and more important not to discuss urban trends in general terms, but to be very precise and accurate about which sector of the employment, about which part of the housing demand, about which elements of the apparatus of facilities, one speaks. In fact, we talk then about several different networks with their own nodes and their own hierarchies. Not one node is the centre for everything and everyone anymore (the old market square as centre for the economy, society, politics and clergy). The good-old one-dimensional Christaller scheme is outdated for spatial planning and more Christaller schemes can be defined for different urban functions both physical and electronical, and at different spatial levels, with their own conditions, rules, and order at the same time (figure 5.1.1).

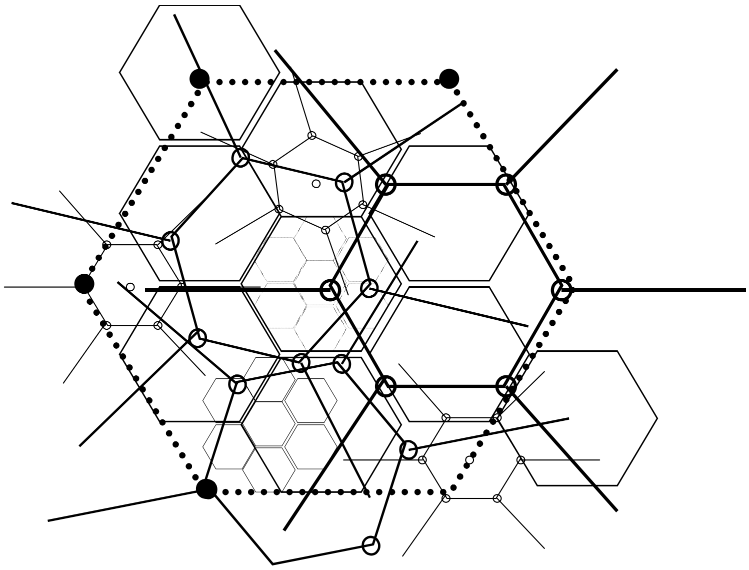


Figure **5.1.1** Multidimensional Christaller scheme; both physical and virtual hierarchies
Source: Boelens, 2000b

Within the hierarchies of networks, transport nodes, the places where (different) hierarchies and spatial levels of infrastructures come together, are (in potential) among the most interesting locations within the Network City (figure 5.1.3). The nodes of the network, such as public squares, stations, park and ride facilities, exits of motorways etc., operate on the field of tension between 'place' and 'flow', as here, the *space of flows* meets the *space of places* directly. In and around the transport nodes the network is linked to the geographical surface and environment. Here, new development potentials, new possibilities, and new threats arise. We'll come back to that extensively in chapters 8 and 9 which focus on the location choice of transfer points specifically.

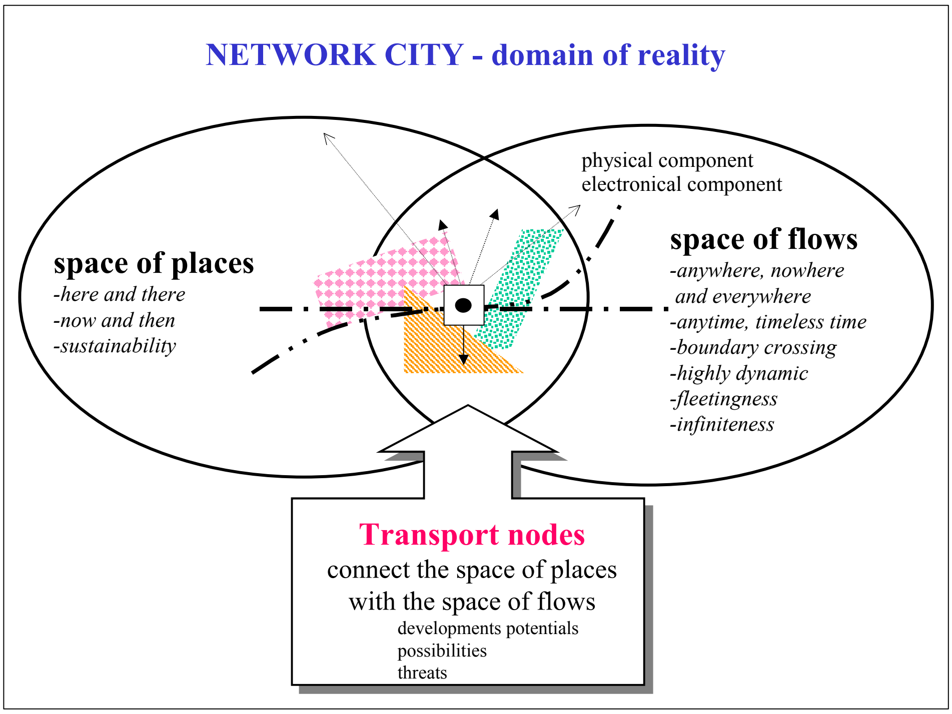


Figure **5.1.2** Scope of the Network City and the role of transport nodes

5.1.4 Related terminology

In the Netherlands, there has been quite some discussion about the definition of the notion of the Network City and related terminology under influence of the development of the Fifth National Policy Document on Spatial Planning (Ministry of Spatial Planning, Housing, and the Environment, 2001). The 5th National Policy Document on Spatial Planning (and the latest focuses at so-called *Urban networks* (figure 5.1.3). Urban networks are defined here as "…strongly urbanised zones that consist of a network of larger and smaller compact cities that each have an own character and profile within this network…". The main political aim is to manage the processes of the urban networks in such a way that the urbanised areas grow into a number of highly connected, yet clearly distinghuisable urban nodes, with open spaces in between.

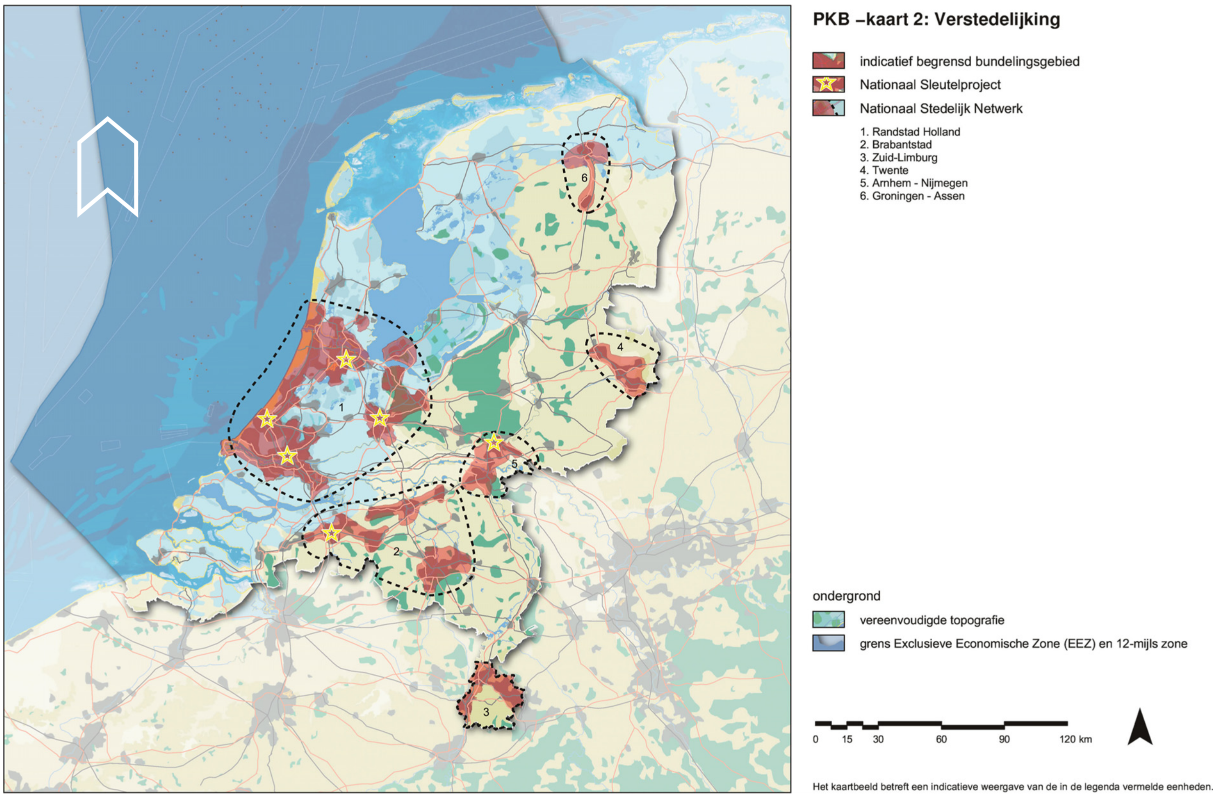


Figure **5.1.3** 6 National urban networks
Source: Ministry of Spatial Planning, Housing, and the Environment, 2004

In their advise on the National Planning Document, The Advisory Council of Spatial Planning, Housing, and the Environment focuses on the concept of the Urban network. They argue that with the notion of the Urban network, the 'old' concept of the 'stadsgewest'[2] is operationalised for more 'stadsgewesten'. Furthermore, they advise (i) to describe the notion of an Urban network more precisely as a principle of structuring on behalf of a desired spatial development, (ii) to differentiate between (Dutch) regions[3] and (iii) to give the notion of the Urban network more focus for specific regions. Finally, they also advise to split up the Urban networks of the Deltametropolis, Brabantstad, and Groningen-Assen in several (regional) Urban networks, as they consider these networks of cities of another spatial level, i.e. the national level.

[2] The notion of 'stadsgewest' applies to the urban area with a mean radius of 10 kilometres. Section 2.3.6 refers.
[3] The notion of a 'region' applies to the urban area with a mean radius of 30 kilometres. Section 2.3.6 refers.

In this last sentence, the notion of a *network of cities* is introduced. A network of cities can be defined as a set of cities which are connected physically, virtually, functionally, economically, and/or culturally etc. It is a concept that can be applied to all kinds of points of view and to all kinds of spatial levels. In earlier days, the cities of the Hanseatic League formed a network of cities with strong mutual economic and social-cultural dependence. But all cities of the Netherlands with more than 50,000 inhabitants and the national motorways can also be seen as a network of cities: the main Network of Dutch cities. It is the author's opinion that the notion of a network of cities is too superficial to be useful for spatial planning: it is a so called container notion that can be applied anywhere without giving proper directions to desired developments.

The difference between the notion of the Network City and the other notions mentioned – monocentric city, multinodal (polycentric city), urban network, network of cities – is that the concept of the Network City (i) explicitly identifies two different kinds of spaces (place and flow), and (ii) identifies an explicit role for ICT's as a new infrastructure (besides water, road, air, rail, pipeline), and their direct and indirect impacts on the physical-spatial environment. The next section primarily focuses on the potential and actual role of ICT's in our society.

5.2 The Network City and ICT

ICT is the abbreviation of Information and Communication Technology. It is the technology to communicate dematerialised data and information. In the literature, the notions ICTT and IC^2T are used as well. ICTT stands for Information, Communication, and Transaction Technology; IC^2T for Information, Communication, Computing Technology. Here, we use ICT as notion that refers to the digital (r)evolution. What the future of ICT's concerns, we can distinguish between short term, medium term, and long term developments.
On the short term the introduction and adoption of UMTS (Universal Mobile Telecommunications Systems) will determine the infrastructure of the tele-communication. On the long(er) term it is to be expected that data-transmission will take place via wireless mobile transmitters and receivers, which can find each other by means of GPS (Global Positioning System). On the medium term (5-10 years) the availability of actual, dynamic, omni-present fluid information will have increased enormously due to broadband and sensory rich, virtual communication.
The reasons for the growing interest of urban observers in city-telecommunications relationships essentially derive from the potential of telecommunications to adjust time and space barriers, which are the basic dimensions of human life (Caso, 1999). Telematics loosen the regime of time and space constraints and challenge the commonly understood notion of time and pace as external environments within which cities and social structures develop (Graham and Marvin, 1996).
In the Netherlands, the Ministry of Economic Affairs (2000) presented three perspectives (Dynamic digital, Conscious digital, Hesitating digital) for The Netherlands based on ICT developments and ICT developments to be expected. It is concluded that till 2010 a lot of developments and their consequences are already predictable and therefore considered to be rather fixed:

- the ICT market grows from adolescence to adulthood;
- the network economy starts to grow;
- the consequences of ICT developments become slowly noticeable in the spatial organisation of society;

- ICT developments lead to a larger need for (spatial) mobility and to a minor increase of the spread of transport patterns; and
- ICT's that offer both advantages for financial-economic aspects and ecological-environmental aspects are adopted quickly, and ICT's are used by the government to monitor the performances of companies with respect to ecology and environment.

The next subsection focuses on the (potential) influence of ICT's on the domain of reality, that is: on people and the society, on the city, and on the mobility of people.

5.2.1 ICT, living and working

The residential area will be one of the most challenged parts of future socio-spatial systems (Caso, 1999). Many services will be accessible to people from residential areas (home or neighbourhood) via telematics connectivity. Beside the traditional interpretation of residential areas as place of consumption, these will be increasingly considered as a place of production too. The new activities enabled by telematics in the residential areas are referred to as tele-activities (Caso, 1999). In line with Caso and Tacken (1993) the following activities can be distinguished:

- *Productive activities*: these are closely related to a specific paid job that members of the household are (e.g. tele-work). They are influenced by the relationship between employer and employee, and they can be enabled by both a public and a private enterprise.
- *Domestic activities*: some tele-activities have a function as part of the management of housekeeping (e.g. tele-shopping, tele-banking, household monitoring). They should be mainly enabled by private enterprises.
- *Supportive activities*: these tele-activities enable specific services at home. They concern activities such as tele-health care and tele-learning, which provide extra services. In principle, they should be enabled by a public enterprise but, in accordance with the trends towards deregulation, there will also be quite some room for private initiatives.
- *Leisure and recreation activities*: people can make a free choice tot participate in services like video-games or video events. These should mainly be enabled by private enterprises.

ICT's also have the potential to influence the working environment to a large extent. This can be seen best in the field of office innovation. ICT is an important drive behind the changes in the design of offices, which has resulted in a variety of new office concepts such as satellite centres, neighbourhood centres, the home as office, cocoon offices, etc.

5.2.2 ICT and ecology

The reasoning behind the influence of ICT on the environment ecologically is that (i) *the material* can be replaced by *the virtual*, that (ii) environment unfriendly behaviour can be overcome with smart apparatus, and that (iii) environmental effects can be measured more precisely. ICT can be seen as an enabling technology: a technology that enables new developments, enlarges the insight in processes, improves the management of processes, leads to new ways of fulfilling societal needs, and because of that leads to new products and activities. ICT is thus both process oriented and a source of new products and services (Advisory Council for Spatial Planning, Housing, and the Environment (2001d).
Moreover, technological innovation has the potential to contribute to the uncoupling of economic growth and ecological burden, which is one of the main goals of Dutch spatial

policy (Ministry of Economic Affairs et al., 1997). The question is however how ICT's can contribute to this process of uncoupling, because a lot of ICT developments have an ánd-ánd character: there can be both positive and negative environmental effects. The (ultimate) effect of ICT on the environment is determined by the balance of first-order (direct) and second-order (indirect) effects.

First-order effects are relatively easy to predict. When books are issued via the Internet or on CD-Roms, it is clear that many environment unfriendly processes are skipped: for example, no fabrication of paper and no printing is needed. But if all people who want to read the book individually print their CD-Rom on paper, the positive environmental effect might diminish completely. Negative second-order effects are often referred to as *rebound effects*.

But there are also positive second-order effects: for example that the digital revolution enables a taxation according to the principle of *the polluter pays*. Many experts expect that the rebound effects of ICT are so large, that the uncoupling potentials of ICT's will only be modest (Advisory Council for Spatial Planning, Housing, and the Environment, 2001d).

5.2.3 ICT and mobility

There is also a lot of uncertainty about the effects of ICT on mobility (Advisory Council for Spatial Planning, Housing, and the Environment, 2001d; Advisory Council for Transport, Infrastructure, and Water Management, 1999; Advisory Council for Traffic and Transport, 1997b). Based on Mokhtarian (1990) and Westerman and Meijdam (1994), we distinguish six possible effects of ICT's on the mobility of people and/or goods (figure 5.2.1). Within the context of this thesis the focus is only on the transport of people. For the transport of goods we refer to the TRAIL FTAM[4] research program.

The first effect has to deal with the substitution of physical trips, because of ICT alternatives. The second effect is called complementation, which refers to how virtual traffic complements physical traffic. The third effect is the generation effect; ICT stimulates extra travel directly. The fourth effect is about operational efficiency. ICT improves the efficiency of the transport system, both the planning and the execution of trips, which results in higher travel speed, so a higher attractiveness of the system, and thus in more travel kilometres. The fifth effect has to deal with long-term spatial planning effects. In the long-term people and businesses may change their interaction and settlement behaviour due to ICT's. Finally, the sixth effect is called supplemation, which refers to a general growth of travel demand, resulting from a gap between the travel demand and transport supply. A new transport system has to offer that extra supply.

[4] Freight Transport, Automation, and Multimodality

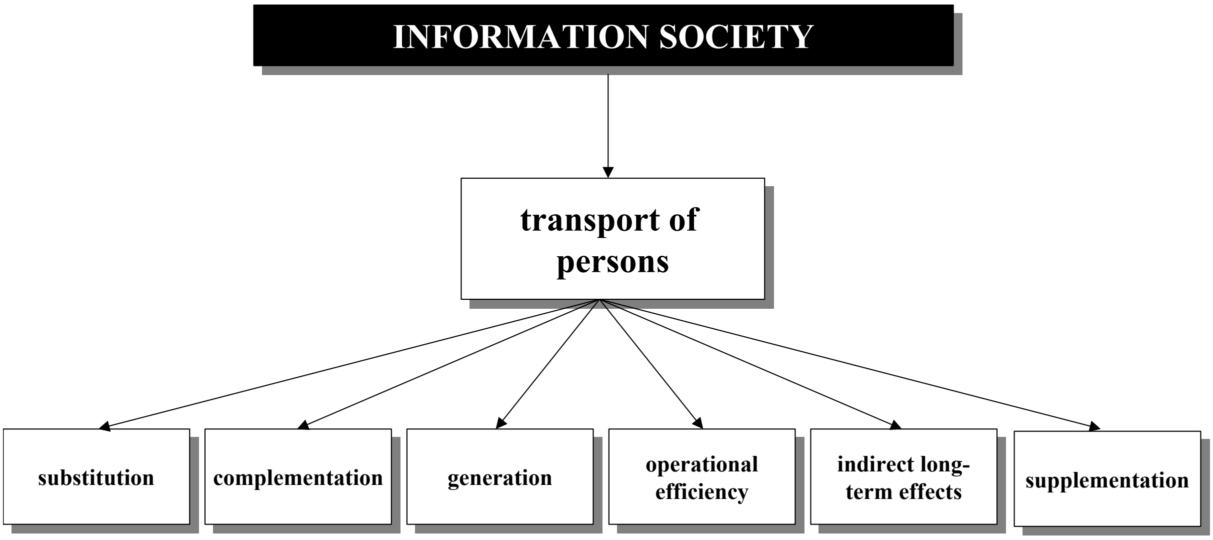


Figure **5.2.1** Information society and travel demand

Discussing the notion of the Network City, we should be careful for the myths, surrounding the information society, such as the *paperless society* and the *death of distance*. With respect to ICT and mobility it should be noted that there is no empirical evidence whatsoever that the laws of mobility as pointed out in chapter 4 (section 4.3.2) are not valid anymore or will be not valid anymore in the future. It seems that people make about 3-4 trips a day (on average) and spend about 70 minutes per day (on average) on (physical) travel with or without ICT's. Of course, there might be some shift in priorities (section 4.4 refers), but that doesn't change the more fundamental travel time budget.

In the Dutch National Policy Document on Telematics Traffic and Transport III (1998-2003), the Ministry of Traffic and Transport (1998) summarises its policy towards ICT's (figure 5.2.2). Five themes are the focus of the Ministry:

- Dynamic Traffic Management;
- Travel information;
- Traffic safety;
- Chain approach for transport of goods;
- Chain approach for transport of people.

Secondly, the Ministry formulates in this document its vision towards the actors that should take (first) responsibility for the themes mentioned. According to the Ministry, the market should take a lot of (R&D) responsibility for multimodal passenger and goods transport and travel information.

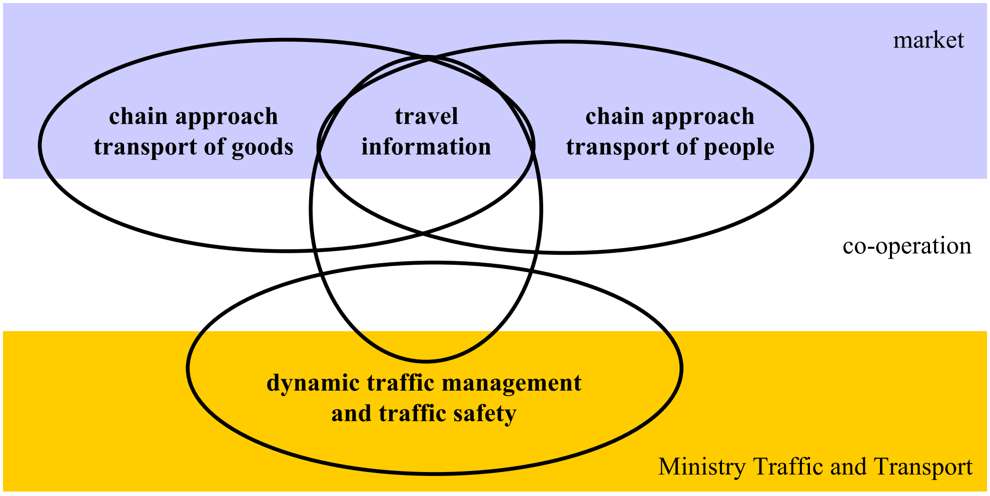


Figure **5.2.2** Roles and tasks Ministry of Traffic and Transport
Source: Ministry of Traffic and Transport, 1998

This section made clear that ICT's have a lot of impact both potentially and actually on the functioning of the society. It is much more uncertain however, (i) how urban practitioners should deal with the ongoing developments in the ICT sector, and (ii) how the 'new', future city should look like. Therefore, the next section focuses on the planning of the Network City.

5.3 The planning of the Network City

5.3.1 ICT and spatial planning

The forces that influence spatial structure today are manifold (Drewe, 2000). As we have already seen not only in this chapter on the Network City but also in previous chapters, major driving forces are individualisation, sustainability, globalisation, glocalisation, the ongoing development of transport systems, and information and communication technologies. Especially the role of ICT's, and their impact on spatial planning is highly uncertain as there are little or no direct links between ICT's and spatial structure.

In introducing ICT in spatial planning, it can be conceptualised as a new type of infrastructure catering for the transport of data or information: as an addition to existing forms of infrastructure and transportation (figure 5.3.1) (Drewe, 2000). The cube shows that the phenomenon can and perhaps should be analysed at different spatial levels ranking from local to world. ICT constitutes a paradigm challenge that meets with resistance from practitioners, because there is no direct link between ICT and spatial structure, and the spatial impacts of the new technology still involve high levels of uncertainty.

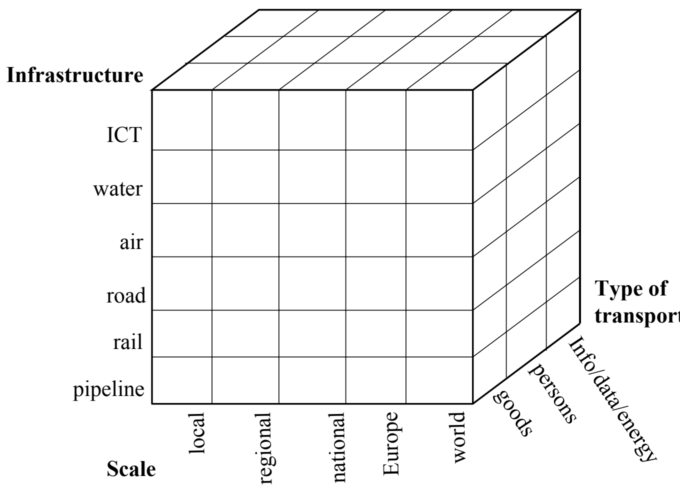


Figure **5.3.1** Infrastructure, scale, and type of transportation
Source: Drewe, 2000

The main challenge for spatial planning is to organise complexity in contrast to the focus on one specific spatial-functional concept for all kinds of different cases. Organised complexity means thinking in terms of multiple options rather than either/or. Moreover, Drewe (2000) says that '…an integrated planning of land use and urban technology networks, including ICT, needs to be developed. And urban ICT initiatives are to be stimulated as real-life experiments…'. And '…of special importance are those initiatives that target the least connected citizens to prevent them from "falling through the net"…'.

In order to illustrate how important urban technology is for urbanism or spatial planning, Drewe (2000) focuses as an example at the road network and the private car. 'Mainstream urbanism has rather been dominated by zonal thinkers as opposed to network thinkers. Creating monofunctional zones for dwellings, work and facilities naturally induces traffic between those zones. The rise of the automobile and the accompanying expansion of the road network have produces a "mobility problem" that is still unsolved today. While there are good reasons for reducing automobile dependence, in order to be effective, measures taken should not impair the quality of services to drivers. Possible solution would be to diversify vehicles and their ownership, or to modify road networks (more, but slower, of faster roads but with less exits). These solutions are based on network thinking, whereas zonal thinking leads to spatial concepts such as the compact city in order to curb private car mobility'.

In addition, Roberts (2000) argues that recognition has to be made of the 'motorisation of people' and of the metropolitan wide social networks that nowadays make up the contemporary fabric of urban life. She concludes that rather than attempting to constrain transport and communication, it has to be made more sustainable (ecologically, economically, and socially).

Secondly, Roberts (2000) focuses on the hubs and nodes of networks of transport and exchange[5]. Whilst these new spaces of 'supermodernity' observably do seem to be gaining in importance, the problem is that they are so often bland and anonymous. Roberts concludes here that it is the task for city planning and design (but also for architects) to reconcile the global with the local, to humanise spaces which may be used by anybody.

[5] In section 5.2 we referred to this notion as 'transport nodes'.

Within Delft University of Technology, the search for new spatial concepts is done within the design studio *The Network City*, a co-operation between the Dutch Ministry of Spatial Planning, Housing, and the Environment and the Faculty of Architecture at DUT (figure 5.4.4). This (design oriented) thesis is part of the design studio. Chapter 10 is completely in line with this way of thinking and working of the Design Studio and presents the conditions for the planning and design of transfer points for the Network City.

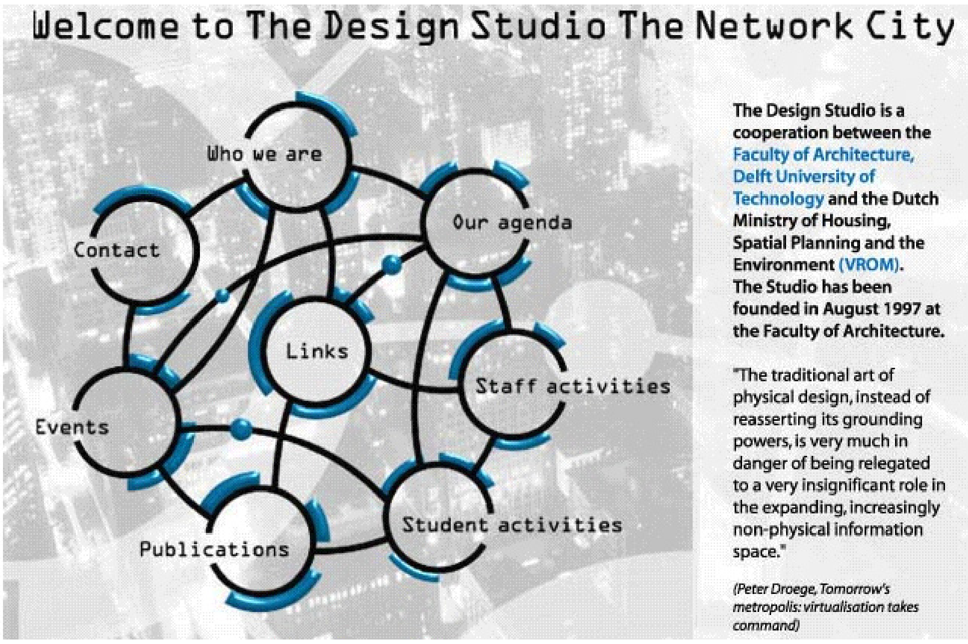


Figure **5.3.2** Design studio The Network City, http://www.networkcity.nl

5.3.2 New paradigms in spatial planning

"Confronted by this whirlwind of social and spatial transformation, the intellectual categories that constituted the foundation of planning in general, and of city planning in particular, have been made obsolete. Yet, the issues treated by city and regional planners are more important than ever, and the stock of skills accumulated in the field, both in the profession and in the academic institutions, are absolutely precious. What is at issue is the ability of city planners to renew their thinking, their framework, and their method, while departing from the world that is left behind: a world centred on the welfare state, on rigid zoning, on the belief in models of metropolitan growth, on the predictability of social patterns, on the legitimacy of national governments, on the long term benefits of economic growth without social and environmental constraints and on the view of the world from patriarchalism as a way of life.
The danger for the profession is to face this transformation defensively. As in all major processes of social change there are extraordinary opportunities to be seized, but also serious costs for those institutions and individuals unable or unwilling to adapt.
Thus, there is an obvious danger of digging the trenches of cultural resistance and resisting change by refining old concepts, or by embarking in a process of self-reflection in which planning itself becomes the goal, rather than the means. While in the professional world, the harsh reality of bureaucracies, politics and markets will leave little room for intellectual escapism, in the academic planning field the building of fantasy worlds made of abstract categories, or the attempt to justify planning by inventing a new academic discipline around an ad hoc theoretical foundation, could substitute for the harsh task of reinventing what to do out there, in an increasingly complex world. It must not be." (Castells, 1997).

Castells further describes in his course 'the education of the city planner in the information age' that in future city and regional planning will have to deal with a wide range of issues, but that some of them will appear at the forefront:
(i) the overarching issue of sustainability;
(ii) the planning of urban and metropolitan infrastructures;
(iii) the reconstruction of cultural meaning in spatial forms and processes;
(iv) the shift towards local and regional governments as decisive instances of governance.
The policy of sustainability is adopted widely: also in spatial planning, economic, ecological, and social aspects should be considered and weighted at the same time. Section 5.5 goes into detail. With respect to the planning of urban and metropolitan infrastructures, it should be added that it can be hypothesised that the connection between the infrastructures on the other hand (i.e. transport nodes) and the relation with the urban programme on the other (i.e. mobility environments, section 5.4 refers) will become crucial for the functioning of the city of the future. That is what this thesis is all about. The reconstruction of cultural meaning in spatial forms matches Roberts' description of the reconciliation of the global with the local, and the humanisation of public spaces (section 5.1 refers).
The governance of all this is a topic on its own. For the Dutch case, one may think that the shift towards local and regional governments as decisive instances of governance is abundant, for the fact that the Dutch 'bestemmingsplan' made by local governments is the only document with respect to spatial planning that is juridical binding for civilians. However, decisions and choices that were made in the Fourth National Document on Spatial Planning (Extra) by the national government consisted of many local decisions. In the Fifth National Document on Spatial Planning, the Ministry of Spatial Planning indeed confronts the regional and local governments with choices to be made by them (=local governments) about the so-called 'red' and 'green' contours around cities.

Boelens (2000a) elaborates on Castells' work and states more generally that spatial planning will more and more have to deal with (i) the changed notions of time and space on the one hand, and (ii) a new steering philosophy on the other hand. Space is not determined only by place anymore but by its position and function in boundless networks. The same applies to the notion of time. The revolution of telematics has resulted in a kind of *timeless time*, that can hardly be measured: we can communicate with the other side of the world within a split second.
But there are dangers. The increased (physical and virtual) mobility and network developments open up new possibilities for segregation: the Fourth World. In contrast to the First World (booming western economies), the Second World (formerly communistic countries), and the Third World (developing countries), the Forth World cannot be localised, but is present in all other three worlds. The Forth World consists of people who live outside (voluntarily or not) the new dynamics which are connected to the information '(r)evolution'. And the information revolution does not only stimulate segregations spatially, but also socially. For spatial planning this puts the public domain on the agenda, not only as a spatial, but also as a social dilemma, and perhaps even as a cultural dilemma.
Until now, spatial planning has derived its steering power from the nation state to a large extent. This state, and the Netherlands is a good example, consists of a hierarchical structure of departments: many local and (a few) regional governments, 12 provinces and one national government. Within the network society, the government is not the only relevant actor and factor for spatial planning, not even the most important anymore, the *primus inter pares*. On the contrary, the government nowadays stands between the other actors, instead of on top of them. It can be expected that the role of the government in the future will predominantly be

directed at defining the conditions (and controlling them), under which developments can take place.

5.3.3 Spatial planning and Geographical Information Systems (GIS)

One of the most promising ICT tools for spatial planning is GIS. GIS are those systems, in which a topographical shell around a core of one or more databases enables analyses that relate location bound (topographical) characteristics to administrative (data set) characteristics (Boelen en Klaasen, 1995). So, the GIS approach focuses on analysing and (especially) visualising geographical data. GIS can thus help interpreting, analysing, and visualising action spaces of people. In other words: Geographical Information Systems have the functional characteristics to combine spatial analysis and visual representation. In this thesis GIS is used for the Maastricht case about 'Collective demand-responsive transport and the activity-travel behaviour of its users, the elderly' (chapter 7).

"Since the early 1990s, there has been a worldwide GIS boom. Interest in information systems that can be used to process and present locational data has been growing exponentially. (...)
(...) Geographical information technology (Geo-IT) comprises a wide range of information systems to process spatial data. These include Geographical Information Systems, Computer-Aided Design, Automated Mapping, Facility Managment, Global Positioning Navigation Systems, Remote Sensing, and so forth. Such systems differ from one another in regard to their primary focus and, by extension, in their underlying data structure and functionality. (...)" (Geertman, 1996).

In his PhD thesis, Geertman identifies several *obstacles* that are blocking the way to a fuller performance of the function of Geo-IT in the framework of strategic spatial policy support:

- the presence of fundamental discrepancies between Geo-IT and physical planning, for example the discrepancy between the concept of space employed in the areas of Geo-IT and physical planning;
- the problem of conversion in the attempt to integrate data from diverse sources;
- the lack of meta information, especially information on the quality of data and the results derived from processing it;
- limited available spatial-analytical functionalities;
- the incorporation of the temporal factor in Geo-IT is at best rudimentary;
- although scientific information makes an indispensable and highly valued contribution to the policy process, the role of Geo-IT in policy support is very much context bound, with the result that neither more nor more rigorous scientific information necessarily leads to better or more appropriate decisions on policy.

Recent Geo-IT developments promise that the obstacles mentioned here will be surmounted. Geertman shows that in the Geo-IT industry there is an increasing interest in aspects such as data integration, use restrictions, user demands, contextual variables, quality aspects, and the incorporation of the temporal factor. There seems to be a transition from a technology-driven Geo-IT to a more use-oriented Geo-IT. For the most recent developments in spatial planning ICT's, we refer to the international CORP platform[6].

It is clear that there is a task for urbanists to design and plan the Network City physically, as urbanism is a field of expertise with a physical orientation. Therefore, the next two sections

[6] See: www.corp.at

focus on physical components of the Network City. Section 5.4 discusses the networks and the coherence between the spatial level, whereas section 5.5 starts from the orientation of sustainability.

5.4 Networks and coherence between spatial levels

Let us now focus on the physical networks[7] and on how consumption and production[8] on these physical networks take place. It should be the focus of every city planner and/or designer to generate a successful urban environment, creating an efficient and liveable, psychologically positive human environment. The city should be used intensively both in time and space! Already from ancient times the (physical) city has been -and most certainly will be in the future- a place of gathering and encounter.

The urban fabric should stimulate, facilitate, and accommodate these gatherings and encounters best as possible. In order to do so, the urban fabric has certain means, the urban components: streets, shops, offices, houses, pedestrian zones, green spaces, plazas parking lots, telephones, cable networks, etc; the technical networks in Dupuy's (1991) terminology. Successful cities -in terms of efficiency, vitality, and liveability- meet both the physical and psychological needs of the human scale with their physical structures and surroundings.

It was already in the 1960's that Jane Jacobs (1968) described the city according to the rules of 'organised complexity'. Projected to today's planning practice, Roberts et al. (1999) argue that '…considering the connections between the traditional urban centres and new sub-centres leads to the notion that it is the communication networks which form the essential building block for a model of the city's structure, rather than either the urban block or the neighbourhood…'

5.4.1 The city as a complex interacting system

Jane Jacobs was among the first to see the city as a complex interacting system. *'Why have cities not, long since, been identified, understood, and treated as problems of organised complexity? If the people concerned with the life sciences were able to identify their difficult problems as problems of organised complexity, why have people professionally concerned with cities not identified the kind of problems they had?'* (Jacobs, 1968).

Still now, architecture and urban design and planning have resisted describing the city in a scientific formulation, in part because of the underlying complexity (Salingaros, 1999a). Yet, this is exactly what human beings implicitly do when they try to understand complex interacting systems. A central component of the human intellect is the ability to establish connections, to see and superimpose patterns and structure: the fundamental difference between mankind and animals. The ability to establish connections applies both to tangent and visual, and less obvious, more abstract processes.

The urban web is a complex organising structure that exists primarily in the space between buildings. Each building encloses and shelters one or more human activity nodes. Coupling elements such as infrastructure and public space link these human activity nodes: streets, pedestrian zones, plazas, bicycle paths, highways, etc. Many urbanists consider the public space as their principal domain, and the infrastructure (within the total of public space) that of the civil engineer (Heeling, 1998).

[7] layer one of the Dupuy scheme of the *urbanism of networks* presented in section 1.2.2

[8] layer two of the Dupuy scheme of the *urbanism of networks* presented in section 1.2.2

Rossi (1982) shows that it is often the street system which is the most enduring part of the city. The street has two fundamental qualities as a route of communication and as a site of transaction, and forms the primary structural network of the city (Roberts et al., 1999). This primary network supports and enables the multitude of private communicative and cognitive networks of the citizens. In the modern city the street network has been altered by the emergence of the car, the tram, the metro. These have allowed the city to expand and, for areas within the city, to become associated with particular land uses. The emergence of increased traffic movements and associated large-scale road infrastructure today means that major inter- and intra-urban roads are now becoming just as dislocated from the city's public life as rail or air transport corridors already are. Interaction with the public realm is increasingly being concentrated at junctions or nodes in these systems.
With this in mind, it is useful to distinguish the most important elements of an urban pattern form the general fabric or 'tissue' of a city (Roberts, et al., 1999). It seems probable that these elements will comprise the following: the most memorable and used streets, the arteries of communication, places of exchange and assembly, and key buildings and complexes in the service and social infrastructures (Roberts, et al., 1999). In brief, it can be referred to as the *armature* of the city. So, the armature is not the network as a whole; rather it comprises the key features of the various urban networks which combine to form a core of movement, activity, and meaning. What in fact has been done is structuring and organising complexity, which leads us to the theoretical foundations of complex interacting systems.
A city without complexity is called 'dead'. Too much complexity without any organisation, without any structure, becomes 'chaotic' and 'unliveable'. Raising the degree of organised complexity appears as one of mankind's fundamental drives throughout the ages (Salingaros, 1999a). One of the principal ideas underlying the city-complexity theory is that a city mimics human thought processes, in that both depend on establishing connections, patterns, and structure.
Salingaros (1999b) clarifies his 'rules' of the composition of complex interacting systems as follows:
'The development of complex interacting systems in time defines an underlying causality. The smaller scales need to be defined before the larger scales: their elements must couple in a stable manner before the higher-order groups can begin to form and interact. Elements on the smallest scale, and their couplings, are thus the foundations of the entire structure. Requiring a hierarchy of nested scales means that not even one scale can be missing, otherwise the whole system is unstable. Connective rules determine whether a system is coherent or not. These general rules assess the stability or effectiveness of a complex system independently of what that system is supposed to do.'

5.4.2 The principles of the theory of the urban web

Interaction between the different elements of the urban fabric - streets, shops, houses, offices, green areas, pedestrian zones, etc. - increases the possibilities of the vitality, the success of cities. For the larger part, the vitality of the city depends on the geometry of the city; that is the connections, the network. The processes that generate the urban web can be summarised in terms of three principles, and may be written as follows (Salingaros, 1999a):

1. **Human activity nodes**. The urban web is anchored at nodes of human activities (activity places) whose connections make up the urban web. There exists distinct types of nodes: home, work, church, museum, restaurant, etc.
2. **Connections**. Infrastructure and/or public space can link nodes of activities. Empirical observations verify that the stronger the connections, and the more substructure the

web has, the more life a city has (Salingaros, 1999a). Too many connections that coincide overload the channel's capacity, which on its turn may result in non-vital deconcentration.

3. **Hierarchy**. A hierarchy rarely can be established at once. When allowed to do so, the urban web self-organises by creating an ordered hierarchy of connections on several different levels of scale. It becomes multiply connected but not chaotic. The organisation process follows a strict order starting from the smallest scales, progressing up to the higher scales. If any connective level is missing, the web is pathological.

Urban nodes are not only defined by structures such as a prominent building or a monument. Human activity nodes most certainly have to attract people for some reason, so this prominent building will mark a human activity node only if there is a well-defined activity as well. Now, the building will not only act as 'landmark', but also as a focus for 'paths' or 'routes', in the terminology of Lynch (1960).

A complex process of organisation connects the different nodes of the urban web. Connections enable one to get easily to any point, preferably by many different paths (Salingaros, 1999b). An ordered urban environment that is strongly connected might look highly irregular from the air. On the other hand, geometrical regularity in the plan might not directly be experienced on the ground.

A mathematical theorem says that two points can be connected by a straight line in only one way, but they can be connected by curved lines in an infinite number of ways. As we want the maximum possible number of connections between urban nodes (Salingaros, 1999a), we cannot only insist on the direct connections.

Human activity nodes and transport nodes

Transport nodes are the links between transport and communication networks on the one hand and the physical surroundings on the other, within which interaction takes place (Boelens, 1999). Transport nodes in general and more specifically multimodal transfer points have in our open, urban society an important position. They are the locations where the potential of physical human interaction is the largest (Bertolini and Dijst, 2000). Bertolini and Dijst refer to these locations as *mobility environments*, as locations where many people can *come*, but also as a location where people can *do* things: they are both accessible nodes and accessible places.

In a more recent publication, these two authors (Bertolini and Dijst, 2003) identify four mobility environments "anchoring (both actual and potential) human interaction in Network Cities". This relative simple typology is based on the dominating transport systems that brings people to the spot: slow modes, public transport, car, air.

[i] **pedestrian/bicycle nodes**: such as squares, pedestrianised streets, public parks

[ii] **railways stations**: in the nineties of the previous century and at the start of the 21st century, Europe experiences a true boom of urban projects connected to railways stations.

[iii] **motorway service areas**: these kinds of nodes near motorways attract all kinds of urban services, such as small supermarkets, laundry services, offices, restaurants, flowers, snacks, besides the traditional sales of petrol

[iv] **airports**: the unique (international, intercontinental) accessibility of large airports is the essential condition for the current emergence of multi-functional concentrations of activities.

There are also risk in combining the world of transport infrastructure and the city. The diversification of activities at gasoline stations, airports, or stations could loosen these transport nodes from their urban surroundings. Yet, Bertolini and Dijst argue that is probably more worthwhile to recognise and manage these developments, than to promote a spatial policy that drifts from the actual societal dynamics.

5.4.3 What to do?

The aims for the city are clear. All Dutch national urban and transport planning documents refer to the same issues: the conservation and creation of vital urban, rural, and nature environments, a sustainable development, and the improvement of liveability and accessibility. However, these aims seem to conflict with social trends such as (i) increasing consumption patterns, (ii) continuous enlargement of individual action spaces - because of an extensive use of environment unfriendly transport modes -, and (iii) spatial planning that can be characterised by large monofunctional residential, commercial and business zones.

The principles of complex interacting systems

From the theory of the urban web and the functioning of complex interacting systems we should learn that urban planners and designers should primarily focus on the nodes of convergence of the movement systems and the ‘armature’ of the city. Moreover, only coherence at the lower scales (building, building block, neighbourhood) between human activity nodes and the connections between them can create coherence at the higher scales. Therefore, the promotion of intra-urban travel possibilities will result in good conditions for urban success. Furthermore, it will improve the position of environment friendly intra-urban transport modes at the same time, which is referred to as 'the greening of urban transport' (Tolley, 1997).

Multimodal couplings

Coherence between the different networks of different scales is essential for the effective and efficient functioning of the urban environment. Multimodal couplings become critical success factors. With respect to the aims for the city as mentioned above, every trip has a theoretically ideal transport mode that depends primarily on the character of the (urban) environment of that trip.

Old city centres fit best for vehicles that have little space consumption (walking, bike, public transport), and/or vehicles that can accommodate large numbers of travel demands (public transport). Rural areas fit best for vehicles that can cover long distances in short times, and/or vehicles that can accommodate little travel demand efficiently. From a coherent urban web point of view, a multimodal trip seems the best alternative for going from rural areas to the (historical) inner-city.

5.4.4 The urban web and SMM

Urban success is closely related to a good functioning and coherent transport system. Mobility fulfils a crucial role in the society as a whole, and especially in cities. The relation between mobility on the one hand, and the societal/urban activities and organisation on the other, can be identified as 'symbiotic'. Mobility patterns reflect the societal/urban activities, but the transport (sub)system(s) also structures the societal/urban organisation both in time and space.

The theory of the urban web shows that a coherent multimodal network results from proper scale thinking. Delft research results (De Jong, 1988; De Jong and Paasman, 1998; Van Nes, 1998, 1999; Van Nes and Van der Zijpp, 2000) show that different infrastructure densities for the different scales, related to a scaling factor 3, should be considered as the basic rule for network coherence, and is thus a precondition for urban success. Besides, the theory of the

urban web states that coherence on the largest scales should only result from coherence at the lowest scales.
Practical problems arise when transport subsystems and modalities of different scales meet. The transfer from one modality to another should be as smooth as possible in both time and space. With that the performance of the intermodal transfer points have become one of the prominent success factors of the multimodal transport system. We will come back to this topic extensively in chapters 8, 9, and 10.

5.4.5 The urban web and the action space of people

The size of individual action spaces of the Dutch population has grown steadily. In 1999 people travelled about 35 kilometres per person per day (CBS, 2000). For the near future there is little chance for radical changes in this pattern of steady growth (1-2% per year). History has shown that new, faster travel modes will be adopted rather quickly. People, as utility maximisers, will optimise their action spaces and therefore will certainly use new, high-quality infrastructure and travel modes. As discussed in chapter three, activity-travel behaviour theory says that trips are only generated if the subjective benefits that go with the specific activity and location of the activity, offsets the costs that go with that activity and the trip to the location of the activity.
According to the theory of the urban web, this trend of growing action spaces doesn't have to interfere with urban success. On the contrary. As long as the high speed and thus high scale infrastructure and modalities (i) result from and (ii) are embedded in low scale urban coherence, the complex interacting system called 'city' will always be stable, but sustainability criteria should be taken into account.

5.5 The Network City and Sustainable Urbanism

In the last decades, the view is widely accepted that a high-energy, high pollution economy is not sustainable in the long term. But today's cities and transport networks are clearly neither energy nor pollution efficient[9]. Roberts et al. argue that car-based transport-intensive urban forms such as suburbs in general, and out-of-town centres particular, compound and magnify the problem many times over. But as an exclusively car-based existence is unlikely to be sustainable in the long term, urban planners and designers must address the issue of how a more urban, multimodal transport based lifestyle can compete with the attractiveness of suburbia. It is the contention of this thesis that giving a tangible character to the concept of the networks will play a vital role in this process.
In line with the notions of *sustainable development* and *sustainable mobility* as discussed in chapter two, *sustainable urbanism* can be defined as 'the urbanism that uses chances and possibilities in all phases of the planning process in order to (i) create a higher spatial quality[10] in combination with a lower environmental impact, (ii) to sustain both of them in time, and (iii) to do it in such a way that future generations can profit from it (Duijvesteijn, 1998).

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[9] Section 1.3 gives a broad analysis of the problems of today's cities and transport networks with respect to sustainability issues.
[10] The Dutch 5th National Policy Document on Spatial Planning (Ministry of Spatial Planning, Housing, and the Environment, 2001) offers seven (non-quantative) criteria for spatial quality: spatial diversity, economic and social functionality, cultural diversity, social justice, sustainability, attractiveness, and human scale.

5.5.1 Sustainable urbanism and the design and planning task for the city

'Differences between cities (form, structure, character and identity, supply of functions and facilities) can and should be used as a driving force for spatial policy. Using the differences between cities should be the central issue, instead of get rid of those differences' (Council for Spatial Planning, Housing, and the Environment, 1999b). The Dutch Advisory Council here focuses at mutual co-operation between the Dutch cities: complementarity instead of competition. In this way, all Dutch cities with their own identity become an interesting part of the whole. This also means that not every city has to be complete, but should cherish and enlarge its own specific qualities. The advantages of the larger scale are to be found in the *extra* facilities that can come within reach of people.

Furthermore, the Council suggests that the concept of diversity should not only be used at a national and/or regional scale, but also at the spatial level of city districts and neighbourhoods: "… a city should also consist of a variety of living environments and interesting different places…" and "…differences and diversity make quality..."

The Dutch Advisory Council (1999b, 2001a) distinguishes four urban design and planning tasks that should be dealt with in relation to the sustainable city:

1. the economic design and planning task;
2. the social-cultural design and planning task;
3. the ecological design and planning task; and
4. the physical design and planning task.

For the Advisory Council, the starting point of all this is *careful space consumption*. Moreover the Council uses the planning concept of the *urban network* as a means that can help to guide the urban design and planning tasks. It should be clear by now that there are differences between the concepts Network City and urban network. The concept of the *urban network* is primarily a spatial concept (for the *space of places*), whereas the *Network City* focuses on both the physical world and the virtual world (the *space of places* ánd the *space of flows,* both physical and virtual), and on temporal aspects (planning processes). Moreover, the Advisory Council (2001b) states that the concept of the urban network primarily is a concept that '…suits the spatial level of the urban region (r=30 km) for the planning of the daily living environment…'. On the other side the Network City is a notion that refers to all kinds of spatial levels.

As discussed in section 2.2 on sustainable mobility, the triangle of sustainability consists of economic aspects, social cultural aspects, and ecological aspects. These three topics are discussed here briefly. Furthermore, the city has to be planned and designed physically. The physical design and planning task, where everything comes together, is discussed in the next subsection.

The economic design and planning task: suitability and sufficiency

The competition advantages that the (traditional) city used to have (nearness, market, facilities) seem to have changed into disadvantages: bad accessibility, insufficient possibilities to grow, unsafety, the lack of attractive living environments for groups with high(er) incomes. The economic potentials of the city are used insufficiently. The role of services become more and more important in our economy (Caso, 1999). This offers chances for the city. In brief, the economic design and planning task can be summarised as 'suitability and sufficiency' (Advisory Council for Spatial Planning, Housing, and the Environment, 1999b, 2001a).

The social-cultural design and planning task: living together

Living together is a social-cultural design and planning task. Large differences between people in background, education, lifestyle, ethnicity, etc. do not only yield problems, but also offer opportunities to create specifically coloured liveable cities, city districts, and neighbourhoods. This integral approach of handling diversity is a policy that aims for full participation of every civilian in societal life. In brief, the social-cultural design and planning task can be summarised as 'liveability, social justice, and identity' (Advisory Council for Spatial Planning, Housing, and the Environment, 1999b, 2001a).

The ecological design and planning task

There is a large ecological design and planning task for the sustainable cities of the future. The design and planning task primarily consists of integrating the ecological targets in spatial planning practice. The ecological design and planning task for cities is complex: ecological problems can be noticed at all spatial levels varying from construction details (asbestos) to the whole world (CO_2 emissions), and both in the presence (noise hindrance) and in the far future (scarcity of resources), and (iii) in all phases of the life cycle of products (the extraction of base materials, producing of materials, construction, use, demolition, waste treatment).

5.5.2 The physical design and planning task: coherence and diversity

The three sustainability components ecology, economy, and society (social and cultural aspects) and their urban design and planning tasks have to be designed and planned physically. The coherence between the different (sectoral) design and planning tasks is of the utmost importance. The word 'coherence' is used here on purpose, and not for example the word 'integration'. For each of the sectoral design and planning tasks have to be made explicit before a coherent vision about considerations between the different design and planning tasks can be formulated.

Coherence between the ecological, economic, and social-cultural design and planning tasks on all spatial levels (figure 5.3.1) is created by (i) making explicit the different design and planning tasks during the whole planning process, and (ii) by striving for the optimisation of quality from all perspectives in stead of minimising negative impacts. A process of urban regeneration is seldom seen as the mutual effort to come to an optimisation from all three perspectives. Optimisation means finding a way out in dilemmas when the separate design and planning tasks have conflicting outcomes. Therefore, a one-way solution for this optimisation process does not exist. At every spatial level and for each concrete physical planning problem, new and/or other considerations have to be made.

The physical design and planning task can be summarised briefly as the careful use of space by using well thought planning concepts: density variation on purpose, multiple space consumption, reversible space consumption, flexibility.

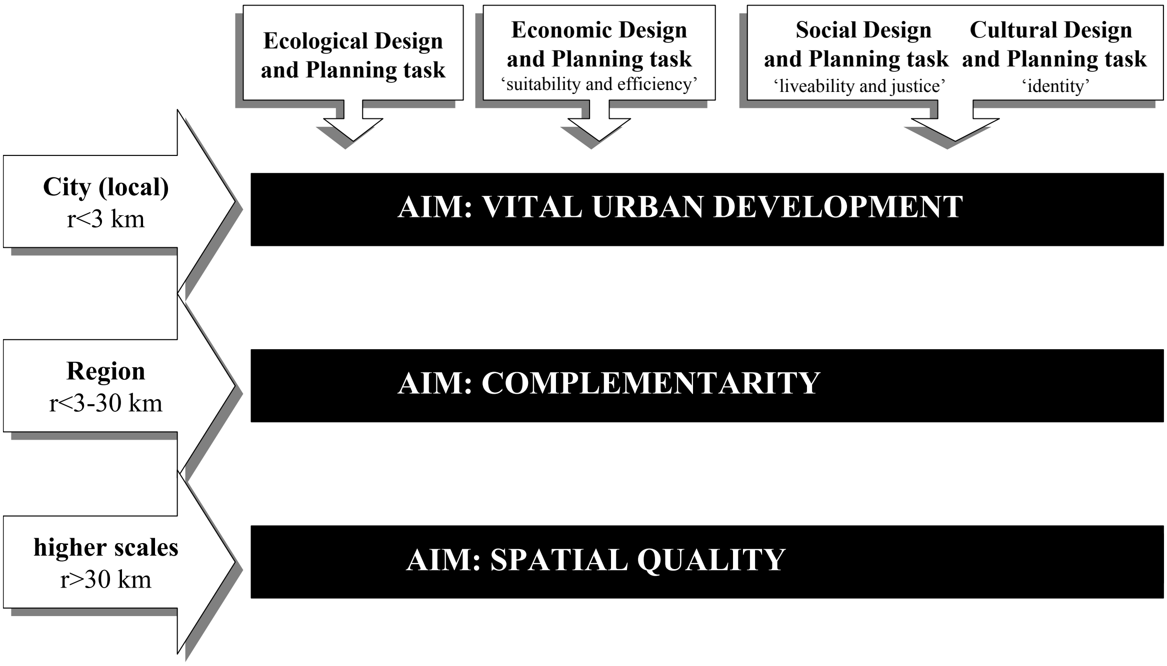


Figure **5.3.1** Urban design and planning tasks
Source: Advisory Council for Spatial Planning, Housing, and the Environment, 1999b

5.6 Summary and conclusions

This chapter focused on the Network City and its planning. The Network City has been defined as both a space of places and a space of flows. The space of places, purely a physical entity, is geographically bound and strives for sustainability. The space of flows is boundary crossing (at all levels of scale, and both physical and virtual), (inter)national oriented and highly dynamic. In the latter, transport and information and communication technologies play an important role. Transport nodes are the places where the space of places and the space of flows explicitly meet. Here, the network is linked to the geographical surface and environment. Moreover, the transport nodes are the places where new development potentials, but also new threats can arise. So, the hierarchy in the urban and transport network, and the location of transport nodes that connect the several sub-networks play an essential role in the efficiency, vitality, and liveability of cities.

