Feasibility study on Delta Transway
An innovative transport concept analysed

Jessica van den Bosch

23 November 2006

Graduation Committee
prof. dr. G.P. van Wee – TU Delft
drs. J.C. van Ham – TU Delft
ir. M. van der Sloot – ARCADIS
dr. J.F.M. Koppenjan – TU Delft
Preface

The report you are reading was written as part of my Master’s Thesis or in Dutch: *afstuderen*. It is the result of 8 months work on a study into the feasibility of an innovative transport concept I did at the engineering company ARCADIS. I am very glad that I got the chance to do my research at this company, because besides the facilities, the knowledge and the help which ARCADIS offered me, I could have a look inside the company. I would like to thank Marco van der Sloot who was my supervisor. I could always give him a call for help and he was very dedicated to the project. I would also like to thank the other ‘Arcadianen’ who spent time helping me with my study: Niels de Groot, Gerrit Morren, Edgar Wever, Lowi Sturrus and Jorrit Nieuwenhuis. They are specialists in topics relevant for my study and their help was very useful.

Besides the ‘Arcadianen’ I would like to thank the members of the advisory panel who gave feedback on my proposal and whom I contacted for information (their names are in appendix A). Especially I would like to thank Anne Tip of LogicaCMG for his time and useful knowledge. Also the people that where not directly in the advisory panel but helped or inspired me I would like to thank: Jeanine Hennis-Plasschaert, Jan van Heest, Marcel Oosterveer and Aschwin Groep.

From my faculty Systems Engineering Policy Analysis and Management of the University of Technology Delft, I would like to thank Bert van Wee, Joop Koppenjan and Hans van Ham for supervising me. Hans van Ham was a very pleasant and thorough first supervisor with whom I spent many Wednesday-end-of-the-days discussing my thesis. Last I would like to thank Eddie for his support.

For those of you who are interested in the results of this feasibility study but have limited time, a summary has been included and for those with very limited time, there is an executive summary. Whether you read the report in full or in part, I do hope it provides for interesting reading material.

Delft, 23 November 2006

Jessica van den Bosch
Executive summary

The aim of the feasibility study presented is to gain knowledge on the feasibility of applying Delta Transway on the bottlenecks for freight transport in the Netherlands. Delta Transway is an innovative transport concept developed by ARCADIS. Trucks can make use of dedicated lanes along the existing road infrastructure on national and regional level but have to make a reservation for the time slot they use. This makes it possible to make optimal use of the capacity of the dedicated lanes without hindrance of congestion because of a lack of capacity. This concept could be a solution to cope with the increasing mobility in the Netherlands. The question answered in this report is the following:

“What are the social costs and benefits of the implementation of Delta Transway for freight transport on bottlenecks in the Dutch national and regional road infrastructure, and where and how can Delta Transway be applied in such a way that its positive results are maximized?”

On the one hand, it is difficult to draw general conclusions. On the other hand, the case study shows that the social costs are high and the social benefits do not go beyond the social benefits of regular capacity improvement. However if the policy is explicitly to give priority to freight transport, Delta Transway has the advantage that all the direct transport benefits are given to this sector and the costs are not significantly higher. In this study some bottlenecks for freight transport on which Delta Transway might be a feasible solution are identified, these bottlenecks however should be analysed more in detail before conclusions can be drawn. The criteria following from the system description, from similar concepts and from the actor analysis should be taken into account for a successful analysis and implementation of Delta Transway.

The most important recommendations for ARCADIS are listed below:

A question that is left unanswered in this study is what the exact effect is of separate freight lanes on the circulation of traffic. This question could be answered by making a detailed traffic model, which was not possible within the scope of this research, but could be useful for a more detailed insight in the transport benefits of Delta Transway.

To get a better idea on the benefits of Delta Transway is would be useful to investigate the number of freight transporters that would use Delta Transway and their willingness to pay. The willingness to use the system determines the success of the concept. A stated preference study in which freight transport companies can express their choices in specific situations could be a method to analyse this.

In the previous section the conclusion was drawn that for private investors alone Delta Transway is not an interesting concept to invest in. However, as mentioned also in the conclusions combinations of private and public investments could be an interesting possibility. This possibility has to be analysed more in detail however. It is recommended to study on feasible options in which both public and private investments are made.
Summary

The road network in the Netherlands faces increasing traffic flows, and the forecasts for the coming years indicate a continued increase of traffic volumes. If no measures are taken, many bottlenecks will arise. Especially for freight transport, these bottlenecks result in significant economic losses. ARCADIS developed a transport concept that might decrease these losses by offering guaranteed travel time. The aim of this study is to gain knowledge on the feasibility of Delta Transway.

To analyse the feasibility of Delta Transway, a research question has been formulated, which was divided into 6 sub questions. The main questions that were to be answered in this research have been phrased as follows:

“What are the social costs and benefits of the implementation of Delta Transway for freight transport on bottlenecks in the Dutch national and regional road infrastructure, and where and how can Delta Transway be applied in such a way that its positive results are maximized?”

To be able to answer this main question, the following sub questions have been formulated:

- What are the system characteristics of Delta Transway?
- What can be learned from current freight transport on dedicated lanes?
- How can bottlenecks for freight transport be measured?
- Which bottlenecks for freight transport can be identified?
- How can Delta Transway be successfully applied on the bottlenecks?
- What are the costs and benefits of Delta Transway when applied to a selected case?

The objective of the first question is to get a clear picture on what Delta Transway is and how it works. The second question is formulated because studies on similar concepts, for instance dedicated freight lanes, can give useful information on the feasibility of Delta Transway. The third, forth and fifth question deal with the bottlenecks for freight transport in the Netherlands. Information on what a bottleneck is and where these bottlenecks can be found is necessary to identify places where Delta Transway can be a useful solution and how the concept can be a useful solution. The objective of the last sub question is to see what can be learned from a case, when Delta Transway would be applied on one of the bottlenecks.

The different parts of the study are represented by the sub questions. Per sub question the methods and the findings of that part will be explained.

What are the system characteristics of Delta Transway?

To answer the question “What are the system characteristic of Delta Transway?” a meeting has been held with an advisory panel in which organisations are represented that have interests concerning transport in the Netherlands. A list of these organisations is included in appendix Fout! Verwijzingsbron niet gevonden. Besides this information, also literature on the different elements of which Delta Transway exists has been consulted. A vision of Delta
Transway developed by ARCADIS was changed into a more short term concept that can be applied on the existing national and regional road network in the Netherlands. Delta Transway is a system that assesses time slots on dedicated lanes to target groups. These target groups, for instance transporters of perishables goods or public transport make a reservation for a certain time slot, which is called trip booking. The users arrive at the entry of the system, check in, and have a guaranteed travel time to the exit point of the system. Because of the trip booking, no congestion or delay will occur. The main system characteristics are:

- Trucks and buses on dedicated lanes
- Optimal use of capacity by trip booking
- User pays for guaranteed travel time

Making use of dedicated lanes creates the possibility of priority for target groups because of social or economical considerations. Several methods of trip booking are possible, but most preferable is a dynamic system that can be coupled to the road pricing system that will probably be implemented in the Netherlands around 2012. Dynamic means that the capacity planning is made flexible because it can be adapted to the locations of the trucks that have made a reservation, with the help of the GPS coordinates that are available by an On Board Unit. The user has to pay a certain amount of money for the guaranteed travel time he receives.

**What can be learned from existing freight transport on dedicated lanes?**

The question ‘What can be learned from current freight transport on dedicated lanes?’ is answered by studying evaluation reports of similar concepts that can be found in the Netherlands. Also persons that are or were involved with the implementation or evaluation have been interviewed. Cases studies that have been studied are the N408 near Nieuwegein, a dedicated lane that was in the past only accessible for buses and is now accessible for trucks, and the A16 and A20 near Rotterdam who have short freight lanes.

It turned out that real travel time savings are likely to only take place during rush hours and even then maybe not always, and the impact on the car circulation might not be that significant. To handle with these problems, an analysis of the specific situation should be made from a traffic circulation point of view. Another interesting point on the travel time savings is that on the N408, the perceived advantages were bigger than the real advantages. The question is whether perceived advantages are found important by policy makers. Perceived advantages are difficult to take into account when a cost-benefit analysis is made.

If Delta Transway is implemented on a former bus lane, it is necessary to define in advance how much delay is allowed for busses compared to the initial situation. It might be necessary to have extra adaptations made to the design of the situation to ensure only limited delay.

One of the points of interest mentioned in the evaluation studies was that slow trucks (trucks that drive less than 80 kilometres per hour) on dedicated lanes have a negative effect on the (saved) travel time. Capacity planning has to deal with this problem. Furthermore, the remark can be made that the longer the dedicated lanes, the more effective. Depending on the situation it should be considered whether the chosen section is long enough to gain significant travel time savings.

Two remarks can be made on the safety. First, the absence of a hard shoulder (in Dutch: *vluchstrook*) has a negative effect on the safety. It is recommended not to use hard shoulders to implement Delta Transway on, but dedicated lanes. Second the situation of a dedicated lane with buses and trucks does not lead to unsafe situations.
**How can bottlenecks for freight transport be measured?**

The question ‘How can bottlenecks for freight transport be measured?’ turned out to be less easy to answer than expected. During the research it turned out that several ways of expressing traffic intensities and congestion are possible. To get a clear overview table 0-1 is constructed in which the different ways are compared. The table shows six ways of measuring freight transport bottlenecks that are used by road maintenance authorities which are compared on the variables used. In the table, variables that are used for the calculation methods are given a ‘+’, a ‘•’ or a ‘+/•’. ‘+’means that the variable is used, ‘•’ means that the variable is not used, and ‘+/•’ means that the variable is sometimes used, in this case only when a distinction between cars and trucks is made.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intensity</th>
<th>I/C-ratio</th>
<th>Total severity of congestion</th>
<th>Economic losses for freight transport sector</th>
<th>Lost vehicle hours</th>
<th>Travel time/free flow ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of vehicles</td>
<td>+</td>
<td>+</td>
<td>•</td>
<td>+</td>
<td>+</td>
<td>•</td>
</tr>
<tr>
<td>Types of vehicles</td>
<td>+/•</td>
<td>+/•</td>
<td>•</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Capacity of the road</td>
<td>•</td>
<td>+</td>
<td>•</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Time</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>•</td>
<td>+</td>
</tr>
<tr>
<td>Duration of traffic jam</td>
<td>•</td>
<td>•</td>
<td>+</td>
<td>+</td>
<td>•</td>
<td>+</td>
</tr>
<tr>
<td>Length of traffic jam</td>
<td>•</td>
<td>•</td>
<td>+</td>
<td>+</td>
<td>•</td>
<td>+</td>
</tr>
<tr>
<td>Frequency of traffic jam</td>
<td>•</td>
<td>•</td>
<td>+</td>
<td>+</td>
<td>•</td>
<td>+</td>
</tr>
<tr>
<td>Value of time</td>
<td>•</td>
<td>•</td>
<td>+</td>
<td>+</td>
<td>•</td>
<td>+</td>
</tr>
<tr>
<td>Free flow speed</td>
<td>•</td>
<td>•</td>
<td>+</td>
<td>+</td>
<td>•</td>
<td>+</td>
</tr>
<tr>
<td>Actual speed</td>
<td>•</td>
<td>+</td>
<td>•</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Distance</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

(+ = variable is used
• = variable is not used
+/• = sometimes a distinction between cars and trucks is made)

The table gives an interesting overview of differences. Intensity takes into account the number of vehicles and sometimes also the type of vehicle expressed in a certain unit of time, often working days or weekdays, while the I/C-ratio adds the information of capacity to it. Therefore an I/C-ratio does tell more about the chance on a bottleneck, because high intensities alone are not a problem, only if the capacity lacks to cope with.

The total severity of congestion does not take into account number or the types of vehicles; it looks at duration, length and frequency of the traffic jam as a whole. A disadvantage is that it is difficult to measure, because it needs to be defined where exactly the traffic jam starts and ends. EVO and TLN involve the individual vehicle again in the calculation of the economic losses by multiplying the total severity of congestion by the number of trucks because they are interested in freight transport especially. Also the Value of Time is included in the calculation, to make it possible to express the losses of time for freight transporters in euros. The lost vehicle hours and the travel time/free flow ratio are more focused on the user and the extra time the user has to spend due to delays. Lost vehicle hours are the extra hours spend by vehicles on the road. Travel time/free flow ratio is less focused on how many cars are impeded and for how long, it only takes into account the difference in speed and the result of this difference on the travel time.

Considering these methods to measure bottlenecks for freight transport, the indicator ‘the economic loss for freight transport’ seems to be most useful for this study, because it focuses
on freight transport (it makes a distinction between types of vehicles) and takes into account the consequences (losses) for the transport sector.

The total severity of congestion does not take into account freight transport and is therefore less suitable. Lost vehicle hours are an appropriate alternative, but only if a difference is made between trucks and cars in the used intensities. If none of the calculations above can be made because of a lack of data (for provincial roads this is often the case), the I/C-ratio and the rush hour/free flow travel time ratio can be calculated. These methods however do not give information about how many road users were influenced by the congestion or the duration of the congestion. One can only assume that the delay (in case of travel time/free flow ratio) causes congestion that affects a lot of vehicles or that the high I/C-ratio leads to congestion that affects a lot of vehicles. Intensity alone does not give enough information on bottlenecks, because high intensities itself are not a problem, only when there is a lack of capacity to cope with the intensities.

**Which bottlenecks for freight transport can be identified?**

“Which bottlenecks for freight transport can be identified?” is answered by searching for data about traffic intensities, especially freight transport intensities, and congestion figures. Distinction is made between bottlenecks on national level and regional level. On national level, TLN & EVO regularly calculate the bottlenecks for freight transport that cause the greatest economic losses for freight transport on the basis of the severity of congestion of road sections on national level. In 2005, the A2 between Holendrecht and Oudenrijn was the number one with 32 million euro losses. The top 20 calculated by TLN & EVO is used as the answer on the question which bottlenecks can be identified on the national level. The national bottlenecks for freight transport are shown in Table 0-2.

**Table 0-2 Congestion top 20, based on economic losses for freight transport (2003-2005) (TLN)**

<table>
<thead>
<tr>
<th>Order</th>
<th>Road number</th>
<th>Province</th>
<th>Specification road section</th>
<th>Loss (million euros)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2003</td>
</tr>
<tr>
<td>1</td>
<td>A2</td>
<td>UT</td>
<td>Holendrecht - Oudenrijn</td>
<td>24</td>
</tr>
<tr>
<td>2</td>
<td>A1</td>
<td>NH</td>
<td>Diemen - Eemnes</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>A28</td>
<td>UT</td>
<td>Knooppunt Hoevelaken</td>
<td>21</td>
</tr>
<tr>
<td>4</td>
<td>A27</td>
<td>NB/ZH/UT</td>
<td>Breda - Utrecht</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>A12</td>
<td>ZH/UT</td>
<td>Gouda - Oudenrijn</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>A13</td>
<td>ZH</td>
<td>Delft - Kleinpolderplein</td>
<td>12</td>
</tr>
<tr>
<td>7</td>
<td>A2</td>
<td>GE/NB</td>
<td>Zaltbommel - Den Bosch</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>A4</td>
<td>ZH</td>
<td>Burgerveen - Leiden</td>
<td>14</td>
</tr>
<tr>
<td>9</td>
<td>A2</td>
<td>UT</td>
<td>Oudenrijn - Everdingen</td>
<td>26</td>
</tr>
<tr>
<td>10</td>
<td>A20</td>
<td>ZH</td>
<td>Knooppunt Kleinpolderplein</td>
<td>16</td>
</tr>
<tr>
<td>11</td>
<td>A10</td>
<td>NH</td>
<td>Knooppunt De nieuwe Meer</td>
<td>12</td>
</tr>
<tr>
<td>12</td>
<td>A50</td>
<td>GE</td>
<td>Ewijk - Grijsoord</td>
<td>8</td>
</tr>
<tr>
<td>13</td>
<td>A10</td>
<td>NH</td>
<td>Coentunnel</td>
<td>13</td>
</tr>
<tr>
<td>14</td>
<td>A15</td>
<td>ZH</td>
<td>Benelux - Vaanplein</td>
<td>7</td>
</tr>
<tr>
<td>15</td>
<td>A16</td>
<td>ZH/NB</td>
<td>Rotterdam - Antwerpen</td>
<td>21</td>
</tr>
<tr>
<td>16</td>
<td>A9</td>
<td>NH</td>
<td>Haarlem - Badhoevedorp</td>
<td>9</td>
</tr>
<tr>
<td>17</td>
<td>A12</td>
<td>UT</td>
<td>Lunetten - Veenendaal</td>
<td>11</td>
</tr>
<tr>
<td>18</td>
<td>A1</td>
<td>GE</td>
<td>Apeldoorn - Deventer</td>
<td>5</td>
</tr>
</tbody>
</table>

The road sections in table 0-2 can be found in the provinces Noord-Holland (NH), Zuid-Holland (ZH), Utrecht (UT), Noord-Brabant (NB) and some in Gelderland (GE). In these
provinces, the economic losses for freight transporters as a result of congestion are the highest.

