Privatizing Road Asset Management

How private companies can contribute to road asset management in the Netherlands
Privatizing Road Asset Management

*How private companies can contribute to road asset management in the Netherlands*

Árni Freyr Stefánsson

Student number: 1284479

May, 2008

Committee:

Prof.ir. Frank Sanders

Delft University of Technology, Transport and Planning section

Ir. Rob Snijders

Arcadis

Prof.dr. Bert van Wee

Delft University of Technology, Transport Policy and Logistics section

Ir. Paul Wiggenraad

Delft University of Technology, Transport and Planning section
Preface

This thesis is the result of the research project undertaken in order to obtain the degree of Master of Science at Delft University of Technology. Since 9th of July 2007, the research was done in cooperation with Arcadis.

In this report the inclusion of a private operator into road asset management for the Netherlands has been studied. This was done by studying road asset management around the globe as well as analyzing both contractual matters and road assets.

I would like to thank the members of my graduation committee; Prof.ir. Frank Sanders, Prof.dr. Bert van Wee and ir. Paul Wiggenraad of the Delft University of Technology and ir. Rob Snijders of Arcadis, for their support and feedback during the past months.

I would also like to thank Pieter Miltenburg and Martin Cornelisse or Rijkswaterstaat and Hans Bruinsma of Grontmij for finding time to discuss road asset management in the Netherlands with me and Hans Bruinsma then especially for giving a valuable feedback in the validation of the framework. Órsteinn Órsteinnsson of the University of Iceland does also deserve credit for his help. I would like to thank Trudie Stoute-Van de Gaarde, Yvonne Sagarakis, Irene Planken, Leandra Koolhoven, Bianca Kerkhof and Debbie Groenewegen for their patience and helpfulness when it came to arranging meetings.

Coming to the Netherlands to conduct my masters-study was a big decision in my life. In short it exceeded my brightest expectations. The quality of TU Delft as a research institution astounded me and the Dutch society is very much of my liking. Although I have chosen to return back to my place of birth, my connection with the Netherlands will always be strong. I would like to salute all my teachers, co-workers, housemates and friends who contributed to making this stay both successful and enjoyable. I would like to end this preface by crediting my family for always supporting me and thus enabling me to move abroad to learn new things.

Delft, 12th May 2008

Árni Freyr Stefánsson
Index

Preface .................................................................................................................. v
Index ...................................................................................................................... vi
List of figures ......................................................................................................... ix
List of tables .......................................................................................................... xi
Abstract ................................................................................................................ xii
1 Introduction ........................................................................................................ 1
  1.1 Asset Management ......................................................................................... 1
    1.1.1 Introduction ............................................................................................ 1
    1.1.2 Benefits of asset management ............................................................... 1
    1.1.3 Requirements of an asset management system ..................................... 2
    1.1.4 Conclusions .......................................................................................... 6
  1.2 Research Goal ............................................................................................... 6
  1.3 Methodology ................................................................................................ 8
2 Institutional organization .................................................................................... 12
  2.1 Introduction .................................................................................................. 12
  2.2 The Netherlands ........................................................................................ 12
  2.3 International overview of road asset management organization ............... 15
    2.3.1 USA ....................................................................................................... 15
    2.3.2 Australia ............................................................................................... 16
    2.3.3 New Zealand ......................................................................................... 17
    2.3.4 England ............................................................................................... 19
    2.3.5 Austria ................................................................................................. 21
  2.4 Lessons learned ........................................................................................... 22
  2.5 Allocation of responsibilities ....................................................................... 26
  2.6 Conclusions ................................................................................................ 31
3 Contracting .......................................................................................................... 35
  3.1 Introduction .................................................................................................. 35
  3.2 Risk analysis ................................................................................................. 35
  3.3 Incentives ..................................................................................................... 38
    3.3.1 Minimum standards .............................................................................. 39
    3.3.2 Bonuses and penalties .......................................................................... 39
    3.3.3 A simple minimum standard incentive scheme ..................................... 40
    3.3.4 The private firms initiated incentive scheme ....................................... 40
    3.3.5 Origin of incentives .............................................................................. 42
    3.3.6 Incentive usage ..................................................................................... 43
  3.4 Contract length ............................................................................................. 44
  3.5 Contract end ................................................................................................ 47
    3.5.1 Premature termination of a contract ..................................................... 48
  3.6 Conclusions ................................................................................................ 49
4 Asset analysis ..................................................................................................... 53
4.1 Introduction ........................................................................................................... 53
4.2 Technical assets .................................................................................................... 54
  4.2.1 Introduction ..................................................................................................... 54
  4.2.2 Analysis .......................................................................................................... 54
  4.2.3 Performance measures / minimum standards .................................................. 56
  4.2.4 Contract inclusion .......................................................................................... 62
4.3 Functional and environmental assets ..................................................................... 63
  4.3.1 Travel time ...................................................................................................... 63
  4.3.2 Reliability ........................................................................................................ 69
  4.3.3 Safety ................................................................................................................ 73
  4.3.4 Air pollution emissions .................................................................................... 76
  4.3.5 Runoff pollution and hydrological impacts ....................................................... 80
  4.3.6 Noise pollution ................................................................................................ 82
  4.3.7 Environmental public goods .......................................................................... 85
4.4 Asset relations........................................................................................................ 87
4.5 Conclusions ........................................................................................................... 90

5 Framework .............................................................................................................. 95
  5.1 Introduction ........................................................................................................ 95
  5.2 Pre-contract phase ............................................................................................... 96
  5.3 Contracting phase ............................................................................................... 97
  5.4 Contract phase ..................................................................................................... 105
  5.5 Contract end phase .............................................................................................. 106
  5.6 Test Case Contract .............................................................................................. 106

6 Conclusions ............................................................................................................. 119
  6.1 Main conclusions ................................................................................................. 119
  6.2 Key findings ........................................................................................................ 120
    6.2.1 Benefits of road asset management ............................................................... 120
    6.2.2 Benefits of having a private operator ............................................................. 120
    6.2.3 Privatized road asset management in the Netherlands .................................... 121
    6.2.4 Contractual issues ......................................................................................... 124
    6.2.5 Asset analysis ............................................................................................... 127
  6.3 Validation of the framework ................................................................................ 130
  6.4 Discussions ......................................................................................................... 135
    6.4.1 Methodology ................................................................................................ 135
    6.4.2 Robustness of conclusions .......................................................................... 136
  6.5 How to continue .................................................................................................. 136

References .................................................................................................................. 139
  Literature ................................................................................................................ 139
  Websites .................................................................................................................. 145
  Interviews ............................................................................................................... 146

Appendix 1: Measures to affect asset quality ............................................................... 147
Appendix 2: Argentinean performance indicators and penalties .................................. 153
Appendix 3: RWS performance measures .................................................................... 154
Appendix 4: Wang and Chou's method of identifying contractual risks ......................... 156
Appendix 5: Glossary of terms ................................................................. 158
Appendix 6: An example of DR-calculation ........................................... 165
Appendix 7: Air pollution emission types and their impacts ..................... 167
List of figures

Figure 1.1: Procedures undertaken within an asset management system (OECD, 2000) ......3
Figure 1.2: The Life-Cycle approach to asset management (Austroads, 2002) .........................4
Figure 1.3: Integrated asset management processes flow diagram (Austroads, 2002) ..............5
Figure 1.4: This figure shows how the scope of the chapters narrows, from talking about road asset management in general, down to analyzing the specific Dutch road-assets themselves. 9
Figure 2.1: the current process of road asset management in the Netherlands .....................13
Figure 2.2: Organizational structure for transport in New Zealand (NZ Ministry of Transport, www.transport.govt.nz) .................................................................18
Figure 2.3: The ASFINAG scheme of road cost accounting (Blindenbacher, 2005) .............22
Figure 2.4: The current (left) and a new (right) institutional organization of road management ..........................................................25
Figure 2.5: Allocation of road funding in the UK in 2005-06 (Highways Agency, 2006) .......26
Figure 2.6: A simple example why traffic management needs national overview (Miltenburg, 2008) ................................................................................28
Figure 2.7: The life-cycle approach to asset management, with the roles assigned to the specific actors ..........................................................33
Figure 3.1: Construction cost indices used by US road authorities (www.wsdot.wa.gov) ......38
Figure 3.2: The private operators' initiated incentive scheme mechanism (Vassallo, 2007)...42
Figure 4.1: Some of the technical assets of the road (Knox City Council, 2007) ...................54
Figure 4.2: The International Roughness Index (Sayers et al., 1986) ..............................57
Figure 4.3: Different types of pavement distress. Clockwise from the left-top is spalling, raveling, rutting and finally, shoving (training.ce.washington.edu/wsdot) ..........58
Figure 4.3: Congestion severity per month in the Netherlands in 2003 and 2004 (AVV, 2004b) ....65
Figure 4.4: Example of a fundamental diagram with discontinuity ........................................66
Figure 4.5: Illustration of a one-tailed test. The unacceptable travel time is the shaded area. ..........................70
Figure 4.6: Factors influencing the reliability of travel times (not exhaustive) (van Lint et al., 2008) ..........................................................................................................................71
Figure 4.7: Typical vehicle emissions by speed (Transportation Research Board, 1995) .......78
Figure 4.8: An Ecoduct on the A50 highway near Woeste Hoeve (nl.wikipedia.org) ............86
Figure 4.9: The relations of the prime road assets .................................................................88
Figure 4.10: Safety's relations. Actions taken to increase traffic safety often cause other externalities. .................................................................89
Figure 4.11: As traffic demand closes in on road capacity, average speeds go down. ...........90
Figure 5.1: The different time phases of the framework ........................................................95
Figure 5.2: The "Delft Network". Highways A4, A13 and A20 forming a ring around Delft. 107
Figure 6.1: The institutional organization and allocation of roles within the privatized road asset management scheme. ................................................................. 122
Figure A.1: Electronic road tolling equipment in Florida ........................................... 148
Figure A.2: In-pavement flashing devices, separating lanes .................................... 150
Figure A.3: Risk allocation by contract clauses (Wang and Chou, 2003) .................. 156
List of tables

Table 3.1: Ranges of life-cycles of road assets in road agencies in Australia and New Zealand (Austroads, 2003b) ................................................................. 45
Table 4.1: Depreciation of technical assets of the New Zealand highway system (Transit NZ, 2007a) ................................................................. 55
Table 4.2: Rating factor, d, related to severity and frequency (Gerber and Hoel, 1999) .... 59
Table 4.3: Congestion figures for Dutch motorways in 1995 (Bovy, 2001) ......................... 64
Table 4.4: Air pollution costs in the USA (2007 Euros per ton) (Wang and Santini, 1994) .... 79
Table 4.5: Maximum allowed noise levels in the Netherlands (www.overheid.nl) .......... 84
Table 5.1: Rating factor, d, related to severity and frequency (Gerber and Hoel, 1999) ..... 109
Table 5.2: Maximum allowed noise levels in the Netherlands (www.overheid.nl) .......... 111
Table A.1: Performance indicators and penalties in Argentina (Austroads, 2003a) ............ 153
Table A.2: Observed distress characteristics for the road segment ................................ 165
Table A.3: Rating factor, d, related to severity and frequency (Gerber and Hoel, 1999) .... 165
Table A.4: Rating factors and distress-types’ weights ................................................... 166
Table A.4: The various types of vehicle air pollution and their impacts (Litman, 2007) .... 167
Abstract

Rijkswaterstaat is currently looking at innovative ways to manage the Dutch highway system and increase its quality. One of these ways is the study of how asset management can be introduced to the management of the road infrastructure. Rijkswaterstaat is not the first road agency to consider road asset management as agencies in New Zealand, England, Australia and USA have already been studying and implementing it for some time.

A private company, Arcadis, is very interested in being an active participant in road asset management in the Netherlands. They are looking at ways in which they could contribute to the process, especially as operators of a road network. As the Dutch transport authority has traditionally been public, the involvement of a private company in the process presents some important questions. The public policies regarding mobility, safety and environmental quality must not be marginalized while the technical assets of the road network must stay in an acceptable condition. This brings us to the research goal of this thesis, namely: “How a private company can be contracted to best fit into the framework of road asset management and to establish the most important factors for such a contract?”

The problem is approached stepwise. First of all the concept of asset management is introduced and explored. Examples from its use for the management of road infrastructure around the globe are studied. Secondly the current institutional organization of road management in the Netherlands is studied and compared with ones from abroad, resulting in a new institutional organization for privatized road asset management for the Netherlands.

Following this the relationship between the private operator and Rijkswaterstaat is studied. Necessary components in a contract between them are analyzed. Finally the road assets themselves are analyzed with relation to how they can be fitted into the privatized road asset management contract. The end-product of the thesis is then the “framework”, where the conclusions and findings of the preceding chapters are brought together to create a framework for the implementation of privatized road asset management in the Netherlands.

The thesis found clear evidence that road asset management has lead to cost savings and other improvements. Highway maintenance costs in New Zealand have reduced by some 17% per annum. At the same time the value of highway assets increased steadily and safety measures managed to reduce accidents by 70% at treated sites. Furthermore both the English and New Zealand road agencies have found that the increased integrity and transparency of their road assets has helped them to get extra funds from the government to conduct important maintenance work. Both these countries have private operators, similar to
the ones that this thesis is suggesting. To further support the inclusion of a private operator the thesis found that private companies are generally much better contract handlers than the government. Evidence from industry indicates that bidding for government contracts is typically 10-50% more expensive than bidding for comparable private contracts. These excessive costs then work as deterrents for possible bidders. Furthermore private companies find it easier to keep hold of its key personnel.

The thesis demonstrates that through innovative contracting, Rijkswaterstaat should be able to employ a private operator to work as a road asset manager for a regional network of highways without losing control of it at the same time. To do so however, Rijkswaterstaat must prepare the ground by establishing minimum standards, performance measures and last but not least a central asset database. Private companies then compete for the contract to manage a road network under the boundary conditions previously set by Rijkswaterstaat. The thesis discussed how incentives could be used to stimulate innovation in all fields of traffic, especially for functional and environmental assets. This would then lead the operators to work not only as infra-providers but also as traffic managers. The incentives are then structured so they would best serve the users and the quality of the assets. This is done by earmarking bonuses and penalties to individual regions as well as conditioning part of the bonuses to be invested back into the infrastructure. Every contract starts with the new operator relaying the pavement surface on his road network. The contract length was the set to depend on the time which the operator was willing to promise as an effective lifetime of his pavement surface. To ensure high performance till the very end of the contract a “carrot” is set at its end in the form of monetary bonus and a possible contract extension.

The thesis explores all relevant technical, functional and environmental assets which should be part of the road asset management scheme. They were analyzed from a contractual point of view, i.e. how they could be measured and fitted into the contract. This analysis showed that not all assets can be treated the same way in the contract and minimum standards and incentives should be thought out for each and every one specifically. The technical assets are mostly protected by minimum standards while the functional and environmental assets also offer bonuses for innovative improvements.

The framework at the end of the thesis is this thesis’s contribution to the industry. The framework is designed to maximize the possible contribution a private company could provide in the implementation of privatized road asset management in the Netherlands. That means that competitive performance is stimulated, but at the same time societal goals are protected. The framework is based on the findings of the whole analysis and can be used as a roadmap by both Rijkswaterstaat and a private operator in the implementation of road
asset management in the Netherlands. Although it sets clear lines for the actors it also makes clear that privatized road asset management is not a one time thing. It is a process of constant improvements and learning and is thus constantly reinventing itself, for the benefit of society.

The robustness of the conclusions of this thesis differs somewhat. For some of them a strong theoretical background as well as proof from practice created a solid basis for the conclusions. This applies especially to the institutional organization, contract length and the technical assets performance measure. In others the conclusions were more an elaboration or ideas based on a literature base. This applies especially to most of the conclusions regarding the incentives, functional and environmental performance measures as well as the risk allocation. Only by implementing privatized road asset management, as it is described in the thesis, could a definite practical proof be attained for these aspects.

Glossary of terms used in the thesis can be found in Appendix 5.
1 Introduction

Road infrastructure represents one of the most precious assets existing in most societies. Their importance to any society is immense, as the mobility it provides is one of the most important pillars to the economy (Garber and Hoel, 1999). Road agencies all over the world are largely responsible for maintaining, operating and improving these assets. At the same time, both financial and human resources needed to achieve the goals are scarce and must thus be managed carefully. As an example, road administrations in Canada, USA, UK and local governments' councils in Australia face formal accountability and reporting requirements on how they manage their assets (OECD, 2000). The Netherlands are no exception in these matters. Rijkswaterstaat is considering many ways of how they can increase the quality of their infrastructure. They have designed four pilots, so called PIM's (Partnerprogramma Infrastructuur Management). One of these pilots is introducing asset management into handling of the road infrastructure (de Wolf et al., 2005).

1.1 Asset Management

1.1.1 Introduction

Asset management is described by The Organization for Economic Cooperation and Development as "A systematic process of effectively maintaining, upgrading and operating assets, combining engineering principles with sound business practice and economic rationale, and providing the tools to facilitate a more organized and flexible approach to making decisions necessary to achieve the public's expectations" (OECD, 2000). In other words, that means that asset management is a tool for both public and private companies to ensure that their facilities are maintained and operated without jeopardizing their profits or wasting taxpayers' money. It represents a step beyond the traditional engineering-oriented approach of managing the infrastructure and utilizes economic theory and business oriented practices (Stalebrink and Gifford, 2005).

1.1.2 Benefits of asset management

Asset management benefits its users and stakeholders in a number of ways (Stalebrink and Gifford, 2005) (Fwa, 2006).

- Enhanced cost-effectiveness and efficiency in managing the road network are usually mentioned as the main reasons for implementing asset management.
- Increased accountability of the state of the road network. A comprehensive and well updated database about the state of the road assets increases their accountability and transparency. This can, for example, lead to capital markets offer increased access to capital at lower rates.

- Asset management should enhance the understanding of the results of the actions taken or postponed on the network.

- Asset management should increase the transparency of the actions of the operator. The transparency increase is due to the implementation of standardized and simplified measurement and presentation of information.

### 1.1.3 Requirements of an asset management system

The main purpose of asset management is to allow managers to take the best decisions with respect to the assets at each time. It’s a continuous cycle of planning, doing, monitoring and evaluating work and then using that knowledge to improve future planning. Thus the first element of asset management is planning. The planning must take into account policies, budget and goals and objectives of the road authorities. The plans are then translated into actual work. The progress of the work is then constantly monitored and compared with the original plans. The experiences and lessons learned from this are then used to aid future planning and to improve the understanding of the stakeholders of the state of the system. It’s clear that the success of asset management relies heavily on the data as it forms the basis of the whole methodology (Stalebrink and Gifford, 2005). It’s integrity and reliability is thus of essence as well as it is fundamental that the right kind of data is being collected. Figure 1.1 shows asset management according to OECD. The four steps between “data” and “implementation” explain a typical planning phase in more detail.
Figure 1.1: Procedures undertaken within an asset management system (OECD, 2000)

Australia and New Zealand are among world pioneers in infrastructure asset management development (Federal Highway Administration, 2005). Their research institute, Austroads, has developed the so-called "life-cycle approach" to road asset management, where these tools of asset management are fully fitted to the needs of the road network.

**Life-Cycle approach to asset management**

The life-cycle approach to asset management is a further elaboration of the concept of asset management to fit the road network. It is defined as "a process for ensuring the requirements of road agencies, road users and other stakeholders are clearly understood and integrated into an asset management framework that optimizes the outcomes achieved from policy and investment decisions" (Austroads, 2002).
Figure 1.2: The Life-Cycle approach to asset management (Austroads, 2002)

Figure 1.2 represents the life-cycle approach to asset management. As one can see there are two circles of physical actions and strategic activities that encircle the main goal of achieving the agreed level of service at minimum life-cycle cost. The physical actions (yellow circles) includes the creation of the road, its operation and maintenance, possible rehabilitation and renewal and finally the road asset disposal or rationalization, which would occur if the road asset was no longer needed or wanted. The pink boxes represent the strategic circle and include the monitoring of the assets, the audit, management review and the strategic planning phase. Figure 1.3 further explains the processes necessary for the road asset management system.
The system is split into 7 phases. The first phase deals with the need of the road agency to define its objectives. To do so it must have knowledge of the situation of all stakeholders of the road network, this includes public institutions, businesses and the general public. The second phase is where the road agency translates the objectives into strategic plans. These strategic plans deal with road use (the level of service that will be provided) and infrastructure (the way in which the specific asset of the road will be planned and managed to achieve the level of service stated in the road use plan). In phase 3 the road agency must define the asset requirements and minimum standards. This involves defining the level of service as well as setting minimum quality standards for technical (and even functional and environmental) assets. Problematic areas which don't fulfill the minimum standards are identified and quantified. And finally there should be a formal process of community consultation. Phase four is where the operator should assess what is needed to address the problematic areas. He should also try to optimize and prioritize the gaps which are addressed, as in many cases there might be shortage of funds or other means which are necessary for the maintenance work. Phase five is where the work is done. It should follow the strategic plans made before and be continuously monitored to ensure asset accountability.
and the overall project process. In phase six the audit is carried out. This is where the actual outcome of the work done by the operator is compared with the original plans. The final phase is where the knowledge gathered from the audit is used to give feedback to those responsible for the strategic planning, minimum standards and stakeholder objectives.

1.1.4 Conclusions

Asset management is being explored as a means to address the challenges of road administrators world-wide. Austroads’ Life-Cycle approach is not the only approach, but it’s a very good example of how road asset management should be conducted. Every road agency which would like to implement asset management would have to address it independently to make it best fit to its circumstances. However, although the approaches might differ, the basic principles of asset management would always have to stay the same as they are all interdependent.

The success of road asset management relies heavily on a central database on the condition of the assets. However, the biggest challenge faced by every agency is how to select the data that is supposed to go into it. How we can get the clearest picture of the true state of the assets. The better we realize the performance of the operator and the condition of the assets, the better the feedback to the strategic planning phase and so on. The asset management cycle is a continuous cycle of improvement and should benefit society greatly in the long run.

1.2 Research Goal

The Dutch road administration is currently contemplating on how they can implement asset management into their road management (de Wolf et al., 2005). The engineering company Arcadis is interested in participating in this revolution as active participants. They are looking at ways in which they could contribute to the process and then especially as operator of a road network. As the Dutch transport management has traditionally been public the involvement of private company in the process poses some important questions. The public policies regarding mobility, safety and environmental quality must not be marginalized while the technical assets of the road network must be in acceptable condition. This brings us to the research goal of this thesis which is: "To find out how a private company can be contracted to best fit into the framework of road asset management and to establish the most important factors to such a contract".

The main research goal is vast and full of uncertainties and to clarify it better a few sub-questions should be established.
1. As the main research goal implies, the aim is to study how a private company A new actor in the road asset management structure means that the current institutional organization must be updated. “What will be the roles of the actors in that new organization?”

2. As the involvement of the private enterprise in road asset management increases the public authority will loose a lot of its direct control over things relating to the transportation network. It must, however, not loose its knowledge and overview of what is happening. The same applies to other authorities and stakeholders. Performance and condition of assets should be regularly reported by the operator. These reports should then be validated by an independent authority. “Who should be consulted and how should the reporting be done?”

3. A multi-year road asset management contract will inevitably experience a lot of changes during its lifetime. Changes in transport behaviour, city planning and environmental restrictions due to international commitments, could all change the initial situation. The manner in which the contracting is done can either help or hinder the addressing of these changes. “How can the contract deal with future developments?”

4. The contract length can have considerable effect on the success of the contract. According to literature short contracts tend to be better for competition. They, on the other hand, are likely to reduce the incentive for investment. Longer contracts are better for investment but can in some cases give the contract holder a monopoly power over the market (Nash, 2005). Longer contracts also incorporate more risks because of uncertain future developments as is discussed in previous question. In any case there are different viewpoints of what contract length is optimal. Therefore the fourth sub-question is: “What is the optimal contract length?”

5. First of all the technical, functional and environmental assets must be identified. Most of them are interrelated in one way or another, thus the condition or performance of one could affect another. These interrelations must be clear in order for the asset management structure to be transparent and increase the capabilities of identifying, fixing and possibly preventing problems. Thus the first sub-question is: “What are the assets and how are they interrelated?”

6. The assets are all of certain value. The RAM-contract should at least guarantee that this value does not decrease and, optimally, result in its increase. But how can one monitor the value of assets such as pavement, travel time and safety? The answer to
that is to utilize a set of indicators that measure the quality of the assets. But what are the indicators? The second sub-question is therefore: "What are the indicators that best demonstrate the true state of the assets?"

7. Roads are essentially natural monopolies. This has caused some to worry that if their management is private, their quality will eventually decline. That profit seeking of a private operator would lead him to discard important societal issues such as safety, travel time and pollution (Nash, 2005). These, along with more questions are valid arguments against private operation of the transport system. Privatization in the transport sector has not always yielded in positive results (Crompton and Jupe, 2003). A vital research question is thus: "How will the level of service and other societal goals be safeguarded or, better yet, improved in a privatized road asset management scheme?"

1.3 Methodology

The subject of asset management for roads is a relatively new one. Only a handful of countries possess any experience in it although many more are interested in exploring its possibilities. Studying the subject will require first and foremost an extensive survey of those experiences which have been recorded to date accompanied by reviewing literature relating to the subject. To gain insight into the Dutch situation the main focus will be on interviewing professionals within the Dutch road management structure which possess knowledge of the institutional and management part as well as the actual maintenance and operational work.

The thesis is built up in four main chapters:

- The first chapter is the introduction. This is where the concept of asset management is introduced and explained why and how it being applied for road infrastructure. This then leads up to the research goal and the methodology with which the research goal will be studied.

- The second chapter is the institutional organization. In this chapter the institutional organization of road asset management in the Netherlands is introduced, followed by a survey over how it is conducted elsewhere in the world, with a special focus on countries which conduct their road management in innovative ways.

- The third chapter further studies the relationship between Rijkswaterstaat and the private operator (the contract). This covers issues like allocation of risks, incentives,
contract length as well as studying issues that surface when a contract is nearing its end.

- The third chapter is the asset analysis. This chapter analyses the technical, functional and environmental assets of the road network. They are introduced for what they are, ways in which they can be measured is discussed and finally their inclusion in the asset management contract is addressed.

- Chapter four is the final chapter. This is the "Framework", or where the complete findings of the thesis are brought together to create a framework for road asset management in the Netherlands.

Figure 1.4: This figure shows how the scope of the chapters narrows, from talking about road asset management in general, down to analyzing the specific Dutch road-assets themselves.

The scope in these chapters differs. The chapter which is now nearing its end (chapter 1) is an introduction into road asset management in general and thus its scope is universal. The second chapter is aimed at studying how asset management should be organized in the Netherlands, by looking at the Dutch situation as well as surveying what is done elsewhere. The third chapter further narrows the scope to the relationship between Rijkswaterstaat and the private operator. The fourth chapter then analyses the assets themselves. The fifth chapter then wraps things up and establishes the framework of implementing road asset management in the Netherlands. Through this the seven sub-questions of the research goal will find its answers.
The first question, "What will be the roles of the actors in the new organization?" is directly related to the contents of chapter 2. To answer this question the current organization of the Netherlands needs to be known and this must be followed up by an international survey of how it is elsewhere. The literature on the institutional organization of road management in the Netherlands is a bit obscure and is mostly in Dutch. Therefore, besides trying to assemble as much information as exists in English, professionals within Rijkswaterstaat will be interviewed and quizzed specifically on this subject. Through literature research, information about institutional organization elsewhere in the world will be assembled. Through knowing the pros and cons of the current Dutch organization and learning from the best practices of abroad, a new organization will be made.

The second question, "Who should be consulted and how should the reporting be done?" relates to the first one and is basically about how stakeholders, who are not directly involved in the day-to-day operation of the road can still, be aware of what is happening. Therefore the same methodology is used, i.e. ask the professionals at Rijkswaterstaat about the current state here in the Netherlands and then use knowledge from the international literature review to make a proposal of how it could be enhanced to fit into the new institutional organization.

The third question, "How can the contract deal with future developments?" is closely related to the subject of contract length and contract risks. The future developments are, in essence, the risks of the contract and the longer the contract is, the less we know about or can predict about the future. The conclusions of those chapters will thus shed some light on how the contract is supposed to be able to handle the future. The methodology used in these chapters is predominantly a literature research in the field of contract science.

The fourth question, "What is the optimal contract length?" is, as was demonstrated before very closely related to question three. However, the contract length is not only about dealing with risks. Other issues that are also important are how the length can contribute to the success of the asset management scheme as a whole. Therefore contract length examples from other countries will be studied as well as general theory on contract length.

The fifth question is "What are the assets and how are they interrelated?" This question is the main focus of chapter four. What is traditionally associated with the road assets, the technical assets, will be analyzed first, followed by an analysis of the
functional and environmental assets. The number of specific technical assets on the roads is very high but there is also considerable experience existing in how they are managed. Therefore for technical assets the main focus is on how they are addressed elsewhere, along with input from research literature. The functional and environmental emphasis of Rijkswaterstaat will serve as the criteria for choosing which functional and environmental assets will be incorporated in the scheme. These assets will then be analyzed by studying literature and experiences from elsewhere. The relationships between the assets can be studied and elaborated when all the assets have been analyzed independently.

- The sixth research question is "What are the indicators that best demonstrate the true state of the assets?" This question finds its answer within the asset analysis. The assets are affected by many different things so the indicators must be clear in the way that there is a direct link between action and outcome. That we know the state of the asset and also understand why the state is as it is. The experiences with road infrastructure related performance indicators will be studied. Learning from the asset analysis itself will also help in deciding on which performance indicators fit to this system best.

- The last research question "How the level of service and other societal goals will be safeguarded or, better yet, improved in privatized road asset management scheme?" is answered first of all by studying incentives and secondly in how incentives can be used on the assets themselves. Therefore the problem is in fact discussed in both chapter three and four. The study of the incentives is partly one of looking at existing incentives and partly an academic literature study. Because this thesis is looking at a new way of road asset management it is not enough just to look at what others are using as incentives, the academic background of incentives must be studied as well. In the asset analysis the incentives will then be suited to each asset, depending on what is suitable each time.
2 Institutional organization

2.1 Introduction

Institutions are essential to society as they provide it with a basic level of justice and equity. They also matter when transaction costs are high. Transaction costs occur because of various reasons, such as the search for a supplier, negotiating the worth of what is being exchanged and the enforcement of agreements. The importance of institutions is that they provide the framework where those transactions can be valued (Rietveld and Stough, 2004).

This chapter will begin by introducing the current institutional organizational environment in the Netherlands, as well as introducing which steps have currently been taken towards road asset management. This is then followed by a section where the institutional organization around road asset management is conducted elsewhere in the world, with a special focus on countries which have already implemented road asset management or are managing their infrastructure in innovative ways. Finally allocation of responsibilities is elaborated. All put together it should show how a new institutional structure of road asset management as well as making it clear what roles each actor will have.

This chapter should shed light on research questions one and two. In other words, when the reader has finished reading these pages he should be clear about what roles each actor has in the new privatized road asset management organization (question 1). He should also know how those stakeholders, who are not involved in the day-to-day running of the road network can still, be involved in the total process as well as being aware of the condition of the assets as well (question 2).

2.2 The Netherlands

The Dutch road infrastructure is owned and controlled by the public authorities and public institutions. The public authority works under a national transportation plan called Nota Mobiliteit. Its principles are (van Zuylen, 2007):

- Mobility demand and growth of mobility are accepted
- Travelers have to pay for mobility
- The first instrument for improving traffic conditions is a better utilization of the existing infrastructure but, where deemed necessary, the infrastructure will be extended.

- Utilization of existing infrastructure should be done on a regional scale with cooperation between different road authorities.

- The goal of better utilization should not only be to reduce congestion but also to increase the reliability of travel times.

- Public-private and public-public partnerships to improve traffic conditions.

These goals all emphasize the need for a greater accountability and efficiency of the road infrastructure. To this date the public authority and Rijkswaterstaat have taken some steps towards a more business-like model. In 2006 Rijkswaterstaat was transformed from an institution to an agency. This was meant to better enable it to interpret the wishes of its environment. It was also meant to stimulate a greater professional scope within long-range planning and to seek a balance between customer focus and value for money. Following this Rijkswaterstaat started to study asset management as well as introducing the so called Service-Level-Agreements (SLA) (de Wolf et al., 2005).

![Diagram]

**Figure 2.1: the current process of road asset management in the Netherlands.**

The SLA is an agreement between the Ministry of Public Works and the top management of Rijkswaterstaat. The top management of Rijkswaterstaat then translates this SLA contract to its regional divisions. These regional divisions use the SLA contract to formulate their own work plans. The work plans are detailed description on how they are going to fulfil the conditions of the SLA. The regional divisions have to report on their performance four times a year. The information from these reports is used to audit existing plans and to give the
Ministry advice to help them with the formulation of the SLA for the following year. Rijkswaterstaat must lobby for funds at the Ministry of Transport which are usually lower than they need to be. There are no earmarked taxes in the Netherlands; all taxes related to transport thus go into the common Treasury, which then redistributes according to the goals and objectives of the public authorities at each time (Miltenburg, 2008). A thing that complicates things like life-cycle management of the Dutch roads is that there are many institutions with stakes in the system. This means that the department responsible for pavement maintenance is in little or no connection with those that analyse traffic safety. Their agendas then conflict, as one doesn’t know what the other ones plans are. This can then lead to wasting of money or unnecessary extra traffic delays on the highways (Bruinsma, 2008)

There are great ambitions within the agency to implement asset management to improve the efficiency of their resources in operating and maintaining the road infrastructure. Some steps have already been taken in that direction and 6 technical and 2 functional performance measures have been defined to inspect the state of affairs in all the Dutch regions every 4 months. The choice of these measures is debatable and some think they are not ambitious enough (Cornelisse, 2008). Maintenance has already been outsourced as well as detailed design. However, Rijkswaterstaat remain as supervisors over both tasks. Customer satisfaction is already monitored, and has a minimum standard of 75% of answerers being satisfied (Cornelisse, 2008) (see Appendix 3). All new major constructions are however not part, and will not likely be part of the asset management since those need legal permission and special funding (Miltenburg, 2008).