With the ongoing development of the space of flows, the perception of people of time and space has shifted: distance as such is not so important anymore as it used to be in earlier days. Virtually, distances can be overcome in a split second. Physically large distance travel becomes more and more attractive due to the introduction and adoption of high speed travel modalities such as the airplane and high speed train. But also processes at the lower scales, such as the development of the home environment, are to be re-considered.

With this shift of people's perception of space and time, spatial planning has to evolve accordingly and should be understood as a process that :

(i) has to deal with a lot of uncertainty;
(ii) has to increase the degree of organised complexity;
(iii) has to focus on multiple option thinking instead of one way solutions for all;
(iv) has to focus on network thinking (all kinds of spatial levels) instead of zonal thinking;

(v) has to facilitate communication and transport sustainable, instead of trying to reduce them;

(vi) has to reconcile the global with the local (the *glocal*), and to humanise public spaces, and;

(vii) has to reconsider the governance of spatial developments and transformations.

Four kinds of design and planning tasks are identified for the city: the economic, the social-cultural, the ecological, and the physical design and planning task. Coherence between these four is a key-notion here. The responsibility and governance for this coherence that used to belong primarily and only to the government shifts to new (public-private) coalitions that have to be defined for the design and planning project identified. It is created by (i) making explicit the different single design and planning tasks during the whole planning process, and (ii) by striving for the optimisation of quality from all perspectives instead of minimising negative impacts.

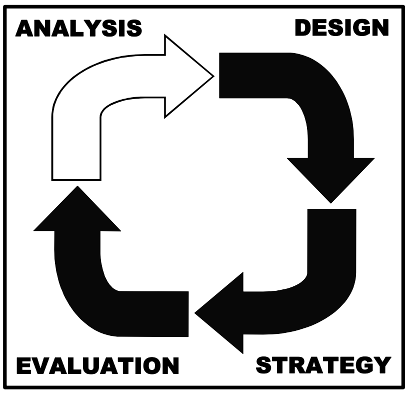
The forces that influence the spatial structure and the functioning of the city today are manifold. The role of Information and Communications within this field of forces is highly uncertain. In introducing ICT in spatial planning, it can be conceptualised as a new, extra type of infrastructure catering for the transport of data and/or information

This chapter and the previous four chapter, belonging to the thesis phase of analysis originated from a more general theoretical point of view on the city, multimodal passenger mobility, and the activity-travel behaviour of people. The chapters 6-9 discuss the thesis case studies, demand-responsive transport and the location of transfer points.

CHAPTER SIX THE CITY AND REGION OF MAASTRICHT

Nemo patriam quia magna est amat, sed quia sua.

No one loves his native country for its size, but for the fact that it is his homeland.
Seneca, Epistulae Morales, no. 66
(for Mart)



The objective of this chapter is to introduce the location of the case studies of this thesis: the city and the region of Maastricht. The city of Maastricht in the south of the Netherlands is among the oldest cities of the Netherlands and is located in the centre of the Maas-Rhine EUregion.
This chapter is divided into three sections. Section 6.1 focuses on the city of Maastricht: history, demographics, spatial structure, transport issues, and current and future developments. Section 6.2 discusses the position of Maastricht within the Maas-Rhine region in more detail. Finally, section 6.3 gives some brief conclusions.

Gemeente Maastricht

6.1 The city of Maastricht

6.1.1 History and spatial structure

The city of Maastricht is located in the south of the Netherlands (figure 6.1.1 and figure 6.1.2), near to the Belgium and German border, and is well-known for its historical city centre. It is among the oldest cities of the Netherlands, and was founded by the Romans: *Mosae Trajectum*, 'a place where you could cross the Maas river'. In 350 A.D. the *pons Mosae*, 'the bridge over the Maas river', was fortified by a late Roman castellum. In 384 A.D., Servatius, the bisshop of Tongeren and later on the bisshop of Maastricht died and he was burried in Maastricht. From that time on, many pilgrims came to the city of Maastricht to honour the late bisshop, which can be seen as the starting point of the rise of the city of Maastricht both economically and culturally.

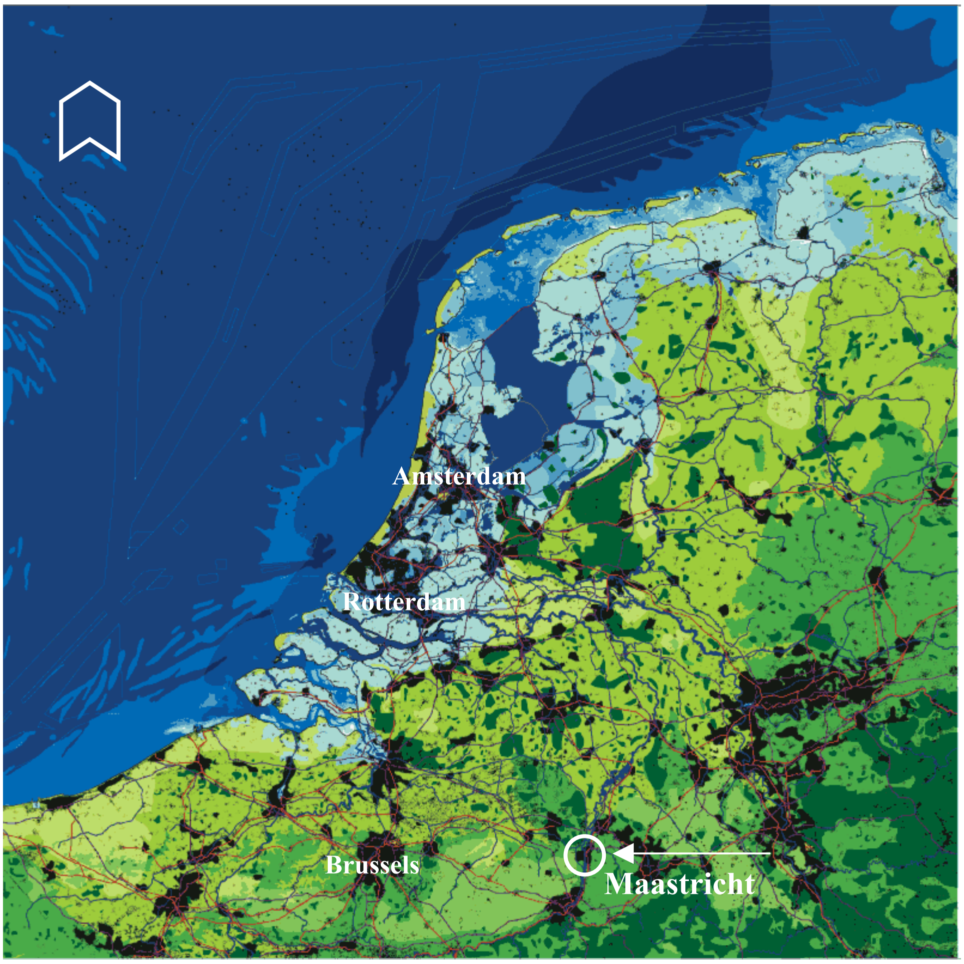


Figure **6.1.1** The city of Maastricht in the Netherlands
Source: the Ministry of Spatial Planning, Housing, and the Environment, 2001

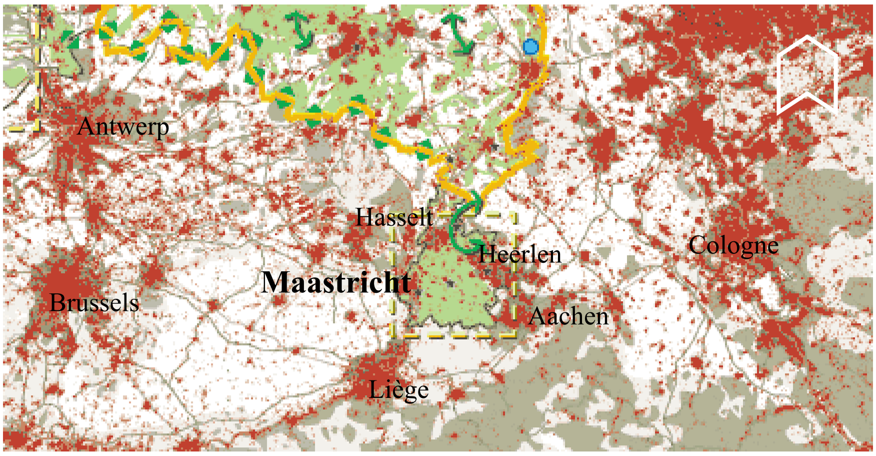


Figure **6.1.2** South Limburg in its context
Source: Ministry of Spatial Planning, Housing, and the Environment, 2001

So, the city of Maastricht owes its existence to the presence of a ford in the Maas river in earlier days. It developed from a walled fortification into a so-called finger city (figure 6.1.3). The first settlements grew at the west side of the Maas river, but later on the extensions of the city exceeded the city walls, both on the west and the east side of the Maas river. Nowadays, the city of Maastricht can be characterised by a *finger city* due to the extensions parallel at the radial infrastructure. At the west side of the city, Maastricht is bordered by the Belgium-Dutch border.

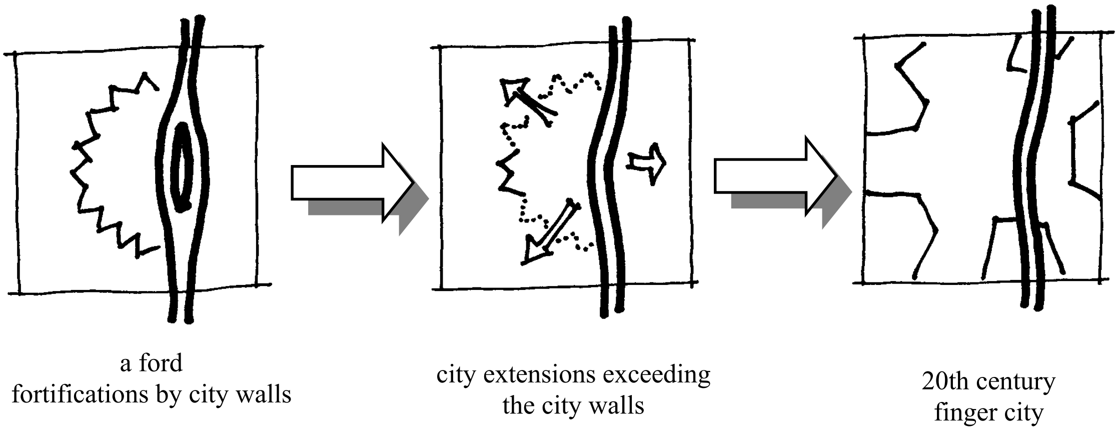


Figure **6.1.3** History of Maastricht
Source: Peeters, 1999

From a historical perspective, the city of Maastricht can be seen as the result of an ongoing process of transformation. Time after time, the city has been capable of renewal without breaking with the past. The shape of the city has not changed, because of the exchange of *the old* by *the new*, but by adding and enriching the existing.
In the 19th century Maastricht develops from an isolated fortification city into an industrial city. In that time, Maastricht was oriented to a large extent at Belgium. And after 1830, Belgium could be characterised by an industrial renewal which went much quicker than in the Netherlands. So, the city of Maastricht began to develop into one of the first Dutch industrial cities.
After the construction of the Zuid-Willemsvaart, the canal from Maastricht to Liège was constructed in 1845. The economic rivalry between Belgium and the Netherlands resulted in the construction of the Julianakanaal at the east side of the Maas river and the construction of

the Albertkanaal at the west side of the Maas river towards Antwerp. So, nowadays Maastricht is located at a point where two large canals can be found at close distance without a proper connection between them. The water structure (figure 6.1.4) still rules the form and functioning of the city to a large extent.
In 1865 the train connection from Liège to Venlo via Maastricht was constructed. The modernisation of infrastructure is continued after WOII with the extension of a new road and motorway network. The motorway A2 is connected to the western part of the city by two bridges crossing the Maas river (Noorderbrug and J. F. Kennedybrug) and a ringway around the historic city centre (figure 6.1.5 refers).
Due to the successful industrialisation and the increase of the number of inhabitants, the city of Maastricht grows out of its fortification boundaries in the second half of the 19th century. The Development Plan from 1941, the Structure plan 1954, and the Spatial Development plan from 1962 guide the city of Maastricht spatially in the post WOII period, from fortification city to finger city.

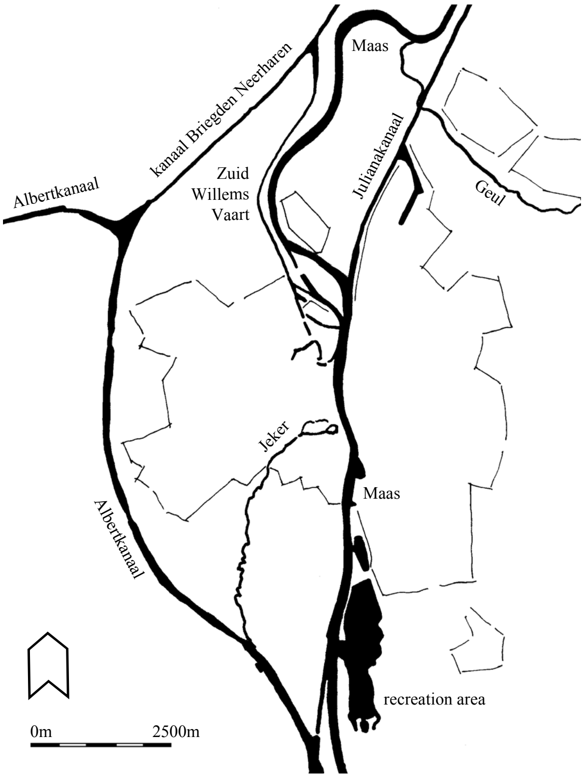


Figure **6.1.4** Water structure of the city of Maastricht

The industries of ceramics, paper, and glass have carried the city economically for decades. But when the medical faculty settles in Maastricht in the early seventies, the city rapidly grows into a university city. And after the modern congress centre MECC is opened in the second half of the seventies, the development of Maastricht into a city of knowledge and services has truly started. Besides the university, the city of Maastricht nowadays accommodates among others an academy for dramatic art, an academy of music, an academy of art, a school for interpreters, and a hotel management school. Today's important employment sectors are the government (local and provincial), health, education, tourism, life sciences and medical technology.
An impressive recent urban project based on the design concept of Jo Coenen is the development of the former factory site of Sphinx-Céramique located at the east bank of the

Maas river. It consists of offices, housing, the Bonnefantenmuseum, and the Céramique Centre which accommodates among others the city library and the municipality archives.
The historic inner city with 1660 monuments (second largest city of monuments of the Netherlands after Amsterdam) has developed into a high quality shopping centre with international fame. The historic centre has a lot of high quality 17th and 18th century architecture. Moreover, Maastricht has many medieval churches and monasteries. Also from the perspective of monumentality, the city functions in relation to her natural hinterland that stretches beyond the borders of the Netherlands. Each year, the historic city centre with its special cultural-historic settings, atmosphere and many places of entertainment attracts over 15 million visitors and tourists.

Figure **6.1.5** City of Maastricht topography

6.1.2 The city of Maastricht in numbers

This subsection gives some numbers on the city of Maastricht with brief comments. Data originates from the Maastricht website (http://www.maastricht.nl).

Table **6.1.1** Population density (2000)

	surface [km2]	number of inhabitants	population density [numb. inh / km2]
the Netherlands	41,500	16,000,000	385
Maas-Rhine EUregion	10,500	3,800,000	360
Zuid-Limburg	690	650.000	940
city of Maastricht	59	122,000	2070

The Zuid-Limburg area has the second highest population density of the Netherlands after the Randstad area. Measured in number of people, the city of Maastricht is the 18th largest city of the Netherlands with some more than 120,000 inhabitants, right behind the cities of Almere and Amersfoort and just before the city of Leiden. The distribution of employment sectors (table 6.1.2) shows that Maastricht is (has become) a city of services.

Table **6.1.2** City of Maastricht: distribution of employment sectors (2001)

Employment sector	%
Agriculture, Fishery, Minerals	0.7
Industry	14.6
Energy, Water Company	1.8
Construction industry	2.7
Commerce, Hotel and catering industry	19.4
Transport/Communication	7.1
Financial institutions, Business services	19.4
Public services, Education, Health	31.4
Other	2.9

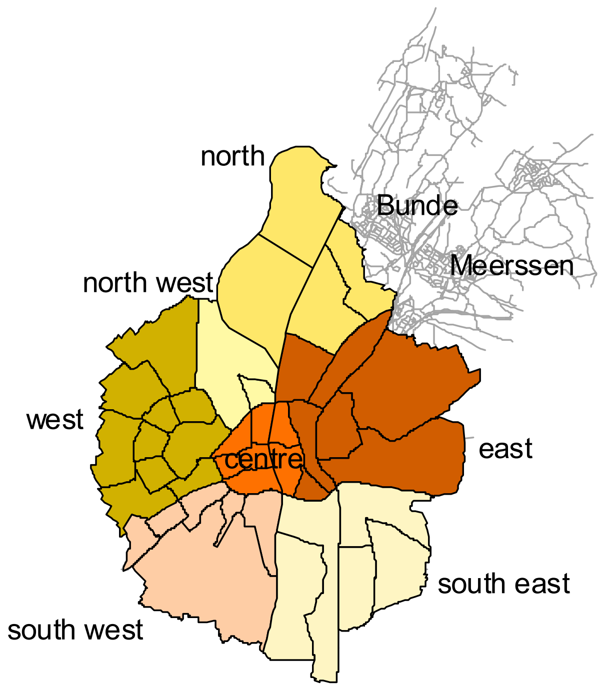


Figure **6.1.6** Maastricht city districts

Table **6.1.3** Maastricht city districts and neighbourhoods

District area	Neighbourhoods
City centre	City, Jekerkwartier, Kommelkwartier, Statenkwartier, Boschstraatkwartier, Wyck, Sint Maartenspoor
West	Oud Caberg, Caberg, Malpertuis, Pottenberg, Brusselsepoort, Belfort, Mariaberg, Daalhof, Malberg, Dousberg
North west	Boschpoort, Bosscherveld
North	Meerssenhoven, Beatrixhaven, Itteren, Borgharen
East	Heugemerveld, Wyckerpoort, Wittevrouwenveld, Limmel, Nazareth, Amby, Scharn
South east	Heugem, Randwyck, De Heeg, Vroendaal, Heer
South west	Wolder, Campagne, Biesland, Jekerdal, Villapark, Sint Pieter

- The city of Maastricht has the highest cafe density of the Netherlands: 1 cafe per 350 inhabitants (Dutch average = 1 per 900 inhabitants). 60% of the cafes and 75% of the restaurants is located in the historic city centre.
- The main shopping area of the historic city centre encompasses about 500 shops.
- Neighbourhood shopping centres in: Malberg, Caberg, Pottenberg, Malpertuis, Daalhof, Sint Pieter, Frankenstraat, Nazareth/Limmel, Amby, Heugem/Randwijck, De Heeg, Heugemerveld, Borgharen, and Itteren
- City district shopping centres in: Heer and Brusselse Poort

6.1.3 Transport

The city of Maastricht has a good multimodal accessibility (table 6.1.6 refers) and is connected to many transport networks at all kinds of spatial levels. Maastricht-Aachen-Airport (MAA) connects Maastricht via Amsterdam Schiphol Airport to the rest of the world. Motorway A2 and the Intercity train station connect Maastricht to the major Dutch cities and to the cities of Liège and Aachen. Within the city of Maastricht the bus system connects all city neighbourhoods and city districts to the Central Station. Also the road and bicycle network are well developed in the city of Maastricht. In this subsection, we elaborate on two specific topics, because of their importance with respect to the accessibility and liveability of the city: the parking in and around the historic city centre and the airport.

Table **6.1.6** Maastricht and its accessibility

Transport modality	Most important connections
Car	Motorway A2 Amsterdam-Genoa, motorway A76 Antwerp-Heerlen-Aachen-Cologne, A79 Maastricht-Heerlen, E324 Antwerp-Aachen
Airplane	Maastricht Aachen Airport
Train	InterCity: Maastricht-Amsterdam and Maastricht-Liège-Brussels Stoptrain: Maastricht-Heerlen
Bus	City bus Maastricht Hermes regional bus system Interliner, Maastricht-Aachen
Taxi	Taxi stops at Central Station, the Market, at the Vrijthof
Shared taxi	Traintaxi (door-to-station/station-to-door), taxi stop at Central Station Tailor-Made Transport (collective demand-responsive, door-to-door), TMT stops at Central Station, Academic Hospital Maastricht, shopping centre Brusselse Poort, the Market
Water	Connected to Rotterdam via Maas and Julianakanaal Connected to Antwerp via Albertkanaal

Source: Municipality of Maastricht, 2001; http://www.maastricht.nl

Parking in and around the city centre

Parking in and around city centres that attract a lot of visitors, tourists, and shoppers, is a large problem for almost all medieval city centres. A clear parking policy is needed to diminish the burden of the parking on the city climate. Parking on the street is limited to a large extent. The city of Maastricht has a digital Parking Information Panel system that guides visitors to parking garages and parking lots. In order to improve the accessibility of the historic city centre, the city of Maastricht adopted a new plan called the *Markt-Maas project*[1]. Among others, this project consists of the construction of a tunnel under the Maasboulevard and a parking garage under the Markt. Figure 6.1.7 shows all large parking garages and parking lots that are connected to the Parking Information System and are located in and around the city centre:

[1] The Griend: 356 places
[2] Railways station, Spoorweglaan: 78 places
[3] Ceramique Noord, Avenue Ceramique: 400 places
[4] Ceramique Zuid, Avenue Ceramique: 160 places
[5] Westoever Maas, Kennedybrug: 100 places
[6] Onze Lieve Vrouwe plein: 369 places
[7] Vrijthof: 505 places
[8] Boschstraat: 400 places
[9] Cabergerweg: 300 places

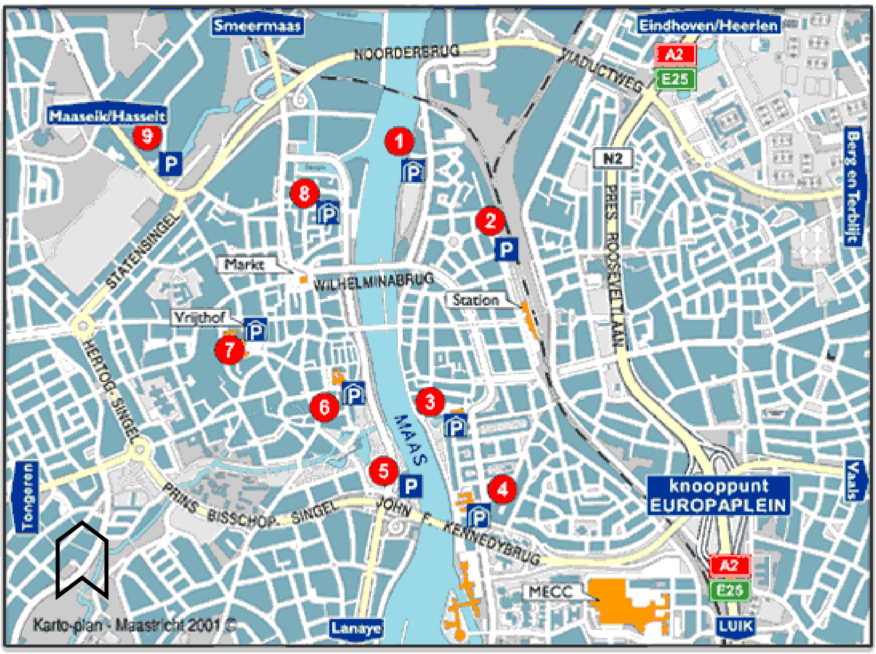


Figure **6.1.7** City plan Maastricht and parking
Source: Municipality of Maastricht, 2001; http://www.maastricht.nl

Maastricht-Aachen Airport (MAA)

At a distance of only 10 kilometres north from the city centre near motorway A2 (figure 6.1.8), Maastricht has its own airport, the second largest airport of the Netherlands after Schiphol Airport. The position and future position of MAA becomes interesting with the presence of two High Speed Train stations relatively near by in the cities of Liège and Aachen. Like Maastricht, the city of Liège also has a (small) airport. How the powers of

[1] For further information http://www.maastricht.nl

(inter)national connectivity will shift with the functioning of the HST system is still uncertain to a large extent.

Figure **6.1.8** Maastricht-Aachen airport

In seize MAA is a middle class passenger airport. From MAA, KLM runs regular services on Amsterdam, Rotterdam, London Stansted, Munich, Milan Malpensa, Berlin, Graz, Innsbruck, and Istanbul. Furthermore, MAA has also a large number of holiday flights to the Mediterranean and the Canary Islands. In 1998, 357,000 passengers used MAA as origin or destination for their flight. MAA was used as origin or arrival harbour by 273,000 line service passenger and charter passengers. Business travel and flight by flying schools account for the other 84,000 travellers (source: MAA, 2001, http://www.maa.nl).
MAA is mainly used by passengers living in the Dutch province of Limburg, the Belgium province of Limburg, and the German region of Aachen. But this regions have a rather high population density: within a radius of 50 kilometres, there are about 4 million people.
MAA isn't only the second largest airport of the Netherlands with respect to passenger transport, but also with respect to freight transport with 35,000 tons of freight in 1998. Considering its good geographical location, MAA has the potential to grow into an international centre for goods transport.

6.1.4 Developments

The vision of the city of Maastricht on the spatial development has to give an answer to the questions (i) where the many, new space consuming functions have to be located within the city, and (ii) how the accessibility and liveability of the city, city districts, and the neighbourhoods can be guaranteed (Municipality of Maastricht, 1999). Maastricht sees the area *city centre-area near the Noorderbrug-area near the J.F. Kennedybrug-area near A2 traverse* (figure 6.1.9) as the core of the city. The municipality of Maastricth considers the corner points of this area to be the most strategic places ('critical details') for urban intervention. Here, new urban programme should be created near the main arteries of the city.

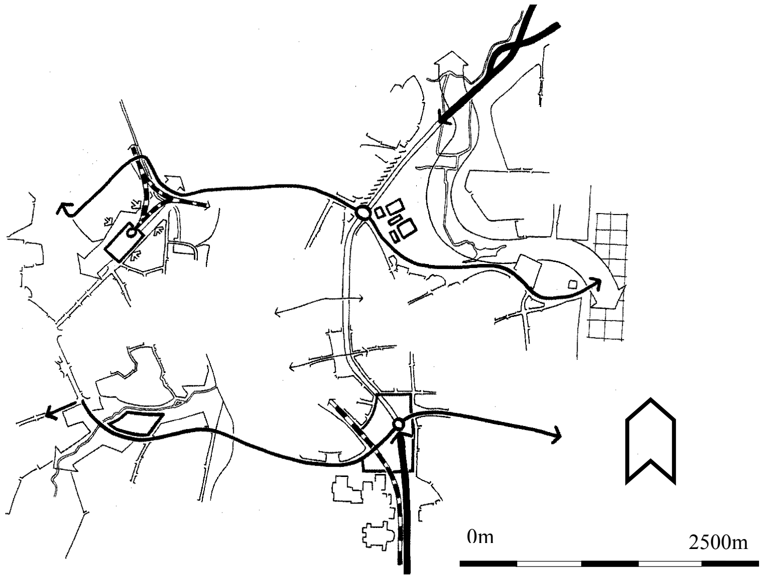


Figure **6.1.9** Four nodes in the city
Source: Municipality of Maastricht (1999)

Figure 6.1.10 shows the main map of the Structure Plan Maastricht 2005 (Municipality of Maastricht, 1999), in which desirable future spatial developments are given. The most important developments are:

- Motorway A2: a good solution has to be designed for the A2 traverse that goes right through the city. Tunnelling the motorway is one of the options.
- Lightrail: the public transport quality of the region is improved by lightrail between Maastricht and Heerlen/Kerkrade under the authority of the Province of Limburg. Moreover, it is studied whether lightrail could also be applied at the western part of Maastricht.
- Relocation public transport axis: in order to increase the flow and speed of the bus in the city of Maastricht, the main public transport axis is relocated. At the west bank, the new public transport axis has been successfully active since summer 2001 (Municipality of Maastricht, 2001, http://www.maastricht.nl). The relocation of the public axis at the east bank is studied.
- Urban renewal and urban extensions at several places in the city.
- Cabergkanaal: it is studied whether the Albertkanaal and Julianakanaal could be connected by a new canal, the Cabergkanaal.
- Markt-Maas project: a structural improvement of the public space in and around the historic city centre, plus extra shopping facilities.

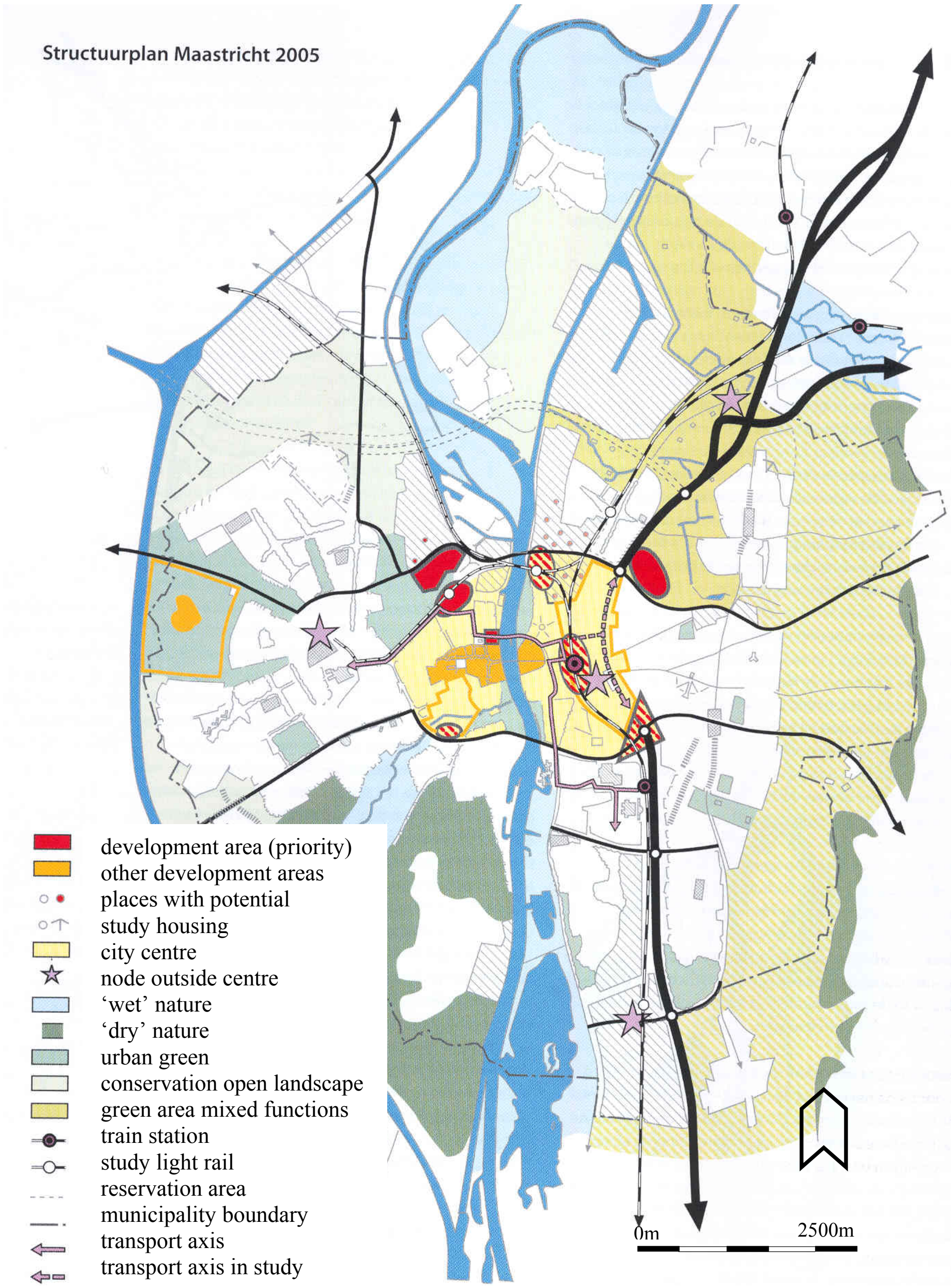


Figure **6.1.10** Structure Plan city of Maastricht
Source: Municipality of Maastricht, 1999

6.2 The region of Maastricht

6.2.1 EUregion Maas-Rhine: spatial structure

Borders are the scars of history. In history, border regions used to be the playthings of nations. This is absolutely true for the Maastricht region, as Maastricht has been German, Belgium, and finally Dutch territory. It is self evident that these kinds of border regions hardly got any chance to develop economically, socially, and culturally. Therefore it isn't strange that a lot of

border regions were poorly connected to the more affluent parts of the country. This disconnection could even result in a loss of identity by the inhabitants of those border regions.
The EUregion Maas-Rhine consists of an urban network of four cities (Maastricht, Heerlen, Liège, Aachen) located around a central green zone (figure 6.2.1). This area that (i) contains three national borders, that (ii) consists of different types of landscapes and spatial atmospheres, and that (iii) has known three currencies till the introduction of the Euro, has been united since 1991 via a legal co-operation programme: the EUregion Maas-Rhine. Until 2001, this co-operation has been mainly of economic nature. Spatially, the co-operation and coherence still have to be developed and physically designed.

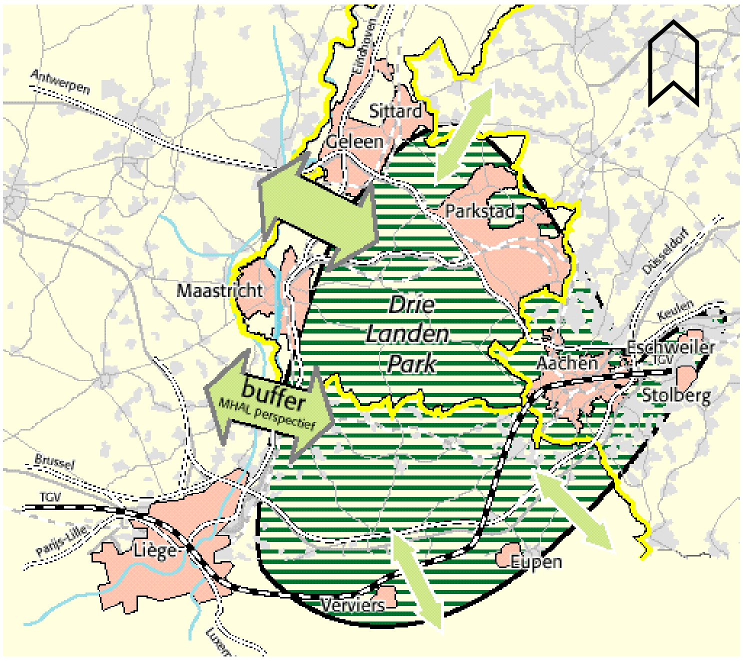


Figure **6.2.1** Drielandenpark
Source: Province of Limburg, 2001

It should be noted that there are different views on the notion of EUregion. From a somewhat broader perspective the cities of Hasselt and Genk are also seen as part of the MHAL-region (figure 6.2.2). Figure 6.2.2 clearly shows the spatial structure of the (large) Maas-Rhine region: two urban zones that meet at Geleen/Sittard and a prominent position for the Maas river and the High Speed Rail connection between Brussels and Cologne via Liège and Aachen.
The history of development of Maastricht, Heerlen, Aachen, and Liège is completely different. Maastricht and Liège developed due to the presence of a ford in the Maas river. Heerlen and Aachen developed because of their location at an old Roman route from Xanten to Trier. Also today's characteristics and functioning of these four cities differs to a large extent and can be called complementary (table 6.2.1), which is a good starting point for ongoing co-operation and coherence, both functionally and spatially, between the cities of the EUregion.

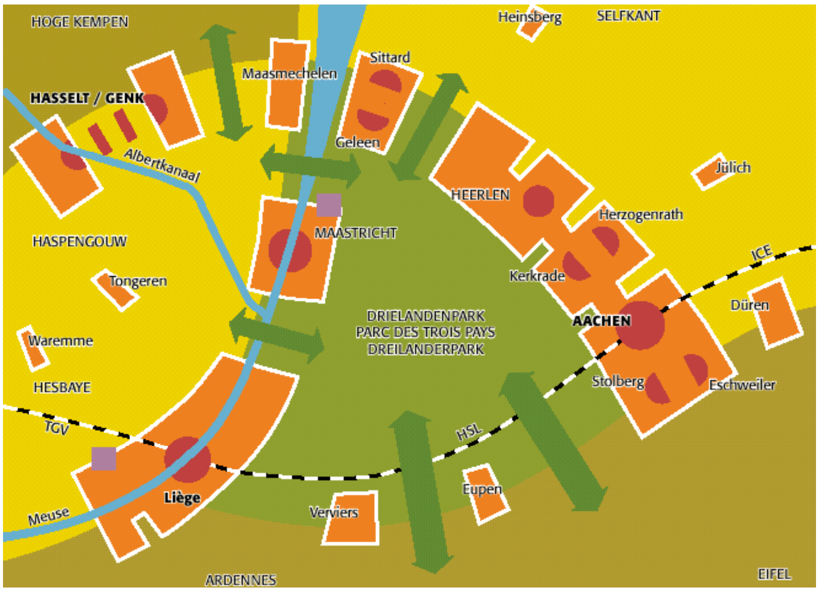


Figure **6.2.2** MHAL perspective
Source: Province of Limburg, 2001

cities	**Maastricht**	**Heerlen**	**Aachen**	**Liège**
image	'smallest metropolis of Europe'	'Parkstad Limburg'	'Charles' city'	'city of Princes'
Regional character	centre of culture and shopping	shopping centre	high-tech centre / R&D	Centre of services, provincial government
national character	tourism, cultural centre	-	centre of knowledge	city of commerce
european character	congress city, tourism	-	centre of knowledge	-
main functions	education, services, tourism	services, shopping centre	education, R&D	city of commerce, inland harbour

Table **6.2.1** Characteristics Maastricht, Heerlen, Aachen, Liège
Source: Peeters, 1999

6.2.2 Transport

The (inter)national and regional connecting road network

The (inter)national connecting road network of the MHAL region is shown in the left picture of figure 6.2.3. For Maastricht, the main connections are the motorway A2 (Liège-Maastricht-Eindhoven) and the motorway A76 (Brussels-Leuven-Heerlen-Aachen). The regional connecting road network of the region of Maastricht is shown in the right picture of figure 6.2.3. Also for the regional spatial level, the motorways A2 and A76 are of importance for Maastricht, but they are complemented by the motorway A79 (Maastricht-Heerlen), and some more radial oriented National Roads.

One of the most strategic design tasks for the MHAL region is the development of the corridor Roermond-Maastricht-Liège (Province of Limburg, 2001). The A2 (in combination with the A76) is an important hinterland connection for the Netherlands for both personal (business travel) and goods transport. A crucial part of this hinterland connection is the motorway A2 between Roermond (Middle Limburg) and Maastricht, which in fact has both an (inter)national and a regional function. According to the Province of Limburg, the maximum capacity of this road section is already exceeded too often, resulting in congestion.

And when the increase of the goods and business transport of the next decades is taken into account, it is feared that this road section will grow into a traffic infarct.
The national government is responsible for the construction and maintenance of the national motorways. Looking at the investment programme of the national government (Ministry of Transport, 2001), the extension of capacity of the A2 will only be realised after the year 2010. In the mean time, the province of Limburg is not willing to wait and see how their most important connecting road of the Zuid-Limburg region will frustrate the functioning of the Limburg economic clusters, and the urban and logistic nodes. Therefore, they would like to discuss possible solutions with all parties involved (local municipalities, the national government, but also private enterprises) in order to prevent the traffic infarct from happening (Province of Limburg, 2001).

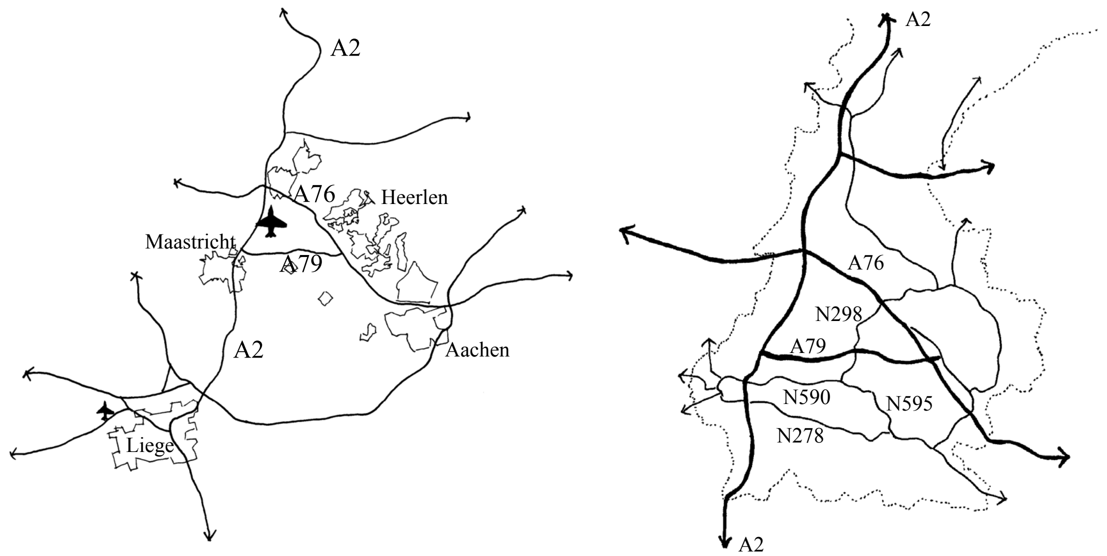


Figure **6.2.3** Car network region Maastricht (MHAL region and South Limburg)

The (inter)national and regional rail network

Figures 6.2.4 show the main train network of the MHAL region. The cities of Liège and Aachen are both stops of the European High Speed Train network (figure 6.2.5). Maastricht has an Intercity station. For a good international accessibility, it is important for Maastricht to be connected directly to the HST-stations of Liège and Aachen.

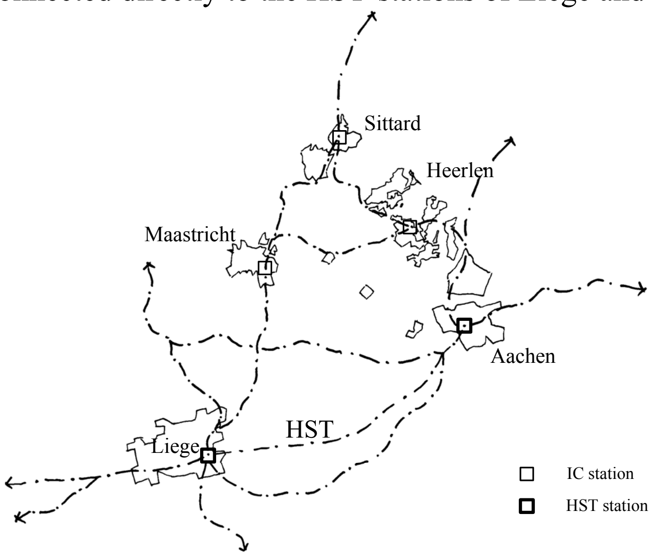


Figure **6.2.4** Train network region Maastricht

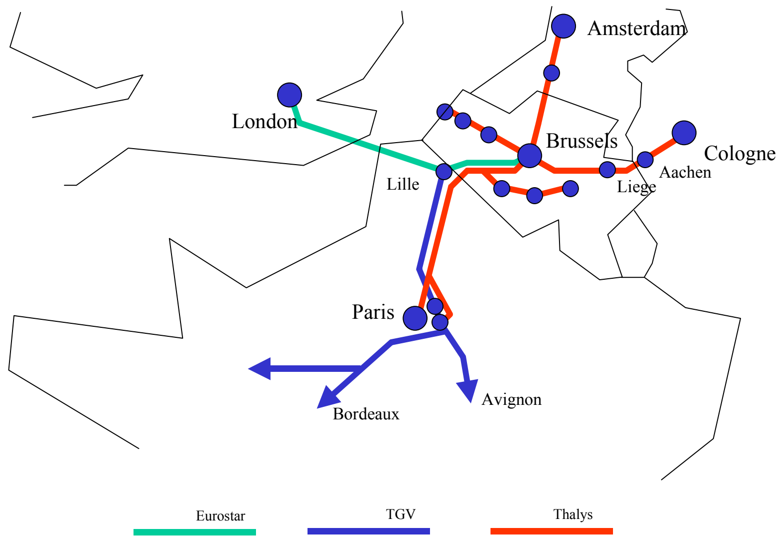


Figure **6.2.5** High speed network region Maastricht

From a regional perspective, the province of Limburg (2001) sees the construction of a light-rail connection between Maastricht and Kerkrade as an important part of the regional connecting rail network. In the future, a high quality regional rail connection (Euroring) is desired between Liège, Maastricht, Sittard, Parkstad, Aachen, and possibly also Hasselt.

6.2.3 Developments

The province of Limburg (2001) identifies three important policy and design tasks for the future of the MHAL region.

1. the development and sustainability of the (A2) corridor Roermond (Middle Limburg)-Liège;
2. the development and greening of the economic cluster Aachen-Parkstad;
3. the development of the boundary crossing Drielandenpark.

Ad 1.
Figure 6.2.6 shows the strategic projects of the development vision of the Province of Limburg (2001), and figure 6.2.7 shows the desired developments around the city of Maastricht.
One of the major strategic projects is the Maastricht Aachen Airport. The aim is focused at a MAA businesspark with international oriented industries (Province of Limburg, 2001). Moreover, the Province of Limburg states that the MAA can and should be integrated in a transport concept for the region of Maastricht. It is argued that the present and future traffic problems can only be effectively dealt with when all transport modes are taken into account simultaneously.

Ad 2.
The position of the urban area Parkstad Limburg / region Aachen North has explicitly to do with its location at the A76 corridor between Antwerp on the one hand, and the Ruhr area and the region of Cologne on the other hand. This urban area is characterised by its similarities in economic developments in the 20th century: both regions at both sides of the Dutch-German border have witnessed a fast urban development due to the rise of the mining industry, which was followed by a large urban re-structuring after the mines were closed. In the city of

Aachen, a successful transformation has taken place ‘from coals to knowledge’ with the Westfälische Technische Hochschule as catalyst. In Parkstad Limburg, operation ‘from black to green’ has only been partly successful, which has to do with problems related to the composition of the population, the housing stock, and the labour force (Province of Limburg, 2001).

Ad 3.
The Drielandenpark can be seen as the Green Heart of the MHAL region. The main aim is to improve the quality of the open space between the cities of Maastricht, Hasselt, Aachen, and Liège (Province of Limburg, 2001).

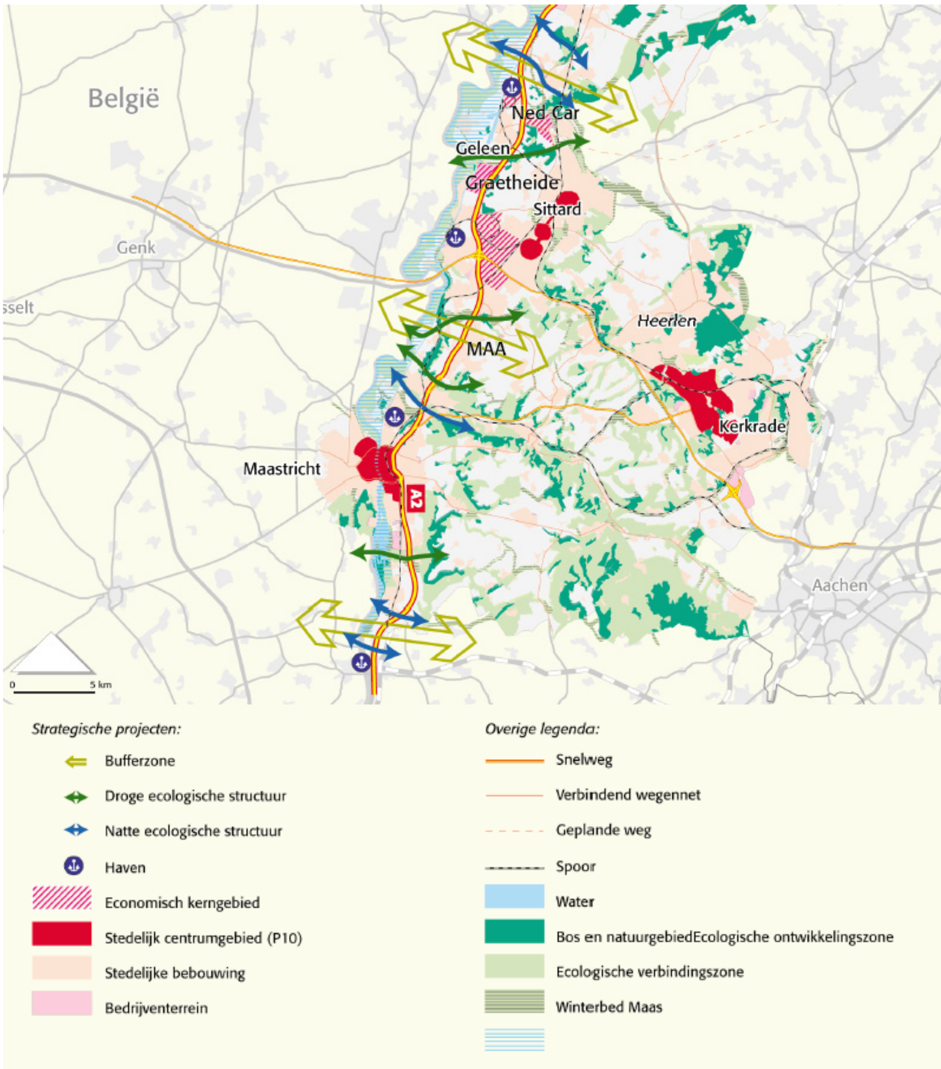


Figure **6.2.6** (Dutch) Stragic projects in the Roermond-Maastricht-Liège corridor
Source: Province of Limburg, 2001

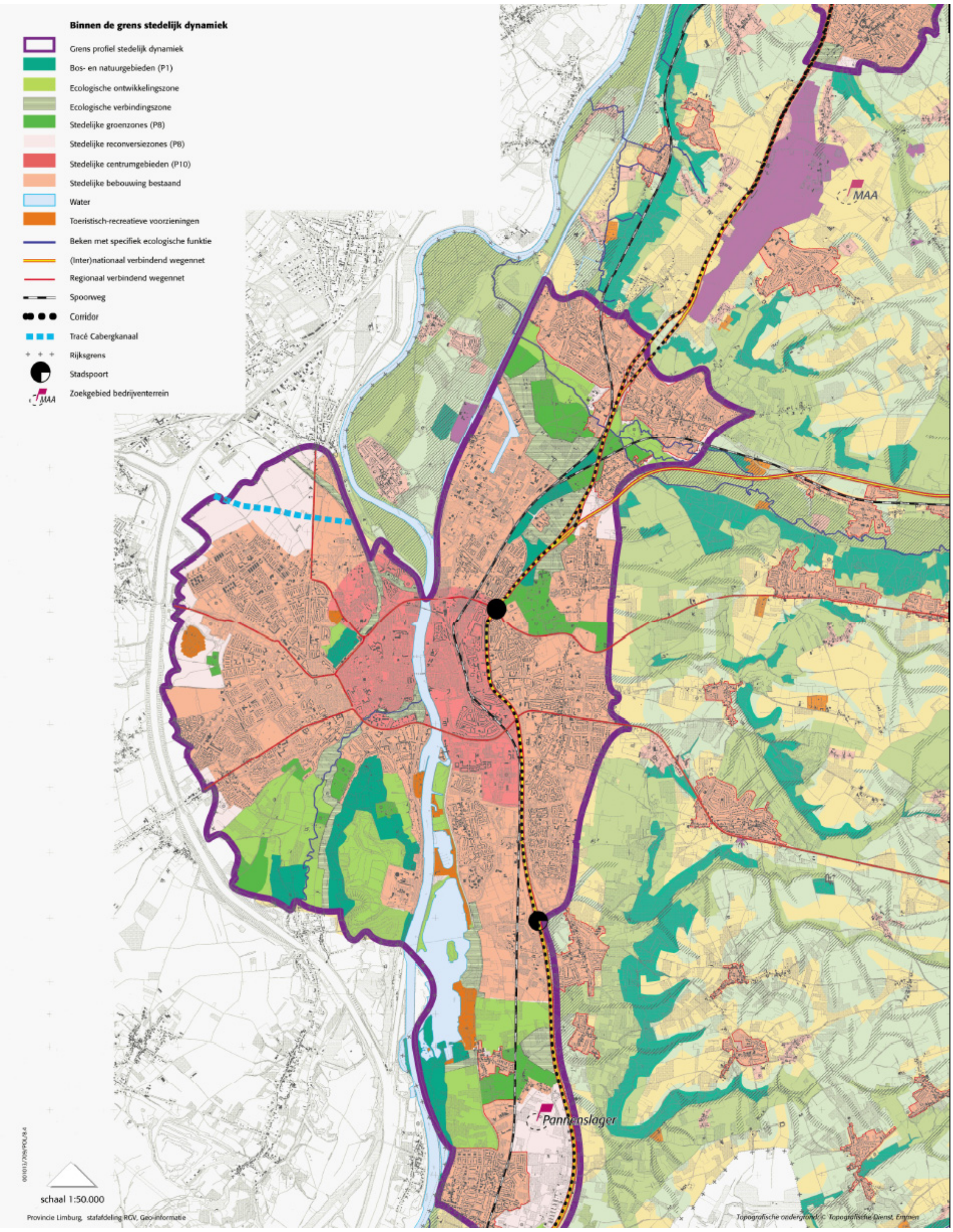


Figure **6.2.7** Development around the city of Maastricht
Source: Province of Limburg, 2001

6.3 Summary and conclusions

As on of the oldest city of the Netherlands, Maastricht is a place full of history and dynamics. Located in the middle of the EUregion Maas-Rhine, it is a city with an international perspective. Also the accessibility profile of the city can also be called 'international'. The presence of the Maastricht-Aachen Airport, two High-Speed Train stations at close distance

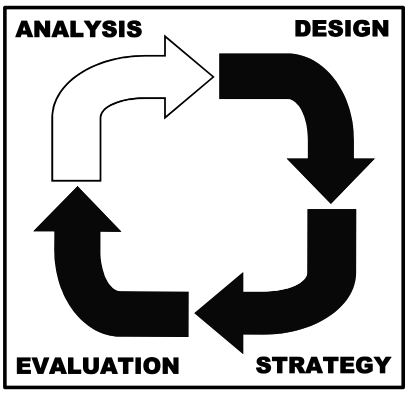
(in Liège and Aachen), and Maastrichts location at the hinterland corridor A2 (in combination with the A76), give the city of Maastricht its international accessibility profile.
One of the major problems of the region of Maastricht is the increasing congestion on the A2 corridor. Both the Province of Limburg and the municipality of Maastricht identify the A2 corridor as a key project that has to be dealt with integrally: a view on the (multimodal) transport system has to be combined with a view on urban programme.