On regional level, for the provinces that have the cope with the highest freight intensities, the bottlenecks for freight transport on regional level have been analysed. Two conditions have to be met to be in the list of bottlenecks for freight transport:

- The I/C-ratio has to be > 0.6
- The intensity of trucks has to be > 4000

For Zuid Holland the following bottlenecks meet these conditions: The N207, N211, N218, N466 and N470. These roads are defined as roads with bottlenecks for freight transport. In Noord-Holland especially the N201 and the N242 have both high truck intensities and ‘relatively high’ I/C-ratios. For Utrecht the N201, N210, the N230 and the N408 have been selected as bottlenecks for freight transport. The N279, the N284 and the N329 are regional roads in Noord-Brabant that all have intensities above 4000 trucks per day and I/C-ratios above 0.6. For Gelderland only the A325 and the N325 have more than 4000 trucks per 24-hours on a working day.

The bottlenecks mentioned above can be seen as bottlenecks for freight transport on the national and regional road network in the Netherlands.

**How can Delta Transway be successfully applied on the bottlenecks?**

Three different analyses have been done to answer this question. First a system description has been made, this resulted in success criteria on how Delta Transway should be implemented. Second the High Occupancy Vehicle (HOV) lane has been analysed, to see what could be learned from the implementation of this concept. Third an actor analysis has been carried out to see what a successful way of dealing with the actors should be.

The criteria following from the system description are described below:

- The target group that will make use of the dedicated lane has to be large enough. How large is large is a question that has to be decided upon by the investors in the infrastructure. Sometimes bus lanes are constructed which are only used by not so many public bus services. However, private investors will demand a certain return on their investments, which takes probably a larger target group.

- It needs to be desirable to give priority to a certain target group due to social or economical considerations. Social considerations can for instance be to give priority to public transport to support a modal shift, economic considerations can be to give priority to freight transport because of high Values of Time.

- The target group is brought past a bottleneck without causing a bottleneck downstream. If the ‘exit point’ of Delta Transway is a crossing that is the actual bottleneck, the implementation of Delta Transway does not improve the situation significantly.

- The more prohibitive physical barriers are located on the route of Delta Transway, the more difficult and therefore expensive the solutions are. So the route should preferable contain as few prohibitive physical barriers as possible.

- There needs to be a possibility to construct a new dedicated lane or a dedicated lane should already be available. Delta Transway is not possible without a dedicated lane.
The congestion on the ‘normal road’ needs to be a result of a lack of capacity that occurs regularly, for instance every morning during peak hours. If the congestion is for instance a result of accidents, a better solution is to analyse why accidents happen, and to improve the safety of the road.

For dynamic capacity allocation, On Board Units are needed. Dynamic capacity allocation is preferred but not necessary.

Users need to be willing to pay for guaranteed travel time. If users are not willing to pay for Delta Transway, no matter what their reason is, the concept will not be a success.

The users of Delta Transway need to gain significant advantages by the use in terms of shorter travel times. The expectation is that users are only willing to pay for the concept if they gain significant travel times.

Obliged separation of vehicles is preferred from a circulation viewpoint but commitment might lack. Obliged separation of vehicle types means that trucks have to pay for the use of the road, without having an alternative.

The mentioned criteria should be taken into account when looking closer at bottlenecks that Delta Transway could be a solution for. It needs to be clear that whether Delta Transway is a feasible or a less feasible solution to the bottlenecks does not say anything about whether Delta Transway is a better or worse solution to the bottlenecks than other systems or solutions are. This study only takes into account Delta Transway, and not its alternatives.

The analysis of the implementation of the HOV-lane resulted in conditions for successful implementation of Delta Transway:

Make sure the data and methods used for analysis are relevant for the situation and accurate. If stakeholders agree on these choices there will be more commitment on the results of analysis.

Good communication to the press can prevent that only negative information is published. With good communication is meant that time and effort is spend on providing the right information.

Spend a lot of time in creating commitment, not only for the actual decision makers, but especially with stakeholders that are influenced by the project. More on stakeholders will be mentioned in the following section.

Be sure the juridical aspects are analysed as well. The system excludes users from using a certain lane which needs a juridical base. It could for instance be necessary that a juridical decision on road use (in Dutch: verkeersbesluit) is taken.

For the actor analysis the goals, interests and problem perceptions of the stakeholders has been analysed. Second the importance and the replaceability of the actors defined whether they were critical or non-critical. For the dedicated critical actors with contrasting perceptions, it is useful to think of possibilities to change the project in such a way that the goals of the critical actors become less contrasting. Of course, if the project changes it has to
be in such a way that the former actors with equal perceptions still have equal perceptions. An example is to make Delta Transway only accessible for clean trucks, which might make the concept more interesting in the light of environmental-friendly policy. The non-dedicated non-critical actors with equal perceptions are actors that do not need attention in the first place. Later in the project, however, they can be interesting allies. It is advisable to elaborate this analysis if more specific details on the location and the location dependent actors (for instance local authorities) are known.

**What are the costs and benefits of Delta Transway when applied to a selected case?**

For the case study the regional road N279 from the intersection with the A2 in Den Bosch to the intersection with the A67 near Helmond is chosen. This road is seen as an alternative to accommodate traffic of the A2 between Den Bosch and Eindhoven which would give the road a national function. Two project cases have been compared on the social costs and benefits. One project case was to change 2x1 lane into 2x2 lanes, the other project case the implementation of Delta Transway in two directions, which makes the new situation 2x1 ‘regular’ road plus 2x1 lane for trucks and buses. The result of the comparison of the project alternatives can be found in Table 0-3. All the effects are calculated as Net Present Values until 2042 with a discount rate of 7%, which is the compulsory rate for infrastructure projects in the Netherlands.

**Table 0-3 Overview of social costs and benefits (Net Present Values until 2042)**

<table>
<thead>
<tr>
<th></th>
<th>2x2</th>
<th>Delta Transway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction, &amp; maintenance</td>
<td>199 million euros</td>
<td>204 million euros</td>
</tr>
<tr>
<td>Operational (8000 trucks)</td>
<td>n/a</td>
<td>2 million euros</td>
</tr>
<tr>
<td>Direct effects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport benefits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car users</td>
<td>53 million euros</td>
<td>0</td>
</tr>
<tr>
<td>Trucks</td>
<td>51 million euros</td>
<td>100 million euros</td>
</tr>
<tr>
<td>External effects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety</td>
<td>-</td>
<td>+/-</td>
</tr>
<tr>
<td>Noise</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Air pollution</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nature</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Indirect effects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New business activities</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Technological spin-off</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Extra benefits for consumers</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

0 = no effect, + = positive effect, - = negative effect

**Costs**

The cost estimations were made with the help of a cost specialist of ARCADIS. 60% of the total costs are the building costs, which are the costs of the actual construction of the road infrastructure. These costs are for the greater part the same for both alternatives. The following can be concluded: Delta Transway turns out to be more expensive. The difference is 7 million euros, which is only 3.5% of the total costs. The extra costs are caused by:

- Extra building costs for the connections with the industrial estates which are also the exit and entry points of Delta Transway
Extra engineering costs, other additional costs and unforeseen project costs because of the extra building costs (these costs estimations are a percentage of the building costs)

Operational costs

Because the differences in costs between the project alternatives are all extra costs for Delta Transway, Delta Transway will always turn out to be more expensive than the 2x2 alternative. It is however questionable whether a difference of only 3.5% is significant. Interesting is that 2/3 of the construction costs (which is 97% of the total costs) is caused by the building costs, and these building costs only differ 3 million euros as a result of the connections of Delta Transway with the industrial estates.

Direct transport benefits

To estimate the direct transport benefits for the two alternatives, a simple traffic model has been made by ARCADIS. This model unfortunately only takes into account the N279 from Den Bosch to Helmond, not its surroundings. The output of the model, expressed in a difference in lost vehicle hours compared to the current situation, has been multiplied with the Value of Time. This Value of Time is 38 euros per hour for freight transport (Rand, 2004) and 10 euros per hour for passenger transport (AVV, 2005b). When this is done, Delta Transway turns out to have fewer benefits than the 2x2 alternative, see also Table 0-3. The difference however is only 3.8%. Interesting to see is that for Delta Transway all the benefits are for the freight transport sector while for the 2x2 alternatives only a bit less than half of the benefits is for the freight transport sector.

The results of the model are influenced by some assumptions that have been made when the model was created. Because the model does not take into account the surroundings of the N279, the number of trucks that might use one of the project cases might be bigger. The same holds for the fact that 2004 intensities were used. Furthermore the model takes not into account the part between Helmond and the A67 which leads to less saved vehicle hours and results of better circulation were not included and only rush hours were taken into account.

A last remark that can be made on the model is the capacity that is added for the alternatives. For the 2x2 alternative the standard capacity for a provincial road is added, for Delta Transway only 200 pae per hour per direction is added. This is the current intensity of trucks. However, when Delta Transway would be implemented, probably more trucks would use the system than that use the N279 now.

Besides the remarks on the model, also a remark can be made on the Values of Time chosen. Not taken into account is the fact that AVV expects the Value of Time to rise until 2020. (AVV, 2005b). This would increase the benefits of both the alternatives. However, if the Value of Time for freight transport will increase faster than the Value of Time for passenger transport, the benefits of Delta Transway could become more than the benefits of the 2x2 alternative. In general it can be said that the estimations made are very conservative, they define the lower boundary of the possible results.

External effects

Also the external effects of the two cases have been analysed. On road safety, the increase in users of the road has a negative effect on the frequency of accidents, but a positive effect of Delta Transway is that it is not possible to overtake. Noise and air pollution will increase due to the increase of traffic intensities. The N279 and its surroundings do not belong to special areas mentioned in the EU Habitat and Bird Directive which results in a ‘neutral’ effect for the indicator nature.
Indirect effects
Indirect effects that were taken into account are ‘new business activities’, ‘technological spin-off’ and ‘extra benefits for consumers’. Both the project cases offer the possibility to develop new business activities on the industrial areas along the N279 as they are ‘opened up’ better by the new infrastructure. For Delta Transway the focus will be on business related to freight transport, for the 2x2 alternative the business activities have a more general character.

Because Delta Transway is an innovative concept, it can have a positive effect on the image of the Netherlands as an innovative economy and the competitive position of the companies involved. The third indirect effect is the lower price that the consumer pays for transport if the transport sector benefits from guaranteed travel times.

Investments and returns for investors
For potential investors in Delta Transway, it is interesting to see what the Internal Rate of Return is. To calculate this measure, some assumptions on the use of Delta Transway were made. The discount rate is 7% the same as for the social costs and benefits used, the investments 206 million, the fee 5 euros (0.10 eurocents per kilometre) and the number of paying trucks 8000. When 261 days per year the system is used, the Net Present Value is 120 million euros negative and the Internal Rate of Return 0.42%.

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Delta Transway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount rate is same as for social costs and benefits NPVs</td>
<td>7%</td>
</tr>
<tr>
<td>NPV Investments same as NPV social costs</td>
<td>206 million euros</td>
</tr>
<tr>
<td>Fee per truck</td>
<td>€ 5 (€0.10 per km)</td>
</tr>
<tr>
<td>Number of trucks per day</td>
<td>8000</td>
</tr>
<tr>
<td>Days per year</td>
<td>261</td>
</tr>
<tr>
<td>NPV investments – cumulous 2042</td>
<td>206 million euros</td>
</tr>
<tr>
<td>NPV fees – cumulous 2042</td>
<td>86 million euros</td>
</tr>
<tr>
<td>NPV cumulous benefits minus costs in 2042:</td>
<td>-120 million euros</td>
</tr>
<tr>
<td>IRR</td>
<td>0.42%</td>
</tr>
</tbody>
</table>

The conclusion can be drawn that Delta Transway is not an interesting concept to invest in. However, some remarks can be made on this conclusion. Construction of infrastructure is always very expensive. The high costs of the infrastructure can in this case, and not only in this case, not be invested only by private investors. It would be interesting to look at possibilities for investments by government and private parties together. Often the government invests in infrastructure without being paid back in a direct way. Besides the possibility that private investors design, build, finance, maintain and operate the infrastructure (DBFMO), it is also possible that private investors design, build and maintain the infrastructure (DBM) and that after for instance 25 years the ‘concession’ ends and the government pays back a part of the investments. Getting paid back a part of the investments for sure makes it of course more interesting to invest for private parties. Another way the investments could be shared is to see Delta Transway as a system that is not always used. When the system is not used, on times when no extra capacity is needed, the lanes can be used as normal roads. This needs some extra investments to make sure to the road users if they are allowed to make use of the lanes. The government could then pay for the part of the investments that belongs to the moments that everyone can make use of it and the private
Main question
The answers on the sub questions above provide the answer on the main question: “What are the social costs and benefits of the implementation of Delta Transway for freight transport on bottlenecks in the Dutch national and regional road infrastructure, and where and how can Delta Transway be applied in such a way that its positive results are maximized?”

On the one hand, it is difficult to draw general conclusions. On the other hand, the case study shows that the social costs are high and the social benefits do not go beyond the social benefits of regular capacity improvement. However if the policy is explicitly to give priority to freight transport, Delta Transway has the advantage that all the direct transport benefits are given to this sector and the costs are not significantly higher. In this study some bottlenecks for freight transport on which Delta Transway might be a feasible solution are identified, these bottlenecks however should be analysed more in detail before conclusions can be drawn. The criteria following from the system description, from similar concepts and from the actor analysis should be taken into account for a successful analysis and implementation of Delta Transway.

Recommendations
A question that is left unanswered in this study is what the exact effect is of separate freight lanes on the circulation of traffic. This question could be answered by making a detailed traffic model, which was not possible within the scope of this research, but could be useful for a more detailed insight in the transport benefits of Delta Transway.

Because of limitations in models and data, it was not possible to include the surroundings of the N279 into the model that was made to estimate the transport benefits. These limitations however do influence the output of the model, and therefore it is recommended to use more detailed models when analysing cases.

To get a better idea on the benefits of Delta Transway is would be useful to investigate the number of freight transporters that would use Delta Transway and their willingness to pay. The willingness to use the system determines the success of the concept. A stated preference study in which freight transport companies can express their choices in specific situations could be a method to analyse this.

Another aspect of Delta Transway that can be investigated in more detail is the design of the ICT system behind Delta Transway: for instance the system that registers the users, an enforcement system and the back office. Designing this system element would give a better insight in the specific costs and needs for Delta Transway.

In the previous section the conclusion was drawn that for private investors alone Delta Transway is not an interesting concept to invest in. However, as mentioned also in the conclusions combinations of private and public investments could be an interesting possibility. This possibility has to be analysed more in detail however. It is recommended to study on feasible options in which both public and private investments are made.