The Netherlands are hesitating in allowing the private sector to enter into the management of their infrastructure. They are, however, facing big problems in their approach. Rijkswaterstaat’s budget is politically decided and hence their managers have to look to the politicians in their quest for funds. Future predictions in Zuid Holland on the development of performance measures even foresee a steady decline in pavement quality until 2012 (see Appendix 3). The politicians often have their own agendas which are not for the best interest of the quality of the infrastructure. Such agendas could be flashy constructions right before elections rather than important maintenance. Rijkswaterstaat is currently under-funded and is facing troubles in 4 years, when a foreseeable costly maintenance work is needed, as it doesn’t have the necessary funds for it (Miltenburg, 2008). One of their strongest arguments against private participation in the road asset management is that the private sector could not handle what Rijkswaterstaat barely handles, that all the amount of information and technical specification regarding the network would overwhelm a private company. They also
claim they would not be willing to outsource something that they had not fully grasped
themselves, “if you outsource chaos, you get chaos back” (Miltenburg, 2008).

2.3 International overview of road asset management organization

The international overview is supposed to shed light on how road asset management is
organized around the globe. The choice of countries selected to view were USA, England,
Austria, New Zealand and Australia. The reasons for these choices are based on a number of
factors. First of all it was apparent after studying available information on the subject that
USA, England, New Zealand and Australia are all deeply involved in road asset management
and have already implemented it to a large extent into their organizational structure.
Austria was added after being suggested as an interesting example of road administration at
a committee meeting (7th of January). Furthermore the availability of information from these
countries was important as well as the fact that they represent different parts of the world
(three continents).

2.3.1 USA

The Federal Highway Administration in USA is the institution under the department of
transport that is responsible for the quality of the roads. Although most of the US highways
are owned by state, local and tribal governments, the FHA provides financial and technical
support to them for construction, improvement and maintenance. The annual budget is $30
billion and is funded by earmarked fuel and motor vehicle taxes (www.fhwa.dot.gov). Each of
the 50 US states operates their own transportation agency, which is responsible for planning,
building, operating and maintaining the highway system (Garber and Hoel, 1999). In times
of steadily increasing traffic demand the states have been addressing the problem in a
number of innovative ways. Many road agencies have been designing management systems
to help their decision making process on issues like safety, efficiency and technical quality of
the infrastructure (Fwa, 2006). An example of that is the State of Virginia. The
Commonwealth Legislation of Virginia enacted legislation in 1995 to authorize PPP’s (public-
private partnership) to build, operate and maintain transport facilities by approval of the
Department of Transportation. By doing this, Virginia became a pioneer by allowing private
contractors to submit unsolicited proposals for maintenance and construction on their
highways (JLARC, 2001). A private maintenance contractor, VMS Inc., sent a proposal to
take over the maintenance and operation of a large part of the Interstate highway system for
five years for a fixed amount. This arrangement proved to be successful and allowed the Department of Transport to save money. The contract was then extended for a further five years in 2002 (Pinero, 2003). VMS has since then taken over the maintenance and operation of more roads in both Florida and Texas (www.vmsom.com).

Others have been introducing more private participation in the infrastructure. Examples of privately built toll-roads are the Dulles Greenway in Virginia, the 91 Express Lanes in Orange County, California and the Chicago Skyway (Samuel and Poole, 2005)(Engel et al., 2006). These roads are additions to the remaining state highway system and have limited access. The Dulles Greenway was built as a second connection between Dulles International Airport and Leesburg, Virginia. The road was supposed to compete with the congested Route 7. However, the project proved unsuccessful since the investors had underestimated how much the commuters disliked paying tolls. Another thing that worked against their interest was the State’s decision to widen the free Route 7, thus easing the traffic situation there. The 91 Express Lanes is a different story though. They were built with the same purpose of easing the congestion on the free remaining State highway. The company is allowed to raise tolls freely and thus always maintaining a free flow. The problem is that in the original contract the State agreed a non-compete rule which restricted them from widening the State highway. That has limited the State to deal with rising traffic demand and the congestion on the free highway has grown worse (Engel et al., 2006).

2.3.2 Australia

The institutional organization of the road sector in Australia is in many ways similar to the one in USA. The states own and operate their own road systems while the Commonwealth distributes grants for a designated use on the Australian highway system (Dowcra, 1993). Two of the most populous states, New South Wales and Victoria have implemented asset management principles into their road administration. In both cases, directives from the state Treasury were the main reasons for their implementation although several other reasons have been mentioned, such as a better “value-for-money” and a call for greater road integrity.

RTA (Roads and Traffic Authority of New South Wales) has outsourced a portion of its road maintenance with the responsibilities of asset management strategies incorporated into the

---

1 This section on road asset management in Australia is mostly worked from (Federal Highway Administration, 2005). That, which is not credited to another source is thus from there.
contracts. Maintenance and capacity expansion is treated separately and expansions are funded specially. In the early 1990’s VicRoads (Victoria) adopted a client/provider model as the major means of program delivery. This meant asset management strategies (e.g. maintenance) could be delivered either by private contractors or by VicRoads labour with service agreements. VicRoads prioritizes its maintenance projects in the way that firstly meeting its statutory responsibilities, secondly preserving the integrity of the roadside and finally meeting environmental goals.

Both states have experimented with public-private partnerships to build some major new projects. The first one, CityLink (VicRoads), consisted of 19.3 km of new urban highway including tunnels, elevated roads and bridges. The concession was granted for 34 years with the concessionaire being responsible for construction, operation and maintenance for the whole time. CityLink has a special group responsible for the owner’s (Victoria’s) interests and for monitoring performance. All maintenance and operations are outsourced. The first PPP of RTA was the Eastern Distributor, a 48-year concession to build, operate and maintain a freeway connecting several of Sydney’s major roads. The operator’s agreement required conducting routine maintenance, and repair, identify premature deterioration, keeping maintenance records and making sure the asset met the handover obligations. The operator provides a maintenance plan for such activities as inspection, cleaning and consumable replacement; reports on unplanned maintenance and undertakes planned major maintenance tasks. The second major PPP project of VicRoads was EastLink (scheduled to open in 2008). It’s a bigger project than CityLink and had the benefit of building on experiences learned during that one. A special thing in EastLink’s case is that a special authority called Southern and Eastern Integrated Transport Authority was established to oversee the project. The operator has to report on performance indicators to that authority in a monthly score-sheet and a quarterly report. In the event of non-compliance an €9.3 million penalty can be charged.

2.3.3 New Zealand

The chief responsibility for road transport in New Zealand is split between two public institutions (Crown entities); Transit NZ and Land Transport New Zealand. Transfund NZ is an integral part of Land Transport NZ. The vast majority of funds for highway projects are distributed through it and as such, Transfund NZ has major influence on transport priorities.

2 This section on road asset management in New Zealand is mostly worked from (Federal Highway Administration, 2005). That, which is not credited to another source is thus from there.
Transit NZ (TNZ) is the public institution (Crown entity) responsible for highways in New Zealand. It was formed in 1989 and reports to an independent authority which operates much like a company board (www.transit.govt.nz). To manage its road assets TNZ has implemented a road asset management structure. The main drivers for that decision were firstly a national legislation requiring all institutions to value the assets under their jurisdiction meant that TNZ had to value replacement costs and depreciation of the system on an annual basis. Secondly maintenance had been privatized and TNZ realized that in order to efficiently manage project deliveries and deciding on the right mix of activities demanded a good information system. Thirdly the government of New Zealand considers a functioning transportation system at desired levels of service as part of the governmental ethic guiding planning and decision-making. For those reasons an asset management
program was thought necessary. In 2004 a new legislation added sustainability to TNZ’s objectives which meant that environmental assets had to be accounted for as well.

TNZ is organized in four main divisions, transport planning, capital projects, organisational support and network operations (where the asset management responsibility lies). About 50 people nationwide have responsibility for asset management. Regional operators are required to maintain their own performance audit systems while Transit NZ audits about 5% of the network to assure quality of performance. If the performance is deemed acceptable the operator is provided with the first right of refusal for all work within his network up to a project value of NZ$400,000 (€210,000). Justification for this is that the operators already posses experience on the network and have a team in place. As part of their road asset management program, Transit NZ regularly conducts user satisfaction surveys. They have a goal that at least 90% of the answers will be good or above. Innovation has not been ousted from the public scene in neither Australia nor New Zealand. In fact, on of the most important sources for this thesis is the common research institute of New Zealand and Australia, Austroads. This does not mean that private operators working under the asset management frameworks of these countries don’t do any research and development. However, it is thought that if innovation were to be entrusted entirely to the private operators there would be a considerable risk that these innovations would not benefit the whole system. Because of the competitive edge that good innovations can give an operator it would be more likely that they would try to hinder others from learning from them. Therefore if the public research institutions are maintained the same level of innovation can be expected as before, and privately initiated innovation could be considered as a bonus (Austroads, 2003a).

In 1999, 10 years after TNZ was formed, it was estimated that highway maintenance cost per annum had reduced by some NZ$23 million (€12 million) or 17%, while professional services reduced by 30% the same period. The value of the highway assets increased steadily and safety measures had reduced accidents at treated sites by 70%. What has also been noted are considerable efficiency gains, improve accountability and reduced risk for public authorities from owning and managing their own fleet of construction equipment and workforce. A downturn has been that TNZ has experienced a loss in skilled staff with knowledge of the highway system (Dunlop, 1999). TNZ has been working on rebuilding that knowledge base, as it is essential when it comes to dealing with operators.

### 2.3.4 England

The English road network is split into two parts, the strategic national network, controlled by the Highways Agency, and the local networks, managed by local authorities. The
Highways Agency has recently implemented an asset management scheme to control its roads. The drivers for that decision are diverse but the most important are changes in government policies and procedures for the last 10 years. The road network is divided into 14 operational areas managed by a private operators working usually under a 5-year contract. There are two forms of contracts for these operators; firstly one where the operator is a separate organization from the maintenance contractor, secondly an operator which both manages and maintains his network. In the latter case the operator can also design and undertake all projects up to a value of £500,000. In either case the Highways Agency manages to establish a single point responsibility for the asset management (including asset data collection) and maintenance in the areas (Federal Highway Administration, 2005).

Although the Highways Agency is not responsible for collecting the asset data, it is the owner of it. This is important, especially when it comes to changing regimes on a network, where a new operator needs access to the asset data (Bruinsma, 2008). A sign of success of the Highways Agencies approach is that a trend of deterioration of British major-roads was brought to a stop in 2004 when significant funding was allocated to maintenance (Federal Highway Administration, 2005). Because of asset management activities of recording and monitoring the state of the assets regularly, the Highways Agency found it easier to justify more funding from the Government. Furthermore, they created a criterion that helped them to prioritize maintenance. This means that optimally the most urgent repairs are always being done (Bruinsma, 2008). There are, however examples already that this criteria is partially flawed (Bruinsma, 2008)(Miltenburg, 2008) but that simply means that the criteria should be adjusted. But that is essentially what asset management is all about, namely to systematically learn by doing and use that knowledge to further enhance decision making. However, at the same time, the local road system was still deteriorating, partly because the funds distributed from the national government to the locals ones, specifically for transport purposes is used for something else. It is estimated that around 8% of these funds are used in that way (Federal Highway Administration, 2005).

The Highways Agency regularly conducts user surveys to check the satisfaction of the public with the performance of the roads (Schirnack, 2001). Public participation is, in fact, steadily gaining more attention, not only in the UK, but throughout the whole of the European Union. The Aarhus convention of 1998 introduced public participation in the EU. Its second pillar demands that member countries implement public participation in their decision making. That means that standard processes such as environmental impact assessments must scan and involve the will of the people. The public should also be involved in programs, plans and policies relating to the environment (Rodenhoff, 2002).
2.3.5 Austria³

The Austrian highway system was build up through state activity from the beginning. In 1982 the state formed the company ASFINAG (Autobahnen und Schnellstraßen-Finanzierungs- Aktiengesellschaft). As the name implies ASFINAG plans, finances, builds, maintains and operates the entire current highway network of Austria. In 1997 the company secured a contract with the government of Austria where they got the right to charge user charges for 50 years, or until 2047. In exchange they overtook an old debt of €5.7 billion and pledged to invest approximately €7.5 billion in new extensions in the system between 2002 and 2012. The charge-rates are determined mainly by political considerations. The Austrian state guarantees ASFINAG’s debt which means that they enjoy similar credit rate as the state and significantly lowers their cost of raising debt. By doing this the Austrian state has in fact removed the highway system out of its books. ASFINAG classifies as ‘outside’ the Maastricht Treaty, which asks member nations to avoid excessive debt, so the debts stemming from the infrastructure are not the debt of the government anymore. Traditionally the operational responsibilities of the highways were in the hands of the 11 regional and Federal organizations in Austria. Recently that changed and the responsibility was moved to ASFINAG. ASFINAG insists that this change was crucial to achieve improvement in the total planning of the infrastructure. A 15% savings from the former setup is mentioned to support that (www.asfinag.at). The new constructions which ASFINAG are obliged to do are being outsourced through DBFO-contracts. The contractual payments are up to a certain degree performance related and ASFINAG mostly operates as an inspector and monitors if the operational and technical quality is up to their own standards (Nagl and Thaler, 2005).

ASFINAG implemented a new road cost account in 2000 in which accidental and environmental external costs were taken into account. Congestion costs, however, were not taken into account. Those external costs were estimated to be €9.2 billion in 2001 in Austria as a whole, of which slightly more than €2 billion stemmed from the highways (Herry, 2007). At the end of 2004 revenues from user charges were €1.2 billion and operating, maintenance and interest costs were €1.45 billion. Therefore it’s clear that if ASFINAG internalizes the external costs they would have to raise user charges considerably or otherwise loose heavily.

³ The main source for the structure of ASFINAG is (Brenck, 2005). That, which is not credited to another source is thus from there.
Figure 2.3: The ASFINAG scheme of road cost accounting (Blindenbacher, 2005)

As can be seen from Figure 2.3, ASFINAG utilizes things like asset values and depreciation to calculate the true technical cost of the Austrian highways.

2.4 Lessons learned

The lessons learned form the international overview can give advice for the Rijkswaterstaat’s problems. The goals of the institutional reform of 2006 were to interpret the wishes of the environment, stimulation of greater professional scope within long-range planning and seeking a balance between customer focus and value for money. Asset management, with its intensive monitoring of all things related to the assets, is a tool to reach all these goals. However, all these goals indicate as well that it will not be enough to simply monitor the technical assets. Goals like customer focus and interpreting the wishes of the environment highlight the importance of treating the functional and environmental aspects of traffic in a similar way as the technical assets. Rijkswaterstaat has already started an asset management cycle, however, a rather limited one. First of all the performance measures currently used are not nearly widespread enough to get a complete picture of the state of the network. The two functional indicators only measure a very limited part of functional aspects of traffic. Secondly, there is the problem Rijkswaterstaat is having with proving necessary funds to operate the roads. Although the regional office of Rijkswaterstaat is considered as the asset manager of the regional road network, things like traffic safety and pollution control is largely under the control of independent institutions, with their own independent agendas. And lack of coordination between these stakeholders reduces the efficiency of the
whole management structure. Finally, there seems to be very little incentive in the system to get the managers to actually do better.

The first problem mentioned here above was about too few and too limited performance measures used today. In both UK and New Zealand there were much more and more detailed performance measures on the technical assets. The set of performance measures has been allowed to develop as more experience is gained from road asset management (NZ started out with 230 indicators, then trimmed it down to 32 because 230 were too many to comprehend, but have increased again to 70 because of environmental concerns (Federal Highway Administration, 2005)). The reason why there were so few and relatively simple indicators in the Netherlands was because it is considered important that the top level managers understand them (Miltenburg, 2008). But that’s also missing part of the point because the performance indicators are not only for the top managers to see, they are also the basis of the asset managers decisions. As a conclusion to this subject it is recommended that the asset managers get more performance indicators and minimum standards than now, and Rijkswaterstaat should always be open for input or recommendations from asset managers regarding adjusting the set of indicators. On the other hand, Rijkswaterstaat could make a nice report where detailed performance indicators are dragged into few, more widespread ones, to make it more easily understood by the Ministry and the public.

The second problem was the issue regarding lack of funds. The international survey showed that for this problem there are a number of solutions. The first one is to stimulate private investors to build needed links or improvements in the system as is done in USA and Austria. This means that less money is needed for capital investment and more share of the funding can be used for maintenance and operation. The second solution is road asset management. In both England as well as in New Zealand experience has shown that because of asset management, the integrity of road asset condition data has increased. This increased integrity has made it easier for the administrators to build strong cases to justify more funding from the government. The greater knowledge of the system, as well as a structured approach to constantly updating or modifying work plans, means that funds are spent more efficiently which basically means that they can achieve more with the same funds than before.

The international survey didn’t find any specific solutions to the third problem. However, in asset management, the asset manager is responsible for the quality of all the assets under his control. If public institutions want to install equipment or deal with the assets in a way that could affect their quality, they should only be able to do so with the knowledge and permission of the manager. This means that the asset manager would work as a coordinator.
of all wishes from stakeholders and he would have the final say in what was done and in what way.

The final problem is the issue of lack of incentive to do better. The solution for this is the same in England, New Zealand and Australia. The operator is private.

**Why should the operator be private?**

In 1998 sir Peter Gershon was hired by British authorities to review civil procurement of the central government. His findings emphasized the benefits of private service delivery. Points from his review that support the UK/NZ arrangement in favor of the Dutch model are amongst others (Gershon, 1999):

- Problems with staff: The public procurement office has a hard time keeping hold of its best staff. In 1997 the procurement function of the UK government lost 17% of its staff, of which almost all were qualified.

- Big difference in prices obtained by the public authority: When the different public institutions where inviting bidders to supply them with electricity and gas the differences between the lowest and highest prices obtained were 66% and 140% respectively.

- Tendering to government is burdensome and costly: Evidence from industry indicates that bidding for government contracts is typically 10-50% more expensive than bidding for comparable private contracts. The main reasons for this are the greater level of details required and more extended time scales. There was also evidence from industry that the magnitude of the costs worked as deterrents for potential bidders.

Last but not least the private operator can be subject to much stronger incentives than a branch of Rijkswaterstaat. The strong incentive means that we can expect that the private operator will put more effort in doing well than the public division. If we don’t want to engage in an outright sale of the infrastructure there will have to be a contract between a public institution and a private company somewhere in the process. The UK/NZ option offers that these junctions are minimized and public institutions are not dealing with a jungle of big and small maintenance, construction and/or operation contracts. They are dealing with a limited number of operating contracts which all have the same characteristics which also eases the evaluation of performance between them. For these reasons, Rijkswaterstaat should focus on an area-(or regional) wise asset management structure with a private operator.
Figure 2.4 demonstrates the current institutional arrangement of Rijkswaterstaat (left) and the one which is practiced in UK and NZ (right). The basic difference is that in UK/NZ the regional office has a single responsible party to deal with and a single contract while in the Dutch plans the regional office is responsible for a variety of maintenance-, traffic management- and construction-contracts. In both cases new constructions and maintenance is only partial since major new constructions usually call for a special investment from the public authority and a part of the traffic management is dealt with on a nationwide scale.

There are more lessons that can be learned from the international overview that are based on experience with road asset management. First of all is the issue of innovation, where road authorities have considered it important that the public road agency maintains their research and development because of the threat that private companies would not publish or allow others to learn from their innovation. Secondly, Rijkswaterstaat should pay special attention to not losing their skill base if they outsource the asset management. They are the ones that must evaluate contract bids from the operators as well as monitoring the performance of the operators and must therefore understand what they are doing.
2.5 Allocation of responsibilities

Which responsibilities should be handed over to the private operator? The private operator is the asset manager of his network and has the goal of increasing the value of the assets and thus returning more quality to the users. We want his ability of reacting to incentives and superior contract handling (Gershon, 1999) to work in the favour of as many assets as possible. Therefore, the conclusion is that the private operator should take on all responsibilities unless there are valid grounds against it. So what could be a valid ground against allocating a task to a private operator? One of the most important arguments against a private operator undertaking a task is if the task cannot easily be verified afterwards by inspection. The only way that efficiency can accurately be measured is if the outputs are measurable. A low degree of output measurability can increase the uncertainty of transactions and the governance of the private operator (Ter Bogt, 2003). The various responsibilities of the road management will now be analyzed with these arguments in mind:

*Periodic maintenance and rehabilitation of technical assets located within the network, including pavements, surfaces, drainage, kerbs, retaining walls etc.*

As can be seen on Figure 2.5, the maintenance of the network is, along with capital investments, the biggest sources of road funding expenditure. Since the ownership of the roads is not being moved to the private operator he will not have to worry about the capital. Therefore the technical maintenance will form the backbone of his contract. There is a wide variety of performance measures existing in this subject and their measurability is good (Federal Highway Administration, 2005). Moreover a clause that the operator should have a first right of refusal for all minor improvements work under certain amount (€210,000 in NZ and £500,000 in UK) could add to the efficiency. The operator has a team in place and should be familiar with circumstances.

![Figure 2.5: Allocation of road funding in the UK in 2005-06 (Highways Agency, 2006)](image-url)
New constructions

Major new constructions such as new links, bridges or tunnels are only started in the Netherlands if they are accepted by the Ministry of Public Works and thus receive special funding (Miltenburg, 2008). The same applies in the UK and NZ where major new constructions are not included in the operators’ contracts (Federal Highway Administration, 2005). However, one can easily imagine a contract which would begin with the operator designing and building a new link and then taking care of its maintenance for a number of years thereafter. Actually, such an arrangement could stimulate the operator to involve future maintenance costs into his initial design.

Slightly smaller new constructions, such as widening the road at a certain place, building a sound barrier or even fencing of the road to prevent wild animals from entering are projects that are not necessarily included in the strategic plans of the Government. The ideas to start these projects arise when experience, user surveys or performance indicators notify us. For these kind of new constructions the operator could be seen as a prime initiator. In other words, it’s part of his performance to actually spot problems and come up with solutions for them. If mechanisms were in place that rewards the operator for achieving improvements, such as increasing the capacity of a bottleneck or fix an accidental prone spot, he could actually build the improvements himself and his payment would be the performance bonus. If the expected benefit were not as easily monetized or just not high enough to justify that the expected bonus would cover the costs, he would still let Rijkswaterstaat know. Rijkswaterstaat could then decide if they still wanted the improvement and could put it into a normal competitive tender.

Structural maintenance of bridges

Structural maintenance of bridges is more a matter of public safety than traffic level of service, as could easily be seen in the tragic events in Minneapolis on the 1st of August 2007, when thirteen people died because the I-35W bridge over the Mississippi collapsed. Although the structural strength of a bridge is weakening, its service level can stay the same. Structural maintenance of bridges is not included in performance related maintenance contracts in Australia and New Zealand (Austroads, 2003a). The reason for this is that the 10-year contract length that is common there is viewed as being too short to realistically monitor their structural performance. A bridge’s structure is designed to hold for a large number of years. Its deterioration is determined by many factors and the correlation between them and the total amount of deterioration their cause is very difficult to model (Austroads, 2003b). However, although the total structural maintenance would not be in the hand of the
private operator, a part of his asset data collection could be to regularly inspect the structural integrity of bridges. He would simply use methods and tools already accepted by Rijkswaterstaat. In that way the asset inventory is complete and is not fed by different actors which then could lead to inconsistency.

**Traffic management**

Traffic management is an umbrella-word for a wide range of actions that can be taken to help the traffic move around efficiently (Van Zuylen, 2005). Some of it is very local in essence but other actions call for a wide perspective. A private operator can take responsibility over local traffic management actions such as road works- and incident-management, homogenization of speeds, traffic buffers, variable lane width, use of hard shoulder, lane control for freight vehicles, ramp metering and fog detection and warning. Furthermore, he should be free to design and implement new traffic management actions if he believed it could improve the situation on his network. However, many traffic management problems are not local in nature which calls for a nationwide scope which then should be under the supervision of Rijkswaterstaat. An example of this kind of problem can be seen in Figure 2.6 where a DRIP giving directions. If it would only have regional information it would direct the traffic to the more heavily congested route A instead of route B.

![Figure 2.6: A simple example why traffic management needs national overview (Miltenburg, 2008).](image)

**Installation and maintenance of speed camera detectors, traffic counting station detectors and recorders, variable message signs, emergency telephones and closed-circuit television**

The installation and maintenance of these equipments are often as a result of requests or needs of other institutions such as the police, nation-wide traffic management and research institutions. Since the private operator is the supreme command on his road network and is
responsible for all the assets he should always have the final say in anyone’s else’s activities on the network. This means that if an outside party (police, research institute, etc.) wants to install equipment on the network they can only do so by sending the operator a request. The operator could then handle the different requests and possibly plan them in accordance with his own operational plan. In this way, Rijkswaterstaats current problem of different institutions working on the roads without knowing about the other is eliminated. Furthermore, unless specially requested by the outside party the private operator would take care of the work. Additionally, as this kind of work is not in the original contract of the operator, the price for it would have to be negotiated especially as additional work.

**Corridor maintenance**

The term corridor maintenance is derived from Transit NZ (Transit NZ, 2007a). Under it fall actions such as; traffic signs, road marking, street lightning, mowing, weed spraying, street cleaning, kerb sweeping, catch pit cleaning, litter patrol, bin cleaning, removal of graffiti and maintenance of railroad/road level crossing warning devices. These are tasks which must be dealt with every day and are important to ensure safety, efficiency of traffic flow and drainage systems and to keep the environment tidy and consistent. These tasks are very costly (nearly 10% of the total annual road infrastructure expenses in New Zealand in 06/07 (Transit NZ, 2007a)) but also very important. It seems obvious that this is a job for the operator of the roads. However a problem relating to performance evaluation can arise. Monitoring the success of corridor maintenance is mainly visual inspection. It is clear that no operator can ever eliminate litter and graffiti and maintain that every traffic light is working. The limit for what is tolerable can thus be a bit hard to define. But some kind of scorecard where the number of failures is summed up could be the answer. In any case, the method must be standard and accepted by both the road administration and the operator.

**Collection and management of asset inventory data**

Two parties need the asset inventory data, the operator to efficiently being able to carry out his maintenance work and Rijkswaterstaat to being able to monitor the progress of the operator. Collecting the data twice is obviously not efficient thus there has to be an agreement between the operator and Rijkswaterstaat who takes responsibility for it. The international overview found that the data collection differs between countries. In Australia the road agency is responsible for it while in New Zealand the operator do the work while Transit NZ makes random checks to verify the integrity of the data (Austroads, 2003a). The scheme that this thesis is promoting is one where the operator has duties, not only to keep
the technical assets in order but also the functional and environmental. He might therefore have special preferences when it comes to data collection. Waiting for Rijkswaterstaat to measure things he wants measured and/or process data could seriously affect the performance of the operator and be frustrating. On the other hand, to keep a certain technical standard and to keep the asset data comparable with data from elsewhere, Rijkswaterstaat should standardize measuring methods for the most vital road assets. But the bottom line is that the private operator should be the one which collects asset data and manages the asset inventory, although he would have to follow Rijkswaterstaats’ standardized set of measurements as well.

**Winter service**

There is no one in a better position than the operator to deal with the traffic hazards of snow and icing. He knows his network and could also know spots that are prone for icing or snow collection.

**Response to public requests, complaints and feedback**

It is for the benefit of the operator to handle the feedback of the users as it can make it easier for him to conduct his operations more efficiently and point out weaknesses in the network that can perhaps easily be improved. Furthermore, every operator should set himself a minimum response time. However, Rijkswaterstaat should also have an open phone, since in case the wishes of the public are not being addressed, they should have some place to take their complaints instead.

**User surveys**

Conducting user surveys is an important part of asset management as it gives feedback on issues that might not surface through other standardized monitoring methods. Australia, New Zealand and UK all implement user surveys into their asset management structure. However, it is notable, that in all these countries it is the task of the public road agency to make them (Federal Highway Administration, 2005). The reasons for that are to guarantee the integrity of the data. A private operator might well try to influence the outcome in some way if he were afraid of the outcomes. However, every operator should also be aware that public opinion matters. Therefore, just for the sake of their own performance, they might regularly conduct their own user surveys.

**Innovation**
The asset management scheme presented in this thesis is designed not only to manage the road assets, but also to stimulate innovation which could increase their value. Each operator should thus conduct his own research and development and try to come up with innovative solutions on their own. However, as was explained in the international overview, it might not be the wisest thing to shut down all innovation activities of Rijkswaterstaat. The reason is that it is very much the interest of the private operators that their innovations are kept hidden. These innovations are their investments and are can give them a valuable competitive edge over other operators. Therefore Rijkswaterstaat should keep their research and development as before, and the privately initiated innovation can thus be considered a bonus.

2.6 Conclusions

The institutional organization chapter was preoccupied with studying the current state of affairs in Dutch road management as well as exploring how it is conducted elsewhere. Two research questions were also asked in the beginning of the chapter. First one asked what the roles of the different actors would be in the new organization. Their roles are as follows:

Government:

- Owner of the infrastructure. In the privatized road asset management scheme the private operator is working to manage the state assets under a limited time contract.

- Legislative authority. In democratic countries all legal authority lies with the government.

- Author of the nation-wide Service-Level-Agreement with Rijkswaterstaat. This agreement should be a sort of all-in-one package for Rijkswaterstaat, where they could find all goals and objectives, not only with relations to traffic but also regarding the environment, safety and other possible fields. The Ministry of public works must thus take all relevant policies, rules and laws from the different ministries into account when creating the SLA.

Rijkswaterstaat:

- Translates the SLA from the government to smaller SLAs with the private operators.

- Manager of the operational contracts with the private operators. And as such is also responsible for the tendering process.
- Owner of asset inventory data. This is important because Rijkswaterstaat need the data for future use.

- Conducts research and development. This is important because of the risk which competitive edge due to innovation would give a private operator over others; he would not allow others to learn from his innovation. Therefore Rijkswaterstaat should retain research and development to ensure that innovation-level will not be reduced.

- Sets standards. To ensure continuity on the roads and to ensure that governmental goals are being met, Rijkswaterstaat should set standards and rules.

- Maintains a nationwide traffic management center. This was because of the fact that traffic problems are often inter-regional and cannot be solved within one region. Rijkswaterstaat should therefore maintain nationwide traffic management which could intervene with regular traffic management of the operators when deemed appropriate.

- Monitors the operators regularly and audits their asset reports. Since Rijkswaterstaat is the author of the original bid and the performance standards and goals, he should be the one that evaluates the final actual performance of the operators and compares it with the original goals of the contracts.

Private operator:

- Maintains and operates the road network. Maintenance involves all technical assets as well as the corridor maintenance. This is the biggest and costliest part of the operators’ work on the network and in a way the backbone of his contract.

- The traffic manager under normal traffic conditions. The nationwide traffic management center can however intervene if they think it’s important.

- Monitors the asset quality and reports it to Rijkswaterstaat regularly. Since the operator is the asset manager he is responsible for the quality of the assets.

- Innovates. Although Rijkswaterstaat should retain their research and development, it doesn’t mean that the private operator shouldn’t do it as well. Optimally he should constantly be looking for innovative ways of improving his network. His innovations are a bonus, on top of other innovations.

- Coordinates all construction work or installations on his network. All institutions will have to get an approval from the operator before they go ahead with doing something
on the network. This is again minimizing the inefficiency of different stakeholders working on the network, running their own agendas that might conflict.

- Advises Rijkswaterstaat on improvements on the network. Being the day-to-day manager, the operator should be very well aware of the state of the roads and have the best knowledge of how to improve them.

Figure 2.7: The life-cycle approach to asset management, with the roles assigned to the specific actors.

Figure 2.7 is the same as was presented as Figure 1.2 in the introduction. The colored boxes indicate who is responsible for each part. The red stands for sole or main responsibility of Rijkswaterstaat. The yellow one stands for the private operator. The box which has red and yellow stripes means that both Rijkswaterstaat and the private operator are preoccupied in that area. The central part is then blue and red and stands for a combined responsibility of Rijkswaterstaat and the Government. The Government is responsible for setting the agreed
level of service (in the form of the original SLA) but it does so only with the help of Rijkswaterstaats' consultation.

The second research question dealt with how stakeholders outside the day-to-day road management can be made aware of what is happening. This basically means how the Government, governmental institutions, NGO's and the users can follow the development. The text above already answers the question about the government. But it was also mentioned in the text that it is not the same to report performance to traffic specialists within Rijkswaterstaat than to politicians (section 2.4). The politicians need to get the data in a more easily understood way than the specialists. Therefore Rijkswaterstaat must translate their information on the performance of the system into a few simple indicators. The same thing applies to the public. Rijkswaterstaat should create a yearly report, available to all, which displays the performance of the different operators.