Chapters 8 and 9 elaborate on the relation between a multimodal transport concept for the city and region of Maastricht and potential urban programme to be realised. The next chapter focuses at the Maastricht demand-responsive transport system called 'Tailor-Made Transport Maastricht'. It describes the role the system plays within the travel behaviour of its users, and its position within the Maastricht transport system and urban network as a whole.

CHAPTER SEVEN COLLECTIVE DEMAND-RESPONSIVE TRANSPORT AND THE ACTIVITY-TRAVEL BEHAVIOUR OF ITS USERS: THE ELDERLY

Quocumque me verti, argumenta senectutis meae video. Veneram in suburbanum meum et querebar de impensis aedificii dilabentis. Ait vilicus mihi non esse neglegentiae suea vitium, omnia se facere, sed villam veterem esse. Haec villa inter manus meas crevit: quid mihi futurum est, si tam putria sunt aetatis meae saxa?

Whether I look right or left, I everywhere see things that prove my old age. I stayed at my properties outside the city, and complained that the crumbling residence had so much maintenance costs. The manager told me that this was not due to neglect. He did everything within his power, but the building simply was old now. This residence has been built during my lifetime. What can I expect when the stones of my age are so friable already?
Seneca, Epistulae Morales, no. 12



Demand-responsiveness is an important feature of Seamless Multimodal Mobility. This chapter presents empirical analyses based on the case study Collective Demand-Responsive Transport and the activity-travel behaviour of its users, the elderly. The objective of this chapter is to show the potential and actual role of (Dutch) demand-responsive transport in [i] the activity-travel behaviour of people, and [ii] the multimodal transport system as a whole.

The first section introduces [1] the notion of demand responsive transport, and [2] the case study Maastricht (case study selection, research hypotheses, methodology, relevance and limitations of case study). As a starting point, section 7.2 gives an overview of international literature on collective demand-responsive transport and on the mobility behaviour of older people. Furthermore it shows what kind of knowledge is added in this chapter. The third section focuses on the activity-travel behaviour of the Maastricht seniors, with an emphasis on the role of multimodal travel and demand-responsive transport. It explicitly discusses the role demand-responsive transport, the Maastricht Tailor-Made transport system, plays within their mobility behaviour. Section 7.4 describes the functioning of the Maastricht demand-responsive service in more detail from a system's point of view. Section 7.5 elaborates on the mobility preferences of older adults en how multimodal travel and demand-responsive systems could fit in. Finally, section 7.6 sums up the main findings of this chapter.

Figure **7.1** TMT Maastricht riding around in the city centre of Maastricht

7.1 Introduction

7.1.1 Collective Demand-Responsive Transport in the Network City

Demand-responsive transport is a type of service that *might play* an important role in the multimodal transport system of the Network City. This kind of service can cope with the increasing traveller's need for flexibility in both time and space. Demand-responsive transport services are provided on demand and eliminate resistances such as access, egress, and transfers, while waiting at a stop or station is replaced by waiting at home or at the activity location (Van Nes, 2002). One of its potentials is to act as feeder system for higher order transport systems such as the train system.

Moreover, one of the greatest values of demand-responsive transport systems is that it stands to expand and enrich individual travel choices. In contrast to the traditional (time-scheduled and line-bound) forms of public transport, demand-responsive transport systems represent an entirely different paradigm for coping with the post-modern, suburban development patterns. They more or less accept the low-density lifestyle and criss-cross travel patterns, and try to effectively adapt to the suburban landscape. At the same time, they can help to reach some societal goals of sustainability (Cervero, 1997): reduction of (the growth of) congestion, emissions, space consumption of vehicles and infrastructure, energy consumption, traffic accidents, infrastructural barriers, stench, and noise.

It should be noted however that future demand-responsive services might be more autonomous dial-a-ride transit systems than known today (and discussed in this thesis) (Dial, 1995). They might employ fully automated order-entry and routing-and-scheduling systems that could reside exclusively on board of the vehicle. Here, 'fully automated' means that under normal operation, the customer is the only human involved in the entire process of requesting a ride, assigning trips, scheduling arrivals, and routing the vehicle. There are no telephone operators to receive calls, nor any central dispatchers to assign trips to vehicles, nor any human planning a route. The vehicles' computers assign trip demands and plan routes optimally among themselves, and the driver's only job is to obey instructions from his vehicle's computer.

Although demand-responsive systems seem to have a lot of potentials, the role that these kinds of systems should and could play within the total multimodal system, is still widely discussed among transport experts. One of the most important limitations for success is the cost effectiveness. Already in 1982, Adebisi and Hurdle showed that in contrast to traditional public transport services, demand-responsive transport systems have no economies of scale. When the systems get larger -that is, attract more travellers- the costs involved grow correspondingly. Also Van Nes (2002) concludes that increasing demand levels will reduce the costs per trip, but that the total costs of the system will increase.

From a travellers' point of view however, it could be still concluded that demand-responsive transport services are to be desired. Individual travel times can be reduced (door-to-door services) and the most important limitation of line-bound public transport can be overcome: the accessibility in time and space. Furthermore, demand-responsive services can be very attractive for specific user groups. The next sections of this chapter elaborate on these specific topics extensively.

7.1.2 Collective Demand-Responsive Transport in the Netherlands

Collective Demand-Responsive Transport (CDRT) is a transportation issue, about which much has been discussed and written in the Netherlands during the last decade. In May 2000, the Ministry of Transport (AVV, 2000a) presented the report 'Evaluation Collective Demand-Responsive Transport (CDRT) 1998-1999'. Here, the Dutch Ministry clearly describes the *policy context* of Collective Demand-Responsive Transport systems. Furthermore, the Ministry also discusses the *position* of Collective Demand-Responsive Transport in the Netherlands, based on the evaluation of three systems in the Netherlands[1].

In the first chapter of the AVV report, the Ministry focuses on the changes in transport policy context during the last decade. Since 1994, a new law on facilities for disabled people has been effective in the Netherlands, which is often referred to as the *WVG* (Wet Voorzieningen Gehandicapten – Law on the Facilities for Disabled People). From that time on, local governments have become (financially) responsible for the facilities of disabled people - transport being one of them. Many local authorities developed collective transport solutions to help a larger group of disabled people -independent of age- with their mobility. Very often, these kinds of demand-responsive transport systems became available for all kinds of travellers (so called open systems), and not only for the specific user group of disabled people (the so called closed systems).

This integration of user groups has been one of the main reasons to change personal transport legislation. Therefore, the first chapter of the AVV report also focuses on another change in legislation about personal transport in the Netherlands: Change Decision Personal Transport[2] (June 6th, 1997). It is reminded that, based on this change in legislation, a new form of public transport was formally created, called Collective Demand-Responsive Transport (CDRT)[3]. Decentral governments (the transport authorities) now got the opportunity to organise public transport that is allowed to ride without a timetable. And the revenues of this transport system are eligible for suppletion from the national subsidy fund for Public Transport. This was impossible before June 6th 1997.

Within the (Dutch) demand-responsive (shared taxi) systems, we can identify a differentiation on a number of system characteristics (De Boer and Van Gent, 2002):

- *the degree of openness of the system*; open systems are available for all people, and closed systems are available for specific user groups, such as disabled or older people.
- *the service area*; the area, in which the system operates. For WVG systems[4] this area should incorporate the most essential daily urban facilities.
- *the service time period*; sometimes 24 hours-a-day service is offered. Most of the time the service time period is from ± 08.00 a.m. till ± 24.00 p.m.
- *the pre registration time*; the period of time that at least should be between the desired moment of travelling and the point of time of the registration. One hour is normal.
- *the allowed deviation of the agreed departure time*; in such a flexible system, the appointment for the departure time can only be a principled agreement. The accepted margin most of the time is around a quarter of an hour earlier and later than the desired departure time. Most CDRT systems offer a service that the client is called 5 minutes before of the actual departure time.

[1] Mobimax in the Achterhoek, Taxiplus in Oldambt, and the Belbus in Almelo
[2] in Dutch: Wijziging Besluit Personenvervoer
[3] In Dutch: Collectief Vraagafhankelijk Vervoer (CVV)
[4] WVG systems are closed systems; i.e. only available for disabled people with a WVG indication given by a doctor

- *the allowed detour factor*; when taxi(s)(buses) are shared, detours are almost unavoidable. A maximum to detours ‘guarantees’ a certain level of service to the client.
- *the presence of trip motives with priority*; for certain trip motives (funeral, appointment with doctor, transfer to other public transport, etc.) the deviation in departure time can be minimised and detours can be avoided.
- *the price rating*; tariff differentiation for different user groups is possible. It depends for example on (local) government policy.
- *rolling-stock adjusted to specific traveller needs*; the accessibility of vehicles varies a lot.

In this research project, we take a closer look at the collective demand-responsive system of the city of Maastricht, which can be referred to as representative for the mean Dutch collective demand-responsive transport system. The next subsection gives deeper insight of the scientific justification why Maastricht was chosen as case study for the analysis of [1] the CDRT system and [2] the mobility behaviour of older people.

7.1.3 Case study Maastricht

TMT Maastricht

In January 1995, the city of Maastricht introduced an ICT supported collective transport system with the aim to increase the accessibility and availability in both time and place of public transport. The system called 'VOM' (Vervoer Op Maat – from here referred to as TMT, Tailor-Made Transport), consists of a demand-responsive door-to-door shared taxi system and time-scheduled low floor buses. Very soon after the introduction of the system, it became clear that the largest user groups of the TMT Maastricht system predominantly consisted of disabled and older people (Goudappel Coffeng, 1997).

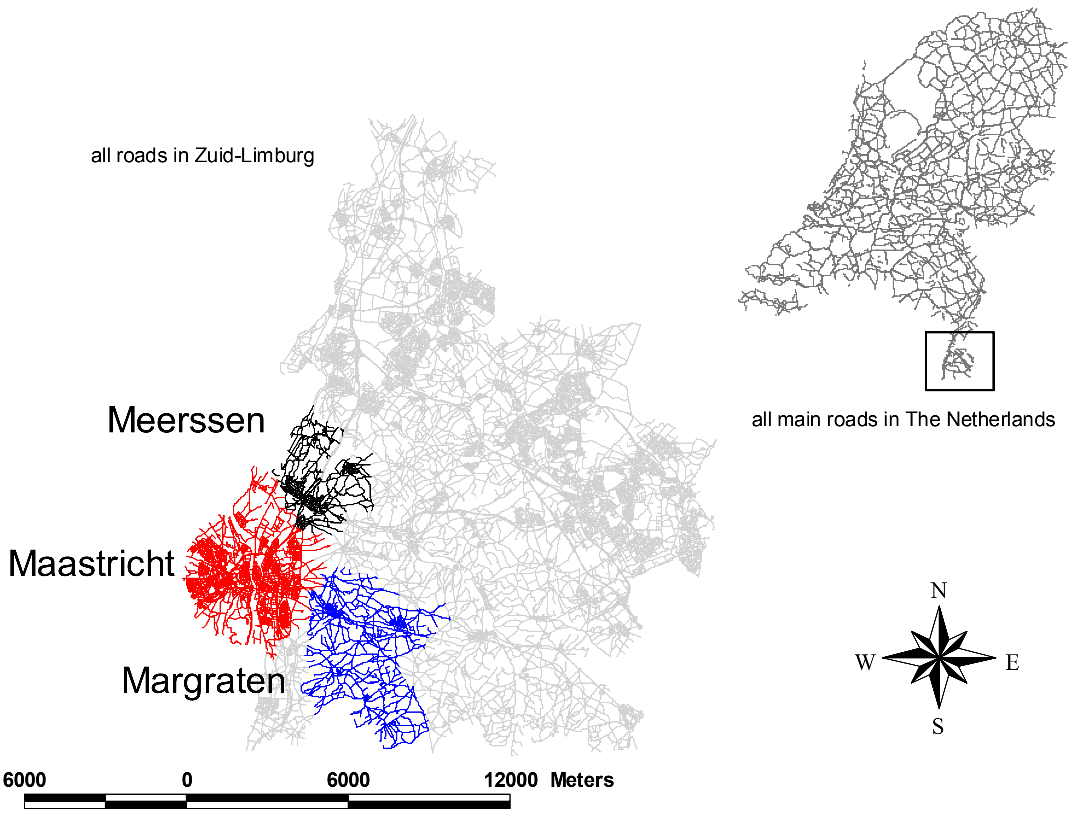


Figure **7.1.1** Municipalities of Maastricht, Margraten and Meerssen within the Netherlands

TMT has characteristics that represent today's generation of demand-responsive transport systems in the Netherlands, which was the most important reason to choose Maastricht as research area:

- door-to-door shared taxi system with commercial shared taxi tariffs;
- open system, reduced fares for disabled people from Maastricht and Meerssen (WVG indicated by the municipalities of Maastricht or Meerssen);
- registration via the TMT call centre with a pre registration time of 1 hour;
- hours of operation: from Sunday till Thursday from 08.00h - 23.30h, and on Friday and Saturday from 08.00h - 01.30h;
- origin and / or destination of the requested trip should be located within the municipality boundaries of Maastricht or the municipality of Meerssen (figure 7.1.1);
- ICT supported trip and vehicle planning;
- rolling stock consists of wheelchair buses;
- an allowed deviation of the agreed departure time of 15 minutes (both earlier and later than the desired departure time) and the service that the traveller is called 5 minutes before the actual departure time;
- 4 TMT stopping points in the city of Maastricht: the hospital, the Market, the Dutch Railways station, shopping centre Brusselsepoort (figure 7.1.2).

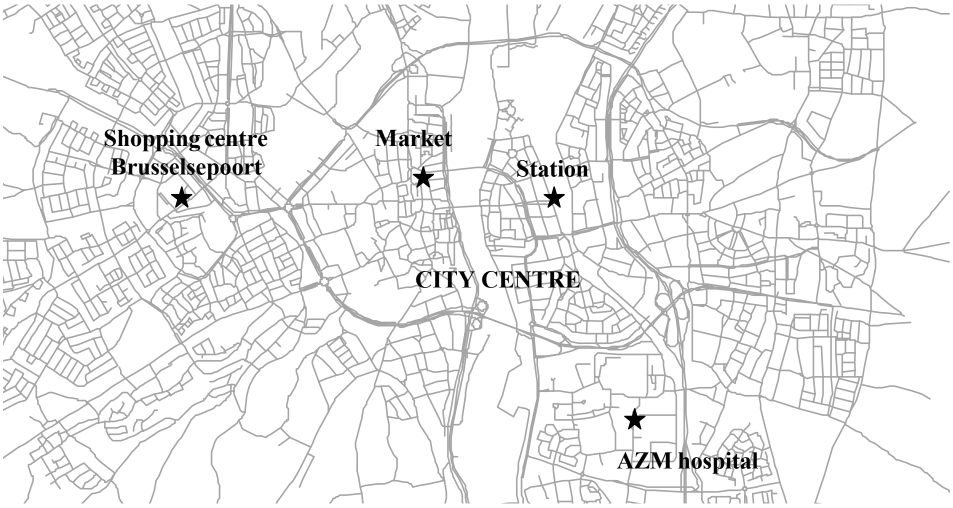


Figure **7.1.2** TMT stops

In the year 2000, we[5] got a large database of Stadsbus Maastricht, the transport operator of the TMT system. In order to use the TMT system, i.e. to make a trip with a TMT taxi, people have to make a reservation by phone. All phone calls are registered digitally at the call centre of the transport operator[6]. The TMT data set, given to Delft University of Technology for research purposes, consists of all reservations for the trips in the period of June 1st - September 20th 1998, January 1st – June 30th 1999, October 1st – October 31st 1999, and December 1st – December 31st 1999: all reservations of 356 days.

The data set contains 295,666 records (reservations for a trip), of which 271,385 have actually resulted in a trip from an origin to a destination. The other 24,281 reservations (8.2%) have been cancelled (15,846), have not been executed (144), are double bookings (1,833), or have been refused to make by a client at the time that the taxi came to pick the passenger up (6,458).

For every record (trip request) the data set contains 41 variables (Appendix 1), which describe the features of both the trip and the traveller. These trip and traveller characteristics give information about the process of the travellers' planning or scheduling of trips, the individual background of the traveller, the planned trips, and the actually executed trips.

MOBILATE

The mobility behaviour of older people is one of the research topics of the Spatial Planning Department of the Faculty of Architecture, Delft University of Technology. The Spatial Planning Department is member of the international MOBILATE[7] research consortium, which has its focus on the outdoor mobility of older people. When a research area had to be chosen for the MOBILATE project, Maastricht again was chosen as the Dutch case study. In this way, we could elaborate on the present knowledge about Maastricht and its demand-responsive system.

The MOBILATE research consists of a large questionnaire and a trip diary that about 4,000 people had to fill in during two days (Van Lamoen and Tacken, 2002; Mollenkopf, et al.,

[5] The Spatial Planning section of the Faculty of Architecture, Delft University of Technology

[6] At the time, the transport operator was Stadsbus Maastricht.

[7] The MOBILATE project is sponsored by the European Commission (Project QLRT – 1999 – 02236). The consortium members come from Finland, Germany, Italy, Hungary, and The Netherlands. The Delft Spatial Planning Department produced several (conference) papers both national and international based on three final reports focusing on the national data, an international comparison and the spatial analysis of trip data (Van Lamoen en Tacken, 2001; Van Lamoen and Tacken, 2002: Rooij and Tacken, 2002 respectively).

2003). The (international) questionnaire contained among others questions related to the concept of collective demand-responsive transport, and moreover the Dutch MOBILATE people were asked for their opinion about the Maastricht TMT system (Appendix 2). Furthermore, the MOBILATE project has a focus on the differences in mobility behaviour between older people living in urban areas and non-urban / rural areas.

To be precise, we registered 7,375 journeys[8] made by 3,950 persons during two days in total (period in the year), which means that a person made 1.87 journeys on average during those two days. 925 persons made no journeys at all during both days. The mobile people, 3,025 persons who thus made those 7,375 journeys, made 2.44 journeys on average during these two days.

The Dutch MOBILATE sample consists of both TMT users and non-TMT users (Van Lamoen and Tacken, 2001). For the Dutch case, the rural municipality of Margraten was chosen besides the city of Maastricht (figure 7.3). When only the Dutch case of the MOBILATE project (Maastricht region) is considered, we can observe that 719 journeys were made during the 2 interview days by 616 respondents minus 173 persons with no diary and minus 98 persons who made no trip. This means that the 345 mobile persons made on average at least one journey a day during the interview period. In terms of trips, it can be said that 1,575 trips have been made by 345 persons during two days, which means that in total the trip mean is 1.8 trips a day for all persons, and 2.3 trips a day for the mobile people.

For this Dutch part of the MOBILATE project, we got the opportunity to gather a lot of disaggregate geographical data, which has been analysed with a Geographical Information System (GIS). For the geographical analysis of the MOBILATE data set, the geographical trip data has to be very accurate in order to be able to geocode the origins and destinations of the actual trips. Geocoding is the process by which you add point locations defined by street address, or other address information, to a digital map. It is the computer equivalent of pushing pins into a street map on the wall.

In fact, two things are needed for this kind of geographical analysis: [1] accurate data on the geographical location of the origins and destinations (street, house number, village/town/city), and [2] a digital map that supports the geocoding process. In the Netherlands, the Advisory Council for Traffic and Transport (AVV, 2000) offers researchers the possibilities of using a digital map that contains all streets, roads, and highways. This map which is referred to as the National Road Data, has been used for trip data analysis.

The accuracy of the available geographical data was moderate, and some adjustments had to be made (table 7.1.1). 375 trips lacked geographical information (i.e. 24% of 1,575 trips). The trips to foreign countries (n = 33, i.e. 2% of 1,575) could of course not be geocoded to the digital map of the Netherlands and are left out in the analysis. If journeys had the motive of a tour (home-home journeys), the numbers of trips of those journeys were reduced to one. Also some journeys had to be complemented with trips back home. All together, the MOBILATE GIS data set consists of 1,184 trips and 571 journeys, made by 284 respondents.

[8] A journey concerns the movement (or series of movements) from home (initial origin) and back home (final destination). In the MOBILATE sample most of the journeys are single journeys, that is a two trip journey: one trip to a destination with a specific motive or for a specific activity, and the trip back home. Some journeys consist of more than two trips: people go out and visit different locations and finally return home.

Table **7.1.1** GIS MOBILATE data set

Data set adjustments	Number of trips
Original	1,575
Minus	
- no info	-159
- too little info	-216
- foreign country	-33
- tour	-24
Plus	
+ complete journey	+41
Result	**1,184**

7.1.4 Research hypotheses and research methodology

The following research hypotheses (as given in subsection 1.4.2) are leading for the contents of this chapter.

Demand-responsive personal transport systems have a (theoretical) potential to play an important role in the total multimodal transport system of the Network City, although nowadays their role in practice is marginal.

The introduction of demand-responsive personal transport systems results in new and/or other activity-travel choices of the travellers and thus in changing activity-travel behavioural patterns of these travellers, although there will be many differences in use according to the spatial setting in which the system functions (urban users, suburban users, and rural users) and the level of service characteristics.

In order to analyse the available data - the MOBILATE data set, the MOBILATE GIS data set, the TMT data set - both a statistical software tool (SPSS) and a Geographical Information System (ArcView) have been used for answering the questions that surround the topic of CDRT and the activity-travel behaviour of its users, predominantly older people. Therefore, this chapter presents both numbers (tables) and pictures (maps) besides the text.

7.1.5 Relevance and limitations of the Maastricht case study

Relevance and limitations of CDRT

Subsection 2.3.4 already focused on the (potential) role of demand-responsive transport within a (seamless) multimodal transport system. Offering transport products adapted to explicit demands for mobility brings the seamlessness aspect of an SMM system a little bit closer. That is the main relevance for the study of collective demand-responsive transport in the Netherlands.

Of course, seamless multimodal mobility doesn't end with a good collective demand-responsive shared taxi system. That may be clear on beforehand. The transport reality is simply too complex. Therefore, the Maastricht case study only gives limited and modest answers to the main problems the field of spatial planning is confronted with (section 1.3 refers). However, a lot can be learned [i] for the SMM system as a whole and [ii] especially for the position of CDRT within the SMM system by analysing demand-responsive transport.

Relevance and limitations of the user group of older people

The largest user group of the CDRT systems in the Netherlands consists of older and/or disabled people. The greying society is simply a fact that many post-modern societies are

confronted with and have to deal with. For the Netherlands this means that, according to sophisticated estimations, the percentage of people over 55 years will grow from 24% in 2002 (about 4 million people) to 34% (over 6 million people) in 2030 (CBS, 2002)[9]. The relevance of the mobility of older people may be clear by that; the group of older people will have a large impact on the functioning of the society as a whole and thus also on the functioning of traffic and transport.
When we limit ourselves to describing the activity-travel behaviour of the group of older people, it is obvious that we don't discuss all those other groups of traffic participants. Therefore, also here the Maastricht case study only gives limited and modest answers to the main problems the field of spatial planning is confronted with (section 1.3 again refers). However, describing the actual behaviour of the present group of older people and registering their opinions about today's traffic and transport system, gives us many clues to organise the SMM of the future better than today; for the group of older people, but also for many others.

7.2 Setting the scene

Collective demand-responsive transport and (more general) travel services for people who experience difficulties during travel, isn't a topic only of today and yesterday. Already during the sixties and seventies of the previous century, all kinds of services for people with disabilities became available in progressive countries such as Sweden.
Sweden has provided Special Transportation Services (STS) as an approach to solving the transportation problems of the disabled at the end of the 1960's (Ståhl, 1990). The purpose of STS was to make transportation available to people who have difficulties using conventional public transit. Initially, STS was conducted on a volunteer basis, but municipalities gradually assumed responsibility for providing this service. The concept spread rapidly during the 1970's, and since 1979 all Swedish municipalities have offered STS.
The Service Route concept appeared in 1983 when the Borås City (Sweden) Transportation Corporation introduced this new type of public transport. It was adapted to the needs of the elderly and disabled by means of special route mapping, special timetables, and smaller buses designed for disabled people (Ståhl, 1990). The achievements and impacts of Service Route traffic have also been recognized internationally and, by late 1991, implemented in other European countries (Denmark, Finland, Norway, and The Netherlands) as well as in Canada.

In the United States, the growth of demand-responsive transit began in the late 1970s and early 1980s. These early systems failed to meet expectations due to low demand requests and deficiency in communication and computer technology to effectively manage such systems. However, with the passage of the Americans with Disabilities Act (ADA) in 1990, which requires that transit agencies provide para-transit or on demand service for the disabled, there has been renewed interest in demand-responsive transport in the US (Cervero, 1997).
This civil rights bill was designed to remove barriers that prevent persons with disabilities from fully participating in American society. In the area of public transportation the ADA clearly states that regular bus service should be the primary means of public transportation for everyone, including people with disabilities. But under the ADA, all municipalities that provide public transit are required to provide curb-to-curb, demand-responsive ParaTransit service that "mirrors" their fixed-route service in terms of service areas and hours of operation. The service is a "safety net", it is only for those persons who do not have the functional capability to ride fixed-route buses.

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[9] Source: Central Bureau for Statistics on-line; http//statline.cbs.nl

A lot of Dutch research with respect to demand-responsive transport results from the changes in transport legislation in the nineties, mainly focusing on the implementation, the functioning and the improvement of functioning those systems (see for example: AVV, 2000a, Diepens & Okkema, 2000, De Boer, 2001). With respect to changes in personal behaviour Goudappel Coffeng (1997) and De Boer and Tacken (1994) show in their work how the introduction of collective demand-responsive transport influences the travel behaviour of its users. CDRT users were asked with what transport modes they used to travel to the destinations they now went to with the CDRT system. The top 3 of 'former transport modes' is the bus, the taxi, and the car as passenger. Furthermore, a relevant number of people (more than 10%) also said that they went to 'new' places with the CDRT system. Finally, it was also said that people had become more flexible with respect to the point of time of traveling compared to the way they used to travel.
When we consider the stream of *recent* international literature on CDRT we can conclude that the main research topic is how to improve the efficiency of operation by:

1. using *intelligent technologies* that help with the planning, the management and the execution of on-demand transport (see for example: Stone et al, 2000; Dessouky and Adam, 1998; Fu and Xu, 2001; Higgins et al, 2000)
2. *removing and/or overcoming organizational, financial, and juridical boundaries* that surround on-demand transport (see for example: Nowak et al, 2000; Peeters, et al, 2001);
3. *integrating on-demand transport in the total (multimodal) transport system* (see for example: Van Nes, 2002; Uchimura and Saitoh, 1999; Trudel, 1999; De Boer and Van Gent, 2002; Heinzel, 1996; Cervero 1997).

Much less attention has been given to how these systems are used spatially. To which kinds of places, located where in the city, and for which kinds of travel motives do people use and travel with on-demand systems? This more spatially oriented research question is discussed in sections 7.3 and 7.4 of this chapter extensively.

This chapter also focuses on the mobility of older adults, one of the main user groups of the collective demand-responsive transport systems. So, now we [i] give the state of the art with respect to the research on the mobility of older people, and [ii] define what can be added by this research project that is also nested in the international MOBILATE project on the outdoor mobility of older adults
The research and analysis of mobility in old age has been focused mostly on the characteristics of trips: mode choice, distances, number of trips etc. (Tacken, 1998). The ECMT roundtable (1998) gives much figures on these aspects in different countries. Most of the explanations discussed in this paper are very commonly accepted. (Leinbach & Watkins, 1994, Chu, 1994, Brög, Erl and Glorius, 1998, Madre & Bussière, 1996, Tacken, 1998, Mollenkopf & Flaschenträger, 1996). It is known that physical condition decreases with age. Older people have more physical deficiencies: in walking, visual acuity, hearing, memory, etc. In the higher age groups more women are surviving their male partners, which means that they are more often widowed and living alone. Older women of the present generation have a lower educational level, a lower income and a lower ownership of cars (and less often a driver's license).
These items mentioned affect the background circumstances of the outdoor mobility of older people and they will explain some of the differences in the activity-travel behaviour we find. In a descriptive way we have much information on the mobility of older people. Much less is known about the perception and experiences of older people concerning their mobility behaviour and the time-space aspects of this behaviour. Based on the COST-A5 project:

Keeping the Elderly Mobile, Tacken (1998) has published a first analysis of some temporal and spatial aspects of mobility of older people. In 1998, an expert group of the OCDE wrote an overview of studies concerning the safety of vulnerable road users. In some of these studies about the mobility of elderly people the distances have been analysed; a Japanese study stresses the need to consider the timing of trips in assessing the risks of this vulnerable user group.
The MOBILATE project has paid more attention to these time-space aspects of the trip making behaviour. In the trip diary the departure times and arrival times have been registered and the activity range has been described in a number of categories. In the Dutch part the addresses of origins and destinations have been asked, which offered the opportunity to link the trips to a digital map. The MOBILATE project offers a unique possibility to analyse more of the time-space behaviour of the older people, to which this chapter addresses (section 7.3).

7.3 Activity-travel behaviour of the Maastricht and Margraten older adults

This section focuses on the MOBILATE project and describes the activity-travel behaviour of the Maastricht and Margraten older people. Moreover, it especially focuses at the role TMT Maastricht plays within the behaviour of the people and how the people evaluate the services offered by TMT Maastricht.

7.3.1 Travel motives

Table 7.3.1 gives an overview of all trip motives for the Maastricht and Margraten elderly. About 42% of all trips concerns the trip back home. From this we can conclude that about 16% of all trips have taken place *between* activity places not being the home location. With about 20% of all trips, shopping is the most common activity for older people. Social interaction is a second motive that covers about 10% of all trips; so, about one of each five journeys has this motive. Making a walk or a tour is also another relevant activity for the older adults. The differences between the Maastricht and non-urban (Margraten) inhabitants is relatively small. The Maastricht people go out for shopping a little bit more often; the Margraten people go out for a short walking tour more often. The differences between the sexes and between the age categories are even smaller.

The travel patterns for the motives shopping and social interaction are looked at in more detail: where do the Maastricht and Margraten people shop? Figures 7.3.1 and 7.3.2 present the shopping destinations of the Maastricht and non-urban inhabitants respectively. They clearly show the differences in travel behaviour. The Maastricht inhabitants predominantly shop in the city centre (daily and non-daily goods), the city district shopping centre Brusselsepoort (daily and non-daily goods) and neighbourhood shopping centres (daily goods). For the non-urban inhabitants Brusselsepoort doesn’t seem to be a relevant shopping alternative. For the daily goods they are focused at their own village centres. For the non-daily goods, the inner city of Maastricht seems to be the appropriate location for shopping. From the pictures we can observe that the main shopping destinations are concentrated at a few points in the city, for both the Maastricht and the Margraten inhabitants.

Table **7.3.1** Percentages of trips (n = 1,575) made with a specific motive in Maastricht and Margraten by age and gender

trip motive in %	Maastricht	Margraten	Male	Female	55 - 74	75+	Total
working	2	4	4	2	4	0	3
meeting friends, relatives, acquaintances	10	10	8	11	10	10	10
helping someone (in household, baby sitting)	1	1	1	1	1	1	1
shopping (e.g. bakery, supermarket, hairdresser, travel agency)	22	17	20	20	19	22	20
attending (e.g. bank, post, authority)	2	2	3	2	2	3	2
health care (e.g. doctor, pedicure, massage)	4	2	3	3	3	2	3
drinking coffee, lunch (in restaurant, bar)	2	3	2	3	2	4	3
visiting cultural event (e.g. concert, theatre)	1	1	1	1	1	0	1
activities in association, voluntary work	3	2	4	3	3	4	3
gardening	0	0	0	0	0		0
sport activities (e.g. bowling, folk dance, ball plays, tennis)	2	2	2	2	2	2	2
religious service, cemetery	2	3	3	2	2	3	2
strolling, walking tour, cycle tour, hiking (home-home)	4	7	6	5	5	5	5
short trip, holiday	1	1	1	1	1	1	1
accompanying someone (e.g. bring away, fetching up)	1	1	2	1	1	1	1
fishing, picking berries, mushrooms	0	0	0	0		1	0
education (e.g. courses, vocational training, senior academy)	0	1	0	1	1	0	0
back home	43	41	42	42	42	42	42

Dutch MOBILATE Survey 2000

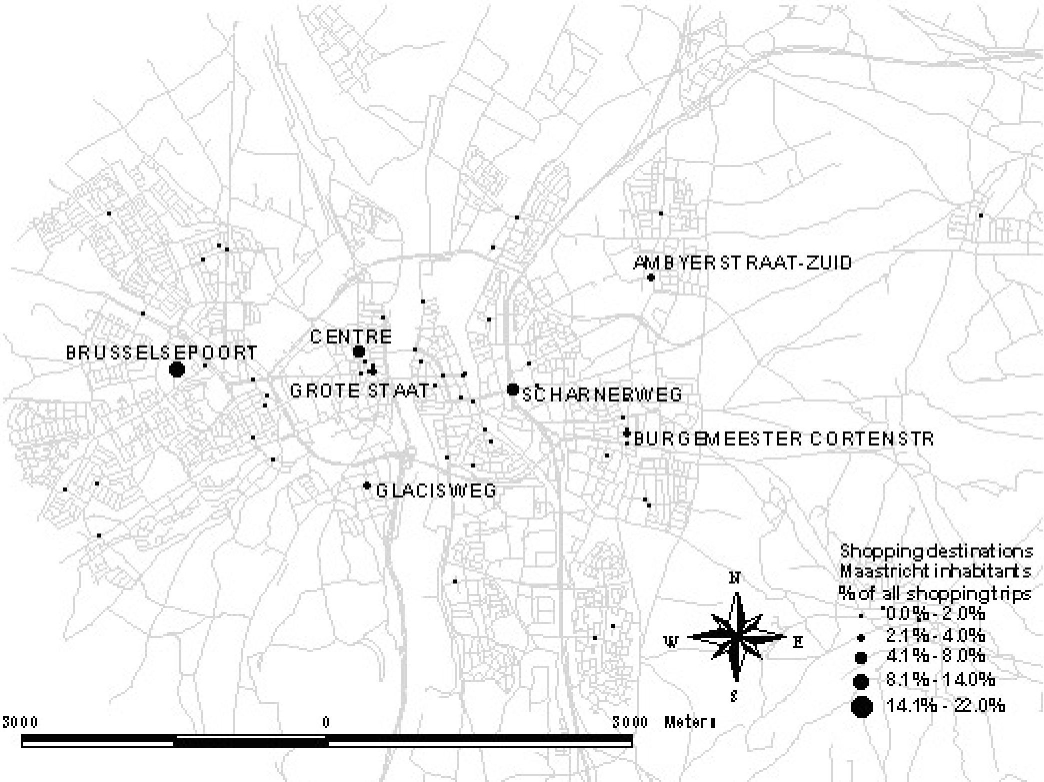


Figure **7.3.1** Shopping destinations, percentage of total shopping destinations (n = 149) Maastricht inhabitants

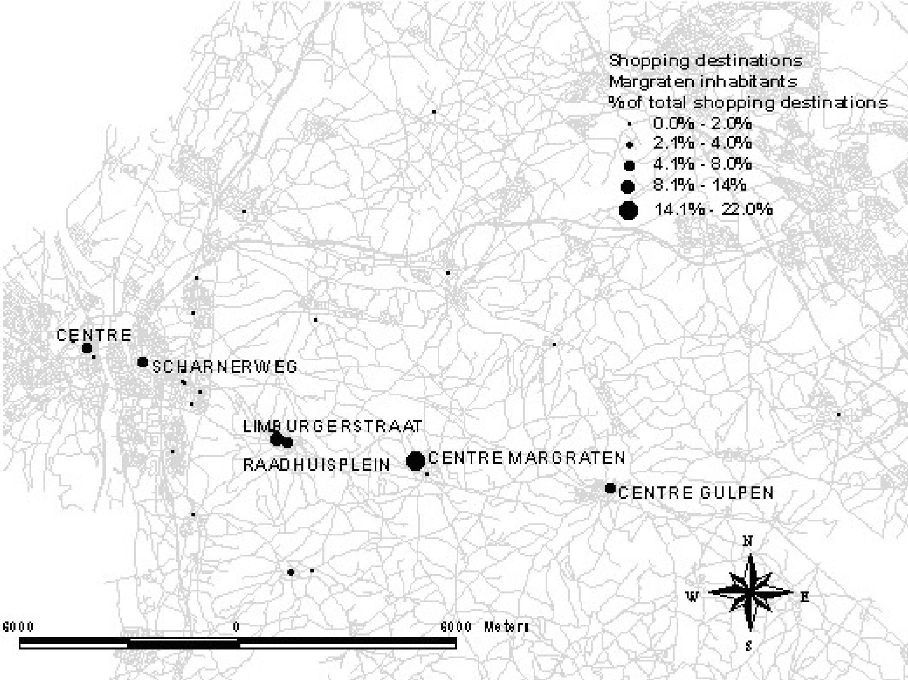


Figure **7.3.2** Shopping destinations, percentage of total shopping destinations (n = 75) non-urban inhabitants

Figures 7.3.3 and 7.3.4 present the destinations for visiting friends of the Maastricht and non-urban inhabitants respectively. In spite of the fact that the absolute number of destinations is lower than for the motive shopping, we can clearly observe a more diverse pattern (more spread) in the location of the destinations than in the case of the shopping destinations. Again, the Maastricht inhabitants are predominantly focused at locations within the city border, whereas the non-urban inhabitants show a more diverse pattern with destination in the whole region of Zuid-Limburg.

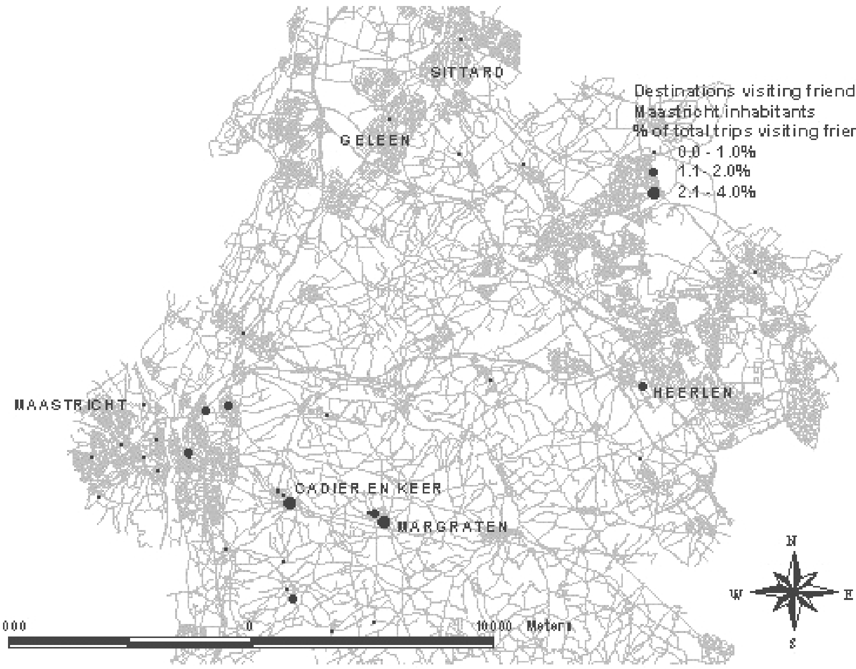


Figure **7.3.3** Destinations for visiting friends, percentage of total destinations for visiting friends (n = 63), Maastricht inhabitants

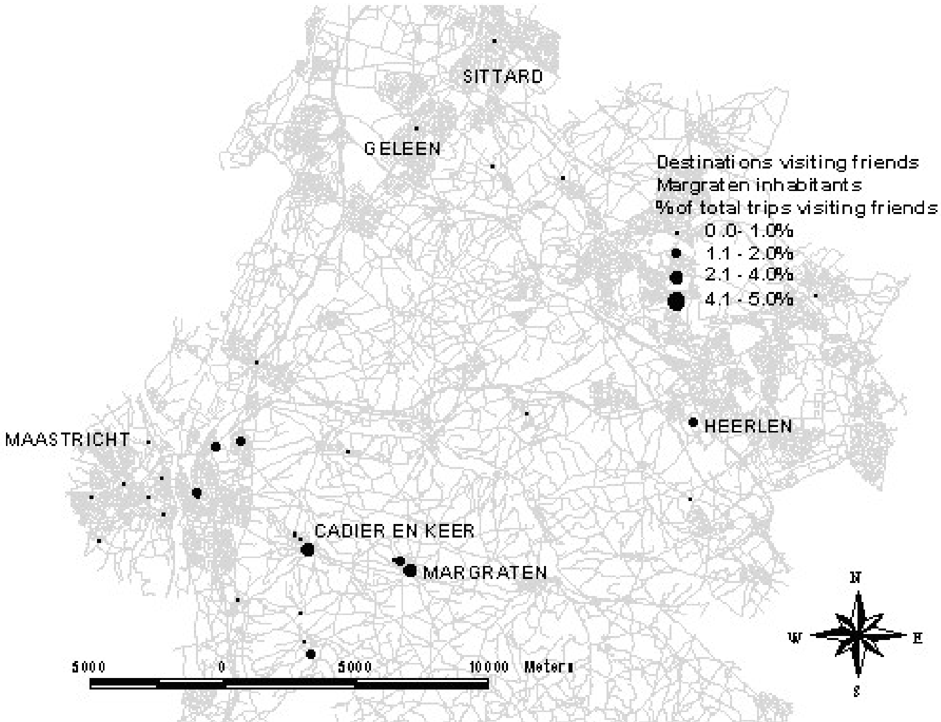


Figure **7.3.4** Destinations for visiting friends, percentage of total destinations for visiting friends (n = 44), non-urban inhabitants

7.3.2 Older adults, multimodal travelling, and the role of TMT Maastricht

Discussing the mobility of older adults, mobility professionals very often have to deal with people thinking that (traditional) public transport, is used a lot by older people. Or that public transport has characteristics that fit the wishes of the older transport users best over other user groups. Table 7.3.2 shows the contrary. It presents Dutch national statistics on the share of people (within age categories) that actually used public transport during the days of interview. It shows [i] that scholars, students, and young adults (12-30 years) use public transport most often, and [ii] that the share of users within the age categories decreases with old age.

Table **7.3.2** Share of persons in age categories that actually use public transport, in sexes

	Men [%]	Women [%]	Total [%]
12-16 years	7.1	9.0	8.1
16-18 years	14.3	16.7	15.5
18-20 years	22.9	32.2	27.2
20-25 years	20.1	25.5	22.8
25-30 years	11.2	13.2	12.3
30-40 years	6.1	6.9	6.5
40-50 years	6.3	5.7	6.0
50-60 years	5.1	5.6	5.4
60-65 years	3.4	5.5	4.4
65-75 years	3.6	5.6	4.7
75+ years	3.8	4.6	4.3
Total	6.9	7.9	7.4

CBS, 2002

From the MOBILATE data we can see in table 7.3.3 the distribution of trips by transport mode, from which we can conclude that for the elderly the individual transport modes are the most important. The car is used most in the rural area and used most by males and younger people. Women and older persons are more often passengers in these car trips. Traditional public transport and TMT only attract a minor share of all trips. It is used most in the city, by women and by older persons. Deeper analysis (Rooij and Tacken, 2002) shows that the Maastricht and Margraten people who say to be public transport users [i] more often have no car available in the household (than the people who say not to be public transport users), and [ii] in general have a lower income.
The slow modes together attract about 50% of the trips. Females and older people travel a little bit more by foot; males and younger people more by bicycle. In Maastricht the slow modes have been used more than in the rural area. Facilities and services are better accessible and at shorter distance in a relatively dense urban environment.

Table **7.3.3** Mode choice by location, gender and sex

transport mode	**location**		**gender**		**age**	
	Maastricht	Margraten	Male	Female	55 - 74	75+
car driver	22	36	43	15	31	20
car passenger	13	15	6	21	14	15
bus	12	4	4	12	8	11
special/TMT	4	2	2	4	1	6
bicycle	17	12	18	12	18	8
foot	33	33	28	37	29	42

Dutch MOBILATE Survey 2000

Although only a few percent of the total trips were made with TMT during the two days of interview, no less than 27% (n = 83) of the people from the Maastricht sample (n = 306), who participated in the travel survey, say to be users of the demand-responsive system[10]. This user group consists of 24 men (9 aged 55-74, and 15 aged 75+) and 59 women (22 aged 55-74, and 37 aged 75+). The non-user group consists of 112 men (63 aged 55-74, and 49 aged 75+) and 111 women (71 aged 55-74, and 40 aged 75+).
Several analyses were done in order to see if some general characteristics could be found for the group of TMT users and non-users. This information could perhaps give an indication, why some people use the demand-responsive system and why others don’t.
In brief, it can be concluded that TMT users more often have a lower income than non-users, more often have a lower educational level, more often are part of a one person household, more often have no car available in the household, less often use a bicycle, and more often have a lower health satisfaction (Van Lamoen and Tacken, 2001).
People were also asked for their opinion about the importance of the different transport modes in order to stay independent in daily life (table 7.3.4). Striking to see is that special transport (TMT) is the most important mode of transport for the users, even (slightly) more important than walking, which comes at second place. Public transport comes at a third place and car as passenger at a fourth place, but they still are very important compared to the remaining modes of transport. For the non-users walking is by far the most important means of transport. Here, TMT only comes at a sixth place. Striking is here that public transport is considered more important than driving a car or travelling as a car passenger. We have to realise that we are

[10] 49 of the 83 persons (59%) who say to actually use the system were selected for the Maastricht sample because they are TMT pass holders. From the other 34 persons (41%) it is unknown whether they are pass holders or not; they were selected, based on age and sex (Van Lamoen & Tacken, 2001).

discussing the Maastricht people. For the Margraten people this value is lower. Furthermore, the Maastricht non-users even indicated that travelling as a car passenger is more important than as a car driver. This, perhaps, is related to the fact that many interviewed women have a partner who will drive when making a trip. Cycling is, as could be expected, significantly more important for non-users than for users.

Table **7.3.4** The average marking that users and non-users gave to the different transport modes, which are important for staying independent in life (1 = very unimportant, 5 = very important)

	users	non-users
walking	4.38	4.58
cycling	2.18	3.22
moped	1.30	1.50
driving a car	1.83	3.18
car passenger	3.50	3.58
public transport	3.75	3.66
special transport/TMT	4.39	2.18

Dutch MOBILATE Survey 2000

The TMT users were asked for their experiences with the TMT system. The users could express their level of satisfaction on a scale of 0 to 10. The group average is 5.5, which is (for Dutch measures) quite low. The users aged 75+ years are more positive than the younger age group (5.9 and 4.8 respectively).
Furthermore, the users were given several statements concerning the comfort of the TMT system (table 7.3.5) and they were asked if they agreed with these statements or not on a scale from '1' strongly disagree to '5' strongly agree. People are quite positive about the door-to-door characteristics and the social aspects of the system, such as the feeling of safety, the helpfulness of the driver, travelling together with other people, and the time to get in and get off the minibus. It appears that the people have most problems with the fact that the bus doesn't always arrive on time and doesn't bring you in time at appointments.

Table **7.3.5** The way in which the TMT users agree with statements concerning the comfort of the TMT system (1 = strongly disagree, 5 = strongly agree)

	mean	standard deviation
the trip is adapted to your needs	3,1	0,2
VoM-stops are comfortable places to wait	3,8	0,1
from your home to the place where you want to be, this is what I like	4,7	0,1
this way of transport gives a feeling of safety	4,2	0,1
I don't have problems to travel with other people	4,3	0,1
I don't like the detour: this makes the trip often too long	3,7	0,1
the bus always arrives in time	1,8	0,2
one can take his time to go in and out the bus	4,5	0,1
making a trip reservation is a peace of cake	3,8	0,2
the bus driver has the time for you and is helpful in getting you in and out of the bus	4,4	0,2
TMT brings you in time at your appointment whit a doctor, hospital or for the train	2,4	0,1

Dutch MOBILATE Survey 2000

An important aspect of the collective transport is the fare, which was debated about a lot in the local government. For the research, statements were presented to the users concerning the costs of the TMT system (table 7.3.6). People are aware that the costs of travelling with a private car or a taxi are higher than making a trip with the TMT transport. People also agree on the fact that 40% reduction for the elderly is nice and that a trip with the TMT transport is worth the money, but the users do not agree on the statements that the TMT is cheap or expensive. This is rather contradictory.

Table **7.3.6** The way in which the TMT users agree upon statements concerning the costs of the TMT system (1 = strongly disagree, 5 = strongly agree)

	mean	**standard deviation**
in general I spend a lot on transport	2,9	0,2
TMT-trips are expensive	2,9	0,2
the TMT-transport is cheap	3,1	0,2
TMT-transport is much cheaper than the normal taxi	4,3	0,1
TMT-transport is much more expensive than the normal bus	3,4	0,2
the own car costs much more than travelling with public transport (bus, metro, tram)	4,4	0,1
a trip with the TMT-system is worthwhile	3,7	0,2
40% reduction of the normal price is a nice contribution that older people get	3,7	0,2

Dutch MOBILATE Survey 2000

Besides the opinion of the users, we also asked for the opinion of the non-users. About 120 people who claimed to know the TMT system but don't use it, were asked why they don't travel with this means of transport. The main reason is that they have a better alternative (48%), like the car. The second most important reason is that TMT is too expensive (13%). Only 2% of the people thinks it takes too much trouble to organise a trip. About 40% of the people gave another reason, namely:

51% not necessary, can travel (faster) by bus
16% too late arrival, have to wait too long, unreliable
15% applied for pass but was refused
7% I have someone who takes me
4% only useful in the winter or at night

Striking is, that there is a large group of people who indicated that they don't need TMT transport or that they can travel (faster) by bus. This group consists mostly of people under the age of 75, who are probably very well capable of driving themselves, riding a bicycle, etc.

7.3.3 Action space

This subsection focuses on the space the Maastricht and non-urban inhabitants 'consume' for their activity-travel behaviour. As discussed in chapter four on action space, action spaces can be classified according to shape and size. Here, where the mobility of older people is concerned, from whom most aren't active any more in a working life, we can observe that the home is the one and only dominant basis location within the activity-travel behaviour[11]. From the MOBILATE GIS data set that contains 1184 trips, 1088 trips (92%) have the home

[11] Chapter four 'Action space' refers; it goes into much more detail on the role of basis locations in the activity-travel behaviour of people.

location of the traveller as origin or destination. So, the elderly predominantly have circular action spaces and therefore, the focus will be on the size of the action space.
Tables 7.3.7 and 7.3.8 present the distribution of trip destinations by the Maastricht and non-urban inhabitants in geographical categories. Table 7.8 clearly shows the focus of the Maastricht inhabitants at the city of Maastricht itself: 93% of all trip destinations are located within the own city boundaries. For the non-urban inhabitants the pattern is significantly different. 16% of the trip destinations is located in the city of Maastricht and 82% in the region of Zuid-Limburg (not being the city of Maastricht).

Table **7.3.7** Distribution of the trip destinations by the Maastricht inhabitants (n=177 persons) in geographical categories

	Number of trips	%
In Maastricht	668	93%
In Zuid-Limburg (not city of Maastricht)	43	6%
Outside Zuid-Limburg	8	1%
Total	719	100%

Mobilate GIS data set

Table **7.3.8** Distribution of the trip destinations by the non-urban inhabitants (n=107 persons) in geographical categories

	Number of trips	%
In Maastricht	76	16%
In municipality of Margraten	323	71%
In Zuid-Limburg outside mun. of Margr.	58	11%
Outside Zuid-Limburg	8	2%
Total	465	100%

Mobilate GIS data set

So, how do the figures presented above influence the average trip distances of the Maastricht and non-urban inhabitants? When we take a look at the average trip distance (table 7.3.9) for the whole MOBILATE GIS data set, we can see that the non-urban women (!) have the largest average travel distance of 8.5 km, which is 2.4 km more than the total average travel distance of 6.1 km. Furthermore, the non-urban inhabitants have a significant longer average trip distance than the Maastricht inhabitants.

Table **7.3.9** Average trip distance for total, men, and women; Maastricht and non-urban inhabitants

	Total	Men	Women
Maastricht	4.9 km	5.2 km	4.7 km
Non-urban	8.0 km	7.5 km	8.5 km
Total	6.1 km	6.1 km	6.1 km

Mobilate GIS data set

Why do the non-urban women have the largest average trip distance? Table 7.3.10 presents the average car trip distance for both men and women, and the Maastricht and non-urban inhabitants. We can see that the average trip distance of the Maastricht inhabitants is somewhat shorter than that of the non-urban inhabitants (10.3 km versus 10.9 km).

When we look at the average car trip distance for both sexes in Maastricht and Margraten the picture is different. It appears that the non-urban women are the most car mobile persons with an average distance of 14.9 km. When we take a look at the average car trip distances for the classes ‘as driver’ and ‘as passenger’, we become curious how the trips in the category ‘non-urban women as passenger’ influence the average numbers. For this specific category the average car trip distance is no less than 21.4 km (!). However, the presence of four trips of about 200 kilometres (made by 2 women) influences the statistics rather drastically. Both women are married, and their husbands (who are the car drivers of those trips) are not in the MOBILATE database. If these four trips are left out of the database, the average car trip distance of the ‘non-urban women car passengers’ shrinks from 21.4 to 8.4 km, and the average distance of the non-urban women in total from 14.9 to 7.8 km. However, this would still mean that the average trip distance for the non-urban women is larger than that of the non-urban men (7.3 km).