A last recommendation is to investigate what the effect would be of the use of Delta Transway by business travellers by car. Interesting would be the effect on the circulation and
on the financial feasibility of Delta Transway. The original concept Delta Transway separates the trucks from the cars, this however reduces the target group.
Contents

Preface ................................................................................................. i

Executive summary ........................................................................ iii

Summary ........................................................................................... v

1 Introduction ............................................................................. 1
  1.1 Reason and aim..................................................................... 1
  1.2 Research problem & questions ........................................... 1
    1.2.1 Mobility in the Netherlands ........................................... 1
    1.2.2 Economic importance of facilitating mobility ............... 2
    1.2.3 Road pricing in 2012 ................................................... 3
    1.2.4 Delta Transway .......................................................... 3
    1.2.5 Research questions ..................................................... 4
  1.3 Methodology ......................................................................... 4
    1.3.1 System description ..................................................... 4
    1.3.2 Lessons learned ......................................................... 5
    1.3.3 Bottlenecks ............................................................... 5
    1.3.4 Choice of evaluation method for costs and benefits ....... 5
  1.4 Structure ............................................................................... 7

2 System description Delta Transway .................................... 9
  2.1 Introduction .......................................................................... 9
  2.2 Vision Delta Transway ......................................................... 9
  2.3 Development Delta Transway .............................................. 10
  2.4 Delta Transway in this study ................................................. 10
  2.5 Characteristics of Delta Transway ....................................... 11
    2.5.1 Introduction ............................................................... 11
    2.5.2 Trucks and buses on dedicated lanes ......................... 12
    2.5.3 Optimal use of capacity by trip booking ..................... 13
    2.5.4 Users pay for guaranteed travel time ......................... 14
    2.5.5 Other elements ........................................................ 14
  2.6 Success criteria following for the system description .......... 15

3 Bottlenecks for freight transport .................................... 17
  3.1 Introduction .......................................................................... 17
  3.2 Measuring freight transport ............................................... 17
  3.3 Comparison of methods to measure freight transport bottlenecks ........................................... 19
  3.4 National bottlenecks ........................................................... 22
  3.5 Regional bottlenecks ........................................................... 22
4 Projects for Delta Transway ................................................. 25
  4.1 Introduction ....................................................................................... 25
  4.2 Lessons learned from joint use of dedicated lanes ....................... 25
    4.2.1 Pilot N408 .................................................................................. 26
    4.2.2 A16 and A20................................................................................ 27
    4.2.3 N213............................................................................................ 28
    4.2.4 Lessons learned ........................................................................... 29
  4.3 Lessons learned from HOV-lane in the Netherlands .................... 29
  4.4 Actors and stakeholders................................................................. 30
  4.5 Selection of case for case study...................................................... 34

5 Case study N279: Costs and benefits ............................................ 37
  5.1 Context of the N279 ......................................................................... 37
  5.2 Definition of boundary.................................................................... 39
  5.3 Base case and project cases............................................................ 39
    5.3.1 Base case .................................................................................... 40
    5.3.2 Project case ‘2x2’ ....................................................................... 40
    5.3.3 Project case ‘Delta Transway’...................................................... 40
  5.4 Costs ............................................................................................... 41
    5.4.1 Method......................................................................................... 41
    5.4.2 Costs of project cases ................................................................. 41
    5.4.3 Uncertainty .................................................................................. 45
    5.4.4 Net Present Value of the costs...................................................... 45
    5.4.5 Conclusion & discussion .............................................................. 46
  5.5 Direct effects.................................................................................... 46
    5.5.1 The Value of Time....................................................................... 46
    5.5.2 Estimated direct transport benefits.............................................. 50
    5.5.3 External effects ........................................................................... 52
  5.6 Indirect effects.................................................................................. 57
    5.6.1 New business activities............................................................... 57
    5.6.2 Technological spin-off ................................................................. 57
    5.6.3 Extra benefits for consumers....................................................... 58
  5.7 Overview social costs and benefits.................................................. 58
  5.8 Investments and revenues for investors.......................................... 59
    5.8.1 Internal Rate of Return ................................................................. 59
    5.8.2 Net Present Value and Internal Rate of Return for Delta Transway 59
    5.8.3 Uncertainty .................................................................................. 60
    5.8.4 Conclusion & discussion .............................................................. 60
    5.8.5 Investments by both government and private parties................ 61

6 Conclusions & Recommendations .................................................. 63
  6.1 Conclusions..................................................................................... 63
  6.2 Recommendations .......................................................................... 71
  6.3 Reflection......................................................................................... 72

References ....................................................................................... 73
Appendices ....................... Fout! Bladwijzer niet gedefinieerd.
   A. Advisory panel .......................................................... Fout! Bladwijzer niet gedefinieerd.
   B. Regional bottlenecks for freight transport - figuresFout! Bladwijzer niet gedefinieerd.
   C. Regional bottlenecks for freight transport - mapsFout! Bladwijzer niet gedefinieerd.
   D. Actors and Stakeholders ........................................ Fout! Bladwijzer niet gedefinieerd.
   E. Preferential alternative BOSE................................. Fout! Bladwijzer niet gedefinieerd.
   F. Standard Calculation Model (SRM1) – Noise ...... Fout! Bladwijzer niet gedefinieerd.
1 Introduction

1.1 Reason and aim
Subject of this thesis is Delta Transway, a transport concept developed by the engineering company ARCADIS. Delta Transway is a concept that makes use of dedicated lanes along national and regional roads in the Netherlands. These dedicated lanes are limited accessible, a reservation needs to be made in advance by the user and the user has to pay for his reservation which guarantees use of the infrastructure without congestion. ARCADIS would like to know whether Delta Transway is a feasible option for the bottlenecks in the Netherlands and how it could be implemented at these bottlenecks. To answer these questions a feasibility study has been carried out. The aim of this study is to gain knowledge on the feasibility of applying Delta Transway on the bottlenecks for freight transport in the Netherlands.

1.2 Research problem & questions

1.2.1 Mobility in the Netherlands
The road network in the Netherlands faces increasing traffic flows, and the forecasts for the coming years indicate a continued increase of traffic volumes. If no measures are taken, many bottlenecks will arise. Figure 1-1 shows the lost vehicle hours in 1990 and 2000 and the forecasts for 2010 and 2020. Red is morning rush hour, yellow is evening rush hour and green represents off-peak hours. It shows that the total amount of lost vehicle hours, which is the sum of all the time that vehicles spend in a traffic jam, will almost double from 2000 to 2020 if no measures are taken.

![Figure 1-1 Lost vehicle hours on national road network (index: 2000=100), red = morning rush hour, yellow = evening rush hour and green = off peak hours. (AVV, 2004)]

Reason for the increasing number of lost vehicle hours is the growing mobility. The development of vehicle kilometres on the Dutch road network is shown in Figure 1-2. Between 2000 and 2020, passenger transport will increase with 35% and freight transport with 70% according to the EC-scenario (AVV, 2004). Because of the higher growth figures of freight transport, the percentage of the total amount of transport will increase from 15% in
2004 to 20% in 2020 (AVV, 2004). Reasons for growing mobility are growth of population, spatial distribution of living and working and individualisation.

Figure 1-2 Passenger and freight transport on Dutch road network, vehicle kilometres (index: 2000=100). (AVV, 2004)

Light blue = cars on national road level.
Dark blue = trucks on national road level.
Light green = cars on regional & local road level.
Dark green = trucks on regional & local road level.

1.2.2 Economic importance of facilitating mobility

The government sees mobility as an aspect of welfare and lowering mobility is no option, as it would decrease our achieved welfare. So, mobility is growing and simultaneously, one of the most important goals of current policy is to keep economic centres accessible. This accessibility (the number of locations that can be reached within a certain time) is an important location factor for foreign companies and is also a critical factor for current industries and businesses. Think for instance of the port of Rotterdam which has to compete with the ports of Antwerp and Hamburg. “The more central a region is located, and the better the infrastructural facilities, the more attractive a region is for business activities” (Manshanden et al., 2005). The importance of accessibility, which leads to short and reliable travel times, can be expressed in the Value of Time. Table 1-1 shows the Value of Time for 3 different motives: commuters, business and ‘other’. For trucks the value is highest: 38 euros per hour.

Table 1-1 Value of time in euros per hour in 2002 (AVV, 2004)

<table>
<thead>
<tr>
<th></th>
<th>Commuter</th>
<th>Business</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>€ 7.99</td>
<td>€ 27.67</td>
<td>€ 5.52</td>
</tr>
<tr>
<td>Truck</td>
<td>-</td>
<td>€ 38.00</td>
<td>-</td>
</tr>
</tbody>
</table>

Road transport is not the only way to transport goods. Also train, barge and pipeline are used to transport goods, shown in Figure 1-3. With respect to volume, road transport and barge are the main modalities used for freight transport. The main strength of road transport is that it is a flexible way of transport. It can reach almost every location in the Netherlands and the units that are transported are not as big as for instance barge. The role of freight transport by road is an important one in the Netherlands.
1.2.3 Road pricing in 2012

In the field of transport by road, road pricing will be the most innovative and important development in the coming years. Probably from 2012 on, the system of road tax (a monthly amount of money for the right to own a car, in Dutch: *motorvoertuigenbelasting*) and car purchasing tax will be replaced by a system in which the user pays per kilometre. The price per kilometre will be differentiated to place, time and environmental vehicle characteristics. This means that a user, who owns a relatively environment-unfriendly car and chooses during rush hours a route that is normally heavy congested, will pay more than somebody who chooses to travel outside rush hours in a less congested area with his environment-friendly car. In spring 2007, the Dutch parliament (in Dutch: *Tweede Kamer*) will make a final decision on the implementation of road pricing. Recently the ministry of Transport has published extensive reports on the costs of the system, which turns out to be cheaper than expected before, because the onboard systems have become less expensive (Ministry of Transport, Public Works and Water Management – News item September 15th 2006).

The price which users will have to pay per kilometre has not been officially decided upon yet, but newspaper Cobouw (Cobouw online – news item September 30th 2006) has recently published an article in which they claim to have been able to derive the prices from the recently published ‘regional network analyses’. According to Cobouw they were able calculate a basic tariff of 3.4 eurocents per kilometre with an extra 8 eurocents during rush hours. These figures are however estimations of Cobouw and are not confirmed by any authority.

1.2.4 Delta Transway

Delta Transway is an innovative transport concept that fits in the current road pricing policy. The system combines the need for short and reliable travel times from the economic perspective with the road pricing system and looks forward to the possibility of guided vehicle systems in the future. The system issues time slots on dedicated lanes to target groups. The users from the target groups make a reservation for a time slot. Guaranteed travel time is offered and the user pays for the capacity he uses. The concept of Delta Transway will be explained extensively in chapter 2.
This concept has been developed by ARCADIS since 2000 and in the mean time several workshops have been held and a number of reports have been written on Delta Transway. Because Delta Transway can be combined with road pricing in the Netherlands, and road pricing will be implemented in 2012, it is currently relevant again. A following step in the development of the concept is this report on the feasibility of Delta Transway. In the following section, the research questions of this feasibility analysis are defined.

1.2.5 Research questions
To analyse the feasibility of Delta Transway, a research question has been formulated, which was divided into 6 sub questions. The main questions that were to be answered in this research have been phrased as follows:

“What are the social costs and benefits of the implementation of Delta Transway for freight transport on bottlenecks in the Dutch national and regional road infrastructure, and where and how can Delta Transway be applied in such a way that its positive results are maximized?”

To be able to answer this main question, the following sub questions have been formulated:
1. What are the system characteristics of Delta Transway?
2. What can be learned from current freight transport on dedicated lanes?
3. How can bottlenecks for freight transport be measured?
4. Which bottlenecks for freight transport can be identified?
5. How can Delta Transway be successfully applied on the bottlenecks?
6. What are the costs and benefits of Delta Transway when applied to a selected case?

The objective of the first question is to get a clear picture on what Delta Transway is and how it works. The second question is formulated because studies on similar concepts, for instance dedicated freight lanes, can give useful information on the feasibility of Delta Transway. The third, forth and fifth question deal with the bottlenecks for freight transport in the Netherlands. Information on what a bottleneck is and where these bottlenecks can be found is necessary to identify places where Delta Transway can be a useful solution and how the concept can be a useful solution. The objective of the last sub question is to see what can be learned from a case, when Delta Transway would be applied on one of the bottlenecks. How these questions will be answered is explained in the following section.

1.3 Methodology
In the previous section the research questions were defined, in this section the methods that will be used to answer these questions are explained. The sub sections are linked to the sub questions. First the method for the system description is mentioned in sub section 1.3.1. Section 1.3.2 describes the methods used to answer the second sub question. The methods used to answer the third, fourth and fifth sub question are mentioned in 1.3.3 and finally the method to define the costs and benefits of a selected case is described in sub section 1.3.4.

1.3.1 System description
To answer the question “What are the system characteristic of Delta Transway?” a meeting has been held with an advisory panel in which organisations are represented that have interests concerning transport in the Netherlands. A list of these organisations is included in appendix 0. Besides this information, also literature on the different elements of which Delta Transway exists has been consulted.
1.3.2 Lessons learned
On some locations in the Netherlands, freight transport lanes are already located. The lessons that can be learned from these cases can be found by studying evaluation reports of these freight lanes and by interviewing the persons that are or were involved with the implementation or evaluation. Only cases in The Netherlands have been analysed because the circumstances of these cases, are more likely to be the same. Vehicles and infrastructure are different in for instance the USA, which influences the results of evaluation studies.

1.3.3 Bottlenecks
To answer the question “How can bottlenecks for freight transport be measured?” reports and data from road authorities have been read. The ways of measuring were compared on criteria. The following question “Which bottlenecks for freight transport can be identified?” was answered by searching for data about traffic intensities, especially freight transport intensities, and congestion figures. Indicators were analysed and defined to analyse the road network on bottlenecks. These indicators are useful for selecting the bottlenecks that are important for freight transport to be solved. The last research question on the bottlenecks “How can Delta Transway be successfully applied on the bottlenecks?” was answered by gathering criteria which follow from the system description, the lessons learned from similar cases and from organisational criteria. The organisational criteria were found by doing a stakeholder analysis. These criteria were then applied on the bottlenecks for freight transport identified earlier.

1.3.4 Choice of evaluation method for costs and benefits
The last of the 6 sub questions asks for the costs and benefits of Delta Transway when implemented on a certain location, which will be a case selected from the identified bottlenecks for freight transport. In this subsection some alternatives methods to analyse the costs and benefits are described and the cost-benefits analysis is chosen.

Cost-benefit analysis, Cost-effectiveness analysis and Multi-criteria analysis
In Table 1-2, three methods to analyse costs and benefits are shown: cost-benefit analysis, cost-effectiveness analysis and multi-criteria analysis. These techniques are the most common used methods to compare measures (Wesemann, Devillers, 2004).

The cost-effectiveness analysis compares the effects on the main target of the measures with the investment costs of these measures. Only the effects on which the measures differ are considered relevant for the analysis. This can be an advantage, because the differences are most relevant, but can also be seen as a disadvantage, because the insight lacks in the effects that are not analysed. Another disadvantage is that it is impossible to compare measures which have different goals.

A multi-criteria analysis uses several criteria on which the alternatives ‘score’. For every criterion a different way of expressing can be used, from plusses and minuses to monetary values. This implies the advantage that also criteria that can not be quantified can be taken into account. To be able to compare the alternatives a set of weights is used to make a distinction between the important and less important criteria. These set of weights is subjective but has a significant influence on the results. Another disadvantage is the high chance of double counting.

This double counting is prevented in the cost-benefit analysis, because more effects and also side effects are measured in more detail. Because of the relatively high amount of effects that are analysed in the cost-benefit analysis, insight is given in all the relevant effects of the measures, even the risks can taken into account. Another advantage is the possibility to show the distribution of the costs and benefits per actor. Do the actors who pay the costs also receive the benefits or does one actor have the benefits and others the costs? This can be an
important factor in the decision making process. A last remark that can be made on the cost-benefit analysis is that the basic principle of evaluation is based on the consumer preferences, while the Multi-criteria analysis gives decision makers explicitly the possibility to change the weights in their own favour. Table 1-2 shows the advantages and disadvantages of the three mentioned assessment techniques.

<table>
<thead>
<tr>
<th>Methods</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost-effectiveness analysis</td>
<td>Mutual comparison on primary goal</td>
<td>Not every effect taken into account (no attention for side effects)</td>
</tr>
<tr>
<td></td>
<td>No attention for effects that do not differ between alternatives</td>
<td>Alternatives with an other primary goal are not comparable</td>
</tr>
<tr>
<td>Multi-criteria analysis</td>
<td>Comparison different types of measures and effects</td>
<td>Weights often subjective, but important for results</td>
</tr>
<tr>
<td></td>
<td>Also effects that are not monetised can be taken into account</td>
<td>High probability of double counting</td>
</tr>
<tr>
<td></td>
<td>Use of weights shows explicitly the political considerations</td>
<td></td>
</tr>
<tr>
<td>Cost-benefit analysis</td>
<td>Insight in relevant effects of the project cases</td>
<td>High demands on availability of input</td>
</tr>
<tr>
<td></td>
<td>Effects mutual comparable (equal unit)</td>
<td>Not all benefits can be monetised</td>
</tr>
<tr>
<td></td>
<td>Risks can be shown</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distribution of costs and benefits per actor is possible</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Because of prevention of double counting, disciplinary character</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preference of consumers is basic principle of evaluation</td>
<td>Preference of consumers is basic principle of evaluation</td>
</tr>
</tbody>
</table>


For infrastructure projects in the Netherlands the cost-benefit analysis is the most commonly used method. This is because all the relevant effects are included in this type of analysis and the effects per actor can be made visible. These advantages fit into the vision of a government that if it decides on investments, should take into account the interests of, and the effects on all the actors. Also in this study the cost-benefit analysis will be chosen because all relevant are included, which is an important aspect of a feasibility study. The following subsection will explain the use of cost-benefit analysis for infrastructure projects in the Netherlands.

Cost-benefit analysis as a method to evaluate alternatives

A cost-benefit analysis can be seen as a method to express the expected costs and the expected benefits of a project. Often, several options (alternatives) are compared. The best alternative is the alternative for which the benefits minus the costs are highest. This basic concept becomes more complex if also aspects that are hard to quantify have to be taken into account, think of the quality of life or environmental damage. This is because of the
characteristic feature of a cost-benefit analysis that all the relevant (social) aspects are not only quantified, but are also monetized if possible. This makes it possible to add up all the benefits and the costs and to compare the final sum for each alternative. Also the costs and benefits per actor can be shown.

Cost-benefit analysis in Dutch infrastructure projects - OEI

In the Netherlands a cost-benefit analysis is compulsory to compare alternatives in large infrastructure projects. In 2000 a guideline was published in which standards are set. It used to be named ‘Research Programme on the economic Effects of Infrastructure’ (in Dutch: Onderzoeksprogramma Economische Effecten Infrastructuur (OEEI)), but because this name implies that only economic effects are taken into account, it has been changed in ‘Overview of Effects on Infrastructure’ (in Dutch: Overzicht Effecten Infrastructuur (OEI)) (Source: Ministry of Transport, Public Works and Water Management – Van OEEI naar OEI). The result of the OEI for a certain project is one of the elements that is considered in the process of decision making on projects. For all the projects in the MIT (In Dutch: Meerjarenprogramma Infrastructuur en Transport) a cost-benefit analysis following the OEI has to be carried out in the ‘planning phase’ (planstudiefase). The more ‘special’ the project, the more extensive this has to be done. The MIT can be seen as an overview that contains all the infrastructure projects the Ministry of Transport is involved in local and regional projects of national importance. (MIT projectenboek 2006).