This allocation of roles is based on the lessons learned from the international overview. The international overview was primarily based on documented experiences of road asset management from around the globe. As such it reflects well the status of road asset management as it is today. Road asset management is not a subject that has one specific truth or answer and is constantly evolving. Therefore the conclusions and recommendations presented here could be proven wrong later.
3 Contracting

3.1 Introduction

The goal and justification of outsourcing the road operations is of course that the assets return more value to society than before. Therefore it seems obvious that if the level of service declines in the new format it will be looked upon as a failure. The whole process should work together to stimulate the operator to increase the efficiency of the infrastructure and at the same time, take societal goals into account. The relationship between the private operator and Rijkswaterstaat is controlled by a contract between them. This contract is thus essential to the success of the scheme. Three research questions should find their answers in this study of the contract, namely: the question on how the contract will be able to handle future developments (question 3), the question on which is the optimal contract length (question 4) and finally the question on how societal goals are protected in the contract (question 7).

As was stated in the methodology section, question 3 is closely related to the subject of contract length and contract risk. The first part will thus discuss the issue of risk, with a special attention on assigning it to an actor with relations to the origin of the risk. After the risk analysis, the issue of contractual incentives is discussed. It was mentioned in the chapter before that the private operator should be subject to incentives in the contract to stimulate him to good performance (section 2.4). This discussion is closely related to the seventh research question, although a more detailed discussion on that issue waits until the next chapter. This chapter finally discusses the issue of contract length (question 4) and looks at issues that surface at the end of the contract.

3.2 Risk analysis

Risks are risks because we are unsure if they will happen or what their scale will be. The total amount of uncertainties affecting a long term, wide spread contract, such as a road asset management contract, is immense. (Wang and Chou, 2003) highlighted the importance of risk management by pointing out that those risks that the contract misses can prove costly to the project. Wang and Chou's method of identifying contractual risks can be seen in Appendix 4. If Rijkswaterstaat bids out the road asset management without imposing any standards on performance or even pricing (in case the operator runs road tolling) it could be said that the transfer of risk is complete (Nash, 2005). That kind of transfer could describe
the Chicago Skyway and the 91 Express Lanes in USA. However, when we are talking about private companies taking over the asset management of public roads there will always be some publicly imposed standards and regulations that the companies must abide to. An important factor in the success of contracting is risk management, how the risks are allocated and dealt with. A very sensible approach is to allocate the risk to those who can best deal with it (Nash, 2005). The private operator should be in the best position to deal with risks relating operations and management while the Ministry and Rijkswaterstaat should bear the policy risk (Abdel Aziz, 2007). To identify each and every risk beforehand is thus unpractical and probably impossible. We can, however, try to envisage where risks might be originating from and thus allocate them. In (Austroads, 2003a) an overview of risk allocation in performance related maintenance contracts are discussed widely. From there we can look at possible risks from their origin point of view:

*Risks associated with policy:*

The operator should be free of political risk as much as possible. The contract should prevent new legislations or taxes to change the conditions of his contract. If the Ministry wants to change policy they can do so during renegotiations or renewal of contract but not in the middle of its tenure, unless the operator agrees (either after getting a compensation payment or after a renegotiation of the original contract).

*Risks associated with work:*

Risks associated with the planning and implementation of work done on the network during the lifetime of the contract is solely under the responsibility of the operator. These things involve risks on financing the work, quality of equipment, quality of materials, labour availability and skill and security on construction sites.

*Risks associated with cooperation:*

Risks associated with cooperation and relations with other parties and stakeholders should also be under the responsibility of the operator. These include reporting on assets to authorities, relations with other operators, relations with other road authorities at the interfaces of roads of different hierarchy and finally gathering of necessary approvals if new constructions or maintenance activities call for them.
Risks associated with nature:
As the operator takes on the task of keeping the traffic moving on his network he is the one who should react if weather conditions make the roads unsafe. Risks relating to other environmental factors should also be allocated to the operator to the extent that he can possibly do something to affect their severity.

Risks associated with traffic demand:
The risk associated with traffic demand can only be transferred fully to the operator if he controls the whole system. The full control of traffic management, as was explained earlier (section 2.5), is not fully in the hands of an area-wise operator. However, he can perform most of the traffic management actions. Therefore the option remains to share the risk between the operator and a nation-wide traffic management (under the control of Rijkswaterstaat) regarding things like seasonal issues and traffic volumes and growth. Other risks like disruption on traffic because of other operators, service authorities, events or vehicle axle loads are better suited for the operator.

Risks associated with asset management:
The result of the asset management itself is mostly the responsibility of the operator. The deterioration of assets is fully the responsibility of the operator and it is his responsibility to keep a record of the asset performance and condition during the lifetime of his contract. Rijkswaterstaat monitors the performance as well and must take responsibility over its own data. Asset data supplied by Rijkswaterstaat prior to the tender are of course under the responsibility of themselves. They should also define what the road assets are beforehand, although the operator will bring feedback during the tenure of his contract, which could possibly change those definitions. Innovation responsibilities could be laid entirely in the hands of the operators. However, as was explained before, that might not lead to the optimal outcome. Therefore the public road authorities should continue with their existing research and development.

Risk of failure:
There will always be a certain risk that an operator will not perform as promised or even get bankrupt. In such cases there is a substantial threat that service will decrease during that phase and until the network has been auctioned out again. Rijkswaterstaat might very well have to step temporarily in to keep the network operational. Therefore they should have an emergency fund available to them to be able to do that. This emergency fund can be created
by mandating the bidders to issue performance bonds. Rijkswaterstaat could also speed the new procurement by having an emergency replacement contract ready.

*Other risks:*

A multi-year service contract means that the operator is not only responsible for foreseeable maintenance work; he must also be prepared to take care of unexpected events to a certain degree. In many construction contracts the operator charges the purchaser for various ancillary services, which were unforeseen beforehand. In these contracts, that should not be the case. However, exceptions must be made in cases which in many contracts are related to as “Acts of God”, or major natural disasters. In those cases the operator should not be held responsible for the disruption of services. Costs and prices can and will probably fluctuate because of inflation or other factors during the lifetime of the contract. The operator should not have to bear the full risk regarding those things. To create a stable source of income for the operator his payments should follow these fluctuations closely. This can be achieved by connecting payments to a certain construction-cost index, see Figure 3.1.

![Construction Cost Indices](image-url)

*Figure 3.1: Construction cost indices used by US road authorities (www.wsdot.wa.gov)*

### 3.3 Incentives

For the private operator to see any point in living up to minimum standards or even outperform expectation he has to be faced by an efficient framework of incentives. If we look at lists of minimum standards from other countries it becomes apparent that the standard for these things are usually very high and 95-100% compliance is usually set (Federal...
Highway Administration, 2005). In such cases it’s hard to stimulate better performance through monetary incentives. For example, it doesn’t really make sense that the operator invests heavily to smoothing out the pavement infinitely much as it will not yield in any measurable difference to social benefit. On the other hand, if we look at performance measures relating to the functional effectiveness of the roads or environmental externalities, the situation changes a bit. Although effective maintenance of the technical assets should relate somewhat to an acceptable performance in these areas, innovative solutions can further increase their contribution to social welfare. These innovative solutions, given that they are cost effective, are very desirable and should be stimulated. The conclusion of this elaboration is that although penalties should always kick in if any kind of performance is unacceptable; bonuses are only suitable in relation with functional and environmental assets. The following text will analyze and elaborate the incentives for the different assets, as well as looking into different incentive structures.

### 3.3.1 Minimum standards

The penalties for breaking minimum standards must be of enough scale to work as effective deterrents. Transit NZ maintains a “three strikes and you’re out” method, where a operator risks loosing his contract if he fails to meet requirements on three occasions. Transit NZ do not believe in monetary penalties as they insist that it could lead to hiding of results and that it would not work in practice (Austroads, 2003a). However, if there was to be a monetary penalty it would have to surpass the cost it would have taken the operator to comply with the standards. In that way, the risk of operators buying the problems away, or paying the penalty instead of doing the job, is eliminated.

### 3.3.2 Bonuses and penalties

Improvements are always welcomed by society. However, improving usually calls for investments. Improving beyond the common level might even call for additional investment in research and development where the outcomes are uncertain. Thus the operator will never engage in such investments if he doesn’t expect some sort of reward. That’s when the incentives kick in. If the expected bonus for improving the assets is likely to be higher than the expected investment cost we have a positive incentive for the operator to invest. However, we do not want to encourage the operator to engage in unfeasible improvements (The cost of improving higher than the expected gross social benefit increase). Thus the bonuses should depend on the improvements expected gross social benefit increase (Vassallo, 2007).
As with the technical assets there will have to be minimum standards in place to define the lowest acceptable level allowed. Original contract clauses could see these minimum standards develop during the life of the contract (for example to meet national or international agendas in safety and pollution). There are two ways of translating this into an incentive mechanism. One, where there are minimum standards which the operator must comply with and get bonuses if he improves more. Another is a mechanism where there are minimum standards, but the operator can use a better projected performance in dealing with these assets in gaining the original contract. These two methods will now be elaborated further.

3.3.3 A simple minimum standard incentive scheme

In this scheme the public authority prepares a list of minimum standards and development objectives to potential bidders. Bonuses and penalties would be added as incentives to the bidders to maintain and/or exceed the desired level of performance asked for by the public authority. The bidders would then try to offer the best bid in which these objectives were met. The value of the bonuses paid out should depend on the improvements impact on gross social benefit. The penalties for dropping the assets below minimum standards could also take the gross social benefit as a precedent. However, in order to withstand minimum standards the operator might very well have to invest in unfeasible projects, where the expected profit is lower than that expected cost. In these circumstances the operator is likely to pay of the penalty instead of fixing the situation. Therefore the penalty should be equal or exceed the cost of fixing it, regardless of gross social cost. This could be very difficult in practice because of the wide variety of uncertainties involved. Therefore a ‘three strikes and you’re out’ system, as are used in New Zealand, might work better. In this case the operator is penalized for failing to live up to minimum standards as he was originally contracted to do.

3.3.4 The private firms initiated incentive scheme

In this scheme, it’s the public authority that simply issues a list of minimum performance standards that must be met by all bidders. The bidders themselves can then design an offer where they would promise a certain level of service and how it would develop during the life-span of the contract. A system of bonuses and penalties would be assigned to the actual performance of the private firm to inspire them to perform better.

The incentive mechanism for the private operators’ initiated incentive scheme is a bit more complicated. The reason for that, is that in the tendering, the bidders not only compete in price, but a combination of price and performance. The incentive mechanism must therefore
involve a factor which reveals the intended and promised level of performance of the successful bidder. The bidders should be stimulated away from sending in unrealistic bids simply to win the tender. However, as before, the private operator should also get rewards equalling the gross social benefit for surpassing the level he originally offered. (Vassallo, 2007) created a mechanism taking exactly this into account (see Figure 3.2). Equations 3.1 and 3.2 display the mechanism mathematically.

\[\text{Penalty} = (P_f - P_d) \cdot \gamma \quad (3.1)\]

\[\gamma = \frac{W(P_f) - W(P_m)}{P_f - P_m} \quad (3.2)\]

Where:
- \(P_f\) = Level of service agreed by the successful bidder.
- \(P_m\) = Minimum level of service allowed by the public authority.
- \(P_d\) = Level of service actually produced by the operator.
- \(W(P_m)\) = Gross social benefit linked with \(P_m\) level.
- \(W(P_f)\) = Gross social benefit linked with \(P_f\) level.

The first half reveals the deviation from the agreed level of service while \(\gamma\) stands as a factor of the social benefit of each unit of performance between the minimum public standards and the successful bid. In this scheme the system of penalties is in two steps. When the operator is performing worse than he promised in the tender he receives monetary penalties equalling the difference in gross social benefit. When the performance drops below the minimum standard the penalties should get harsher and a penalty exceeding gross social benefit or a threat of termination could be initiated.
Figure 3.2: The private operators’ initiated incentive scheme mechanism (Vassallo, 2007).

Figure 3.2 demonstrates the private operators' initiated incentive scheme mechanism. Point M is the minimum performance standard, Point F is the agreed performance of the successful bidder. Point D is a below-par performance and Point E is above-par. Segments FR and ES indicate the difference in gross social benefit from the agreed level and the one actually produced. All these explanations reveal that this system is more complicated than the simple minimum standards incentive scheme. It could thus be more cumbersome in practice. However it has the advantage of giving more competitive operators greater freedom to outshine less competitive ones in the original bid.

An important issue that has not been addressed yet is that while Rijkswaterstaat is already complaining about a lack of funds, how will there be funds not only to run a privatized asset management system but also to pay out bonuses for good performance?

3.3.5 Origin of incentives

The amounts in bonuses or penalties awarded for every operator is an unknown factor in the beginning of each tender. This is a limitation to the model that could in some cases prove troublesome as getting extra funds from the government is usually no easy feat. There must thus from the very beginning exist a special incentive fund which should cover incentive payments. It would work as follows:

- When the budget for road asset management is allocated to Rijkswaterstaat, a portion of it is earmarked as a contribution to the incentive fund.
- Penalties could contribute to this fund.
If the incentive fund grows very big because little bonuses have been paid out it could partially start to work as Transfund NZ. That means that institutions and companies can bring suggestions for improvements in the road network and compete for capital from the fund to realize these improvements.

3.3.6 Incentive usage

The main justification of incentives is their effect on the operators' performance. In some cases, however, the incentives can fail completely and even result in a worse system than before. An example of this is an operator, which is not performing well, and is subject to penalization. If he has to pay a monetary penalty that would go straight into the common Treasury it means that he is worse off financially afterwards and is thus less likely to be able to increase his efforts. This then results in a possible worse situation for the users, those that were originally supposed to gain from the scheme. This highlights an important issue that the penalties must not drain money away from roads. As was mentioned before, an incentive fund should exist and the penalties should be directed there. The penalties would then be made available for improvement projects on that same network. The operator can of course compete for the funds just as everyone else. This means that while the operator is penalized for poor performance, the network under his supervision should not suffer as much.

If we further elaborate this and think of how bonuses could also contribute to the assets, one idea is that they will partially be devoted to improvements in the network. This means that an operator that has managed to improve the network would receive a bonus that is partially a direct monetary payment, and partially funds for construction on his network. These funds could then be used to construct something like sound barriers or make safety adjustments. This basically means that if a company manages to gain a bonus, he has an option to construct on his network and further improve his chances of getting another bonus, and so on. This means that we create cycles of competitive improvements where the operator is using the system of bonuses to gain extra money and the users gain immensely as well. Everyone wins.

Incentives for improvements of assets should be paid out every six months or yearly during the contract period. It's important that the operators don't have to wait for too long to get their payments because it would reduce the efficiency (for example if the operator took a loan to improve the network. If he would have to wait for a few years before he would get paid the loan would collect interests and thus become more expensive than before).
3.4 Contract length

The issue of contract length is a very important one for various reasons. Shorter contracts maximize the competitive pressure of contracts but may lead to limited pressure to invest (Nash, 2005) while long ones might obscure beneficial market forces (Ellman, 2006). Road infrastructure is a perfect example of a so called natural monopoly. That means that, because of economies of scale, it makes no sense to have competing road infrastructures, there should be only one. Williamson mentions three versions of contracts which fit in the cases of natural monopolies (Williamson, 1985):

*Once-and-for-all contracts*

These kinds of contracts are dismissed by Williamson because they are infeasible and/or pose execution hazards.

*Incomplete long-term contracts*

These contracts can be feasible, but that feasibility can be reduced because of the following factors:

- The initial award criterion can be artificial or obscure (That original contract terms prove wrong or were fuzzy)
- Execution problems in relation to price/cost ratios could develop (that original price for service evolves away from the cost of providing the service), performance evaluation and political respects (if renegotiations are common, the private firms ability to deal with politicians could be excessively important)
- Unequal situation of bidders during contract renewal (because of the current operators' knowledge of his network)

*Recurrent short-term contracts*

They have an advantage over incomplete long-term contracts because they facilitate future developments better. Poor performance because of failure in definition of contract terms will only last for the duration of the short contract. However the success of the short-term contracts relies heavily on a complete parity between bidders in every renewal, which is highly unlikely in reality.

As can clearly be seen from the above there is no golden solution. There are solutions, but all of them have some flaws. The issue is to figure out which one suits each case the best.
Williamson doesn’t really clarify in the text how long he considers the short-term or the long-term contracts. Thus the characteristics he mentions can be viewed as things that might aggravate as the contracts get longer. The test-case which he uses to demonstrates his theory is on American cable TV companies, which compete for providing cable TV in limited areas. Most of these contracts ended up as being for 10-15 years.

But road networks are not directly comparable with the cable-TV business. The contract length of an operating contract should primarily depend on the characteristics of the road assets. But this is where things get a bit complicated. Road assets have very different life-cycles. In fact, when the CityLink project was being prepared in Melbourne, officials noted that the project consisted of a variety of infrastructure assets with different life-cycle characteristics. For example, structural assets have and estimated life of more than 30 years, mechanical and electrical systems usually vary between 10 to 30 years and electronic tolling instrumentation having the shortest life, or from 3 to 10 year (Federal Highway Administration, 2005). Austroads made an overview-study on road asset life-cycles used in different road agencies in Australia and New Zealand. The results can be seen in Table 3.1.

**Table 3.1: Ranges of life-cycles of road assets in road agencies in Australia and New Zealand** (Austroads, 2003b)

<table>
<thead>
<tr>
<th>Road Formation</th>
<th>Road Pavements</th>
<th>Bridges</th>
<th>Other Asset Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formation: 80-infinite years</td>
<td>Surfacing: 7-10 years</td>
<td>Steel/concrete: 70-100 years</td>
<td>Traffic signals: 12-33 years</td>
</tr>
<tr>
<td>Drainage: 60-100 years</td>
<td>Pavement: 30-50 years</td>
<td>Timber: 25-60 years</td>
<td>Sound barriers: 90 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Major: 100-250 years</td>
<td>Traffic facilities: 15 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Street lightning: 25-50 years</td>
</tr>
</tbody>
</table>

As can be seen from this table the life-cycle for the various road assets vary considerably. Most structures and systems are designed to last for many years, even centuries. The road surface has the shortest life span.

As the job of the operator will be to maintain and attend to these assets it makes a lot of sense to determine the contract length with relation to their life cycles. That could create a sort of “cradle-to-grave” environment where the operator will have to live with his initial investment. Then the question is which of the assets is suitable to be used as a basis of the contract. That particular asset should be of fundamental value to the infrastructure. As such,
the road pavement and bridges come to mind. A concrete highway bridge has an estimated life-cycle of more than 70 years. This is an immensely long time and the developments which can occur are highly uncertain (just imagine a how a contract signed in 1938 could be outdated today). Initial contract failures could be incredibly costly if they would be in place all that time. The pavement base has an estimated life time of more than 30 years. This could be an option although 30 years is also a very long time with large uncertainties with regards to future developments. The 7-10 year life cycle of the pavement surface creates the shortest contract. That means that risks relating to contractual failures and development uncertainties are minimized. This however means that an operator will lay his own surface on a pavement base created by someone else. However, it could be argued that if an operator would initially be contracted to renew both the surface and the base he would have to design and construct both with durability and future maintenance costs in mind. While the operator would surely maintain and attend the surface from cradle to grave, he would also have to live with the pavement base for 20-33% of its life-cycle. Carelessness in the design and construction of the base could thus just as well backfire in that time and create unwanted costs for the initial operator. Therefore taking the surface life-cycle as the basis for determining the contract length of a road asset management contract is a valid solution. Other assets do have their life-cycles as well. Installing a clause about their renewal in an operational contract would be the responsibility of the highest authority of the road asset management, namely Rijkswaterstaat.

The 2003 study from Austroads where Table 3.1 is derived from officials from the same road agencies were quizzed about their experiences with performance related maintenance contracts. They claimed that experience had shown that a 10 year contract length is optimal (Austroads, 2003a). The rationale behind the 10 year contracts is that it allows for amortization of risks and investments by the operator and is considered a long enough time to create an economic incentive for the companies to meet long-term performance goals by (Austroads, 2003a):

- Being able to invest.
- Having the flexibility to design appropriate treatments.
- Having to live with its mistakes.
- Being able to invest up-front and reduce ongoing costs.
- Being able to invest not merely in physical resources but also in building an asset management culture.
Furthermore it was noted that the 10 years would limit the risk of possible increase in traffic demand and axle loading. From the international overview it is evident that, for example in the case of the Chicago SkyWay and the Austrian highway system, considerably longer contracts have been made. However, the rationale behind the long contracts in Chicago and Austria is that in the former the road was bought and in the latter the company overtook all outstanding debts, in exchange for usufruct. Thus the companies need revenues over a long period to cover their liabilities.

From the preceding elaboration it is pretty apparent that 10 years is considered to be a very good contract length. However, we can also look at this issue from another point of view. What if there was no single contract length. That contract length could be a matter of agreement between the operator and Rijkswaterstaat. The operator would simply state in his original bid for how long he estimated his pavement surface would last and the contract length would match that time. This gives the operators more freedom in designing their bids and rewards ambitious operators with good ideas. It's very likely that most of the contracts would be around 10 years in length, and thus having mostly the same positive characteristics as the strict 10 year contracts.

Finally, in a road asset management scheme where the functional and environmental aspects are considered assets, which need to be maintained and improved just like any other assets, their rate of change must be included in the discussion of contract length. There are also possibilities that although the contract is originally set out to be around 10 years it could have a termination clause if the situation drastically changes. What is considered as “drastic changes” would of course have to be defined in the contract as well.

### 3.5 Contract end

As the contracts are not endless there will always be a period of renegotiations near the end of their tenure. At these times the public authority has the option of renewing the contract with the existing operator or to put his network up for a new tender. Many cost factors favor renegotiating the contract with the existing operator, as for example the cost of preparing a new tender and the cost of renewing personnel, technology or equipment. A possibility of a renewal will spur the existing operator to trying to enhance his performance. Any contract renegotiations would have to start some time before the end of the existing contract so there remains time to prepare a new tender in case they break up. One of Williamson’s points against incomplete long-term contracts was that during renewal the existing firm will have advantage over others. However, if the renewal is ongoing because of malpractice it is
unlikely that the existing operator will have any advantage, given his bad reputation. If the renewal is because renegotiations were not successful the existing operator is not likely to bid, since his former requests were not agreed. Another point that even outs the competitiveness of bidders is that if the highway system is split into many small networks, each with a special private operator, there are bound to be companies elsewhere, with a proven record of performing well and willing to try their luck in a tender for more networks.

Another issue relating to the end of the contract is the risk of reduced performance by the operator. The reason is that when there are only a few months left of his contract, a penalty in the form of contract rift is just not have the same effect as before. Another thing is that not all flaws might be discovered until at the very end of the contract period. This presents a problem as it would mean the periods of malpractice and fast deterioration of assets could arise periodically when contracts near their end. It is known from contracting that defect liabilities are included to protect the owners of the infrastructure against defects discovered after the contract period of the operator ends (Austroads, 2003a). That means that the operator is responsible for his work for a reasonable amount of time. This is reasonable and should install some sense of responsibility into the work of the operator. However, it’s not a direct incentive that ensures top performance all the way till the end of the contract. There should be a powerful ‘carrot’ at the end of the contract, rewarding good performance the whole time. Two ideas for such an incentive are the following:

- A monetary bonus paid at the end of the contract after the assets have been verified as being in a satisfactory condition. The amount can depend on the size of the contract. That means that perhaps 5-10% of the total contract value will depend on the quality of the assets at the end of the contract.

- A limited time contract extension. Meaning that if the assets are in a good enough condition, the operator could get an extension of his contract for a year or two. This basically means that if the operator manages not only to return the road assets in satisfactory conditions but they still have quite some remaining life in them.

These two incentives would both reward good performance and asset quality at the end, but the possibility of earning a limited time contract extension could spur the operator to try and maximize the remaining residual life of the assets.

### 3.5.1 Premature termination of a contract

There is always a threat that the contract will take a premature end. The reasons for this can be that the operator goes bankrupt or either party of the contract will, under some
circumstances, prematurely terminate the contract. Whatever the reasons there are for the premature end, it is a problem that must be addressed swiftly. It’s simply not acceptable that a road network will close down for a few days because there is nobody attending it. In case Rijkswaterstaat decides to prematurely end the contract they can notify the operator with some advance, enough so that a new tender can be prepared for the operation. However, if the operator goes bankrupt it can happen very suddenly and without enough time for the operator to prepare a new tender. To deal with these situations contracts usually include a so called surety bond (also known as performance bond). A surety bond is a tool that is used to guarantee that in case of performance failure or bankruptcy, there are funds available to keep the operator afloat until a new tender has been prepared and executed (Calveras et al., 2004). To further facilitate this process Rijkswaterstaat could have a ready made emergency replacement contract. This contract would be somewhat shorter in length than the original contract, as its main purpose would be to guarantee that the road assets were maintained until the original time factor, the road surface, has been fully depreciated.

### 3.6 Conclusions

The success of outsourcing road operations will in large part depend on the quality of the contract between Rijkswaterstaat and the private operator. This chapter went through some of the most urgent factors of the contract design. The first research question, presented in the introduction, was on the subject of the contract and future developments. Future developments are basically risks and the longer the contract is the greater the chances are of risks occurring. Risks were analysed and allocated with regards to their origin. The allocation was as follows:

- **Risks associated with policy**: The government bears the risk of policy. If they change rules and regulations that change the original condition of the operating contract the operator should be compensated in some way (renegotiating or payment).

- **Risks associated with work**: This risk is under responsibility of the operator since he is the one that plans and conducts the work.

- **Risks associated with cooperation**: The private operator bears the risk of his cooperation with stakeholders as it is his responsibility as asset manager.

- **Risks associated with nature**: Operators should bear all naturally occurring risks if they have any means of dealing with them. That basically means all times except for disasters such as extreme flooding, tornados or earthquakes.
- Risks associated with traffic demand: The operator is under most conditions the main traffic manager. In some cases the nationwide traffic management of Rijkswaterstaat intervenes. The risk is thus partly shared by the operator and Rijkswaterstaat, with the operator taking the bigger share.

- Risks associated with the asset management process: These risks are assigned with the actor's role in the asset management process in mind (Figure 2.7).

- Risk of failure: If the operator fails or goes bankrupt Rijkswaterstaat might temporarily have to step in. Therefore the risk is in their hands to try to design the tender so the best operator is chosen.

- Other risks: "Acts' of God" are the responsibility of the government. These kinds of tragedies are likely to have widespread influence on society and such cases should always be dealt with by the supreme command, the government. Risk of costs and payments is limited for the operator by tying it to a construction cost index. The only one that really is taking a risk then is the one paying for the service, namely the government.

The direct answer to question three is thus that we deal with future developments by trying to envisage where risks might come from in the beginning, and allocate them according to that. These conclusions work as a recommendation into how risk allocation should be conducted for privatized road asset management. They are elaborations based on the sources available on the subject. These sources related to risk management theoretically (Nash, 2005), (Abdel Aziz, 2007) and (Wang and Chou, 2003). (Austroads, 2003a) then gave input from the practice as it reviewed risk allocation in a number of real performance based maintenance contracts. The most important thing is to realize where the risks are coming from. The risk allocation itself is then a matter of agreement and it could well be that different contracts would allocate it differently.

Research question four was on the subject of contract length. The conclusion of the chapter was that contract length should depend on the expected lifetime of the pavement surface. This means that the operator would start by laying a new surface which was supposed to last until the end of his contract at least. This means that his initial design and work plan would be aimed at getting as good quality as possible, as it is the operator himself that would get all the trouble if the quality is not good enough. A conclusion was also that there was no single optimal contract length. The length should be variable and depend on the amount of years that the operator was prepared to keep his pavement surface in order. This should help an ambitious operator with good ideas to excel in the original tender.
The final conclusion is an elaboration into how contract length could best serve to stimulate competitive operators. It is based on strong arguments based on both evidence from theory (Williamson, 1985) and practical experience (Austroads, 2003a).

Finally was the issue of protecting societal goals (question seven). Rijkswaterstaat can protect societal goals by creating minimum standards for them and implementing an efficient framework of incentives to stimulate good performance. The study of incentives furthermore led to the following conclusions:

- No single type of incentive that works for everything. Minimum standards should safeguard an agreeable quality of the assets. Those assets that return value to society with relation to their quality should have bonuses tied to them, stimulating the operator to improve them. Harsh penalties should be imposed for poor performance where the quality of assets drops below minimum standards.

- Bonuses should be paid out if assets are improved. It was furthermore discussed that bonuses would be partly a direct monetary payment and partly earmarked funds for more improvement work. This could then lead to an improvement cycle, where the operator improves one asset and gets funds to improve another, which then could get him another bonus and so on.

- A need for a special bonus at the end of the contract was highlighted as a necessity to ensure that performance would not drop in the end of the contract. This special bonus can be both monetary and/or a contract extension for a limited amount of time.

- To ensure that funds were not drained away from the roads all penalties and bonuses would go through a so-called incentive fund. This fund would originally be financed by the government, meaning that part of the total cost of an operational contract would go directly to this fund. This then ensures that there should always be available money to pay bonuses.

These conclusions present a quite more complex system of incentives than the very simple practical example of Transit NZ “three strikes and you’re out” rule. However the literature of (Vassallo, 2007) along with discussions and elaborations with the thesis-committee inspired the idea that incentives could be used more extensively. These conclusions are thus mostly elaborated ideas of how the incentives can be used in an inventive way to stimulate as good performance as possible. They are mostly not based on practical examples and will thus only be completely verified after having been put into practice.
This research question will be revisited in the end of next chapter, as that chapter discusses the individual societal goals which the contract is supposed to safeguard.
4 Asset analysis

4.1 Introduction

Road asset management, as it has been described here before, is primarily in the hands of two parties; Rijkswaterstaat and the private operator, with the operator being the one that actually deals with the assets day-to-day. Since the operator is ultimately responsible for the quality of the assets under his control, they are analyzed from his point of view. In other words, it studies how the operator can maintain and improve the assets in an effective and transparent way. The analysis distinguishes between three types of road assets; technical, functional and environmental. In the traditional sense most people would probably only associate road assets with the technical assets. But if we just look at assets as items of value then we see that it's not only the roads and the bridges that carry actual value. Travel time, safety and pollution are also items of value. It is of value to society that delays, accidents and pollution are minimized. Research questions five and six, "what the asset are and how they are interrelated" (question five) and "which indicators that best demonstrate the true state of the assets" (question six), will find their answers in the chapter. Furthermore the question on the safeguarding the societal goals is revisited as each asset will be elaborated with regards to how it can fit into the contract.

The first part of the analysis looks into the technical assets. As has been mentioned before (section 2.3), technical assets have already been introduced to road asset management schemes accompanied by sets of minimum standards and performance measures. The focus here is thus to gather experiences and recommendations about these assets in combination with input from international research literature. This is then used to create a set of minimum standards and performance measures that should work and be sufficient to safeguard the integrity and quality of the assets. Finally it will be demonstrated how of these standards and measures can be included in the contract between Rijkswaterstaat and the private operator.

The second part analyses the functional and environmental assets. These assets are widely measured and analyzed all over the world. However, the goal of this analysis is to look at ways in which the performance measures can be directly related to the actions of the operator. Because this is something that does not have a true precedence in road asset management elsewhere, the analysis will be more detailed and based more on international research literature. The purpose is the same as with the technical assets, namely to establish
solid performance measures when they are possible. Finally their inclusion in the contract is explained. The final part is a review of the assets and connections between them are elaborated.

4.2 Technical assets

4.2.1 Introduction

The term “technical assets” of the road system refers to the entire physical infrastructure which is needed to allow vehicles to move around safely. This is thus a very broad term and incorporates a vast range of assets which differ in nature and life-cycles.

![Diagram of technical assets](image)

*Figure 4.1: Some of the technical assets of the road (Knox City Council, 2007)*

Figure 4.1 displays the technical assets of the pavement and the roadside. It, however doesn’t show other technical assets such as the bridges, noise barriers, trees, light posts, signs and other electrical equipment needed for ITS and traffic management. As was discussed before, the technical maintenance along with paying of capital investments takes up most of the funds allocated to road infrastructure. The technical assets will thus make up the backbone of any asset management contract.

4.2.2 Analysis

A large percentage of road funds are devoted to the technical assets, as can be seen in Figure 2.5. When we speak of the total value of a nations’ infrastructure we are usually talking
about the total value of the technical assets of the infrastructure. As can be seen in Table 4.1, the most valuable technical assets are usually the supporting structures; the pavement base and the bridges. This is further supported by (Highways Agency, 2006). When a new highway is constructed these along with land acquisition and the formations needed form the most significant cost items. As can also be seen in Table 4.1, is that in the long run, these items are not the ones which necessarily will cost the most. As was mentioned in Table 3.1 in section 3.4, the technical assets vary quite a lot in their life-cycles. Most of them have estimated lives of tens, even hundreds of years. The surfacing stands a bit out with its relatively short life-cycle. If we look at depreciation costs of the technical assets in Table 4.1, the road surface also stands out as a dominant cost item. This comes as a result of its relatively high initial capital cost and short life span. Other assets, such as the pavement base and bridges, are a more expensive initial investment but bear less annual depreciation cost because of their long life-cycle. The land and formation here show no depreciation. This comes as a result of the view of Transit NZ that these assets have infinite life-cycle.