Table **7.3.10** Average car trip distance for total, men, and women; Maastricht and non urban inhabitants

	Total	**Men**	**Women**
Maastricht	10.3 km	10.6 km	9.9 km
Non-urban	10.9 km	7.3 km	14.9 km
Total	10.6 km	8.9 km	12.5 km
Total as driver	*8.2 km*	*9.3 km*	*5.9 km*
Total as passenger	*15.6 km*	*6.4 km*	*17.4 km*

Mobilate GIS data set

This brings us to the conclusion about the action space differences between the urban and non-urban inhabitants. For the Dutch case of the MOBILATE project, the travel distance and means of transport are the main discriminators between the two categories: non-urban inhabitants travel larger distances, which results from more car driving.
However, it should not be forgotten that these conclusions only apply to the older adults who actually made trips. Therefore, it should be noted that when all MOBILATE people are considered, both mobile and non-mobile, the conclusions cannot be put so straightforward anymore. When we look at the mean number of trips per MOBILATE country in table 7.3.11, we can observe that:

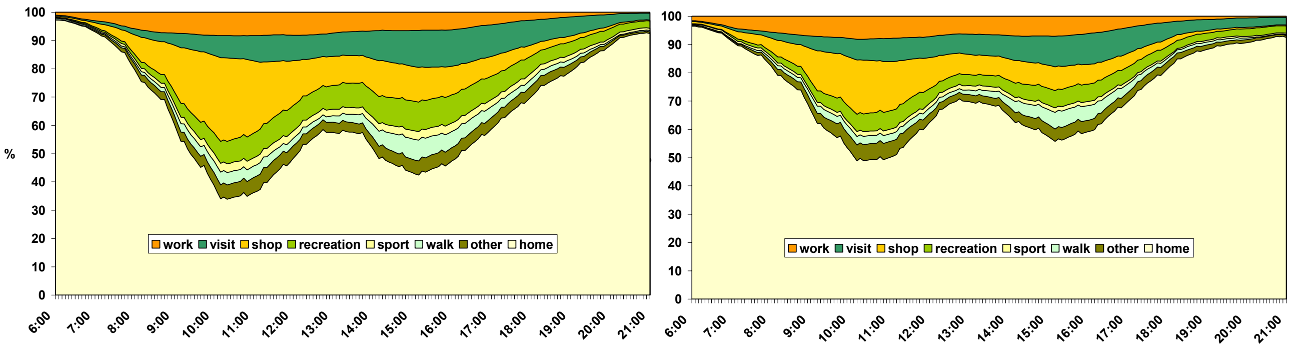
- if all people are concerned, the urban inhabitants are on average more mobile than the rural people;
- if all mobile people are concerned, the urban inhabitants are about as mobile as the rural inhabitants;
- if we look at the differences between all people and all mobile people, the difference for the rural inhabitants are higher than for the urban inhabitants, in all countries.

All this results in picture 7.8 that shows that the urban inhabitants spend more time out of the home for activities than the rural inhabitants. It seems that the spatial organisation influences the mobility behaviour of the elderly quite a lot. The presence of urban facilities near by, makes the elderly indeed travel to those facilities.

Table **7.3.11** Mean number of trips per person per day per country

		Finland	Germany East	Germany West	Hungary	Italy	The Netherlands
All people	Urban	3.0	2.0	2.0	2.0	2.6	1.7
	Rural	2.7	1.9	2.2	1.2	2.3	1.1
All mobile people	Urban	3.2	2.4	2.4	2.5	3.1	2.4
	Rural	3.1	2.4	2.8	2.3	3.1	2.5
Difference all - mobile	Urban	0.2	0.4	0.4	0.5	0.5	0.7
	Rural	0.4	0.5	0.6	1.1	0.8	1.4

MOBILATE data set, 2000, weighted



MOBILATE data set, 2000

Figure **7.3.5** Time spent out the home for activities, urban inhabitants (left), rural inhabitants (right)

7.3.4 Use of TMT Maastricht: where to?

The final topic that is dealt with in this section is the role of TMT Maastricht in the actual activity-travel behaviour of the Maastricht MOBILATE elderly spatially: to which places do people travel with the TMT system? Table 7.3.12 presents the average (TMT) trip distance for both the Maastricht and non-urban inhabitants. We can see that the average trip distance of the Maastricht inhabitants is a bit longer (4.8 versus 3.9 km) than that of the non-urban inhabitants.

Table **7.3.12** Average special transport trip distance; Maastricht and non-urban inhabitants

	Total
Maastricht	4.8 km
Non-urban	3.9 km
Total	4.6 km

Mobilate GIS data set

Table 7.3.13, and figure 7.3.6 present the TMT trip motives and the TMT trip destinations respectively for both the Maastricht and non-urban inhabitants. Despite the low numbers of trips (n = 39) it is interesting to observe that 21% of the trips (7 trips motive 'health, 1 trip motive 'sports activities') go to activity places with a medical function: the Academic Hospital Maastricht is visited three times, nursing home Klevarie twice, the hospital Vijverdal twice and the hospital in Heerlen once.

It is obvious that not many conclusions may and thus can be drawn with respect to the role of the system in the mobility behaviour of people spatially from such a small number of TMT trips. The TMT system seems to have played a minor role in the mobility behaviour of the MOBILATE older adults during the two days of interview. The next section discusses the functioning of the TMT system in detail. So the research perspective now shifts from the travellers to the transport service.

Table **7.3.13** Distribution of special transport trips in urban categories

motive	Number of trips	%
Meeting friends	4	10%
Shopping	3	7%
Attending	1	3%
Health	7	18%
Voluntary work	3	7%
Sports activities	2	5%
Back home	19	49%
Total	39	100%

Mobilate GIS data set

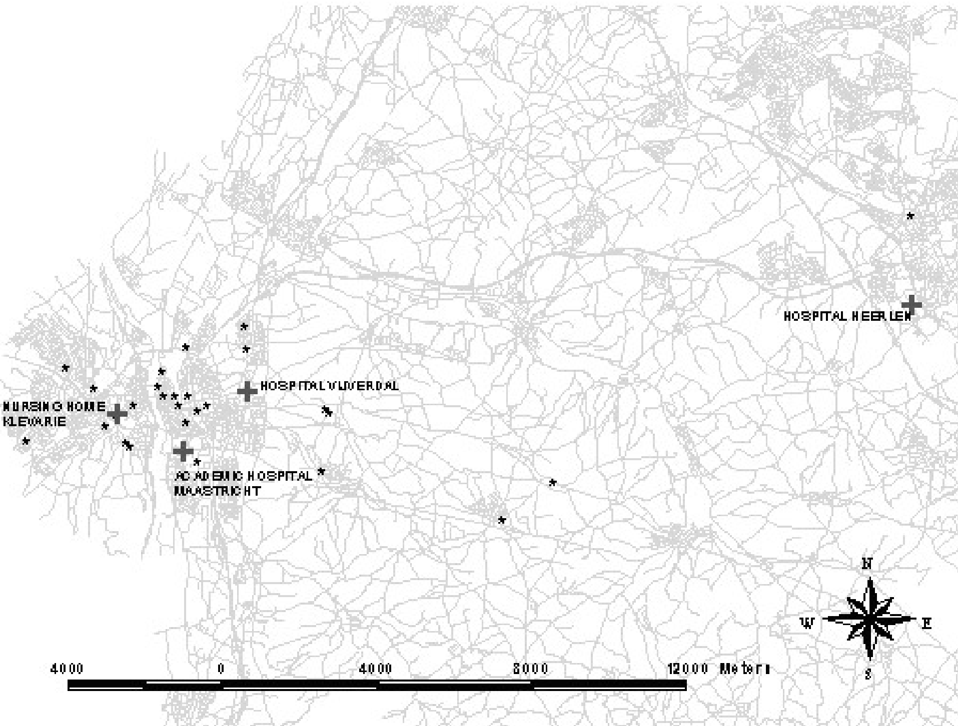


Figure **7.3.6** TMT trip destinations, Maastricht and non-urban inhabitants (n = 39 by 17 persons)

7.4 Tailor-Made Transport in the city of Maastricht

As already discussed in subsection 7.1.3, the TMT data set consists of all reservations for TMT trips of 356 days. The data set contains 295,666 records (reservations for a trip), of which 271,385 have actually resulted in a trip from an origin to a destination. What we haven't mentioned so far, but is important for the interpretation of the analyses to come, is that the TMT system distinguishes pass holders and private users. Pass holders are known users of the system and have become pass holder because they are entitled to get travel fare reductions. The Maastricht pass holders group consists for the larger part of WVG indicated people. The Meerssen pass holders group consists of WVG indicated people and 75+ years old people.

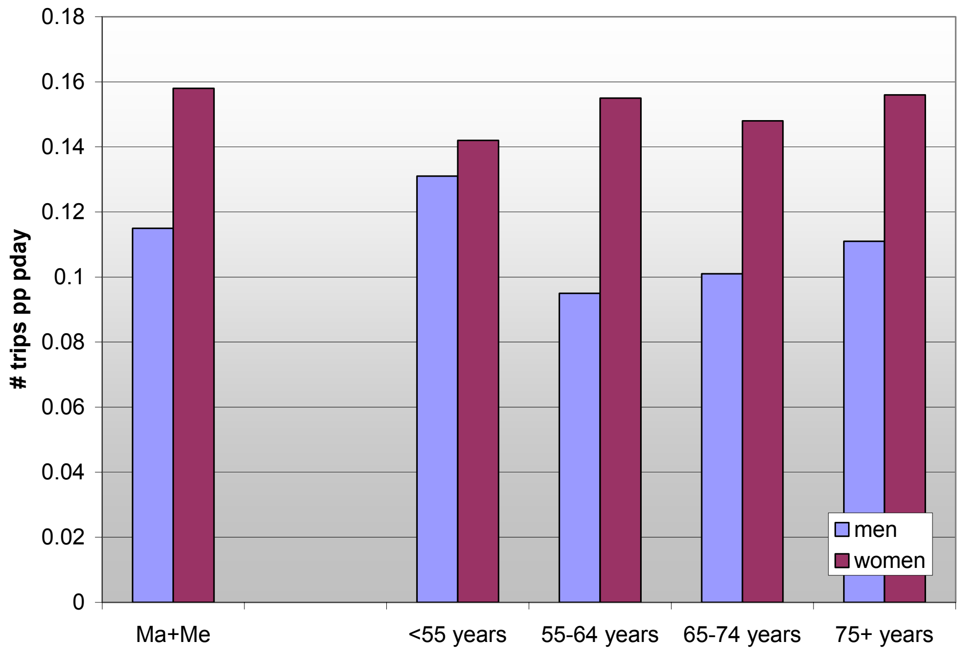
7.4.1 User groups

Table 7.15 shows that the TMT system made 271,385 trips in 356 days: about 770 trips a day. It can be read from the table that most of these trips (87%) are made by the Maastricht pass holders. Private persons account for 6.1% of all trips. Persons with a wheelchair account for 11.0% of all trips.
Table 7.4.1 and figure 7.4.1 also present the number of trips per person per day (made with the TMT system) for the different user groups. For the private persons no results are available because of the lack of background information about this user group. For all Maastricht and Meerssen pass holders, the numbers in the table and in the chart apply. They show that (i) the Maastricht pass holders make more trips per day than the Meerssen users, and (ii) women make more trips per day than men. Women make about 0.16 trips per person per day, men about 0.11.
From activity-travel behaviour research it is known that people make about 3 to 4 trips per person per day (chapter x refers). For older people these numbers are somewhat less (section 7.3, Tacken, 1998, Tacken et al., 1999, Rooij and Tacken, 2001). Therefore, we may *cautiously* conclude that the TMT system accounts for about 5% of all trips made by the older Maastricht and Meerssen pass holders using the TMT system. The word 'cautiously' is used here on purpose, because there is little scientific knowledge about the impact of disabilities on the activity-travel behaviour of people. From the MOBILATE research (Van Lamoen and Tacken, 2002), we indeed know that health has a strong relation with the outdoor mobility of people. So, it could be hypothesised that the TMT system is even more important in the total activity-travel behaviour of its disabled users than the 5% mentioned.

Table **7.4.1** Distribution of number of trips in user groups

	# trips frequency	%	# trips per person per day
private persons	16,456	6.1	-
without wheelchair	14,232	5.2	-
with wheelchair	2,224	0.8	-
Maastricht pass holders	236,084	87.0	0.15
without wheelchair	211,206	77.8	0.16
with wheelchair	24,878	9.2	0.10
Meerssen pass holders	18,844	6.9	0.08
without wheelchair	16,246	6.0	0.09
with wheelchair	2,598	1.0	0.07
total	271,385	100.0	-

TMT data set



TMT data set

Figure **7.4.1** Trips per person per day in age classes for all Maastricht and Meerssen people

We can read from table 7.4.2 that the age of many travellers is missing. This is due to the fact that (i) all private trips (n = 16,456) lack background information (no pass holders), and (ii) the data set also lacks some background data about the pass holders, especially the Meerssen users. 82% Of the trips, from which we do know the age of the traveller, is made by people older than 65 years, and 9% by people younger than 55 years.

Table **7.4.2** Distribution of trips in age categories

	# trips frequency	%
0-17 years	639	0.2
18-54 years	15,222	5.6
55-64 years	16,176	6.0
65-74 years	50,880	18.7
>75 years	97,466	35.9
Missing	91,002	33.5
Total	271,385	100.0

TMT data set

Table 7.4.3 shows that 71.3% of all trips are made by women and 23.8% by men. Here, we should be careful to conclude that the TMT system is only suited for women, or that men do not use the TMT system as intensively as women do. In order to confirm or deny these premature conclusions, we should look at the distribution of sexes within the older population of Maastricht and Meerssen (figure 7.11). We just saw that the system is used mainly by older people. It can be hypothesised that, in relative terms, more older men use the TMT system because of their absence in absolute terms in Maastricht and Meerssen.

Figure 7.4.2 shows the ratio of older men and women per Maastricht neighbourhood. The size of the circle represents the absolute number of older adults living in each neighbourhood. The larger the circle, the more older people. The map shows that in most neighbourhoods there are more older women than men, but not to such an extent as could be suggested when looking at the number of TMT trips by sex. But what we (still) don't know is whether there are more older *disabled* women than older *disabled* men in Maastricht. On this subject, no information is available. However, we now can conclude with some more certainty that women use the TMT system more intensively than men. So, the group of older (disabled) women is the main user group of the TMT system.

Table **7.4.3** Sex of the traveller

	# trips frequency	%
Men	64,712	23.8
Women	193,501	71.3
Other	316	0.1
Missing	12,856	4.7
Total	271,385	100.0

TMT data set

Figure **7.4.2** Ratio between the number of older men and women in Maastricht per neighbourhood (source: Municipality of Maastricht (2000), section Geoinformation and section Education, Culture, Public Welfare, and Sports)

7.4.2 TMT Maastricht and multimodal travel

One of the most important theoretical potentials of a demand-responsive shared taxi system is, as identified in section 2.3 on *Passenger Chain mobility*, its feeder function to higher order transport systems such as the train network. In the TMT data set we do not have any variables that indicate that people transferred to another transport mode nor that they actually reached their trip destination. We do know however how often people got out at the Dutch Railways train station, where TMT Maastricht has its own stop. It may be assumed that most people leaving the TMT bus at the railways station continue their trip by train.

Table 7.4.4 shows the percental share of all TMT trips with the Dutch Railways station as origin or destination. We can see that only 1-2% of the TMT trips goes to the station. It can be concluded that the feeder function of the Maastricht TMT system is very limited, which can be explained by the fact that:

- on the one hand, multimodal / public transport travelling plays only a minor role in the total travel behaviour of people at the moment (Van Nes, 2002), and older people especially (subsection 7.3.2 refers);
- and on the other hand, for travelling to the Maastricht Railways station the people from Maastricht have in fact three public transport alternatives: [i] the regular, time-tabled bus, [ii] the Traintaxi, a shared taxi service from and to the station, and [iii] the TMT system.

In section 7.2 we already discussed that the introduction of demand-responsive transport resulted in the shift of travel mode for a number of trips. The bus, the taxi, and the car as passenger were the most important former modes of the (new) demand-responsive shared taxi travellers. It can be assumed that such a shift of modality will only take place if the former transport mode in one way or another does not meet (all) the traveller's needs. If the needs however are sufficiently met, the need and urge to shift to another alternative is low. With two other good alternatives available in the city of Maastricht, it is understandable that TMT attracts not too many trips to the station.

Table **7.4.4** Percental share of trips with the Dutch Railways station as origin or destination (n = 271,385)

	As origin [%]	As destination [%]	Total [%]
Private users	0.9	1.1	2.0
Maastricht passholders	0.6	0.4	1.0
Meerssen passholders	0.8	0.5	1.3

TMT data set

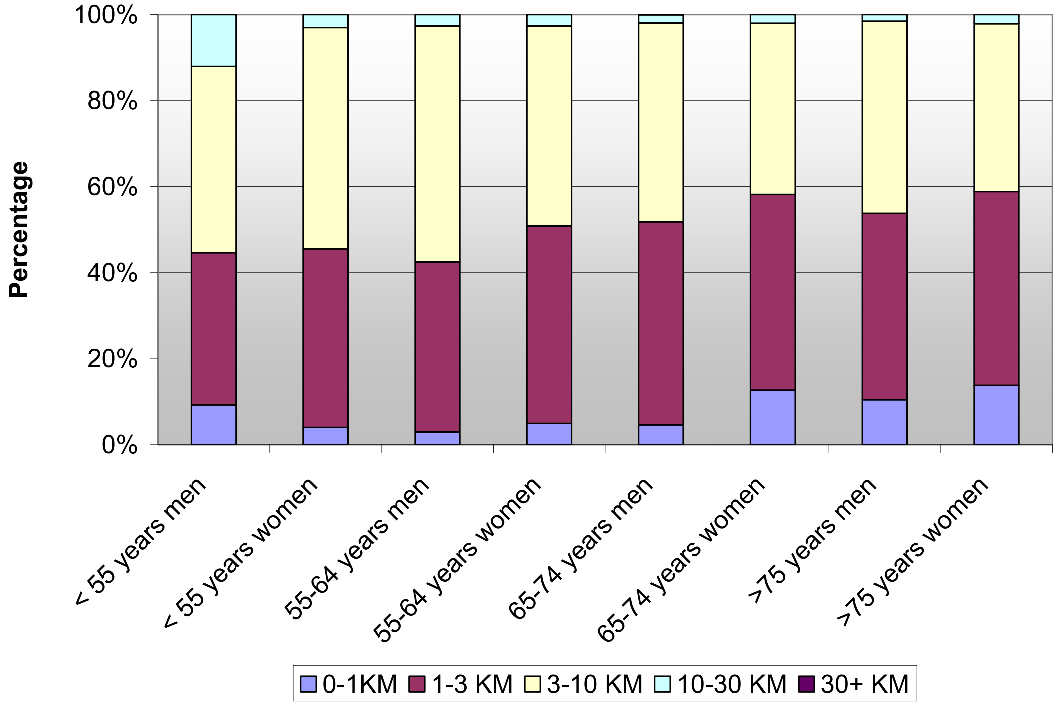
7.4.3 Distance behaviour

The second hypothesis presented in section 7.1 deals with the differences in use between urban and non-urban people. Figures 7.4.3 and 7.4.4 present the distribution of trips in distance classes for the largest user groups in Maastricht and Meerssen: the WVG indicated people without wheelchair. The trips of the Maastricht people take primarily place in the distance classes 1-3 and 3-10 kilometres. Furthermore the chart shows that:

[i] less trips take place in the higher distance classes for the 'older' age categories.

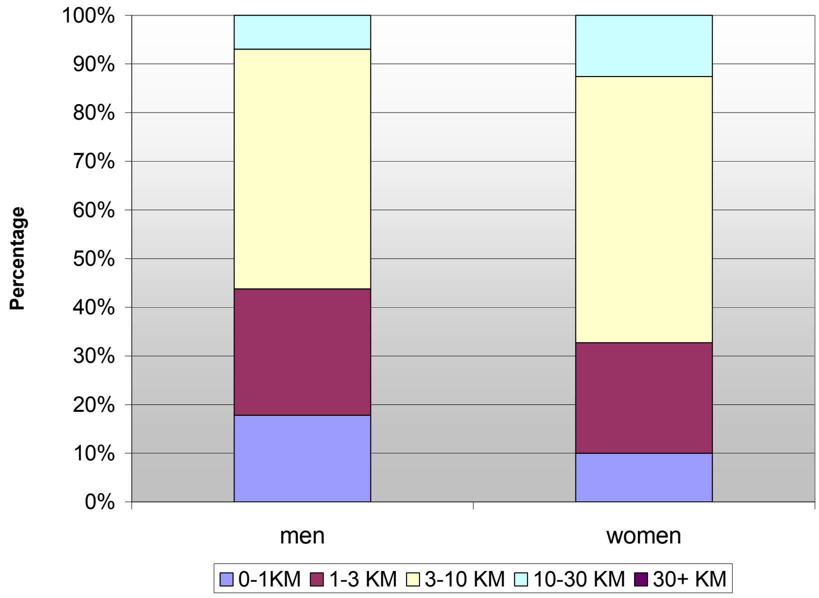
[ii] the trips made by men are more often in the higher distance classes than the trips made by women.

In the chart of the Meerssen people, the trips are not distributed in age classes because of the lack of age information on the Meerssen pass holders. Here, the most striking is the relative importance of the higher distance classes (3-30 km); for the women, about 70% of the trips are longer than 3 kilometres. This is easy to understand when we consider the geographical location of the village of Meerssen related to Maastricht. For many urban facilities people from Meerssen depend on the city of Maastricht. In order to travel to Maastricht (by TMT) the Meerssen people obviously have to travel quite a bit further than the Maastricht inhabitants.



TMT data set

Figure **7.4.3** Distribution of trips in distance classes for all WVG in Maastricht without wheelchair



TMT data set

Figure **7.4.4** Distribution of trips in distance classes of Meerssen WVG users without wheelchair

7.4.4 Top destinations

In addition to the previous subsection this subsection focuses on the top destinations of the Maastricht and Meerssen users. The analyses are based on one month of the total TMT data set, December 1999[12]. Figure 7.4.5 and table 7.4.5 show the most important destinations of all Maastricht and Meerssen user groups that in total produced just over 20,000 trips during December 1999. Here, we can see:

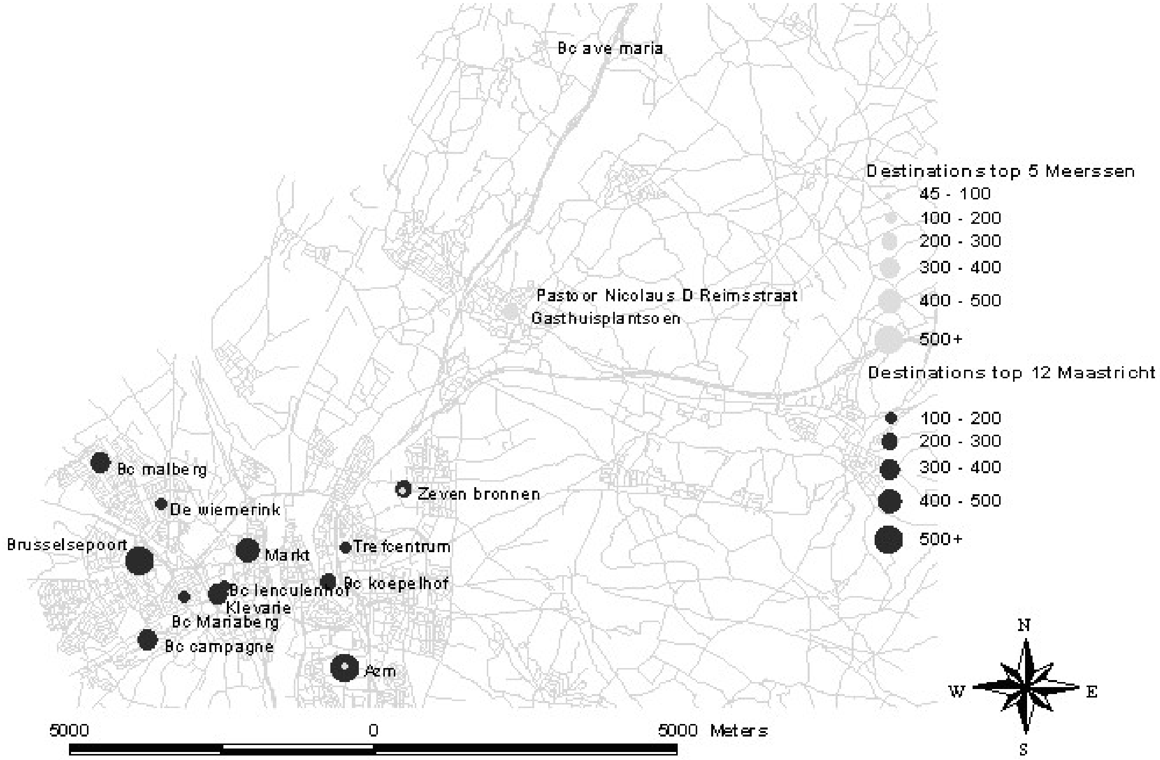
- the importance of all kinds of urban facilities, such as the hospital, shops, and elderly homes;
- that these top destinations are spread to all kinds of city districts (on both sides of the Maas river);
- that the Maastricht academic hospital (Azm) and the nursing hospital Zeven Bronnen are important destinations for both the Maastricht and the Meerssen users.
- Three of the four TMT stops the hospital, shopping centre Brusselse Poort, and the Market, belong to the most important destinations. The fourth TMT stop at the Dutch Railways station isn't even in the top 25 of destinations.

Table **7.4.5** Top 12 destinations all Maastricht users

Ranking	Address	Function
1	AzM	Hospital
2	Brusselsepoort	Shopping centre
3	Markt	Market, city centre
4	Klevarie	Elderly home
5	Bc Campagne	Elderly home
6	Bc Malberg	Elderly home
7	Bc Koepelhof	Elderly home
8	Zeven Bronnen	Nursing hospital
9	Bc Lenculenhof	Elderly home
10	Trefcentrum	Community centre
11	Bc Mariaberg	Neighbourhood centre
12	De Wiemerink	?

TMT data set

[12] Beuckens (2002) shows that the top destinations of the TMT system are about the same for several months of the data set; seasonal influences on the top destinations are limited.

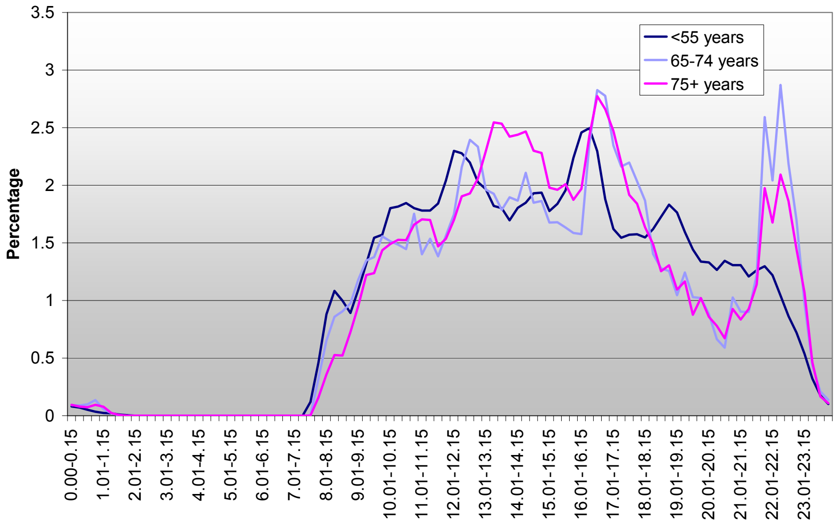


TMT data set

Figure **7.4.5** Top destinations of the Maastricht and Meerssen users in the month December 1999 (number of times that a location is TMT trip destination)

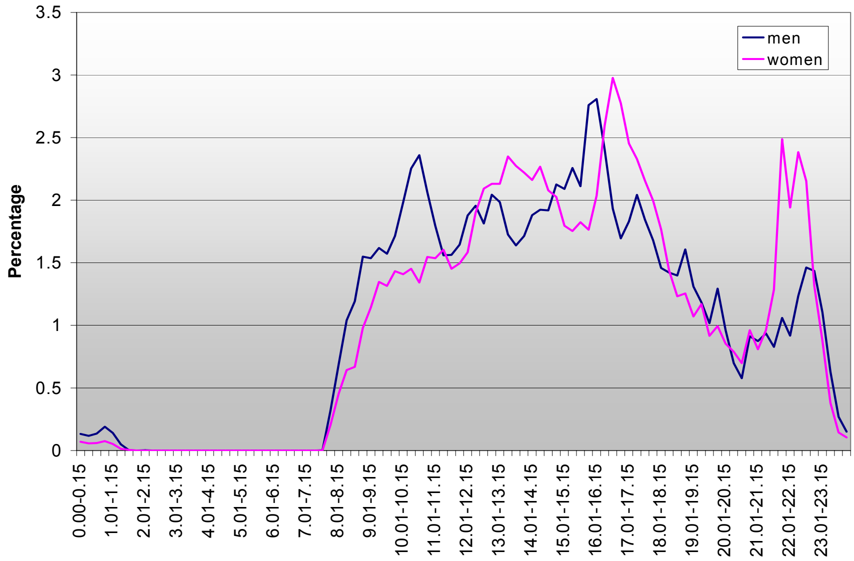
7.4.5 Use in time

An important issue for more vulnerable travellers such as older and disabled people is the social safety of the transport system. From time use analysis (Van Lamoen & Tacken, 2002) we know that people in general, but especially older people, do not prefer to travel during the 'unsafe' hours of the day: in darkness and in bad weather conditions (section 7.5 refers). Therefore it is interesting to see that the TMT system is used till late in the evening by the older user groups (figure 7.4.6), and especially by the women (figure 7.4.7). It seems that the TMT system is a social safe system, that does not prevent people from going out in the evening.



TMT data set

Figure **7.4.6** TMT Time use: Maastricht WVG users without wheelchair



TMT data set

Figure **7.4.7** TMT Time use: Maastricht WVG users without wheelchair

7.5 Mobility preferences of older people from an international perspective

From section 7.3 and 7.4 we can conclude that for the larger part the TMT system is used by a limited group of people: predominantly older people, predominantly women, and predominantly people with disabilities or impairments. However, this kind of service seems to have potential for a lot more people than just this selected group of users. We have also seen that the role of multimodal transport in the travel behaviour of older adults is very limited.

In the MOBILATE programme, all people were asked for their opinion about [i] all kinds of transport service characteristics, [ii] emerging technologies, [iii] today's traffic situation, and [iv] transport improvements. This section deals with these questions in order to be able to conclude if collective demand-responsive transport is indeed only feasible for the identified minority group of users and if, more generally, (seamless) multimodal transport has potential for travellers at older age.

7.5.1 Flexible demand-responsive public transport

All people (n = 3,950) in the MOBILATE survey were asked for their opinion about some more or less negative system characteristics of today's Dutch demand-responsive transport system (table 7.5.1). Although not all foreign MOBILATE people had a clear understanding of the functioning of a demand-responsive system, their imagination was challenged and the statistical results give rise to some interesting conclusions.
It appears that the fact that 'the vehicle can be up to 15 minutes early or late' is evaluated most negatively by four out of the six countries involved. In this question it isn't taken into account that many Dutch demand-responsive systems offer the service of a phone call 5 minutes before the actual pick-up time. 'Making a detour' is evaluated as second most troublesome. On the other hand, the fact that 'you have to share the vehicle with other passenger' is evaluated most positively. Also 'travelling in a wheelchair bus', which could enforce feelings of the stigmatising of frailty and independence, is evaluated rather positively.

Table **7.5.1** Mean ranks of concessions to do for demand responsive transport (1 most troublesome to 5 least troublesome)

	Finland	Germany East	Germany West	Hungary	Italy	The Netherlands
	Mean	Mean	Mean	Mean	Mean	Mean
you have to order the vehicle at least one hour in advance	2.7	2.7	3.1	3.3	2.8	2.9
the vehicle can be up to 15 minutes early or late	2.4	3.2	3.2	2.8	2.6	2.3
you have to share the vehicle with other passengers	4.0	3.2	3.5	3.8	3.3	3.6
often a wheelchair bus will be used to carry out the trip	3.2	2.8	3.2	3.7	3.4	4.0
you often have to make a detour in order to pick up or drop off other passengers	2.6	2.2	2.5	3.2	2.9	2.7

Mobilate Survey 2000, n = 3,950, weighted

7.5.2 Age and technology

In several ways, new technologies intrude into the lives of older people, innovative transport services being one of them. We can for example think of in-vehicle route planning devices, personal intelligent travel assistants based on mobile phone technology with up-to-date, dynamic, multimodal travel information, trip chain integrators, etc. In general, the introduction of new techniques should make things easier for the users. But most of the time, older people are less accustomed to these new ways to do things. For example, today's older generation has not learned to handle menu-controlled users' interfaces of equipment. And most of the modern equipment has changed in the last decennia from directly controlled by physical action into menu-controlled with many layers in those menus.
Many of these new technological developments are subjects of discussion. The replacement of bank offices by Bancomats, the introduction of the chipcard for parking and public transport, the ticket machines for the trains and public transport, all these changes have serious opposition. The Dutch government tries to convince banks and post offices to maintain local

offices. In her dissertation, Docampo Rama (2001) distinguishes different age groups with different attitudes to handling complex users' interfaces. These attitudes were based on the way the generations were exposed to different types of control of equipment. The oldest generation has less experience, and, therefore, more problems with menu-controlled equipment. In the MOBILATE survey, people were asked, if they use some of the new technologies and if they agree that these devices make their lives easier (tables 7.5.2 and 7.5.3).

Table **7.5.2** Users of new technologies by age, gender and area (%)

	urban				rural			
	55-74		75+		55 -74		75+	
	male	female	male	female	male	female	male	female
Automatic ticket dispenser	35	39	24	24	21	23	16	15
Automatic teller machines	62	55	34	25	56	51	28	21
Card-operated telephones	28	27	14	9	24	26	7	6
Automatic admission systems	34	36	30	22	25	20	15	7
Electronic cash (PIN)	43	32	17	13	37	30	14	11
Telebanking	5	3	2	3	5	1	1	0
Mobile telephones	38	25	18	10	28	20	10	6
Internet	13	7	3	1	5	3	2	0

MOBILATE Survey 2000, N=3,550, weighted

Table **7.5.3** Users who enjoy the use of this equipment, by age, gender and area (%)

	urban				rural			
	55-74		75+		55 -74		75+	
	male	female	male	female	male	female	male	female
Automatic ticket dispenser	70	70	62	67	67	78	50	70
Automatic teller machines	83	86	82	75	83	84	69	74
Card-operated telephones	67	71	72	65	64	75	56	79
Automatic admission systems	65	76	71	67	68	76	70	60
Electronic cash (PIN)	85	88	83	72	82	95	90	92
Telebanking	77	84	100	80	90	67	100	83
Mobile telephones	82	85	83	81	89	88	79	93
Internet	84	69	100	67	94	70	100	100

MOBILATE Survey 2000, N=3,550, weighted

Although large differences can be found between the countries[13], we focus here on age, sex, and place of residence. For all groups, the bancomats belong to the most common equipment. For most new technologies we can observe that the younger people belong more often to the users than the older people. In general, the same can be said for urban people in contrast to the rural people, except for the bancomats which are more common in non-urban areas.

When we take a look at the percentages of people who enjoy the use of these technologies, we can conclude that the elderly are generally very positive. In most cases, between 70%-90% of the users enjoys the use of the equipment. No real patterns can be found between the different groups identified. The conclusion seems to be in line with one of the findings by Docampo Rama, that experience with the new equipment and the need to use it offer a good condition for acceptance. One of the problems is that older people often feel no need to start using new technologies, except in those cases where they feel they have no alternatives.

[13] For example, in Hungary some technologies, such as the Internet, are hardly available or aren't available at all.

This argumentation is in line with the findings of chapter three on mobility behaviour from a theoretical point of view, where it was concluded that people will not change (travel) behaviour quickly, if their present (travel) alternatives meet their (travel) needs sufficiently. And for older adults, so concludes Docampo, this is even more true than for younger adults.
What can we learn from this? If we want new (transport) technologies and (travel) services to be adopted by older adults, we should also pay a lot of attention to the explaining how the new technology functions and what kinds of credits result from using the technology. Information and communication are the keywords here.
Transport innovations are introduced in existing market of travel and transport demand and supply. Therefore, it is good to be aware of what the end users (in casu the travellers) think of their current situation. The next subsection deals with the older people's experiences and perceptions of today's traffic situation.

7.5.3 The traffic today and suggested improvements

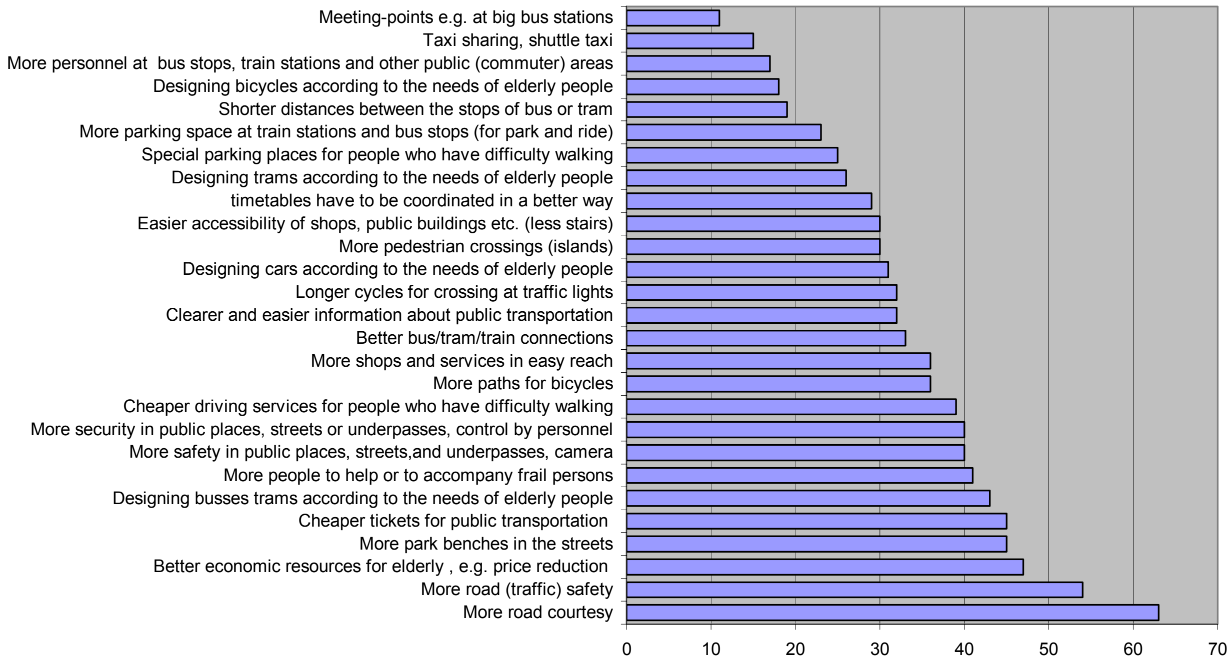
All MOBILATE elderly were asked for their opinion about today's traffic situation. Table 7.5.4 shows all statements about experienced and perceived problems that could be overcome by collective demand-responsive transport. The main problem that the older adults mention here is that 'too few people offer their seats in the bus for a person who needs to sit down'. In case of CDRT a person doesn't only make a reservation for a trip, but also for a seat. The rural users have complaints about the frequency of public transport. Of course, this is no issue for CDRT, where the (mini)bus will come at your request. The other statements have to do with the accessibility and riding comfort of the vehicle, and feelings of safety and vulnerability. Individually oriented, door-to-door services such as the CDRT systems described in this chapter, have the characteristics to take away those burdens of physical and mental discomfort that the older people experience and perceive for other travel modes.

Table **7.5.4** The average score on general statements on the traffic today that could be overcome by collective demand-responsive transport (1= true, 2 = partly true, 3 = not true)

	urban				rural			
	55-74		75+		55 -74		75+	
	male	female	male	female	male	female	male	female
I have difficulty getting in and out of the bus because of the high steps.	1,5	1,8	1,9	2,1	1,5	1,8	1,8	2,1
The automatic closing and opening of bus doors is poorly installed, so that you can easily get caught in the door.	1,5	1,7	1,7	1,8	1,5	1,5	1,6	1,6
The buses start too quickly and jerkily such that one is thrown about.	1,7	1,9	1,9	2,0	1,6	1,6	1,6	1,7
Buses run too infrequently at certain times of the day.	1,9	1,9	1,8	1,8	2,1	2,1	2,2	2,2
Too few people offer their seat in the bus for a person who needs to sit down.	2,4	2,4	2,4	2,3	2,3	2,1	2,2	2,1
Traffic is sometimes so busy that you don't dare to go out on the street.	1,6	1,8	1,8	1,9	1,6	1,7	1,8	1,8
Nowadays I often feel helpless in traffic.	1,5	1,7	1,6	1,8	1,5	1,7	1,7	1,9
As an elderly person you feel disadvantaged in today's traffic.	1,8	1,9	1,9	2,0	1,7	1,9	2,0	2,0

MOBILATE Survey 2000, N=3,950, weighted

Figure 7.5.1 shows the most important suggested transport improvements that the MOBILATE people were asked for. The number one improvement -over 60% of the people mentioned this item- is the desire for more road courtesy. Number two (54%) has to do with the road (traffic) safety, and number three (46%) with price reductions for older people.



Mobilate 2000, all countries

Figure **7.5.1** Statements concerning the improvement of transport

When we look at all suggestions of improvement from the viewpoint of (seamless) multimodal transport, we can see that quite a number of suggestion deal in one way or another with this issue. The most important suggestions with respect to multimodal transport are ‘designing buses and trams according to the needs of older people’ (top 6 and top 22), ‘better bus/tram/train connections/timetables’ (top 13 and top 19), ‘clearer and easier public transport information’ (top 14), and ‘better park and ride facilities’ (top 22), ‘more personnel at bus stops, train stations’ (top 25). It appears that most suggestion focus on the ‘seamless’-aspects of multimodal transport: in physical terms (accessibility of vehicles, certain additional facilities), in terms of time (diminish the burden of waiting of the intermodal transfer), and in terms of organisation and information (more personnel, better information).

With respect to the accessibility of public transport (vehicles and stations) the Dutch Ministry of Transport has adopted a policy that has to lead to a completely accessible public transport system in 2030: it is estimated that 94% of the total Dutch population should be able to use the public transport system without any problem, and that 6% of the total population will be in need of assistance during travelling (Kahmann, et al., 2001).

With respect to the connections in time of different transport systems, it can be said that the largest challenge lies in the organisational tuning between transport operators (Veeneman, 2002). For the information services we can observe that the mobile phone industry indeed has started to offer travel information.

When we look at all suggestions of improvement from a more general perspective, we can conclude that there are basically three types of suggestions: socially oriented improvements (safety, behaviour, manners, people), physically oriented improvements (transport and traffic system, urban environment), and financial-economic oriented improvements (reductions, cheaper services for older people and especially for older people with a disability). From this observation, we can conclude that improving the mobility situation of older people means more than only improving the transport system.

But thinking about improving the mobility situation for older people we should take into account that (older) people can differ quite a lot in their mobility: independence and health are important indicators for the outdoor mobility of older people. Independent and healthy elderly can fulfil their activity and mobility needs most of the time without any problems and on their own. It is expected for the near future that this increasing mobile group of older people will travel more and more (both in frequency and duration); among others under influence of increasing time and money budgets for the social-recreative travel motives, such as visiting friends, leisure and sports, excursions, and short and long holiday trips. But also under influence of new (transport) technologies which will make travelling easier and more comfortable. Moreover, it is expected that we will be able to recognise the high level of (car)mobility of today's young adults in the older people of the future.

It may be clear that this group of mobile older people (will) perceive and experience a relatively small number of problems during travelling. However, in general getting older implies decreasing physical and mental abilities. As a lot of research on (the mobility of) older people has shown, the processes of getting older and their impact on the outdoor mobility can be referred to as a *sliding scale* downwards (Rooij and Tacken, 2001). The number of bottlenecks and obstacles both perceived and experienced (will) grow by age. So, for the group of older people who do meet all kinds of physical and/or mental constraints, the story differs completely from the mobile old adults. They will be to a large extent dependent for their outdoor mobility on (offered) transport services, both private (children, family, friends or neighbours) and professional / commercial (public transport, taxi services, etc.).

The MOBILATE project shows that, in order to improve the conditions for the outdoor mobility of people at old age, it has to be clear that only measures related to 'the physical', i.e. the transport and traffic system and the urban environment, is by far not enough. Integral policy making is the key-word here: physical measures have to be accompanied by social (the 'human') and financial measures (figure 7.5.2).

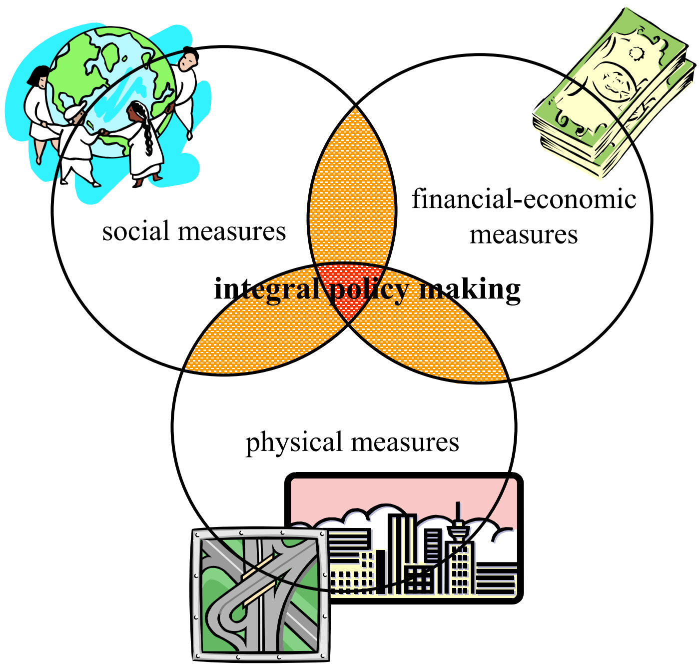


Figure **7.5.2** Integral policy making: improving the conditions for the outdoor mobility of older people

7.6 Summary and conclusions

This chapter started with the three hypotheses that originate from chapter one, section 1.4. In this section, those hypotheses are discussed, based on the analyses presented in this chapter. Conclusions are drawn, new questions are given.

Demand-responsive personal transport systems have a (theoretical) potential to play an important role in the total multimodal transport system of the Network City, although nowadays their role in practice is marginal.

This chapter identifies that the main potentials of demand-responsive transport concern its feeder function to higher order transport systems, its ability to adapt criss-cross travel demand patterns, and its flexibility in both time and space to access the transport network. On the other hand, one of the most important limitations for the success of today's demand-responsive transport systems is the cost effectiveness. When the systems get larger -that is, attract more travellers- the costs involved grow correspondingly. Costs per trip decrease, but the total system costs increase.

From the MOBILATE research on the outdoor mobility of older people, we can learn that the actual share of demand-responsive transport in the total travel behaviour of older adults is very modest. From the TMT data set we can conclude that the main user group of the Maastricht demand-responsive system -as a good representative for the Dutch Collective Demand-Responsive Transport systems- is the group of older and disabled people, mostly females.

Furthermore, the TMT data set shows that only a very limited number of TMT trips goes to or originates from the Dutch Railways station. The door-to-door, shared taxi system does not seem to function as a feeder system at all. Among others, this can be explained by the fact that the city of Maastricht has also two other public transport alternatives to go the station: the line-bound bus system and the Train taxi, a demand-responsive system from and to the station. From a cost saving perspective, it could be a suggestion to investigate whether the integration of the two demand-responsive systems is more cost effective.

But the costs aren't the only issue here. A more fundamental discussion is needed about what kind of (subsidised) transport services the government wants to offer its citizens? The government does not only have the task to offer transport systems that reduce travel times of people as much as possible, and keep subsidies as low as possible. With respect to mobility, it has a social task besides the transport task and economic task. It could be questioned however at what costs people should be able to make trips. Moreover, according to policies such as the integration of all people in society, the government should help people who have difficulties using the traditional transport modes.

The introduction of demand-responsive personal transport systems results in new and/or other activity-travel choices of the travellers and thus in changing activity-travel behavioural patterns of these travellers, although there will be many differences in use according to the spatial setting in which the system functions (urban users, suburban users, and rural user) and the level of service characteristics.

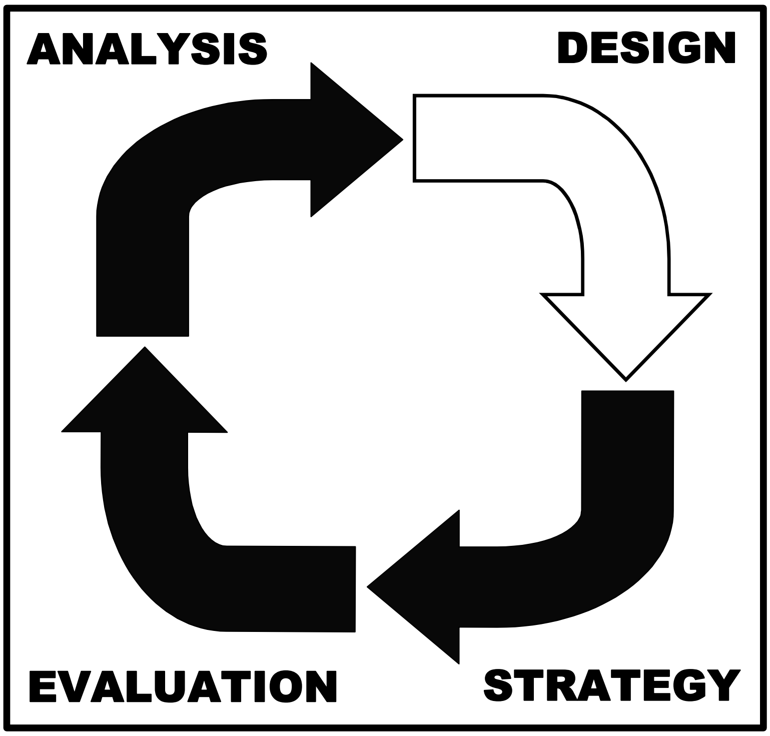
The data bases used in this chapter do not prove the first part of this hypothesis on the change in travel choices and travel patterns. However, the available literature shows that this statement is true: the introduction and adoption of demand-responsive transport indeed resulted in new choices and new patterns, and in changes in individual action spaces.

The own data bases do present differences in mobility between the urban and non-urban (older) travellers. When we consider the differences in use of the TMT system between the Maastricht urban inhabitants and the Meerssen suburban inhabitants, we can conclude that the

urban inhabitants travel significantly shorter distances. For the urban inhabitants, the TMT top destinations, urban facilities such as the hospital(s), the shop(ping centre)s, and the elderly homes are located at shorter distances than for the non-urban inhabitants.
From the MOBILATE research we learn that urban older adults in general get out more often and spend more time outdoors than rural older adults. Here, it seems that the supply of potential activity destinations indeed creates a (travel) demand. For urban inhabitants, these potential urban activity destinations are relatively easy accessible (short distance, many transport facilities) and are *thus* visited.
One of the most interesting findings of the Maastricht demand-responsive system with respect to the travel patterns, is about the points of time that the system is used by its travellers. Many older adults use the TMT system until the late evening hours. It seems that the TMT system is a social safe system, with which older adults dare to travel till the dark hours of the day.

So, the vulnerable user groups of older people with a disability is today's main user group of these kinds of systems. The MOBILATE research on older adults shows that system characteristics such as uncertainty about the exact time of departure and arrival, and making a detour are evaluated quite negatively. Therefore, it seems that the service characteristics of the demand-responsive shared taxi systems serve the wishes of the most vulnerable user groups best.
Supplementary to the discussion above, the MOBILATE research also shows that it is untrue that many older adults use public transport a lot, or that public transport (in general) is suited perfectly for elderly. For their travel behaviour, older people primarily depend on the private travel modes. Walking and the car are the most important travel modes for the elderly. Younger adults (especially scholars and students, but also young working adults) use public transport much more often than older adults.
But as we know, age comes with impairments, and sometimes with disabilities. The accessibility of transport becomes crucial for those with impairments in order to be able to get out of the home. In the Netherlands for example, the accessibility of traditional public transport (vehicles and stations) still has to improve a lot in order to be referred to as 'good', despite good initiatives and many governmental subsidies (Peeters et al., 2001). In the MOBILATE project, the older people give many suggestions how to improve the transport system as a whole: not only suggestions are given for the physical appearance of vehicles, infrastructures, and transport nodes, but also their social and financial context.
With respect to multimodal transport, most suggestions deal with the 'seamlessness' of today's public transport in both time and space: vehicles, stations, transfers, accessibility, waiting, social safety. Most suggestions are true for all users independent of age. But for older people these bad links in the transport chain are even more important (more vulnerable users) than for younger adults, who are in general physically and mentally more resistant.
A final remark is made on the adoption of new and/or innovative (transport) technologies and (travel) services by older end users. For many older adults, it is not always easy to use or to get used to new technologies. The MOBILATE project, but also other research sources, show that if a new technology is good and there is an urge for people to use it, older people will soon adopt, and if necessary adapt. With respect to the new technologies that come with Seamless Multimodal Mobility (multimodal travel information devices, trip planning software, etc.), the older travellers belong to an interesting market to explore for the suppliers of technologies.

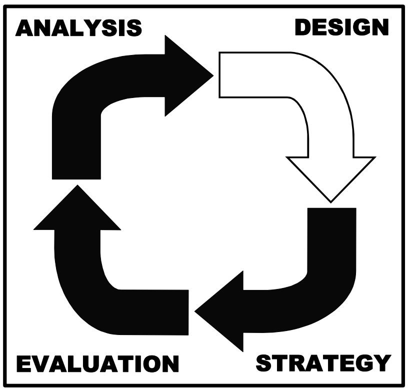
PART B
DESIGN



CHAPTER EIGHT LOCATION OF TRANSFER POINTS

Magis quis veneris quam quo, interest.

When arriving at your destination, it is more important to know in what kind of mental state you are, than at which location.
Seneca, Epistulae Morales, no. 28



This chapter introduces to the second case study of this thesis and relates to the planning (and design) of multimodal transfer points in general, and the location choice of the multimodal transfer points specifically. The objective of this chapter, as the first part of the design phase of this thesis, is [i] to present the changing conditions for the city with respect to multimodal transport and especially the transfer points, and [ii] distil recommendations for the location choice process.
This chapter starts with a focus on the changing conditions for the city (section 8.1). Furthermore, it gives an overview of existing typologies of transfer points (8.2), it shows failure and success factors of transfer points (8.3), and it describes existing problems and present methods with respect to the location choice process (section 8.4). Section 8.5 focuses on the method of the planning cycle that can be considered to be a guide for design and planning problems, design and planning objectives, and design and planning solutions. Finally, section 8.6 gives the summary and conclusions of this chapter.

8.1 Changing conditions for the city

The city of the future is the Network City, in which (seamless) multimodal transport supports a growing range of possible inter-relations for a variety of activity-travel goals (chapter five refers). Therefore, the Network City requires the development of new multimodal transport strategies and concepts, which are to be used in the planning and design of future socio-spatial settings. As discussed in chapter five on the spatial planning of the Network City, transport nodes in general and especially the multimodal transfer points have the potential to become important mobility environments. Here, the *space of flows* meets the *space of places* directly. Therefore, transfer points are locations where a very large potential exists for physical human interaction, so where the city of the future could take place.
In this discussion, the *node-place quality* of transfer points (Bertolini, 1996) is a key-notion that refers to two different perspectives: (i) the accessibility of the location and (ii) the reach of people from that location. Accessibility, as a characteristic of a location, refers to the area, within which a number of persons is situated, who can choose that specific location as destination, against acceptable (time) costs. In brief: how easy people (from outside) can get to that location. The reach of people refers to the area, within which a number of activity places is located, which a certain person can choose as destination, against acceptable (time) costs. In brief: how easy people can reach destinations from that location. Bertolini speaks of the *node-value* and *place-value* respectively.
Bertolini's place-node model (figure 8.1.1) has been initially conveyed in a simple xy diagram. In the diagram, the y value corresponds with the node-content of a location (the accessibility of the node, the transport value), and thus to its potential for physical human interaction. The x value corresponds to the place content of a location, or to the intensity and diversity of activities there.