For this research, the OEI is used as a reference for the way of analysing the costs and benefits. However, the obligatory OEI is going into a level of detail that will not be realised in this project, but following the OEI guidelines has the advantage that it is clear for stakeholders what they have to expect because of the status of the guideline. All the main elements of the OEI are treated in this study but not in the level of detail that is needed for an obligatory OEI application.

1.4 Structure

In the following chapter, a system description is made. This system description tries to give an overview of the different elements of Delta Transway and results in criteria for successful implementation of Delta Transway. Chapter 3 describes the way freight bottlenecks can be measured and also identifies which bottlenecks for freight transport can be found in the national and regional road system in the Netherlands. In chapter 4 a study is described on the lessons that can be learned from similar cases and also included an actor analysis in which the perceptions, goals and interests of the actors related to Delta Transway are described. Together with the system description the actor analysis and the lessons from similar cases result in a list of criteria that should be taken into account when Delta Transway is implemented. The last section of chapter 4 is spent on the choice which bottleneck to use for the case study in chapter 5. In chapter 5 the costs and benefits of Delta Transway applied on the case is analysed. Chapter 6 contains the conclusions as well as the recommendations that follow from this study and the reflection.
2 System description Delta Transway

2.1 Introduction
In this chapter a system description of Delta Transway is presented. Its goal is to show the reader what Delta Transway is and to explain the difference between the vision for the far future and the short term version that is used for this analysis. It starts with a vision of a network of cities, connected by Delta Transway, which is devised by ARCADIS. After that, a short overview on the development in the last six years is given. Section 2.4 describes the difference between the vision of Delta Transway described in section 2.2 and the version of the system that is used in this research, which is described in section 2.5. Section 2.5 describes the different characteristics of the system which will give the reader a better picture of what Delta Transway is and what it would look like when implemented. The last section contains a list of criteria for successful implementation that follow from the characteristics.

2.2 Vision Delta Transway
The concept Delta Transway as it is developed by ARCADIS links up to the vision of network cities in the Nota Ruimte (2006), the main policy document on long term spatial planning in the Netherlands. The economic centres in the Netherlands are described as vertices (points) in a network, which are connected by infrastructure (edges). This infrastructure is very important to make the exchange of goods, people and communication possible. To optimize the use of capacity of infrastructure for the exchange of goods and people, Delta Transway is developed as an innovative logistic concept for road transport. It is assumed that despite the effort for a modal shift a lot of transportation will be by road. Delta Transway is developed as a smart concept to cope with this growth in mobility.

Figure 2-1 Impression Delta Transway in network city (ARCADIS)
The principle of Delta Transway is transport of goods and people (public transport) by vehicles on tires that make use of their own infrastructure along existing infrastructure in urban areas which can be guided by an Intelligent Transport System (Sloot, 2002). The capacity of the dedicated road is allocated by the use of time slots. Slots can be allocated to public transport and/or sold to transporters, depending on the desirable policy. Transporters can choose between paying for guaranteed travel times and using the ‘regular road’ with running the risk of congestion. At the start of the dedicated lane, an intersection with the ‘normal road’ is located. At this intersection a ‘transfer location’ (in Dutch: transferium) can be created which makes it possible to switch transport mode or to switch from the ‘regular road’ to the dedicated lane.

In Figure 2-1, an impression of the network city is shown, including the transfer locations at the border of the network city. A truck arrives at one of the transfer locations and enters the system. It can continue its route without hindrance from congestion. Delta Transway can be the start for a high quality transport network, starting with current vehicles on a couple of lanes, developing into a future with automatic guided vehicles on an extensive network.

2.3 Development Delta Transway

A short history of the development of Delta Transway by ARCADIS is shown below:

<table>
<thead>
<tr>
<th>Year</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 2000</td>
<td>Start intern development of Delta Transway</td>
</tr>
<tr>
<td>April 2000</td>
<td>First plan of approach</td>
</tr>
<tr>
<td>October 2000</td>
<td>Patent applied</td>
</tr>
<tr>
<td>May 2001</td>
<td>Workshop with stakeholders in which stakeholders are asked to think along with ARCADIS on Delta Transway</td>
</tr>
<tr>
<td>June 2002</td>
<td>Patent granted</td>
</tr>
<tr>
<td>August 2002</td>
<td>Wouter Smits graduates on a stakeholder analysis for Delta Transway</td>
</tr>
<tr>
<td>2003, 2004</td>
<td>Due to economic and political situation, no attention for Delta Transway</td>
</tr>
<tr>
<td>June 2005</td>
<td>Delta Transway receives ‘Vernufteling’ incentive prize (Ingenieur, 2005)</td>
</tr>
<tr>
<td>Present</td>
<td>Positive reactions on prize and renewed attention for Delta Transway</td>
</tr>
<tr>
<td>Future</td>
<td>Feasibility study on Delta Transway by author.</td>
</tr>
<tr>
<td>Future</td>
<td>Development of Delta Transway in combination with road pricing plans of government</td>
</tr>
</tbody>
</table>

2.4 Delta Transway in this study

Delta Transway as it is described in the first section should be seen as a vision for the long term. The Netherlands as a network with the economic centres connected via a high quality network is a description of how it should be in the far future. This research, however, tries to determine the feasibility of Delta Transway on the relatively short term, during the next 10 to 15 years. This implies guided vehicles or vehicles not on tires are not taken into account as feasible options and this research only includes current vehicles on tires on asphalt. Before guided vehicles can be implemented in the Netherlands on such a large scale, more development on the reliability and safety of such systems is needed.

Another difference between the vision and the system in this research is the focus on freight transport. The vision focuses on transport of people as well, but this study focuses on freight transport. The main reason is the important economic value of freight transport. It does however not exclude the use of the Delta Transway by for instance public bus services, but in the bottleneck analysis, the focus is on bottlenecks that are experienced by freight transport.
By taking these bottlenecks for freight transport as a starting point, the benefits in terms of economic value of time and reliability are maximized. More about the value of travel time can be found in chapter 5. Also a network of cities, connected by Delta Transway, is not feasible on the short term. One link between two cities that in the future might be developed into a network is more realistic for a first implementation. The network vision is the optimal future state which will be kept in mind when the short term future concept is developed. The next section will describe the system characteristics as they will be analysed in this research.

2.5 Characteristics of Delta Transway

2.5.1 Introduction

Delta Transway is a system that issues time slots on dedicated lanes to target groups. These target groups, for instance transporters of perishables goods or public transport make a reservation for a certain time slot, which is called trip booking. These users arrive at the entry of the system, check in, and have a guaranteed travel time to the exit point of the system. Because of the trip booking, no congestion or delay will occur. Delta Transway is most useful in situations where the other lanes face congestion but the users of Delta Transway can pass freely on their dedicated lane. Impressions of the appearance of Delta Transway can be found in Figure 2-1 or on the title page.

Delta Transway offers the possibility to give priority to certain target groups, which are groups that get priority on the base of economic or social considerations. Think of priority for bus services to stimulate the use of public transport, priority for freight transport on locations where the economic interests are important, or a High Occupancy Vehicle lane (in Dutch: carpoolstrook). Also combinations of target groups are possible. Target groups have to be big enough to make sure the number of users is high enough. Giving priority to target groups can be part of the policy of the Ministry of Transport, Public Works and Water Management. On European level it is not usual to give priority to freight transport over passenger transport, but in the Netherlands this is the other way around, because of the perceived importance of freight transport for the economy. Also societal considerations are possible to give priority to target groups, think of priority to public transport.
To get a more detailed idea on what Delta Transway is, a system description is made following the three main characteristics of the system:

- Trucks and buses on dedicated lanes
- Optimal use of capacity by trip booking
- Users pay for guaranteed travel time

### 2.5.2 Trucks and buses on dedicated lanes

If priority for target groups as described above is given, dedicated infrastructure is needed to realise travel time advantage for users. Delta Transway makes use of dedicated lanes. This can be existing bus and or freight lanes or new infrastructure. Because of the trip booking component, Delta Transway without dedicated lanes is not possible.

As defined in CROW publication 148 in 2000, a dedicated lane is a lane which is separated from the rest of the traffic, and for which any congestion on the other lanes has no effect on traffic on the separated lane. This ‘separation’ can be physically, with for instance an extra crash barrier, or just with signs above the road. Two reasons for applying dedicated lanes are mentioned, the first reason is to guarantee a certain quality level for the movement of a target group of users, and the second reason is to influence the mobility behaviour of the user. Delta Transway is focused on the first reason; its goal is to give priority to certain target groups. The target group is brought past a bottleneck or gets priority by passing a bottleneck. Two other criteria can be thought of for the construction of dedicated lanes. First, no prohibitive physical barrier should prevent this and second, the congestion should be of a structural nature, this means that the congestion is not accruing incidentally, but that a structural lack of capacity is the main problem.

Dedicated lanes can be divided into lanes the user has to pay for directly and lanes that are free to use, and can be divided according to the types of vehicles that are allowed on the dedicated lane. In the Netherlands, at the moment the only locations where users have to pay are the Kiltunnel and the Westerscheldetunnel, but no dedicated lanes are located there. The most common dedicated lane is the bus lane; this type is widely spread in the Netherlands, especially within cities. Less common is the bus- and freight lane and the HOV-lane (HOV = High Occupancy Vehicle). In chapter 4, more on HOV-lanes and joint use of bus lanes can be found.

A result of the dedicated lanes is that different vehicle types are separated. Buses and trucks that make use of Delta Transway are separated from cars. The cars drive on the ‘regular’ lane, the buses and trucks make use of the dedicated lane. The separation of these different types of vehicles has a positive effect on the circulation of the traffic. This is mainly because the different characteristics of the vehicles. Think of buses and trucks that need more time to accelerate and also more time to slow down, compared to cars. Also the maximum speed of cars is higher than that of trucks and buses. This mechanism works both ways, the cars are not troubled by the trucks and buses and the other way around. Whether buses and tucks are free to choose for the dedicated lane or are obliged can be discussed. The initial idea is to let the buses and trucks choose whether they want to use Delta Transway. The effect will be more significant if buses and trucks are obliged to use the dedicated lane, because the interaction with cars is minimal, but the commitment of bus companies and transporters to implement Delta Transway will be less, because they loose their freedom to choose.

If trucks do not have to accelerate and slow down again, this can have a positive effect on the emissions. It is however hard to express this mechanism in figures, because the emission numbers depends on a lot of factors. It depends on type of vehicle, emission filters, loading ratio, behaviour of driver, type of road, fuel type, presence of buildings and road profile.
2.5.3 **Optimal use of capacity by trip booking**

The use of trip booking is what makes Delta Transway innovative. Joint use of dedicated lanes is realised already in the Netherlands on a couple locations, but assessing time slots to users has never been applied before. The advantages of trip booking are multiple. First it results in guaranteed travel time. The user knows that if he books a certain slot, he will be able to reach a certain location within a certain time. Second, the capacity can be used optimal. The slots can be assessed in such a way that as many as possible users can profit without risking congestion. Another advantage is the possibility to give priority within the trip booking. This is relevant when more than one target group makes use of the system, but one has more priority than another. For instance, when the bus service has a higher priority than trucks that make use of the system, this can be arranged with the help of trip booking. Trip booking also implies that if the maximum capacity is reached, extra users are not welcome anymore. A capacity constraint is needed to guarantee a congestion free trip to the users.

To discuss the technical features of such a system, an interview with Anne Tipp, principal consultant at LogicaCMG was held. Two ways of capacity management (regulating when which vehicles make use of Delta Transway) are possible: a static and a more advanced dynamic one.

**Dynamic trip booking**

The advanced dynamic way is to combine trip booking with the road pricing as will be introduced in the Netherlands in the coming years. The expectation is that every car in the Netherlands will have an On Board Unit (OBU) that receives signals from satellites via a GPS system. With help of around 5 satellites (in theory 3, but in practice more) the OBU can calculate its position. By recording the coordinates the car is passing and the use of map software, the vehicle’s route can be calculated. This information can be sent via mobile communication to a back office which combines the route information with the pricing fees, differentiated to time and place and takes care of the payment procedures.

A characteristic of this system is that it is possible to know the exact location of every car. This makes it possible for a trip booking system to have a dynamic capacity planning. Around 60 to 70% of the capacity of the dedicated lane can be booked in advance, and the last 30 – 40% can be allocated at the last moment, if it is clear whether the users will reach the entry point on time, or have a delay, or are earlier than expected. The advantage of such is that users who are 5 or 10 minutes late do not have to wait to use Delta Transway, which results in a more use friendly system, a disadvantage is the need to know where the vehicles are located on the road. However, if the maximum number of trucks is reached, which means that besides the 60-70% that is reserved beforehand also the other 30-40% is allocated for instance to trucks that were too late for their earlier slots, no entry is possible anymore.

**Static trip booking**

If this dynamic capacity allocation is not possible, a static way can be used. Again a slot has to be booked in advance, but this time the system does not know where the users and the ‘coming’ users are. The user checks in on the time he has made a booking for. If he is too late for his slot, he has to contact the system again and see if he can get another slot. If he is too early he has to wait at the entry point of the system.

The main difference between the dynamic and static capacity planning is the information that is available in the system. Therefore the planning of the dynamic system can be optimised according to the needs of the users, which results in less waiting time for the users.
Making a reservation

How can transporters that make use of Delta Transway make a reservation? A system needs to be designed that processes and confirms the requests and manages the capacity. The actual design depends on the type of trip booking (dynamic/static) that is chosen. From the perspective of the user it is desirable to be able to make reservations by internet as well as by telephone. Especially for truck drivers that are on the road, telephone is the most convenient way of communicating. For reservations that are made from office locations, internet is a fast way.

2.5.4 Users pay for guaranteed travel time

Because the user has to make a reservation for his trip, he has to ‘identify’ himself, which makes it relatively easy to add a system which makes the user pay for the trip. The user pays for the ‘guaranteed travel time’ he receives in return. By letting the user pay for a specific trip, it is possible to differentiate between time and place. How much the user pays is dependent on the moment he travels (more expensive during peak hours) and the place he is (congested areas more expensive). Differentiated pricing is also used in the plans for road pricing on national scale as will be implemented in 2012.

Making the users pay for the use of infrastructure fits in the policy of the European Communities as described in the White Paper (2001): “As prices do not reflect the full social cost of transport, demand has been artificially high. If appropriate pricing and infrastructure policies were to be pursued, these inefficiencies would largely disappear over time”. Costs of air pollution, climate change, infrastructure, noise, accidents and congestion should be internalised via a road pricing system that differentiates in time and place.

The Ministry of Transport, Public Works and Water Management also wants the user to pay for the use of infrastructure, but has other considerations, the main goal is to decrease travel time. Increasing travel times are a major problem for road transport in the Netherlands. One of the measures that the ministry wants to take to reach this goal is the introduction of road pricing. For the Ministry, the decrease of travel time is a major goal, internalising all the external costs as the European Communities sees as the main goal, is a secondary goal for the Ministry. (Nota Mobiliteit I, pp.23, 2004)

To stimulate users to book their trip on time, which makes the capacity planning easier, for a trip that is booked earlier a lower price can be charged than a trip that is booked short before departure. A similar way of pricing structure is used in the airline industry where early booked tickets are cheaper.

If enough information on the situation on the road is available, prices can be differentiated. If there is no congestion on the ‘regular lane’ the price of Delta Transway can be similar to the ‘regular lane’, which will be zero or more. If there is congestion, the tariff for the dedicated lane could be dependent on the received travel time advantage.

2.5.5 Other elements

Besides the subjects that are described in this section, some other elements need to be designed before the system can be implemented.

Enforcement

Because the system is only available for users that have made a reservation, some enforcement is needed. This can be done with entrance gates at which users have to check in, which makes the number of illegal users very small, but makes the time that users have to spend longer. An alternative is to let everybody enter freely, and to check with cameras the licence plates of the users and to match this with the reservations. This makes illegal use easier but the check in faster and cheaper. When the design of this system is made, it is
important to compare the alternatives on the criteria price, user-friendliness and ease of misuse of the system.

**Foreign users**
Because the user of Delta Transway has to pay for the use of the system, it is only possible for foreign companies to make use of the system if the paying can be arranged in such a way that it is possible to make all the users pay for the use of Delta Transway, including the international users.

**Transfer places**
At the places where trucks gather to enter the system, parking places with facilities for the users and transfer places for public transport can be created. Whether these places are needed depends on the type of trip booking that is chosen. The more dynamic the system, the less the user has to wait, the fewer facilities are needed.

**Accidents**
The expectation is that on the dedicated lane of Delta Transway fewer accidents will happen because no overtaking is possible and less traffic has to filter in. However, accidents can of course not be excluded. Arrangements that can be made to limit the problems that arise because of accidents are often dependent on the willingness of the road maintenance authority to make sure the lane is available again as soon as possible. For the design it would be smart to include possibilities to swerve, think of hard shoulders and passing places.