Table 4.1: Depreciation of technical assets of the New Zealand highway system (Transit NZ, 2007a)

<table>
<thead>
<tr>
<th>Description</th>
<th>Yearly depreciation charge (NZ$M)</th>
<th>Replacement cost (NZ$M)</th>
<th>Valuation (NZ$M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td>0</td>
<td>6,511</td>
<td>6,511</td>
</tr>
<tr>
<td>Formation</td>
<td>0</td>
<td>5,355</td>
<td>5,355</td>
</tr>
<tr>
<td>Pavement (base)</td>
<td>53</td>
<td>3,776</td>
<td>2,987</td>
</tr>
<tr>
<td>Pavement (surface)</td>
<td>142</td>
<td>969</td>
<td>576</td>
</tr>
<tr>
<td>Drainage</td>
<td>11</td>
<td>671</td>
<td>370</td>
</tr>
<tr>
<td>Traffic facilities</td>
<td>31</td>
<td>491</td>
<td>299</td>
</tr>
<tr>
<td>Bridges</td>
<td>46</td>
<td>4,277</td>
<td>2,454</td>
</tr>
<tr>
<td>Culverts &amp; subways</td>
<td>5</td>
<td>331</td>
<td>193</td>
</tr>
<tr>
<td>Other structures</td>
<td>11</td>
<td>890</td>
<td>755</td>
</tr>
<tr>
<td>Total</td>
<td>299</td>
<td>23,270</td>
<td>19,400</td>
</tr>
</tbody>
</table>

To assess the replacement cost of the assets Transit NZ has composed an Asset Valuation Manual which defines methods for evaluating each and every asset. Big questions that Transit NZ officials are still dealing with are as follows: When is structural integrity compromised, and thus the end of useful life? How can we determine remaining useful life of assets like ITS equipment? The basis for the replacement cost calculations are mostly based on contract experience from recent or nearby similar projects. Transit NZ also intensely
utilizes a construction cost database made by Opus International Consultants (A New Zealand engineering firm) (Federal Highway Administration, 2005).

Causes for the deterioration of the various assets are very diverse. Light posts, signs and other road furniture deteriorates through metal corrosion, accidents (when vehicles crash into them) and can even be damaged as a result of bad weather. Light bulbs in the light posts, DRIPS and other illuminated road signs have their estimated lifetime. That lifetime, however, varies so some of them will work much shorter than was expected. The structural part of the system, the bridges and the pavement, deteriorate due to many things like variations in climate, drainage, soil conditions, traffic intensity and axle loads (Gerber and Hoel, 1999). The responsibilities of the operator are not necessary to maintain everything as it was new. His main task is to maintain the assets so they stay in a safe and agreeable condition. Intensive condition monitoring allows for proactive instead of reactive maintenance could prevent deterioration from escalating and thus even extend the estimated remaining life of the assets. For this to happen the operator needs standards to follow, minimum standards which he should not break.

4.2.3 Performance measures / minimum standards

The selection of minimum standards stands for the lowest tolerable state in which the road assets are allowed to enter. They should be viewed as a line which the private operator should never cross, and in case he does so, he would face heavy fines or even a premature termination of his contract. Since the penalties for the breaking of the minimum standards are so heavy their selection must be realistic and relevant to social preferences. (Hensher, 2005) listed five key principles for selecting performance indicators. They were:

1. The indicators must relate to the objectives of an enterprise (which include internal and external considerations).

2. They must be clearly definable and unambiguous in their interpretation such that a particular numerical value or change in value is unambiguously good or bad.

3. Indicators must adequately distinguish between factors outside the control of an organization and those within it over well-defined time periods.

4. They must be simple to comprehend by those who are in a position to influence the numerical magnitude, including those who directly contribute to the outcome.

5. The results must be related to the overall analysis of performance. This requires an unambiguous definition of an improvement in performance.
Keeping these principles in mind, let's now analyse which factors should have minimum standards and what should the minimum standards be.

The single most important asset under the responsibility of the operator is without a doubt the surface of his roads. The surface's quality is a large factor in the safety of the road as well as its level of comfort. Today the factors that are mostly used to evaluate surface quality are pavement roughness, pavement distress, pavement deflection and skid resistance (Gerber and Hoel, 1999). This is confirmed in a case study conducted by Austroads in 2003 where 54 professionals from the road infrastructure industry were quizzed about their experience with performance contracts (Austroads, 2003a).

**Pavement roughness**

Pavement roughness mostly affects the comfort of driving, as it is a measure of smoothness of the road. The international roughness index was developed by the World Bank in the 1980's (UMTRI, 2002). IRI is used to define the characteristic of the longitudinal profile of a travelled wheel track. In other words, it's a measure of the evenness of the road. From Figure 4.2 we can see that the lower limit for new pavements is set at 3.5 mm/m.

![Figure 4.2: The International Roughness Index (Sayers et al., 1986)](image)

Countries have set different lower values for roughness such as 2.7 mm/m in USA, 4.0 mm/m in Spain and 6.0 mm/m in Honduras (Arellano et al., 2006). The US decision of 2.7 mm/m could have been chosen as it is slightly above well maintained older pavements. As can be seen on Figure 4.2 the comfort level affects the safe maximum speeds on the road in question. As motorways in the Netherlands can have a maximum speed of 100 km/h the roughness
should not exceed 3.0 mm/m on those roads. If roughness exceeds that number the maximum speed would also have to follow.

**Pavement distress**

The term pavement distress refers to the condition of a pavement surface in terms of its general performance. Distress modes can be broadly classified into the following three groups (Gerber and Hoel, 1999):

- Fracture (cracking, spalling).
- Distortion (rutting, corrugation).
- Disintegration (stripping, raveling and scaling).

![Figure 4.3: Different types of pavement distress. Clockwise from the left-top is spalling, raveling, rutting and finally, shoving (training.ce.washington.edu/wsdot)](image)

Pavement distress affects the safety of the road as well as its asset value. Cracks in the surface can allow water to flow into the supporting layers of the road and damage its load bearing capacity. The measurement of the severity of most of these factors (besides rutting) is done through visual inspection and can thus be subject to debate. Both Transit NZ and Rijkswaterstaat, for example, only measures rutting (Appendix 3) (Federal Highway
In (Gerber and Hoel, 1999) a method to evaluate pavement distress rating (DR) is presented:

\[ DR = 100 - \sum_{i=1}^{n} d_i w_i \]  

(4.1)

Where:

- \( d_i \) = The number of points assigned to distress type I for a given severity and frequency.
- \( n \) = number of distress types used in rating method
- \( w_i \) = relative weight of distress type i

Factor \( d_i \) is found from Table 4.2.

**Table 4.2: Rating factor, \( d_i \), related to severity and frequency (Gerber and Hoel, 1999)**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Severity</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not Severe</td>
<td>Severe</td>
<td>Very Severe</td>
</tr>
<tr>
<td>None</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rare</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Occasional</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Frequent</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
</tbody>
</table>

An example for DR-value calculation can be seen in Appendix 6. This method combines the measurement for all types of pavement distress and takes into account their severities, frequencies and the importance of each one. Rutting can be kept outside this equation and, in line with Rijkswaterstaats' current rules, a maximum rutting depth of 18mm on less than 1% of the network could be introduced. The DR-indicator, as has been stated before, is subject to visual inspection and is thus a subject to debate. As such, it's perhaps not a very suitable performance indicator or a minimum standard. This is still an important factor of the pavement quality and should be monitored. It is partially monitored through the measurement of pavement roughness (the more cracked the pavement, the rougher it will be). However, for its full evaluation to happen, a more concrete method to measure it must be developed.

**Pavement deflection**

Pavement deflection is an indicator for the pavement's structural adequacy (Gerber and Hoel, 1999). As importance as it may sound the fact is that its measurement is done for
design purposes only and not for pavement maintenance management. Assigning a minimum value for pavement deflection is thus not applicable.

**Skid resistance**

Skid resistance is closely related to road safety as it is an indicator of the friction between the road and the tires and thus the stopping length a vehicle needs (Gerber and Hoel, 1999). Skid resistance value (SFC) is calculated by dividing the lateral or frictional force needed to cause two surfaces to move tangentially to each other with the force that is working perpendicularly on these two surfaces. Minimum values for this range between countries somewhat below SFC = 0.5 while it is 0.38 in the Netherlands (Appendix 3). In Swiss a SFC-value of 0.32 is considered poor or critical and thus very unsafe. However, a Swiss-study on the safety implications of skid resistance did not prove a direct relationship between accident rate and inadequacy of skid resistance (Lindenmann, 2004). Therefore it can be questioned if the private operator should be pressured to maintain a very high skid resistance if is proving costly. Perhaps SFC minimum value of 0.32 is in fact adequate and could be lower without jeopardizing traffic safety. To be on the safe side, the Netherlands can implement the Swiss-minimum since that was proven to be safe by Lindenmann. Further studies in the future could lower this number, or raise it, depending on which relationships are found.

**Visibility of road markings**

Visibility of road markings is primarily a safety issue. A general rule of thumb should be that all road markings are visible, even in bad visibility conditions, all the time. The visibility is measured with so called retroreflectometers (www.johngodrich.co.uk/road.htm). According to (Austroads, 2003a) road marking visibility is not currently being used as a performance measure. However, since there exists machinery to measure them there is no reason why it cannot be included in the set of minimum standards. Road markings should always be visible so the minimum standard should be that a vast majority (+95%) of road markings are sufficiently visible.

**Drainage**

Insufficient drainage is a safety hazard and can affect traffic conditions as well. The effects of malfunctioning drainage are very clear as big pools of water are formed. Quite simply that should never happen. If one gully is clogged another ones near by should be able to handle the extra burden. Therefore the operator should be able to eliminate this threat by regularly checking and keeping most of the gullies open. In Tasmania a minimum standard of 70% of gullies must be open while Western Australia requests 75%. New Zealand and Virgina (USA)
put their threshold at 90% of gullies working (Austroads, 2003a). The Netherlands are a quite wet country and thus so is the importance of effective drainage. Therefore the minimum standard should take aim of the strictest standards and perhaps a bit more. So a minimum standard in case of drainage efficiency should be that 90-95% of gullies are functioning and water will never collect on the highway itself.

Response time for routine repair

There should be a minimum time the operator has to respond to routine repair. Light posts, railings, signs and other traffic related objects can be damaged as a result of accidents or other incidents. Light bulbs in signs and light posts also regularly go defunct. These objects should not stand damaged for a long time as they are supposed to increase safety and the comfort of driving. Although most people would take it as given that highway lighting is an important safety measure, studies have yet to confirm it and to establish a correlation between highway lighting and safety. One study even found lighting not to have any impact (Yannis et al., 2007). (Staplin et al., 1997), on the other hand, surveyed a number of studies that showed that highway lightning truly has an impact on safety. These studies, however, were preoccupied with extreme cases where either all lights were turned off or if every other was not working. This concludes that although it might be inevitable and rather harmless that a few light bulbs are not working on the network, it is not feasible that they become too many. A max of one week should be given to complete these tasks and 99% of all light bulbs should be working at any given time. If the max time to handle routine repair is surpassed, a known method to punish the operator is to charge him hourly, daily or weekly charges for it (Austroads, 2003a). An example of such penalties can be found in Appendix 2.

Corridor maintenance

Corridor maintenance, as described before, is not an easy thing to accurately measure. It involves a whole range of little things that together can affect safety of the road and last but not least, the satisfaction of the users. People are not happy when the streets are filthy and road structures full of graffiti. The best way to measure performance in corridor maintenance is thus probably through user surveys. The threshold for bad performance is very vague, but somehow people should sense it when that threshold has been passed. A minimum standard of 90-95% satisfaction of road users of corridor maintenance should be suffice.
4.2.4 Contract inclusion

The management of the technical assets will be the prime factor when it comes to estimating the price for the service contract. It has now been explained that the prime objective of the operator is to maintain the technical assets above the minimum standards. Investments in creating the perfect assets are not being motivated and thus there are no bonuses available for that. This means that during the tendering the operator will be asked to produce a lump sum that covers technical maintenance for the whole length of his contract. The way this amount is paid out can vary and would probably be somewhat dependent on the available budget of Rijkswaterstaat. As was discussed in section 3.2, the payments would be connected with the Dutch construction cost index.

Penalties, as was discussed in section 3.3.3, must be severe enough to prevent the operator from letting quality fall below minimum standards. The choice stands between a termination rule and a monetary penalty. The termination rule is quite simple and means that the operator risks losing his contract in case of bad performance. The monetary penalty is trickier. Rijkswaterstaat needs to have good information about the costs of fixing the different aspects that should be defended by minimum standards (e.g. how much it costs to fix skid resistance over a certain stretch). The penalty must then be set somewhat higher than that number. This is where Transit NZ stopped and claimed it wouldn't work in reality. So perhaps the termination clause is easier, although it will involve the unfeasible situation of having to tender the operations again.

Other types of penalties could be that Rijkswaterstaat could demand certain actions or investments from the operator. This was done in the UK where the First Great Western rail company was penalized for poor performance by being ordered to cut rates, hire new drivers, engineers and guards and improve their platform information systems. The total penalty was estimated as being worth £29 million (Department for Transport, 2008). For an operator of the road, similar penalties could be that the operator would be obliged to construct a noise barrier, eco-duct or other construction that Rijkswaterstaat would like to see done. This would of course have to be included in the original contract papers and the penalties would have to be realistic (not demanding that the operator builds a tunnel under the Maas river for failing a skid resistant test once).
4.3 Functional and environmental assets

The functional quality of the infrastructure is the factor that probably is the most important from the users’ point of view. It’s the users that are hit the hardest, if there is congestion on the road or if it is unsafe. Functional factors of the infrastructure are measured by most road agencies and most countries have a strategic national plan aiming to improve them. However, for some reason they don’t seem to play an important part in those performance related maintenance contracts of New Zealand and UK (Federal Highway Administration, 2005). In Australia, safety and environment are a part of a so called non-price attribute criteria assessment, which takes place in the tender selection process. They score a maximum of 10 points, out of a total of 100. In New Zealand mentioning that all constructions should withstand national environmental legislation is made to suffice (Austroads, 2003a). However, the operator is a big player in the road infrastructure and many decisions or actions depending on him can drastically affect the functionality and environmental quality of the roads. The criteria for selecting the functional and environmental assets are decisions of Rijkswaterstaat themselves. On the webpages of Rijkswaterstaat and AVV (www.rijkswaterstaat.nl and www.rws-avv.nl) one can see which functional and environmental issues they emphasise. For functionality, travel time and travel time reliability are by far the most important ones which are directly under the control of the operator. Safety is also a top-issue. The most pressing environmental issues are water, air and noise pollution, and then a host of other things, which here fall under the umbrella term of environmental public goods.

The following piece will first take a look at the most important functional assets; travel time, travel time reliability and safety, and look at ways in how they could possibly be addressed in a road asset management contract. Thereafter the environmental issues of emissions-, runoff- and noise-pollution along with environmental public goods are dealt with in the same way.

4.3.1 Travel time

The functional asset of the road network that probably affects us the most is travel time. The time we invest in travelling is precious and most of us get really bothered when we have to spend more time than usual to travel a given route. In 2007 the “Kennisinstituut voor Mobiliteitsbeleid” (KiM) estimated that congestion costs in the Netherlands in 2006 totalled around 0.5-0.6% of the total Dutch gross national production, or €2.6-3.4 billion (KiM, 2007). Others have, however, placed a far greater value on it (€8.62 billion in 1995 (Infras/IWW,
2000)). This latter value has though been criticized as being excessive (Koopmans and Kroes, 2003).

**Analysis**

Queues usually grow from so called bottlenecks in the system. Typical bottlenecks are bridges, tunnels and discontinuities on the roads (entries, exists, weaving sections and lane number alterations). These bottlenecks are usually known to local road authorities (Bovy, 2001). In the Netherlands 20 locations were identified as recurrently building up queues at least once a day in 1995. About 50 queues were reported for an average working day having an average duration longer than 1 hour and having an average maximum length of 4 km. As can be seen in Table 4.3 three quarters of the queues are of recurrent structural nature.

**Table 4.3: Congestion figures for Dutch motorways in 1995 (Bovy, 2001)**

<table>
<thead>
<tr>
<th>20</th>
<th>Locations of permanent peak hour queue building</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>Queues each working day</td>
</tr>
<tr>
<td>&gt;1</td>
<td>Hour average queue duration</td>
</tr>
<tr>
<td>200</td>
<td>Kilometres total daily queue length</td>
</tr>
<tr>
<td>20%</td>
<td>Of peak hour drivers in Randstad Area end up in queues</td>
</tr>
<tr>
<td>100,000</td>
<td>Hours travel time loss daily</td>
</tr>
<tr>
<td>75%</td>
<td>Of jams are recurrent</td>
</tr>
<tr>
<td>15</td>
<td>Minutes travel time loss per trip in queue</td>
</tr>
</tbody>
</table>

That leaves about 25% of the queues being caused by incidents, accidents or road works. This number is further analysed in Figure 4.3. The recurrent jams exist because there is simply more traffic demand existing than the current infrastructure can handle. Fixing them would likely call for investment in increased capacity or even creating new links.
Figure 4.3: Congestion severity per month in the Netherlands in 2003 and 2004 (AVV, 2004b)

All bottlenecks, man-made or structural, are harmless when the traffic demand stays well below the road capacity.

Capacity

The capacity of a highway is fundamental to its value. The fact that the first capacity studies of highways date back to 1920, indicates that its importance was realized early by stakeholders of the transport system. It is usually defined as "The maximum hourly rate at which persons or vehicles can reasonably be expected to traverse a point or uniform section of a lane or roadway during a given time period (usually 15 minutes) under prevailing roadway, traffic and control conditions". Figure 4.4 displays the so called fundamental diagram of traffic flow. The y-axis stands for traffic intensity and the x-axis for traffic density. $K_c$ is what we usually call critical density of the road and that is where the traffic intensity matches the capacity of the road. An interesting thing about the capacity is that studies show that as soon as the so called critical density of the road is reached, a certain "capacity drop" occurs. On the Figure 4.4 this is portrayed as the discontinuity between $q_{c1}$ and $q_{c2}$. This drop varies and can range between -1% and -15% drop in the capacity of the road. When the critical density is surpassed the result is congestion. A possibility to increase the efficiency of the road thus lies in the diagram. If we manage, through some actions, to influence the traffic so that it stays behind the critical density we can avoid the capacity drop, maintain more flow and make more use of the capacity.

---

This section on road capacity is mostly worked from (Hoogendoorn, 2005)
We can look at the capacity of a freeway in the same way as we look at the output-potential of a factory. And as can be done in the factory, the capacity can be increased by either adding or upgrading the infrastructure or by enhancing the remaining one. The operator has tools already that can delay the moment that traffic density passes its critical value. Variable lane width, ramp metering and hard shoulder use, to name a few, can increase available capacity and delay the critical density and thus congestion and the capacity drop.

Traffic demand\(^5\)

Our longing and need to travel creates the traffic demand. We choose to travel alone in our personal car, live in a village a long way from our office in the city, and after work we like to go to the supermarket on the other side of town to buy groceries. Our choice to develop our own lifestyles is vast. It is, however, clogging the transport networks because of their inability to cope with all the growth in traffic demand. Traffic demand has been rising almost non-stop ever since the invention of the car. Various factors stand behind this growth such as population growth, income growth, spatial de-concentration of activities, increase in car ownership and better accessibility through better roads. Freight traffic demand has increased even faster than the trends of increased welfare because of structural changes in goods production and logistics, and increased international trade. These are all macro-economic factors, way beyond the operators’ sphere of influence. Therefore the best tools to deal with traffic demand lie at the highest level of public authorities (national, regional or municipal). The traffic operator himself can only affect traffic demand by trying to influence

\(^5\) This section on traffic demand is mostly worked from (Bovy, 2001)
our decisions, especially when it comes to departure time choice and route choice. Dynamic traffic management and congestion pricing are considered the best tools in this regard.

Performance indicators / Minimum standards

The first thing that comes to mind when thinking about performance indicators for travel time is simply to measure speeds on the highways and quantifying congestion severity. Here we must however measure how the operator faired in dealing with the congestion. We should thus focus on those actions that the operator is supposed to do and are known to affect traffic conditions. Furthermore, in line with the principles of performance measures (section 4.2.3), they must be accurately measurable.

Traffic management approval

Dynamic traffic management was mentioned as one of the best tools available for road authorities to deal with traffic demand and capacity. Dynamic traffic management is an umbrella-term for a wide range of actions further detailed in Appendix 1. When one looks at that list it's easy to see that this is a very vibrant subject open for innovative solutions that can further improve the road efficiency. However, one will also notice that measuring the exact result of each of these measures is very hard. The reason is that they will often be used together and are not always simply meant for the sole reason of reducing congestion. The performance of the operator in managing the traffic can thus only be measured in a rather general way. That means that historical data is used to estimate the actions. So measuring specifically how much impact his, say homogenization of speeds, is having is hardly possible. Only how X amount of cars are able to drive through the network compared with previous examples of X amount of cars with similar circumstances. As traffic management is not only a congestion relieving job but also a service to the users, the day-to-day traffic management, also when there is no congestion, can be measured with the help of user surveys, similarly corridor maintenance. The minimum standard would then be a minimum user approval.

Delay caused by maintenance or construction

The management of all maintenance and construction is in the hands of the private operator. The timing, scale and frequency of these actions can all affect traffic conditions. It can be hard to define minimum standards when it comes to delays caused by necessary maintenance of the roads, as the maintenance can be of all sorts. However the delay caused by this can and is measured (as can be seen in Figure 4.3). The total amount of delay, as a
result of maintenance and construction can thus be used as a performance measure. Rijkswaterstaat should also set a minimum standard for this issue, based on historical data.

**Delay caused by incidents and accidents**

In Figure 4.3, incidents and accidents are credited with a large share of delays. The efficiency in which they are dealt with can thus have considerable influence on traffic conditions and delays. Automatic incident detection systems are useful when it comes to alerting all necessary parties (emergency services and cleaning crews) of their existence with as short time as is possible. If we look at incidents and accidents from delay-creating point of view the critical thing is how the traffic is managed while they are on the road, working as a bottleneck and for how long they exist as a bottleneck. According to AVV's Incident Manual the road operator is relatively powerless while emergency services are attending the accident. He can only wait until police; medical personnel or the fire brigade finishes their work and allows the lane to be reopened for traffic (AVV, 1995). Rijkswaterstaat has set minimum standards relating to reaction time, in case of accidents/incidents. They focus on the cases when emergency services are actually needed and are thus more of a safety issue. However, emergency services are not always needed (Cornelisse, 2008). In these cases it's entirely up to the operator to react and clear the road. These cases could be quantified into a performance measure. Taking precedence from the current “reaction time” performance measure of Rijkswaterstaat (Appendix 3) the measure could differ, based on where the accident happens and be an average time it takes to clear the road. Incentives could then be assigned with gaining better performance in clearing the road.

**Contract inclusion**

Considering the frequent delays already experienced in The Netherlands the inclusion of incentives for improvements is a very lucrative idea. It’s inclusion in the contract is very difficult because of the complexity in determining the effects of individual activities on total travel times. Because of this the range of tasks that can be effectively contracted out to the private operator are somewhat limited.

Minimum standards with relation to reaction times to accidents can be included in the same way as minimum standards for the technical assets (section 3.3.1). This minimum standard is more an issue of public health than travel time as the reaction time can be crucial in case of accidents but an extra delay of a few minutes is not as serious. For accidents, where no emergency services are needed, the operator should have a minimum average response and
clearance time. This should be awarded and a bonus/penalty should be assigned for a good performance in responding and clearing the road.

A minimum standard for user approval of traffic management could be connected with bonuses and penalties. Because it is not possible to calculate the gross social benefit of good approval the bonuses and penalties would have to be decided beforehand.

Performance of the operator to minimize delays caused by maintenance and construction activities is an ideal performance measure. The total delay is already measured and its contribution to gross social welfare can easily be quantified by magnifying the delay severity with a value of delayed hour. When competing for a contract in a tender, companies could use the estimated amount of construction related delays as a unit of value in their bid. This would then form a delay-quota for the private operator. If he doesn't use his entire quota, he will get a bonus, but if he exceeds it, he must pay a penalty. This inclusion must be well prepared by the tendering party, as there are a number of issues he should be aware of. First of all the amount of delay allowed to bid should be capped in the tender. The reason for this is that the bidders could in theory group together before the tender and decide to offer a very high amount of delays expected and thus securing future bonus payments when they produce much less. The second thing is the decision of how high the bonus/penalty will be to surpass or not fulfill the delay quota. If a company is running out of quota but must conduct necessary maintenance it might be tempted to do it faster and perhaps worse than is feasible.

As was stated before, congestion usually has its roots in so called bottlenecks in the network. An interesting idea that could stimulate unexpected, innovative solutions is to include a possible reward, an innovation-bonus, for an operator that can demonstrate and prove that an action of his has reduced the severity of a bottleneck in his system. By comparing historical traffic data of a certain bottleneck, with new data after an innovative solution was installed the total gross social benefit and thus the expected bonus can be calculated. This clause is special in the way that it deals with uncertainty and it’s likely that not every operator would actually manage to get it. However, it would stimulate and reward innovation, which is so valuable to social welfare.

4.3.2 Reliability

The reliability of traffic has been defined as “The likelihood of a traveller’s expectations being met. Reliability is measured as the variability between the expected travel time (based on scheduled or average travel time) and the actual travel time (due to the effects of non-recurrent
Reliability has thus great influence on our utility of transport. For instance, a recent study of travel time variability in California by the Transportation Research Board estimated a value of 12.6$ per hour of standard deviation in travel time, compared with a value of travel time of 5.3$ per hour for normal travel time (Norwood and Casey, 2002).

**Analysis**

![Illustration of a one-tailed test](image)

*Figure 4.5: Illustration of a one-tailed test. The unacceptable travel time is the shaded area.*

It can be hard to put a finger on what exactly is acceptable reliability. Small fluctuations in travel time from day to day are very normal. Fluctuations in travel time can surely be both sided, i.e. unusually short travel time or unusually long one. It is however very unlikely that an unusually short travel time is of any discomfort. Therefore the area of concern is the part of travel times that are longer than usual as can be seen in Figure 4.5. Unreliability can be caused by a wide range of things as can clearly be seen on Figure 4.6.
The operator can influence the outcomes in case of man-made bottlenecks such as construction and incident delays. The same can be said of special events. However, uncertain factors such as weather-disturbance and travel time fluctuations of unknown consequences are mostly beyond him. To increase reliability it is clear that the impact of random disturbances must be minimized. With predictable causes the operator can prepare countermeasures or at least warn the commuters in one way or another of the predicted delay. To deal with construction work the counter measures must take aim of the expected traffic situation during the construction period. The choice of measures is entirely up to the operator and can range from a simple sign signalling a closed lane up to a special side road, constructed for the traffic to bypass the construction site. In case of bad weather, informing the commuters might not lessen their delay. However, it could decrease their discomfort since they knew beforehand that delay was expected. Commuters can be informed before their trip through media (TV, radio, internet) or en-route through GPS applications such as Tomtoms and digital information panels (DRIPS). More traffic management applications that can be used to deal with travel time unreliability are mentioned in Appendix 1.

Figure 4.6: Factors influencing the reliability of travel times (not exhaustive) (van Lint et al., 2008)
Performance measures

Travel time unreliability performance measures are somewhat debateable but therefore remain an important issue in transport research. (van Lint, 2008) created an overview of some of the main methodologies being used today to assess travel time reliability. These are methods such as statistical range methods, buffer time methods, “tardy-trip” measures and probabilistic measures. These methods all try to describe travel time unreliability on a given road stretch. However, if we look at them from a service-contract point of view, they are all worthless. They are worthless because they are describing a situation as a whole and make no reference to what is causing the unreliability or what might even be solving it. On Figure 4.6 we see the causes of unreliability. Besides incidents and accidents, the only thing on this picture that is in the hands of the operator is a part of the traffic management / control. This can mean traffic management in general or traffic management during special events. Delay caused by special events, where traffic control is needed could be measured. This refers to sporting events, concerts, large scale celebrations or other kinds of special events.

For traffic management in general it’s perhaps best to focus on measuring reliability from the users’ point of view. In the same way as the users’ approval of traffic management (section 4.3.1), their perception of the reliability of travel time can be measured as well. This is perhaps the most important measure, as the majority of the “cost” associated with delays and unreliability, is the distress of the users. So if the users are happy, then things are working fine.

Contractual incentives

As has been revealed in the text, the inclusion of travel time reliability is not easy. The reasons are, as with travel time, that the causes are so wide ranging, unpredictable and distant from the operators’ sphere of influence that they will only have a limited contract inclusion. Three causes of unreliability were mentioned that the operator can have influence over; accidents, road works and special events. As both accidents and road works management were already dealt with in the travel time section it is unnecessary to do it again here. Special events usually happen outside peak hours (weekends or evenings). This is of course good for traffic and means that delays because of them are limited. However, very large events can create jams and must be controlled and dealt with. The contract could have a list for special events where acceptable delays are detailed with relation to the size of the event. This would be performance related and the operator would be working on a bonus/penalty basis. Minimum standards for recurrent special events (North Sea Jazz Festival, Feyenoord games, Queensday, etc.) should be based on historical data. Other,
random events will have to go without minimum standards and dealt with in best possible way.

A minimum standard and performance incentive could be installed for the user approval of travel time reliability. Like with traffic management, since user-approval is not measured in monetary terms, the bonuses and penalties have to be predefined in the contract.

The innovation bonus for travel time (section 4.3.1) could also be used for travel time reliability and work in the same way. The bonus could be based on a similar valuation of delayed hour as was presented in the beginning of this section (4.3.2).

4.3.3 Safety

On August 17th 1896 Bridget Driscoll, a mother of two, died after being hit by a car while on her way to a dancing display in Crystal Palace, London. The driver, Arthur Endsell, had been tinkering with the engine of the car, causing him of running at the ‘tremendous speed’ of 4 mph. After a six hour inquest the jury returned the verdict of “accidental death”. At the inquest the Coroner declared that “This must never happen again” (www.roadpeace.org).

Today more than 3000 people die from road accidents every day worldwide. However, 85% of these deaths happen in middle and lower income countries (Peden et al., 2004). In 2005 there were 41,600 deaths in the European Union, down from 50,000 in 2001. This is happening while the EU is working on its goal of getting the fatalities down to 25,000 by 2010. Societal costs of traffic related accidents are huge as they are estimated to be €12 billion annually in the Netherlands alone. That amounts to 2.6% of the total gross national production every year (AVV, 2006). All these numbers highlight the burden that traffic accidents are on our society. However, as can be seen from the progress made in the EU, this is a problem that can be dealt with. Getting the fatalities down by 8400, from 50,000 to 41,600 in four years is certainly a positive improvement, although it might be a bit short of the goal of 25,000 by 2010. But what is it that actually makes road traffic unsafe?

Analysis

The risk factors of traffic are many and concern the vehicles, the drivers, the weather and last but not least the infrastructure (European Transport Safety Council, 1999). The traditional view of road safety is that the crashes are usually the sole responsibility of the driver, although other factors beyond their control may come into play. It is still widely believed that up to 90% of traffic accidents are as a result of human error. However, human error does not necessarily have to lead to a crash. Furthermore, the human error can sometimes have its underlying cause in other factors (Peden et al., 2004). According to
(Rumar, 1999) safety problems can be separated into three levels. First order problems are the most obvious ones. These are direct numbers, such as fatalities or injuries, as well as total cost of crashes. Second order problems are a bit more obscure. They should show up after closer analysis of the crashes. They include factors such as pavement quality, vehicle condition and so forth. Third order problems are the most obscure ones. They include public awareness for road safety, cooperation in traffic safety research and lack of traffic safety targets.

The factors that according to many studies are most important for traffic safety are (European Transport Safety Council, 1999):

- Exposure (Time spent on the road).
- Speed.
- Alcohol/Drugs.
- Various injury reducing measures.

Other major road safety problems recognised in most countries are high crash/injury rates:

- Among young and new drivers.
- For unprotected road users (for example pedestrians and cyclists).
- For heavy vehicles (mainly dangerous for other road users).
- In bad visibility conditions (such as darkness and fog).
- In low friction conditions (for example, on ice, snow, heavy rain).
- For tired drivers.
- For drivers driving a vehicle without being authorised to do so.
- For old drivers.

Factors that increase the injury consequences of crashes are:

- Delayed rescue service.
- Injury causing constructions of various kinds (for example lighting columns, the vehicle interior and vehicle crashworthiness).

Missing from this list are special geographical attributes that can in some cases create dangerous spots on the road. An example of this are lows in the landscape where under some circumstances cold air can gather, possibly creating icing on the road even though the general weather is above freezing.
Running down the list from the European Transport Safety Council, it is apparent that most of the safety factors are not under the control of the operator. He has no say in if people are tired, old, young, unprotected, drunk or unauthorized. This is not to say that the operator is powerless in increasing safety. Taking care of winter service and alerting emergency services are a major contribution of his to safety. Appropriate measures to ensure road safety around road works and taking road safety into account when setting up roadside equipments (which later could cause injury in case of accident) are also important.