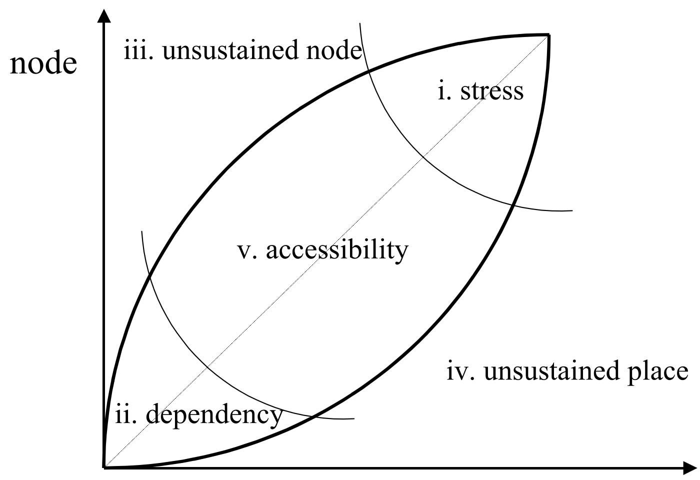


Figure **8.1.1** Place-node model
Source: Bertolini, 1996

In the figure, five typical situations can be distinguished. Along the middle diagonal, the node and the place factor are equally strong. At the top of the line, the location is under stress. Here, the intensity and diversity of transport flows and urban activities are at a maximum, which indicates that the potential for human interaction is highest. However, these are also locations where the great concentrations of flows and activities result in equally great chance of conflicts between multiple, extensive claims on a limited space. At the bottom of the middle diagonal, there is a second typical situation, represented by the dependent location, where the struggle for space is minimal, but the demand for transport and urban activities are so low that the location becomes dependent. Also, two unbalanced situations can be identified. The left side of the diagram refers to the unsustained nodes, locations where the transport facilities are relatively overdeveloped compared to the urban functions. On the right side of the diagram the urban functions are relatively overdeveloped compared to the transport facilities. The fifth area within the diagram is the balanced area between the four others.

In this chapter, we focus on more detailed information about transfer points and the location (choice process) of those transfer points. It therefore relates to the second research question of this thesis on how the spatial planner chooses the best locations for the intermodal transfer points in the multimodal transport network within the Network City. This chapter should be read as background information for chapter nine that focuses on the design workshop ‘The location choice of transfer points’. Let us now zoom in at transfer points as such, and secondly at the location choice process of those transfer points of the multimodal transport network.

8.2 Transfer point typology

Transfer points are facilities where travellers can transfer from one means of transport to another. In chapter 2 we already categorised possible transfers according to the level of scale, on which the modes of transport visiting the transfer point operate, and whether the transport modes are individual or collective means of transport (section 2.3.5 and figure 2.3.4 refer). In practice we see that a transfer point very often offers several transfers for several spatial levels and for more than two (individual and/or collective) modes of travel.

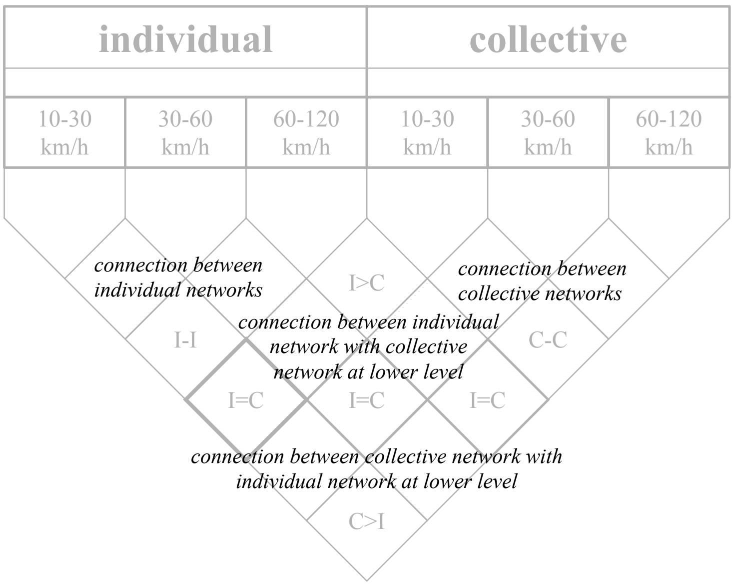


Figure **8.2.1** Access and transfers (figure 2.3.4)

In multimodal travelling, most of the time the transfer determines the quality of the trip as a whole, from door-to-door. In other words: from practice we know that the transfer usually is the weakest link in the chain of multimodal travelling. Furthermore, people in general only tend to shift from unimodal travel to multimodal travel if this shift offers an advantage in one way or another. In line with the Dutch knowledge centre CROW for Traffic, Transport, and

Infrastructure (2002) it can be stated that people will shift from unimodal to multimodal transport if it enables them to make their trip:

- more rapidly;
- more cheaply;
- more comfortably.

So, the quality of the transport hub is critical. CROW presents the most important quality aspects of the transport hub (figure 8.2.2), based on Peek and Van Hagen (2001): safety & reliability, speed, ease, comfort, and experience. Without sufficient (subjective feelings of) safety and reliability, multimodal travelling will be no option. Also travel time and ease are referred to as so called 'dissatisfiers'. If the demands that originate from these quality aspects are not met, the traveller will evaluate the transfer point as insufficient, independent of the more subjective design demands such as comfort and architectural experience quality (the so called 'satisfiers').

Furthermore, CROW states that these aspects can be translated into the demands of travellers with regard to facilities at the transfer hub, maximum waiting times, maximum walking distances, etc. The designer / planner should then translate the demands of travellers into transfer point design requirements. In principle, the design requirements are different for each transport hub, given the different locations and different targeted users.

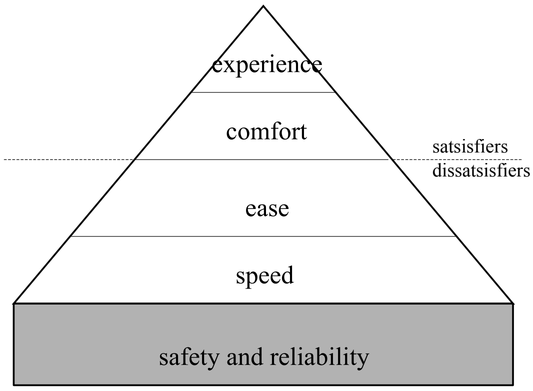


Figure **8.2.2** Quality aspects of the transport hub
Source: Peek and Van Hagen, 2001

To develop a general approach for similar situations CROW has categorised the transfer points according to the *accessibility* of the transfer point on the one hand and the *location and function* of the transfer point on the other. CROW determines the accessibility of a transfer point on the basis of the accessibility by car and by public transport (table 8.2.1 and figure 8.2.3). The locations and functions indicate for which group of travellers the transfer point is intended. Transfer points with a destination function are usually located near the access roads to these destinations. The relatively short distance between the transfer point and a destination can be travelled using a regular public transport connection. Transfer points with a central origin function are usually located in city centres, close to where the travellers begin their journeys. These transfer points offer the opportunity to transfer to public transport in order to reach destinations that are further away. Transfer points with a peripheral origin function are mainly located on the edge of the origin areas (the periphery) or at some distance from both the origin and destination area.

Table **8.2.1** Typology of transfer points

Function Scale	Destination function	Central origin function	Peripheral origin function
International	-	HSR Central [1]	P + HSR [2]
National	Major Urban Entry Point [3]	IC Central [4]	P + IC [5]
Regional	Minor Urban Entry Point [6]	(A)R Central [7]	P + (A)R [8]
Local	-	-	-

Source: CROW, 2002

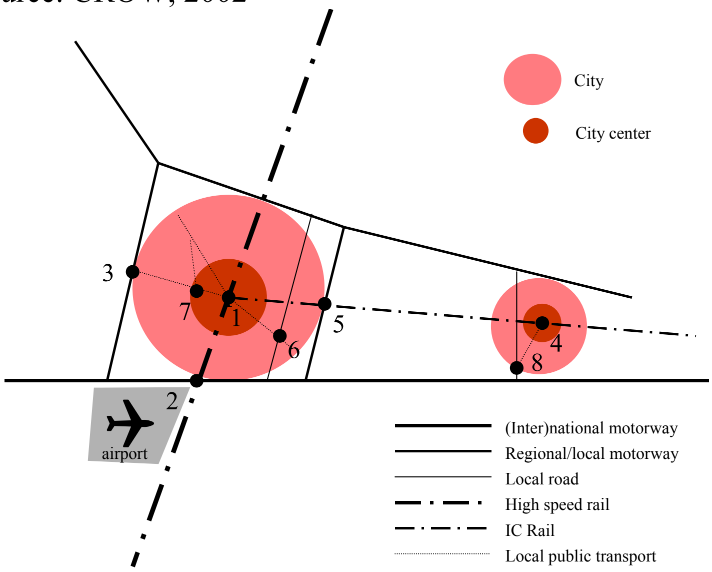


Figure **8.2.3** Typology transfer points

In his PhD thesis, Van der Spek (2003) presents a transfer point typology based on network characteristics, geography, and volume of use. The network characteristics are also based on the levels of scale of individual and collective modes, as presented before. Van der Spek discusses that the naming of transfer nodes follows a hierarchical process. The highest level network that visits the transfer point is leading for the naming of the transfer point, even if this specific transfer (from and the highest level of scale) is not the most important expressed in numbers of physical transfers.
For the geography, Van der Spek identifies four different situations:

1. **main-ports**: object of transfer point is identity determining, location of transfer point is of minor importance.
2. **centre-ports**: the location is identity determining, centrally located.
3. **edge-ports**: the location is identity determining, located at city edges.
4. **trans-ports**: location nor object is identity determining.

For the use of transfer points, Van der Spek uses the total number of physical transfer movements in the transfer point during a day (all modalities). He identifies four categories:

1. small: <3,000 transfer movements per day.
2. medium: 3,000 – 30,000 transfer movements per day.
3. large: 30,000 – 300,000 transfer movements per day.
4. extra large: >300,000 transfer movements per day.

When we take into account the ‘rules’ for the form and structure of complex networks as presented by Barabasi (2002; section 2.3.6 on Scale thinking refers), we can come up with a

number of starting points for the design and planning of the network of transfer points. Barabasi shows that complex networks, such as the transport network, follow power law distributions forcing us to abandon the idea of a scale, or a characteristic node. The largest (best connected) node is closely followed by two or three somewhat smaller hubs, followed by dozens that are even smaller, and so on, eventually arriving at the numerous tiny nodes. There is no intrinsic scale in these kinds of networks. This is why these networks are referred to as scale-free.
Furthermore, Barabasi argues that in good functioning complex networks we cannot see the ‘spider phenomenon’, one dominant node or hub with lots of lowly connected nodes and without middle highly connected nodes. A spider makes the network instable and easy to mess up because of the network’s dependence on the spider.

Defining a typology of transfer points helps to identify possible solutions for several design ambitions, although the success of transfer points depends on more than only the physical design. It is worthwhile to elaborate on this in somewhat more detail.

8.3 The failure and success of transfer points

The design and planning of transfer points involves a complicated process: where should they be built, how should they look, who should be involved, etc.? A very important issue when discussing the design and planning of transfer points, is *when a transfer point can be called a success*. CROW (2002) states that a transfer point can be called a success if the transfer point satisfies the intended policy goals for the transfer point on the one hand, and if it has a good exploitation on the other. An intended policy goal can for example be that the environment pressure (noise, stench, etc.) on an inner city per car visiting that city centre should decrease. A good exploitation means that the transfer points makes at least as much money as it costs.
We have seen in this section that the location of transfer points plays an important role in the typology and classification of transfer points. The next section goes on with the discussion how the location of transfer points influences the success of the transfer points.

Table **8.3.1** Park & shuttle

When can park & shuttle become a success?
Parking facilities should be directly located at the main road infrastructure, with which the traveller enters the city
Adequate (dynamic) signposting
Recognisable, well appointed parking facilities
Shuttle connection with high frequency
Safe parking spots (sufficient guarding, social safety)
Direct routing from the parking facilities to the city centre
Shuttle stops in the city centre, close the to main urban facilities
Recognisable, covered stops with seating facilities, both by parking lot and the city center
(Actual and dynamic) Information about the park & shuttle system (time schedule, prices, etc.)
A moderate tariff; cheaper than parking in the city center
Tariff for both parking and the shuttle (combi tickets for all car passengers)
Supply of public transport adapted to working and shopping hours
Extra facilities at the parking lot (shuttle stops), such as toilet, coffee machine, bicycle rent, shopping services, salespoint for travel tickets

Source: Stienstra, 1997

In the Netherlands, many local governments experiment with park & shuttle services in order to decrease the (parking, environmental) burden for the city centres. Already in 1997, Stienstra presented an interesting list of factors for failure and success of park and shuttle transfer points (table 8.3.1). From this list it can be concluded that the success and failure factors belong to a lot of different fields: traffic and transport engineering, urbanism and architecture, finance, information and communication technology, and more social-pshycological factors, showing that the design and planning of transfer points is in fact a multidisciplinary task.

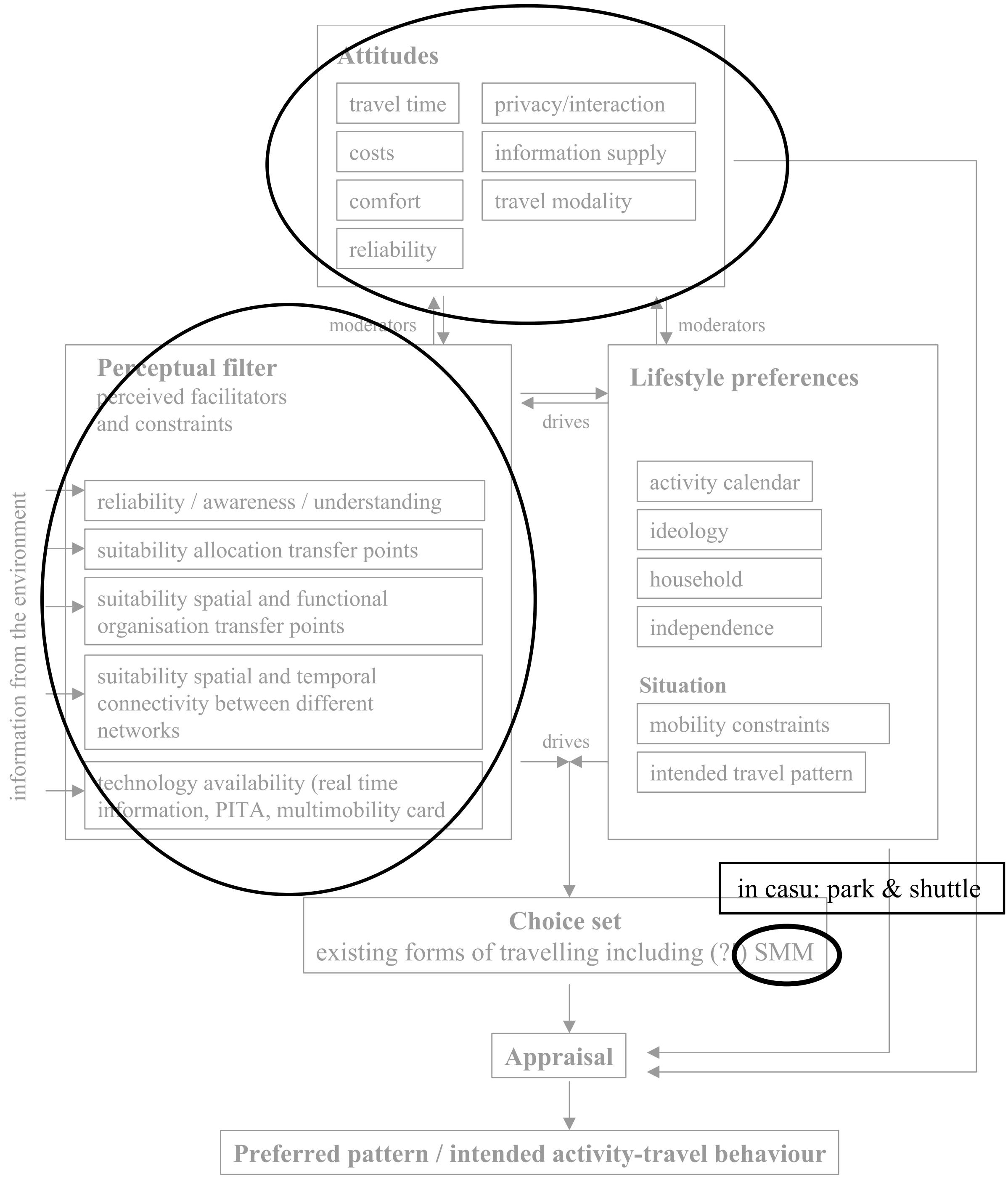


Figure **8.3.1** The traveller's internal decision context: P&S

From the table we can also observe that (the perception of) the location of, and the routes to and from the transfer point are considered to be important factors for the potential success of transfer points, and thus multimodal travelling. When we bring in mind the traveller's decision context as presented in chapter three, we can observe that the conceptual descriptions of the individuals' perception and attitudes are in line with this more practical list of determining factors for success and failure for park and shuttle (figure 8.3.1).

8.4 Location choice process

Although there are millions of transfer points all over the world, Diepens and Okkema (2000) conclude that there are only very few countries that have a *national* policy on the design and planning of transfer points. For the case of national policy making, the Netherlands Ministry of Transport is frontrunner in the world with the project called 'Transferia[1]' (see for example Ministry of Transport, 2000, Transferia. Een handreiking bij voorbereiding en realisatie).
The B&A consulting group (2001) evaluated the planning and design processes of the Dutch 'transferia' and came up with six important lessons to be learned :

1. **Commitment**
   - Don't expect all parties involved to have the same amount of commitment; get the right people involved at the right time.
   - Invest in commitment at a personal level, but also in formalising agreements and appointments, for example in a covenant.
   - Commitment is enforced by time pressure.
2. **A good analysis of the field of powers/forces**
   - Interests don't always have to coincide precisely, as long as they are in the same direction, and are not conflicting.
   - Be aware of hidden agendas of people and parties.
   - Let the role that a party plays in the process be connected as much as possible to the interest of that party in the project.
3. **Support**
   - Creating support is a continuous process.
   - Try to anchor realised support.
4. **Users**
   - The wishes of users should be the starting point for the realisation.
   - That means: high quality public transport, a guaranteed safety, and a smooth transfer.
   - Secure actual use of the transfer point in advance, by means of the issuing of subscriptions, the leasing of parking place, the construction of office space etc. in order to prevent financial problems.
   - The user is *the* factor of success and by that the most important partner in the process. That is also true during the phase of exploitation and management, when the user is the customer.
5. **Finances**
   - The role of subsidies can be diverse: a steering part of the project, or can be used to balance the budget in the end.
   - Search for possibilities for the financing in multifunctional use.
6. **Finally**
   - A good process is no guarantee for a successful transfer point, but does contribute to it as such.

[1] The Ministry of Transport (2000) defines a transferium as a comfortable transfer point between car and public transport that: [1] is located logically in the route between origin and destination, [2] causes little loss of time at the transfer, [3] is provided with high quality public transport between transferium and destination, and [4] has high quality facilities and a high quality design, adjusted to the needs of the demanding car traveler.

- Realising a transfer point is not easy. Not only the architectural and urban design is decisive for success, but also the process. For every transfer point the field of powers is different, and the process architecture should be adapted to the specific situation.

An interesting design methodology for the location choice of transferia was presented by Van Binsbergen et al. already in 1992. For the search for transferium locations two societal objectives are defined:

1. reducing the number of car kilometres
2. building transferia for relations where no public transport alternative is available

The authors suggest that the search for transferium locations should take place at different levels of abstraction. In principle, the working method is from a high to a low(er) level of abstraction, but feed-back mechanisms should be included. The authors present the levels of abstraction as follows:

Table **8.4.1** Levels of abstraction in the choice process of the location of transferia

Relations
Define the (transport) relations for which the transferia are needed

Potential locations
Search for the location that could be considered as options

Urban design and planning
Make the transferia fit at the local level, spatially and functionally (e.g. infrastructural)

Architectural design
Lay-out, internal transport both horizontally and vertically

Source: Van Binsbergen, et al. (1992)

The process of (iteratively) generating and selecting transferium locations is given in figure 8.4.1. Especially the third step ‘searching for transferium locations’ is interesting to look at in more detail. Van Binsbergen et al. show that this step consists of five different substeps. In order to be able to use these transportation planning oriented substeps, information on the streams of travellers is needed.

1. choosing transferium locations as close as possible near origin areas (among others bases on the objective to minimise car kilometres);
2. selecting those locations that are situated logically with respect to the expected travel direction;
3. estimate the potential use;
4. if the estimated potential use is too low: join some transferia (repeat this substep till estimated use is sufficiently high);
5. further judgement of the locations found: in some cases the estimated use will be so that the total (regional) design has to be reconsidered.

Although the method of location choice presented above only deals with transferia and is based on societal objectives that could be discussed, it gives good suggestions for defining a method for the location choice process of transfer points in general. In the next section the spatial planning cycle, introduced in chapter one, is given as the basic structure for spatial (urban and transport) planning and design. We shall see that some of the main points of the method of Van Binsbergen et al. will be part in this more integral way of thinking.

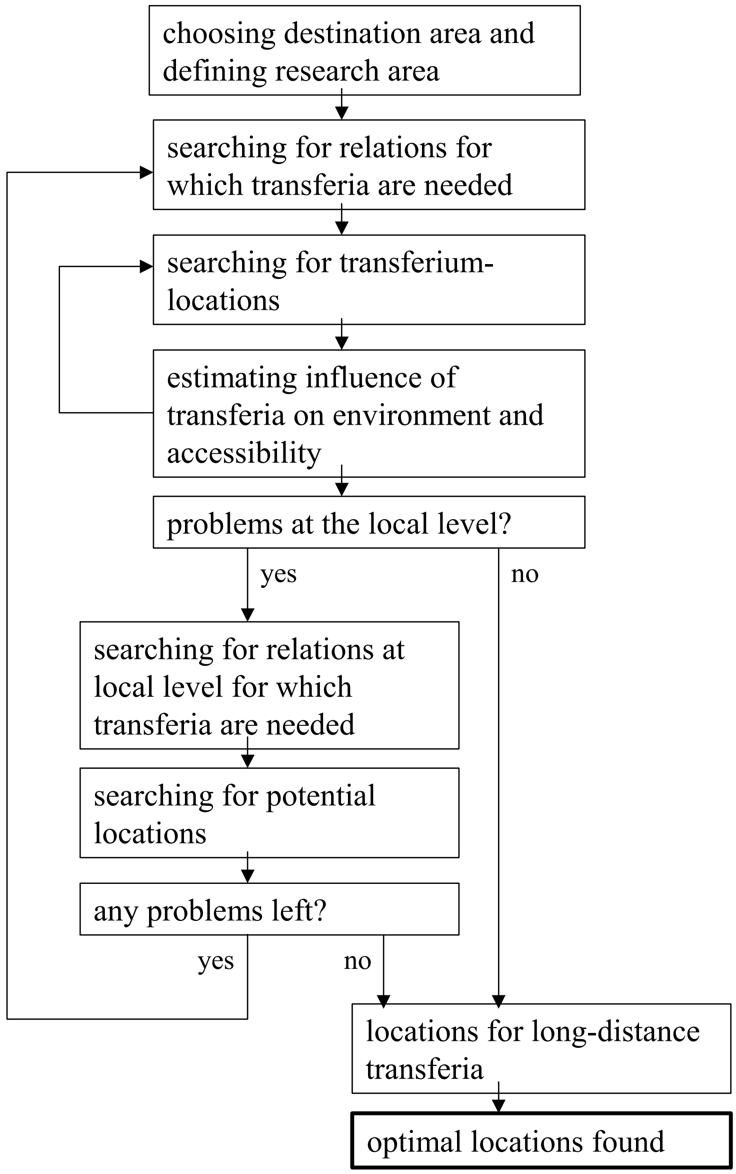


Figure **8.4.1** 10 Steps for generating and selecting transferium locations
Source: Van Binsbergen et al., 1992

8.5 The Planning cycle

The planning and design of transfer points is a multidisciplinary activity: the main actors are urbanists, and transport and traffic engineers. The spatial planning cycle, as the symbol for spatial planning, helps designers and planners to order and conceptualise their activities. The cycle should be seen as a closed circle, or as a combination of connected circles, a spiral 'upwards' in the meaning of more insight and a better overview (Zeisel, 1984, Hulsbergen and Kriens, 2000, Hulsbergen, 2001).

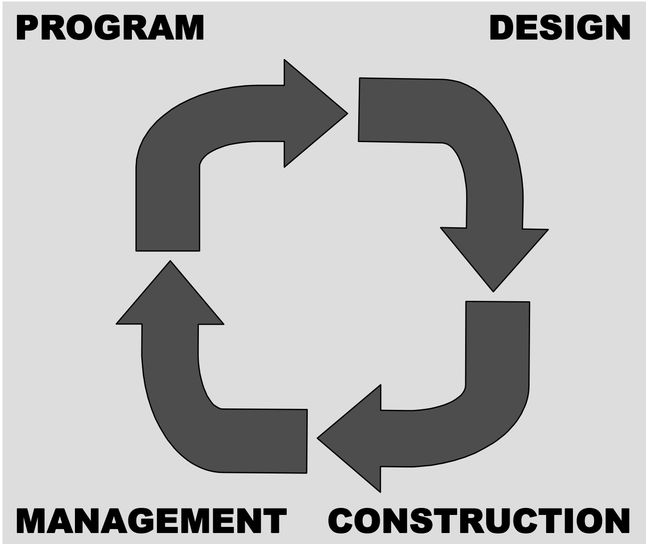


Figure **8.5.1** The basic spatial planning cycle

The basic cycle consists of the phases program-design-construction-evaluation (figure 8.5.1). In this cycle ‘construction’ refers to the actual realisation of a design. A large part of spatial planning however isn’t focused on the realisation of a design, but on the development of a design. For such a development planning cycle, the phases can be defined as: analysis-design-strategy-evaluation.
When we talk about the design and planning of transfer points in the Network city, the transfer from the phase of analysis to the phase of design is crucial. Here, the objectives and the spatial-functional concept should be made explicit based on an multidisciplinary analysis (figure 8.5.2). They are important means of communication (in words and drawings) for the spatial planners towards the other actors involved in the total process, such as the employer, the financers, politicians, civilians, etc., for the choices that are made at the beginning of the process, have much influence on the process and (related) costs to come. A good diagnosis of the actual problems and objectives is therefore a crucial activity at the end of the phase of analysis.
The phase of analysis deals therefore first of all with the definition of the design area. Furthermore, knowledge should be acquired with respect to the morphology, geography, urban form and function, spatial planning conditions, traffic and transport issues, and the activity-travel behaviour of people of the design area in order to define the main transport and urban problems and design objectives. The phase of strategy deals with issues such as feasibility (technical, financial-economic, societal, political), whereas the evaluation phase focuses on if and how objectives are met, and what to do about it ‘if not’. For urban and transport design, the phase of design in the planning cycle is the most important, because here the design alternatives (possible transfer locations) are developed.

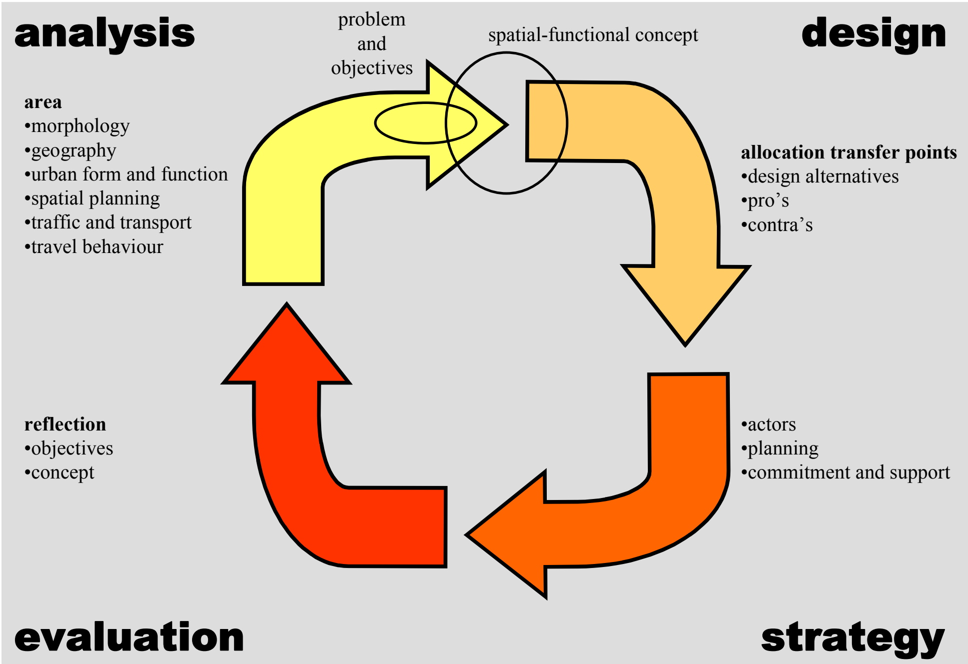


Figure **8.5.2** Spatial planning cycle for the design and planning of transfer points

The result of the design phase should not only be a map with a set of the best locations for transfer points, but also a description of the nature of those transfer points as discussed in the section on transfer point typology. So, first of all the objectives resulting from the phase of analysis have to be translated into activity-travel relations and into definitions for the transfer point typology.

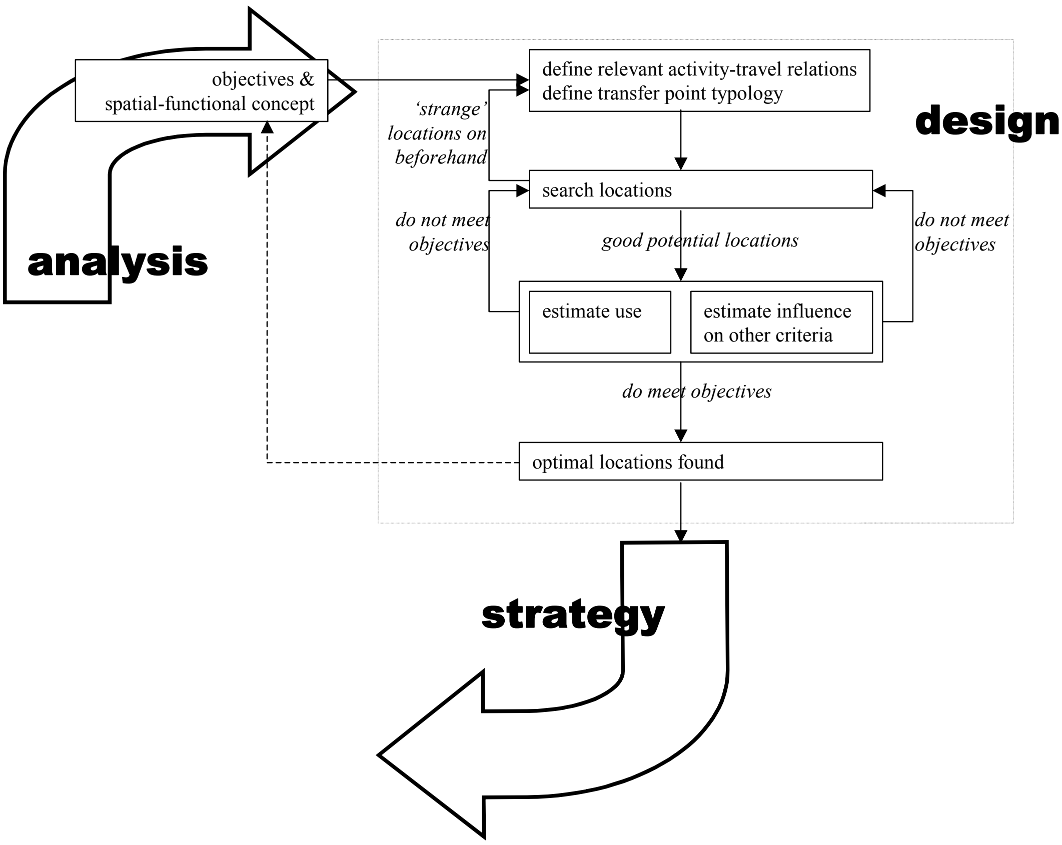


Figure **8.5.3** Phase of design location choice process of transfer points

Following Van Binsbergen et al. (1992), the search for potential locations has to take into account the urban and transport planning, and the behavioural limitations and starting points, which are formulated as a result of the phase of analysis. If objectives cannot be met, there is a need for a new search for locations. The potential use is a crucial design criterion as it defines the potential success (functioning, exploiting, etc.) to a large extent.
In planning it is almost inherent that at the end of (a range of) process steps, one knows best what should have been the question or objective to start with. So, the planning cycle offers explicitly the possibility to change the starting points of a phase (in casu: the phase of design by the feedback loop from 'optimal locations found' to the 'objectives and spatial-functional concept' (figure 8.5.3).

The planning cycle as a whole doesn't refer to level of scale as such, but in the phase of analysis the design area has to be clearly defined. As has been stated earlier in this thesis, the level of the region seems to be the most important level of scale to discuss the location of transfer points, because the daily action space of people primarily takes place at this level of scale (see chapter four, but also: Dutch Advisory Council for Spatial Planning, Housing, and the Environment, 2001b, and Verroen and Ter Brugge, 1997). However, we should take into account that in today's spatial planning practice it is not easy to let actors feel responsible, and let them act accordingly, for the total concept of all transfer points in a region. The design and planning of the location of transfer points inevitably is a multi-actor process.

8.6 Summary and conclusions

The functioning and vitality of the Network City is closely related to the hierarchy and structure of its transport system. The design of the Network City and its transport system thus is a multidisciplinary task.

The location of transfer points within the Network City is one of the key success factors for multimodal transport, and together with the architectural lay-out, the urban environment, and the transport function of transfer points, it plays a crucial role in establishing the (desired) hierarchy and structure of a transport system of the Network City.

These two hypotheses were given in section 1.4 of this thesis on the 'Research approach'. Chapter 10 'Towards the conditions for the planning and design of the Network City' elaborates on these two hypotheses. But some first remarks and conclusions can be given now.

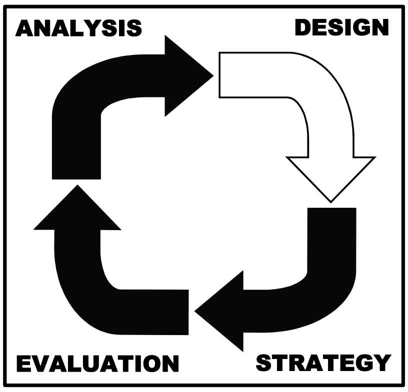
The design and planning of the location of transfer points is a multi-actor process, in which urban and transport designers and planners play an important role in the phases of analysis and design of the spatial planning cycle. What kind of transfer nodes are desired (typology), and at which locations, depend primarily on the design objectives that have to be clearly defined if one wants to 'measure' (potential and/or actual) failure or success. Evaluative research from the Dutch 'Transferia' program shows that the location choice process -when and how do actors get involved- also plays an important role as a factor defining failure or success.
Within the design and planning approach of the spatial planning cycle, existing methods of transfer node typology and transfer point location search from a transportation point of view can be implemented. The integral and multidisciplinary way of thinking and working that is

stimulated by the planning cycle therefore is suggested as the design and planning method to be used for design and planning problems such as the location of transfer points.
The next chapter focuses on the design workshop ‘The location choice of transfer points’ that was held for this PhD research. A multidisciplinary group of participants covering the fields of urban and transport design and planning and transport sociology (travel behaviour) focused on urban and transport design proposals for the region of Maastricht during one day. Here we can see whether this approach really deals with all of the most important aspects that are part of this complex design issue.

CHAPTER NINE THE DESIGN WORKSHOP

Animum debes mutare, non caelum.

You have to change your mentality, not your place of settlement (lit.: the sky).
Seneca, Epistulae Morales, no. 28



The objective of this chapter, as the second and final part of the design phase of this thesis, is to give an overview of the results and discussions of the design workshop 'Location choice of intermodal transfer points', which aimed at [i] looking if the workshop participants were helped by the planning cycle methodology, and [ii] checking if the debate on design proposals lead to conflicts with the conceptual model (chapter three) of the adoption of seamless multimodal travelling.
The first section (9.1) focuses on the aims of the workshop more specifically, and the second section (9.2) on the participants, the venue, and the organisation of the workshop. Section 9.3 gives the results of the questionnaire which has been filled out by the workshop participants at the start of the workshop. The next three sections follow the phases of the planning cycle: analysis (9.4), design and strategy (9.5), and evaluation (9.6). Section 9.7 illustrates how design ideas and/or alternatives can be dealt with effectively making use of methodology of the planning cycle. The final section (9.8) gives an evaluation of the workshop and the design alternatives for the Maastricht region as a whole.

9.1 Aims of the design workshop

The main goal of this PhD research is to supply urban designers and planners with information on the relationship between multimodal transport and the (development of the network) city. To reach this aim we carry out several steps according to the planning cycle: analysis-design-strategy-evaluation. The phase of analysis has resulted in seven chapters on urbanism, mobility and activity-travel behaviour. Demand-responsive transport and the location of transfer points have been considered to be two important issues for the future seamless multimodal transport system of the network city, and they have been discussed in chapters 7 and 8 accordingly.
Demand-responsive transport has been dealt with in this thesis in an empirical way (chapter 7). For the location of transfer points we adopted a research by design approach that is at issue in this chapter originating from the thought that the relevance of the (so far) produced knowledge (chapters 1-8) needed to be tested in a design laboratory. The aim was to test the knowledge with respect to multimodal travelling and the city, by exploring how the design items developed in the phase of analysis of this thesis can face concrete problems in a real spatial setting and how they can lead towards improvements in the present situation. The locations chosen for the design workshop were the city of Maastricht, The Netherlands, because of the specific knowledge already made available by the analysis of the demand-responsive transport system of Maastricht[1], and the region of Arnhem-Nijmegen.
With this design workshop we did not expect to obtain very developed and detailed design proposals for the city of Maastricht and the Arnhem-Nijmegen region, which we considered to be impossible due to the short time available, but, rather to check several points:

- To see if the workshop participants were helped by the planning cycle methodology in defining the design problems, the design objectives and the design brief on the one hand, and in proposing good location alternatives for the intermodal transfer points on the other;
- To check if the debate on the design proposals leads to conflicts with the conceptual model of the *adoption of seamless multimodal travelling* (chapter 3).

With respect to multimodal transport, the hypothesis is that the multimodal transfer points, where the *space of places* and the *space of flows* meet, could be in fact among the most important urban nodes (mobility environments) of the future network city. How they should look like (in an architectural sense) is not dealt with in this thesis[2]. Here, we focus on where they should be located and how to choose the right locations (choice processes).

9.2 Participants, venue, and organisation of the workshop

The design workshop took place in May 2001 at the TRAIL research school in Delft throughout one day of intensive work. The participants[3] who were invited, had a background

[1] See also chapter 1 where the choice for the case studies is explained in more detail.
[2] SMM researcher Stefan vd Spek (2003) goes into much more detail on this specific topic in his PhD thesis.
[3] Prof. Ir Frank Sanders (chair of the day) – professor Infrastructure planning, Faculty of Civil Engineering, DUT, project leader SMM programme; drs Mart Tacken (sociologist) – associate professor Spatial planning, Faculty of Architecture, DUT, daily supervisor of this PhD project; ir Jeroen Buis (civil engineer), researcher DIOC The ecological city, DUT; ir Esther Balvers (urbanist), researcher DIOC The ecological city, DUT, ir Theo Schoemaker (civil engineer) – associate professor Transport engineering, Faculty of Civil Engineering, DUT; ir Rob van Nes (civil engineer), researcher SMM programme, DUT; ir Iwan Kriens (urbanist), senior

in urbanism, sociology, or transport and traffic engineering. One week before the day of the workshop, all participants received a 40 page introductory reader, in which the organisations of the workshop, and the topic of multimodal transport are discussed (Rooij, 2001): several transport subsystems, the characteristics of today's multimodal traveller, a typology of transfer points, the location choice of intermodal transfer points, the planning cycle methodology, and the conceptual model *Adoption of seamless multimodal travelling*.
The workshop day consisted of several stages. After the opening of the chairman of the day, all participants had to fill in a questionnaire with all kinds of questions related to multimodal travel. After the questionnaire two different lectures were given; the first lecture was by ir Remon Rooij on the main topics of the reader, and the second lecture was given by dr ir Nanne vd Zijpp on the modelling of the search for location points and what kind of indicators should be measured, calculated, and evaluated. The third part of the morning consisted of the introduction of the case studies[4], in casu the region of Maastricht and the region of Arnhem-Nijmegen. After these plenary sessions the group split up in 3 disciplinary subgroups with a specific focus: urbanism, transport engineering, and behaviour. These subgroups had to define from the perspective of their fields of interest and expertise a clear problem definition for designing and planning transfer points.
In the afternoon, multidisciplinary subgroups were formed and design objectives and proposals were made for the location of transfer points. In the second half of the afternoon the design proposals were presented and discussed in a plenary session. A final debate concluded the design workshop at the end of the afternoon.
During the day students took notes of the plenary and group discussions. Also the chair(wo)men of the subgroups were asked to evaluate their group discussions and their design process. The contents of this chapter is (to a large extent) based on this material.

9.3 Questionnaire results

To get the workshop started, all participants were asked to fill in a brief questionnaire. In this way, the participants were -as an introduction- directly focusing on the *why's* and *hows* of multimodal travel and a small body of knowledge from experts in the field was thus created (see appendix 3). The six question that had to be answered were:

1. *For which problems in spatial planning (top 5) could seamless multimodal travel be a solution?*
   The answers of this question can be categorised in *car related problems*, such as parking, long distance travel by car, car dependency, *public transport related problems*, such as the quality and reliability of public transport, the economic basis of public transport and long travel times, and *spatial planning related problems*, such as spatial dispersion, vitality urban areas.
   The *accessibility of city centres* is mentioned most often as the problem for which multimodal transport could be a solution. Congestion is number two, the production of

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advisor research and education Spatial Planning, Faculty of Architecture, DUT; ir George Hotze (civil engineer), associate professor Urban design, Faculty of Architecture, DUT; ir John Westrik (urbanist), associate professor Urban Design, DUT; several students from the departments of Urbanism, Faculty of Architecture, DUT, and from Traffic and Transport Engineering, Faculty of Civil Engineering, DUT; drs Enne de Boer (sociologist), associate professor Infrastructure planning, Faculty of Civil Engineering, DUT; dr ir Nanne vd Zijpp, associate professor Transport modelling, Faculty of Civil Engineering, DUT

[4] in fact, two case studies were discussed during the day of the workshop: the region of Maastricht and the region of Arnhem-Nijmegen. Although the focus of the thesis is only on Maastricht, the designs for the region of Arnhem-Nijmegen are discussed as well in section 9.5 to illustrate the design and planning processes.

travelled car kilometres number three, spatial dispersion number four, and the quality of public transport number five.

2. *What do you consider to be the top 5 of most important critical success factors for multimodal transport?*
   Many factors are given by the participants. So, it can be concluded that many aspects are considered to be important and to be decisive for success and/or failure. The answers can be categorised in factors related to the *quality of public transport*, such as frequency, reliability, availability, comfort, etc., related to the *quality of the transfer (point)*, such as functional lay out, transfer time, car accessibility, and related to *spatial planning aspects*, such as the location of transfer points, the place value of the transfer points.
   The transfer (time) is mentioned most often. The frequency of public transport is number two, the car accessibility of transfer points is number three, the location choice of transfer points is number four, and the (door-to-door) travel time and the safety are the numbers five.
3. *For which travel motives (top 5) is multimodal transport suited best?*
   Work (top 1) and *education* (top 2) are considered to be the most important travel motives for which multimodal transport is suited best.
4. *For which distance classes (top 5) is multimodal transport suited best?*
   The participants suggest that for *all distance classes over 3 kilometres*, multimodal transport has potential. For the smallest spatial levels (< 3 km) multimodal is not considered to be an option.
5. *For which point of time during the day (top 5) is multimodal transport suited best?*
   The *peak hours* are considered to be the points of time best suited for multimodal travel.
6. *What are -according to you- the 5 most important drives for a person to travel multimodally, based on the assumption that multimodal travel functions well?*
   Travel time is considered (by far) to be the most important personal drive to travel multimodally. *Comfort* is number two, *costs* number three, *being able to do activities during travelling* number four, and *reliability* number five.

9.4 Phase of analysis

In the phase of analysis the participants split up in 3 disciplinary groups: urbanism, transport, travel behaviour. From their fields of interests and expertise the groups were asked to define the most important problems related to the location of transfer points. The groups were allowed to use the case studies for input for their discussion.

Urbanism
The group urbanists defined 2 specific problems:

1. An inherent conflict exists between the (an) urban design task (concentration and deconcentration) and the functioning of the (multimodal) transport system:
   a. Concentration of urban activities might lead to transport problems (congestion, parking, etc.) to and in centres;
   b. Deconcentration of urban activities (spatial dispersal) conflicts with the economic basis of collective public transport.
2. There is a lack of a high quality public transport system in general (high quality: excellent access in time and space, high frequency, comfortable vehicles).

Furthermore, this group developed 3 starting points that were considered to be important for the discussion about the problems and potential solutions:

1. every traveller should be allowed to own a car;
2. every traveller should be able to get 'everywhere' by public transport (criss-cross relations);
3. every traveller should (at least) have 2 'equal' (travel time, costs, comfort) travel alternatives for every trip.

Transport

The group of transport experts defined the following 2 problems:

1. Different relevant transfers exist that all have their own (theoretical) ideal location:
    a. Urban scale, destination oriented: travellers would like to park in the (old) city centre and local governments wants to move this burden to a transfer point at the edge of the city centre;
    b. Regional scale, destination oriented: travellers from the region want to reach city and transfer points at the edge of the city give travellers the opportunity to transfer to urban public transport;
    c. Regional scale, origin oriented: citizens want to transfer to public transport at the edge of the city for travelling towards other cities in the region/country;
    d. Regional scale, origin oriented: citizens want to transfer to higher order public transport in the centre of the city for travelling towards other cities in the region/country.
2. the use of space of the car system: vehicles and infrastructure.

This group also developed a list of important starting points for designing and planning transfer points:

1. a clear differentiation should be made between transfer points that are focused on origins and on destinations;
2. a clear differentiation should be made between transfer points with a regional and an urban influence;
3. a clear differentiation should be made between transfer points that focus on short distance and long distance travelling.

Behaviour

The group that looked at the location points from a behavioural point of view formulated 3 important questions to tackle:

1. How can we get multimodal transport on the mental map of the traveller?
2. Whether people (will) use multimodal transport depends on many (veto-)criteria. How can these criteria be integrated in the design and planning process?
3. How can we distillate target groups (from the analysis of individual travel behaviour) which can be served by multimodal transport?

The phase of analysis ended with brief presentations of the disciplinary groups in a plenary session and some brief comments of the chairman of the day with respect to those presentations. He summarised that car ownership 'equals' car use, which has large impact on today's society as a whole. So nowadays, car use is widely accepted as a part of life and so should do the spatial planners and designers. Secondly, the chairman refers to the fact that knowledge on quantitative demands (e.g. potential use, costs, travel time, transfer time) are necessary conditions for a good planning of transfer points, but that issues such as safety, atmosphere, experience, etc. determine the actual use of the transfer points.

9.5 Phase of design and strategy

In the phase of design and strategy the workshop participants split up in 3 multidisciplinary groups. Two groups focused on a design proposal for the region of Arnhem-Nijmegen, the third group focused on the region of Maastricht. The design processes were documented (afterwards) by the chairs of the subgroups. These notes are discussed in the following subsections.

9.5.1 Arnhem-Nijmegen: group A

According to this group, the disciplinary formulated problems did not seem to conflict and were therefore not debated in much more detail any further. The group's design objective was formulated as the *improvement of the accessibility of the city centres*. Figures 9.5.1 and 9.5.2 can be seen as the (conceptual) design that builds on the group discussion on the physical and social characteristics of the region on the one hand, and probable spatial developments on the other.
The backbone of the design is a public transport line (metro/tram-like) that connects the most important city districts of Arnhem and Nijmegen and the region in between; from Duiven to Westervoort, Arnhem, Elst, Lent, Nijmegen, Dukenburg, Wijchen. The location of transferia (transfer from car to public transport) are represented by the arrows, situated near the main entrance arteries of the urban areas. The discussion in the group primarily focused on transport aspects (typology transfer points, quality public transport connections) and behavioural aspects (most important traffic streams, role of the bicycle in reaching transfer points).

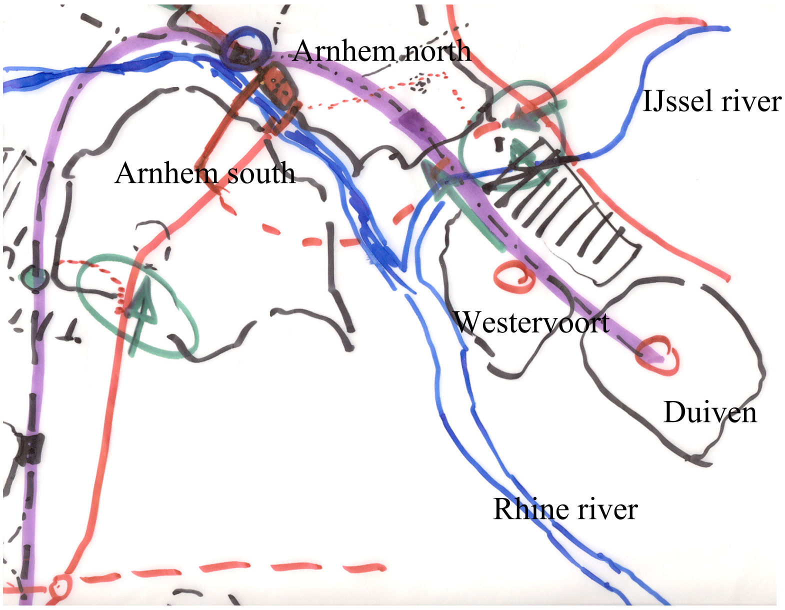


Figure **9.5.1** Spatial concept for the KAN region: city of Arnhem (group A)

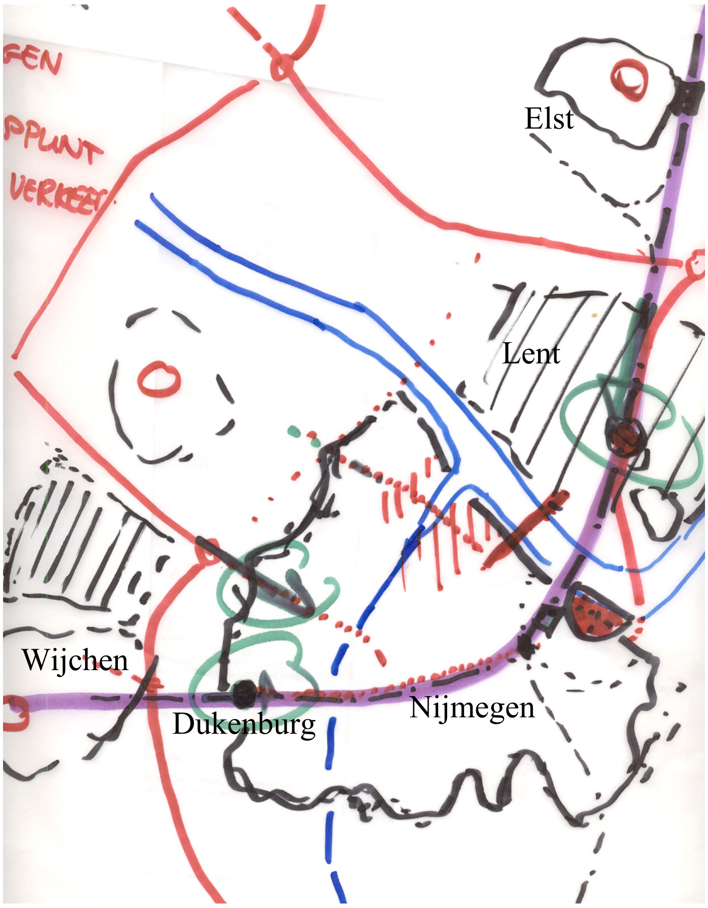


Figure **9.5.2** Spatial concept for the KAN region: city of Nijmegen (group A)

9.5.2 Arnhem-Nijmegen: group B

Also this group did not spend much time on discussing the disciplinary problem definitions and accepted them as given. An explicit design objective was not formulated by this group and the chairman of this group concludes that the group members had difficulties to follow the steps of the planning cycle and started to discuss all kinds of solutions and design alternatives before defining the objectives.

This group developed different spatial models and made a translation of the model that was chosen (figure 9.5.3) towards the topography (figure 9.5.4). The urban aspects that were discussed in the group during the process of designing the models had to deal with landscape values, orientation and identity, and the vitality and atmosphere (climate) of city centres. The transport aspects that were under debate concentrated on the different types of public transport and the hierarchy and relation between those different types of public transport, the conditions for the right to exist for transferia, travel times, the dispersal of transfer points, and the shape of the car infrastructure around the major urban conurbations. The main behavioural aspect that was discussed focused on how spatial designs could help to integrate multimodal transport in the travel options of people as a matter of course.

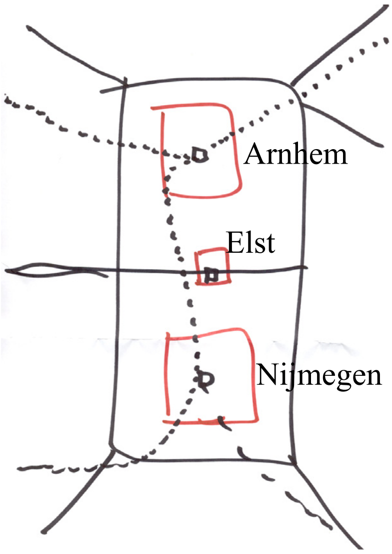


Figure **9.5.3** Spatial concept for the region Arnhem-Nijmegen (group B)

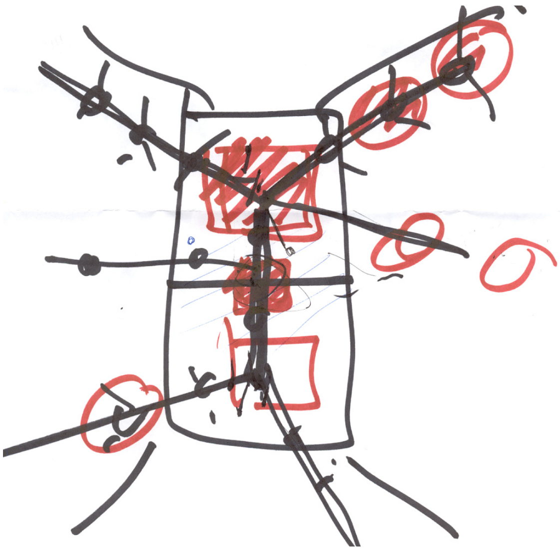


Figure **9.5.4** Situative spatial concept for the region Arnhem-Nijmegen (group B)

9.5.3 Maastricht: group C

Also this group didn't spend much time on discussing the problems presented by the disciplinary groups of the analysis phase. The design objective here is to *connect several different spatial levels (node value) in multimodal transfer points and to determine the urban program (place value) according to the node value.*

An important starting point for this group is to connect Maastricht (multimodally) with the cities of Aachen (HST stop) and Liège (HST stop, international airport) on the regional spatial level, and with the Randstad area (IC connection) on the national level. Liège is connected with Aachen via Maastricht with light rail. Several transfer points are introduced (figure 9.5.5): 2 important so-called 'city gates' near highway A2 where the light rail stops. Specific shuttle services are operated towards the highest order transport services available in the region (HST Aachen and Liège, airport). Another important transfer point is Maastricht Central Station in the city where people can come by urban public transport and slow modes of travel such as walking and cycling.