### 2.6 Success criteria following for the system description
Whether Delta Transway is a feasible solution to certain bottlenecks depends on many factors. Partly, these factors are related to the characteristics which are described above. Many factors are location based and difficult to generalize into criteria that can be applied to every situation. However, the list below should be taken into account when looking more closely at potential locations. All the criteria below follow from the characteristics described above.

- **The target group that will make use of the dedicated lane has to be large enough.** How large is large is a question that has to be decided upon by the investors in the infrastructure. Sometimes bus lanes are constructed which are only used by not so many public bus services. However, private investors will demand a certain return on their investments, which takes probably a larger target group.
- **It needs to be desirable to give priority to a certain target group due to social or economical considerations.** Social considerations can for instance be to give priority to public transport to support a modal shift, economic considerations can be to give priority to freight transport because of high Values of Time.
- **The target group is brought past a bottleneck without causing a bottleneck downstream.** If the ‘exit point’ of Delta Transway is a crossing that is the actual bottleneck, the implementation of Delta Transway does not improve the situation significantly.
- **The more prohibitive physical barriers are located on the route of Delta Transway, the more difficult and therefore expensive the solutions are.** So the route should preferable contain as few prohibitive physical barriers as possible.
- **There needs to be a possibility to construct a new dedicated lane or a dedicated lane should already be available.** As explained in the previous section, Delta Transway is not possible without a dedicated lane.
The congestion on the ‘normal road’ needs to be a result of a lack of capacity that occurs regularly, for instance every morning during peak hours. If the congestion is a result of accidents, a better solution is to analyze why accidents happen, and to improve the safety of the road.

For dynamic capacity allocation, On Board Units are needed. Dynamic capacity allocation is preferred but not necessary, see also the explanation on dynamic trip booking in the previous section.

Users need to be willing to pay for guaranteed travel time. If users are not willing to pay for Delta Transway, no matter what their reason is, the concept will not be a success.

The users of Delta Transway need to gain significant advantages by the use in terms of shorter travel times. The expectation is that users are only willing to pay for the concept if they gain significant travel times.

Obliged separation of vehicles is preferred from a circulation viewpoint but commitment might lack. Obliged separation of vehicle types means that trucks have to pay for the use of the road, without having an alternative.

The mentioned criteria should be taken into account when looking closer at bottlenecks that Delta Transway could be a solution for. It needs to be clear that whether Delta Transway is a feasible or a less feasible solution to the bottlenecks does not say anything about whether Delta Transway is a better or worse solution to the bottlenecks than other systems or solutions are. This study only takes into account Delta Transway, and not its alternatives.
3 Bottlenecks for freight transport

3.1 Introduction
As explained in the first chapter, the focus in this report will be on freight transport. To be able to define the feasibility of Delta Transway for freight transport it is necessary to know at which locations in the Netherlands a significant part of the freight transport faces structural congestion on national and regional roads. ‘Structural’ refers to congestion that is a result of a lack of capacity, so congestion that occurs practically every working day on the same time, contrary to congestion which results from incidents. The focus is on both national and regional bottlenecks. When the term bottleneck is used, it refers to parts of the road infrastructure where the road capacity is not sufficient to cope with the traffic, which results in congestion during peak hours on working days. Before the bottlenecks themselves are described, a comparison is made on the different ways of measuring bottlenecks. This was done because it turned out that different authorities use different methods. The comparison of the used methods can be found in section 3.3. Finally the national bottlenecks are described in section 3.4 and the regional bottlenecks in section 3.5.

3.2 Measuring freight transport
Figure 3-1 shows the development of traffic during an average working day on national roads in the Netherlands. The yellow line represents cars and motorcycles (numbers on the left vertical axis), the red line trucks and buses (numbers on the right vertical axis) and the green line the total traffic intensity. The graph shows the difference of staggering of intensities between trucks and cars. Trucks tend to avoid the morning rush hour and do not have strong peak hours as cars have. These intensities provide a clear picture of the amount of freight transport and how it is staggered during the day. Next to these intensities, other indicators are interesting to use, because intensity itself does not indicate whether congestion occurs which leads to a bottleneck. To find these bottlenecks for freight transport, different ways to measure can be used. The most common ways are described and compared below.

Intensity
Rijkswaterstaat and provinces often monitor intensities on roads by simply counting the vehicles per hour passing a certain location. This information is, for this research, only useful when it is combined with information on capacity (I/C-ratio, see below). Intensity itself is not a problem, only when the infrastructure capacity is not sufficient to cope with the intensity, structural congestion will occur. When the term ‘structural congestion’ is used, it refers to the congestion that is a result from lack of capacity, so congestion that occurs practically every working day on the same time, contrary to congestion as a result of incidents.

I/C-ratio
This is the ratio of Intensity (I) and Capacity (C) of the road. When the I/C-ratio is < 0.6 during rush hours on working days, no capacity problems will occur. When the I/C-ratio approaches 1, structural congestion is happening (AVV, 2005a). Problematic is that when
I/C-ratios are published, it is often not clear whether the used intensities are working day averages, weekday averages, or rush hour intensities. A weekday average results in a lower I/C-ratio then the use of a working day average. The highest I/C-ratio is reached if the rush hour intensities are used.

Severity of congestion

This measure is used by Rijkswaterstaat to be able to rank road section on the basis of ‘amount of congestion’. Severity of congestion is the product of the average length of a traffic jam on a certain location in kilometres and the duration of the traffic jam. The total severity of congestion for a certain location is the sum of the severity of congestion of the traffic jams taking place within a certain period on that location. (AVV, 2006)

\[ SoC = l_{\text{average}} \cdot t \quad [\text{km min}] \]  \hspace{1cm} \text{(Equation 3.1)}

\( l_{\text{average}} \) is the average length of the individual traffic jam in minutes

\( t \) is the duration of the existence of an individual traffic jam

\[ SoC_{\text{total}} = SoC_1 + SoC_2 + \ldots + SoC_n \quad [\text{km min}] \]  \hspace{1cm} \text{(Equation 3.2)}

\( SoC_{\text{total}} \) is the sum of the severity of congestion for all traffic jams \( SoC_1 \) to \( SoC_n \), if \( n \) traffic jams occur on a certain road section over a certain period of time.

Lost vehicle hours

To calculate the total of lost vehicle hours, all the extra time that vehicles spend on a certain road section as a result of congestion (or driving under a certain speed level) is added (AVV 2006). This can be calculated separately for the different types of vehicles.
Economic losses for freight transport as a result of congestion

In 2004, EVO and TLN started publishing a list of the national road sections where congestion contributes most to the losses for freight transport. Since then they publish an update of this list every 6 months under the name of “Economische wegwijzer” (Steijn, Rheenen, 2004). The reason for this publication is the attention these organisations want to draw to the economic costs of congestion for freight transport. The top 20 of the list differs from the top 20 of ‘congestion severity’ because some roads have relatively more freight transport than others, and following the method of ‘economic losses’, these roads are listed higher. The method of calculating the economic losses starts with the congestion severity per road section, calculated by AVV as shown in equation 3.1 and 3.2. These figures are multiplied by the number of trucks on the different road sections. It results in a list of sections which are prioritized. Then estimates made by the Ministry of Transport, Public Works and Water Management for the Nota Mobiliteit are used to estimate the total costs of congestion. In this estimate, the unreliability of travel times and the costs for ‘evading behaviour’ (choosing other routes or times) are included and the extra inventory costs and the costs of logistic adaptations excluded. These estimated costs are then divided over the road sections according to the ranking of the sections. This method includes the assumption that all freight transport is equally important. It is however debatable whether this is correct. For instance, with increasing delay, perishable goods loose value faster than other kinds of goods.

Ratio travel time during rush hour compared to the free flow travel time

This ratio compares the travel time during the busiest hours with the free flow travel time. If this ratio is 1, the travel time is the same for both moments. If the ratio is 2, the actual travel time is twice the free flow travel time.

3.3 Comparison of methods to measure freight transport bottlenecks

Table 3-1 shows the differences between the ways to express the bottlenecks for freight transport in a schematic way. In de most left column, the variables that are part of the calculation methods to measure bottlenecks for freight transport are listed. These variables will be described below.

Number of vehicles

With the help of detection loops it is possible to count every single vehicle passing a certain point.

Types of vehicles

When single vehicles are counted, it is possible to distinguish between cars and trucks, because of the different distance between the wheels. This difference in distance results in time differences between the passing of the detection loops by the wheels.

Capacity of the road

Only when the I/C-ratio is calculated, the capacity of the road is used in the calculation. This capacity is the maximum number of vehicles that can pass per hour without causing congestion. The number of vehicles is then often expressed in pae (in Dutch: personenauto equivalent), which is the equivalent of 1 car; a truck is equivalent to 2 or 3 pae.
Time unit
All the outputs of the methods to express bottlenecks for freight transport are expressed in a
time unit: per hour, per day, or per year. Intensity for instance can be expressed in the
average number of vehicles per day. Often weekdays or working days are used. For working
days Saturday and Sunday are not included, which leads to higher average intensities.

Duration of congestion
The duration of congestion does not include the individual cars. It can be seen as the time
between the first moment congestion is reported and the moment the end of congestion is
reported. Congestion is when the speed on national roads drops below 50 km/h for at least 2
kilometres.

Length of the traffic jam
The length of a traffic jam can for instance be defined by measuring the speed of vehicles
passing as certain point. Especially on highways it is clear that if the speed drops below 50
kilometres per hour, ‘something is wrong’.

Frequency of congestion
Frequency of congestion is taken into account to calculate the severity of congestion.

Free flow speed and the travel time
The free flow speed is usually equal to the maximum speed allowed to drive. The free flow
speed leads to a ‘free flow travel time’ that can be compared with actual travel time, which
results in the travel time/free flow ratio.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intensity</th>
<th>I/C-ratio</th>
<th>Total severity of congestion</th>
<th>Economic losses for freight transport sector</th>
<th>Lost vehicle hours</th>
<th>Travel time/free flow ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of vehicles</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Types of vehicles</td>
<td>+/*</td>
<td>+/*</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Capacity of the road</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Time</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Duration of traffic jam</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Length of traffic jam</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Value of time</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Free flow speed</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Actual speed</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Distance</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

+ = variable is used
* = variable is not used
+/ = sometimes a distinction between cars and trucks is made

The table gives an interesting overview of differences. Intensity takes into account the
number of vehicles and sometimes also the type of vehicle expressed in a certain unit of
time, often working days or weekdays, while the I/C-ratio adds the information of capacity
to it. Therefore an I/C-ratio does tell more about the chance on a bottleneck, because high
intensities alone are not a problem, only if the capacity lacks to cope with.
The total severity of congestion does not take into account number or the types of vehicles; it looks at duration, length and frequency of the traffic jam as a whole. A disadvantage is that it is difficult to measure, because it needs to be defined where exactly the traffic jam starts and ends. EVO and TLN involve the individual vehicle again in the calculation of the economic losses by multiplying the total severity of congestion by the number of trucks because they are interested in freight transport especially. Also the Value of Time is included in the calculation, to make it possible to express the losses of time for freight transporters in euros. The lost vehicle hours and the travel time/free flow ratio are more focused on the user and the extra time the user has to spend due to delays. Lost vehicle hours are the extra hours spend by vehicles on the road. Travel time/free flow ratio is less focused on how many cars are impeded and for how long; it only takes into account the difference in speed and the result of this difference on the travel time.

**Conclusion**

Considering these methods to measure bottlenecks for freight transport, the indicator ‘the economic loss for freight transport’ seems to be most useful for this study, because it focuses on freight transport (it makes a distinction between types of vehicles) and takes into account the consequences (losses) for the transport sector. The total severity of congestion does not take into account freight transport and is therefore less suitable. Lost vehicle hours are an appropriate alternative, but only if a difference is made between trucks and cars in the used intensities. If none of the calculations above can be made because of lack of data (for provincial roads this is often the case), the I/C-ratio and the rush hour/free flow travel time ratio can be calculated. These methods however do not give information about how many road users were influenced by the congestion or the duration of the congestion. One can only assume that the delay (in case of travel time/free flow ratio) causes congestion that affects a lot of vehicles or that the high I/C-ratio leads to congestion that affects a lot of vehicles. Intensity alone does not give enough information on bottlenecks, because high intensities itself are not a problem, only when there is a lack of capacity to cope with the intensities.
3.4 National bottlenecks

The AVV Transport Research Centre monitors the traffic intensities on the Dutch national roads. This data is used by EVO and TLN to calculate the economic losses for freight transporters as explained in the previous section. Table 3-2 shows the 20 road sections where congestion results in the greatest losses for freight transport. Extra indirect costs, for instance as a result of delayed production processes and extra inventory costs are not taken into account. More background information on the way these figures are calculated is given in the previous section. During the last couple years some bottlenecks have become more important (higher ranking than before) and other have become less important (lower ranking than before) but which bottlenecks are in the list stays more or less stable. The expectation is that the bottlenecks in this table will still be bottlenecks in the coming years, if no measures are taken.

Table 3-2 Congestion top 20, based on economic losses for freight transport (2003-2005) (TLN)

<table>
<thead>
<tr>
<th>Order</th>
<th>Road number</th>
<th>Province</th>
<th>Specification road section</th>
<th>Loss (million euros)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2003</td>
</tr>
<tr>
<td>1</td>
<td>A2</td>
<td>UT</td>
<td>Holendrecht - Oudenrijn</td>
<td>24</td>
</tr>
<tr>
<td>2</td>
<td>A1</td>
<td>NH</td>
<td>Diemen - Eemnes</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>A28</td>
<td>UT</td>
<td>Knooppunt Hoevelaken</td>
<td>21</td>
</tr>
<tr>
<td>4</td>
<td>A27</td>
<td>NB/ZH/UT</td>
<td>Breda - Utrecht</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>A12</td>
<td>ZH/UT</td>
<td>Gouda - Oudenrijn</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>A13</td>
<td>ZH</td>
<td>Delft - Kleinpolderplein</td>
<td>12</td>
</tr>
<tr>
<td>7</td>
<td>A2</td>
<td>GE/NB</td>
<td>Zaltbommel - Den Bosch</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>A4</td>
<td>ZH</td>
<td>Burgerveen - Leiden</td>
<td>14</td>
</tr>
<tr>
<td>9</td>
<td>A2</td>
<td>UT</td>
<td>Oudenrijn - Everdingen</td>
<td>26</td>
</tr>
<tr>
<td>10</td>
<td>A20</td>
<td>ZH</td>
<td>Knooppunt Kleinpolderplein</td>
<td>16</td>
</tr>
<tr>
<td>11</td>
<td>A10</td>
<td>NH</td>
<td>Knooppunt De nieuwe Meer</td>
<td>12</td>
</tr>
<tr>
<td>12</td>
<td>A50</td>
<td>GE</td>
<td>Ewijk - Grijsoord</td>
<td>8</td>
</tr>
<tr>
<td>13</td>
<td>A10</td>
<td>NH</td>
<td>Coentunnel</td>
<td>13</td>
</tr>
<tr>
<td>14</td>
<td>A15</td>
<td>ZH</td>
<td>Benelux - Vaanplein</td>
<td>7</td>
</tr>
<tr>
<td>15</td>
<td>A16</td>
<td>ZH/NB</td>
<td>Rotterdam - Antwerpen</td>
<td>21</td>
</tr>
<tr>
<td>16</td>
<td>A9</td>
<td>NH</td>
<td>Haarlem - Badhoevedorp</td>
<td>9</td>
</tr>
<tr>
<td>17</td>
<td>A12</td>
<td>UT</td>
<td>Lunetten - Veenendaal</td>
<td>11</td>
</tr>
<tr>
<td>18</td>
<td>A1</td>
<td>GE</td>
<td>Apeldoorn - Deventer</td>
<td>5</td>
</tr>
<tr>
<td>19</td>
<td>A20</td>
<td>ZH</td>
<td>Gouda - Tergregtsteplein</td>
<td>-</td>
</tr>
<tr>
<td>20</td>
<td>A27</td>
<td>UT</td>
<td>Hilversum - Utrecht</td>
<td>3</td>
</tr>
</tbody>
</table>

The road sections in Table 3-2 can be found in the provinces Noord-Holland (NH), Zuid-Holland (ZH), Utrecht (UT), Noord-Brabant (NB) and some in Gelderland (GE). In these provinces, the economic losses for freight transporters as a result of congestion are the highest. The regional situation of these provinces will be analysed in the next section.

3.5 Regional bottlenecks

For the bottlenecks on regional roads, no economic analysis is available. To identify these bottlenecks, figures about freight transport are needed, which were obtained from provinces, the road authorities of regional (also called provincial) roads. Unfortunately these data are not always gathered in the same way, and calculations are based on different input. Think for instance of ways to measure intensity: during peak hours, the average intensity per day
or the average intensity during a working day. Because of these kinds of differences it is very hard to compare the situations of provinces.

To cope with this problem, the provinces are analysed separately, no comparison is made between provinces, and two different aspects are analysed, which are chosen in such a way that for every province at least one aspect can be analysed with the available data.