**Performance indicators / minimum standards**

Most minimum standards of a service contract will in one way or another relate to the safety of the highway. The minimum standards for the technical assets are not only concerned about the deterioration of asset quality but also of their contribution to safety. Traffic safety is monitored all over the world by counting the number of accidents, injuries and fatalities on their roads as well as estimating the societal cost of these accidents (Peden et. al., 2004). These numbers give a picture of how the overall situation is. However, they give very limited information about the specific causes of accidents or injuries nor the effectiveness of individual efforts to deal with them. For a service contract it must be clear how successful the operator actually is in preventing accidents and increasing traffic safety. Therefore it is more fruitful to focus on Rumar’s second order problems, namely the conditions of the infrastructure around accidents. As has been stated, minimum standards relating to the pavement-condition were dealt with in the technical assets’ section. The following minimum standards are of different kind but directly relate to the operators’ success in traffic safety.

*Total amount of accidents*

Simply measuring the amount and severity of accidents, which can be associated with poor asset condition, road icing or delayed rescue services, is a good performance measure in itself. Because the operator is responsible for almost all the operations on the road network, he can, and should, be credited for it if safety increases. Minimum standards can thus be created by combining historical data from the network and governmental goals for traffic safety.

*Response time for emergencies*

Rijkswaterstaat already uses this as a performance measure. The time they deem suitable is 15 minutes in urban areas and 30 minutes in rural ones. It’s hard to determine scientifically what response time is optimal as the general rule it is basically the sooner the better. So
these minimums should be maintained and the operator should be made to fulfil them in the vast majority of instances.

**Response time for winter service**

Responding to icing on the road and clearing snow is a big safety factor. It’s in most cases foreseeable, as the operator can use weather forecasts to prepare and even try to hinder icing altogether from happening. To increase the efficiency of the winter service actions the operator should have a strategic plan on how to deal with it. The strategy can be to treat the links according to their traffic intensity (with heavy traffic links receiving service first and so on). The strategy can also be to pre-salt the roads during the night if a frost is expected the following day. In the UK a minimum response time of one hour is advised (Leeds City Council, 2006). That response relates to how long it takes until the road authority instructs salting or snow clearing until it is actually started. The work on the whole network should thereafter take no more than 2 hours. Perhaps this is not the best minimum standard for a service contract for a private company. The minimum standard should persuade the operator to eliminate icing altogether. Therefore the minimum standard should simply state that icing is not allowed to form on the highway. To further emphasize this, the operator can be made responsible for accidents that are clearly caused by icing on an untreated site.

**Contractual inclusion**

The minimum standards for both emergency- and winter-service response times should be treated the same way as other minimum standards (section 3.3.1). For safety related to other activities of the operator a bonus / penalty clause should be in place. The total social benefit of fewer accidents is measurable and thus the incentives for reducing accidents should take aim of that.

Furthermore an innovation bonus should be in place for safety improvements (sections 4.3.1 and 4.3.2). Thus the operator can gain bonus-payments if he fixes an accidental prone spot on the network.

**4.3.4 Air pollution emissions**

Vehicle emissions are one of the most apparent of pollutants connected with road traffic, and are certainly one of its worst external effects. It affects a wide range of things, from global warming (Quadrelli and Peterson, 2007) and human health (Clougherty et al., 2007) to reduced aesthetics (Hamilton-Wentworth Air Quality Initiative, 1997) and even the corrosion of historic buildings like the temples on top of Acropolis hill (Sikiotis and Kirkitsos, 1995) in
Athens. Therefore it should come as no surprise that reducing air pollution is a high priority issue for policymakers around the globe (Gwilliam et al., 2004).

Air pollution emissions are an issue that has received special attention from Dutch policymakers. In 2004 the Dutch Ministry of the Environment (VROM) issued the Traffic Emissions Policy Document (VROM, 2004). The report looked at the state of environmental affairs in the transport sector and studied ways of making it more sustainable. With regards to road traffic three priority points were stated along with performance targets:

- Reduced air pollution from road traffic
  - To contribute to achieving the NOx emissions ceiling for traffic of 158 kiloton in 2010 in order to meet the EU’s NEC Directive.
  - EU standards for air quality should be met in 2010 (NO2 and particulate matter) at as many locations as possible, and in 2015 to meet the EU standards for NO2 at all locations.
  - EU standards for air quality (NO2 and particulate matter) should be met at as many locations as possible in 2010, and to meet the EU standards for NO2 at all locations in 2015.

- Reduced CO2 emissions from road traffic
  - CO2 emissions from traffic may not exceed 38 megaton in 2010. This is excluding implementation of the EU Biofuels Directive.
  - Biofuels should reach 2% of the energy content of diesel and petrol in 2006, which is to be provided as much as possible by second generation biofuels where feasible and in such a way that lock-in effects are avoided.
  - A reduction of vehicle CO2 emissions by 40% to 60% by 2030.

- Quieter roads and rail traffic (presented in the noise pollution section 4.3.6)

It’s obvious that these goals touch on a much wider perspective than the operator’s. The analysis should clear his position and how he can contribute to these goals.

Analysis

Road traffic produces various types of chemicals that pollute the air. Table A.4 in Appendix 7 lists them up as well as their sources, scale and harmful effects. As can be seen from the table most of the chemicals have their point source in the tailpipe of the vehicles, in other words, they are resulted because of design of the car engine or the fuel they use. The type of
fuel, the efficiency of the engine and the tailpipe filter, to name a few, is thus the primary points of concern. The emissions are in part related to vehicle speed as can be seen in Figure 4.7. The Figure shows that emissions are the lowest between 25-90 km/h average speeds. From that we can draw the conclusion the emissions are minimized if the traffic remains in relative free flow. Excessive speeds as well as heavy congestion thus result in more air pollution. Other factors that can also contribute to emissions are road geometry and intersection control. Dust that inevitably collects on the streets is mentioned in Table A.4 as well.

![Figure 4.7: Typical vehicle emissions by speed (Transportation Research Board, 1995)](image)

But where can the operator contribute here? He is not involved in vehicle or fuel design and in most cases he did not design the road geometry. However, as was mentioned earlier (section 4.3.1), he can be stimulated to make his activities have as little influence on travel times as possible. The extra costs due to wasted fuel and extra emissions due to queues cause by his road works or his traffic management in general could be a factor that is used to evaluate a possible penalty (or bonus). Clearing dust of the roads is a part of his “corridor maintenance” and should be treated according to that. Furthermore, the activities of the operator have environmental effects. All his machinery, choice of methods and materials will determine the amount of pollution he creates. In New Zealand potential operators must issue an environmental strategy plan when they bid for contracts. This plan details how they will try to minimize the environmental effects of their activities. This is a very good idea and can be used to evaluate bids.
Performance indicators

Most of the air polluting chemicals are measured simply by the amount they are released into the atmosphere. By measuring the connection between traffic speed and the emissions of a selected group of known air pollutants (like is done on Figure 4.7) we can create an index for air pollution. After that we can use traffic counts and average speeds to estimate the total amount of emissions. (Wang and Santini, 1994) created a method to monetize the various air pollutants. (Litman, 2007) took numbers from this publication and updated them to reflect inflation. These numbers are displayed in Table 4.4, however, with US dollars now converted to Euros (currency rate of 19.11.07).

Table 4.4: Air pollution costs in the USA (2007 Euros per ton) (Wang and Santini, 1994)

<table>
<thead>
<tr>
<th></th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon monoxide (CO)</td>
<td>€ 495</td>
<td>€ 0</td>
</tr>
<tr>
<td>Nitrogen oxides (NOx)</td>
<td>€ 17,570</td>
<td>€ 10,010</td>
</tr>
<tr>
<td>Volatile organic compounds (VOC)</td>
<td>€ 16,430</td>
<td>€ 13,470</td>
</tr>
<tr>
<td>Particulate Matter (PM)</td>
<td>€ 6,090</td>
<td>€ 2,980</td>
</tr>
<tr>
<td>Carbon dioxide (CO2)</td>
<td>€ 20.65</td>
<td>€ 20.65</td>
</tr>
</tbody>
</table>

A similar table as Table 4.4 for the Netherlands could not be found. However, (Singels et al., 2005) estimated that the total cost of air pollution in the Netherlands were at least €4.5 billion, and possibly as much as €40 billion. The bulk of this can be traced to combusting processes (road traffic, shipping, etc.). What that report fails to produce is a similar table as Table 4.4, where the cost of each emissions-type is presented. That kind of figures is needed to monetize a possible changes in emissions, cause by the operator. Furthermore they can be used to estimate the monetary value of the environmental plan, issued by the operator. Dust pollution can be measured in user surveys, as other corridor maintenance activities.

Contractual inclusion

The contractual inclusion of air pollution is mostly done by incorporating the value of air pollution to other items, such as the operators' caused delay and the corridor maintenance user surveys. However the environmental plan is a special thing. It is created by the operator and is forms a part of his initial bid for providing the service. This plan must be followed up by inspection and be audited by the public road authority. How to deal with failure to live up to this environmental plan is debatable. It could be considered a minimum standard for the operator to live up to his own set of standards. It could also be looked at through incentives...
and penalize or compliment the operator according to his performance. The issue of measuring accurately the amount of emissions created during road works and other activities might eliminate the penalty / bonus option. Therefore treating it simply as a minimum standard (section 3.3.1) is probably the best solution.

### 4.3.5 Runoff pollution and hydrological impacts

A road is a major construction usually reaching some kilometres. As such it is bound to influence the area in which it is built on. The hydrology of the land is one of those things. Roads can act as a source of water when it flows off their surface. They can act as sinks where water accumulates on the roads. They can act as barriers for water flowing downhill, but can also speed the removal of water. In an overview of transport related water pollution (Litman, 2007) mentions that an estimated 46% of US vehicles leak hazardous fluids including crankcase oil, antifreeze, transmission-, hydraulic- and break fluid. An estimated 30-40% of the 5.3 billion litres of lubricating oils used in automobiles are either burned up in the engine or lost in drips and leaks, and another 680 million litres are disposed improperly onto the ground or into sewers. Other polluting agents originating from the roads are road de-icing damage (caused by salt), roadside herbicides and air pollution settlement to name a few.

Together these impacts impose various environmental costs including polluted surface and ground water, contaminated drinking water, increased flooding and flood control costs, wildlife habitat damage, reduced fish stocks, loss of unique natural features, aesthetics losses (Litman, 2007), and soil erosion (Coffin, 2007).

### Analysis

As can be seen from the introduction, the majority of the runoff pollution is originating from the vehicles using the roads. The operator can not be expected to deal with leaking engines but he can be expected to treat it after it has landed on the road. The environmental impact of the hazardous elements depends a lot on how the runoff is drained off the road. Not all roads are as vulnerable to the effects of runoff pollution. Most people would agree that a road through a national park or near the sources of fresh-water deposits of a city are more vulnerable than, say, the ring-road around Rotterdam. Installing drainage with some mechanism, either removing the pollution or minimizing it is something that the operator of the road can do to deal with the problem. However, a normal drainage can usually only be expected to deal with normal, day-to-day leakage from traffic. In case of a traffic accident involving truck carrying oil or other pollutants some other methods would have to come in.
The hydrological effects come as a result of the initial road design, how well the designers knew the geology and ground water streams in the area. When the road is already in place, there is not much that can be done to change its effect on the hydraulics. (Engelhard et al., 2007) found a strong link between copper pollution and high traffic intensity. The reason for this is that copper pollution originates in the break-pads of vehicles. So the pollution rises fast as roads get congested, where vehicles drive in a so called start-stop way, and intensively using their breaks. Reducing congestion thus will also reduce copper pollution in the runoff. Water and soil can also get polluted as a result of road works. Road works normally call for heavy vehicles and sometimes vast amounts of chemicals. The choice of chemicals and the state of machinery and equipment as well as the preparation of the construction site (Caltrans, 2003) can have a big difference on water pollution created by road works.

**Performance measures**

The performance of reducing runoff pollution is measured in those areas that could possibly be affected by it. Taking samples from nearby lakes, streams and soil could indicate if pollutants are flowing from the roads into the environment. However, accounting for runoff pollution from traffic in a service contract is very challenging. First of all it is very hard to identify how much motor vehicles and roads contribute to the water pollution problems since impacts are diffuse and cumulative. Road runoff usually meets water quality standards (Litman, 2007). Even if we manage to identify exactly the runoff pollution stemming from the roads, we still face the problem of monetizing the effects. Building treatment facilities that can handle all the runoff from the highways would be major projects and are not within the scope of day-to-day road management. These kinds of facilities would thus only be constructed if the public authority would want it and fund it specially.

As with air pollution, the operator should state in his environmental strategy how he will minimize the pollution of water as a cause of his activities. This involves taking special care of machinery or containers not leaking oil or other hazardous materials onto the ground. The choice of chemicals can also take aim of the environment and, whenever feasible, the operator should always seek the most environmentally friendly option.

**Contractual incentives**

The performance of the operator to live up to his environmental strategy with regards to runoff pollution is included and treated the same way as with air pollution. As congestion and queues cause the traffic to start running in a start-stop fashion the extra amount of copper pollution can be used in the penalty/bonus calculations for operators’ inflicted delays.
Finally, to underline the operators’ responsibilities with regards to his own environmental strategy, he should be made responsible if water pollution caused by his machinery or by clogged drainage points under his supervision, pollute or damage. This damage can be stemming from flooding into a house, polluted farmland or the fish stocks in a valuable fishing river. In all these cases the relevant stakeholders would have the right of demanding compensation for their losses from the operator.

In case of great runoff pollution disasters, such as if an oil truck had an accident, the operator could also face penalties if conditions on the road is proven to be the blame. This factor, which is also much related to safety in general, is a challenging one because the penalties in these cases could be very high. One accident close to an expensive fishing river could mean a multi million euro lawsuit from the owners of the fishing rights. Operators might be tempted to simply ban these vehicles from their network. A solution for this might be that the operator would only allow these trucks to enter their network if they were “environmentally insured”. That they in fact oblige the oil companies or other transporters of contaminants to take over the environmental risk that is associated with their movements.

4.3.6 Noise pollution

Traffic noise pollution refers to unwanted sounds caused by traffic. According to the WHO about 40% of citizens of the European Union are exposed to traffic noise exceeding 55dB(A) during daytime. 20% are exposed to noise exceeding 65dB(A). 30% are exposed to noise pollution exceeding 55dB(A) at night, a sound level that is disturbing to sleep. In contrary to most other environmental problems, noise pollution keeps growing. This growth is unsustainable since it involves direct, as well as cumulative, adverse health effects (Berglund et al., 1999). Noise pollution doesn’t only affect our health. (Kim et al., 2007) showed that a 1% increase in traffic noise associated with a 1.3% decline in land price. There we have direct and measurable monetary losses resulting from noise pollution.

Noise pollution was addressed as a priority issue in the previously discussed Traffic Emissions Policy Document (VROM, 2004) (section 4.3.4). The key targets with relation to noise pollution were:

- A sharp reduction of noise levels from road and rail traffic in the long run.
- Road traffic noise should be reduced by at least 2dB(A) by 2010.
Analysis

The Victoria Transport Policy Institute mentions several factors that affect the amount of noise created by traffic (Litman, 2007):

- Type of vehicle. Motorcycles, heavy vehicles, and vehicles with faulty exhaust systems.
- Traffic speed, stops and inclines. Lower speeds tend to produce less engine, wind and road noise. Engine noise is greatest when the vehicle is accelerating or climbing an incline. Aggressive driving, with faster acceleration and harder stopping, increases noise.
- Pavement condition and type. Rougher surface tend to produce more tire noise.
- Barriers and distance. Walls and other structures, trees, hills, distance and double-paned windows tend to reduce noise impact.

Dealing with noise pollution is not only a matter of reducing noise production. Another thing, no less important, is to try and reduce the severity of the noise and thus its impact. For that three factors are very important (Bickel et al., 2006).

- Time of day: When is noise being generated? High noise levels from the traffic or maintenance work at night could have more disturbing effects than the same noise during daytime. Marginal costs as a result of noise pollution are generally higher at night, with a difference of up to a factor of 3.
- Number of people affected: The population density varies along the road and thus the potential impact of the noise level created by the traffic on them.
- Number of vehicles and their speeds.

The Traffic Emission Policy Document highlighted “quieter infrastructure” as one of the prime solutions to the noise objectives of achieving a generic reduction of noise output by 2 dB(A) in 2010 (relative to forecasts). Since 1989 only pervious coated macadam (ZOAB) low noise pavement has been used on Dutch motorways. Today enhanced types of ZOAB exist which are 5-6 dB(A) quieter than ordinary asphalt. These are already being used at high traffic intensity areas (VROM, 2004).

Noise is probably the environmental externality which the operator can do the most positive work. First of all he is the one who will lay and maintain the pavement surface on the roads in his network. This means that he has great influence on noise levels all over his network.
Secondly, road works create noise. Taking special care of minimizing noise pollution severity when road works are ongoing in densely populated areas is something he could work on.

**Performance measures / minimum standards**

*Maximum allowed noise levels*

There are already maximum noise level standards in the Netherlands (see Table 4.5). So it looks straightforward that these same standards would be inserted into the service contract. This clause must however be evaluated in every case, as conditions differ. In some cases simply laying ZOAB will not be enough and new or improved sound barriers are needed. In these cases the public road authority should be aware of this and either give a special exemption from the standard or arrange funds for building more structures to battle the noise.

*Table 4.5: Maximum allowed noise levels in the Netherlands (www.overheid.nl)*

<table>
<thead>
<tr>
<th>Source</th>
<th>Preferred level</th>
<th>Maximum allowable if conditions are met</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>New Residential area</td>
</tr>
<tr>
<td>Road traffic (local)</td>
<td>50 (+5) dB(A)</td>
<td>65 (+5) dB(A)</td>
</tr>
<tr>
<td>Road traffic (Motorways)</td>
<td>50 (+3) dB(A)</td>
<td>55 (+3) dB(A)</td>
</tr>
<tr>
<td>Industrial areas</td>
<td>50 dB(A)</td>
<td>55 dB(A)</td>
</tr>
<tr>
<td>Impulse noise</td>
<td>50 dB(A) (-5)</td>
<td>50 dB(A) (-5)</td>
</tr>
</tbody>
</table>

For the maintenance activities of the operator he should of course try to minimize noise pollution as much as possible. It could prove quite hard to measure the total amount of noise created though. Perhaps the best way of realizing how well the operator did in minimizing the noise pollution severity of his projects is to survey the people that live close to the work area. The operator should then state in his environmental strategy some minimum appreciation standards (for example more than 95% slightly or not bothered by noise).

**Contractual inclusion**

The minimum standards for noise pollution should be treated and included in the service contract in the same manner as other minimum standards (section 3.3.1). For breaking the noise minimums of the operators’ environmental strategy a penalty should be in place. It
should be high enough so the operator will not just buy it off instead of complying with it. That means that it must be higher than the cost of lowering construction noise severity.

Furthermore the operator should state in his environmental plan how he will gradually reduce noise pollution on his network. Incentives should be attached to this goal, which means that he could expect bonuses if he does well or has to pay a penalty if he fails. Calculating the total incentive should be standardized with a value being attached to a reduction of every decibel per person affected.

4.3.7 Environmental public goods

Around the turn of the century, citizens of Kern County, California, killed nearly all natural predators in the area to protect domestic animals and children. Unfortunately, all they got in return was the largest rodent infestation experienced in the United States, destroying crops and causing untold mental stress (Hanley et al., 1997). This small example demonstrates how hidden externalities within the ecosystem can backfire if tempered with. The phrase “environmental public goods” relates to the vast amount of environmental assets that possess a value to society which, however, can be hard to estimate. An example of that are wetlands which can act as a local public good by “buffering the economy from natural and man-made shocks by adjusting to fluctuating water levels from tides, precipitation and run-off, by providing water purification and habitat services” (Hanley et al., 1997). Another example is an ecosystem which can provide public services, “given its ability to underpin and buffer the market economy against the external shocks of production and consumption activities” (Hanley et al., 1997). The building and operation of a transport network is bound to have a profound influence on these things in the area that surrounds them.

Analysis

Transport influences environmental public goods in a number of ways. (Coffin, 2007) listed up the most important of them, and besides air-, water- and noise pollution and hydrologic changes she pointed out the following components:

Abiotic components
- Microclimate
- Wind and light adjacent to roadsides

Biotic components
- Animal and plant population
- Roads act as conduits introducing and facilitating the spread of exotic species.

**Ecological effects**

- Loss of habitat due to the transformation of existing land covers to roads and road-induced land-use.
- Reduced habitat quality by fragmentation and the loss of connectivity.

Most of these components stem from the original geometrical placement of the road and not necessarily the traffic of vehicles themselves. The impact can thus be estimated beforehand in an environmental impact assessment. The solutions are thus also not necessarily road-management related but rather special constructions, specially aimed at solving a specific problem, with the so called “ecoducts” on the Dutch highways being a good example (see Figure 4.8). Fencing or digging dykes next to the road to hinder animals from entering it are other examples.

![Figure 4.8: An Ecoduct on the A50 highway near Woeste Hoeve (nl.wikipedia.org)](image)

As has been stated before, the environmental public goods can have hidden or obscure externalities. This means that to people with limited or no background in biology or ecology are not likely to figure out inventive solutions for them. The initiative to create things like ecoducts or other ecological constructions is thus unlikely to come from road maintenance...
operators but rather from environmental NGO's or institutions. It has already been discussed that the operator should formulate an environmental strategy where he details how he will work in an environmentally friendly way and limit air, runoff and noise pollution (section 4.3.4). These actions form the basis of the operators’ contribution to protecting environmental public goods. By trying to use less polluting chemicals (or less of them) and to prevent oil leaking from vehicles and other equipment he is contributing to a lesser environmental impact.

**Contractual incentives**

As was stated before the contribution of the operator to environmental public good is to try to act environmentally friendly and follow a pre-agreed environmental strategy.

As monetizing the gross social benefit of an ecoduct can prove impossible the standard bonus/penalty system (section 3.3.2) hardly works for environmental public goods. The initiative for new constructions, supporting the environmental public goods is likely to come from someone else than the operator. Thus they should be treated in the same way as other "outside" construction on the network (section 2.5). That means that the operator accepts requests for constructions and plans them to best fit into his own plan of activities.

### 4.4 Asset relations

Most assets of the road system are interrelated in one way or another. Vast majority of the technical assets main role is to provide safe mobility (section 4.2.3). Environmental externalities come as a product of this system and usually grow as the mobility increases (sections 4.3.4 and 4.3.6). The combination of speed and traffic flow has great influence for safety (section 4.3.3), noise (section, 4.3.6), emissions (section 4.3.4) and runoff pollution (4.3.5). Figure 4.9 sums up the main road assets discussed in this section along with the main objectives of the operator, namely to maintain and operate the road network. This Figure is very simplified and is supposed to highlight the main connections. For example, the way maintenance is planned and conducted can affect traffic safety, but it’s a very small factor. Its main contribution to the assets is to enhance the quality of the technical assets, but as it forms a temporary bottleneck on the road, it can influence travel time and travel time reliability as well. High quality technical assets are of course the basis that we can offer mobility to the users. However, its quality is mostly a safety issue as cars can drive fast on all kinds of roads. The main difference is how safely they can drive.
Traffic management is supposed to increase all functional aspects of the road traffic. That means safety, travel time and travel time reliability. However increased speeds also decrease safety (section 4.3.3). If speeds reach above certain limits they also start to increase emission- and noise pollution (Figure 4.7 and section 4.3.6). Increased safety can increase travel time reliability, as fewer accidents mean fewer, unexpected temporary bottlenecks on the road (section 4.3.2). But safety can also greatly contribute to pollution. That particular case will be studied now.

Safety contribution to pollution

The safety asset deserves a special notion, since it is a rather unique asset. Traffic safety is a major externality and is thus a hot subject. Therefore a lot of effort is being put into innovation in the field and many solutions, aiming at increasing it, have been introduced (Appendix 1). As such safety itself is special as it is an externality of traffic that can influence it very much as well. Safety itself doesn’t pollute, but in order to increase safety we sometimes must pollute. Light pollution of street lightning and the runoff pollution caused by salting of the winter service and road paint are indirect environmental externalities caused by our actions to increase safety. Furthermore, higher speeds (and lower travel times) can affect safety for the worse. And in cases where un-safety leads to accidents, travel times grow and become unreliable because of the bottleneck created by the accident. If we put this together, we must pollute to a certain point to increase safety, which in turn can have positive effect on travel times and travel time reliability. Figure 4.10 sketches up safety’s relations with other road related assets. Blue lines mean that an increase in asset will have positive effect on the other asset but the red ones demonstrate the instances when it leads to the opposite.
There is not always need to pollute to increase safety. Maintaining a safe pavement surface (smooth and without excessive rutting) will not increase pollution, on the contrary, it decreases noise (VROM, 2004). Another twist to the story is the case of roadside objects. Objects are placed on the roadside for various reasons, usually good in nature. They can however sometimes distract the driver and thus reduce safety. They also form hindrances in the roadside, which can cause a collision and increase the risk of injury in case of an accident (Holdridge et al., 2005).

**Travel time**

Travel time is also an asset that brings mixed effects. Excessively high or low speeds tend to have greater externalities than those in between. A vehicle riding fast (above 90km/h) will produce more noise (section 4.3.6), emissions (Figure 4.7) and is more dangerous to both its driver and the other commuters around than a vehicle riding with a speed of 70km/h (section 4.3.3). However, a vehicle can only speed up when the road capacity allows it, i.e. when the capacity is greater than the demand. Thus, as demand grows, average speeds will eventually drop. But that does not necessarily mean that environmental externalities get better. In some cases they do on an individual vehicle basis, but it’s the combined effect that matters. Increased demand will thus also increase noise, air pollution, runoff pollution and have worse effect on the road ecology. The effects vary however. Runoff pollution and road ecology generally gets worse as traffic demand rises (because of increased copper pollution and the
increased likelihood of roadkills, for example). Air pollution and safety effects change somewhat differently. Figure 4.11 depicts the relationship between speed on the one hand and air pollution and traffic safety on the other hand. Rate of accidents has a strong correlation with road exposure (Rumar, 1999). But vehicle speeds have a great effect of the risk of injury in case of accidents. Thus, traffic safety (with relation to risk of injury) should generally increase per vehicle/km with reduced speeds. However, air pollution increases dramatically per vehicle/km as average speeds fall below 25km/h.

![Figure 4.11: As traffic demand closes in on road capacity, average speeds go down.](image)

For both safety and pollution the optimal position is a fairly healthy traffic state, where the demand is less than the capacity and speeds are kept moderate by speed limits.

**Contractual inclusion**

The issues presented on the asset relations cannot really be put directly into the contract itself. They are more an issue that both Rijkswaterstaat and the operator should be aware of when they are creating their minimum standards and environmental- and functional-plans respectively. Rijkswaterstaat must realize when they demand intensive winter service that it will lead to more salting and thus more runoff pollution. The operator must thus also know this when creating his plans.

**4.5 Conclusions**

The aim of this analysis was to study the assets of the road network and look for solutions on how they can be included in a service contract between Rijkswaterstaat and a private operator. The first two of the three research questions (question 5 and 6) mentioned in the introduction, were which assets are important and how they are interrelated and which performance indicators suit them. In the analysis the important assets were identified in three categories; technical, functional and environmental. The technical assets are numerous...
and are not nearly all identified especially here in the text. Instead, for simplicities sake, they were identified as; land, formation, pavement (base), pavement (surface), drainage, traffic facilities, bridges, culverts, subways and other structures. The performance indicators deemed suitable for the road asset management contract were:

- Pavement roughness: Affects comfort and safety of driving as well as contributing to noise pollution (section 4.2.3).

- Pavement distress: A safety issue but also an issue of quality. A bad level of pavement distress can have diverse affects on the structural layers of the road (section 4.2.3).

- Skid resistance: A safety issue as it is a measure of the friction between the road and the tires and thus the stopping length a vehicle needs (section 4.2.3).

- Visibility of road markings: A safety issue. Its function in separating traffic streams is jeopardized if they are allowed to fade (section 4.2.3).

- Drainage: Affects safety as well as traffic conditions. Water cannot be allowed to form pools on the highway (section 4.2.3).

- Response time for routine repair: An issue that can affect many things. Malfunctioning roadside equipment are not performing the job they should be doing and could also cause an extra safety hazard because of its state (section 4.2.3).

- Corridor maintenance: An issue of safety as well as user acceptance of the environment (section 4.2.3).

Functional assets analyzed were travel time, travel time reliability and safety. For travel time the following performance indicators were chosen (section 4.3.1):

- Traffic management approval: Because of the difficulty in measuring the exact performance of individual traffic management actions, the option was chosen to measure the user perception of the management.

- Delay caused by maintenance and construction: Chosen because it can easily be measured and is currently a great source of congestion. It's a performance measure that the operator sets himself. He can offer a maximum value of maintenance and construction related delay in the tendering process, which will then be translated into a minimum standard.
Delay caused by incidents and accidents. The delay itself is not being measured, but rather the average response-time of the operator. This affects both safety and traffic conditions as accident scenes form bottlenecks where they are.

For travel time reliability the option was taken to measure reliability approval, in the same fashion as the traffic management approval is done (section 4.3.2). Furthermore an inclusion dealing with delays caused by special events was discussed.

Safety is measured primarily by accumulating the total amount of accidents and fatalities, which are believed to be caused by unsafe infrastructure, rather than driver or vehicle condition. Furthermore the response time for emergencies as well as for winter service is measured (section 4.3.3).

Noise pollution is measured as it is done today and the minimum standards should comply with the national legislation regarding maximum noise levels. The pollution itself is a product of noise levels and the number of people affected (section 4.3.6).

The other environmental assets; air- and runoff-pollution and environmental public goods are measured, with regards to the environmental-plan of the operator. This basically means that the operator states in the original bid how he will contribute to these environmental assets with his operations and through the environmental management of his construction and maintenance (section 4.3.4).

The conclusions regarding the technical assets are quite robust. They are based on examples of performance measures that are already being used by road agencies. They were analyzed along with input from international research literature and in one case the literature indicated that the currently used standards could be changed.

The conclusions for the functional and environmental assets are not as clear cut. Both asset groups were analyzed from the operators' point of view which is reflected in the choice of performance measures. Some of these performance measures don't really have a true precedent elsewhere and thus don't have a concrete validation. They are suggestions based on the analysis and the position of the private operator. Future experience could prove them successful or as failing. In case they fail, the underlying causes should be analyzed and the performance measures adjusted to meet them.

The third research question presented in the introduction (question 7) is one that first was addressed in chapter 3. In this chapter the individual incentives for each and every asset were discussed. Performance measures and contract inclusions for technical assets are already widely used in similar contracts and a great deal of experience has been gathered.
These measures are wide ranging and detailed to such a degree that the private operator can be entrusted to take care of the vast majority of tasks needed to run the roads. The technical assets all fall into the first type of contractual inclusions mentioned in section 3.3.1, namely to withstand minimum standards without a bonus for improving beyond them. The reason is that the minimum standards are set where the quality of the infrastructure is becoming either dangerous or where its state can start to influence the deterioration of other assets. Before the assets become like that they simply work well and there is no social profit of exceeding that state. A number of methods were mentioned to penalize operators who fail minimum standards. Two of them call for good knowledge of the actual costs of maintaining the infrastructure above minimum standards. The third one is much simpler; simply a termination clause in case an operator repeatedly fails minimum standards. Calculating the costs of staying above minimum standards is not easy as situations can vary greatly, and no examples of actually doing that were found during the research. For that reason the conclusion is that while there remains only limited experience in road asset management, monetary penalties accurately valuing the cost of withstanding minimum standards is hardly possible. The British example does not say that the actual costs of maintaining The Great Western network were used as a role model for deciding on their penalties, the approach of terminating the contract in the event of repeated failure should be applied. Later on, when more experience has been gathered and perhaps more research has been devoted to the subject the monetary penalty could be considered.

The functional and environmental assets are dealt with in a more diverse way. For some of them minimum standards, just like the ones set for the technical standards, are made suffice. For others incentives should be in place to stimulate enhanced performance. Approval of traffic management and travel time reliability is measured from the users’ point of view, through user surveys. The operator strives to satisfy the users and is subject to a bonus/penalty relating to his approval rating. Delay caused by constructions and maintenance is a perfect example of a performance measure that should be stimulated into the right path with the help of incentives. The same applies to traffic safety. Minimum standards for response times in case of accidents and winter service are placed in the same bracket as the technical standards. Noise pollution minimum standards should gradually decrease, according to national the Dutch national targets (VROM, 2004). Better performance should be rewarded. Other environmental assets are included in the setup mainly with an eye on the operators’ activities. A certain environmental strategy plan should be asked for from the operator at the bidding phase. This plan can be used to evaluate bids and, later on, to evaluate performance. If the operator is found to violate his own
environmental plan it should be treated as a violation of a minimum standard. This should then lead to the operators making a realistic plan, since it could be costly for them to overstate their abilities just to win the bid. It was furthermore suggested that environmental externalities were taken into account when the bonuses/penalties of the construction related delays were calculated.

The way in which incentives and minimum standards protect societal goals was discussed in the conclusions of chapter 3 (section 3.6). In this chapter the focus was on how these mechanisms could be designed to fit the performance measures of each asset type. Therefore these conclusions are “educated elaboration” and their success has yet to be verified in practice.