The most important transport lines are located at the east bank of the Maas river. In order to connect the western parts of the city to the network, the light rail is extended westwards. The

light rail has also some more local oriented stops, both at the west bank and east bank of the river.
Finally, it is suggested that every major transfer point should have its own identity and that the urban program should help to create this specific identity. Due to lack of time, the group could not give more specific urban and/or architectural details how this should be interpreted or should look like. The chairwoman of this group concludes that all three perspectives – urbanism, transport, behaviour- have had influence on the spatial concept for (the region of) Maastricht.

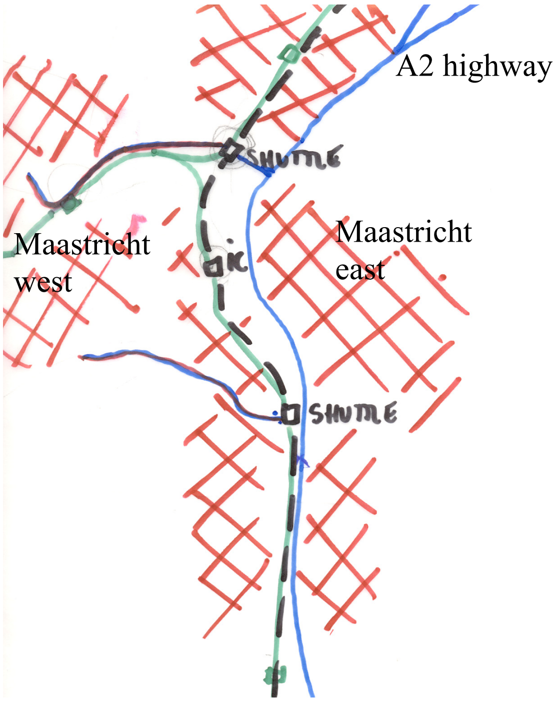


Figure **9.5.5** Spatial concept for the city of Maastricht (group C)

9.6 Phase of evaluation

At the end of the afternoon, all multidisciplinary subgroups presented their design proposals. The designs were discussed and finally the chairman of the day gave a brief summary of the day. He concluded that it seemed that the physical-spatial configuration appears to be decisive for the location choice of the transfer points. In other words: all designs were based on the present, actual spatial situation and therefore it can be concluded that the conditioning role of the present situation defines to a large extent future spatial developments.
In all design proposals the function of the traditional city centre was debated. It therefore could be observed that a big change was suggested for the role of the central railways station, traditionally located near the (medieval) city centre, in the total concept of transfer points. In all designs, the function of the central station became more limited, more specific. The so called ‘city gates’ are introduced to give space to multimodal travellers who use their cars for specific parts of their trips.
The workshop day ended where it began: with a brief presentation on the results of the questionnaire. People were satisfied to see that the top 5 answers on the questions 1 and 2 about the major problems related to multimodal travel (accessibility city centres, congestion, car km’s travelled, spatial dispersion, quality PT), and on the critical success factors (transfer (time), frequency PT, the car accessibility of transfer points, the location of transfer points,

door-to-door travel time and safety) indeed, had played an important role in the uni- and multidisciplinary discussions during the workshop phases of analysis-design-strategy-evaluation.

9.7 Designing the location of transfer points within the city and the region of Maastricht

It became clear during the workshop that designers come with many ideas and possibilities for non or badly defined problems, right from the beginning of the design and planning process. To use design alternatives or design ideas as starting points in the process is no problem at all as long as the whole planning cycle is considered. In this section, exactly this process is shown and discussed more thoroughly. We start in 9.7.1 with presenting three design ideas for three spatial levels (city district, city, region) and their (potential) effects[5]. Section 9.7.2 shows how these design ideas could be realised and which actors could play a major role. In the phase of evaluation (subsection 9.7.3), analyses present the pro's and contra's of the ideas and their strategies. From these evaluation analyses we can come up with new questions that need be tackled before defining the (final) design objective and/or spatial-functional concept for the design and planning of the locations of transfer points in the city and region of Maastricht.
So, the result of this exercise is not the best design for the location of transfer points for the city and region of Maastricht. It is presented here as an example of the method by which objectively and systematically information, insight and arguments are acquired for tackling urban design problems and making design choices within the multi-actor planning field.

9.7.1 Design ideas

Urbanism is (among others) about designing through the spatial levels. Therefore we first present design ideas for three relevant spatial levels: region, city and local. They are design ideas on their own and are given without taking into account the effects they might have on and conditions they might imply for the other design ideas.

Region

At the regional level, we suggest (figures 9.7.1) an urban-infrastructural development at the north side of the MHAL-region. Proper railway connections and railway services are established between the main (high level) transfer nodes of the region, based on the present main urban structure (figure 9.7.2) : HST station Aachen, Maastricht-Aachen Airport at the north side of the city of Maastricht, Maastricht Central Station and HST station Liège. Maastricht-Aachen Airport would become even more interesting as a multimodal transfer point if it could be connected to the rail network. The road network is improved on two important places; motorway A2 (through the city of Maastricht) is put underground and Aachen HST station becomes easy accessible from the motorway (north side of the city).

[5] The design ideas were created by ir. George Hotze, Assistant Professor Urban Design, faculty of Architecture, Delft University of Technolgy and ir. Remon Rooij

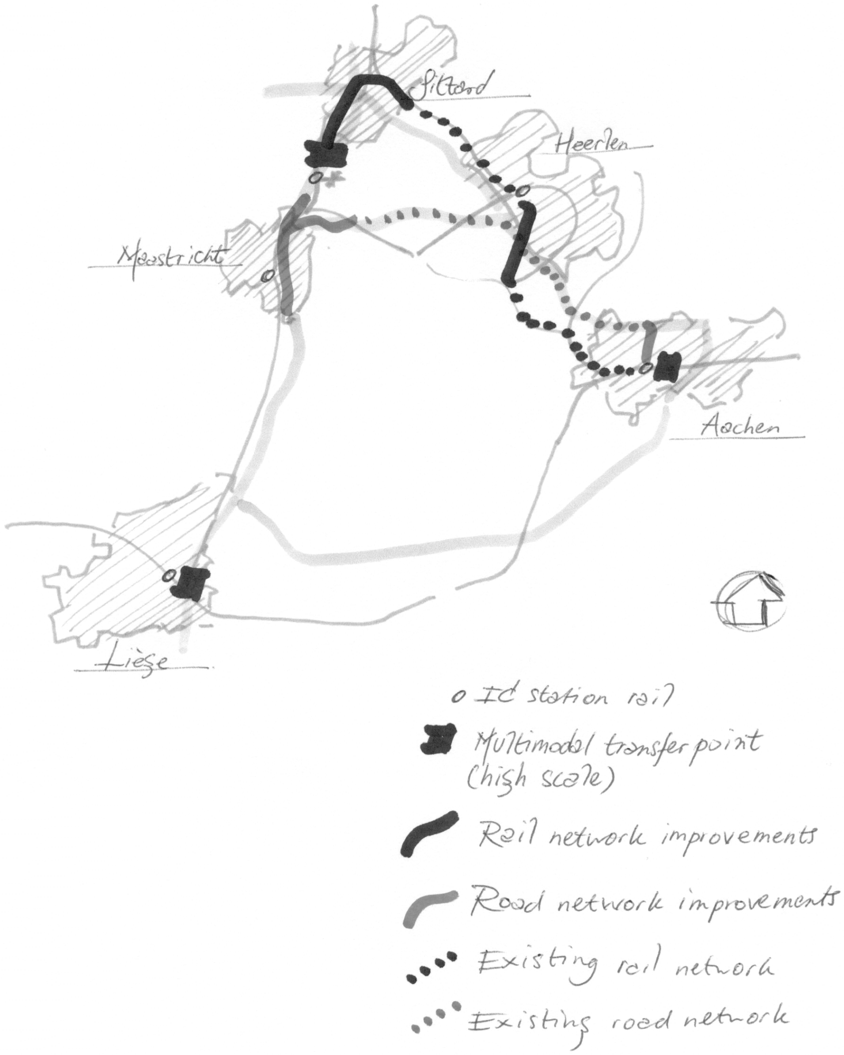


Figure **9.7.1** Regional design proposal

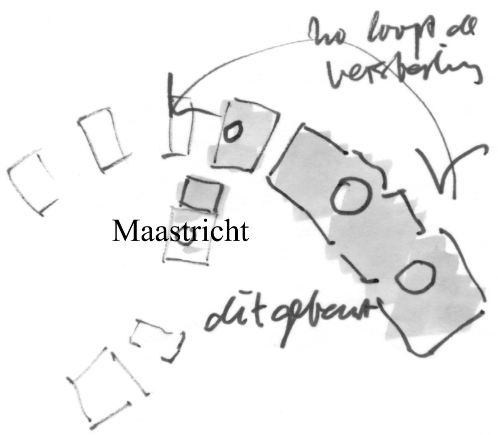


Figure **9.7.2** Regional effects: MHAL structure is strengthened

City

At the level of the city of Maastricht, we suggest (figure 9.7.3) a better connection between the road network (A2 motorway, city centre ring road) and the Central Station by introducing a (new) light rail with 3 (extra) multimodal transfer points. Both the central station (via transfer point near motorway A2) and the city centre become better multimodally accessible. The improved multimodal accessibility of the (new) transfer points have the potential to generate new urban developments.

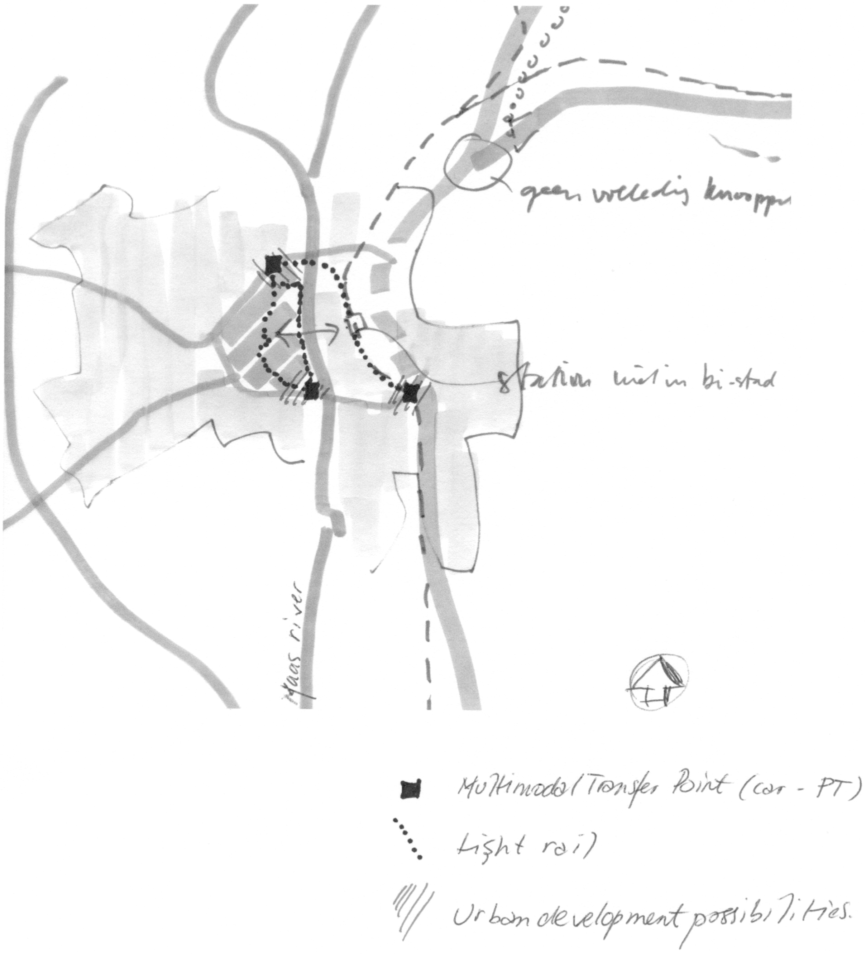


Figure **9.7.3** City design proposal

Local

At the local level of the motorway A2 which is located underground, we suggest (figure 9.7.4) a better connection between the A2 and the Central Station by introducing a motorway ramp near the Central Station and a large transfer facility for car travellers. The dotted line represents a good connection (slow modes, shuttle services / people mover) between the Transfer Building and Central Station Maastricht. A new entrance to the (back side of the) station has to be constructed. Furthermore, the local (built) environment has to undergo some major changes in order to accommodate these transfer improvements.

Figure **9.7.4** A2 corridor design proposal

9.7.2 Strategic aspects

Strategic characteristics of all three design ideas concern the medium and/or long term planning horizon. These design ideas would take relatively long time to realise, which makes it all very uncertain. Another mutual strategic component is the interest of all three layers of Dutch governments: municipality(ies), province of Limburg, (national) Ministry of Traffic and Transport and the (national) Ministry of Spatial Planning. The Dutch Railways also play in all three designs an important role as potential initiator and/or facilitator. In all transport design alternatives, urban effects can be expected. So, in all three situations, both private (urban) investors can play a role, and the local inhabitants living near the urban interventions.
The regional design idea is complicated by cross-border strategic planning and governance (The Netherlands, Belgium, Germany). An important extra strategic element of the urban design for Maastricht is the competitive nature of the new transfer points. The good multimodal accessibility of these points of transport interchange (car and public transport) might attract several new urban functions, but might also attract urban functions that are presently located in the city centre. Furthermore, the introduction of the light rail may also be looked at from a regional point of view (connections to Liège and Aachen). Important strategic actors for the design of the Transfer Building in the local design idea are the potential exploiters, such as parking companies, rent-a-car companies, etc.

9.7.3 Evaluation

Table 9.7.1 shows some important pro's and cons of the design ideas presented in the previous subsections. We can observe that some of the pro's and cons of the different design ideas are related. For example: the (expected) positive influence of both the regional and the local design idea on long distance travel. But these design ideas might also bring potential conflicts. When both of the ideas would be realised, it can be reasoned that building 2 large multimodal transfer points near the motorway A2– in casu the multimodal transfer point near Maastricht-Aachen Airport and the Transfer Building in the city of Maastricht- might be both inefficient and ineffective. If both transfer points 'compete' for the same kinds of travellers, it could be more cost effective to build only one of them. (Political) Choices are needed here and more argumentation (e.g. traffic modelling) is needed to be able to make these choices properly.

Table **9.7.1** Pro's and cons of the design ideas

Regional	Urban	Local
+ the connection (physically and in terms of transport services) of the high level nodes improves long-distance travel opportunities for the inhabitants of the MHAL region + A2 underground gives the city of Maastricht the opportunity to improve internal urban network coherence + the multimodal accessibility of the city centre of Aachen is improved drastically	+ the multimodal accessibility of the city centre of Maastricht improves the travel possibilities (both urban and regional/national/international) for the Maastricht inhabitants + Parking policy for the city centre of Maastricht can be more strict, because of the new (multimodal) travel possibilities for visitors of the city centre	+ the connection of the Dutch Railways station Maastricht Central Station and the motorway A2 Transfer Building improves long-distance travel opportunities for the inhabitants of the city of Maastricht + The Transfer Building can be a good alternative for visitors of the city centre of Maastricht who travel by car (car park problems city centre)
_ the construction of the connection between MAA en the railways is problematic due to their present location _ to improve motorway networks in cities (Maastricht and Aachen) are difficult transformation processes in terms of planning	_ the exploitation of the light rail can be a difficult issue. It could be better to look at the introduction of a light rail from a regional point of view.	_ There is still a relatively large distance (few hundred metres) between the A2 Transfer Building and Maastricht Central Station

9.7.4 Analysis

Based on the design ideas, the strategic aspects and the pro's and cons, a series of questions can be launched and should be analysed before better design objectives and design suggestions can be made. A new cycle can start then.

Here, we give a few of the questions that remain for the design and planning of the location of transfer points within the city and region of Maastricht, based on the presented design ideas:

- How badly is the city of Maastricht in need for city centre parking alternatives?
- How many travellers would the multimodal transfer points located near the motorway A2 and the city centre ring-road attract? Are the transfer points complementary, or are they competing for the same travellers?
- Is there potential for a regional light rail? In terms of economic feasibility and transport demand.
- How can the Transfer Building be connected to the Maastricht Central Station as seamless as possible?
- What political and societal obstacles can be expected planning the Transfer Building?

9.8 Summary and conclusions: an evaluation of the workshop

The location of transfer points within the Network City is one of the key success factors for multimodal transport, and together with the architectural lay-out, the urban environment, and the transport function of transfer points, it plays a crucial role in establishing the (desired) hierarchy and structure of a transport system of the Network City.

This hypothesis was formulated in section 1.4 on the 'Research approach' and has been dealt with in this chapter and is debated also in the next chapter 'Towards the conditions for the planning and design of the Network City'. Some first conclusion can be drawn.

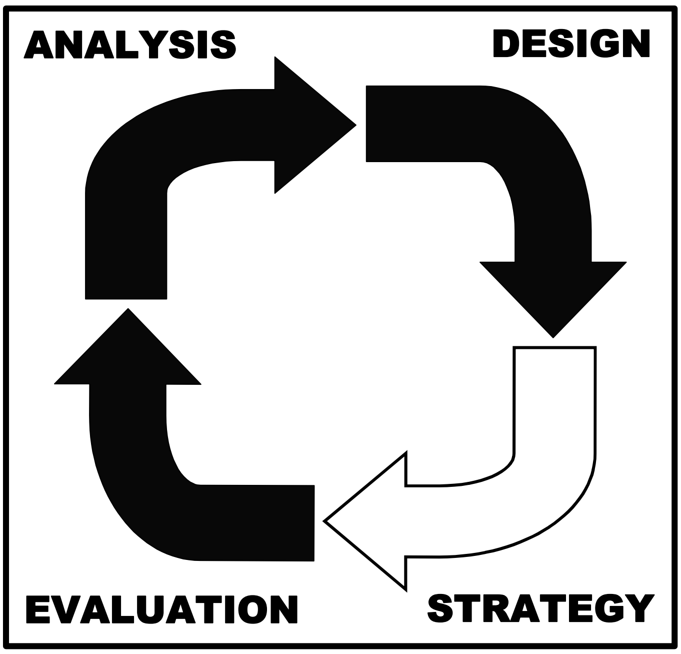
Concerning the general goals of the workshop outlined in the first section of this chapter, difficulties were detected in using the planning cycle. Designers seem to think in solutions before defining problems and objectives. To skip the phase of analysis and start with the phase of design is in principle no problem if the designers evaluate their design options and conclude what kind of problems they tackled with their design proposals or what kind of design objectives they reached (and which not). So, it doesn't matter in which phase of the planning cycle one starts, as long as the complete cycle is passed through. The organisation of the workshop which was based on the working path of [1]analysis-[2]design-[3]strategy-[4]evaluation did not foresee this, and at least one group had difficulties to follow the prescribed steps[6].

We can be very positive about the multidisciplinary oriented discussions during the workshop day; the three perspectives of urbanism, transport, and (travel) behaviour were all debated intensively. It could be observed that all participants agreed on the fact that an integral and multidisciplinary design approach is best for such a design and planning task as the location choice of transfer points.

With respect to the second objective of the workshop, which relates to the conceptual model *Adoption of seamless multimodal travelling*, no particular fundamental contradictions could be observed. Also here, it seems that the multidisciplinary character of the model (the perceptual filter includes the (perceived) spatial context, referring to both urban and transport issues) is the right way to conceptualise this phenomenon of the adoption of SMM.

[6] This was concluded by the chairman of group B that focused on the Arnhem-Nijmegen region.

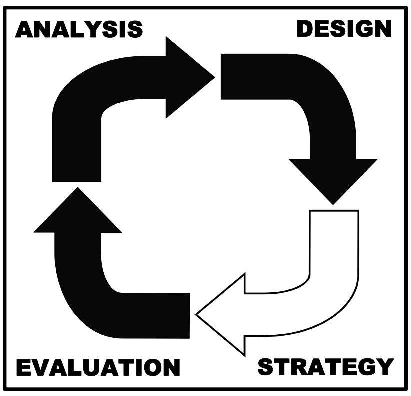
PART C
STRATEGY



CHAPTER TEN TOWARDS THE CONDITIONS FOR THE PLANNING AND DESIGN OF THE NETWORK CITY

Ille ex futuro suspenditur cui irritum est praesens.

He who ruins his presence, will be the slave of his future.
Seneca, Epistulae Morales, no. 101



Chapter ten forms the phase of strategy in this thesis and deals with the conditions for the planning and design of the Network City. It reconsiders the major design and planning problems for spatial planning (section 10.1), and formulates the most important design and planning objectives (section 10.2). Section 10.3 sums up the main findings of this chapter.

10.1 Reconsidering the design and planning problem

Chapter one, the introduction of this thesis, focused among others on the main problems that today's field of spatial planning is confronted with: first, the space consumption of infrastructures and vehicles, secondly the decrease of accessibility of urban areas, and thirdly the absence of coherence between the spatial, hierarchical levels in the urban network (section 1.3 refers). There, the question was raised how a (multimodal) transport system can 'help' to let the post-modern city function successfully and thus cope with these problems sustainably. The next two subsections elaborate on the notion of success and the relation between the city and its transport system, as key indicators of this main question.

10.1.1 Successful cities

The notion of success has also been discussed in section 8.3 on the success and failure of transfer points. There, success has been defined as [i] meeting the intended policy goals and [ii] a good exploitation. Let us be clear: the success of cities is not easily defined, which is also expressed in the numerous discussions about *spatial quality* and their subjective interpretations. The *Balance spatial quality 2001* of the Dutch Ministry of Housing, Spatial Planning, and Environment (2002) clearly shows that the spatial quality criteria identified, so to say the success criteria for cities, have much more components than only physical (urban) ones:

- spatial diversity;
- economic and societal functionality;
- social justice;
- cultural diversity;
- sustainability;
- attractiveness;
- human scale.

In fact, this list shows the integrative character of the field of urbanism; integration of the other societal fields (economy, justice, culture, aesthetics, demography, and of course other spatial oriented fields such as transport, landscape, and environment engineering, architecture, (social) geography, etc.) is acquired via the design and planning of space.

Furthermore, the debate on the success of cities becomes even more complicated when we consider the time paths of urban areas. Cities are durable; they are constructs for centuries, and what can be called successful now, could be, most probably will be (partly) unsuccessful in the future. Society changes inherently over time, resulting in an ongoing need for reconsidering the physical conditions of those human interactions. In the field of urbanism this is referred to as the processes of *urban transformations*[1].

From this perspective of urban transformations, Drewe and Hulsbergen (2002) position urban research in the three dimensional matrix *society, technology, and space*. Moreover, the

[1] In the research portfolio of the Faculty of Architecture (2002) Urban Transformations is one of the two research programmes of the cluster Urbanism: '*In the programme Urban Transformations the research focus is on processes of change that the urban space experiences under influence of recent technological, economic, social and demographical developments. Main themes are the schaalvergroting of spatial constructs, the development of urban networks and infrastructures as well as the transformation of urban nodes, the changing demands for dwellings and dwelling environments, the use of public space and the re-use of existing urban fragments. Based on the analysis of transformation processes, strategies are both researched and developed for the design, planning and management of a sustainable urban space.*'

authors discuss that the European Commission (1999) couples[2] the notion of 'sustainable spatial development' with three fundamental goals:

[i] economic and social cohesion;
[ii] preservation of the natural basis of life and the cultural heritage;
[iii] a balanced ability for competition within the EU.

It is suggested that for a balanced spatial development, the focus should be on these three goals and their interactions simultaneously. Therefore, spatial and urban policies are considered to be directed at:

[i] the development of a balanced and multinodal urban system, as well as a new relation between the urban and the non-urban;
[ii] an equal access to infrastructure and knowledge;
[iii] sustainable development, intelligent management, and the preservation of nature and cultural heritage.

With the description of these three goals and these three policy directions, the EU has presented her opinion about the relation between *sustainable environment* and *spatial development*. By doing so, she has shown when she considers cities and regions to be successful.

The New Charter of Athens 2003, authored by The European Council of Town Planners, also discusses the success of cities thoroughly from both an economic and an environmental point of view. "…In the 21st century, the cities that will be economically successful will be those that capitalise upon their competitive advantages. For this purpose, a high degree of multi-level connectivity will prove to be a major asset. Capitalising on cultural and natural attributes of cities, managing their historical character, and promoting their uniqueness and diversity will be a significant advantage." "…The emotional connection between human beings and their environment –their sense of place – is a fundamental need for successful urban living. The best-loved cities and urban places offer a rich and environmental experience. Environmental quality is a major factor in guaranteeing the economic success of a city – it also contributes to social and cultural diversity."

Salingaros (2000) argues that "…an essential quality shared by all living cities is a high degree of organized complexity. The geometrical assembly of elements to achieve coherence results in a definite and identifiable urban morphology. It turns out that this morphology closely resembles that of traditional cities and towns: unplanned villages of many different cultures around the world; cities as they were before the middle of the nineteenth century; and to some degree, free squatter settlements. The morphology of a geometrically coherent system resembles planned twentieth-century cities the least of all. Contemporary rules for urban form, which reduce both complexity and connectivity in today's cities, are not capable of generating urban coherence."

Futhermore, Salingaros argues that "in living cities, every urban element is formed by the combination of subelements defined on a hierarchy of different scales. Complementary elements of roughly the same size couple strongly to become an element of the next-higher order in size. Different types of connections tie elements of different sizes together, so that every element is linked to every other element. The strongest connections are local (close-range) ones. Connections between smaller and larger elements, or between internal subelements of distinct modules, are weaker. Repeated similar units do not connect: coupling works either by contrasting qualities, or via an intermediate catalyst. Elements are therefore necessary, not only for their own primary function, but also for their secondary role in linking other elements that cannot couple directly by themselves."

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[2] in her European Spatial Development Perspective

Finally, Salingaros (2000) presents nine structural rules that have evolved in the study of complex systems. Of the many different possible statements of system rules, the following list is considered critically relevant to urban design.

- Rule 1. **COUPLINGS**: *Strongly-coupled elements on the same scale form a module. There should be no unconnected elements inside a module*.
- Rule 2. **DIVERSITY**: *Similar elements do not couple. A critical diversity of different elements is needed because some will catalyze couplings between others*.
- Rule 3. **BOUNDARIES**: *Different modules couple via their boundary elements. Connections form between modules, and not between their internal elements*.
- Rule 4. **FORCES**: *Interactions are naturally strongest on the smallest scale, and weakest on the largest scale. Reversing them generates pathologies.*
- Rule 5. **ORGANIZATION**: *Long-range forces create the large scale from well-defined structure on the smaller scales. Alignment does not establish, but can destroy short-range couplings.*
- Rule 6. **HIERARCHY**: *A system's components assemble progressively from small to large. This process generates linked units defined on many distinct scales.*
- Rule 7. **INTERDEPENDENCE**: *Elements and modules on different scales do not depend on each other in a symmetric manner: a higher scale requires all lower scales, but not vice versa*.
- Rule 8. **DECOMPOSITION**: *A coherent system cannot be completely decomposed into constituent parts. There exist many inequivalent decompositions based on different types of units.*

In developed countries, cities are designed and planned. So, another question that raises here, is: 'when can we call an urban plan or design successful?' A simple answer could be: when the plan or design meets its objectives. But this is only partly true. The objective of urbanism is sometimes indeed to make plans or designs on their own, for example to open a discussion within a certain community about possible futures of a specific area. But urbanism is mainly a profession that is directed at the physical *reality*. From this point of view, we should call an urban plan or design successful when the actual functioning of the city that was designed, meets the design objectives. We can conclude that both *ex-ante* and *ex-post* research, based on objective evaluation criteria, (should) play a major role in defining both potential and actual success of urban plans and designs.

10.1.2 The city and its transport system

The research in this thesis has shown that in the last decades the activity-travel demand patterns of people have grown extensively (action spaces) and have become more diffuse than ever (criss-cross patterns). The traditional city is under pressure and ideas for sustainable spatial developments have to be distilled from *network thinking* instead of *zonal thinking*, from *integral* instead of *sectoral* design and planning approaches. Choices have to be made about which kind of transport (sub)systems within which urban areas have the best potential to contribute to the success of urban areas. Moreover, choices have to be made if, how and where the subsystems have to be connected via transport nodes and transfer points. Not an easy task in a socio-spatial reality that changes quicker than ever and that is nowadays designed and planned by varying and changing teams of actors.

The (multimodal) transport system -both as a fundament for the functioning of the city and as a representation of the societal organisation- consists of subsystems providing transport services that can be categorised along three perspectives, relevant for travellers:

- **speed**: travel speed is a determinant factor for the size of action spaces of individual(s) (households). The introduction and adoption of new transport technologies very often deal with the increase of door-to-door travel speed and thus with the accessibility of more remote activity places. However, it should not be forgotten that most trips that people make are oriented locally: 75% of all trips in The Netherlands is less than 10 kilometres (CBS, 2002).
- **degree of collectivity**: Egeter and Van Binsbergen (1996) define the degree of collectivity of transport (sub)systems according to the criteria:
  [i] *transport service*: we talk about a transport service if the vehicle is not driven by the traveller;
  [ii] *logistic service*: we talk about a logistic service if the vehicle is not administered and managed by the traveller;
  [iii] *control over vehicle*: when a traveller has no control over the vehicle during travel, we also logically deal then with a transport service, referred to as a collective transport service. It is different for the other way around: the taxi offers a transport service with complete control over the route, time of departure, etc.
  [iv] *bundling of access points*;
  [v] *bundling of vehicles*.
  When mixed, these criteria show a whole range of possibilities between completely collective and completely individual transport (sub)systems.
- **degree of flexibility/availability in time and space**: traditional public transport has a fixed time-table, fixed points to halt, a fixed route, a professional driver, fixed equipment, resulting in a limited, but known, availability in time and space for travellers. We know the car system as a *territorial adapter* (Dupuy, 1995) with a relatively high flexibility in time and space, although its flexibility nowadays meets its boundaries: peak hour congestion and city centre parking problems are two examples where those boundaries are met. Between traditional public transport and the car system lies a field of system alternatives. Collective demand-responsive transport is a development that can be referred to as such a market that lies in between.

10.2 Formulating the design and planning objectives

The previous section reconsidered this thesis' main question how a transport system can contribute to the success of cities. This section gives the most important design and planning objectives for the future planning and design of the Network City in order to tackle this main question. In subsections 10.2.1-10.2.3, it follows the three main problem fields of spatial planning identified in chapter one and reconsidered briefly in the previous section. Subsection 10.2.4 discusses the network approach more thoroughly, and what it can mean for urbanism. Finally, subsection 10.2.5 focuses on planning methodology.

10.2.1 Space consumption of infrastructures and vehicles

An excessive space consumption of infrastructure and vehicles endangers the liveability of urban areas with respect to:

- traffic safety;
- emissions, noise, stench;
- parking;

- barriers in the city;
- intersecting of green structures;
- congestion.

Collective ways of transport are economical with space. They are therefore suited for dense urban areas. Moreover, the quality of collective transport can improve (on the longer term) when usage is high: because of higher travel demand, the frequency of the transport service can rise. A disadvantage of collective transport is that the use of it is bound by availability restrictions: timetables and stops (transfer points).

It can be reasoned that most modes of transport have certain (transport) characteristics that fit certain (spatial) circumstances best. On the other hand, these systems will probably function relatively bad under (certain) other (spatial) circumstances. Therefore, we can distinguish several 'ideal' modes of travel for different *types of trips* (table 10.2.1). In fact, for certain types of trips a *combination* of travel modes could be best: the option of multimodal travel.

Table **10.2.1** 'Ideal' transport mode under certain circumstances, examples

Under these circumstances…	the traveller has wishes for his or her transport service…	…and thus would like to travel with …
Urban environment, Medium long distance	I want to move freely and I don't want to have to park	Metro, train, bus
Urban environment Short distance	I want to move freely and I don't want to have to park	Bicycle
Long distance	I want to walk, eat, pee and I don't want to drive	Intercity, HST, airplane
Non-urban area	I want to move freely and I don't want to wait for ever	My car
In a hurry	I want to move fast and with certainty	Sometimes the car, sometimes the train
Shopping	I want to be able to take stuff with me and I don't want to drag my luggage	Car
I would like to work	I want a quiet environment and I don't want to drive	Train

Source: Bovy, 2002

Bovy (2002) reasons that if a traveller comes from a rural area, and has his/her destination is located in a large city, and (s)he thus has to travel a large distance, that we then (for example) can assume that (s)he could prefer to start the trip by car and reach the destination by tram or bus. Furthermore, an IC train could be best for the part in between. So, the traveller has to choose between a compromise (for example the whole trip by car), or a multimodal trip (car-train-tram). In many cases the car is a moderate or good alternative. However, this example shows that if the demands with respect to the transport services are different for the several parts of that trip (departure, arrival, bridging of distance), multimodal travelling truly becomes an option, besides the always present option of a compromise (very often the car).

Multimodal travel can be attractive for spatial-geographical reasons (Bovy, 2002), such as for trips:

- between areas with a (very) high urban density and areas with a low urban density;
- over long distances;
- between areas with medium urban densities;

and for other reasons (very often in combination with the previous ones):

- trips during times of the day that the alternative of the compromise offers insufficient quality (very often: congestion periods, such as peak hours);
- the desire to work during travelling;

- other specific traveller demands.

From this perspective of spatial-geographical reasoning, it is concluded (Bovy 2002; Van Nes, 2002, AVV, 2002) that unimodal travelling is suited best for most trips and that multimodal travel is only suited for limited niche markets, resulting in a limited share of the total mobility now -about 3% of all trips are multimodal trips- and in the future -potentially about 6%. It is good to remember that a multimodal trip is defined as a trip (movement between two activity places for one specific motive) with two or more transport modes/services. 'Walking' is not considered to be an access or egress mode here[3]. From this point of view, walking-car-walking trips, walking-bus-walking trips, walking-tram-walking trips, walking-train-walking trips, walking-bicycle-walking trips, etc. are all considered as unimodal trips.

On a national level, multimodal transport can therefore only contribute to the solutions for the problems of congestion, environment, etc. to a very small extent. Moreover, the limited success of multimodal transport has also to do with issues such as the inability of the transport sector to react to certain promising niche markets, the wrong choices for the location of transfer points, parking conditions in city centres (still too cheap), insufficient linkage to existing, good functioning collective transport systems in city centres, and insufficient multimodal mobility services (Bovy, 2002).

However, for certain market segments multimodal travel is crucial (section 2.3 refers), and has the potential to increase even more in the future. For some relations the share of multimodal trips is 20-25%. Therefore, at the local level the meaning of multimodal travel can be quite significant (Van Nes, 2002) and the effects on the liveability (and accessibility) of urban areas can become essential.

In his PhD thesis, Van der Hoeven (2001, p. 165) relates infrastructure (and the problems that accompany infrastructure) to the necessity 'to use space more intensively and with more quality.' *'...Large scale infrastructural links use more and more space in order to cope with more and more traffic; also much **indirect space**. Large zones near those links can only be used to a limited extent because of a bad quality of living environment around.'*

So, Van der Hoeven elaborates that *'...the underground construction of infrastructure has two important advantages:*

- *due to the construction of a second ground level above the rail or road infrastructure, the space of that infrastructure can be used double;*
- *at the same time that double bottom absorbs the hindrance that one usually gets from (the use of) that specific infrastructure.*

In this way, the indirect use of space of the specific infrastructure can be optimised, which is important because the indirect claims on space of motorways or railways usually is much larger than the direct claims. The direct claims on space of a heavy connection seldom is wider than 100 metres. On the other hand, the zones that are exposed to all kinds of hindrance can be even more than one kilometre: a multiple of the direct use of space.'

10.2.2 Decrease of accessibility of urban areas

Urban areas, and city centres specifically, bundle all kinds of functions at a relatively small area, so that all kinds of efficiency advantages can be reached, such as the nearness of functions and the nearness of persons. On the other hand, high urban densities might result in increasing problems for the accessibility by car of those urban areas. The metaphor of the fish-trap is well known for describing the car accessibility problems in cities. The fact that this

[3] This is due to the fact that in the (inter)national research and statistics on the travel behaviour of people, 'walking' very often is not considered as a separate transport mode.

situation has worsened during the last decades and still worsens today, is primarily due to - what we referred to in subsection 2.1.2- the *disintegration*, i.e. the *dispersal of activities*; a process that takes place also *because of* the bad accessibility situation. The spatial constellation and organisation of The Netherlands make it impossible to guarantee a perfect (=without congestion) car accessibility[4], nor to exploit an attractive and competitive public transport system everywhere. Moreover, the spread of activity places worsens the accessibility by bicycle drastically.

This line of reasoning makes clear that multimodal transport towards and from cities is very important, not only for The Netherlands, but also for many other countries with similar accessibility problems. Multimodal accessibility enables to maintain and even to improve the urban structure(s), resulting in possibilities to offer better public transport facilities. Therefore, we can conclude, in line with Bovy's (2002) conclusions, that multimodal passenger mobility is above all important for a good functioning of (high density) urban areas: keeping up and raising to a higher level of the essential urban (centre) functions such as retail, culture (museums, theatres, cinemas, etc.), machineries of government (town-hall, justice, etc.), hotel and catering industry (restaurants, cafes, etc.), public spaces (library, churches, squares, etc.), leisure (discotheques, sports arenas, etc.), tourism, head offices of multinationals.

So, the city has to be accessible at least by collective ways of transport, but the total accessibility of urban areas improve, if a traveller has multiple options: unimodal, multimodal, individual, collective. Improving the multimodal transport system, i.e. both improving separate subsystems (unimodal, multimodal, individual, collective) and the coherence and connectivity between those, therefore isn't meant to force a so called modal shift, but to realise a better, more efficient and effective accessibility of cities.

In section 5.1.3, the multidimensional Christaller scheme (figure 5.1.1 refers) was introduced to conceptualise the shift from the traditional (medieval) city centre towards today's reality of several urban centres consisting of concentrations of activity places with their own characteristics. *Selective accessibility* is a key word here. Today's Network City with a diversity of urban centres can benefit from a diversified approach towards their accessibility. High density city centres may profit from a multiple option accessibility as discussed above. The accessibility for urban centres that rule under specific time and/or space conditions (for example opening hours, events at specific days, etc.) may profit from a variation of accessibility based on those specific time-space conditions.

Moreover, with the ongoing introduction and adoption of new communication and information technologies, the notion of accessibility has become both physical and virtual of nature. Section 5.2 referred to the relation between the physical and virtual accessibility by describing possible effects of ICT's: substitution, complementation, generation, operational efficiency, indirect long-term effects, and supplementation. So, the effects of ICT's can vary for different cities, resulting in changed or changing time-space conditions for the physical accessibility.

It can be summarised and concluded that no blueprint can be given here for the 'best' physical (or virtual) accessibility of cities. Each urban entity (village, town, city, agglomeration, region, country) has to make choices, based on their own analysis of what is 'best'. In fact, talking about 'choosing' is talking about the *governance* in spatial planning. Who's in the lead? It used to be simple that governments looked after the (spatial) interests of the community as a whole and took responsibility for all. But things have changed into a situation, in which the government has become (only) one of the actors in the multi-actor field

[4] Bovy (1993) has shown that a completely congestion free car network is undesirable for a society; the costs are simply too high to prevent congestion from happening completely. He speaks about an optimal level of congestion, where the marginal (societal) costs and marginal (societal) benefits are in balance.

of interests. Both private and public actors have interests and a say in spatial planning processes. What has become crucially important is the *commitment* and *identification* of the individual actors, both private and public, with the main line of decisions and intended spatial developments. Urban space cannot be changed nor improved on your own.

10.2.3 Absence of coherence between the spatial levels in the urban network

Based on the work of Salingaros, section 5.4 elaborated on the topic of coherence in spatial levels and started with the idea that a city should be looked at as a complex interacting system with its 'rules' of composition:

- smaller scales need to be defined before the larger scales;
- elements of smaller scales need to couple in a stable manner before higher-order groups can begin to form and interact;
- a hierarchy of nested scales means that not even one scale can be missing, otherwise the whole system is unstable.

Based on de Jong (table 10.2.2), Van Nes (2002) referred to these principles of the composition of complex interacting systems in his PhD thesis as a 'hierarchy in (transport) networks by scale factor 3 as a natural phenomenon'. The urban network as a whole becomes instable if the transport network makes leaps in this hierarchy. Illustrative is the example of the road network suggestions of Immers for the southern wing of the Randstad area (figure 10.2.1). He suggests in order to improve the functioning of the road network (flow of traffic, accessibility of urban areas, congestion) the *secondary* network should be extended. Presently, the primary, motorway network is used for several activity-travel goals, among which some (for example intraregional travel) explicitly belong to the (not sufficiently present) secondary network.

Table **10.2.2** Spatial level and infrastructure network

Spatial level name	R= … km	Density [km/km2]	Connection every … km	Spacing in km
National	100	0.02	30	100
Regional	30	0.07	10	30
Agglomeration	10	0.20	3	10
City	3	0.70	1	3
City district	1	2.0	0.3	1
District quarter	0.3	7.0	0.1	0.3
Neighbourhood	0.1	20.0	0.03	0.1

Source: De Jong and Paasman 1998

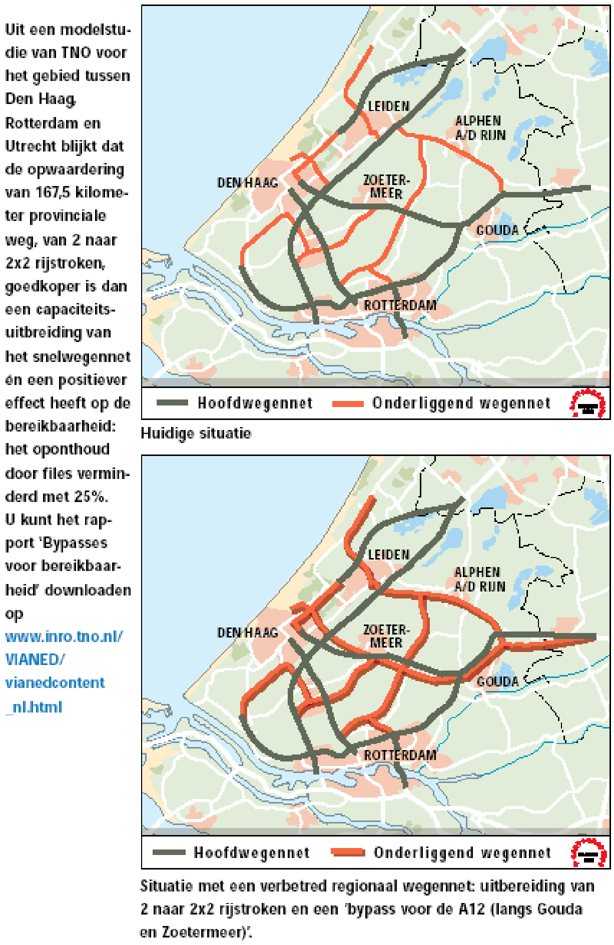


Figure **10.2.1** Hierarchy in the road network in the south wing of the Randstad area by Immers
Source: ANWB, 2002

In section 2.3 on Passenger chain mobility, we saw that specific collective transport systems, actually specific collective transport services, operate on their own spatial levels. Referring to the location of transfer point, we can hypothesise that potentially ideal locations for transfer points are those places where the function of collective of individual infrastructure networks shift from spatial level. From a behavioural point of view (chapter three refers) they are locations where 'things change' and thus it is not so strange to change travel behaviour (e.g. transfer) as well.

When discussing the hierarchy in spatial levels within the city, it is worthwhile to take a look at some new insights on networks from completely other fields of expertise than urbanism and transport engineering. Rules of hierarchy in complex networks have been studied by physicst Barabasi (2002). When we take into account the 'rules' for the form and structure of complex networks as presented by Barabasi, we can come up with a number of starting points for the design and planning of the network of transfer points.
He shows that (good functioning) complex networks are in fact so called *scale-free* networks, in which the power-law rules. The largest node (best connected) is closely followed by two or three somewhat smaller hubs, followed by dozens that are even smaller, and so on, eventually arriving at the numerous tiny nodes. Furthermore, he argues that the scale-free topology is a natural consequence of the ever expanding nature of real networks.

It is up to the field or urbanism self to take a closer look at the concept of the city as a scale free network and its related rules. Many complex networks grow 'naturally' or 'organically', that is without (too much) human intervention (planning and design), e.g. the human body. With respect to the city, after-war urban design and planning didn't succeed in creating new vital urban areas. It can be hypothesised that the rules of scale free networks are missing here. In depth research will have to prove.

10.2.4 Networks as central theme

Throughout the 20th century cities have been planned, and in doing so, networks for the transport, not only of passengers and goods, but also of water, energy and information, have played an ever increasing role. However, seldom urbanism has been (re)thought in terms of networks: their topology, nodes, connectivity, capillarity or similarities. Some urbanists nevertheless have understood, at least in part, the meaning of networks to cities already a long time ago, marginalized later by the mainstream zonal urbanism of the Athens Charter of 1933 (Drewe, 2002). The network in its modern meaning is characterised by three principal criteria[5]:

- **Topological criterion**: topology refers to the geometric or physical configuration of a network, the way in which the nodes of a network are physically connected. Networks are not abstract entities, they are related to the spatial dimension by connecting links via nodes in space. This involves discontinuity and heterogeneity. The topology of a network is open and united, and it is opposed to separations such as city/countryside, centre/periphery and zoning.
- **Kinetic criterion**: kinetics pertains to movement and communication between nodes. It is basically a relationship between space and time: speed. The rapidity of the connections within a network is a measure of the quality of the network itself. So, instantaneousness, homogeneity of speeds, the interest for rapid transfers and transits without losses of time or interruptions makes the network apt to movement and defines the kinetic criterion.
- **Adaptive criterion**: adaptability concerns the capacity for the evolution of networks over time and space. From the one side a network should be able to modify its structure to welcome new systems or to extend the applications of existing ones. On the other side, it should adapt itself to the needs and desires of its users by offering a multiple choice for the reaching of goals.

Dupuy's layer scheme represents the modern version of the Network City (figure 1.1.4 refers). It is not a new spatial **concept**, but a new **approach** to urbanism that can lead to new concepts. Therefore, it challenges the traditional art of physical design. Furthermore, the use of the Network City as a new approach to urbanism is like a pudding. Its proof is in the eating, i.e. designing new urban concepts.

The Network City requires an integrated planning of land use and urban technology networks, in particular transport and information and communication technologies. This is basically the result of network thinking in urbanism as opposed to mainstream zonal thinking. Creating monofunctional zones for housing, work and facilities such as recreation naturally induces traffic between these zones. The rise of the automobile and the accommodating expansion of the road network have produced a 'mobility problem' a problem of automobile dependency that is still largely unsolved today. So, the Athens Charter of 1933 that served as a blueprint for post-war urbanism was based on two false premises:

[5] The definitions of topology, kinetics, and adaptability are based on Caso (1999) and Drewe (2002)

- It is desirable to concentrate functions into giant packages;
- The geometry within each package is homogenous.

A city contains so many complex functions that it is impossible to isolate them, let alone concentrate them, so that imposing a simplistic geometry on urban form inhibits the human activities that generate living cities.

By discussing the role of *mobility environments* in the Network City (section 5.4 refers), Bertolini and Dijst (2003) hope for a better integration of mobility and accessibility considerations into urban planning and design. They present four steps to come to urban development strategy based on the concept of mobility environments:

[i] *The identification of different sorts of mobility environments in an urban-regional context.*

[ii] *The public actor has to set its investment priorities. A leading criterion in this should be the promotion of the specialisation of and complementarity between different sorts of mobility environments, in order to help a diverse range of connected central places at multiple spatial scales to emerge.*

[iii] *The public actor is increasingly dependent on private actors. Forms of governance appropriate to the scope and scale of the strategy are needed.*

[iv] *A final point is how urban planning and design professionals can contribute to reaching such broader objectives at the project implementation level.*

In the opinion of both authors, urban planning and design strategies, in which mobility environments –as up-coming central places within Network Cities- should be a leading **approach**, can be effective in influencing spatial developments in an increasing mobile society.

In its vision for the city of the 21st century, The European Council of Town Planners focus on the *Connected City*. The Council suggests that "…The connected city is comprised of a variety of connective mechanisms acting on different scales. These include tactile and visual connection to the built environment, as well as connections between a diversity of urban functions, infrastructure networks, and information and communication technologies." With respect to *Movement and Mobility*, the Council states that "…within city networks, mobility will be improved by interchange facilities between the various modes of transport." To do so "…the spatial organisation of the connected city will include a full integration of transportation and town planning policies. They will be complemented by more imaginative urban design and easier access to information…" "… Ease of movement and access will be a critical element of city living, together with greater choice in mode of transport."

10.2.5 Network city's planning methodology

The previous subsection made clear that there is no blue-print for what the Network City should look like. The same line of reasoning can be given for the question how the Network City should be planned. *Spatial planning* deals with clarifying and interpreting societal and environmental complexity and uncertainty, and related developments, in order to identify consequences for urban design tasks, distinguishing them from, as well as combining them with, non-spatial tasks. The essence of spatial planning is (Hulsbergen and Kriens, 2000):

[i] a *cyclic-iterative process*;

[ii] *arguing* proposed spatial interventions;

[iii] *communicating* with the relevant actors;

[iv] the practical *organisation* of and the *reflection* on urban transformations;

[vi] the *methods and techniques* used in these activities.

Urban and regional design and spatial planning together are the core domains of urbanism.

Although no blue-print for the planning of the Network City can be given, it is worthwhile to take into account the fundaments of planning, and especially the fundaments of spatial planning (Hulsbergen and Kriens, 2000), which are both conceptualised in the planning cycle (figure 10.2.2). These cycles can be seen as a closed circle, or as a combination of coupled circles: an upwards oriented spiral.

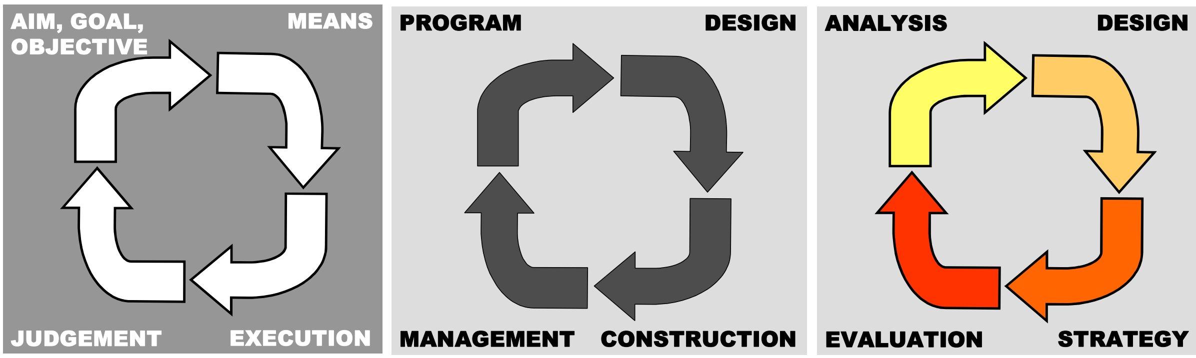


Figure **10.2.2** Planning cycles

The essence of cyclic working and thinking is twofold. First, one can start in each phase of the cycle, as long as one passes through the total cycle. In this way, the planning cycle doesn't hamper the creativity of the spatial designer/planner by defining a specific starting point. Secondly, the cycle serves as an aid for the processes of learning and improvement. The separate phases of the planning cycle only have a ritual value if one doesn't have the desire to learn during planning and to implement what has been learned.

The most basic planning cycle consists of the phases: **aim/goal/objective – means – execution – judgement**. After judging the result, the aims can be adjusted if necessary, and a new cycle can start. In spatial planning practice, the cycle consists of the phases: **program – design – construction – management**. In this cycle, 'construction' refers to the situation that a design is actually realised, and the (urban) 'management' might result in new programmatic needs. However, a large share of spatial planning isn't focused on realising a design, but on developing a design. For such cases the spatial planning cycle is translated into the phases of **analysis – design – strategy – evaluation**. In this cycle, 'strategy' refers to issues such as how the design could and should be realised, where priorities could and should be, which actors could and should play a major role, etc.

So, from the planning cycle we learn that spatial plans such as urban designs gain surplus value when they adopt the planning principles described above. However, the spatial planning cycle presented is not a blueprint for all design and planning processes, its principles can be used anywhere is gains in value if it is adapted to the specific spatial circumstances, the time planning horizon of the specific project and the actors involved.

In the communication with those other actors who are part of the spatial planning processes[6], urbanism, both design and planning, has to make clear and justify choices made in order to get those spatial proposals approved and adopted by these other actors. Urban designs have to be part of the construct of problem definition, the definition of aims, conceptualisation, (objective) arguments, and judgement based on (objective) evaluation criteria.

In all kinds of actual spatial planning approaches (figures 10.2.3 - 10.2.5), the planning cycle plays an important role. In the **mixed-scanning** approach, spatial functional development perspectives are translated into concrete projects. In this way the planning doesn't get stuck in abstractions. On the other hand, projects become 'strategic', because they are connected

[6] for example: transport and traffic engineers, landscape architects, spatial economists, environmental specialists, politicians, etc.

within a development perspective (this in contrast to ad hoc projects). The spatial planner alternately works form large to small and from small to large.

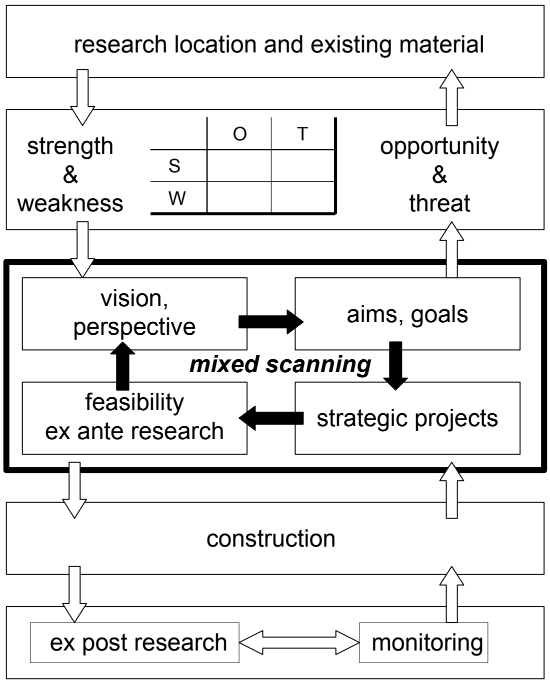


Figure **10.2.3** Mixed scanning approach

The **strategic choice** approach (figure 10.2.4) presents via a fixed method the choices that have to be made and the relations between those choices. Priorities can be made visible. This way of planning explicitly deals with uncertainties. The influence of the uncertainties on the desired result is measured and judged. Then it is deliberated whether the risks are to be reduced or can be accepted.