The following two aspects are analysed:
- The I/C-ratio
- The number of trucks (intensity)

The I/C-ratio gives information about where capacity lacks and the number of trucks shows the places where a lot of freight transport passes. In general, if the I/C-ratio on a specific road section is > 0.6 it is an interesting section to take a closer look at (If the I/C-ratio is below 0.6, there is no capacity problem (AVV, 2005a)). If also the number of trucks is more than 4000 per 24-hours, it is expected that freight transport will face economic losses. If road sections with less than 4000 trucks per 24-hours would also be taken into account, too many sections would need to be investigated in this research. For instance for the province Utrecht: more than 20 bottlenecks would have to be investigated if ‘more than 3000 trucks per 24-hours would be the limit. It seems that 4000 trucks is a suitable boundary to select the bottlenecks for freight transport.

To conclude: two conditions have to be met to be in the list of bottlenecks for freight transport:
- The I/C-ratio has to be > 0.6
- The intensity has to be > 4000

Below the road sections that met the criteria as described above are analysed per province. Only the provinces that can be seen as the provinces with the highest economic losses as follows from the previous section are taken into account.

**Zuid-Holland**

For Zuid-Holland, the same figures that are used for the “Kwaliteitsnetwerk Goederenvervoer Randstad” (GOVERA, 2006) are used. In appendix B the road sections with more than 4000 trucks per 24-hours are shown in table. In appendix C the bottlenecks are shown on a map. The crossed out sections (N209, N213) are in the ‘kwaliteitsnetwerk of GOVERA’ but nevertheless are not defined as bottlenecks for freight transport in this report, because the I/C-ratio is smaller than 0.6, also during rush hours. The N207, N211, N218, N466 and N470 are defined as roads with bottlenecks for freight transport.

**Noord-Holland**

In appendix B the road section on provincial level with more than 4000 trucks per day are shown in a table, in appendix C they are shown on a map. The figures for the I/C-ratios can not be compared with the other provinces, because for the intensity, the average day-intensity is used, while the intensity during rush hours will be higher. This method results in relatively low I/C-ratios. The reason for showing them anyway is to compare the road sections within Noord-Holland. Especially the N201 and the N242 have both high truck intensities and ‘relatively high’ I/C-ratios.

**Utrecht**

In appendix B the road sections with more than 4000 trucks per hour are shown, these are concentrated on 4 roads. From this province, no figures on I/C-ratios are available. The N201, the N210, the N230 and the N408 have the highest freight intensities.


**Noord-Brabant**

Appendix B shows the road sections with more than 4000 trucks per 24-hours. From these sections, only the road to the Efteling has an I/C-ratio that is less than 0.6 and has therefore no structural congestion problems.

Seven of the ten road sections on which more than 4000 trucks are counted, are part of the N279. Next to the N279, the N284 and the N329 have high freight intensities.

**Gelderland**

Only the A325 and N325 have truck intensities of more than 4000 per 24-hours on a working day. No useful figures of I/C-ratios of Gelderland or Lost vehicle hours are available for analysis. The figures of Gelderland can be found in appendix B.
4 Projects for Delta Transway

4.1 Introduction

Whether Delta Transway is a suitable solution for specific bottlenecks is hard to define in general terms because of the importance of location dependent factors. However, a lot of factors can be identified that are important.

Besides this section, chapter 4 contains four sections. In section 4.2, the lessons learned from joint use of dedicated lanes are described. This section contains several case studies. In section 4.3, the lessons that can be learned from the implementation of the HOV-lane in the Netherlands are explained. This case is analysed from a more organisational point of view. Section 4.4 describes an actor analysis that is made on the possible implementation of Delta Transway. Finally in section 4.5 a case for the case study will be chosen. Several bottlenecks have been analysed, but only one can be selected for the case study.

4.2 Lessons learned from joint use of dedicated lanes

Delta Transway makes use of dedicated lanes. One of the possible ways to implement Delta Transway is to use the existing bus infrastructure. This would result in joint use of bus lanes by trucks. In the Netherlands, some experience is already available on this topic. This chapter will describe this experience and draw some conclusions that might be useful for the implementation of Delta Transway.

In May 2006, the province Noord-Holland announced to start an investigation on the joint use of bus lanes for regular services by other types of transport, for instance special transport of disabled or elderly people, but also for freight transport (Noord-Holland, province, 2006). For the joint use by freight transport the research focuses on the Zuidtangent, a service on a dedicated bus lane between Amsterdam, Schipol and Haarlem with regular service. Noord-Holland is not the first province that investigates joint use of bus lanes by freight transport. In recent years, two evaluative studies are performed on the joint use of dedicated lanes by buses and trucks, one study on the N408 near Nieuwegein and one on the A16 and A20 near Rotterdam.

Next to these lanes, from the auction in Naaldwijk a dedicated lane for buses and trucks is situated in the direction of Rotterdam. No evaluation study is done on these lanes, so is will only described shortly.

First the results of the pilot on the N408 will be described; second the results of the evaluation on the A16/A20 will be described. The focus is on the lessons that can be learned in the light of this feasibility study on Delta Transway. Last the situation on the N213 will be described.
4.2.1 Pilot N408

The Utrecht province started a pilot project in 2001 in which the bus lane on the N408, in the past only accessible for regular bus services, became also accessible for freight transport. This pilot was converted into a permanent situation in June 2003 (Visbeek et al., 2003).

The goal of the pilot was to analyse whether utilization of residual capacity by freight transport would have a positive effect on the traffic flow of freight transport. The use of the dedicated bus lane only by buses seemed to be a very inefficient use of the capacity of the road. However, the use of the dedicated lane by freight transport was not allowed to cause too much delay for the busses. The location for the pilot is shown in Figure 4-1.

Some conclusions, related to targets and boundaries, are drawn by Visbeek et al. in 2003: A boundary that was set beforehand was the maximum delay for buses. 80% of the delays were not allowed to exceed 1 minute. The expected delay, modelled from the situation before the pilot was 41 seconds per trip. The amount of data on the delays during the pilot was too small but the conclusion is that the boundary is exceeded. However, because of a new layout of the crossing, that was not yet ready when the data was gathered, it is expected the delay is now within the boundary that was set. Furthermore, no complaints are submitted by bus users.

The expectation was that the pilot would have positive effects on both the trucks on the dedicated lanes and the cars at the ‘regular’ lanes. The target was set at a travel time improvement for the trucks of 25% during both morning and evening peak hours. This target is not realised on all sections, the improvements in travel time differ between 15 and 50%. For the cars, no significant improvement in traffic circulation was recorded, but also no significant setback.

Figure 4-1 Overview of bus lane (5 sections) N408 (Visbeek et al., 2003)
Further remarks that can be made on the new situation:

- No unsafe situations were reported during the pilot
- The drivers of both truck and cars perceive the situation as safer
- The drivers of both truck and cars perceive the circulation for both cars and trucks as improved

Because of the positive perception of road users, the province has finally decided to convert the pilot into a permanent situation, which is still the case nowadays.

4.2.2 A16 and A20

Since 1993 a dedicated lane along the A16 is available for trucks and buses. In 1995 another lane, this time even separated physically from the other lanes by a crash barrier, was constructed along the A20. The precise locations of these dedicated lanes are shown in Figure 4-2. These dedicated lanes were constructed, but were never evaluated until 2004, when Rijkswaterstaat (DHV, 2004) needed the evaluation to gain more insight in the possibilities and constraints of dedicated lanes. The conclusions (that are relevant for this study) are described below.

Figure 4-2 Dedicated lanes along A16 and A20 (Dedicated lanes in red) (Source: DHV, 2004)
It turns out that 75% of the vehicles longer than 5 meter (trucks and cars with trailer) on the A16 make use of the dedicated lane, equal to an average of 6500 trucks per 24-hours on a working day. On the A20 this is 6750, only a bit more.

Travel time advantages on the dedicated lanes are not always measured, because the maximum speed is determined by the slowest truck (overtaking is not possible). On the A16, if there is no congestion on the ‘regular’ road, no travel time savings are gained by the users of the dedicated lanes. If there is congestion on the ‘regular’ road, the average travel time saving for the users of the dedicated lanes is 3.5 minutes.

The number of accidents has risen a bit, but also has the vehicle intensities, the weighted average is about the same. The number of accidents in which a truck was involved has decreased, and the distribution of these accidents over the different types of accidents is the same as elsewhere in Zuid-Holland. A last point to mention on the accidents is that almost all the accidents on the dedicated lane on the A16 that were reported were on the part where no hard shoulder is available.

Furthermore a remark can be made on the efficiency of the dedicated lanes, they would be more effective if they are connected to each other; the majority of trucks on the dedicated lane on the A20 comes from the A16 and has to filter in with the other traffic at the end of the A16, has to change lane at the begin of the dedicated lane on the A20, and has to filter in with the other traffic at the end again, which takes time and is not convenient.

4.2.3 N213

On the situation of the N213 no studies could be found by the author. All the information mentioned is gained from an interview by telephone with a civil servant from Stadsgewest Haaglanden, Peter Dubbeling. The dedicated lane is situated along the N213 from the crossing with the Middel Broekweg southwards to the crossing with the N223. From the moment the lane was constructed, it is accessible for both buses and trucks. There was never a reason to evaluate the situation, no complaints or problems were mentioned about the joint use of this lane. Figure 4-3 shows the location of the N213.

![Figure 4-3 N213 dedicated lane for buses and trucks](image)
4.2.4 Lessons learned

It would be interesting to compare these studies and see whether joint conclusions can be drawn. Unfortunately the points of departure are different. The N408 used to be a dedicated bus lane, and the study compares the new situation to the old one. The A16/A20 is already from the start a dedicated lane for joint use for buses and trucks, and the focus of the evaluation is on the use and safety of the dedicated lanes. For the N213 there is no evaluation available. It will be clear that to compare these cases is not convenient. Even the travel time savings for the dedicated lanes, 15-50% for the N408 and 3.5 minutes for the A16 can not be compared easily. However, some ‘lessons’ can be learned from these studies which can be relevant for Delta Transway. These lessons are described below:

- Real travel time savings are likely to only take place during rush hours and even then maybe not always and the impact on the car circulation might not be that significant. To handle with these problems, an analysis of the specific situation should be made.
- The situation of a dedicated lane with buses and trucks does, in general, not lead to unsafe situations
- The absence of a hard shoulder (in Dutch: vluchtstrook) has a negative effect on the safety. It is recommended not to use hard shoulders to implement Delta Transway on, but dedicated lanes.
- The perceived advantages might be bigger than the real advantages. The question is whether perceived advantages are found important by policy makers. Perceived advantages can not be taken into account when a cost-benefit analysis is made.
- Slow trucks (trucks that drive less than 80 kilometres per hour) on dedicated lanes have a negative effect on the (saved) travel time. Capacity planning has to deal with this problem.
- The longer the dedicated lanes, the more effective. Depending on the situation it should be considered whether the chosen section is long enough to gain significant travel time savings.
- If Delta Transway is implemented on a former bus lane, it is necessary to define in advance how much delay is allowed for busses compared to the initial situation. It might be necessary to have extra adaptations made to the design of the situation to ensure only limited delay.

4.3 Lessons learned from HOV-lane in the Netherlands

Different from the lessons from the joint use of dedicated lanes, the focus this time is not technical, but more managerial or organisational. It is not about the saved travel times and whether they were sufficient, it is about the way of dealing with the different stakeholders. The HOV-lane (HOV = High Occupancy Vehicle) is chosen because it was also an innovative infrastructure project.

The first and only HOV-lane in the Europe was opened in October 1993. It was constructed between the existing lanes between Diemen and intersection Muiderberg. Only cars with 3 or more passengers were allowed to use this extra lane which is also a ‘wisslstrook’ (it is
used by turns for both directions). This HOV-lane concept was copied from the United States where it is applied often. (NOS – website)

One year after the opening of the lane, the former minister of Transport, Tjerk Westerterp used the HOV lane alone and took the case to court as a test case. The court decided that the law is not familiar with the term ‘HOV-user’ (carpooler) and the principle of equality was affected. This was the end of the HOV lane which is now open for all traffic, by turn for the different directions.

In 1995, Orsel published an article in the TUDelta, an independent magazine of the University of Technology Delft, in which he analyses ‘what went wrong’ with the HOV-lane in the Netherlands. Some reasons for failure mentioned in this article are listed below:

- The figures that were used to forecast the demand by users were flattered
- Assumptions that were made in the USA were copied for the Netherlands, which was not always possible
- After the negative publicity in the media, the project team did not want to defend the benefits of the new concept, so finally only negative information was published
- The process of creating commitment by local authorities and companies was started too late
- Also in national politics, less commitment was created
- No research was done on the juridical feasibility of the HOV lane, it turned out that the term ‘HOV-user was not known by Dutch law, which results in a judgement by Court that the principle of equality was effected by the HOV-lane.

These failures can be translated into conditions for successful implementation of innovative infrastructure projects:

- Make sure the data and methods used for analysis are relevant for the situation and accurate. If stakeholders agree on these choices there will be more commitment on the results of analysis.
- Good communication to the press can prevent that only negative information is published. With good communication is meant that time and effort is spend on providing the right information.
- Spend a lot of time in creating commitment, not only for the actual decision makers, but especially with stakeholders that are influenced by the project. More on stakeholders will be mentioned in the following section.
- Be sure the juridical aspects are analysed as well. The system excludes users from using a certain lane which needs a juridical base. It could for instance be necessary that a juridical decision on road use (in Dutch: verkeersbesluit) is taken.

4.4 Actors and stakeholders

An innovative transport concept as Delta Transway is not only complex because of technology that is not yet used in such a way, but also because of the impact it has on a lot of people and organisations. Because of the interests of different stakeholders are being influenced by the project, the stakeholders will act in a certain way to safeguard their interests. Stakeholders are persons or (representatives) of organisations whose interests are or will be influenced by the activities undertaken by actors (De Bruijn, Ten Heuvelhof, et al., 2002). If a stakeholder plays an active role, he can be seen as an actor, which is an individual or group that plays an important role within a problem situation.

Because someone is a stakeholder (his interests are influence), he can become an actor in a (decision making) process. In this section, the general term actor is used because it is assumed that all the people and organisations identified will play a role in the process of implementation of Delta Transway. To make this process successful, it is important to
analyse the perceptions, goals and interests of the actors and to determine how to deal with it. Smits (2002) analysed the perceptions, goals and objectives of the actors for Delta Transway and advised ARCADIS to create a consortium and a ‘steering committee’ with actors. This steering committee should be involved in the decision making process in an early stage already. The focus in this section will be on the description on the actors which is ARCADIS dependent on for the successful implementation of Delta Transway. To determine which actors are critical in the process, the following steps will be followed:

- listing and categorising the actors
- analysing the perceptions, goals and interests of the actors
- analysing the dependency on the actors

Below a list of all the (potential) actors:

**Governmental**:

- Ministry of Transport, Public Works and Water Management
- Ministry of Housing, Spatial planning and the Environment
- Province and cooperative bodies in which provinces participate
- Local authorities (communities as well as cooperative bodies in which they participate)

**Companies (public and private)**:

- Trucking companies and branch organisations (TLN, EVO)
- Public Transport companies
- Developers of hardware and software for Delta Transway
- ‘Mainport’ authorities
- Investment companies

**Organisations in social sphere**

- Environmental organisations
- Residents of potential locations of Delta Transway

This list is a very general one and should be made more specific when looking at potential locations where Delta Transway could be implemented.

The next step is to analyse the perceptions, goals and interests of the actors. Actors have perceptions, which is the view that they have on the situation. Because of the complexity of the situation, different problem perceptions are possible. A local government can see Delta Transway as extra lanes with more trucks that cause noise and emissions, while the concerned province can see it as the solution to make an industrial estate attractive for companies to settle. These perceptions are related to the goals of the actors. “The goals define which situation the actors want to reach: which change do they want to establish or what do they want to preserve?” By asking the question: “Why does this actor aspire this goal?” the interests of the actors can be determined. They are usually less related to a specific situation but can be applied more generally (Enserink et al., 2002). Examples of interests are ‘a clean environment’ or ‘maximum profit’. The description of the actors and their perceptions, goals and interests can be found in appendix 0.

To analyse which actors are critical in the process of implementing Delta Transway, it is necessary to analyse whether the actor is replaceable and or important. The important and not replaceable actors can be called the ‘critical’ actors, which can be seen in Table 4-1, with the critical actors in the right upper corner. For Delta Transway the Ministry of Transport,
Public Works and Water Management, the province and the local authorities are critical because of their role in the decision making as well as the financial support that is needed to implement Delta Transway. Also the mainport authorities are identified as of high importance. They have a lot of lobbying power and have money available, but are not replaceable. For instance, if Delta Transway is implemented on the A15 between the Maasvlakte and the Vaanplein, the Port of Rotterdam authority is certainly not replaceable and is an actor that can influence the decision making. Trucking companies and their branch organisations are not replaceable because of the big influence of the branch organisations. They have significant lobby possibilities and the trucking companies are the potential users of Delta Transway. There are a lot of trucking companies so they seem replaceable, but on a certain location, the transport is often dominated by big companies. They are for that certain location not easy replaceable.