Finally the latter half of (question 5), asset relations, was discussed. The operator must be aware that some of his efforts to improve one asset can in fact have diverse effects on another. It is important for all stakeholders to realize these things when it comes to evaluating plans and strategies created by the public authority or activities and environmental plans by the operator. However it is evident that most externalities increase with increased traffic demand. At congested level, some of them get out of hand. Thus it seems that maintaining a fairly healthy traffic state while at the same time applying measures to reduce or limit externalities is the optimal performance.

These conclusions are mostly based on findings from the asset analysis. The findings come from international research literature which means that the basis is relatively solid.
# Framework

## 5.1 Introduction

This thesis has so far been focusing on the way road asset management can be implemented in the Netherlands and how private companies can be involved and improve the process as well as the system as a whole. This final chapter of the thesis is aimed at presenting a framework for privatized road asset management for the Netherlands. It will describe the process and show how the individual parts work together. This chapter will not answer specifically any of the seven research goals presented in the first chapter. This combines all the findings and thus basically answering the main research question, or to demonstrate how a private company can be best fitted into the framework of road asset management in the Netherlands.

As can be seen in Figure 5.1, the framework is split effectively into four time phases; pre-contract, contracting, contract period and contract end. The first phase deals with things that

<table>
<thead>
<tr>
<th>Pre-contract phase</th>
<th>Contracting phase</th>
<th>Contract phase</th>
<th>Contract end phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLA</td>
<td>SLA</td>
<td>SLA</td>
<td>SLA</td>
</tr>
<tr>
<td>SLA</td>
<td>SLA</td>
<td>SLA</td>
<td>SLA</td>
</tr>
<tr>
<td>SLA</td>
<td>SLA</td>
<td>SLA</td>
<td>SLA</td>
</tr>
<tr>
<td>Central asset database</td>
<td>Monitoring institution</td>
<td>RWS</td>
<td>RWS</td>
</tr>
</tbody>
</table>

**Figure 5.1: The different time phases of the framework**
take place before the private operator can be contracted. The second phase, contracting, deals with the contract itself. The third period is about what happens during the contract period itself, when the actual work is being done. The last phase is then the contract end, or the transition period when a contract is about to end and has to be renewed.

5.2 Pre-contract phase

Before any contracting can take place, both the Ministry of Public Works and Rijkswaterstaat need to prepare the playing-field. They have to prepare the institutional organization and legal frameworks for changes in the road operation. The Ministry is the one that creates the original Service-Level-Agreements (SLA) (section 2.3). This means that they set the course on how they want road transport to develop in the future. The SLA must be accompanied by a budget and possibly some legislative adjustments because of the introduction of the private operator to the institutional organization.

Rijkswaterstaat must prepare for asset management in a number of ways. First of all, they must create a complete inventory, a central database, of the road assets in the Netherlands (section 1.1). This inventory should include an estimated value of every asset as well as its estimated remaining lifetime, and thus their depreciation values. From the original SLA from the Ministry, Rijkswaterstaat must create special SLA’s for each operational area or region (as is the case today) (section 2.3). This document should include detailed descriptions of how mobility, safety and environmental issues are supposed to develop in the relevant area. This basically means that Rijkswaterstaat has to create a set of minimum standards for all relevant aspects (chapter 4) (the minimum standards are further detailed in the contracting phase). To monitor the performance of the operators Rijkswaterstaat should introduce a monitoring institution (section 2.5). This institution would also specify standard ways of monitoring, so that the asset data is comparable between different regions (section 2.5). Incentive mechanisms, aimed at preserving the assets should be introduced to be included in the contracts for the private operators (section 3.3). Finally, Rijkswaterstaat should retain their research and development (section 2.4) and nationwide traffic management center (section 2.5).
5.3 Contracting phase

In the contracting phase itself Rijkswaterstaat invites private companies to take part in a competitive tender for the rights of operating in specific areas. The final contract is a mixture of standards and rules made by Rijkswaterstaat and different plans made by the operator. The operators’ bid will be evaluated by his offer in combination of price, plans as well as his credibility and experience.

Tender evaluation procedure

As the road asset management has been described in the thesis so far the important things that the operator should hand in to Rijkswaterstaat are:

- Functional plan: How the operator is going to improve functional aspects of the traffic and what the effects of it are supposed to be. Under this falls things such as how much delays his maintenance and construction activities are likely to take (section 4.3.1), how he will increase safety and how he will do that (section 4.3.3), and how he will manage the traffic (section 4.3.1). As one can see on the figure there is an arrow between minimum requirements and the functional plan. This is because, as has been stated here, the operator partially is the author of his own minimum standards.

- Environmental plan (section 4.3.4): How the operator is going to minimize the effects that he has on the environment and what the impact of his actions is likely to be. This effectively creates the environmental minimum standards for the operator. This again is displayed with the arrows on the figure.

- Technical maintenance plan (Austroads, 2003a): The operator puts together a plan of how he will manage to keep the technical road assets in order for his tenure on the network. This allows Rijkswaterstaat to gain insight into what the operator plans to do and to judge if they think it’s realistic.

- Price: The total amount that the operator wants in return for taking care of the network. The thesis didn’t specifically elaborate on this subject but it’s plain to see that the price the operator wants for his services are a major factor in the evaluation of his bid.
- Other issues: Experience from other similar projects, financial strength and reputation. (Section 3.5) discussed the effect that experience and reputation could improve the chances of an operator in his efforts to get a new contract. However, checking the financial strength of the bidders is also a common thing to do to reduce risk in tendering (Austroads, 2003a).

**Risk allocation (section 3.2)**

- Policy risk: The responsibility of the legislative authority. If they want to impose new legislation into an existing contract, the operator must be compensated or have his contract renegotiated.

- Risk associated with work: The work is done or managed by the operator and he is thus the one who is responsible for its outcome.

- Risks associated with cooperation: Cooperation is very much related to work and should thus be under the responsibility of the operator.

- Risks associated with nature: The operator is the one that should react to all natural factors that can be considered within normal limits.

- Risks associated with traffic demand: This is a risk the operator must mostly bear. He, however, doesn't have the complete control over the nationwide traffic management. Therefore there should be some risk sharing here.

- Risks associated with asset management: Again mostly the responsibility of the operator. This risk should be allocated depending on where in the asset management cycle the risk comes from.

- Risk of failure: If the operator fails, either by performing poorly or by going bankrupt, the responsibility lies at Rijkswaterstaat. The reason is that it is Rijkswaterstaats' responsibility to design the tender in a way that allows them to find the best operator.

- Other risks: Risks relating to payments to the operator ultimately lie with the government. The payments to the operator must be protected for inflation by connecting them with construction cost indices. Furthermore, the risk of “Acts of God” lies with the government. These are issues which no human can influence such as earthquakes, severe flooding and tornadoes.

**Size of network**
The conclusion of chapter 2 was that the Dutch asset management scheme should be area or regional wise (section 2.6). This means that there are a number of areas of limited size that must be established by Rijkswaterstaat. It is the responsibility of Rijkswaterstaat to define these areas.

**Work type**

The work which the operator is supposed to carry out is (section 2.5):

- Periodic maintenance and rehabilitation of technical assets located within the network, including pavements, surfaces, drainage, kerbs, retaining walls, etc.: This is the prime responsibility of the operator and the issue that will take most of his funds. Because of the familiarity of the operator with his network and the ease of which he can be contracted he should have the right to recommend improvements and have the first right of refusal for all improvement work under the amount of €1,000,000. The one million is chosen with the UK and NZ precedence in mind, but is higher than there because this scheme is much more functionally improvement oriented than in those countries. Thus the operator should have good cap space for new improvements.

- Traffic management: The operator is supposed to perform all traffic management actions during normal conditions. However, because some traffic situations need a larger scope to deal with the problem a national traffic management center should be maintained by Rijkswaterstaat that would have the right to overrule management actions of the operator.

- Corridor maintenance: Corridor maintenance includes for example traffic signs, road marking, street lighting, mowing, weed spraying, street cleaning, kerb sweeping, catch pit cleaning, litter patrol, bin cleaning, removal of graffiti and maintenance of railroad (and waterway) / road level crossing warning devices.

- Winter service: The operator is responsible for treating the roads during wintertime and keeping them safe and free of ice and snow.

- Response to public requests, complaints and feedback: The public must be able to voice their opinion about the actions of the operator. The operator should also address these opinions, as it can both be in his own benefit, but its also an obvious right of the public to be allowed to have their say in what goes on around them.

- Structural maintenance of bridges: The operator should monitor the structural strength of bridges on his network according to predefined and accepted methods.
from Rijkswaterstaat. Based on his findings he could advise maintenance actions and charge specially for them.

- Collection and management of asset inventory data: As was discussed in section 2.5, this is done differently in Australia and New Zealand. Because the operator is the one that is responsible for the condition of the assets he should be the one that collects the asset condition data. This data would then be stored in a central database, owned by Rijkswaterstaat. Rijkswaterstaat should predefine the methods in which the asset data is collected beforehand to ensure comparability of the data.

- Installation and maintenance of speed camera detectors, traffic counting stations detectors and recorders, variable message signs, emergency telephones and closed circuit televisions: The installation and maintenance of these equipments are often as a result of requests or needs of other institutions such as the police, nation-wide traffic management and research institutions. Since the private operator is the supreme command on his road network and is responsible for all the assets he should always have the final say in anyone’s else’s activities on the network. As this kind of work is not in the original contract of the operator, the price for it would have to be negotiated especially as additional work.

The work which Rijkswaterstaat is supposed to carry out is (section 2.5):

- Major new constructions: Because new constructions have to be accepted especially by the government they will not fall into the scope of road asset management. Therefore Rijkswaterstaat must deal with new constructions independently and tender them out regardless of other road asset management schemes. However, as was also explained, it could in many cases be very convenient for both Rijkswaterstaat as well as for the good of the assets if the constructor would also have to take care of his construction for a number of years afterwards.

- User surveys: As a part of its collection of asset inventory data and to check the satisfaction of the public with the infrastructure, Rijkswaterstaat should regularly conduct user surveys.

Contract length (section 3.4)

Road asset management contracts should be of variable contract length. The length is based on the time which the operator is ready to promise his pavement surface to last. The justification for this is as follows.
- Basing the contract length on the estimated lifetime of the pavement surface means that the operator starts his contract by renewing the pavement surface. This means that he lays and maintains his own pavement surface for the whole contract period. It thus creates a “cradle to grave” environment where the operator lays the pavement surface he is going to live with for the whole period of his contract.

- Pavement surface is generally considered to last for about 7-10 years (see Table 3.1). This means that most contracts would be around that long. The Austroads survey (Austroads, 2003a) found that 10 years was optimal because it meant that operators would; be able to invest, have flexibility to design appropriate treatments, would have to live with their mistakes, would be able to invest up-front and thus reduce ongoing costs and finally that it would give the operator enough time to build up an asset management culture himself.

Furthermore it was discussed in (section 3.5) that in the event of very good asset condition in the end of contract term the operator could have the chance of earning one or two extra years on the network. This will be discussed further in the Contract End Phase later on.

**Quality assurance**

The quality of the network is protected with a set of minimum standards detailed better in the following paragraphs. However, to compare performance with original plans Rijkswaterstaat must develop an audit (section 1.1.3). This audit then reports their conclusions to other stakeholders, such as the Ministry of Public Works and to the public. This ensures transparency of the process as well as keeping the learning cycle in check.

**Technical minimum requirements**

- Pavement roughness (section 4.2.3): According to the IRI index, it is not considered suitable to allow speeds up to 100km/h unless pavement roughness is less than around 3 mm/m. This should thus stand as a minimum standard in the Netherlands.

- Pavement distress (section 4.2.3): Rutting depth should not exceed 18mm on more than 1% of the network. This is due to its impact on safety. Other pavement distress issues should be monitored with the DR-value (equation 4.1, table 4.2 and Appendix 6). The DR-value should stay above 90 for every 100m sections of the road. However it should be noted that there are limitations to the DR-value that one should be aware of, that is that it’s credibility is not solid because of its reliance on visual inspection.
- Skid resistance (section 4.2.3): The minimum skid resistance value should be $SFC = 0.32$. The reason for this number is the assumptions of Lindenmann’s study (Lindenmann, 2004) which revealed that road with this skid resistance value didn’t show signs of causing incidents in Swiss.

- Visibility of road markings (section 4.2.3): The visibility is a safety issue. Vast majority of road markings should be sufficiently visible at all times.

- Drainage (section 4.2.3): Since the Netherlands are quite a wet country the minimum threshold for drainage should take aim of what is strictest. 90-95% of all gullies must thus be open and working at all times.

- Response time for routine repair (section 4.2.3): Roadside facilities can and will be damaged for a variety of reasons. The important thing is that they are not allowed to stand damaged for a long time. Therefore the operator should have a minimum standard for responding to it and repairing them. A max of one week is allowed and after that he starts being penalized according to a standard table (see an example in Appendix 2).

- Corridor maintenance (section 4.2.3): Corridor maintenance is important but quite hard to accurately measure at the same time. The best way to estimate it is to ask the users directly what they think. Therefore user surveys should be conducted by Rijkswaterstaat and a minimum of 90-95% of road users should be satisfied with the corridor maintenance.

**Functional minimum requirements**

- Delay caused by maintenance or construction (section 4.3.1): Delay caused by maintenance or construction does not have an actual minimum requirement. However, as was stated before, a part of the operator functional plan is an estimation of how much delays his actions will cause. This estimation forms his “delay-quota” (section 4.3.1). If he uses less, he will get a bonus, if he needs more, he will have to pay a penalty.

- Traffic management approval (section 4.3.1): The user approval of traffic management is measured by user surveys. A healthy majority (+75%) of the users should be satisfied.

- Travel time innovation incentive (section 4.3.1): This clause deals with a special issue, which is unexpected improvement to the asset. It means that if the operator manages, through innovation, to ease traffic conditions (by for example creating
greater capacity around a bottleneck), he should be awarded a bonus. This bonus
should be based on its total contribution to gross social benefit. This is important as
only in that way do we manage to stimulate the operator to build only feasible
improvements and skip those that are not feasible.

- Delay caused by minor accidents (section 4.3.1): The operator should have a
  minimum reaction and clearance time for minor accidents (those accidents when no
  emergency services are needed). A minimum standard should be based on historical
data.

- Travel time reliability approval (section 4.3.2): The same way as the traffic
  management approval is measured; travel time reliability should be monitored. The
  same amount of users should be satisfied with the reliability of the network as with
  the traffic management.

- Delay caused by special events (section 4.3.2): The operator should deal with traffic
  disturbances caused by special events. For recurrent events, minimum standards
  should be based on historical data.

- Travel time reliability innovation incentive (section 4.3.2): Innovative solutions that
  increase travel time reliability should be awarded for what they are worth in the
  same way as the innovation incentive for travel time.

- Total amount of accidents and fatalities (section 4.3.3): The total amount of accidents
  and fatalities, that can not be traced to things outside the control of the operator
  (driver and vehicle condition), should be accumulated and they should gradually
  reduce. This should be based on national goals in traffic safety.

- Safety innovation incentive (section 4.3.3): Like the innovation incentive for travel
  time and travel time reliability, the operator should be awarded a bonus if he
  implements innovative solutions to solve a safety problem.

- Response time for emergencies (section 4.3.3): The minimum standards that
  Rijkswaterstaat already has (15 min in urban areas and 30 min in rural ones) should
  be maintained. These standards should be withstood in majority of times, or 90%.

- Response time for winter service (section 4.3.3): Icing is not allowed to form on the
  highways. This is not really a minimum standard, but the operator faces a penalty
  each time an accident happens on an untreated site, which can directly be related to
  icing.
Environmental minimum requirements

Most environmental minimum requirements are actually created by the operator himself, in his environmental plan (section 4.3.4). This means that the operator will set his own goals in emissions, waste management, noise, runoff pollution and environmental public goods.

- Maximum allowed noise levels (section 4.3.6): There are already maximum allowed noise levels existing in the Netherlands (table 4.5) which should effectively create the minimum requirements with regards to noise. Furthermore, the operator should outline in his environmental plan how he plans to reduce noise pollution during his contract. If he manages to do better than his plans suggested he should be awarded with a bonus. The bonus should be standardized with a value being attached to a reduction of every decibel per person affected. If he, however fails to perform as planned, his penalty should depend on equations 3.1 and 3.2.

Payment terms and mechanism for bonuses or penalties

- Bonuses and penalties are paid out and into the so called Incentive fund (section 3.3.5). A part of the total cost of every operation contract will go directly into this fund, which should guarantee his strength in dealing with commitments when it comes to paying out bonuses.

- Bonuses are paid out partially in the form of direct money and partially as access to funds earmarked for improvement works on the road network (section 3.3.6). This means that if an operator gets a bonus he will be able to construct in further improvements on the network and not necessarily only in the field where he got the bonus from in the first place (a bonus for low delays can be invested in safety or other subject).

- Penalties are monetary and go directly into the incentive fund. However, the penalties should be earmarked to be reinvested in the network they originated. The reinvestment is put out to an open tender where the most competitive idea and bid win (section 3.3.6).

There were a number of different kinds of incentives presented in the preceding paragraphs. There are on one hand simple minimum standards and on the other, incentive driven performance measures. The minimum standards are meant to protect what we have. The possibilities to protect the minimum standards were elaborated in (section 4.2.4). The penalties are either; risk of loosing early termination of contract, monetary penalty or a penalty in the form of investments and constructions. The problem is to really get to grips
with knowing what kind of an investment is really needed to prevent the assets from dropping below their minimum standards. Therefore perhaps a gradually increasing penalty with a termination clause in the end is ideal. This means that breaking minimum standards a few times will lead the operator to pay rather low penalties, but as soon as the frequency of minimum standard breaking increases, so do the penalties and in the end they risk losing the contract.

Incentives for improvements of assets should be paid out every six months or yearly during the contract period. It’s important that the operators don’t have to wait for too long to get their incentives because it would reduce their efficiency (section 3.3.6).

**Premature termination of contract**

If the contract is prematurely terminated because of bankruptcy or other reasons, Rijkswaterstaat must have a readymade plan in place to prevent a performance drop on the road network. Section 3.5.1 elaborated on this and things like surety bond (to guarantee funds to deal with the transition period between one operator leaving and another one coming) and that Rijkswaterstaat keeps an emergency replacement contract ready to speed up the new tender.

### 5.4 Contract phase

The contract phase is the time when the operator is conducting his work on the road network. The operator collects all asset data based on the standards set by Rijkswaterstaat, while they at the same time monitor the total performance of the operator and penalize or award him bonuses according to his success. During the contract phase the operator will constantly be reviewing his own performance as well as following trends and developments in factors that can influence his activities. His own success will depend a lot on how well he manages to deal with changes and developments and how he can adjust his own plans according to them (Bruinsma, section 6.2.3). However, as most of the important aspects of asset management and therefore this thesis, takes place in the transition periods between contracts this phase will not be elaborated any further.
5.5 Contract end phase

When the operational contract is nearing its end, Rijkswaterstaat must conduct a large scale survey on the condition of the road assets. This is done so that they know exactly how well the operator did and what the real value of the network, which is going to be tendered out again, is. This survey would also serve as the final chance of the operator to gain a bonus, perhaps the most lucrative bonus of the whole scheme (section 3.5). First of all, a large monetary sum is kept until the end and is only paid out if the assets withstand all minimum standards. If, however, the state of the assets is considered to be very good, especially if the surface is considered to still have some remaining life in it, the operator could get a bonus contract extension for up to two years. The reasons for these lucrative bonuses at the end are to stimulate the operator, and especially the last months and years of his contract.

As soon as it is evident that a new operating regime is going to be installed a new tender should be prepared (section 3.5). The new tender will take into account different times and a different SLA from the government, which is also based on feedback from the audit (section 1.1.3). All the feedback obtained from the preceding process is used to adjust new plans and contracts and should thus make the following process better.

5.6 Test Case Contract

Now that the framework has been finished a “dummy-contract” can be created, based on the framework. The “dummy-contract” is between Rijkswaterstaat and the private operator and basically describes their interactions. The contract in question is one where an operator is taking over the asset management of the so called “Delft Network”.
The “Delft Network”

![Map of Delft Network](image)

Figure 5.2: The “Delft Network”. Highways A4, A13 and A20 forming a ring around Delft.

The network consists of the combination of the A4, A13 and the A20 around Delft. The A13 is a 13km long highway, the A20 is 5km long and the current A4 is 8km. In the year 2011 the remaining 7km to connect it with the A20 are due to be completed. That same year is formally the beginning of the operator’s tenure at the network. This means that by that time he will not only have finished with building the missing link, but he will also have renewed the pavement surface of all the other parts of the network.

In line with the way the contract was presented in the framework it begins by presenting the requests, standards and other input from Rijkswaterstaat. This will then be followed with the input that is the operator provides himself.
Work type

The operator is supposed to entirely take care of:

- Lay a new layer of pavement surface on the whole network, which is supposed to last the whole length of the contract.
- Periodic maintenance and rehabilitation of technical assets located within the network, including pavements, pavement surfaces, drainage, kerbs, retaining walls, railings, etc.
- Traffic management, Rijkswaterstaat retains the right of interfering at any moment it sees fit.
- Corridor maintenance. This means taking care of traffic signs visibility, road marking, street lightning, mowing, weed spaying, street cleaning, kerb sweeping, catch pit cleaning, litter patrol, bin cleaning, removal of graffiti and maintenance of railroad (and waterway) / road level crossing warning devices.
- Winter service
- Response to public requests, complaints and feedback.
- Collection and management of asset inventory data. The assets should be monitored and measured with accepted and standardized methods of Rijkswaterstaat
- The operator should create an asset condition report every 3 months and deliver it to Rijkswaterstaats' monitoring institute.
- Design and build the 7km extension of A4 before 1st July 2011.
- The operator is free to construct at will on the network. However payments he can expect are in the form of incentive bonuses which are calculated on the basis of a certain criteria presented in the end of this contract.
- Coordinate all work done by outside stakeholders such as installation and maintenance of speed camera detectors, traffic counting stations detectors and recorders, variable message signs, emergency telephones and closed circuit televisions.

Work that the operator is not obliged to take care of and should be consulted with before it is installed is:

- Rijkswaterstaats’ monitoring institute will regularly make spot checks on the network to validate the asset condition reports from the operator.
- Rijkswaterstaat will value the condition of all assets on the network before the start of the contract period and then again before the end of it.
- Rijkswaterstaat will regularly conduct user surveys to check the satisfaction of the public with traffic management, corridor maintenance and travel time reliability.

**Minimum standards**

*Technical minimum requirements*

- Pavement roughness: Should be no less than 3mm/m on the IRI index.
- Pavement distress: Rutting depth should not exceed 18mm on more than 1% of the network.
- Other pavement distress issues should be monitored with the DR-value which should stay above 90 for every 100m sections of the road. The DR-value is calculated as follows:

\[
DR = 100 - \sum_{i=1}^{n} d_i w_i
\]  

(5.1)

Where:
\[d_i = \text{The number of points assigned to distress type } I \text{ for a given severity and frequency.}\]
\[n = \text{number of distress types used in rating method}\]
\[w_i = \text{relative weight of distress type } i\]

Factor \(d_i\) is found from Table 5.1.

*Table 5.1: Rating factor, \(d_i\), related to severity and frequency (Gerber and Hoel, 1999)*

<table>
<thead>
<tr>
<th></th>
<th>Severity</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not Severe</td>
<td>Severe</td>
<td>Very Severe</td>
</tr>
<tr>
<td>None</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rare</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Occasional</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Frequent</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
</tbody>
</table>

- Skid resistance: The minimum skid resistance value should be SFC = 0.32.
- Visibility of road markings: 99% of road markings should be sufficiently visible at all times.
- Drainage: 90% of all gullies must be open and working at all times.
- Response time for routine repair: A max of one week is allowed and after that he starts being awarded with penalties. The penalties are from a standard list, of which an example can be seen in Appendix 2.
- Corridor maintenance: A minimum of 90% of road users should be satisfied with the corridor maintenance.

**Functional minimum requirements**

- Delay caused by maintenance or construction: Delay should be no more than the average construction and maintenance related delay per km/lane of the five years before the start of the contract (2006-2011).
- Traffic management approval: Should be no less than 75% at all times
- Travel time reliability approval: Should be no less than 75% at all times
- Delays caused by special events should be no more than the average five years before the start of the contract (2006-2011).
- Total amount of accidents and fatalities: The total amount of accidents and fatalities, which can not be traced to things outside the control of the operator (driver and vehicle condition), Should be reduced on average by 3.5% every year. The starting number is the average number of accidents and fatalities for the five years before the contract (2006-2011).
- Response time for emergencies: Response for emergencies in urban areas should be minimally 15 min and 30 min in rural areas. The “Delft Network is considered is considered to be inside the Randstad Metropole and is thus completely in an urban area.
- Response and clearance time for accidents where no emergency services are needed: Bottlenecks created by minor accidents should not be allowed to stay on the road for more than 30 min in urban areas and 45 min in rural ones.
- Response time for winter service: Icing and snow is not allowed to accumulate of form on the highway. The operator is responsible for incidents which happen due to this at untreated sites.
Environmental minimum requirements

- All construction and maintenance work must comply with Dutch environmental standards.
- Maximum allowed noise levels should comply with the national legislation of the Netherlands (Table 5.2). Furthermore, the maximum allowed noise will evolve according to the national goal of reducing noise from traffic by 2 dB(A) by 2020.

Table 5.2: Maximum allowed noise levels in the Netherlands (www.overheid.nl)

<table>
<thead>
<tr>
<th>Source</th>
<th>Preferred level</th>
<th>Maximum allowable if conditions are met</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>New Residential area</td>
<td>New Source</td>
</tr>
<tr>
<td>Road traffic (local)</td>
<td>50 (+5) dB(A)</td>
<td>65 (+5) dB(A)</td>
</tr>
<tr>
<td>Road traffic (Motorways)</td>
<td>50 (+3) dB(A)</td>
<td>55 (+3) dB(A)</td>
</tr>
<tr>
<td>Industrial areas</td>
<td>50 dB(A)</td>
<td>55 dB(A)</td>
</tr>
<tr>
<td>Impulse noise</td>
<td>50 dB(A) (-5)</td>
<td>50 dB(A) (-5)</td>
</tr>
</tbody>
</table>

Innovation bonus

The operator is entitled to innovation bonuses in case goals for minimizing delays, increasing travel time reliability and safety and decreasing noise, agreed in this contract are exceeded. The same applies to good outcome from user surveys regarding traffic management, travel time reliability and corridor maintenance approval. The mechanism for these bonuses, along with monetary values for each asset, is presented at the end of this contract.

Risk allocation

Risk is allocated with relation to its origin.

The Ministry of public works is responsible for risks that come as a result of:

- Legislation.
- 'Acts of God'.
- Nationwide service-level-agreement.
- Payments to the operator.

Rijkswaterstaat is responsible for risks that come as a result of:
- Traffic demand. This risk is shared with the operator with Rijkswaterstaat accepting 25% of the risk.
- Asset data integrity supplied by Rijkswaterstaat.
- The quality of the audit.
- Failure of the operator.

The operator is responsible for risks that come as a result of:
- Maintenance and construction work.
- Cooperation with other stakeholders or contractors.
- Nature.
- Traffic demand. This risk is shared with Rijkswaterstaat with the operator accepting 75% of the risk.
- Asset data integrity collected by the operator.

**Contract length rules**

The starting length of the contract is set as long as the contractor is willing to guarantee a satisfying pavement surface. If the overall asset condition at the end of the contract is valued as higher than it was at the being a and the pavement surface still has some working life left, Rijkswaterstaat will award the contractor with a contract extension, based on the expected remaining pavement surface life. Payments for the contract extension should be in line with the payment structure of the original contract.

**Premature end of a contract**

In case the operator goes bankrupt or is found guilty of serious malpractice, Rijkswaterstaat has the right to cash out the surety bond which the operator must issue before the contract. This bond amounts to €4,000,000 and should be sufficient to finance the operation and maintenance of the network until a new operator has been contracted to take care of it.

**Tender evaluation procedure**

The tender evaluation procedure is effectively describing what the operator needs to supply Rijkswaterstaat with so that they can assess their bid. This bid is also the contribution of the operator to the contract as it effectively sets payments and some minimum standards. So the things that the operator must involve in their bid are as follows:
Technical maintenance plan

- The operator will lay a new, low-noise, ZOAB pavement surface on the whole network and guarantees its life of 11 years. This will be reached by using only the best available materials, as well as using preventive maintenance, to hinder cracks or other faults from damaging more.

- As the operator has good experts in the field of pavement management and structural maintenance, he will incorporate and monitor these tasks himself.

- The operator has hired sub-contractor X which specializes in drainage maintenance to handle the maintenance. The operator will oversee the sub contractors’ activities.

- The operator commits himself to having a minimum of 5 working day response time to malfunctioning or damaged road facilities.

- The operator commits himself to reaching a 90% user satisfaction with corridor maintenance by:
  - Hiring responsible sub-contractors, A, B, C and D, in all relevant fields.
  - By effectively monitor and supervise to contractors to ensure the quality of their work.

Functional plan

- The operator commits himself to stricter safety goals than were set as minimum by Rijkswaterstaat, which he intends to reach with the help of effective traffic management and other improvement works. He sets the standard at 4% average reduction in accidents and fatalities that can not be traced to things outside the control of the operator (driver and vehicle condition), every year for his contract tenure.

- The operator commits himself to causing a maximum of 90% of the allowed delay (average of 2006-2011) due to maintenance, construction and special events for the total lifetime of his contract. This commitment, however only holds if traffic demand changes no more than 15% from what it was (2006-2011). In case it exceeds 15% the commitment changes by 7.5% in the same direction as traffic demand changed.

- Traffic management approval. The operator intends to continue the good work that is already being done in traffic management. Through innovation the operator is willing to commit to a minimum of 80% user approval.
- Travel time reliability approval. Through innovative traffic management, the operator commits himself to increasing travel time reliability. The minimum user approval is set at 82.5%.
- The operator commits himself to responding to emergencies within 15 minutes in 90% of times.
- When no emergencies are needed the operator commits himself to clear the bottleneck within 30 minutes in 90% of instances.
- By monitoring weather-forecasts the operator commits himself to the statement that he will not allow icing to form or snow to accumulate on the roads.

**Environmental plan**

The environmental plan of the operator is as follows (The precedence for this is the environmental plan of Highways Agency, www.highways.gov.uk).

- Air pollution emissions:
  - Effective street-cleaning will limit dust pollution by 5% by 2022, compared with levels of 2011.
  - Air pollution emissions control will be kept in mind and improved during construction and maintenance activities.

- Runoff pollution:
  - Special attention will be on stopping vehicles and containers from leaking. At any given moment a maximum of 15% of them can be leaking.
  - The most environmentally friendly chemicals available will always be chosen to conduct maintenance and construction.
  - Polluted snow, cleared of the road, will be dispensed at areas where it will cause less pollution. This means that the area around Delftse Hout, Negenhuizen and De Zweth will be kept mostly clean of snow cleared of the highway.

- Noise pollution
  - Through the use of innovative ZOAB pavement surface, keeping pavement surface roughness low and by systematically study how noise barriers can be enhanced, the operator commits himself to reduce noise pollution by 3dB(A).
by 2020. This number will however depend on developments in traffic demand. For every 6% change in traffic demand the goal changes the same way by a factor of 0.2dB(A).

- Environmental public goods
  - All excessive materials and waste will be recycled
  - No runoff will be allowed to enter untreated from A13 to the area around Delftse Hout
  - Around De Zweth and Negenhuizen the highway will be fenced so that livestock from the surrounding farms cannot enter the road.

Price

For the design and building of the missing link on A4 the operator will receive a sum of €85,000,000, or roughly 2 million euros per lane/km.

For the maintenance and operation of the entire network from 1st July 2011 until 1st of July 2022, the operator will be paid a total amount of €110,000,000 based on the rate of the Dutch construction cost index on 1st of July 2011. Because of the relatively high costs during the first year (the year all the pavement surface is renewed), the operator will receive €25 million at the start of the contract. Another €5.5 million will be reserved until the end of the contract and will only be paid out if at least 95% of the assets fulfill minimum requirements at the end of the contract. The rest will be paid out in even payments every 6 months. These payments will follow the development of the Dutch construction cost index starting from 1st of July 2011.

Other issues

The operator must inform Rijkswaterstaat about its financial strength as well as experience from similar projects. Rijkswaterstaat reserves the right to further study the reputation of any operator that takes part in the bid.

Payment terms and mechanism for bonuses or penalties

Bonuses and penalties are paid out and into the so called Incentive fund. Bonuses are paid out partially in the form of direct money and partially as access to funds earmarked for improvement works on the Delft Network. Those improvement works do not necessarily have
to be in the same area as the bonus was gained in. Incentives for improvements of assets should be paid out every six months or yearly during the contract period.

Penalties are monetary and go directly into the incentive fund. However penalties are earmarked to be reinvested in the Delft Network.

Penalties for breaking minimum standards for technical standards as well as those set in the environmental plan (except for noise pollution) will be as follows:

- First 3 times no penalty
- Times 3-6 a penalty of €12,500 each time
- Times 6-10 a penalty of €35,000 each time
- Times 10-15 a penalty of €90,000 each time
- 16th time renegotiations between Rijkswaterstaat and the operator with the possibility of the contract being terminated. This is also the time where Rijkswaterstaat reserves the right to cash out the surety bond of the operator.