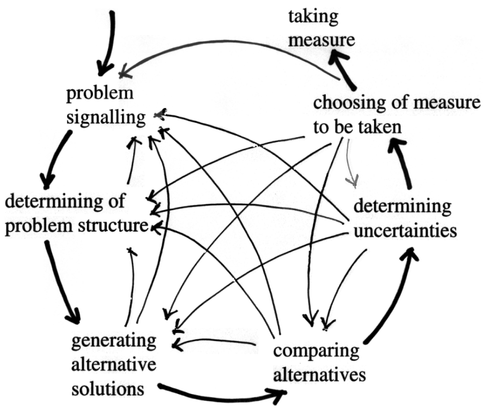


Figure **10.2.4** Strategic choice approach
Source: Van der Valk and De Boer (1999)

In order to design a Planning Support System for regional transport and land use development planning, Le Clercq et al. (2001) present an image of its planning process (figure 10.2.5). '…It shows the most important actions in the policy making and plan development processes. Instead of being a blueprint, the processes are decomposed into a number of moments that together form the network of actions.' For the cyclic character of the steps identified, each

moment in the diagonal line of **opinions/trends – goals – strategy – projects/program exploration – implementation of projects** is linked to its previous step with a feedback loop. Furthermore, the authors suggest that '… two phases in the process are of particular importance: a communicative phase and an operational phase. It is useful to make a clear distinction between the two. In the communicative phase, policy intentions and conceptions of several actors (often representing divergent professional areas of expertise) are exchanged and discussed. The main goal in this phase is to build a widely supported consensus for a strategy to be followed. In the operational phase the elaboration of the plan is under discussion. Communication is also important but at this point more in terms of practicability and desirability. At this stage the leading goal is to attain feasible projects.
In the communicative phase it is important that relevant actors meet each other in an open and informal way and that together solutions are found, which serve multiple goals. During the forming of ideas, little by little the skeleton framework for partnerships around multidimensional solutions emerges. In infrastructure projects for example, the incorporation of land use projects can increase the support for the initially isolated development of a transport system. In the operational phase agreements become more concrete and the relations within the partnership more formal and binding. Hereby projects and procedures enter the stadium of implementation.'

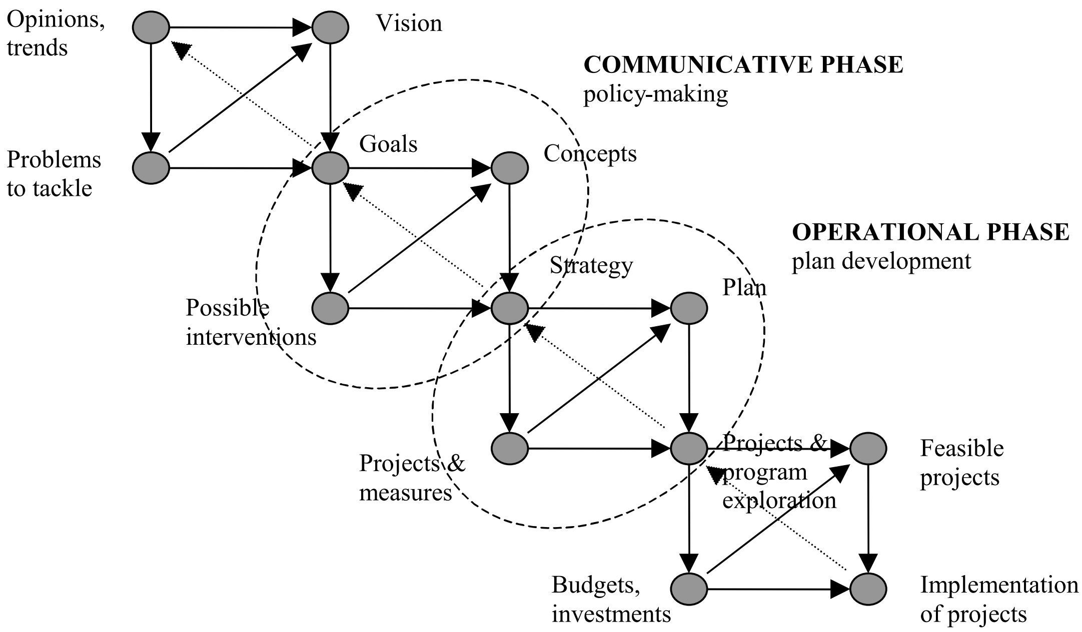


Figure **10.2.5** Steps in policy making and plan development processes
Based on: Le Clercq, et al. (2001)

It can be concluded from this subsection that cyclic-iterative thinking and working are essential for urbanism, both planning and design. The design workshop (chapter nine) that was held for this PhD project, showed that a lot of designers have a natural preference for thinking in solutions rather than defining problems first. With respect to the planning cycle, this means that they will choose the phase of design as starting point for getting through the total planning cycle. In fact, **research by design** is a research method in which the act of designing is explicitly used for contributing to fundamental scientific questions or to the application in practice. So, starting at the phase of design is valuable if the total planning cycle is indeed covered, and if design is used -by exploring possible futures and their effects-for better definitions of problems and aims to tackle as input for a new, or better design (figure 10.2.6).

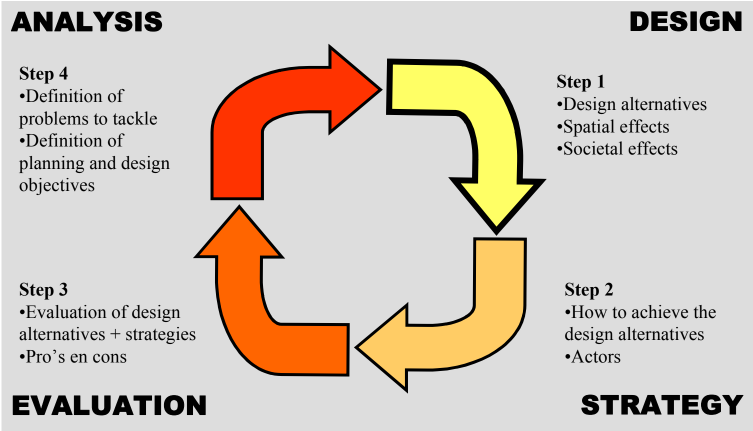


Figure **10.2.6** Planning cycle; phase of design to start

Finally, figure 10.2.7 shows a planning strategy that can be helpful for designers as well. It tells us that the urban designer can start with all phases of the spatial planning cycle at the same time, but has to take into account the coherence between the separate phases. It is this coherence that explicitly forms the framework of arguments of the urban designer for the communication with and towards the other actors in the planning process.

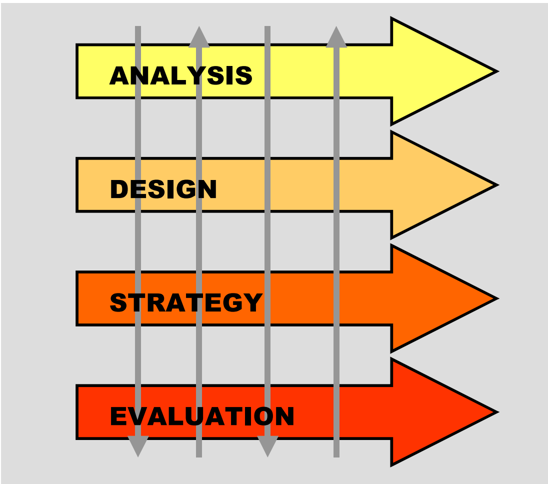


Figure **10.2.7** Planning cycle; parallel phases

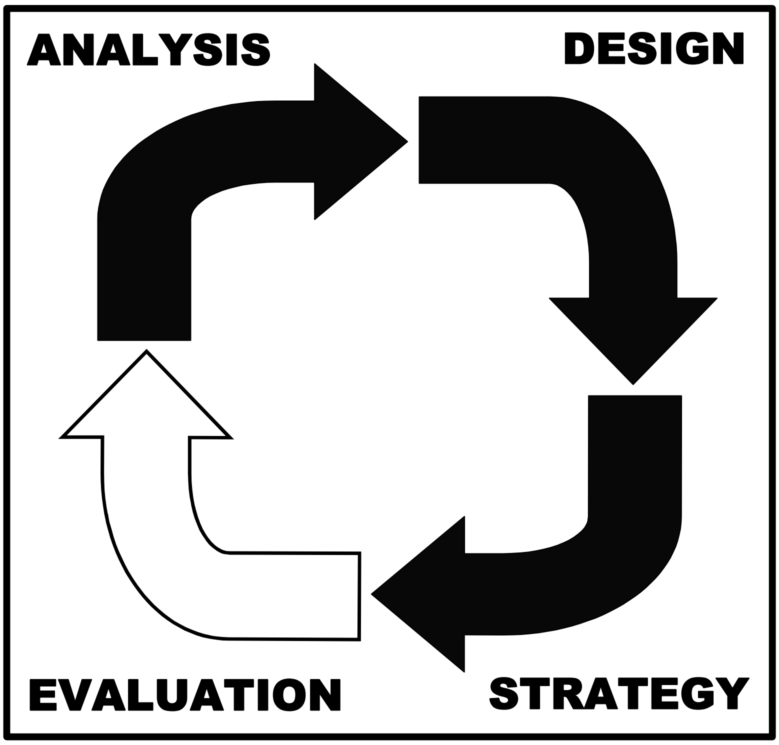
The Charter of Athens 2003 presents the role of spatial planning for the cities of the 21st century in its own vocabulary. It says that "…spatial planning is essentially trans-disciplinary teamwork involving different professionals and actors in complex processes." "…Spatial planners analyse, draft, implement and monitor strategies, supporting policies, programmes and key projects…" Furthermore, "…it is widely recognised that planning is not solely concerned with plan preparation. It is also part of a political process aiming to balance all relevant interests…" "…This points to the importance of the role of the planner as mediator and negotiator."

10.3 Summary and conclusions

The functioning and vitality of the Network City is closely related to the hierarchy and structure of its transport system. The design of the Network City and its transport system thus is a multidisciplinary task.
The city of the 21^{st} century is the Network City. The New Charter of Athens 2003 of the European Council of Town Planners speaks about the *Connected City* as an aim spatial planning should strive for. It states that connectivity – physically, socially, and economically – will become crucial for urban success and vitality. A multidisciplinary design and planning approach has the potential to guarantee a balanced decision and planning process.

The location of transfer points within the Network City is one of the key success factors for multimodal transport, and together with the architectural lay-out, the urban environment, and the transport function of transfer points, it plays a crucial role in establishing the (desired) hierarchy and structure of a transport system of the Network City.
Transfer points play a crucial role in the multimodal transport network. Without transfer points, there is no exchange between the different transport modalities. From network theory we learn how we can make complex interacting systems into stable systems. These 'rules of composition' mainly deal with the importance of the smaller scales and the coherence between spatial levels (built up from the smallest spatial level). With respect to the location of the transfer points, it can be reasoned that the (theoretically) ideal location of transfer points is where the function of infrastructure networks shift from spatial level.

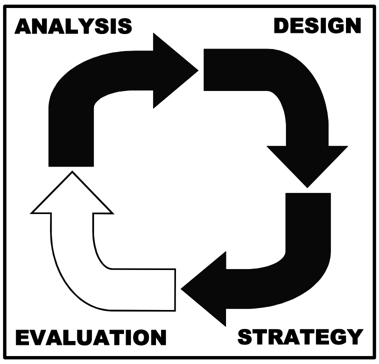
PART D EVALUATION



CHAPTER ELEVEN SUMMARY AND CONCLUSIONS

Aperta quoque apertiora fieri solent.

What is clear, can always be made more clear.
Seneca, Epistulae Morales, no. 94



After an introduction in section 11.1, this chapter describes the main results of the research work, by summarising the main findings with respect to the research aims and the main research objective: conceptual model Seamless Multimodal Mobility (section 11.2), demand-responsive transport (section 11.3), location of transfer points (section 11.4), and the planning and design of the Network City from a mobility point of view (section 11.5). In the final section 11.6, a reflection on the thesis research claim and an outlook for future research are given.

11.1 Introduction

Thinking about the future of cities and their (desirable and possible) level of mobility, the field of spatial planning is confronted with the notion of a city that has changed quite a lot over the last decades and centuries. Traditionally, a city could be defined as the concentration of buildings around one centre. However, this definition of the city – as a uni-nodal conglomerate of functions – does not fit the urban developments of the last decades.

Bertolini and Dijst (2003) reason that "…the lives of people are increasingly independent of urban physical and administrative boundaries…" and that "… both the spatial reach of people have increased and the diversity of activity and travel patterns." These processes have lead and still lead to "…an increasing disentangling between human activity patterns and the physical city. Each individual may increasingly create his own virtual city, which has no set physical and administrative borders, but is rather a specific, changeable combination of activity places, connected by transport, information, and communication networks, within definite socio-economic and behavioural constraints."

So, it is networks that have taken their own prominent places in (daily) life and have increasingly proven their own dynamics. They determine in their own way economic, social, cultural, political, and spatial developments (Boelens, 2000). The dynamics that accompany this world-wide network society puts not only the city and rural areas under pressure, but also the social-economic and social-cultural interactions (urbanity and rurality), as well as the present structure of government and governance.

With the increase of motorised mobility, the action space of people has increased enormously during the last centuries in general and especially during the last decades. The multi-nodal and hierarchical infrastructure network has to accommodate the movements of personal transport. From the viewpoint of the spatial planner, this accommodation process should always take into account and strive for the *vitality of urbanised areas*, the core business of spatial (urban) planners and designers. Based on a wide variety of urban and transport research, the author holds the view that this vitality is endangered most by:

[i] the *space consumption of infrastructure and vehicles*;
[ii] the decrease of the *accessibility of urban areas*;
[iii] the absence of *coherence between the hierarchical levels* in the urban web.

These three issues should be seen as the largest problem fields to tackle for the urban professionalists in the next decades and have been dealt with in this thesis. Chapter two shows that Seamless Multimodal Mobility (SMM) is considered (by many) to be a possible solution for some of the problem fields in spatial planning, as mentioned above (see also: Bovy, 2002; Van Wee, 2002). First of all, it is discussed as a congestion and space consumption mitigation strategy, and as a strategy to increase the liveability of cities and city centres, and to increase the multimodal accessibility of activity places. Furthermore, a proper hierarchy in the multimodal network with seamless (in both time and space) transfer points might result in optimal conditions for a vital city (Rooij, 1999). It is suggested in the TRAIL research program that '…seamless multimodal trip chaining at regional scale could be the answer to growing restrictions in using the car for personal travel. Sophisticated information and communication technologies as well as real-time transport process control could offer the means for effective and efficient multimodal transport services exhibiting an unprecedented high level of quality able to compete with the car…' (TRAIL, 1999).

Supported by high-tech information and communication technologies, the traveller can compose and direct his own trips by combining several separate transport modes within one trip. On the other hand, the traveller may also *order* a multimodal door-to-door trip. In this concept a chain conductor could responsible for the perfect connection between trains, buses, taxis, automated guided vehicles etc., referred to as *demand-responsive* multimodal transport. Within the TRAIL SMM research programme, two (finished) PhD studies are closely related to the topic of this research work, *the planning and design of the Network City*. Rob van Nes (2002) focused on the *design of multimodal transport networks* and Stefan van der Spek (2003) on the *design of intermodal transfer points*, the so-called connectors.

Problem setting

It is widely agreed among urban experts that the new urban technologies, among others transport technologies, play a major role in (the development and transformation of) today's socio-spatial environment. But it is still quite *unclear* **how** these new technologies **should be interpreted** in terms of the planning and design of the (network) city. The **main objective** of this thesis therefore has been to *generate guidelines and recommendations for the planning and design of the Network City from a mobility point of view*. Besides, the aim of this research project has also been to provide:

[i] a conceptual model that describes the impact of seamless multimodal travelling on the activity-travel behaviour of people;

[ii] knowledge about how the introduction and adoption of the demand-responsive transport system -as important feature of the SMM system of the future- influence the action space of its users, mainly older and disabled people;

[iii] a set of guidelines for the planning of the location of transfer points, considering both the configuration of the Network City and the activity-travel behaviour of people.

Chapters 2-7 deal with the right above-mentioned aims [i] and [ii], while goal [iii] is the focus of chapters 8 and 9. The main objective of this thesis -guidelines and recommendations for the planning and design of the Network City- is discussed in detail in chapter 10. The main objective and the three research aims are reached by testing the four hypotheses posed in chapter one (box 11.1.1). In the concluding sections of the chapters 2-10 these hypotheses are debated thoroughly. They focus on the relation between the city and its multimodal transport system (hypothesis 1), the location of transfer points (hypothesis 2), and demand-responsive personal transport (hypotheses 3 and 4).

Box **11.1.1** Research hypotheses

1. The functioning and vitality of the Network City is closely related to the hierarchy and structure of its transport system. The design of the Network City and its transport system thus is a multidisciplinary task.

2. The location of transfer points within the Network City is one of the key success factors for multimodal transport, and together with the architectural lay-out, the urban environment, and the transport function of transfer points, it plays a crucial role in establishing the (desired) hierarchy and structure of a transport system of the Network City.

3. Demand-responsive personal transport systems have a (theoretical) potential to play an important role in the total multimodal transport system of the Network City, although nowadays their role in practice is marginal.

4. The introduction of demand-responsive personal transport systems results in new and/or other activity-travel choices of the travellers and thus in changing activity-travel behavioural patterns of these travellers, although there will be many differences in use according to the spatial setting in which the system functions (urban users, suburban users, and rural users) and the level of service characteristics.

The next sections focus on the main objective of this thesis -guidelines and recommendations for the planning and design of the Network City- and the three research aims, as described above: conceptual model Seamless Multimodal Mobility, demand-responsive transport, and the location of transfer points.

11.2 First aim: conceptual model SMM

The first research aim focuses on *providing a conceptual model that describes the impact of seamless multimodal travelling on the activity-travel behaviour of people*.

11.2.1 Introduction and adoption of seamless multimodal travelling

For decades, all kinds of researchers with different scientific backgrounds have come up with theories about activity-travel behaviour: transport experts, economists, geographers, and social scientists. Chapter three discusses several activity-travel theories that originated from these different scientific fields and ends with presenting a conceptual model of the introduction and adoption of seamless multimodal travelling (figure 11.2.1).
As an approach to understand the decision process of the traveller's adoption of SMM, the following structure is suggested (based on Salomon, 1997). An individual is exposed to an environment which defines the context within which one can act (perform activities and travel to activity places) and which includes facilitators and motivators. The environment includes technological, economic, cultural, and political facets. The individual is also subject to numerous constraints, some of which are long-term or permanent and others may be temporary. Within this environment and these constraints, the individual, shown as the black box, can make his choices.
There is a dynamic aspect to this structure, as indicated by the dashed arrows in the figure. Actual behaviour provides experience and new information that may lead to an alternative choice when the situation arises again. The feedback mechanism acts on all elements described above. The changes in many individuals' behaviour may change the environment. And the changes may alter the constraints and they may affect the individual's perception of the choices.

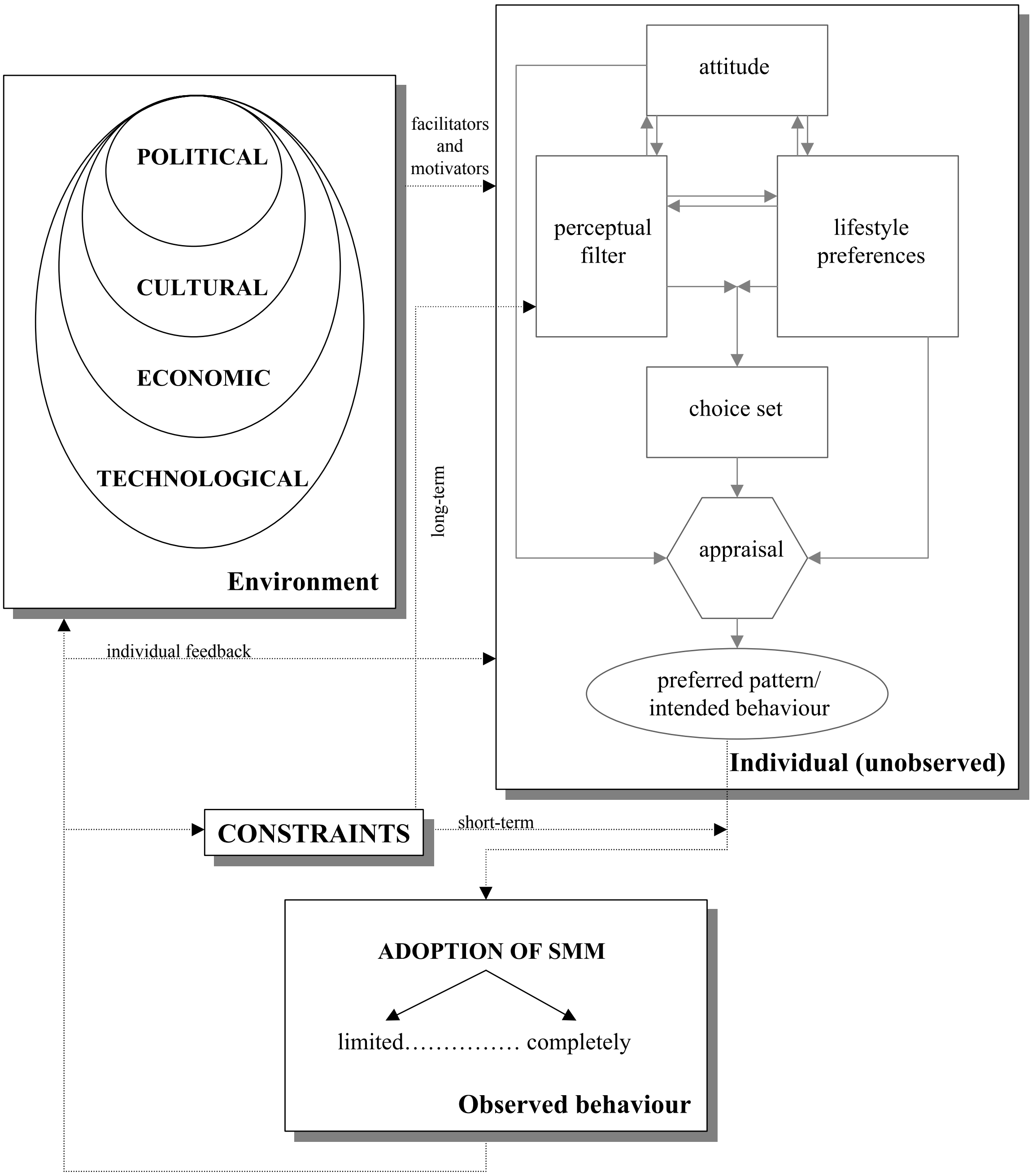


Figure **11.2.3** A schematic model of the seamless multimodal travelling decision context

11.2.2 The role of multimodal transport

In contrast to *unimodal transport*, which refers to trips made with one mode of transport, the term *chain mobility* or *multimodal transport* is a concept that refers to the combination of several (collective and/or individual) transport modes in order to travel from an origin (activity place A) to a destination (activity place B) (TRAIL, 1999, Ministry of Traffic and Transport, 1998). Therefore, a multimodal trip is defined (in chapter two) as a trip, in which different transport modes (or services) are used resulting in a physical transfer during the trip.
The Dutch Advisory Council for Traffic and Transport (2002) conducted a research programme on today's (and the future) market for multimodal transport. Interesting conclusions were drawn with respect to the following topics:

- **The present market of multimodal transport**: about 3% of all trips can be considered multimodal. The most important main modes of transport in multimodal trips are the train (59%), bus/tram/metro (21%), and the car (14%). The most important access and egress modes of transport are the bicycle and the bus. Although the number of taxi trips is relatively limited, the taxi is used quite a lot as access/egress mode: 19% of all taxi rides have their origin or destination at a railways station. In most national travel behaviour statistics, walking is not separately considered as an access or egress mode, rightly or wrongly.
- **The multimodal traveller**: most multimodal trips have the motive work or education (53%). For all trips (both unimodal and multimodal) this is 22%. People between 15 and 25 travel multimodally quite a lot: 39% of all multimodal trips are made by this group, compared to 16% for all trips. Partly this can be explained by the fact that this group has relatively often no car available as alternative.
- **Time and space**: multimodal travelling takes places mainly during the peak hours and on working days, over distances longer than 10 kilometres and between (large) urban areas; 38% of all multimodal trips in The Netherlands have their origins in one of the four largest cities (Amsterdam, Rotterdam, The Hague, Utrecht).

In general, transferring from one mode of transport to another is only attractive if the trip travel time, the trip travel costs, and/or the service (during the trip) outweigh the loss of time and comfort that takes place during the process of the transfer. Multimodal transport has especially potential for success in the long-distance trips between urban conurbations. From research in the Netherlands (Advisory Council for Traffic and Transport, 2003; Goeverden and Van Nes, 2000) we know that nowadays multimodal transport has a small share of all trips, nearly 3%. This share increases if typical trip types are considered, for instance, 20% of all interurban trips to the main cities in the Netherlands, or 80% of all train trips.

The main objective of this thesis -to give recommendations for the planning and design of the Network City- results (among others) from the question *how a seamless multimodal mobility system can contribute to the successful functioning of cities?* The next two subsections present how seamless multimodal transport can contribute to a solution for the important problems that the field of spatial planning is confronted with. Two questions are raised here: [i] What can seamless multimodal transport *mean* for the city? And [ii] What can seamless multimodal transport *not mean* for the city?

11.2.3 What can seamless multimodal transport mean for the city?

First, a seamless multimodal transport system primarily stands for, or in other words, has the potential for improving the effectiveness and efficiency of transporting people into and out of (relatively dense) urban areas, and by that to increase the (multimodal) accessibility of cities. The accessibility of a location refers to the area, within which a number of persons is situated, who can choose the that specific location as destination, against acceptable (time) costs (see also section 4.1).

Seamless multimodal mobility diminishes (the burdens of) transfer times and total travel times on an individual level and/or aggregate level, thus improving the effectiveness of travelling. Furthermore, seamless multimodal travelling increases the efficiency of the transportation process, among others due to sophisticated information and communication technologies (e.g. demand-responsive), but also due to the physical connecting of different transport subsystems seamlessly (i.e. transport nodes and transfer points). In this way, societal costs per travelled kilometre can be minimised, and the number of people transported into and out of cities maximised, resulting in a more efficient use of infrastructures and vehicles on the one hand, and their space consumption both direct and indirect, on the other.

Secondly, multimodal transport is suited very good for long distance travel (> 30 km). The (multimodal) connecting of urban conglomerations at a large scale improves the accessibility of those city areas accordingly. Traditional multimodal transport modes as the airplane and high speed rail are indeed today's most effective and efficient means of transport for (inter)continental and cross-national travelling. But also for the car there seems to be a role in (inter)national long distance, multimodal trip making, both as access or egress mode, and also as main means of transport, especially for travel motives where a degree of flexibility is desired such as recreation and tourism.
Within The Netherlands, the InterCity train network plays an increasing important role in the multimodal accessibility of the Dutch cities. Already for quite a number of years the so called *Rondje Randstad* is openly debated: a high quality IC service that connects the four largest cities of the Netherlands, Amsterdam, Rotterdam, The Hague, and Utrecht, all located in the Randstad area, at high speed, so that travel times between two of the four cities is always shorter than half an hour.

Thirdly, a good multimodal transport system combines *transport system differentiation* (speed, degree of collectivity, degree of time-space flexibility) and *organisational coherence* between those subsystems. Individual activity-travel patterns are more diffuse than ever, and personal action spaces have grown, and most probably will grow even larger with economic growth, whether sustainable or not (chapter four refers). The large variety (in both time and space) of trips is in need of a variety of transport alternatives and services. If car access is restricted at specific times or places more and more, as we can see happening today, good alternatives have to be available also more and more for the traveller in order to maintain and to improve the accessibility of cities.
Every transport system has characteristics that function best under certain circumstances, spatially, socially, etc. With respect to the spatial circumstances, it seems wise to connect subsystems where those spatial circumstances change. It then is clear for the traveller that it is an advantage for the traveller to shift modes, because the new systems to which the traveller transfers is adapted much better to the new spatial conditions than the access mode. Furthermore, this physical connection of different spatial circumstances, most of the time connecting different spatial levels, has the potential to improve the (spatial) coherence of the urban web accordingly.

Fourth. Intermodal transfer points, as urban focus points in the city, open up possibilities for new mobility environments, places interesting for both their transport connectivity and their urban programme. Specific connectivity between transport (sub)systems (individual versus collective, slow modes versus fast modes) offer different potentials for different urban programmes.
Talking about the transfer points and especially the location choice process, we should be aware that transport engineers and urbanists are not the only actors involved. Customers, governments (politicians), financers, transport providers, developers and contractors all are parties who might have a say in these kinds of complex processes. So, multimodal transport is not only a matter of technology, but also a matter of inter-organisational optimisation, a process of management and negotiation.

11.2.4 What does seamless multimodal transport not mean for the city?

Seamless multimodal mobility stands for enriching people's mobility choices, improving the efficiency and effectiveness of the transport system as a whole with a minimum of societal costs per travelled kilometre. Transport history (see also chapter four) shows us that the introduction and adoption of new, faster, more efficient or effective transport technologies result in more travelling, i.e. in more kilometres travelled. Personal travel takes place under the law of constant travel time. Only economic recession seems to have a negative impact on the mobility of people.
We have to disappoint the people who expected or hoped for seamless multimodal mobility to be a guideline for diminishing the mobility of people. It is the contrary, we might say. Better, new alternatives lead indeed to more travel. Supply creates demand. But it does stand for improving the efficiency and effectiveness of the transport system as a whole, and by that for improving the accessibility of cities and the reach of people.

Seamless multimodal mobility isn't also a one way ticket to solving the congestion problem of most industrialised countries. As discussed in chapter 5, congestion is a sign of a good functioning network, how contradictory this may look. In fact, it can be reasoned that there is an optimum level of congestion for all kinds of networks, when marginal societal costs (that have to be made to prevent congestion from happening) are balanced by the marginal societal benefits (the savings in time and money if there is no congestion).
But seamless multimodal mobility does mean something for the environment. Transport systems with characteristics that fit best in certain spatial circumstances, are to be favoured in those circumstances. Where the pressure on the space is high, e.g. in dense city centres, the less space consuming (infrastructure and vehicles) transport systems are to be promoted. Where pressure on space is low, individual means of transportation should be the main operating system.

11.3 Second aim: demand-responsive transport

The second research aim focuses on providing *knowledge about how the introduction and adoption of the demand-responsive transport system -as important feature of the SMM system of the future- influence the action space of its users, mainly older and disabled people*.

11.3.1 Potential role in transport system

Chapters one and two introduce the notion of demand-responsive transport briefly. Chapter seven elaborates extensively on the fact that demand-responsive transport is a type of service that *might play* an important role in the multimodal transport system of the Network City. It discusses that these kinds of services can cope with the increasing traveller's need for flexibility in both time and space. Demand-responsive transport services are provided on demand and eliminate resistances such as access, egress, and transfers, while waiting at a stop or station is replaced by waiting at home or at the activity location (Van Nes, 2002). One of its potentials is to act as feeder system for higher order transport systems such as the train system.
Moreover, one of the greatest values of demand-responsive transport systems is that it stands to expand and enrich individual travel choices. In contrast to the traditional (time-scheduled and line-bound) forms of public transport, demand-responsive transport systems represent an entirely different paradigm for coping with the post-modern, suburban development patterns.

11.3.2 Actual role in transport system; the Maastricht case of Tailor-Made-Transport

Although demand-responsive systems seem to have a lot of potentials, the role that these kinds of systems should and could play within the total multimodal system, is still widely discussed among transport experts. One of the most important limitations for success is the cost effectiveness. Already in 1982, Adebisi and Hurdle showed that in contrast to traditional public transport services, demand-responsive transport systems have no economies of scale. When the systems get larger -that is, attract more travellers- the costs involved grow correspondingly. Also Van Nes (2002) concludes that increasing demand levels will reduce the costs per trip, but that the total costs of the system will increase.

From both Dutch and international travel behaviour research we know that the largest user groups of today's best integrated forms of demand-responsive transport systems, i.e. shared taxi systems, consist of older and/or disabled adults, mainly females. From the MOBILATE research on the outdoor mobility of older people in the city and region of Maastricht, we can learn that the actual share of demand-responsive transport in the total travel behaviour of older adults is also very modest. From the Maastricht Tailor-Made-Transport data set we can conclude that the main user group of the Maastricht demand-responsive shared taxi system -as a good representative for the Dutch Collective Demand-Responsive Transport systems- is indeed the group of older and disabled people, mostly females.

Furthermore, the TMT data set shows that only a very limited number of TMT trips goes to or originates from the Dutch Railways station. The door-to-door, shared taxi system does not seem to function as a feeder system at all. Among others, this can be explained by the fact that the city of Maastricht has also two other public transport alternatives to go the station: the line-bound bus system and the Train taxi, a demand-responsive system from and to the station. From a cost saving perspective, it could be a suggestion to investigate whether the integration of the two demand-responsive systems is more cost effective.

The TMT data bases present differences in mobility between the urban and non-urban (older) TMT users. When we consider the differences in use of the TMT system between the Maastricht urban inhabitants and the Meerssen suburban inhabitants, we can conclude that the urban inhabitants travel significantly shorter distances. For the urban inhabitants, the TMT top destinations, urban facilities such as the hospital(s), the shop(ping centre)s, and the elderly homes are located at shorter distances than for the non-urban inhabitants.

Furthermore, one of the most interesting findings of the Maastricht demand-responsive system with respect to the travel patterns, is about the points of time that the system is used by its travellers. Many older adults use the TMT system until the late evening hours. It seems that the TMT system is a social safe system, with which older adults dare to travel till the dark hours of the day.

11.3.3 Future role in transport system

In the international MOBILATE research programme, all older adults were asked for their opinion about today's traffic situation. A lot of the problems they experience or perceive, could be overcome in one way or another by (collective) demand-responsive transport. The main problem that the older adults mention is that 'too few people offer their seats in the bus for a person who needs to sit down'. In case of a demand-responsive shared taxi system, a person doesn't only make a reservation for a trip, but also for a seat. The rural users have complaints about the frequency of public transport. Of course, this is no issue for demand-responsive transport, where the (mini)bus will come at your request. Other statements have to do with the accessibility and riding comfort of the vehicle, and feelings of safety and vulnerability. Individually oriented, door-to-door services such as the demand-responsive

shared taxi systems, have the characteristics to take away those burdens of physical and mental discomfort that the older people experience and perceive for other travel modes.
So, from the societal perspective of the integration of less mobile people in a (greying) society, there seems to be a perspective for demand-responsive transport, such as the shared taxi system that is discussed in this thesis. But some more societal discussion will be needed about costs and benefits between responsible governments, transport suppliers, and the group of vulnerable users themselves.

11.4 Third aim: location of transfer points

The third research aim focuses on providing *a set of guidelines for the planning of the location of transfer points, considering both the configuration of the Network City and the activity-travel behaviour of people*.

11.4.1 Transfer points: connectors

So, the city of the future is the Network City, in which (seamless) multimodal transport supports a growing range of possible inter-relations for a variety of activity-travel goals. Therefore, the Network City requires the development of new multimodal transport strategies and concepts, which are to be used in the planning and design of future socio-spatial settings. As discussed in chapter five on the spatial planning of the Network City, transport nodes in general and especially the multimodal transfer points have the potential to become important mobility environments. Here, the *space of flows* meets the *space of places* directly. Therefore, transfer points are locations where a very large potential exists for physical human interaction, so where the city of the future could take place.
In his PhD thesis, Van der Spek refers to transfer points as ‘connectors’. *Connectors* are connecting objects between different means of transport, between several origins and destinations, and between the spatial levels in the urban web. The notion of *connectors* makes clear that the *transfer* is the central issue, and not for example the meaning of the word ‘station’, namely: the standing still of vehicles.
The design and planning of transfer points involves a complicated process: where should they be built, how should they look, who should be involved, etc.? A very important issue when discussing the design and planning of transfer points, is *when a transfer point can be called a success*. CROW (2002) states that a transfer point can be called a success if the transfer point satisfies the intended policy goals for the transfer point on the one hand, and if it has a good exploitation on the other.
Chapters 8 and 9 show that the location of transfer points is one of the main factors for the success or failure of the multimodal transport system as a whole. From a spatial planning perspective, it is obvious that the location *choice process* of the transfer points is most interesting.

11.4.2 Location choice process

The planning and design of transfer points is a multidisciplinary activity: the main actors are urbanists, and transport and traffic engineers. The spatial planning cycle, as the symbol for spatial planning, helps designers and planners to order and conceptualise their activities. The cycle should be seen as a closed circle, or as a combination of connected circles, a spiral 'upwards' in the meaning of more insight and a better overview (Zeisel, 1984; Hulsbergen and Kriens, 2000; Hulsbergen, 2001).

When we talk about the design and planning of transfer points in the Network City, the transfer from the phase of analysis to the phase of design is crucial. Here, the objectives and the spatial-functional concept should be made explicit based on an multidisciplinary analysis (figure 11.4.1). They are important means of communication (in words and drawings) for the spatial planners towards the other actors involved in the total process, such as the employer, the financers, politicians, civilians, etc., for the choices that are made at the beginning of the process, have much influence on the process and (related) costs to come. A good diagnosis of the actual problems and objectives is therefore a crucial activity at the end of the phase of analysis.

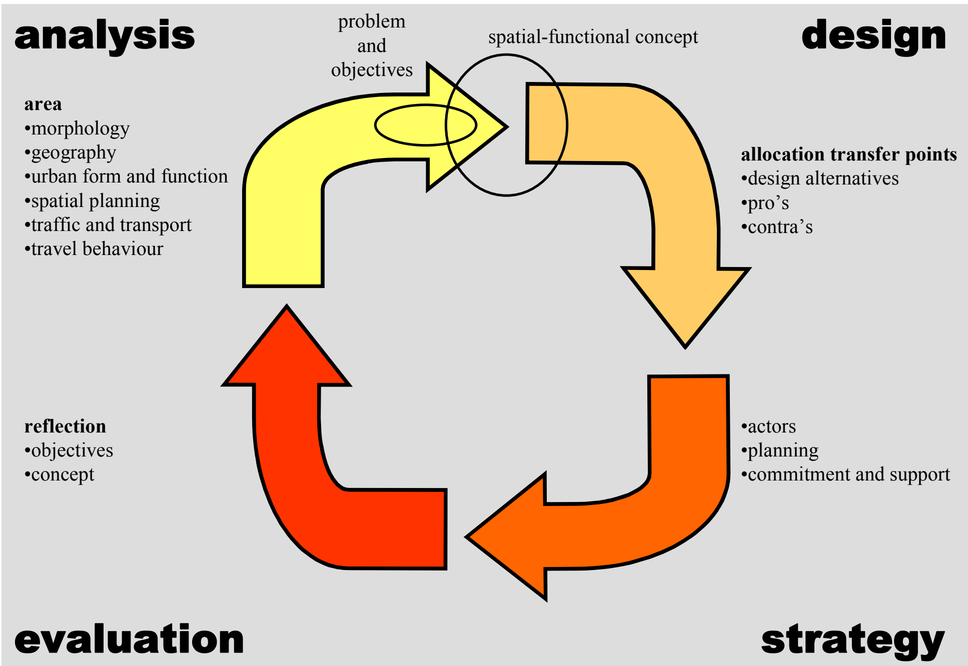


Figure **11.4.1** Spatial planning cycle for the design and planning of transfer points

Following Van Binsbergen et al. (1992), the search for potential locations has to take into account the urban and transport planning, and the behavioural limitations and starting points, which are formulated as a result of the phase of analysis. If objectives cannot be met, there is a need for a new search for locations. The potential use is a crucial design criterion as it defines the potential success (functioning, exploiting, etc.) to a large extent.
In planning it is almost inherent that at the end of (a range of) process steps, one knows best what should have been the question or objective to start with. So, the planning cycle offers explicitly the possibility to change the starting points of a phase and adjust (in casu: the phase of design by the feedback loop from 'optimal locations found' to the 'objectives and spatial-functional concept' (figure 11.4.2). In section 9.7, one cycle of the process steps (design –

strategy – evaluation – analysis) are described that deal with the design and planning of transfer points in the city and region of Maastricht. Here, it is shown that starting with design ideas (and not with the phase of analysis) can be a fruitful way to start the design and planning process as a whole, as long as the design ideas are evaluated properly (and their potential effects) and result in a proper design objective.

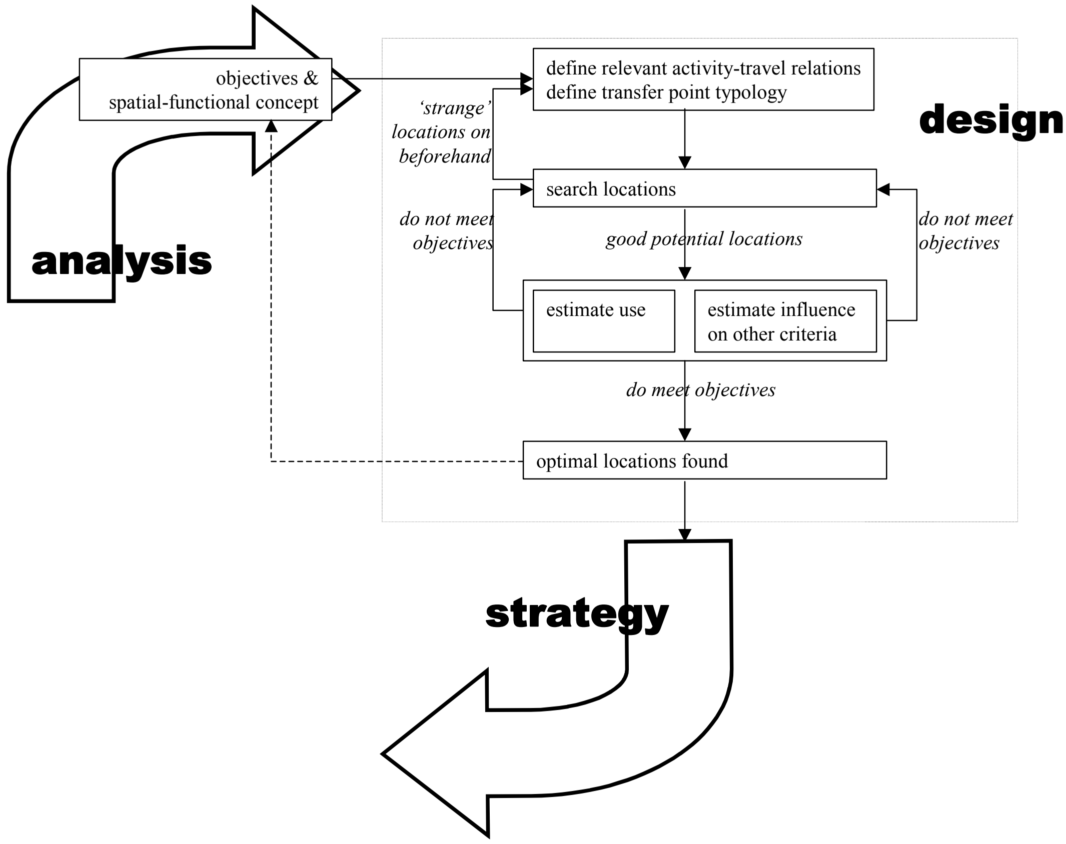


Figure **11.4.2** Phase of design location choice process of transfer points

11.5 Main objective: planning and design of the Network City from a mobility point of view

The main objective of this thesis is *to generate guidelines and recommendations for the planning and design of the Network City from a mobility point of view*.

11.5.1 Urbanism of networks

Throughout the 20th century cities have been planned, and in doing so, networks for the transport, not only of passengers and goods, but also of water, energy and information, have played an ever increasing role. However, seldom urbanism has been (re)thought in terms of networks: their topology, nodes, connectivity, capillarity or similarities (Drewe, 2002). The network in its modern meaning is characterised by three principal criteria[1]:

- **Topological criterion**: topology refers to the geometric or physical configuration of a network, the way in which the nodes of a network are physically connected. Networks are not abstract entities, they are related to the spatial dimension by

[1] The definitions of topology, kinetics, and adaptability are based on Caso (1999) and Drewe (2002)

connecting links via nodes in space. This involves discontinuity and heterogeneity. The topology of a network is open and united, and it is opposed to separations such as city/countryside, centre/periphery and zoning.

- **Kinetic criterion**: kinetics pertains to movement and communication between nodes. It is basically a relationship between space and time: speed. The rapidity of the connections within a network is a measure of the quality of the network itself. So, instantaneousness, homogeneity of speeds, the interest for rapid transfers and transits without losses of time or interruptions makes the network apt to movement and defines the kinetic criterion.
- **Adaptive criterion**: adaptability concerns the capacity for the evolution of networks over time and space. From the one side a network should be able to modify its structure to welcome new systems or to extend the applications of existing ones. On the other side, it should adapt itself to the needs and desires of its users by offering a multiple choice for the reaching of goals.

Chapters one and ten present Dupuy's layer scheme representing the modern version of the Network City (figure 11.5.1). It is not a new spatial **concept**, but a new **approach** to urbanism that can lead to new concepts. Therefore, it challenges the traditional art of physical design. Furthermore, the use of the Network City as a new approach to urbanism is like a pudding. Its proof is in the eating, i.e. designing new urban concepts.

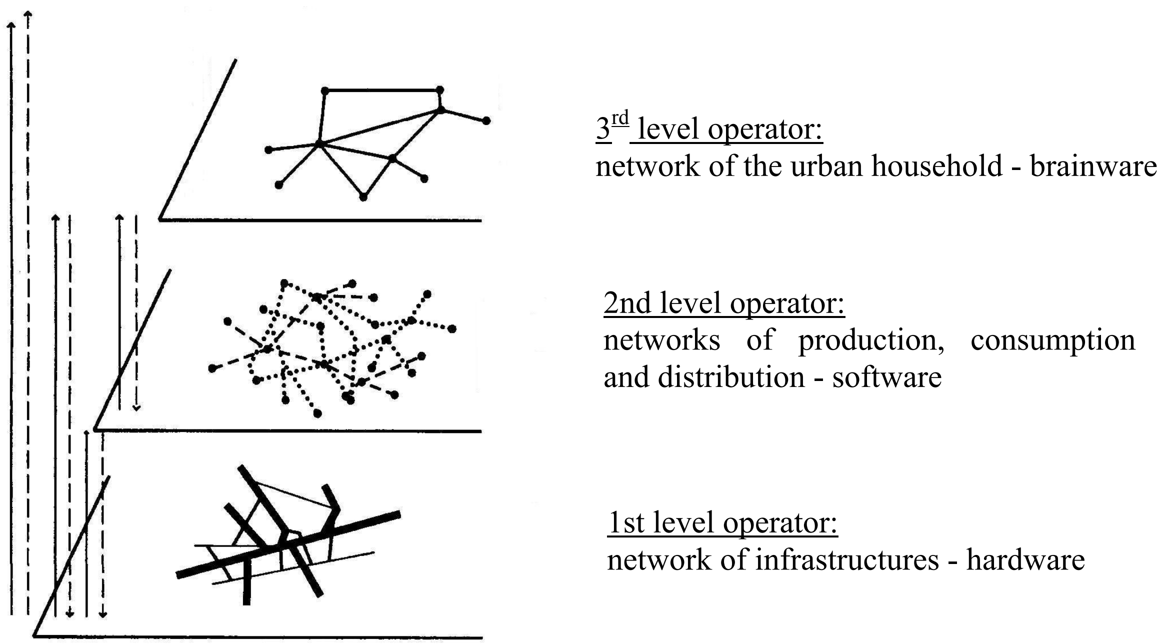


Figure **11.2.1** Network City
Source: Dupuy, 1991

The Network City requires an integrated planning of land use and urban technology networks, in particular transport and information and communication technologies. The three network layers stand for the analysing and planning of the hardware, software, and the brainware of the city. This is basically the result of network thinking in urbanism as opposed to mainstream zonal thinking. Creating monofunctional zones for housing, work and facilities such as recreation naturally induces traffic between these zones. The rise of the automobile and the accommodating expansion of the road network have produced a 'mobility problem', a problem of automobile dependency that is still largely unsolved today. Let us focus on this mobility discussion in more detail.

11.5.2 Mobility in a 21st century society

Chapters two and five focus on one of the main themes that is debated in the discussion on the mobility of people in the 21st century: the separation of time and space due to world wide transport, information and communication networks. Well-known geographical notions such as the centre and the periphery are not that significant and meaningful anymore as they used to be. No longer the linear movement from A to B is important, but the -more or less- permanent participation of people in extensive networks of movements and activities. In this context, Castells (1991) refers to the transition of a *sense of place* towards a *sense of flow*.
The notion of travelling has changed a lot since earlier days. The traveller has evolved from *homo viator*, someone who travels on his own, into (i) a *homo transportandus*, someone who is transported (mechanically), and (ii) a *homo transportans*, someone who transports (goods, information, data, energy). Following Van de Riet (1997, 1998a, 1998b) the transport system can be considered to be a set of markets: a system with dynamic interaction between demand and supply. In this interaction, implicit and explicit choices are made on both the demand side and the supply side. These choices interact. The result of the interaction is three-fold: a realised supply, a realised demand, and an allocation of the demand to the supply. Three submarkets can be distinguished in the transport system: *a movement market*, *a transport market*, and *a traffic market*. Each subsystem has its own supply and demand sides (figure 11.5.2 refers).

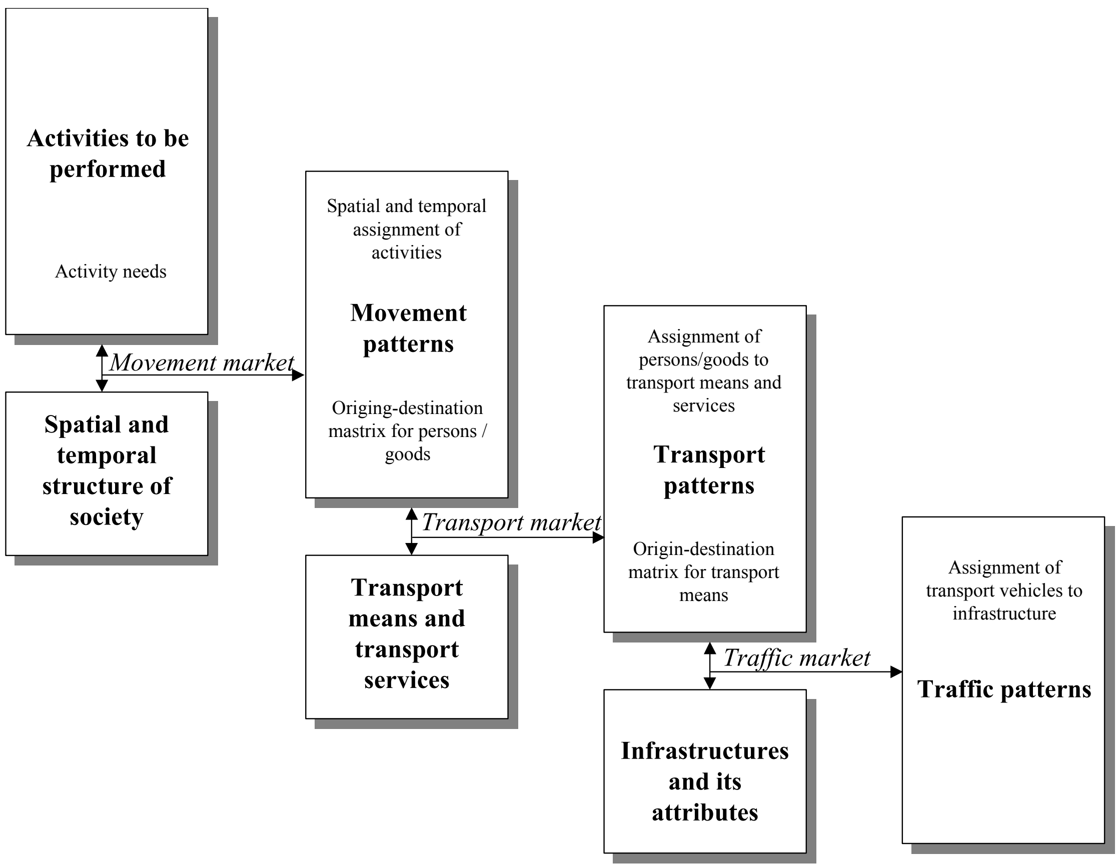


Figure **11.5.2** Mobility and its markets
Source: Van de Riet, 1998a

The present and expected developments of personal transport do not only imply blessings. The increased mobility in general and the large increase of individual motorised transport specifically has lead to large (social) problems of different nature (see box 11.5.1). We -as both individually and collectively motorised travellers- have taken a growing claim to the

physical and social environment. Damage is caused on an ecological, social, and economic level (Steg, 1996).
But a reduction of the mobility of people seems to be both socially improbable and impossible in the near future. And it even can be socially undesirable. It seems that in most societies it is determined culturally that economic growth, whether sustainable or not, is at the top of the lists of priorities. And the past has shown the irreversibility of the positive relation between economic growth and the growth of mobility. As long as the collective concepts on economic growth are imbedded in our society, the fields of transport planning, spatial planning, and urban design are (only) confronted with the problem of facilitating and accommodating the increasing demand for mobility as sustainable as possible. So, to manage and control mobility instead of reducing it.

Box **11.5.1** Individual motorised mobility; the case of car mobility

Already in the seventies, Christopher Alexander foresaw the drastic consequences for society of excessive car use. In his masterpiece, *A pattern language*, he dedicates pattern no. 11 to the car.

“***Cars give people wonderful freedom and increase their opportunities. But they also destroy the environment, to an extent so drastic that they kill all social life.***

The value and power of the car have proved so great that it seems impossible to imagine a future without some form of private, high-speed vehicle. Who will willingly give up the degree of freedom provided by cars?At the same time, it is undeniably true that cars turn towns to mincemeat. Somehow local areas must be saved from the pressure of cars or their future equivalents.... ...Let us start with a list of the obvious social problems created by the car: air pollution, noise, danger, ill health, congestion, parking problem, eyesore...
...The fact that cars are large, is in the end, the most serious aspect of a transportation system based on the use of cars, since it is inherent in the very nature of cars. Let us state this problem in its most pungent form. A man occupies about 5 square feet of space when he is standing still, and perhaps 10 square feet when he is walking. A car occupies about 350 square feet when it is standing still (if we include access), and at 30 miles an hour, when cars are 3 car lengths apart, it occupies about 1000 square feet. As we know, most of the time, cars have a single occupant. This means that when people use cars, each person occupies almost 100 times as much space as he does when he is a pedestrian.
If each person driving occupies an area 100 times as large as he does when he is on his feet, this means that people are 10 times as far apart. In other words, the use of cars has the overall effect of spreading people out, and keeping them apart.
The effect of this particular feature of cars on the social fabric is clear. People are drawn away from each other; densities and corresponding frequencies of interaction decrease substantially. Contacts become fragmented and specialized, since they are localized by the nature of the interaction into well-defined indoor places –the home, the workplace, and maybe the homes of a few isolated friends.

11.5.3 The role of network thinking: spatial levels, hierarchy and coherence

Thinking about the future of cities and their (desirable and possible) level of mobility, the concept of ‘networks’ helps to organise the urban complexity that is a main characteristic of the city. We identify five guidelines that are helpful for integrating the network-thinking into urban planning practice, with respect to our mobility point of view.