Table 4-1 Importance and replaceability of actors

<table>
<thead>
<tr>
<th>Low importance</th>
<th>High importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministry of Housing, Spatial planning and the Environment</td>
<td>Ministry of Transport, Public Works and Water Management</td>
</tr>
<tr>
<td>Public Transport company</td>
<td>Province and cooperative bodies in which provinces participate</td>
</tr>
<tr>
<td>Environmental organisations</td>
<td>Local authorities</td>
</tr>
<tr>
<td></td>
<td>‘Mainport’ authorities</td>
</tr>
<tr>
<td></td>
<td>Trucking companies and branch organisations</td>
</tr>
<tr>
<td></td>
<td>Residents</td>
</tr>
<tr>
<td>Developers of hardware and software for Delta Transway</td>
<td></td>
</tr>
<tr>
<td>Investment companies</td>
<td></td>
</tr>
</tbody>
</table>

The residents can be important during a decision making process if they have different interests, for instance because they do not agree on the development of extra infrastructure near their village. The other actors: The Ministry of Housing, Spatial Planning and the Environment, the public transport company, the developers of hardware and software and the investment companies are less important. The development of Delta Transway as well as infrastructure does not directly influence their main interests. The environmental organisations are placed in the box of low importance. The reason is that the infrastructure for Delta Transway is added to existing infrastructure, which does not make it a very controversial project, contrasting to, for instance, a new road that crosses valuable nature on a place where no road was before.
Table 4-2 Critical and non-critical actors

<table>
<thead>
<tr>
<th>Equal perceptions, objectives and goals</th>
<th>Dedicated actors</th>
<th>Non-dedicated actors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical actors</td>
<td>Ministry of Transport, Public Works and Water Management Trucking companies and branch organisations Province and cooperative bodies in which provinces participate Local authorities ‘Mainport’ authorities Residents</td>
<td>Public Transport company</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contrasting perceptions, objectives and goals</th>
<th>Dedicated actors</th>
<th>Non-dedicated actors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Province and cooperative bodies in which provinces participate Local authorities Residents</td>
<td>Public Transport company Environmental organisations</td>
<td></td>
</tr>
</tbody>
</table>

The actors in the upper right corner of Table 4-1, which have ‘low replaceability’ and are of ‘high importance’, are the critical actors. These actors are in Table 4-2 divided in dedicated or non-dedicated and in equal perceptions, objectives and goals, and contrasting perceptions, objectives and goals. The perceptions of the actors can be found in appendix 0. A remark has to be made on the provinces, local authorities and residents. Whether they have equal or contrasting perceptions, depends on the specific situation. The non-dedicated actors are the ones which interest are not directly related to a potential implementation of Delta Transway.

The division in ‘blocks’ of different kinds of actors gives insight in the different types of actors. For a successful implementation of Delta Transway it is necessary to approach these different kinds of actors in different ways. The actors in the two upper left corners are potential allies in the project. From this group the critical actors are of course the most
important ones to create commitment with. It is advisable to discuss the plans already in an early stage with these actors. For the actors in the two bottom left corners, it is useful to think of possibilities to change the project in such a way that the goals of the critical actors become less contrasting. Of course, if the project changes it has to be in such a way that the former actors with equal perceptions still have equal perceptions. An example is to make Delta Transway only accessible for clean trucks, which might make the concept more interesting in the light of environmental-friendly policy.

The non-dedicated non-critical actors with equal perceptions are actors that do not need attention in the first place. Later in the project, however, they can be interesting allies. It is advisable to elaborate this analysis if more specific details on the location and the location dependent actors (for instance local authorities) are known.

4.5 Selection of case for case study

In chapter 3 the bottlenecks for freight transport in the Netherlands have been analysed. A result of this analysis is a list of bottlenecks. In chapter 5, one of these bottlenecks is elaborated upon in a case study. Which bottleneck to choose for the case study will be described in this section. The optimal method would be to analyse all the bottlenecks by using the success criteria formulated. However, to do this, detailed information on all the bottlenecks is needed that is not directly available. Therefore an extra criterion is added that first will be applied on the bottlenecks.

This extra criterion is not a success factor; it follows from the method that will be used in chapter 5, the case study. For a case study it is important that the case is relevant, because a lot of information is needed on the situation. Trying to do a case study on a bottleneck that will be solved in the near future, or a bottleneck for which there is no attention at all is difficult because of a lack of information. The criteria are the following:

- The bottleneck will not be solved in the near future (near future: final decisions have already been taken on measures to solve the bottlenecks)
- There needs to be some attention for the bottlenecks by authorities to solve the bottleneck in the coming years.

If these criteria are fulfilled it will probably possible to gain information for the case study. On the base of these criteria, Table 4-3 shows the bottlenecks that are not selected.

<table>
<thead>
<tr>
<th>National bottlenecks</th>
<th>Regional bottlenecks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 Diemen- Eemnes</td>
<td>N207</td>
</tr>
<tr>
<td>A1 Apeldoorn- Deventer</td>
<td>N210</td>
</tr>
<tr>
<td>A4 Burgerveen- Leiden</td>
<td>N211</td>
</tr>
<tr>
<td>A9 Haarlem- Badhoevedorp</td>
<td>N230</td>
</tr>
<tr>
<td>A10 Kn. De nieuwe Meer</td>
<td>N242</td>
</tr>
<tr>
<td>A10 Coentunnel</td>
<td>N466</td>
</tr>
<tr>
<td>A12 Gouda- Oudemrijn</td>
<td>N470</td>
</tr>
<tr>
<td>A12 Lunetten- Veenendaal</td>
<td></td>
</tr>
<tr>
<td>A27 Hilversum- Utrecht</td>
<td></td>
</tr>
<tr>
<td>A28 Knooppunt Hoevelaken</td>
<td></td>
</tr>
</tbody>
</table>

At the national level, the bottleneck on the A1 Diemen-Eemnes is in the near future solved by use of the hard shoulder during rush hours, extension of the ‘wisselstrook’, ‘toeritdoserings’ and upgrading the Vecht bridge. A solution for the A1 Apeldoorn-Deventer is not planned before 2020.
The bottlenecks on the A4 and A9 are solved in the near future. For the bottleneck on the A4 extra lanes are constructed, for the bottleneck on the A9 the intersection at Badhoevedorp is changed.

The bottleneck on the A10 Knooppunt De Nieuwe Meer and the A27 Hilversum-Utrecht is not mentioned in the MIT (Meerjarenprogramma Infrastructuur en Transport), they have less priority to be solved than other bottlenecks. This applies also for the A28 Knooppunt Hoevelaken.

At the A10, the Coentunnel II will be realised in the coming years, at the moment several consortia are bidding on the project. This will solve the bottleneck A10 Coentunnel. The bottlenecks in the A12 near Utrecht will be solved by smarter use of the existing capacity (In Dutch: benutten).

At the regional level, for the N207 plans for the near future are made to increase safety and circulation. A ‘voorsorteerstrook’ and a roundabout will be constructed. For the N210, N211, N466 and N230, no plans are made to solve the bottlenecks. For the N242, especially the crossings were in the past important bottlenecks. However, these are now under construction, it will become fly-overs. The N470 bottleneck will be solved by a new road that is constructed between Delft, Rotterdam and Zoetermeer.

The remaining bottlenecks, shown in Table 4-4, are possible bottlenecks to use for the case study.

<table>
<thead>
<tr>
<th>National bottlenecks</th>
<th>Regional bottlenecks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2 Holendrecht- Oudenrijn</td>
<td>N201</td>
</tr>
<tr>
<td>A2 Zaltbommel- Den Bosch</td>
<td>N218</td>
</tr>
<tr>
<td>A2 Oudenrijn- Everdingen</td>
<td>N279</td>
</tr>
<tr>
<td>A13 Delft- Kleinpolderplein</td>
<td>N284</td>
</tr>
<tr>
<td>A15 Benelux- Vaanplein</td>
<td>N325</td>
</tr>
<tr>
<td>A16 Rotterdam- Antwerpen</td>
<td>N329</td>
</tr>
<tr>
<td>A20 Knooppunt Kleinpolderplein</td>
<td>N408</td>
</tr>
<tr>
<td>A20 Gouda- Terbregtsteplein</td>
<td></td>
</tr>
<tr>
<td>A27 Breda- Utrechtplein</td>
<td></td>
</tr>
<tr>
<td>A50 Ewijk- Grijsoord</td>
<td></td>
</tr>
</tbody>
</table>

To select one bottleneck that will be analysed further in the next chapter, the criterion of commitment of potential stakeholders is used. To which extent are potential stakeholders interested in plans for Delta Transway and do these plans fit into their interest?

An interview with Harald Bresser of Schiphol, who is concerned with the accessibility of Schiphol and is familiar with the plans for the N201, turned out that Delta Transway does probably not fits into the plans for the N201 because freight transport should be stimulated to use the A9 instead of using the N201. An interview with someone from the Utrecht province made clear that the N408, a dedicated lane for buses and trucks already, is not seen as a bottleneck for freight transport, because freight transport already gets priority by making use of the dedicated lane.

Unfortunately not for all road section interviews with relevant people were possible. Finally the most commitment was found for the N279 for which the province investigates the possibility of upgrading. Very recently, Hezemans (2006) reported on the plans of authorities in Noord-Brabant to investigate the N279 as an alternative of the A2 (see also Figure 4-4). This would imply that the N279 will become a road that has to facilitate a lot of South-Eastbound freight transport. This makes a study on the feasibility of Delta Transway a
relevant contribution to the plans that are being made and that will be made in the future. The number of trucks on the N279 reaches the 6000 trucks per day on the section between the industrial estate “De Brand” and the A2, which is a very high number for a regional road (see also chapter 3). Also on other parts of the N279 relatively high truck intensities are measured, and if the N279 will be developed as an alternative for the A2, these numbers will rise.

“[…] Het aantal auto’s en vrachtwagens op snelwegen in deze regio groeit volgens de prognoses met veertig tot tachtig, of zelfs honderd procent.

Alle overheden zijn er daarom van overtuigd dat er wat moet gebeuren om een verder verkeersinfarct in de regio tegen te gaan. De provincie laat daarom samen met Rijkswaterstaat onderzoeken of een verbreding van de N279, de provinciale weg langs de Zuid-Willemsvaart tussen Den Bosch, Helmond en Asten, soelaas biedt.

Dat is volgens gedeputeerde E. Janse de Jonge een alternatief voor een verbreding van de A2 tussen Eindhoven en Den Bosch. Die uitbouw is volgens hem onmogelijk omdat de snelweg bij Vught niet breder kan worden gemaakt. Daarvoor is er te veel waardevolle natuur langs de weg […]”

Figure 4-4 Fragment Eindhovens Dagblad (Hezemans, 2006)

Concluding, the best indication for commitment by stakeholders was found for the N279 and it will be used for the case study, which is presented in chapter 5. However, the other remaining bottlenecks are still interesting to keep in mind and might be interesting cases for the future.
5 Case study N279: Costs and benefits

To give an idea on the possible costs and benefits of Delta Transway, this chapter describes a case study on the N279. Along this road, Delta Transway is one of the alternatives to cope with the relatively high number of freight transport. Delta Transway is compared to another alternative and the existing situation to give an idea on the costs and benefits, not only absolute but also relatively to another project alternative. This case describes a fictitious situation, in reality no plans are made to implement Delta Transway. However, the N279 and its context provide a relevant case, the upgrading of the N279 from 2x1 lane to 2x2 lanes is a possibility that the Noord-Brabant province investigates. The province investigates the N279 together with Rijkswaterstaat to see if upgrading the N279 is a way of coping with a part of the traffic that is now causing problems on the A2. The best way to analyse the N279 would be to analyse the complete region. This implies the need for an extensive ‘traffic model’. This would however, take much time and effort of specialists in modelling, which is not a possibility for this study. Therefore the choice was made to focus on the N279, despite the expectation that this influences the results significantly. In section 5.1 the context of the N279 is described to give an idea on what is going on in the region and the position of the N279 in it. This context however is not part of the following analysis.

In the second section, the boundaries that are set on this context are explained. In section 5.3 the base case and the project cases will be described. The costs of the project cases are calculated in section 5.4. In section 5.5 the direct effects will be analysed, in section 5.6 the indirect effects. In section 5.7 an overview of the costs and benefits will be given from the social cost-benefit analysis. Section 5.8 analyses the costs and benefits more from the perspective of the investor.

5.1 Context of the N279

The part of the N279 that is analysed is the connection between Den Bosch, via Veghel and Helmond, with the A67. In the future, the N279 could be seen as an alternative route for traffic that now uses the A2 between Den Bosch and Eindhoven. Despite the fact that the region around the N279 will not be part of the analysis (see also section 5.2), the context of the N279 will be described in this section. Reason for this is to give an idea on the function of the road in the region.

Figure 5-1 shows a schematic picture of the region around the N279. It runs from Den Bosch, South-Eastwards, crosses the A50 from Oss to Eindhoven at Veghel, continues to Helmond and crosses the A67. It continues further southwards, but this part is not taken into account in this study. This section continues with a description of several elements that are a part of the context of the N279.

**Eindhoven**

The ring road of Eindhoven misses the North-East link. This results in the situation that traffic from the North, which comes via the A2, has to pass Eindhoven at the west side, or has to cross the city. This leads to an undesirable amount of traffic in the city and congestion on the ring road.
To solve this problems, there is a plan called BOSE (in Dutch: Bereikbaarheid Oostelijk deel van Stadsregio Eindhoven). In Figure 5-1 the plans for this new road are shown in green. However, the shown route is just one of the many alternatives that are investigated at the moment by the Noord-Brabant province and Rijkswaterstaat. The preferred route is shown in appendix D. The Minister of Transport, Public Works and Water Management has promised to pay part of the construction. Problems around the planning of this road are mainly caused because it would cross the Dommelvlei, which is valuable for its nature.

A2
The A2 is a road of national importance that begins in Amsterdam and continues via Utrecht, Den Bosch, Eindhoven and Maastricht to the border with Belgium where it becomes the A25 to Luik/Liège. Between Den Bosch and Eindhoven (as well as on other parts of the A2) the capacity is not sufficient to cope with the traffic. On the short term Rijkswaterstaat will construct rush hour lanes to solve this problem; on the long term plans for extra lanes are made.

In the light of solutions for the A2, the N279 is mentioned as an alternative or additional solution for the capacity problems. The N279 can be upgraded to a national road, for instance with fly-over junctions instead of road level junctions. This is based on the thought that traffic from the North, going southwards, can choose at Den Bosch whether it will take the A2 or the N279. Plans to upgrade the N279 are still in an initial phase.

Industrial areas
The three triangles in Figure 5-1 represent the three important (groups of) industrial areas along the N279. To select the most important areas, the analysis of Incodelta in which a ‘quality network’ is designed is used to determine the important areas. Following the
arguments of this analysis, an industrial estate or a group of industrial areas should be part of the ‘quality network’ if the size of the estate is more than or equal to 30 hectare and realises more than or equal to 2500 truck movements per 24 hours and/or 1400 or more passenger movements. The following (groups of) industrial areas meet these requirements:
- De Brand (Den Bosch)
- De Dubbelen, Oude Haven and Amert (Veghel)
- Hoogeind, Bokhorst, Rietbeemd and BZOB (Helmond)

Because these areas will be the ‘reason’ for a lot of freight transport, it is desirable to have the entry and exit points of Delta Transway near these areas.

5.2 Definition of boundary

Before the effects can be described, it is necessary to define the boundaries of the project and what is taken into account. The larger the area analysed, the more extensive the analysis will have to be. The N279 and its traffic is not an autonomous system, it is part of a regional road network, of which also the A2 and the A50 are important connections. It is therefore useful to include not only the N279 in the analysis, but also the region Den Bosch – Eindhoven. However, there are some reasons to focus on the N279 and let the region out of this analysis. First, including the region would imply the need for extensive models to calculate the effects of the project alternatives. These models have to be made specific for the situation and would take much time and effort. This is not feasible for this research.

Second, the goal of this research is to draw conclusions on the feasibility of Delta Transway. Therefore the most interesting part of this analysis is the comparison of the effects of the two project alternatives of which one will be Delta Transway. This comparison will give insight in the difference between widening the N279 and Delta Transway as will be defined in more detail in section 5.3.

A last reason to not take into account the region around the N279 is that it is too much work to complete within the time and possibilities of this research. However, the most important effects are taken into account. A consequence is that only conclusions on the N279 can be drawn, not on the regional situation.

An important remark has to be made on the use of the name N279. When ‘N279’ is used in this analysis, the part of the N279 between Den Bosch and the A67 is meant, not the complete N279 which continues southwards of the A67.