Bonuses for surpassing performance agreed in the original contract for the functional assets of travel time, travel time reliability and safety as well as noise pollution should be calculated with relations to their impact on gross social benefit (see values below). Penalties for failing to live up to performance promised by the operator in the tender are calculated with the following equations:

\[
Penalty = (P_F - P_D) \cdot \gamma \\
\gamma = \frac{W(P_F) - W(P_M)}{P_F - P_M}
\]

6 In accordance with what was the conclusions of the Payment terms and mechanism for bonuses or penalties in the Framework and the conclusions section of chapter 4 (section 4.5) the decision was taken to implement gradually increasing penalties with a termination (or renegotiations) clause at the end for technical assets and the environmental plan.

7 The two types of penalty mechanisms come as a result of the fact that not every minimum standard or performance measure can be directly monetized or valued according to gross social benefit. This mechanism, derived from (Vassallo, 2007) is for those instances where a gross social benefit can be calculated.
Where:

\[ P_f = \text{Level of service agreed by the successful bidder} \]
\[ P_m = \text{Minimum level of service allowed by the public authority} \]
\[ P_0 = \text{Level of service actually produced by the operator} \]
\[ W(P_m) = \text{Gross social benefit linked with } P_m \text{ level} \]
\[ W(P_f) = \text{Gross social benefit linked with } P_f \text{ level} \]

The gross social benefit for the specific performance measures are calculated using the following values:

- Travel time: €5.3 for every vehicle/hour.
- Travel time reliability: €12.6\(^8\) for every vehicle/hour.
- Noise: €10 for every dB(A) per person affected\(^9\).
- A higher approval rating for traffic management, travel time reliability and corridor maintenance will be awarded in the following way\(^{10}\):
  - Three times in a row with more than 5\% more approval means a bonus of €30,000
  - Three times in a row with more than 7.5\% more approval means a bonus of €60,000
  - Three times in a row with more than 12.5\% more approval means a bonus of €180,000
  - Three times in a row with more than 15\% more approval means a bonus of €300,000

\(^8\) (Norwood and Casey, 2002)

\(^9\) The section which analyzed noise pollution (section 4.3.6) did not produce a monetary value for every dB(A) per person affected. This does thus not have backing from literature.

\(^{10}\) As approval ratings can hardly be valued into gross social benefit, the decision is taken to fix bonus payments with it.
- Exceeding expectations and goals in the reduction of accidents and fatalities will result in a bonus that amounts for the total gross social benefit which this reduction results in.
6 Conclusions

The last chapter compiles the findings of the thesis. Firstly the main conclusions are summarized into five statements. After that key findings detail the main conclusions in much more detail. Thereafter, a validation of the framework is presented. This chapter then ends in discussions regarding the methodology, robustness of the conclusions and finally recommendations for future research.

6.1 Main conclusions

- Asset management has led to cost savings and other improvements. Proof of such cost savings and safety improvements have been reported in New Zealand. Furthermore road agencies have found that the increased integrity and transparency of their road assets has helped them to get extra funds from the government to conduct important maintenance work.

- There is clear evidence that involving private operators in the asset management can have beneficial effect. Evidence from industry indicates that bidding for government contracts is typically 10-50% more expensive than bidding for comparable private contracts. Furthermore private companies find it easier to keep hold of its key personnel.

- The inclusion of a private operator does not result in Rijkswaterstaat loosing their control of the highway system. To do so however, Rijkswaterstaat must prepare the ground by establishing minimum standards and performance measures for the assets.

- Not all assets can be treated the same way in the contract and minimum standards and incentives should be thought out for each and every one specifically. The technical assets are mostly protected by minimum standards while the functional and environmental assets also offer bonuses for innovative improvements.

- The contract can be further designed to enhance performance. The optimal contract length is around 10 years, or the lifetime of the pavement surface. Bonuses should be in place at the end of the contract to ensure top performance till the end.
6.2 Key findings

This study developed a framework for the implementation of privatized road asset management in the Netherlands. The study is based on four main pillars, as the chapters 1-4 demonstrate, starting with looking at asset management for roads in general, and then came the institutional organization and contractual matters. Finally there was a thorough analysis of the road assets themselves. The key findings will now be presented in the order in which they appeared in the thesis itself:

6.2.1 Benefits of road asset management

The thesis found that road asset management is an issue that is gaining a lot of attention from road agencies worldwide. Its systematic approach to gather data, setting goals and, later, auditing them with relation to measured performance has extensive benefits such as:

- Enhanced cost-effectiveness and efficiency in managing the road network (section 1.1.2). New Zealand has managed to reduce their highway maintenance cost per annum by some 17%. At the same time the value of highway assets increased steadily and safety measures managed to reduce accidents at treated sites by 70% (section 2.3.3).
- Road asset management enhances the understanding of results of actions taken or postponed on the network (section 1.1.2).
- The increased integrity and transparency of road assets and asset data has helped road agencies to get extra funding from the Government to conduct important maintenance work (section 2.4). This can also give road administrators access to other capital funds with lower interest rates (section 1.1.2).
- Road asset management increases the decision-makers understanding of the wishes of their customers. Because of the great role that performance measures play in asset management, they are constantly being evaluated and revised with relation to their ability to achieve the desired results (section 2.4).

6.2.2 Benefits of having a private operator

Installing a private operator can have a very positive impact on the final outcome of the road asset management scheme. However, in order to do so, Rijkswaterstaat must have a solid framework in place which is able to capture the competitive spirit of the market and utilize it for the good of society. The thesis found the following benefits in having a private operator.
- Installing a private operator allows Rijkswaterstaat to implement strong incentive schemes, driving the operator to always trying to achieve the best results (section 2.4).

- Better value for money. Evidence from industry indicates that bidding for government contracts is typically 10-50% more expensive than bidding for comparable private contracts. There is evidence, as well, that the magnitude of these costs worked as deterrents for potential bidders to take part in the tender (section 2.4).

- Problems with staff. Public institutions have a harder time in keeping hold of their best staff. In 1997 the procurement function of the UK government lost 17% of its staff, of which almost all were qualified (section 2.4).

- Big differences in prices obtained by the public authority. When the different public institutions were inviting bidders to supply them with electricity and gas the differences between the lowest and the highest prices obtained were 66% and 140% respectively (section 2.4).

- ASFINAG of Austria has demonstrated that they produced cost savings of 15% by taking over operational responsibilities on the highways from the regional and federal organizations in Austria (section 2.3.5).

6.2.3 Privatized road asset management in the Netherlands

Road asset management is already being explored in the Netherlands (section 2.2). A rather cautious scheme has already been implemented with 8 performance indicators supporting an auditing process, which is used to improve the annual Service-Level-Agreements of the Ministry. This thesis suggested that a private operator would be installed at regional level, taking over the responsibility of road asset management, and thus effectively taking over most of the responsibilities of the current regional offices. This is further explained in Figure 6.1.
Figure 6.1: The institutional organization and allocation of roles within the privatized road asset management scheme.

From the Figure it is apparent that Rijkswaterstaats role in the management of the highways is reduced. It basically gets rid of its regional function but continues to be the national manager. This setup is designed with Rijkswaterstaat setup in mind. Since the private operator is basically installed instead of the regional division of Rijkswaterstaat, it limits major structural changes elsewhere within the organization. Furthermore, Rijkswaterstaat already conducts widespread data-collection. That means that new functions would not necessarily be created from scratch, but rather that existing functions would be adapted to the needs of the asset management structure.

In more detail the roles of the three main actors (Government, Rijkswaterstaat and operator) are as follows (sections 2.4 & 2.5).

Government:

- Owner of the infrastructure. In the privatized road asset management scheme the private operator is working to manage the state assets under a limited time contract.

- Legislative authority. In democratic countries all legal authority lies with the government.
- Author of the nation-wide Service-Level-Agreement with Rijkswaterstaat. This agreement should be a sort of all-in-one package for Rijkswaterstaat, where they could find all goals and objectives, not only with relations to traffic but also regarding the environment, safety and other possible fields. The Ministry of public works must thus take all relevant policies, rules and laws from the different ministries into account when creating the SLA.

Rijkswaterstaat:

- Translates the SLA from the government to smaller SLAs with the private operators.
- Manager of the operational contracts with the private operators. And as such is also responsible for the tendering process.
- Owner of asset inventory data. This is important because Rijkswaterstaat need the data for future use.
- Conducts research and development. This is important because of the risk which competitive edge due to innovation would give a private operator over others; he would not allow others to learn from his innovation. Therefore Rijkswaterstaat should retain research and development to ensure that innovation-level will not be reduced.
- Sets standards. To ensure continuity on the roads and to ensure that governmental goals are being met, Rijkswaterstaat should set standards and rules.
- Maintains a nationwide traffic management center. This is because of the fact that traffic problems are often inter-regional and cannot be solved within one region. Rijkswaterstaat should therefore maintain nationwide traffic management which could intervene with regular traffic management of the operators when deemed appropriate.
- Monitors the operators regularly and audits their asset reports. Since Rijkswaterstaat is the author of the original bid and the performance standards and goals and should thus be the one that evaluates the final actual performance of the operators and compares it with the original goals of the contracts.

Private operator:

- Maintains and operates the road network. Maintenance involves all technical assets as well as the before-mentioned corridor maintenance. This is the biggest and
costliest part of the operators' work on the network and in a way the backbone of his contract.

- The traffic manager under normal traffic conditions. The nationwide traffic management center can however intervene if they think it’s important.

- Monitors the asset quality and reports it to Rijkswaterstaat regularly. Since the operator is the asset manager he is responsible for the quality of the assets.

- Innovates. Although Rijkswaterstaat should retain their research and development, it doesn’t mean that the private operator shouldn’t do it as well. Optimally he should constantly be looking for innovative ways of improving his network. His innovations are a bonus, on top of other innovations.

- Coordinates all construction work or installations on his network. All institutions will have to get an approval from the operator before they go ahead with doing something on the network. This is again minimizing the inefficiency of different stakeholders working on the network, running their own agendas that might conflict.

- Advises Rijkswaterstaat on improvements on the network. Being the day-to-day manager, the operator should be very well aware of the state of the roads and have the best knowledge of how to improve them.

Furthermore Rijkswaterstaat should regularly issue a report on the asset condition for those stakeholders which are not involved in the day-to-day operation of the roads. This report should be aimed for people who do not pose specialized knowledge in traffic management or road making.

### 6.2.4 Contractual issues

For contractual issues the thesis mainly focused on three issues, risk analysis, incentives and contract length.

**Risks**

Because the actual risks themselves are largely uncertain, the best way to deal with them beforehand is to decide on who will take responsibility with relation to their origin. Risks were thus analysed and allocated with regards to that. The allocation was as follows (section 3.2):
- Risks associated with policy: The government bears the risk of policy. If they change rules and regulations that change the original condition of the operating contract the operator should be compensated in some way (renegotiating or paying compensation).

- Risks associated with work: This risk is under responsibility of the operator since he is the one that plans and conducts the work.

- Risks associated with cooperation: The private operator bears the risk of his cooperation with stakeholders as it is his responsibility as asset manager.

- Risks associated with nature: Operators should bear all naturally occurring risks if they have any means of dealing with them. That basically means all times except for disasters such as extreme flooding, tornados or earthquakes.

- Risks associated with traffic demand: The operator is under most conditions the main traffic manager. In some cases the nationwide traffic management of Rijkswaterstaat intervenes. The risk is thus partly shared by the operator and Rijkswaterstaat, with the operator taking the bigger share.

- Risks associated with the asset management process: These risks are assigned with the actor's role in the asset management process in mind (Figure 6.1).

- Risk of failure: If the operator fails or becomes bankrupt Rijkswaterstaat might temporarily have to step in. Therefore the risk is in their hands to try to design the tender so the best operator is chosen.

- Other risks: “Acts' of God” are the responsibility of the government. These kinds of tragedies are likely to have widespread influence on society and such cases should always be dealt with by the supreme command, the government. Risk of costs and payments is limited by tying it to a construction cost index. The only one that really is taking a risk then is the one paying for the service, namely the government.

**Incentives**

The incentives of the contract are tools that are supposed to spur the operator to a high performance. A number of observations were made:

- Technical assets differ somewhat from functional and environmental assets in a way that there is not necessarily a direct benefit for society accompanied by increasing their quality endlessly (section 3.3 and 3.3.1). The functional and environmental assets will however return social benefit comparable to their improvement (section 3.3.2).
- Incentives have a twofold objective, to preserve minimum quality and to influence the operator to a higher performance level. Hard penalties should be imposed for poor performance where the quality of assets drops below minimum standards. Bonuses should be paid out if functional and environmental assets are improved (sections 3.3.3 and 3.3.4).

- For the penalties to work they have to be greater than the cost of avoiding them. This can mean a monetary penalty, a termination clause penalty (section 3.3.1 and 3.3.3) or a penalty where Rijkswaterstaat imposes a number of improvement projects on to the operator (section 4.2.4). The termination clause is the easiest to install, as then Rijkswaterstaat doesn’t have to estimate a suitable monetary sum. It, however, has the drawback of the troubles it can have to the operations of the road in the transition phase. The contract at the end of this thesis presented a somewhat fusion between these alternatives, with penalties steadily rising as the faults of the operator increase with a termination clause in the end. This gives the operator some chances but also punishes him hard if he underperforms seriously. This issue, however, is one which should be arranged and optimized as experienced is gained.

- If the operator is allowed to bid with performance in the tender, the incentives should also stimulate him to bid realistically. This means that if he promises higher level of service than he actually can produce, the penalties will increase. This makes it easier for Rijkswaterstaat to choose the most competitive operator in the tender (section 3.3.4).

- Incentives should all be paid in and out of a special incentive fund. The incentives should not drain funds away from the roads to the national treasury, but rather be reinvested again in the network (section 3.3.5).

- To ensure that there is always enough money in the incentive fund to pay out bonuses the Government should always earmark a portion of the budget made available for road asset management at Rijkswaterstaat to go directly to the incentive fund (section 3.3.5).

- If the incentive fund grows excessively large due to little bonuses being paid out, it could start to function a bit like Transfund NZ. That means that institutions and companies can bring suggestions for improvements in the road network and compete for capital from the fund.

- Bonuses should be partly a direct monetary payment and partly earmarked funds for more improvement work. This could then lead to an improvement cycle, where the
operator improves one asset and gets funds to improve another, which then could get him another bonus and so on (section 3.3.6).

**Contract length**

The length of the contract is a big issue. This thesis suggested that the contract length should match the lifetime of the pavement surface of the network. In other words, that the contractor would get a contract for as long time as he would be willing to promise a suitable pavement surface. This is beneficial because of the following reasons:

- This creates a "cradle-to-grave" environment, where the operator designs, constructs and maintains his own pavement surface for the whole tenure of his contract (section 3.4).

- With pavement surface having an estimated life-cycle of around 7-10 years, it means a contract-length of a moderate length which should minimize risks relating to contractual failures. Furthermore it limits the risk of possible increase in traffic demand and axle loading (section 3.4).

- Two, special kind of incentives should be placed at the end of the contract to ensure that the operator maintains a high performance till the very end of the contract. First of all a portion of the total contract value should be kept until the end. It would only be paid out if the assets were deemed in a good enough condition. Furthermore, if the assets are in a very good condition, and there is still some remaining life in the pavement surface, the operator could be granted with a limited time contract extension (section 3.5).

- If the contract is prematurely ended (because of bankruptcy or other reasons) Rijkswaterstaat should have a ready made "emergency contract" which could be tendered out in a short time. Every contractor should be made to issue a surety bond before the contract starts to ensure that there exist funds to bridge the gap between two operators (section 3.5.1).

**6.2.5 Asset analysis**

In the analysis the important assets were identified in three categories; technical, functional and environmental.
Technical assets

The technical assets are many and are not nearly all identified especially here in the text. Instead, for simplicities and clarities sake, they were identified as; land, formation, pavement (base), pavement (surface), drainage, traffic facilities, bridges, culverts, subways and other structures. The performance indicators deemed suitable for the road asset management contract were (section 4.2):

- Pavement roughness: Affects comfort and safety of driving as well as contributing to noise pollution.
- Pavement distress: A safety issue but also an issue of quality. A bad level of pavement distress can have diverse affect on the structural layers of the road.
- Skid resistance: A safety issue as it is a measure of the friction between the road and the tires and thus the stopping length a vehicle needs.
- Visibility of road markings: A safety issue. Its function in separating traffic streams is jeopardized if they are allowed to fade.
- Drainage: Affects safety as well as traffic conditions. Water cannot be allowed to form pools on the highway.
- Response time for routine repair: An issue that can affect many things. Malfunctioning roadside equipment are not performing the job they should be doing and could also cause an extra safety hazard because of its state.
- Corridor maintenance: An issue of safety as well as user acceptance of the environment.

Functional assets

Functional assets analyzed were travel time, travel time reliability and safety. For travel time the following performance indicators were chosen (section 4.3.1):

- Traffic management approval: Because of the difficulty in measuring the exact performance of individual traffic management actions, the option was chosen to measure the user perception of the management.
- Delay caused by maintenance and construction: Chosen because it can easily be measured and is currently a great source of congestion. It’s a performance measure that the operator sets himself. He can offer a maximum amount of delay he will cause
in the tendering process, which will then be translated into a minimum standard for him.

- Delay caused by incidents and accidents. The delay itself is not being measured, but rather the average response-time of the operator. This affects both safety and traffic conditions as accident scenes form bottlenecks where they are.

For travel time reliability the option was taken to measure reliability approval, in the same fashion as the traffic management approval is done (section 4.3.2).

Safety is measured primarily by accumulating the total amount of accidents and fatalities, which are believed to be caused by unsafe infrastructure, rather than driver or vehicle condition. Furthermore the response time for emergencies as well as for winter service is measured (section 4.3.3).

**Environmental assets**

Noise pollution is measured as it is done today and the minimum standards should comply with the national legislation regarding maximum noise levels. The pollution itself is a product of noise levels and the number of people affected (section 4.3.6).

The other environmental assets; air- and runoff-pollution and environmental public goods are measured, with regards to the environmental-plan of the operator. This basically means that the operator states in the original bid how he will contribute to these environmental assets with his operations and through the environmental management of his construction and maintenance (sections 4.3.4, 4.3.5 and 4.3.7).

**Asset relations**

The operator must be aware that some of his efforts to improve one asset can in fact have diverse effects on another. It is important for all stakeholders to realize these things when it comes to evaluating plans and strategies created by the public authority or activities and environmental plans by the operator. However it is evident that most externalities increase with increased traffic demand. At congested level, some of them get out of hand. Thus it seems that maintaining a fairly healthy traffic state while at the same time applying measures to reduce or limit externalities is the optimal performance (section 4.4).
6.3 Validation of the framework

The end-product of the thesis was the framework. The framework demonstrates that asset management is not only a concept or a philosophy. It's a continuous process that is constantly reevaluating itself and trying to achieve better results. The framework is intended to serve as a basis for the implementation of privatized road asset management within Rijkswaterstaat. As such it provides guidelines for all main actors, the Government, Rijkswaterstaat and the operator, in what to do and how to do it at all stages of the asset management cycle.

Because this research is based on literature research and interviews it misses the definite validation which a physical experiment can offer. Therefore, to give the framework more validity, the decision was taken to ask two professionals (one within Arcadis and one from Grontmij, that have experience in contracting and asset management, to read it over and give their comments.

Rob Snijders (Arcadis):

"Is it possible to describe more functional demands in the contract, it is now all very technical. The other question is, what's the benefit of Rijkswaterstaat and what is the basic role of Rijkswaterstaat?"

"Is it possible that the tender for the contract has a fixed price but the bidding is for the length of the contract?"

"On the contract, is there a line between innovation and the contract length? The shorter the contract, the less innovation maybe?"

Hans Bruinsma (Grontmij):

"On the whole you have created a solid framework for the contracting of maintenance on a highway network and I think that the framework as such can work. When going into more detail I can find a number of items that should be further developed, before actually putting the framework in practice."

"First there is the issue on the functional demands and the design of the road network. As presented the contract is lasting the life cycle of the pavement, but of course the entire road network has been designed (once) to perform a function over a time period. This time period
can be 70 to 100 years (looking at the technical life span of certain elements of the road). Essential though is that the functional life cycle is used for the lead. Unfortunately, this life cycle span is usually not identified: the moment that the "Delft network" becomes obsolete and will be demolished is not known."

"Even more complicating is that the functional demand constantly changes. This is related to legislation, environment and stakeholders, climate change, developments in automobile industry, changes in driver attitude, public opinion, technical innovation, politics, etc. etc. Therefore I have some difficulty seeing the 'contract phase' reduced to simply 'work'. All the contracting, planning, scheming, organizing and pricing that is done during the contracting phase will be repeated (on a smaller scale) during that 'contract phase'. It is impossible that during that phase the efforts are limited to doing the work as agreed upon in the contracting phase. This means that in the framework provisions must be taken (like procedures for pricing and sharing of risks) to handle these 'unknown certainties' during the contract phase. It is not possible to simply put out an open tender, like suggested at the incentive fund (p.114): change in the assets of network will cause a reevaluation of the entire scheme for the operator. This includes dependencies and related investments on the network that can't possibly be taken in account by other bidders."

"As a result the framework is now based upon the technical specifications (pavement roughness, skid resistance, etc.) for the road surface only and the functional demands for the traffic. Unfortunately other stakeholders have a say in things as well. Usually we build a structure in the highway not because the car drivers enjoy that so much, but because we have to make provisions for other systems. Like a crossing over another road, a rail- or waterway. Somehow their functional demands for these crossings must be met also. The relation with other stakeholders (counties, provinces, landowners etc.) is also a political matter and can't be left to the operator only."

"Traffic management should be treated with some care. There are two fundamentally different types of systems:

- Those that (dynamically) influence the capacity of the road (ramp metering, plus lanes, hard shoulder running, dynamic road marking, homogenization of speeds etc.)
- Those that influence traffic flows (DRIP's, road pricing, variable route guidance etc.)

The first can be the competence and responsibility of the operator. The second type much less so. This has to do with the fact that we don't want private parties directly directing traffic flows and secondly because there is a risk an operator will trade between customer
friendliness and safety with his own cost by redirecting traffic on a different network to meet the requirements on its own network or simply to avoid wear of its own assets.”

“In the 'contract end phase' you assume that the quality of the road surface will be minimal. This places a heavy burden on the operator of the new contract. Within months after having been rewarded the new contract the entire network should be resurfaced. That would mean that the entire network will be disrupted, without the possibility of any proper preparation. Usually these major reconstruction schemes are planned well in advance together with stakeholders and with timely and extensive communication to the end-users. Also network operations will not allow all roads in the network to be done at the same time (in fact not even two roads in the same network). So despite the fact that the technical risks for the road surface are minimized, other risks and responsibilities come in return. It will be the responsibility of the network owner (Rijkswaterstaat) to plan and prepare the reconstruction schemes in advance (together with the 'old operator') in order to enable the new operator to start with the schemes at short notice after being commissioned. An alternative would be to commission the new operator one year in advance (giving him enough time for preparation and purchase), leaving him with the risk of the performance level of the old operator over that last year. To complicate things further is the relation (both technical as well as functional) of the road surface with the other assets. From the Asset Management point of view it could be beneficial to combine works on different assets in stead of dealing with the assets separately when technology demands. A small investment for the old operator could be beneficial on the whole, but when the profit only goes to the new operator, it won't work.”

"Which leads me to my last remark: during the 'contracting phase' and the 'contract end phase' items must be 'valued'. This applies amongst others to the asset value and asset quality, this applies to the risks involved and this applies to the 'functional plan' and the 'environmental plan'. When offering for a contract the operator must know how to calculate his optimal performance and his best bid. And therefore he must have insight in how much value a certain effort in functional or environmental quality will generate and how much cost is involved for such an effort. Specifically on the environmental plan I haven't found information on how you would value that.”

Elaboration of validation

Rob Snijders’ comments were mostly in the form of questions. The questions touched on a number of subjects, which were studied in the thesis. The questions will now be addressed:
"Is it possible to describe more functional demands in the contract, it is now all very technical. The other question is, what's the benefit of Rijkswaterstaat and what is the basic role of Rijkswaterstaat?"

The functional demands come as a conclusion of the asset analysis (chapter 4). It was the decision of this research to focus on the same functional demands as Rijkswaterstaat is focusing on. Furthermore the criterion for the choice was that the operator would be able to influence the functions. The aim of privatized road asset management is not necessarily that Rijkswaterstaat gains, but rather that society as a whole benefits. Sections 1.1.2 and 2.4 mentioned several benefits for society. Section 5.2 of the framework details the role of Rijkswaterstaat.

"Is it possible that the tender for the contract has a fixed price but the bidding is for the length of the contract?"

This is of course possible. However, by keeping both parts free gives the bidders more freedom to create their bids. It would thus increase the chances that the most competitive bidder can fully demonstrate his capabilities and to thus win in the tender.

"On the contract, is there a line between innovation and the contract length? The shorter the contract, the less innovation maybe?"

Indeed there is. This was discussed in the beginning of section 3.4.

Hans Bruinsma pointed out some items which need further development. His comments can be dragged into the following points. For all the points the position and conclusions of the thesis will be explained below the statement.

- **Functional demands vs. contract length:**

  It was discussed in the thesis that the road network is a mixture of assets with very different life-cycles (section 3.4). The 70-100 year life-cycle of some of the components of the road was deemed as being too long and therefore the road surface was taken as the model for the contract length. With regards to changes in functional demands during the contract length, it's indeed true that saying that only 'work' is done during the contract period itself. Thus the section 5.4 (Contract Phase) was updated to make it clear that indeed a lot of reevaluation, planning, scheming goes on during this phase.

- **Problems with an open tender:**
The reason why the ‘open tender’ method was suggested was that it could stimulate competition between more actors to come up with creative and successful improvements on the network. If this is not possible, then the remaining operator will be the one to do the work. In such a case, Rijkswaterstaat could request a certain investment or work and use the penalties to pay for it. This is similar to the case of the First Great Western in England (section 4.2.4).

- **Technical specifications from outside parties:**

  If outside parties have special technical requirements for the road asset management, they will have to be analyzed in the same way as was done in chapter 4. If the requirements are only technical they should be turned into minimum standards or technical specifications for the operator. If they have a societal value which should be enhanced, they could be assigned with bonuses/penalties.

- **Cooperation risk:**

  The risk allocation was a suggestion based on a practical experience from Australia and New Zealand (Austroads, 2003a). It was furthermore discussed in (section 3.6) that the risk allocation was a matter of agreement and could thus differ in the different contracts.

- **Traffic management which influences traffic flows:**

  This specific detail was discussed in (section 2.5) and is the justification why there would have to be a nationwide traffic management center.

- **Plans for relaying the road surface on the whole network would have to be planned at least a year before they are done:**

  The renewal of every contract would have to be planned with things like this in mind. Furthermore, the renewal of the road surface would not necessarily have to be done exactly all at the same time. In gradual steps the renewal could last over a few years (perhaps 2 or 3 years) in the beginning of the contract. The contract length would depend on the time the first surface was renewed. The next operator would then, through information he would get from the asset inventory, be able to create his own renewal plan, with relations to the status of the different sections of road surface.

- **Problems with investments of the ‘old’ operator when the contract is nearing its end, especially when the benefits all go to the ‘new’ operator:**
An attempt to address this problem was done in section 3.5, that is to have bonuses available at the end of the contract for the ‘old’ operator if the assets are in a good enough state. In this way Rijkswaterstaat could state in the beginning what they consider as being a suitable asset-condition at the end of the contract.

- The valuation of an environmental plan:

Valuation of an environmental plan can be done through multi-criteria analysis. Rijkswaterstaat would simply assign the environmental plan with a number of points in their tender evaluation process. An example of this method was mentioned in section 4.3. The thesis didn’t really elaborate on multi-criteria analyses but there is abundance of information about it available, like for example here: http://www.defra.gov.uk/environment/economics/rtgea/8.htm

Conclusions of the validation

The conclusions which can be dragged from the validation is that on the whole, the framework works. The basic ideology (of using incentives to stimulate private companies to protect and enhance societal goals of the road network) in which it is based on was not debated. There are however, as Bruinsma pointed out, a number of issues that need to be developed further.

6.4 Discussions

6.4.1 Methodology

For a civil engineering Masters-thesis, this one is quite extraordinary. There is no experiment which serves as the focal point of the study. Instead this research consisted mostly of extensive literature research accompanied by interviews with experts of road management at Rijkswaterstaat. A limiting factor in the literature research was the author’s limited knowledge of Dutch. This is why the interviews with the professionals within Rijkswaterstaat were the main basis for the knowledge regarding the way roads are being handled in the Netherlands. Otherwise, literature was abundant for most of the subjects as not only universities but also research institutions of road agencies worldwide have issued a number of papers on most subjects relating to road management in general.
6.4.2 Robustness of conclusions

The robustness of the conclusions of this thesis differs somewhat. For some of them a strong theoretical background as well as proof from practice created a solid basis for the conclusions. This applies especially to the institutional organization, contract length and the technical assets performance measure. In others the conclusions were more an elaboration or ideas based on a literature base. This applies especially to most of the conclusions regarding the incentives, functional and environmental performance measures as well as the risk allocation. Only by implementing privatized road asset management, as it is described in the thesis, could a definite practical proof be attained for these aspects. The robustness of the conclusions for the specific research questions were presented after they were answered in the conclusions in the end of every chapter.

6.5   How to continue

Privatized road asset management is currently in its infancy. This thesis was mainly aiming at finding out how it could be implemented successfully in the Netherlands. This subject has by no means been depleted from study areas. But before privatized road asset management can be fully implemented in the Netherlands the following actions must take place:

- Institutional organization: The Ministry of Public Works should prepare the Dutch legal framework for changes in road management. Rijkswaterstaat would also have to prepare their regional offices with changes in their functions.

- A Dutch asset database. A Dutch asset database including all road assets of the highway system must be constructed by Rijkswaterstaat before any privatized road asset management takes place. Things such as asset valuation as well as depreciation rates must be decided.

- Assets: As Bruinsma mentioned in his validation of the framework, there are more parties than only Rijkswaterstaat which would have to have a say in the establishment of performance measures and minimum standards. Therefore, Rijkswaterstaat should hold conferences and workshops with all these stakeholders. Provide them with all necessary information on how road asset management is conducted and organized. And last but not least, get them to describe their demands.

- All the functional and environmental assets need to be monetized. This means that all of them have a value which can easily be used to calculate the actual worth of improvements. An example of this is to further break down the value which (Singels
et al., 2005) presented of €4.5 billion in air pollution costs into a table where each emissions type is valued per ton. Rijkswaterstaat should commission universities and research institutes to produce these values.

- Private companies need to realize their ability to operate a road network. As Miltenburg pointed out, private companies sometimes buckle by just getting technical specifications regarding a single highway bridge (Miltenburg, 2008). Therefore the private companies need to know where they stand and find out in which areas they need to hire specialists and where their own staff is good enough.

**Further research**

Furthermore, other important questions which remain unanswered and should be studied further are:

- Is this feasible? This study didn't touch on economical factors which eventually will have a lot to do with the success of the scheme. A thorough analysis, from a transaction cost economics point of view should be conducted to evaluate what the true cost of installing the private operator into the institutional organization of Rijkswaterstaat.

- Remaining asset life. The question of how much life and asset still has is one which troubled most of the road agencies studied (section 2.3). This gives plenty of research ideas about how we can value the life of the different road assets.

- Privatized road asset management at different levels. This study analyzed a privatized road asset management for highways. However, lower level road authorities might well be interested in exploring its possibilities. Privatized road asset management for cities calls for a special study in itself as it's problems and environment somewhat differs.

- Environmental public goods. The literature which was studied for the analysis of the environmental public goods demonstrated that this field is vastly unexplored. To effectively include the environmental public goods in the road asset management environmental plan, more concrete knowledge must be gathered on the subject.

- Valuation of an environmental plan. Bruinsma presented a problem in his validation regarding the problem with valuing different environmental plans. The establishment of monetary values for environmental assets as presented here above would greatly ease that valuation. This is a subject which should be studied further.
- Constant reevaluation of performance measures. Lessons learned from the asset management process itself will give some clues about the actual quality of the remaining performance measures. Rijkswaterstaat should never hesitate to change the measures if they feel it would improve the asset management process.
References

Literature


Blindenbacher, F. (2005), *Study of Methods of Road Capital Cost Estimation and Allocation by Class of User in Austria, Germany and Switzerland*, Ottawa: Transport Canada Economic Analysis Directorate


Websites

ASFINAG: www.asfinag.at (Last time viewed: 04.03.08)

AVV: www.rws-avv.nl (Last time viewed: 03.04.08)

Federal Highway Administration: www.fhwa.dot.gov (Last time viewed: 28.01.08)

Florida Department of Transport: www.dot.state.fl.us (Last time viewed: 18.02.08)

Highways Agency: www.highways.gov.uk (Last time viewed 25.03.08)

John Goodridge: http://www.johngodrich.co.uk/road.htm (Last time viewed 08.05.08)

New Zealand Ministry of Transport: www.transport.govt.nz (Last time viewed: 28.01.08)

RoadPeace.org: http://www.roadpeace.org/articles/worldfir.html (Last time viewed: 18.02.08)

Rijkswaterstaat: www.rijkswaterstaat.nl (Last time viewed: 03.04.08)

Transit New Zealand: www.transit.govt.nz (Last time viewed: 28.01.08)

VMS Inc: www.vmsom.com (Last time viewed: 14.01.08)
Interviews

[96] Pieter Miltenburg, Rijkswaterstaat, 18th January 2008
[97] Hans Bruinsma, Grontmij, 2nd April 2008
[98] Martin Cornelisse, Rijkswaterstaat, 2nd April 2008
Appendix 1: Measures to affect asset quality

Dynamic Traffic Management actions (Van Zuylen, 2005):

- Allowing the use of the hard shoulder during peak hours: It doesn’t call for any large scale investments and provides a certain increase in capacity. The hard shoulder is usually only used during congestion times or in case of an incident. A drawback of using the hard shoulder is that it can delay emergency services.