‘Rules’ of composition of complex networks

Research on networks from the fields of biology, computer science, physics, sociology, mathematics present a number of basic ‘rules’ for the structure and composition of complex networks. Salingaros (2000) presents nine structural rules that have evolved in the study of complex systems. Of the many different possible statements of system rules, the following list is considered critically relevant to urban design and planning.

- Rule 1. **COUPLINGS**: *Strongly-coupled elements on the same scale form a module. There should be no unconnected elements inside a module*.
- Rule 2. **DIVERSITY**: *Similar elements do not couple. A critical diversity of different elements is needed because some will catalyze couplings between others*.
- Rule 3. **BOUNDARIES**: *Different modules couple via their boundary elements. Connections form between modules, and not between their internal elements*.
- Rule 4. **FORCES**: *Interactions are naturally strongest on the smallest scale, and weakest on the largest scale. Reversing them generates pathologies.*
- Rule 5. **ORGANIZATION**: *Long-range forces create the large scale from well-defined structure on the smaller scales. Alignment does not establish, but can destroy short-range couplings.*
- Rule 6. **HIERARCHY**: *A system's components assemble progressively from small to large. This process generates linked units defined on many distinct scales.*
- Rule 7. **INTERDEPENDENCE**: *Elements and modules on different scales do not depend on each other in a symmetric manner: a higher scale requires all lower scales, but not vice versa*.
- Rule 8. **DECOMPOSITION**: *A coherent system cannot be completely decomposed into constituent parts. There exist many inequivalent decompositions based on different types of units.*

Barabasi (2002) shows that good functioning complex networks are so called scale-free networks. The largest node (best connected) is closely followed by two or three somewhat smaller hubs, followed by dozens that are even smaller, and so on, eventually arriving at the numerous tiny nodes. There is no intrinsic scale in these kinds of networks. This is why these networks are referred to as scale-free.

Low-scale networks as the basis of successful urban functioning

From the research on complex networks we learn that low-scale elements and low-scale sub-networks are the basis of successful urban functioning and/or a vital urban environment. Local connections are the strongest. Low-scale elements (and sub-networks) are necessary, not only for their own primary function, but also for their secondary role in linking other (higher order) elements. Based on the work of Salingaros, we can say that:

- smaller scales need to be defined before the larger scales;
- elements of smaller scales need to couple in a stable manner before higher-order groups can begin to form and interact;
- a hierarchy of nested scales means that not even one scale can be missing, otherwise the whole system is unstable.

This shows the crucial importance of proper planning and design of the slow mode networks (pedestrian zones, cycling paths) within both the total multimodal transport network and the urban fabric as a whole. In subsection 1.3.4 we discussed that "…already from ancient times the city has been -and most certainly will be in the future- a place of gathering and encounter (low-scale, personal interactions). The urban fabric should stimulate, facilitate, and accommodate these gatherings and encounters best as possible. In order to do so, the urban fabric has certain means, the urban components: streets, shops, offices, houses, pedestrian zones, station buildings, green spaces, plazas, parking lots, etc. Successful cities -in terms of efficiency, vitality, and liveability- meet both the physical and psychological needs of the human scale with their physical structures and surroundings. Successful cities provide *spatial quality*."

(Multimodal) Transfer node network as a scale-free network

When we apply the principles of a scale-free network to the (multimodal) transfer point network, we can conclude that a good transfer point network consists of many transfer points with relatively low connectivity, a certain degree of transfer points with medium high connectivity, and a few hubs with high connectivity (power law distribution).
Section 2.3 on Passenger chain mobility, shows that specific collective transport systems, actually specific collective transport services, operate on their own spatial levels. Referring to the location of transfer points, we can hypothesise that potentially ideal locations for transfer points are those places where the function of collective of individual infrastructure networks shift from spatial level. From a behavioural point of view (chapter three refers) they are locations where ‘things change’ and thus it is not so strange to change travel behaviour (e.g. a transfer) as well. In the design for the city and region of Maastricht in section 10.3, this starting point is developed in a conceptual design and planning strategy for the location of transfer points.

Infrastructure network as a scale-free network

When we apply the principles of a scale-free network to the infrastructure network, we can conclude that a good infrastructure network consists of many low-order elements (e.g. streets), a certain degree of medium high-order elements (e.g. city road, local motorway), and a few high-order elements (e.g. national motorway). The observations of De Jong and Paasman (1998) and Van Nes (2002) that the hierarchy in infrastructure networks follow a scale-factor 3 (as a “natural phenomenon”) affirm the principles of coherence in scale-free networks.

Network City as an approach

In the discussion on networks it is important to see the Network City as an approach of thinking and working rather than a spatial-functional concept that can be used anywhere. The topologic, kinetic, and adaptive characteristics of networks challenge the traditional art (i.e. zoning) of physical design. The approach of networks (or: the Network City) gives room for coping with the diverse space-time activity-travel patterns of the 21st century citizens, who are as mobile as ever. The approach of networks forces planning and design to adapt to specific spatial circumstances and to new forms of governance (multi-actor processes).

11.6 Directions for further research

This thesis presents a lot of data, information and knowledge. It is important to realise ‘what is new and innovative’ about this work. In subsection 1.4.6 a research claim was formulated, which deals with the in-depth, three dimensional (urbanism, activity-travel behaviour, transport), δ(esign and planning)-orientation of this research project. This way of looking offers new perspectives for the field of urbanism towards urban development and transformation. This thesis states and shows that it is important for actors in urban development and transformation processes to think at the same time in terms of the city hardware networks, city software networks ánd city brainware networks from the perspective of sustainable connectivity. The connecting of people is the major factor that makes cities function successfully and that makes cities places you want to go to.

In this thesis it is concluded that ‘The city of the future is the Network City, in which (seamless) multimodal transport supports a growing range of possible inter-relations for a

variety of activity-travel goals'. So, networks play a crucial role in the planning and design of the city of the 21st century. More fundamental knowledge of complex networks' principles might help the planner / designer in their task to organise the complex interacting system, called 'the city'. In other fields than urbanism (e.g. biology, computer science) knowledge and 'rules' have become available for the composition of complex networks. Barabasi shows for example the rules of power law distributions (section 10.2 refers) and the growth of complex networks into so called scale-free networks. Within the Chair of Spatial Planning, PhD research is done in this more fundamental direction of urban and regional design and planning (Klaasen, 2003).
An important thing that we learn from complex networks research is the role of the lowest spatial levels. Salingaros (2000) formulates is as follows: "…To achieve geometrical coherence in any system, a tightly-knit and complex whole is generated via general rules. Geometrical coherence is an identifiable quality that ties the city together through form, and is an essential prerequisite for the vitality of the urban fabric. The underlying idea is very simple: a city is a network of paths, which are topologically deformable. Coherent city form must also be plastic; i.e., able to follow the bending, extension, and compression of paths without tearing. In order to do this, the urban fabric must be strongly connected on the smallest scale, and loosely connected on the largest scale. Connectivity on all scales thus leads to urban coherence."
Future research for urbanists should therefore be directed at knowledge-based design principles for these lowest spatial levels, whereas post-war architecture and urban design seem to have forgotten the pedestrian to a large extent.

The nodes in the (transport) network are potential locations of so called mobility environments. In order to truly understand the effects of the functioning of mobility environments within the urban web, thorough research is needed focusing on all kinds of multimodal transfer points - i.e. railway stations (HST, IC, AR), bus stations, metro stations, tram stations, transferia, etc. airports – how they are used within the activity-travel behaviour of people, and their impact on the functioning of the city. In fact, such a good overview is needed for transfer points functioning on *all* spatial levels, from neighbourhood to continental oriented transfer points.

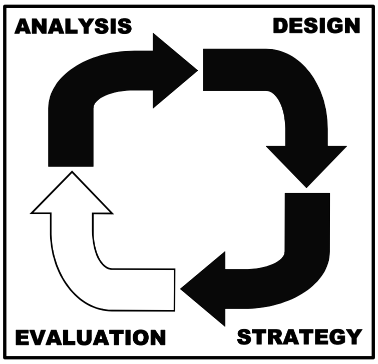
In order to improve the transport system and its role in the city as a whole, an ongoing evaluation of promising new transport systems is needed. Here, we can think of transport systems that [1] are more sustainable than today's systems in terms of e.g. physical, social, and financial-economic accessibility (accessible for all), [2] are directed more at the wishes of the travellers (demand-responsive), or [3] are results of technological developments (propulsion and driving mechanism, fuel technologies, etc.). The evaluation should explicitly focus on both the functioning within the urban web and the role within the activity-travel behaviour of people.

Finally, suggestions for further research can be given in the direction of integral spatial planning; i.e. integral in terms of both space and time. The evaluation of the effects of integral policy making might show that spatial aims will be realised better and/or sooner. Integral planning should include both policy making on all spatial levels (from neighbourhood to Europe) and policy making on the temporal aspects, i.e. the effects of, and the conditions for spatial interventions. This urban time policy approach has become more and more important, because new activity and travel rhythms are introduced with the development of the Network City (Drewe, 2004; Bailly and Herugon, 2001).

CHAPTER TWELVE SAMENVATTING EN CONCLUSIES

Aperta quoque apertiora fieri solent.

Wat duidelijk is, kan altijd nog duidelijker gemaakt worden.
Seneca, Epistulae Morales, no. 94



Dit hoofdstuk beschrijft de belangrijkste resultaten van het onderzoek. Na een inleiding (paragraaf 12.1) volgen drie paragrafen die ingaan op de relatie tussen mobiliteit en de stad: over wat naadloze multimodale mobiliteit juist wel (paragraaf 12.2) en niet (paragraaf 12.3) kan betekenen voor de stad, over de stedebouwkunde van de netwerken (paragraaf 12.4).

12.1 Inleiding

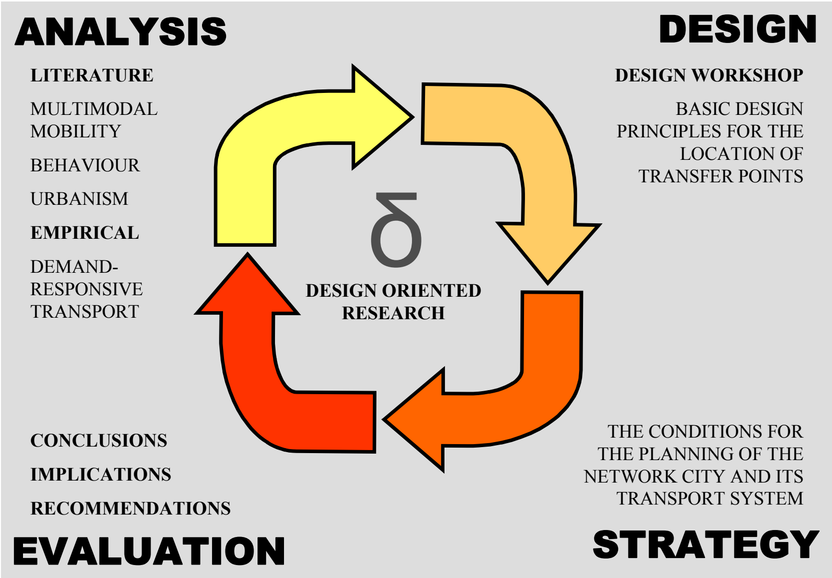
De stad is veranderd. De mens is veranderd. Waar een mens in de middeleeuwen vaak niet verder kwam dan zijn of haar stadsgrenzen, reist de westerse wereldburger van de 21ste eeuw vaker, comfortabeler en vooral verder dan ooit. Ondersteund door allerlei vervoers-, informatie- en communicatietechnologie is er geen berg te hoog en geen plek te ver of je kunt er komen. De eerste maantoerist is een feit. Een belangrijke, wellicht dé belangrijkste motor achter de groeiende individuele mobiliteit van mensen is de groei van de economie, al dan niet duurzaam. Al het (Nederlands) overheidsbeleid van de laatste decennia om de groei van de mobiliteit van de Nederlandse bevolking te beteugelen, kan bestempeld worden als mislukt. Waar de economie groeit, groeit -vooralsnog- de communicatie- en vervoersbehoefte van mensen. De Netwerkstad is een feit.

De kern van de (praktiserende) stedebouwkunde betreft het maken van plannen ten behoeve van vitaal stedelijk gebied. De groei van de (vooral gemotoriseerde) mobiliteit brengt echter naast de vele individuele voordelen (gaan en staan waar je wilt), ook meerdere collectieve nadelen, die negatieve impact hebben op de gewenste stedelijke vitaliteit; we spreken van een sociaal dilemma. Op basis van een breed scala aan stedebouwkundig en vervoerskundig onderzoek komen we tot de conclusie dat de vitaliteit van de hedendaagse stad (vanuit een mobiliteitsperspectief) het meest in gevaar wordt gebracht door:

1. het (direct, maar vooral ook indirect) ruimtegebruik van infrastructuur en voertuigen;
2. het verslechteren van de bereikbaarheid van stedelijke gebieden;
3. de afwezigheid van samenhang tussen de hiërarchische niveaus in het stedelijk netwerk.

Naadloos multimodaal personenvervoer, ook wel naadloze ketenmobiliteit, wordt door velen beschouwd als een mogelijke oplossing voor veel van de problemen waarmee de stedebouwkunde zich geconfronteerd ziet. De essentie van naadloos multimodaal personenvervoer is de verknoping in zowel tijd en ruimte van vervoerdiensten ondersteund door dynamische, actuele reisinformatie voor zowel reiziger als vervoerder, zodat de meest effectieve en efficiënte reis gemaakt kan worden. Ketenmobiliteit staat ook voor het inzetten van het juiste vervoermiddel in de juiste ruimtelijke context: collectief openbaar vervoer organiseren op het platteland is bij voorbaat kansloos, en individueel, privaat gemotoriseerd vervoer in hoogstedelijk gebied leidt gegarandeerd tot (onaanvaardbare) druk op het stedelijk weefsel.

'New urban technologies' zoals vervoerstechnologie en ICT, spelen een belangrijke rol in de hedendaagse socio-ruimtelijke leefomgeving van de mens. Echter, het is nog onduidelijk hoe deze technologische ontwikkelingen geïnterpreteerd moeten worden in termen van de planning en het ontwerp van de (Netwerk)stad. Het hoofddoel van dit onderzoek is dan ook geweest om te komen tot *richtlijnen en aanbevelingen voor de planning en het ontwerp van de Netwerkstad vanuit een mobiliteitsperspectief*. De werkwijze van dit onderzoek is gevisualiseerd in figuur 12.1.1., bestaande uit de 4 stappen van de plancyclus (analyse-ontwerp-strategie-evaluatie), en uit literatuuronderzoek (multimodale mobiliteit, verplaatsingsgedrag, stedebouwkunde van de netwerken), empirisch onderzoek (vraagafhankelijk vervoer), en research-by-design (lokatiekeuze overstappunten).



Figuur **12.1.1** Werkwijze van onderzoek

12.2 Wat kan naadloos multimodaal vervoer betekenen voor de stad?

De belangrijkste rol die naadloos multimodaal vervoer kan hebben, betreft het effectief en efficiënt vervoeren van mensen in en uit (hoog)stedelijk gebied, door het perfect op elkaar afstemmen van vervoerdiensten naar de stad (intercitytreinen, snelwegen, e.d.) en vervoerdiensten in de stad (stedelijk openbaar vervoer, individueel langzaam verkeer e.d.). In feite spreken we hier over het verbeteren van de *multimodale bereikbaarheid* van steden. Maatschappelijke kosten per gereisde kilometer kunnen geminimaliseerd worden, het aantal vervoerde mensen gemaximaliseerd.
Een tweede aspect betreft de rol van multimodaal vervoer op *lange-afstandsverkeer* (> 30 kilometers). Verplaatsingen per vliegtuig en per hogesnelheidstrein zijn vaak per definitie al multimodale verplaatsingen; er zijn immers niet zoveel opstappunten en daar moet je eerst naar toe reizen. Onderzoek naar de mobiliteit van mensen tot 2050 laat de verwachting zien dat met name het aandeel van de langeafstandsverplaatsingen zal toenemen. Kansen volop dus voor ketenmobiliteitsdiensten.
Ten derde heeft een goed multimodaal vervoersysteem aandacht voor *systeemdifferentiatie* (in termen van snelheid, flexibiliteit en beschikbaarheid in tijd en ruimte, mate van collectiviteit, e.d.) maar tegelijkertijd ook voor een *organisationele samenhang* tussen die subsystemen. Systeemdifferentiatie kan (moet) zorgen voor alternatieve paden in een netwerk, een eigenschap van goed functionerende complexe netwerken. ICT levert belangrijke bijdrage om de vervoerders te voorzien van actuele informatie met betrekking tot bijvoorbeeld de vervoerdiensten en de infrastructuur, zodat de afstemming tussen verschillende diensten real-time geoptimaliseerd kan worden.
Een laatste belangrijke aspect betreft de (nieuwe) rol van de overstappunten in het multimodale vervoersnetwerk. Als nieuwe stedelijke focuspunten in de stad kunnen zij groeien tot belangrijke plekken, niet alleen qua vervoersmogelijkheden (multimodale bereikbaarheid), maar ook qua stedelijk programma. Men spreekt wel over mobiliteitsomgevingen.

12.3 Wat betekent naadloos multimodaal vervoer niet voor de stad?

We moeten de mensen teleurstellen die denken dat naadloos multimodaal personenvervoer zal of kan leiden tot een vermindering van het aantal gereisde kilometers per persoon per jaar. Hoogwaardige ketenmobiliteit betekent onder andere een vergroting van de keuzemogelijkheden van mensen (waar ga ik heen, hoe ga ik dat doen?). De geschiedenis leert ons dat de introductie van nieuwe vervoerstechnologieën, die het reizen effectiever, efficiënter en vooral sneller maakten, keer op keer hebben geleid tot grotere verplaatsingsafstanden. Nieuwere, betere verplaatsingsalternatieven leiden tot meer mobiliteit (onder een economie die niet drastisch fluctueert). Echter multimodaal vervoer betekent ook het verbeteren van de bereikbaarheid van steden en het bereik van mensen.
Naadloos multimodaal vervoer betekent ook niet een einde aan de fileproblematiek. Congestie op een netwerk is trouwens een teken dat het goed gaat met het gebruik op dat netwerk, hoewel er wel sprake is van een optimaal niveau van congestie, waar de marginale maatschappelijke kosten (die nodig zouden zijn om congestie te voorkomen) in balans zijn met de marginale maatschappelijke baten (de besparingen in tijd en geld wanneer er geen congestie zou zijn). Maar multimodaal vervoer heeft wel degelijke positieve aspecten met betrekking tot milieu en leefomgeving. De idee is immers dat elk vervoersysteem het best kan functioneren onder bepaalde ruimtelijke omstandigheden. Daar waar druk op de ruimte groot is (bijvoorbeeld in hoogstedelijk gebied), vervoersystemen moeten ingepast worden die weinig ruimte innemen, direct en indirect, qua voertuigen en infrastructuur.

12.4 Naar een stedebouwkunde van de netwerken

Denkend aan en filosoferend over de toekomst van steden en hun (gewenste) mobiliteitsniveau, kan het netwerkdenken helpen om orde in de chaos te scheppen. Wij komen tot vijf richtlijnen die helpen om het netwerkdenken te integreren in het ruimtelijk planvormingsproces. Dit alles vanuit een mobiliteitsperspectief.

'Rules of composition' voor complexe netwerken

Onderzoek naar de compositie en structuur van complexe netwerken in de biologie, computerwetenschappen, natuurkunde, sociologie en wiskunde komen tot een aantal basisprincipes voor de compositie en structuur van die complexe netwerken. Salingaros (2000) definieert negen principes die uiterst relevant zijn voor ruimtelijke planning en stedebouwkundig ontwerpen, als de twee kerndisciplines binnen de stedebouwkunde.

- Rule 1. **COUPLINGS**: *Strongly-coupled elements on the same scale form a module. There should be no unconnected elements inside a module*.
- Rule 2. **DIVERSITY**: *Similar elements do not couple. A critical diversity of different elements is needed because some will catalyze couplings between others*.
- Rule 3. **BOUNDARIES**: *Different modules couple via their boundary elements. Connections form between modules, and not between their internal elements*.
- Rule 4. **FORCES**: *Interactions are naturally strongest on the smallest scale, and weakest on the largest scale. Reversing them generates pathologies.*
- Rule 5. **ORGANIZATION**: *Long-range forces create the large scale from well-defined structure on the smaller scales. Alignment does not establish, but can destroy short-range couplings.*

- Rule 6. **HIERARCHY**: *A system's components assemble progressively from small to large. This process generates linked units defined on many distinct scales.*
- Rule 7. **INTERDEPENDENCE**: *Elements and modules on different scales do not depend on each other in a symmetric manner: a higher scale requires all lower scales, but not vice versa.*
- Rule 8. **DECOMPOSITION**: *A coherent system cannot be completely decomposed into constituent parts. There exist many inequivalent decompositions based on different types of units.*

Barabasi (2002) laat zien dat goed functionerende complexe netwerken in feite *scale-free* netwerken zijn. De grootste knoop (best verbonden) wordt op de voet gevolgd door een aantal iets kleinere hubs, gevolgd meerdere nog wat kleinere knopen, uiteindelijk eindigend bij heel veel hele kleine knopen. Er is feitelijk geen intrinsieke schaal in dit type netwerken. Daarom wordt dit soort netwerken *scale-free* genoemd.

De kracht van de lage schaal

Vanuit het onderzoek over complexe netwerken leren we dat de elementen op de laagste schaal de bouwblokken van het netwerk zijn, i.e. de basis van het succesvol functioneren van stedelijk gebied en/of stedelijke vitaliteit. De lage schaal elementen (en sub netwerken) zijn niet alleen belangrijk voor hun primaire functie, maar ook om andere hogere orde elementen aan elkaar te verbinden.

Dit maakt het belang duidelijk van de planning en het ontwerp van langzaam verkeersnetwerken (voetgangersgebieden, fietspaden, pleinen, parken, e.d.) binnen het totale multimodale netwerk. Vitale steden komen tegemoet aan de fysieke en psychologische behoefte van de *menselijke schaal* met hun fysieke structuren en omgeving. Vitale steden hebben ruimtelijke kwaliteit.

Netwerk van overstappunten als *scale-free* netwerk

Wanneer we de principes van de *scale-free* netwerken toepassen op het netwerk van multimodale overstappunten, kunnen we concluderen dat een goed netwerk van overstappunten zou moeten bestaan uit een (beperkt) aantal knopen met hoge vervoerswaarde (hoge connectiviteit), een middelgroot aantal knopen met middelhoge vervoerswaarde, en heel veel (kleinere) knopen met relatief lage vervoerswaarde. Een ‘spin in het web’-netwerk, één superverbonden knoop (super hoge connectiviteit) samen met heel veel kleinere knopen, maakt het totale netwerk kwetsbaar en is dus een netwerkstrategie die vermeden zou moeten worden.

Infrastructuurnetwerk als *scale-free* netwerk

Wanneer we de principes van de *scale-free* netwerken toepassen op het infrastructuurnetwerk, kunnen we concluderen dat een goed infrastructuurnetwerk zou moeten bestaan uit heel veel lage schaal elementen (bijvoorbeeld straten, pleinen), een wat groter aantal middelhoge schaal elementen (wijkverzamelweg, stadsweg, lokale snelweg), en een beperkt aantal hoge schaal elementen (nationale snelweg). De observaties van De Jong en Paasman (1998) en Van Nes (2002) met betrekking tot de hiërarchie in (goed functionerende) vervoersnetwerken die gedomineerd worden door een hiërarchische samenhang met een schaalfactor 3 zijn in lijn met de principes van de *scale-free* netwerken.

Netwerkstad als een wijze van denken en benaderen

Het is belangrijk in de discussie over de stedebouwkunde van de netwerken om het idee van de Netwerkstad te zien als wijze van denken en benaderen, en niet als een ruimtelijk-functioneel concept dat je zonder meer overal kunt kopiëren. De topologische, kinesthetische en adaptieve eigenschappen van netwerken brengen de traditionele wijzen van ruimtelijke ordening en ontwerp in een nieuw daglicht. De netwerkbenadering geeft ruimte aan de verscheidenheid aan activiteiten- en verplaatsingenpatronen van de burgers van de 21ste eeuw, die meer mobiel zijn dan ooit. De netwerkbenadering dwingt de disciplines van planning en ontwerp om plannen te maken die passen in de specifieke ruimtelijke condities van het specifieke ter tafel liggende plangebied. En de netwerkbenadering biedt ruimte aan nieuwe vormen van beleid maken: multi-actor planvormingsprocessen.

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APPENDICES

Appendix 1 Tailor-Made-Transport variables

01 Date
02 Action time
03 Action code
04 Client number
05 Client name
06 Trip code
07 Client code
08 Street address origin
09 House number origin
10 Additions origin
11 Zip code origin
12 Village/city orgin
13 Street address destination
14 House number destination
15 Additions destination
16 Zip code destination
17 Village/city destination
18 Number of passengers
19 Number of guiding people
20 Number of people with wheelchair
21 Trip kilometers
22 Trip duration
23 Means of payment
24 Trip fare client
25 Trip fare debtor
26 Earliest boarding time
27 Latest boarding time
28 Latest getting off time
29 Booked by
30 Date of trip reservation
31 Time of trip reservation
32 Reservation changed by
33 Date of trip reservation change
34 Time of trip reservation change
35 Driver
36 Vehicle
37 Actual boarding time
38 Actual getting off time
39 Percentage
40 Cancellation code
41 Description

Appendix 2 Tailor-Made-Transport questionnaire (in Dutch)

53A Kent u vervoer op maat (VOM)?

Interviewer: Let op filter!

ja (ga naar vraag 53B)
nee (ga naar vraag 54)

53B Zijn de volgende stellingen over het VOM volgens u juist, onjuist of weet u het niet?

	juist	niet juist	weet ik niet
Ik moet mij minimaal 2 uur van tevoren aanmelden als ik een reis wil maken			
VOM brengt mij naar elke willekeurige plek binnen de gemeente Maastricht waar een busje mag komen			
De bus neemt altijd de voor mij kortste route			
VOM heeft 4 halteplaatsen, nl. Academisch ziekenhuis, Brusselse Poort, station en de Markt			
Voor ouderen geldt een korting op de ritprijs van 40%			

53C Gebruikt u het VOM-vervoer wel eens?

Interviewer: Let op filter!

ja (ga naar vraag 53E)
nee (ga naar vraag 53D)

53D Waarom gebruikt u het VOM niet?

Interviewer: Meerdere antwoorden mogelijk!

te duur	(ga naar vraag 53H)
te veel ‘geregel’	(ga naar vraag 54)
ik heb een beter alternatief, b.v. de auto	(ga naar vraag 54)
anders, nl.: ______________________________	(ga naar vraag 54)

53E Hoe vaak gebruikt u het VOM?

meerdere keren per week
eens per week
meerdere keren per maand
een keer per maand
paar keer per jaar

53F Hoe tevreden bent u met het VOM?

Interviewer: Laat schaal 14 zien!

zeer ontevreden								zeer tevreden	
1	2	3	4	5	6	7	8	9	10

53G We hebben enkele uitspraken over het comfort van het VOM-systeem. Kunt u aangeven in hoeverre u het met deze uitspraken eens bent?

Interviewer: Laat schaal 14 zien!

1 = helemaal mee eens
2 = eens
3 = maakt niet uit
4 = oneens
5 = helemaal mee oneens

	1	2	3	4	5
- de rit wordt aangepast aan uw wensen					
- deze manier van vervoer geeft een veilig gevoel					
- ik vind het geen probleem met anderen samen te reizen					
- omrijden vind ik niet prettig, de rit is vaak onnodig lang					
- de bus komt altijd op tijd					
- je hebt alle tijd met in- en uitstappen					
- reserveren van een rit gaat erg gemakkelijk					
- de chauffeur heeft alle rijd voor je en is – zo nodig – behulpzaam bij in- en uitstappen					
- VOM brengt je op tijd op je afspraak (b.v. bij doktor, ziekenhuis, station)					
- VOM-haltes zijn aangenaam om te wachten					
- het is mooi dat je thuis wordt opgehaald en teruggebracht					

53H Komt u wel eens in ....? Gebruikt u dan VOM?

buurt- of wijkcentrum
verzorgingshuis
dienstencentrum
buurtinformatiecentrum

53I We hebben een paar uitspraken over de kosten van het VOM-vervoer. Kunt u aangeven in hoeverre u het met de uitspraken eens bent, oneens of dat het niet uitmaakt?

Interviewer: Laat schaal 15 zien!

1 = helemaal mee eens
2 = eens
3 = maakt niet uit
4 = oneens
5 = helemaal mee oneens

	1	2	3	4	5
in het algemeen geef ik veel geld uit aan vervoer					
het VOM-vervoer is duur					
het VOM-vervoer is goedkoop					

VOM-vervoer is veel goedkoper dan de taxi
VOM-vervoer is veel duurder dan de normale bus
een eigen auto kost meer dan het openbaar vervoer (bus, trein, VOM)
een rit met het VOM-vervoer is zijn geld waard
40% reductie van de normale prijs is een aardige tegemoetkoming voor ouderen

53J Heeft u verleden jaar gebruik gemaakt van het VOM-vervoer?

Interviewer: Let op filter!

ja (ga naar vraag 53K)
nee (ga naar vraag 54)

53K Heeft u gemerkt dat het VOM-vervoer nu door een andere vervoersmaatschappij wordt uitgevoerd dan een jaar geleden?

Interviewer: Let op filter!

nee (ga naar vraag 54)
nauwelijks (ga naar vraag 54)
ja (ga naar vraag 53L)

53L Wat vindt u van de huidige organisatie?

organisatie is nu beter
organisatie is nu slechter
anders, nl: ______________________

54 We have talked about the different transport systems. What importance do these different means of transportation have on maintaining your daily living/staying independent in your daily life?

Interviewer: Please present scale ...!

	not important at all	1	2	3	4 very important	5
walking						
cycling						
riding a moped/motorcycle						
driving a car						
car as a passenger						
public transportation						
special services						

55 An ideal form of transportation would be a vehicle that brings you where you want, when you want. However, this mode of transportation, in order to remain affordable, might entail a few concessions.
Here is a list with some possible concessions. Can you order these concessions from most troublesome to least troublesome for you?

Interviewer: shuffle deck of cards and give them to the interviewee!

1 You have to order the vehicle at least one hour in advance
2 The vehicle can be up to 15 minutes early or late (arriving up to 15 minutes before

or after the arranged departure time) 3 You have to share the vehicle with other passengers 4 Often a wheelchair bus will be used to carry out the trip (FREE ITEM) 5 You often have to make a detour in order to pick up or drop off other passengers

Appendix 3 Workshop questionnaire results

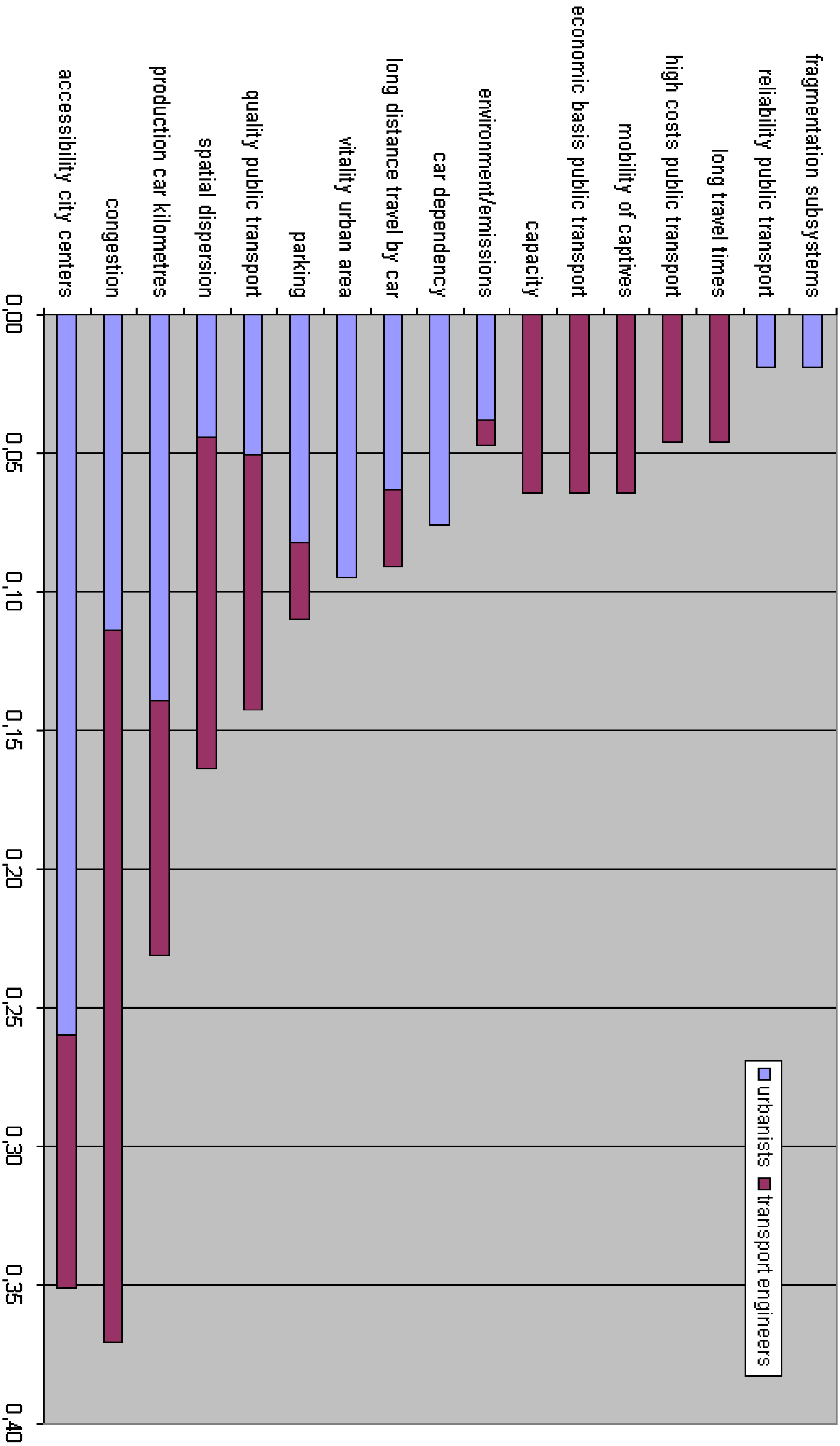

Figure 1 Question 1: For which problem is multimodal travelling a solution? (all urbanists = 1.0; all transport engineers = 1.0)

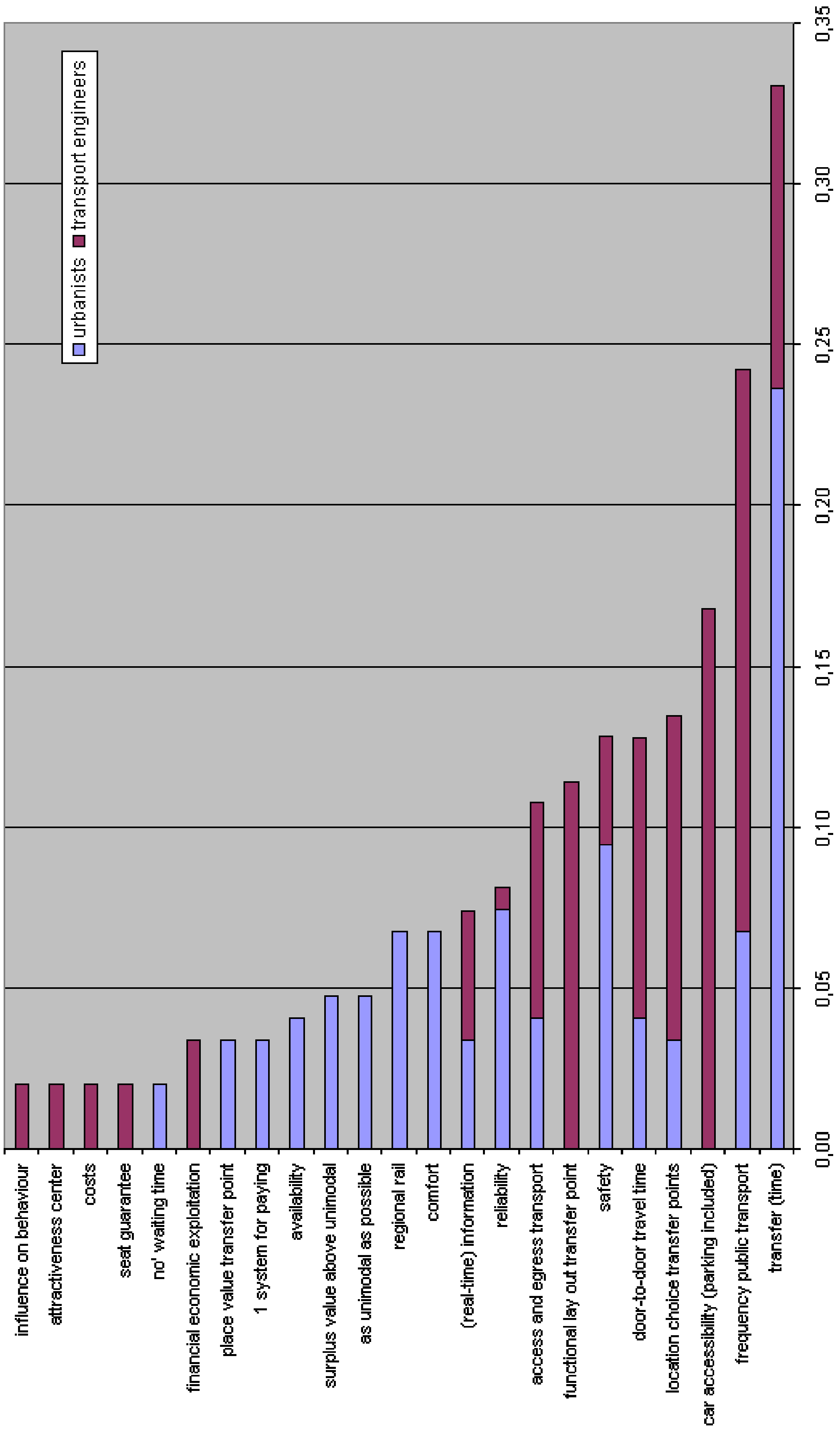

Figure 2 Question 2: What are the most critical success factors of multimodal transport? (all urbanists = 1.0; all transport engineers = 1.0)

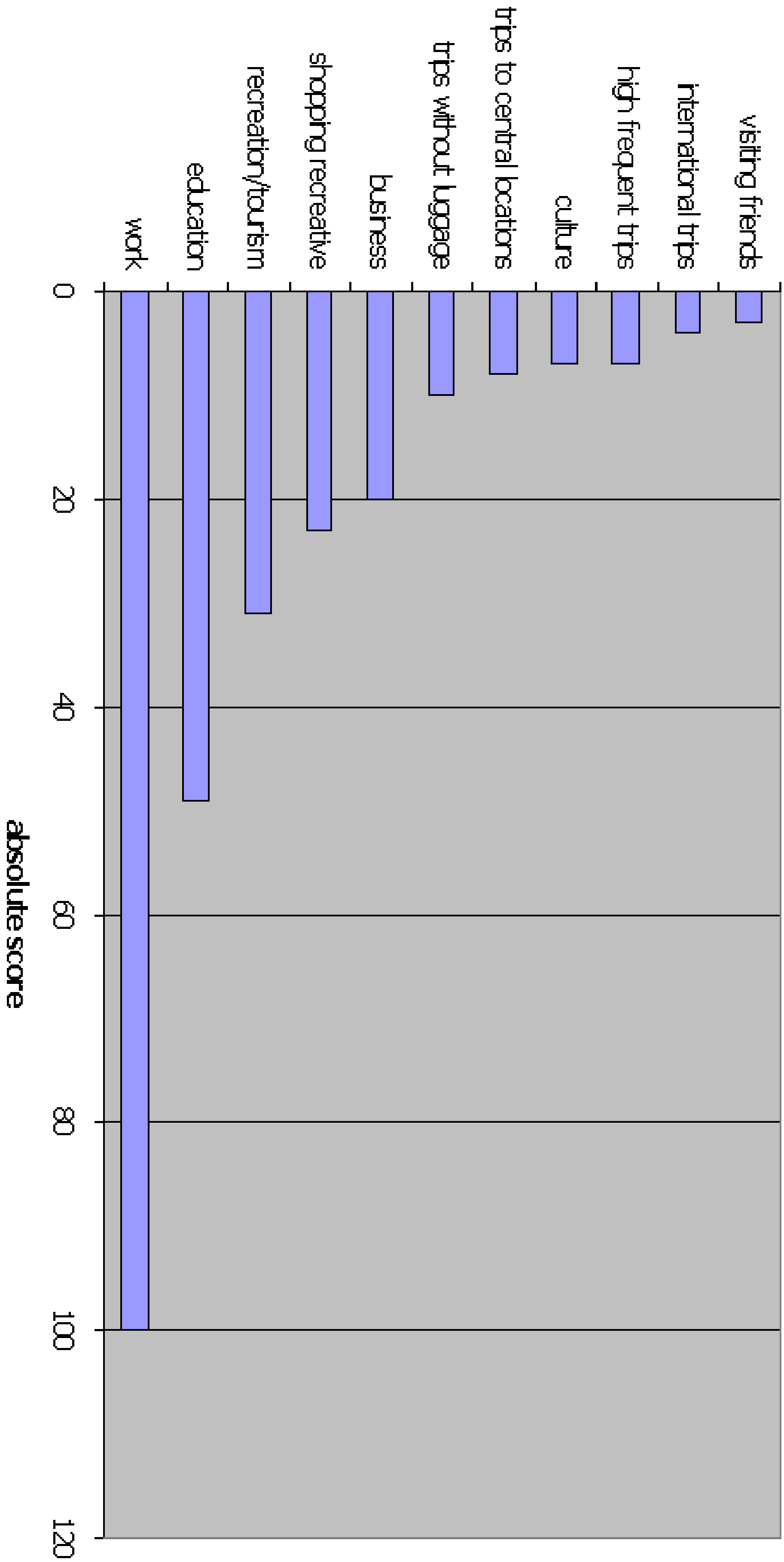

Figure 3 Question 3: For which travel motive is multimodal transport suited best?

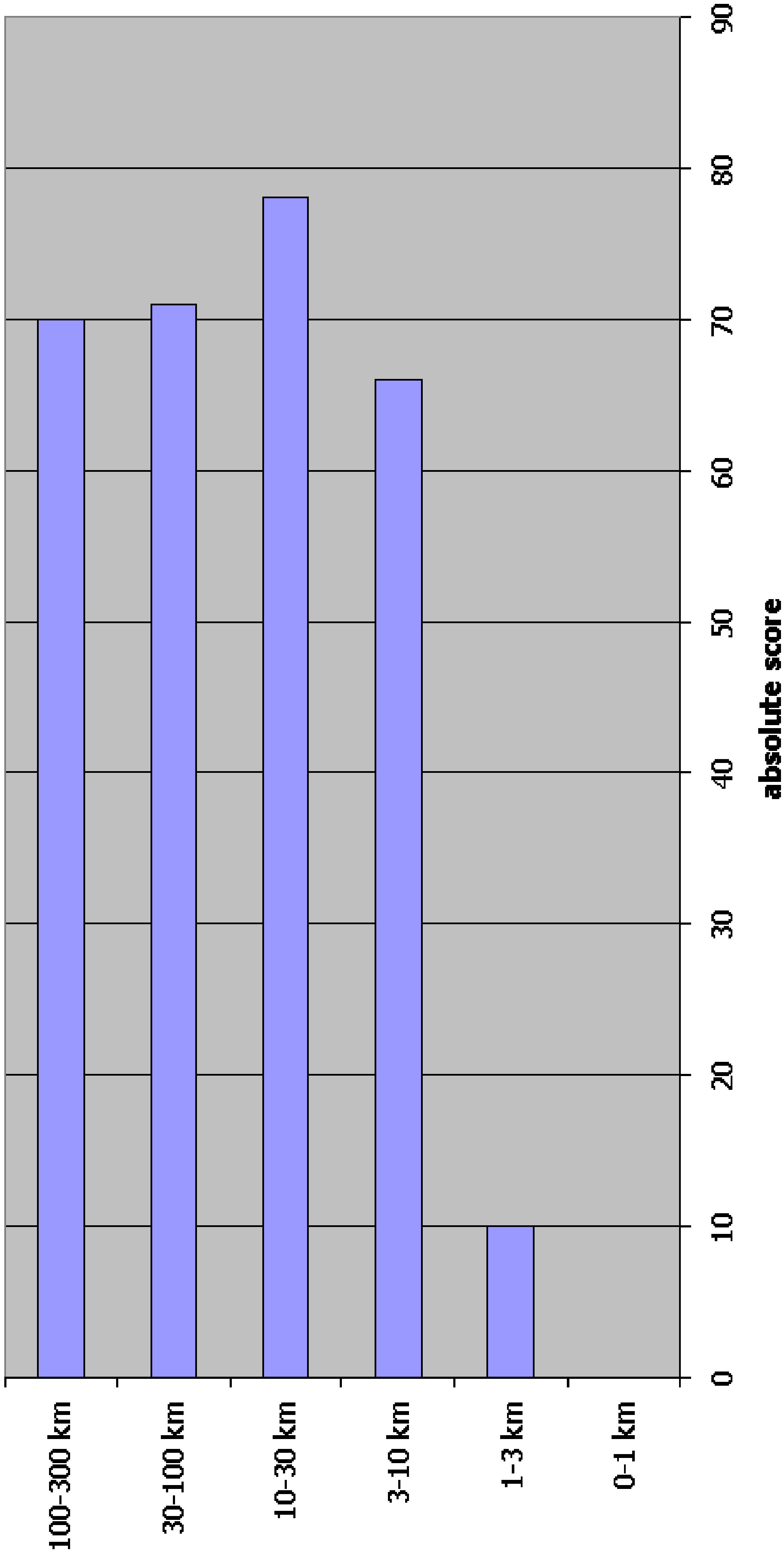

Figure 4 Question 4: For which travel distance is multimodal transport suited best?

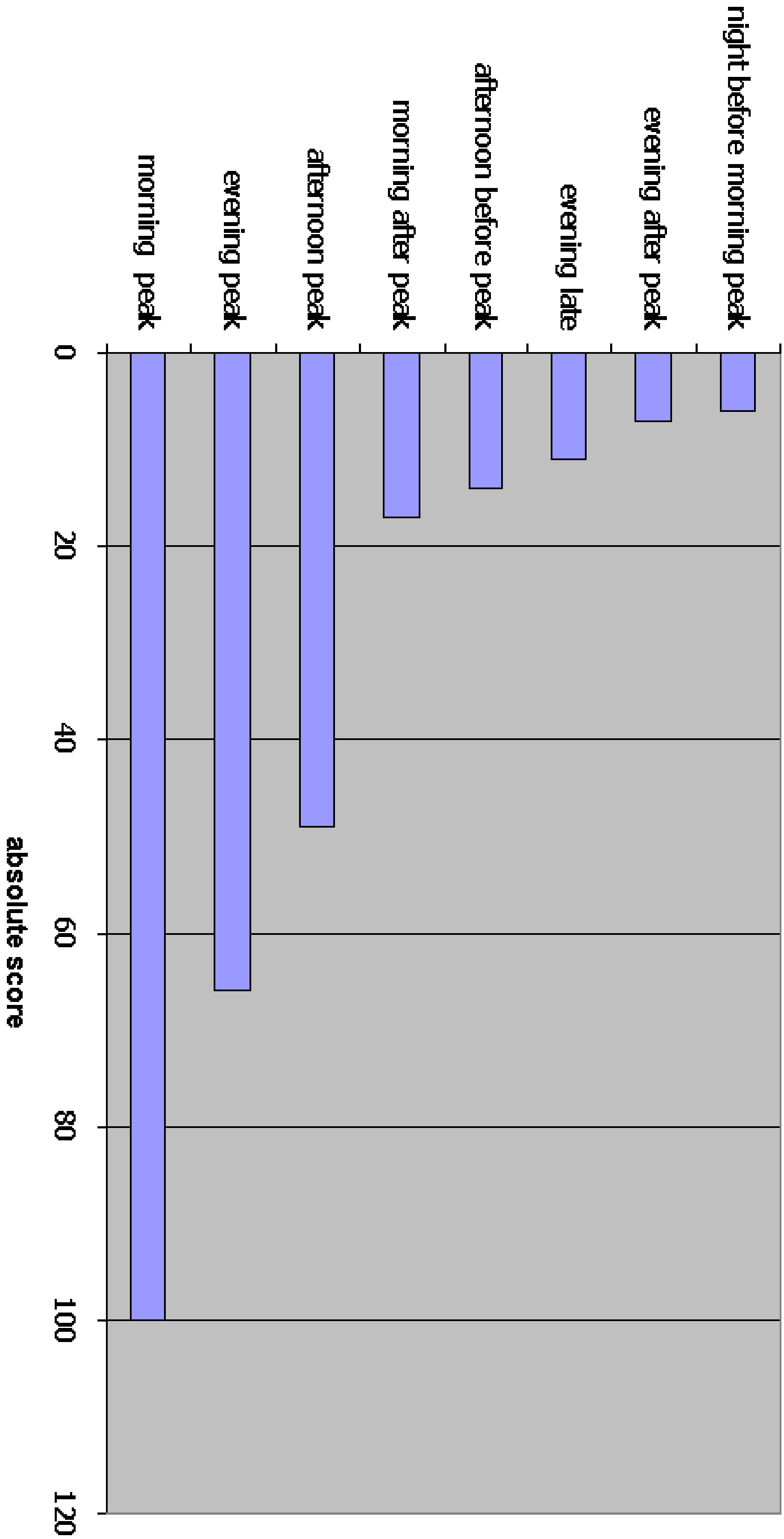

Figure 5 Question 5: For which time of the day is multimodal transport suited best?

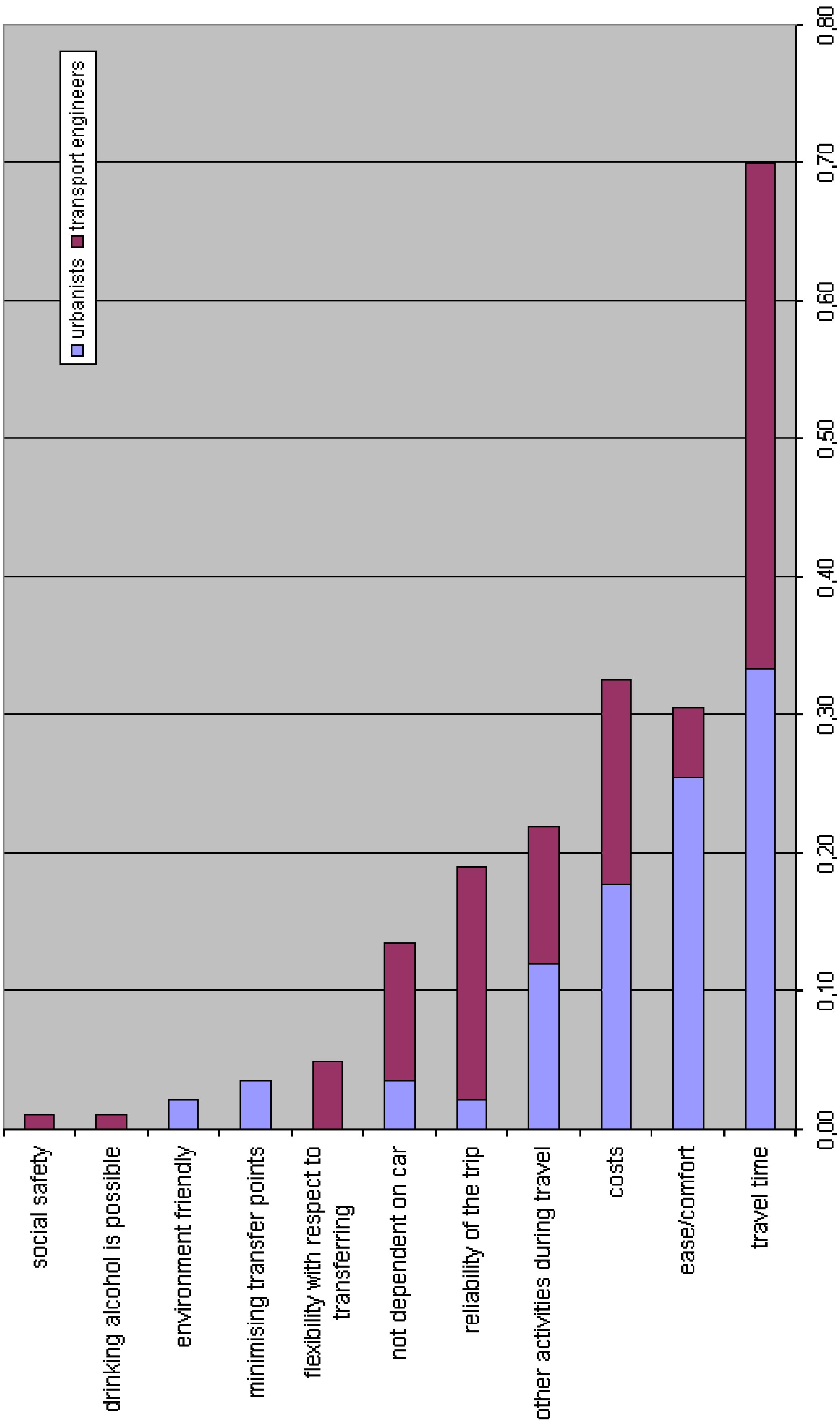

Figure 6 Question 6: What are the most important personal drives to travel multimodally?
(all urbanists = 1.0; all transport engineers = 1.0)

CURRICULUM VITAE

Remon Michel Rooij was born in 1973 in Vlaardingen, The Netherlands. He finished the Gymnasium β at the RSG in Den Briel in 1991, and then attended the Delft University of Technology to study both Urbanism and Construction & Real Estate Management at the Faculty of Architecture. He graduated in 1997 on his thesis about *Living, Working, and Mobility*. After his graduation project, Remon worked for three months at the Cantho University in Vietnam designing and planning a new university campus.

At the end of 1997, he started to work as a PhD student at the Spatial Planning chair of the Faculty of Architecture, Delft University of Technology, participating in the Seamless Multimodal Mobility programme of the TRAIL research school and the Design Studio The Network City VROM of the Faculty of Architecture. During his PhD period he got interested and involved in research topics such as the urbanism of networks, the design and planning of the Network City, urban transformation processes, Geographical Information Systems, activity-travel behaviour of people, multimodal transport, demand-responsive transport services, and the mobility of older and disabled people. In this period, he attended several (inter)national conferences where he presented his work to a broad audience. Furthermore, his work resulted in a number of papers, articles, and reports.

Since 2002, Remon has worked for the Spatial Planning chair as Assistant Professor (Universitair Docent). Besides his research work, he gives courses and supervises student projects on spatial planning, GIS, programming research, design strategies for so called ‘problematic city districts’ and participates in the research lab Urban Transformations. Since 1999, he has also been member of the works council of the Faculty of Architecture.

In his spare time, Remon is gymnastics trainer/coach of talented boys in Pijnacker (Oliveo Gymnastiek) and in Rotterdam (SDS / Rotterdam Topturnen). At least five times a week, he can be found in the sports centre in Pijnacker or in Rotterdam.

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