- Dynamic road marking: Using so called led-lights the road markings on the highway can be manipulated in a variety of ways. During congestion, for example, the lanes can be narrowed in order to add a lane. They can also be used in ramp metering and creating buffer zones to name a few. The throughput can be enhanced considerably.

- Homogenisation of speeds: When traffic load is about to reach saturation the speed limit is lowered on the highway and thus calming the traffic. The impact on capacity is negligible.

- Ramp metering: By controlling the flow of traffic from the on-ramps, the operator can prevent, or at least delay, congestion to take place. This however has its drawbacks as people will instead experience delays while waiting to be allowed onto the highway of the on-ramps.

- Car sharing lanes: By stimulating people to share their rides we can lower the amount of vehicles needed and thus keeping the traffic demand down. This has more to do with dealing with demand rather than capacity. It can even have capacity-reducing effect on the highway if it is underused because of unwillingness of people to share rides.

- Road pricing: Through road pricing the operator can influence route choice, time of departure and even perhaps modal choice. Road pricing in the past, with the help of tollbooths causing extra delays and un-comfort for drivers is no longer necessary. Road pricing has mainly influence on the demand side, but can also have influence on the capacity by delaying the saturation of the highways.
Figure A.1: Electronic road tolling equipment in Florida

- Automatic Incident Detection System (AID): AID is a system that detects incidents with the help of road detectors. It has been shown to reduce secondary accidents by 40% and improve throughput by 4-5%.

- Road works: Using a signaling system to warn drivers beforehand of road works is estimated to increase throughput by 5-10%.

- Fog detection and warning: Warns drivers beforehand of bad visibility conditions. Increases safety.

- Traffic buffers: Traffic buffers can help to protect highway exits from blocking because of queues.

- Variable lane usage and tidal lanes: Lanes can be allocated to special classes of vehicles (busses, freight vehicles). They can also be used for the larger flow during the peak hours (serve one direction during the morning and another during the evening).

- Dynamic Route Information Panels (DRIPS) and Variable Message Signs (VMS): Panels for commuters giving information on queues, travel time, availability of parking spaces, alternative transport modes etc. The main purpose of DRIPS is to influence route choice.

- Variable route guidance: In special cases (such as football games or accidents) traffic can be redirected to other routes.

- Video speed monitoring: Measures the average speed of a vehicle between two observation points. The complete speed controlling device.

- Lane control for freight vehicles: When traffic nears saturation, freight vehicles are banned from overtaking and can only drive on a special freight lane.
Traffic control in cities: Traffic control on intersections can be optimized to control queues and to meter the amount of traffic coming into an on ramp.

Parking control and guidance: Lets people know where there are free parking spaces, thus preventing them from roaming the inner city looking for a parking space.

Traffic information: Route guidance systems with real time information about traffic. Can help direct traffic from congested areas. It also prevents people from roaming around, lost, thus taking up space on the highway.

Travel information: Information about travel modes and interconnections between them before or during the trip.

Pay lanes: Privately built connection in line with 91 Express Lanes and Dulles Greenway in USA.

Road safety measures

Solutions regarding the factors that the operator can influence are:

- Exposure (Traffic volume): Many studies show that there is a very strong correlation between traffic volume and the number of crashes (Rumar, 1999). Therefore a great challenge regarding traffic safety is to try and reduce the traffic volume without affecting the total mobility of the commuters. One way of reaching this goal is if commuters are always aware of the shortest route, in other words, that the traffic is deterministic. If the commuters always know of the shortest route they will skip unnecessary by-routes and their total travel time is reduced, thus reduced exposure but unchanged mobility. Completely deterministic traffic is, however, an unrealistic idea. We can, on the other hand, try to stimulate shortest routes usage in a number of ways. Reporting traffic information through media (TV, radio and internet) can influence the commuters before they start their trip. Increased usage of in-car route guidance systems also opens up chances of influencing the 'right' choice of drivers.

- Speed: The operator of a highway can not control speed directly. His sphere of influence is mostly through setting speed limits. The enforcement of those limits is then in the hands of the police. An operator of inner city network has a bit more powerful tools in hand. Through speed-bumps and roundabouts on intersections he can push down speeds.

- Unprotected road users: Unprotected road users are best protected from motorized traffic by separating them. If cycling and walking paths are constructed just by the
highway but rather a few meters away, perhaps with a line of trees in the middle to further separate. Where the streams cross such as at intersections the streams are further kept apart for example by having special walking and cycling traffic lights as is already the norm in The Netherlands. As for motorcyclists, their situation is trickier since they usually travel along with the cars in motorized traffic. Creating some special rules to protect them could be very hard, if possible.

- Heavy vehicles: Heavy vehicles are not necessarily more likely to cause a crash than smaller vehicles. On the other hand, the consequences of such a crash are likely to be far greater than in the case of two small vehicles. To decrease the danger that smaller cars stem from heavier vehicles, we need ways to minimize their interaction. One way to achieve that is to confine the larger vehicles to a special truck-lane as is already common practice. The heavier vehicle could also be stimulated to operate more in low-intensity hours.

![In-pavement flashing devices, separating lanes](image)

**Figure A.2: In-pavement flashing devices, separating lanes**

- Bad visibility conditions: The best cure for darkness is light. However light bulbs have limited lifetime and will eventually go out. That’s why there will always be some dark spots on the highway. The role of the operator is to try to keep as low ratio of dead light bulbs vs. good ones as possible. That can either be done by chasing after every single one that goes dead or by simply changing the light-bulbs in the entire system with a certain frequency. That’s the choice of either being reactive or proactive. Foggy conditions are of different nature. There is final cure, but we can try to lessen the effect. One way is to warn drivers beforehand of fog through media or ITS (Intelligent Transport Services). Another is to place railings on outer side of the road or in-pavement flashing devices. They warn the driver even if he doesn’t see the
flashes, because of the vibration and the sound heard when the tires interact with the devices.

- Low friction conditions: Low friction conditions are usually quite predictable. Weather forecasts, especially for a few hours ahead of time, are relatively reliable. Common practice in removing icing from the surface is spreading salt. Snow and ice is cleared with the help of snowploughs. Heavy rain can be troublesome if the drainage is insufficient or if the pavement is seriously rutted. Drainage can get clogged due to debris, ice or other things, and must thus be surveyed. The greatest causes of rutting in pavement are heavy vehicles and nailed tires (common thing in arctic areas). Solid pavement management is thus the key to minimize this threat.

- A large number of injury causing constructions: Things that are considered necessary on the side of the road like light posts, gantry posts (for DRIPS and road signs) and even trees can pose a safety threat in themselves. In the case of cars either sliding or simply driving out of the road (for example because of driver tiredness) the existence of a light post or a tree in his way can increase the chance of injury quite significantly. A way of dealing or minimizing the threat could be to look into the design of the posts. Could they be designed from weaker materials like plastic instead of steel? Could the design somehow make them give away in case of a crash? However trees will hardly be redesigned. Their placement next to the road (as with all other possibly injury causing constructions) should always be looked at with the safety risk they undeniably pose.

**Air pollution measures**

Air pollution stemming from traffic can be reduced or limited with a number of measures.

- Intersection control, especially by applying a so called “green wave” (traffic lights coordinated so vehicles are likely to drive consistently on green light through many of them), can reduce the need for acceleration and breaking of vehicles and thus lead to less emissions.

- Dust can be cleaned of the road with the help of specially designed road cleaning vehicles.

- The road geometry is important as vehicles need less energy if the terrain and the road are flat. In hilly or mountainous areas, minimizing altitude changes in the road design can reduce the future emissions on that road.
- Maintaining steady traffic flow and moderate speeds can contribute to reduction of air pollution.

**Water pollution measures**

The possible measures that the operator can do to limit runoff pollution are mainly limited to the drainage. How the drainage is working and how the polluted runoff is handled is crucial. Sediment ponds next to highways are one method of handling polluted runoff from roads before it is flushed further on. Other methods are reducing congestion as it will reduce copper-pollution.

**Noise pollution measures**

- Noise barriers: A nice way to protect a number of houses and populous neighbourhoods from noise problem.

- Sound proof houses: A good solution where there are not many houses to protect. Provides instant noise protection, however, only to the inner part of the houses themselves.

- Quiet pavement: Some types of pavement create less noise than others. Not only do they reduce the noise experienced in the vicinity of the road, but they also reduce the noise on the road itself, and thus the noise pollution experienced by the commuters themselves.

- Lower speeds: Increased speed increases traffic noise. Thus a lower speed limit could reduce noise pollution. It also decreases the capacity of the road and travel times.

- Maintenance noise management: Although maintenance should, with regard to minimizing delays and travel reliability on the road, preferably be performed during night, its resulting noise could provide nuisance to the nearest neighbourhood. If maintenance is already scheduled to take longer than one night, the noisiest work-parts should be performed during day-time.
Appendix 2: Argentinean performance indicators and penalties

Table A.1: Performance indicators and penalties in Argentina (Austroads, 2003a)

<table>
<thead>
<tr>
<th>Service Provided</th>
<th>Performance Indicators</th>
<th>Penalties US$</th>
<th>Response Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. To Road</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Users</td>
<td>1. No pothole more than 2 cm deep on paved roads.</td>
<td>110/day/pothole</td>
<td>2 days</td>
</tr>
<tr>
<td>Riding Quality</td>
<td>2. No edge failure on paved roads (uplift or settlement due to plastic deformation).</td>
<td>110/day/failure</td>
<td>2 days</td>
</tr>
<tr>
<td>(Smoothness)</td>
<td>3. No rutting more than 20m long and 12mm deep on paved roads.</td>
<td>55/day/rut</td>
<td>5 days</td>
</tr>
<tr>
<td></td>
<td>4. No cracking or ravelling on paved roads.</td>
<td>88/week/km or part of</td>
<td>8 days</td>
</tr>
<tr>
<td></td>
<td>5. Travel speed of at least 50km/hr on earth roads and 70km/hr on gravel roads (geometrical standards permitting).</td>
<td>176/day/km or part of</td>
<td>2 days</td>
</tr>
<tr>
<td></td>
<td>6. No pothole more than 2 cm deep on paved shoulders.</td>
<td>44/day/pothole</td>
<td>3 days</td>
</tr>
<tr>
<td>Safety Features</td>
<td>7. No gullies or rutting more than 2 to 3 cm deep and extending over 0.5m from pavement edge, on unpaved shoulders.</td>
<td>440/wk/km or part of</td>
<td>3-5 days</td>
</tr>
<tr>
<td></td>
<td>8. Drains, ditches, culverts and other drainage structures to be cleaned.</td>
<td>44/day/culvert or drain</td>
<td>10 days</td>
</tr>
<tr>
<td></td>
<td>9. No obstructions on the pavement, such as fallen trees, dead animals, broken-down cars, slope slides...</td>
<td>44/hr or fraction per obstruction</td>
<td>1 day</td>
</tr>
<tr>
<td></td>
<td>10. Vertical signs to be well-placed, clean and visible day and night.</td>
<td>88/day/stat. Sign</td>
<td>5 days</td>
</tr>
<tr>
<td></td>
<td>11. Horizontal lane markings to be well maintained.</td>
<td>44/sq.m/day</td>
<td>3 days</td>
</tr>
<tr>
<td></td>
<td>12. Guardrails to be clean, well maintained and visible during day and night time.</td>
<td>44/day/section</td>
<td>3 days</td>
</tr>
<tr>
<td></td>
<td>13. Traffic control and safety in work zones to be fully operational and in accordance with standard specifications.</td>
<td>22/day/km or part of</td>
<td>5 days</td>
</tr>
<tr>
<td></td>
<td>14. Bush height not to exceed 0.15 m on shoulders and slopes, and 1 m beyond but within right of way.</td>
<td>22/day/km or part of</td>
<td>8 days</td>
</tr>
<tr>
<td></td>
<td>15. Trees and rest areas to be adequately maintained.</td>
<td>22/day/km or part of</td>
<td>5 days</td>
</tr>
<tr>
<td></td>
<td>16. No litter or residues on or around pavement.</td>
<td>44/day of delay</td>
<td>5 days</td>
</tr>
<tr>
<td></td>
<td>17. Maintain an operation centre for supervision team with adequate furniture, rest room, and communication system (radio, phone).</td>
<td>660/absence</td>
<td>15 days after contract signed</td>
</tr>
<tr>
<td></td>
<td>18. Be present during inspection.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B. To Road</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agency</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Penalties are applied if any of the conditions are not met within the specified time frame.
### 12. Bijlage 2 Service Level Agreements

**Hoofdwegennet**

**Basispakket: harde normen**

<table>
<thead>
<tr>
<th>Rijkswaterstaat Dienstverlening</th>
<th>Bepaling</th>
<th>Beschikbaarheid in %</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Betrouwbaar en tijdige Re-informatie</td>
<td>In % van de gevallen is de aanzienlijke toediening in de spits ten hoogste 15 minuten op de plus-trajecten en 30 minuten op de niet-plus-trajecten.</td>
<td>% van de gevallen</td>
<td>95</td>
<td>95</td>
<td>95</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>Doorstrooming en veiligheid</td>
<td>Voldoen van verhardingen aan de BON- norms (streeftaarden)</td>
<td>% van de gevallen</td>
<td>95</td>
<td>95</td>
<td>95</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>Doorstrooming en veiligheid</td>
<td>Voldoen van viaducten, aquaducten, bruggen en tunnels aan de BON-normen.</td>
<td>% van de gevallen</td>
<td>83</td>
<td>83</td>
<td>83</td>
<td>83</td>
<td>83</td>
</tr>
<tr>
<td>Doorstrooming en veiligheid</td>
<td>Het toonden van inhoudelijke verkeerskundige boodschappen op de DRIP's is in X% van de gevallen mogelijk.</td>
<td>% van het aantal spits &amp; niet-spits periodes</td>
<td>95</td>
<td>95</td>
<td>95</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>Doorstrooming en veiligheid</td>
<td>Aantal keren dat de spits-, plus- en bufferstroken geopend conform regime.</td>
<td>% van de gevallen</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Doorstrooming en veiligheid</td>
<td>Bij een (tijdelijk) blokkeren ten gevolge van een technische storing aan de bruggen en de grote rivierovergangen bij de Waal, Waal en IJssel zal de blokkeren binnen maximum 24 uur na constatering opgeheven zijn.</td>
<td>% van de gevallen</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
</tbody>
</table>

* De IM+ trajecten zijn de delen van het hoofdwegennet waar de IM+ inspecteurs actief surveilleren. Deze trajecten worden aangewezen door de programmateams IM+. Performance measures used today to evaluate the performance of regional offices of Rijkswaterstaat (Cormilisse, 2009).
**Publieksgericht Netwerkmanagement** - Groot Onderhoud

<table>
<thead>
<tr>
<th>Basispakket</th>
<th>Prestatie indicator</th>
<th>Enheid 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beleidsoverzicht nat en droog</td>
<td>Per RD 2 belevingsonderzoeken op projectniveau laten uitvoeren, 1 wegenproject en 1 voorwegingsproject</td>
<td></td>
</tr>
<tr>
<td>Files door wegwerkzaamheden</td>
<td>De norm van de Tweede Kamer is 0% files door wegwerkzaamheden als percentage van het totale aantal files. Per RD wordt het percentage files door wegwerkzaamheden berekend als percentage van het totale aantal files (ergschacht: de corrosie in dezelfde regio). Per RD mag het percentage niet hoger zijn dan onderstaande tabelwaarden. Dat leidt voor RWS totaal tot 7.5% (DI is in 2008).</td>
<td></td>
</tr>
<tr>
<td>Beloofbaarheid file-informatie droog</td>
<td>Per RD mag er niet meer dan 1 keer per jaar een nacht/avond-file en in het weekend, 3 km en langer, die veroorzaakt wordt door wegwerkzaamheden en waar de weggebruiker vooraf niet voor gewaarschuwd is.</td>
<td></td>
</tr>
<tr>
<td>Beloofbaarheid van voorweging/hinderinformatie</td>
<td>Per RD mag er niet meer dan 3 keer per jaar dat er trilling ontstaat, waar (minimaal) 20 beroepsschippers onbevredigd (c.q. te laat) lopen over zijn geïnformeerd en dus onnodig wachtlijn oplopen van meer dan 2 uur (hinderklasse 4).</td>
<td></td>
</tr>
</tbody>
</table>

---

**Toelichting publieksgericht netwerkmanagement**

Om in 2008 ons gewaagde doel van de 'meest publieksgerichte overheidsorganisatie' te bereiken, gaat RWS Zuid-Holland in 2008 verder op de ingeslagen weg. De informatie afkomstig uit de publieksfeedback via onder andere de landelijke informatielijn en de informatie voortvloeiende uit de diverse gebruikersonderzoeken zal gebruikt worden bij de uitvoering van de diverse projecten van dit Managementcontract. Tevens zal deze informatie nauwgezet benut worden bij het opstellen van het Managementcontract 2009.


Net zoals in 2007 zal er een plan van aanpak Publieksgericht Netwerkmanagement voor elke directie worden opgesteld. In dit plan van aanpak worden per directie de belangrijkste publieksgerichte activiteiten benoemd. Dit plan van aanpak geeft tevens aan hoe PNMM in 2008 verankerd zal worden in het werkproces van onze organisatie.

Appendix 4: Wang and Chou’s method of identifying contractual risks

(Wang and Chou, 2003) split risk allocation by contract clauses into seven kinds of conditions:

1. Type A: The risk is contractually allocated to the owner
2. Type B-1a: The risk is contractually allocated to the operator, without him opposing.
3. Type B-1b: The risk is contractually allocated to the operator, however with him opposing.
4. Type B-2: The risk allocation is unclear in the contract and therefore remains unconfirmed.
5. Type C-1: The risk allocation is not specified in the contract but both contracting parties agree that the owner should bear the risk.
6. Type C-2: The risk allocation is not specified in the contract but both contracting parties agree that the operator should bear the risk.
7. Type D: The risk allocation is not specified in the contract and the contracting parties do not agree on who should bear the risk.

Figure A.3: Risk allocation by contract clauses (Wang and Chou, 2003)

Those risks that the contract misses can prove costly to the project. Thus types C and D should not be too frequent. Wang and Chou studied six highway projects in Taiwan and were
unable to find any C-1 or D type risk allocation and the only C-2 were about the operators securing their own working site and maintaining good neighbourhood relationships.
Appendix 5: Glossary of terms

Act of God: Legal term relating to things outside of human control such as floods, tornadoes or other natural disasters.

Allocate: To allot, to distribute

Amortization: The process of decreasing or accounting for an amount over a period of time

Ancillary services: Extra services

Asset: A property that has money value and/or a useful or valuable quality

Audit: An official examination of accounts, goals or other objectives to see if they are in order

Award criterion: A standard or test in which different bids can be compared

Bottleneck: A narrowing of a road, resulting in reduced capacity.

Capacity drop: A phenomenon that happens when critical density of a road is reached, a 1-15% capacity drop can occur.

Concession: A contract to operate a business (a road) within the premises of some institution. In this case a concession is selling the right to run a toll-road for a number of years.

Corridor maintenance: A term derived from Transit NZ (Transit NZ, 2007a). Under it fall actions such as; traffic signs, road marking, street lightning, mowing, weed spraying, street cleaning, kerb sweeping, catch pit cleaning, litter patrol, bin cleaning, removal of graffiti and maintenance of railroad/road level crossing warning devices.

Corrugation: Contraction into winkles.

Cost-effective: Returning a benefit that justifies the initial investment.

Cradle-to-grave: The full life-cycle of a product, from the creation (acquisition) phase to usage phase and finally to disposal phase.

Credit rate: Interests charged on loans

Critical density of the road: Critical density of a road is the point where the traffic intensity exceeds the road capacity.

Crown-entity: An organization that forms part of New Zealand’s state sector.

DBFO-contract: A contract where the contractor designs, builds, finances and operates the project.
**Depreciation rate:** The rate in which an asset depreciates. This basically means that if it supposed to last for 10 years, it will depreciate for 10% every year.

**Deterrent:** Something which discourages or prevents one from doing something.

**DRIP:** Dutch digital highway information panels

**Earmark:** To specify for a special purpose

**Emergency services:** Services needed in case of emergency, such as police, ambulance or fire brigade

**Emission pollution:** Pollution stemming from emissions

**Enterprise:** A company

**Environmental assets:** Valuables of the environment. This includes clean air, water and low noise

**Environmental impact assessment (EIA):** An assessment of the likely positive and/or negative influence a project may have on the environment

**Envisage:** To see something with one’s mind

**Equity:** Fairness

**External costs:** An impact (positive or negative) on any party not involved in a given economic transaction

**First right of refusal:** A contractual right that gives its holder the option to enter a business transaction with the owner of something, according to specified terms, before the owner is entitled to enter into that transaction with a third party

**Functional assets:** Assets of functional value to the road. This includes travel times, travel time reliability and safety

**Gross social benefit:** Utility experienced by the infrastructure users and external agents, according to a quality level provided by the contractor

**Gully:** A road drainage point

**Handover:** The transference of authority, control or power from one agency to another

**Incentive:** Something that motivates rouses or encourages

**Inflation:** Expansion in the money supply beyond the increase in available goods or services

**Initiator:** One that initiates, starts
Innovation: Introduce something new

Institutional organization: The organization of actors within an institution

Internalize: To incorporate

ITS: The term intelligent transport systems, or (ITS), refers to efforts to add information and communications technology to transport infrastructure and vehicles in an effort to manage factors that typically are at odds with each other, such as vehicles, loads, and routes to improve safety and reduce vehicle wear, transportation times and fuel consumption.

Jurisdiction: The limits or territory within which authority may be exercised

Level of service: A measure by which transportation planners determine the quality of service on transportation devices, or transportation infrastructure

Life-cycle: The useful life of a product or system

Lobby: The class or group of people who try to lobby or influence public officials; collectively, lobbyists

Macro-economics: The study of the entire economy in terms of the total amount of goods and services produced, total income earned, the level of employment of productive resources, and the general behavior of prices

Malperformance: Poor or inadequate performance

Minimum standard: The worst allowable state of something

Monetize: To convert something into currency

Nation-wide traffic management: Traffic management which need a broad, nationwide scope. This can mean various methods influencing subjects like route choice, modal choice, departure time choice, decision to take a trip and destination of a trip.

Natural monopoly: Control over the market for a product which occurs when a firm gains large benefit from economies of scale, or from a superior business model or product, and is thus able to produce a very large percentage of the total market demand for a given product and unintentionally exclude meaningful competition via price structures

Non-compliance: Not complying to instructions, rules or laws

Non-governmental organization (NGO): A legally constituted organization created by private persons or organizations with no participation or representation of any government
Non-price attribute criteria assessment: A method in which items of no monetary value can be evaluated or compared

Oust: To expel or remove

Outsource: To transfer the management and/or day-to-day execution of an entire business function to a third party service provider

Parity: Equality

Partnerprogramma Infrastructuur Management (PIM): PIM is a program dedicated to improving working processes. The final aim is better, more intelligent maintenance of the highways and waterways, and a faster flow. Taxpayers will get better value for their money; the clients of Rijkswaterstaat (i.e. all members of the public) will be more satisfied. And the people, who carry out maintenance or highway management on a professional basis, can do a better job.

Pavement deflection: Measures pavement structural failure

Pavement distress: Measures surface condition

Pavement roughness: Measures pavement rideability

Performance bond / surety bond: a bond issued by an insurance company to guarantee satisfactory completion of a project by a contractor.

Performance indicator: are financial and non-financial metrics used to help an organization define and measure progress toward organizational goals

Performance related maintenance contracts: Maintenance contract in which payments rely partially on performance.

Policy risk: Risk associated with policy and lawmaking

Price/cost ratio: The measure of a price paid for something relative to its income or return

Private operator: A private company taking care of both maintenance and operation of a road network

Proactive: Acting in advance to deal with an expected difficulty

Procurement: The act of procuring or obtaining; obtainment; attainment. The act of getting possession of something

Public authority: Public entity to which the government has entrusted the organization and monitoring of the management of a particular infrastructure.
**Public-private partnership (PPP):** Describes a government service or private business venture which is funded and operated through a partnership of government and one or more private sector companies.

**Rationalization:** To restructure or change in line with modern, efficient or systematic lines.

**Raveling:** Separation of particles in the road pavement because of adhesion (loss of bond).

**Reactive:** React to the past.

**Recurrent:** Something happening repeatedly.

**Regime:** A period of rule.

**Rehabilitation:** To restore or repair.

**Replacement cost:** The amount that an entity would have to pay, at the present time, to replace any one of its assets.

**Residual:** A remainder left over at the end of some process.

**Road formation:** The earthworks and constructions that sit under the road pavement.

**Road infrastructure:** The set of assets that collectively create a road network.

**Road pavement:** The structural layer of the pavement, sitting beneath the road surface.

**Road surface:** The top layer of the road is the surface.

**Runoff:** Water flowing off or from the road.

**Rutting:** A track in the pavement, formed by passage of many wheels along a road.

**Scaling:** Removal of a layer of the surface.

**Scheme:** A systematic plan for future action.

**Seasonal issue:** Issues rising on special dates of the year, such as Christmas, Easter or just summer holiday’s.

**Service Level Agreement (SLA):** An agreement between two parties that one of the promises to provide a pre-specified level of service for a certain amount or money.

**Severity:** The degree of something undesirable.

**Single-point responsibility:** When only a single person or actor is made responsible for a range of things.

**Skid resistance:** A measure of the friction between the tires and pavement surface.
Social welfare: Utility experienced by society

Spalling: A type of fracture in the pavement

Stakeholder: A person or organization with a legitimate interest in a given situation, action or enterprise

State activity: Something done by the state or government

Stripping: A fault in pavement surface, when aggregates lose their bondage and disintegrate

Suffice: Enough

Technical assets: The technical aspects of the road infrastructure such as pavement, structures, signs, light posts, drainage, etc.

Tender: An offer to buy or sell something

Tenure: A period of time during which it is possessed

Traffic demand: Demand for mobility

Traffic intensity: The number of vehicles flowing through the road

Transaction cost: a cost incurred in making an economic exchange. For example, most people, when buying or selling a stock, must pay a commission to their broker; that commission is a transaction cost of doing the stock deal.

Travel time reliability: The reliability of travel time relates to how predictable traffic conditions are. If we expect a certain travel time before the trip starts the reliability measures how likely it is that it will in fact be that time.

Umbrella term: A single term used to describe a group of things

Unsolicited proposal: Not requested proposal

User charges: Charges for the use of a road. They can be in the form a tax or a direct charge.

Usufruct: The legal right to use and derive profit or benefit from property that belongs to another person, as long as the property is not damaged

Value for money: The measure of how much quality the money returns, basically the effectiveness of investments

Variable message sign: Digital panels over highways used for traffic management
Vehicle axle load: The maximum weight of a vehicle per pair of tires

**Wear and tear**: A term for damage that naturally and inevitably occurs as a result of normal use or aging

**Winter service**: Services required on the highway during winter time. This includes de-icing and snow clearing

**Work plan**: A plan detailing how work will be planned and done
Appendix 6: An example of DR-calculation

The formula for the DR-factor is as follows:

\[ DR = 100 - \sum_{i=1}^{n} d_i w_i \]  

(4.1)

Where:

\( d_i \) = The number of points assigned to distress type I for a given severity and frequency.

\( n \) = number of distress types used in rating method

\( w_i \) = relative weight of distress type i

A visual inspection of a given road section resulted in the following conclusions:

**Table A.2: Observed distress characteristics for the road segment**

<table>
<thead>
<tr>
<th>Distress Characteristic</th>
<th>Frequency</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cracking</td>
<td>Rare</td>
<td>Not Severe</td>
</tr>
<tr>
<td>Rutting</td>
<td>Occasional</td>
<td>Severe</td>
</tr>
<tr>
<td>Raveling</td>
<td>Frequent</td>
<td>Very Severe</td>
</tr>
<tr>
<td>Shoving</td>
<td>None</td>
<td>Not Severe</td>
</tr>
<tr>
<td>Spalling</td>
<td>Rare</td>
<td>Severe</td>
</tr>
</tbody>
</table>

From section 4.2.3, we have the following table for the factor \( d_i \):

**Table A.3: Rating factor, \( d_i \), related to severity and frequency (Gerber and Hoel, 1999)**

<table>
<thead>
<tr>
<th>Severity</th>
<th>Not Severe</th>
<th>Severe</th>
<th>Very Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rare</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Occasional</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Frequent</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
</tbody>
</table>

This is now combined in the following table along with the weight Rijkswaterstaat assigns to the distress-type in question:
Table A.4: Rating factors and distress-types' weights.

<table>
<thead>
<tr>
<th>Distress Characteristic</th>
<th>Rating Factor, $d_i$</th>
<th>Weight, $w_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cracking</td>
<td>1</td>
<td>2,4</td>
</tr>
<tr>
<td>Rutting</td>
<td>4</td>
<td>1,0</td>
</tr>
<tr>
<td>Raveling</td>
<td>9</td>
<td>1,0</td>
</tr>
<tr>
<td>Shoving</td>
<td>0</td>
<td>0,9</td>
</tr>
<tr>
<td>Spalling</td>
<td>2</td>
<td>2,3</td>
</tr>
</tbody>
</table>

By applying the values from Table A.4 into equation 4.1 the distress rating for the given road section is as follows:

$$DR = 100 - \sum_{i=1}^{n} d_i w_i$$

$$= 100 - (1 \cdot 2,4 + 4 \cdot 1 + 9 \cdot 1 + 0 \cdot 0,9 + 2 \cdot 2,3)$$

$$= 100 - 20 = 80$$
### Appendix 7: Air pollution emission types and their impacts

Table A.4: The various types of vehicle air pollution and their impacts (Litman, 2007)

<table>
<thead>
<tr>
<th>Emission</th>
<th>Description</th>
<th>Sources</th>
<th>Harmful Effects</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide (CO2)</td>
<td>A product of combustion</td>
<td>Fuel production and tailpipes</td>
<td>Climate change</td>
<td>Global</td>
</tr>
<tr>
<td>Carbon monoxide (CO)</td>
<td>A toxic gas caused by incomplete combustion</td>
<td>Tailpipes</td>
<td>Human health, climate change</td>
<td>Very local</td>
</tr>
<tr>
<td>CFCs and HCFC</td>
<td>A class of durable chemicals</td>
<td>Air conditioners and industrial activities</td>
<td>Ozone depletion, climate change</td>
<td>Global</td>
</tr>
<tr>
<td>Fine particulates (PM10; PM2,5)</td>
<td>Inhaleable particles consisting of bits of fuel and carbon</td>
<td>Diesel vehicles tailpipes and other sources</td>
<td>Human health, aesthetics</td>
<td>Local and regional</td>
</tr>
<tr>
<td>Lead</td>
<td>Element used in older fuel additives and batteries</td>
<td>Fuel additives and batteries</td>
<td>Human health, ecological damages</td>
<td>Local</td>
</tr>
<tr>
<td>Methane (CH4)</td>
<td>A flammable gas</td>
<td>Fuel production, tailpipes</td>
<td>Climate change</td>
<td>Global</td>
</tr>
<tr>
<td>Nitrogen oxides (NOx)</td>
<td>Various compounds, some are toxic, all contribute to ozone</td>
<td>Tailpipes</td>
<td>Human health, ozone precursor, ecological damage</td>
<td>Local and regional</td>
</tr>
<tr>
<td>Nitrous oxide (N2O)</td>
<td>Major urban air pollutant caused by NOx and VOCs combined in sunlight</td>
<td>NOx and VOC</td>
<td>Human health, plants, aesthetics</td>
<td>Regional</td>
</tr>
<tr>
<td>Ozone (O3)</td>
<td>Major urban air pollutant caused by NOx and VOCs combined in sunlight</td>
<td>NOx and VOC</td>
<td>Human health, plants, aesthetics</td>
<td>Regional</td>
</tr>
<tr>
<td>Road dust (non-tailpipe particulates)</td>
<td>Dust particles created by vehicle movement</td>
<td>Vehicle use, brake linings, tire wear</td>
<td>Human health, aesthetics</td>
<td>Local</td>
</tr>
<tr>
<td>Sulphur oxides (SOx)</td>
<td>Lung irritant and acid rain</td>
<td>Diesel vehicles tailpipes</td>
<td>Human health and ecological damage</td>
<td>Local and regional</td>
</tr>
<tr>
<td>VOC (volatile hydrocarbons)</td>
<td>Various hydrocarbon (HC) gasses</td>
<td>Fuel production storage &amp; tailpipes</td>
<td>Human health, ozone precursor</td>
<td>Local and regional</td>
</tr>
<tr>
<td>Toxics (e.g. benzene)</td>
<td>Toxic and carcinogenic VOCs</td>
<td>Fuel production and tailpipes</td>
<td>Human health risk</td>
<td>Very local</td>
</tr>
</tbody>
</table>