5.3 Base case and project cases

In this section, the base case and the project cases are described. One of the project cases is Delta Transway, the other project alternative is a project that improves the capacity of the N279 by constructing extra lanes accessible to all road users. According to the OEEI-manual part I, the base case is the best alternative for the project. The project effects are the difference in the project case and the base case. In this case study, 2x2 (upgrading the N279 from 2x1 lane to 2x2 lanes) is the best alternative measure. ‘2x2’ means to lanes in two directions, so in total 4 lanes. However, the choice is made to see 2x2 alternative as a project alternative and to consider the current situation as the base case. Reason for this is the possibility this way of comparing offers. As can be seen in Table 5-1, comparing the base case, which is the current situation, with two project alternatives results in an overview of the total costs and benefits of the project cases. If the base case is 2x2, the project effects which are the differences between the project case and the base case, would only show the differences between the alternatives and not give insight in the costs and benefits of constructing the alternatives. The effects of the alternatives are both expressed relative to the base case and compared with each other.
Table 5-1 Choice base case and project cases

<table>
<thead>
<tr>
<th></th>
<th>Comparison of alternatives possible?</th>
<th>Overview of total costs and benefits of alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case = 2x2</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Project case = Delta Transway</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base case = current situation</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project case 1 = 2x2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project case 2 = Delta Transway</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.3.1 Base case

In this analysis, the base case is the current situation, when no measures are taken to upgrade the N279 to a road that is suitable to cope with (freight) transport. In this situation the priority is on other projects, which are not taken into account in this analysis. The profile shown in Figure 5-2 is the current situation on the N279.

5.3.2 Project case ‘2x2’

The first alternative is to construct extra lanes alongside the existing lanes; instead of 2x1 lanes, the N279 becomes 2x2 lanes. The extra lanes will be constructed at the east side of the road. The new road profile is shown in Figure 5-3.

5.3.3 Project case ‘Delta Transway’

A second possibility is to keep the N279 2x1 lane and construct extra lanes for Delta Transway in both directions. The trucks and buses will have the possibility to choose between the N279 and the Delta Transway lane. The traffic on this lane will get as much priority as possible and this lane guarantees an optimal travel time and reliability between Den Bosch and the A67. The crossings will be level road junctions if they are so at the moment and will be on different level (fly-overs) if they are so at the moment. The new road profile is shown in Figure 5-4. On level road junctions, the traffic of Delta Transway will get as much priority as possible.

Extra investments on road infrastructure level for Delta Transway will be one entry point near the A2 at industrial estate De Brand, one entry- and exit point near the A50 to connect industrial areas De Dubbelen, Oude Haven and Amert as well as possible, one entry- and
exit point to connect industrial areas Hoogeind, Bokhorst, Rietbeemd & BZOB and an exit point near the A67 at interchange ‘Ei van Ommel’.

Figure 5-4 Road profile ‘Delta Transway’

5.4 Costs
This section will give an overview of the costs for the project alternatives. The section is divided into some sub sections. The first sub section describes the method used to estimate the costs. In the second sub section an overview of the cost estimation is given, the different types of costs are explained. The third sub section mentions the uncertainty, the fourth one explains the Net Present Value that is applied on the cost estimations. The last sub section contains the conclusion and some discussion on the costs.

5.4.1 Method
With the help of Gerrit Morren, specialist in cost calculation at ARCADIS, rough estimations on the costs of the construction of the two project alternatives have been made. The figures used to make estimations on construction and maintenance costs are figures that follow from earlier projects carried out by ARCADIS. No manual is available; the figures are a combination of experience in earlier projects and the tacit knowledge of the specialists. This results in a lack of references on the cost estimations.

The same holds for the estimations on the operational costs and the specific investment costs for Delta Transway. These are estimations for an innovative concept, and it is therefore not possible to use information on experience in the past. However, similarities can be drawn with other road pricing systems. Fortunately, Anne Tipp of LogicaCMG who has a lot of experience with designing road pricing systems in Europe was willing to help with these cost estimations.

5.4.2 Costs of project cases
The costs for the project cases can be divided into different categories. The main categories are construction, operational and maintenance costs. Construction costs are all the costs that are made before the system is ready to use, the operational costs which are only relevant for Delta Transway are the costs to keep the system running and the third category includes the costs for maintenance, see also Figure 5-5.

Construction costs
The construction costs can be divided into 6 sub categories. Besides the building costs (2/3 of total construction costs), also real estate costs, engineering costs, other additional costs, investments in Delta Transway and the unforeseen project costs are mentioned. These sub categories will be discussed below.

In the estimation of the costs some assumptions are made. These assumptions influence the outcome of the estimations and are therefore important to mention:

- The costs for adaptations of any systems as lighting systems, traffic regulating machines etc. are not included, as well as costs for soil improvement and VAT costs. However, these costs would not differ significantly for the two project cases.
To be able to construct 2 extra lanes, the road profile has to be expanded with 9 meters.

Because of the difference in extra space needed (9 meters), constructions (for instance fly-overs) have to be renewed.

Around Helmond, the N279 has to be re-routed for 3 kilometres.

Crossings of other infrastructure with Delta Transway are level road-junctions if this is the case at the moment; the number of construction stays the same as the base case.

### Table 5-2 Building costs

<table>
<thead>
<tr>
<th></th>
<th>2x2</th>
<th>Delta Transway</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thousands of euros</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Re-routing at Helmond</td>
<td>3 3,000</td>
<td>3 9,000</td>
<td>-</td>
</tr>
<tr>
<td>Extra road profile</td>
<td>2.1 43,000</td>
<td>2.1 90,300</td>
<td>-</td>
</tr>
<tr>
<td>(per m road)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crossings (per crossing)</td>
<td>1,500 21</td>
<td>1,500 21</td>
<td>-</td>
</tr>
<tr>
<td>New constructions</td>
<td>2,500 17</td>
<td>2,500 17</td>
<td>-</td>
</tr>
<tr>
<td>(per construction)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adaptation crossings</td>
<td>1,000 5</td>
<td>1,000 5</td>
<td>-</td>
</tr>
<tr>
<td>with waterways</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connections with</td>
<td>- - -</td>
<td>1,000 3</td>
<td>3,000</td>
</tr>
<tr>
<td>industrial areas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total building costs</strong></td>
<td><strong>178,300</strong></td>
<td><strong>181,300</strong></td>
<td><strong>3,000</strong></td>
</tr>
</tbody>
</table>
Building costs
As the building costs are more or less 60% of the total costs, it is useful to take a closer look at the different elements that determine the building costs. Table 5-2 shows the elements of the building costs. At Helmond, no space is available to construct an extra lane along the existing road, which means it has to be re-routed for three kilometres. Along the rest of the road, the road profile has to be broadened. All the crossings have to be adapted, which costs 1,500,000 Euro per crossing and all the constructions (bridges, fly-overs, etc) have to be renewed because of the extra space needed. For Delta Transway, new connections with three industrial areas are included for 1 million euro per connection. In the most right column of the table the differences between the project cases can be seen, which is caused by the connections to the industrial estates.

Real estate costs
For the real estate costs, 25 euro per m² is calculated for 400,000 m² (which is 9 meters times 45 km, the length of the road). It is very difficult to make a good estimation on the real estate costs, because the value of real estate differs.

Engineering costs
The engineering costs are the costs for the engineers that design the project alternatives and make the plans ready to be carried out by the construction firm. For this project, the engineering costs are estimated at 15% of the building costs.

Other additional costs
Also the other additional costs are 15% of the building costs, including soil research, permits and costs for compensating and mitigating measures (for instance planting new trees for the ones that were sacrificed).

Investments in system Delta Transway
For the investment costs for Delta Transway, the assumption is made that cameras are needed for enforcement. The investments are shown in Table 5-3. The number of cameras is quite high, if physical barriers are placed in such a way that the lanes are only accessible on some points, the number of cameras can be decreased. Furthermore a back office and a reservation system need to be developed.

<table>
<thead>
<tr>
<th>Investments in Delta Transway</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thousands of euros</strong></td>
</tr>
<tr>
<td>Cameras</td>
</tr>
<tr>
<td>- 100 cameras a €25,000</td>
</tr>
<tr>
<td>- 200 dummy cameras a €5,000</td>
</tr>
<tr>
<td>Back office</td>
</tr>
<tr>
<td>Reservation system</td>
</tr>
<tr>
<td><strong>Total costs:</strong></td>
</tr>
</tbody>
</table>

Unforeseen project costs
The unforeseen project costs are estimated on 10% of the total costs. This is a standard percentage used for infrastructure investments.

An overview of the construction costs is given in the table below. The most right column shows the differences between the two project cases. As described in the sub section on the building costs, a difference of 3 million euros is caused by the connections with the
industrial estates. Because the estimations of the engineering costs, the other additional costs and the unforeseen project costs are percentages of the building costs, also these estimations differ for the project cases. Another difference is of course made by the specific investment costs for Delta Transway.

Table 5-4 Construction costs

<table>
<thead>
<tr>
<th>Construction costs</th>
<th>2x2</th>
<th>Delta Transway</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building costs</td>
<td>178,300</td>
<td>181,300</td>
<td>3,000</td>
</tr>
<tr>
<td>Real estate costs</td>
<td>11,250</td>
<td>11,250</td>
<td>-</td>
</tr>
<tr>
<td>Engineering costs</td>
<td>26,745</td>
<td>27,195</td>
<td>450</td>
</tr>
<tr>
<td>Other additional costs</td>
<td>26,745</td>
<td>27,195</td>
<td>450</td>
</tr>
<tr>
<td>Investments in Delta Transway</td>
<td>-</td>
<td>2,250</td>
<td>2,250</td>
</tr>
<tr>
<td>Unforeseen project costs</td>
<td>24,304</td>
<td>24,919</td>
<td>615</td>
</tr>
<tr>
<td><strong>Total costs</strong></td>
<td><strong>267,344</strong></td>
<td><strong>274,109</strong></td>
<td><strong>6,765</strong></td>
</tr>
<tr>
<td>Uncertainty</td>
<td>+/-30%</td>
<td>+/-30%</td>
<td></td>
</tr>
</tbody>
</table>

Maintenance costs

The second category of costs is the maintenance costs. For these costs, a distinction is made between ‘small’ and ‘big’ maintenance. Small maintenance is needed every 8 years and big maintenance is needed every 16 year. The maintenance costs are dependent on the surface of the road that needs to be maintained. Only the extra surface needed for the project alternatives is taken into account.

Table 5-5 Maintenance costs

<table>
<thead>
<tr>
<th>Type of maintenance</th>
<th>Euros per m2</th>
<th>Road surface (m2)</th>
<th>Maintenance costs (€ x1000)</th>
<th>Once in…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>3</td>
<td>414,000</td>
<td>1,242</td>
<td>8 years</td>
</tr>
<tr>
<td>Big</td>
<td>20</td>
<td>414,000</td>
<td>8,280</td>
<td>16 years</td>
</tr>
</tbody>
</table>

Operational costs

The operational costs are costs that are made to keep the system running. For the 2x2 project case no such costs have to be made. For Delta Transway photos of users have to be processed, mobile communication of the On Board Units with the system has to be paid and financial transactions are needed. The operational costs are expressed per vehicle that makes use of the the system. More about the estimations on the number of vehicles can be found in section 5.8.2 on page 59.

To make a rough estimation on the costs for processing the photos, the assumption is made that road charging on the national roads is implemented and 90% of the users has an On Board Unit, their data can be processed by the national road pricing system. 10% of the data processing costs is extra and is taken into account in the operational costs estimation. With the help of Anne Tipp (LogicaCMG) estimations have been made on the costs of processing the data, which are the photos that have to be matched with the data from the reservation system. This turned out to be 30 euros per vehicle. These costs are caused by the labour that is needed because the matching of photos and number plates has to done by hand in 10% of the cases.
The other operational costs are the costs for the communication and the financial transactions needed; these costs are around 5 euros per vehicle.

5.4.3 Uncertainty

The estimation of the costs is, as said before, a rough estimation. For the estimations for both the construction, maintenance and operational costs a margin of 30% has to be kept in mind. For investments of 270 million euros, this means it could also be 190 million euros or 350 million euros or any number in between.

According to Gerrit Morren, the cost estimations are averages in such a way that the chance that the costs turn out to be higher is equal to the chance that the costs turn out to be lower. Because this study is a first exploration of the possibilities of implementing Delta Transway along the N279, the uncertainty of 30% is accepted. If in the future more detailed studies on this case would be carried out, more attention needs to be paid on reducing the uncertainty.

5.4.4 Net Present Value of the costs

The Net Present Value of the costs takes into account the fact that a euro in 2006 is worth more than a euro in 2007. Therefore all the investments are calculated in euros of 2006. The same will be done for the direct transport benefits in section 5.5.2. The formula that is used to calculate the NPV is shown in equation 5.1.

For infrastructure projects, the discount rate (r) is 4% (4% is the average real interest for risk free investments on the long term international capital market), plus a factor for the risks taken of 3%, which makes it 7%. This discount rate is compulsory to use in studies on infrastructure projects in the Netherlands.


\[
NPV = \sum_{t=0}^{n} \frac{B_t - K_t}{(1 + r)^t}
\]

(Equation 5.1)

Where project life runs from 0 to n

- \(B_t\) is the undiscounted benefit in time period \(t\)
- \(K_t\) is the undiscounted cost in time period \(t\)
- \(r\) is the social discount rate

The assumption is made that all the investment are made between 2008 and 2012. The engineering costs and the real estate costs in 2008 and 2009, the building costs between 2010 and 2012 and the other additional and unforeseen costs between 2008 and 2012. The road would then be finished in 2012. Also the maintenance costs are included, after 8, 16 and 24 years maintenance is planned. For the life span of the infrastructure, 30 years (from 2012 until 2042) is taken which is standard for roads.
Calculating the Net Present Value for the all the costs results in the figures shown in Table 5-7. Delta Transway turns out be more expensive, the difference is 7 million euro.

<table>
<thead>
<tr>
<th>Net Present Value of the costs until 2042 - Millions of euros</th>
<th>2x2</th>
<th>Delta Transway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction costs</td>
<td>196</td>
<td>201</td>
</tr>
<tr>
<td>Maintenance costs</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Operational cost (for 8000 users per day)</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Total costs</td>
<td>199</td>
<td>206</td>
</tr>
</tbody>
</table>

5.4.5 Conclusion & discussion
Delta Transway turns out to be more expensive. The difference is 7 million euros, which is only 3.5% of the total costs. The extra costs are caused by:
  - Extra building costs for the connections with the industrial estates which are also the entry and exit points of Delta Transway
  - Extra engineering costs, other additional costs and unforeseen project costs because of the extra building costs (these costs estimations are a percentage of the building costs)
  - Operational costs

Because the differences in costs between the project alternatives are all extra costs for Delta Transway, Delta Transway will always turn out to be more expensive then the 2x2 alternative. It is however questionable whether a difference of only 3.5% is significant. Interesting is that 2/3 of the construction costs (which is 97% of the total costs) is caused by the building costs, and these building costs only differ 3 million euros as a result of the connections of Delta Transway with the industrial estates.

5.5 Direct effects
Direct effects are the effects that follow directly from the implementation of the project. Two main categories can be distinguished: the transport benefits generated by the project, and the external effects generated also by the project. The first part of this section is about the transport benefits, expressed with the help of the Value of Time. In sub section 5.5.1 the term Value of time will be explained extensively. Sub section 5.5.2 describes the transport benefits that result from the two project cases. The last sub section will be spend on three external effects: safety, noise and nature

5.5.1 The Value of Time
Two ways of looking at the Value of Time (VoT) are possible, depending on the view on the carrier. The carrier can be seen as a consumer of the ‘product’ Delta Transway that is willing to pay for this product or as a supplier that wants to supply a certain amount at a certain price, for which Delta Transway can lower the costs. The following subsections will describes these two views on the VoT.
Because in the Delta Transway alternative the user has to pay, the user becomes both a consumer of a service and producer of a service. Therefore the value of travel time can be seen from two perspectives. These perspectives are explained below.

Value of Time and consumer surplus
The VoT for the carriers can be defined as the price they are willing to pay for a specific amount of travel time savings. In Figure 5-6 the demand curve of the carriers is shown, the
curve that shows how many users would want to make use of a product at every possible price. If the price is too high, no one would want to pay for travel time savings, the lower the price, the more carriers are willing to pay the price. If the price is set at level A, D carriers are willing to pay this price. The carriers at the right of D only want to pay if the travel time savings become cheaper. The carriers at the left of D pay the price, and moreover, they would have been willing to pay a higher price for the travel time savings. The money they save because of the low price A is shown by the triangle ABC and is called the ‘consumer surplus’. The consumer surplus (or buyer surplus) is the difference between a consumer’s total benefit from some quantity of purchases and her or his actual expenditure (Png, 1998).

Rand Europe made an extensive study on the value that shippers and carriers attribute to travel time. In this study (Rand Europe, 2004) the Value of Travel time is defined as the value that carriers and shippers assign to 1 hour shorter travel time per transport. To find these values, a stated preference survey was held with 200 respondents. All respondents were shippers or carriers of goods. To each respondent, several pairs of alternatives were shown of which the respondent had to choose the best one. One of the attributes was the travel time. By modelling all the results of the respondents, the value of travel time could be calculated. This was done separately for different kinds of products, because the expectation was that this would differ. The results are shown in Table 5-8. Semi-finished goods result in general in relatively high value of time, because these goods are needed for a production process, which means that labour and machines ‘have to wait’ which makes it expensive to have delays in the supply of the semi-finished goods. The total, average value of time is 38 Euro; the dimensions of the categories are weighted in this number.

<table>
<thead>
<tr>
<th>Segment of road transport</th>
<th>Value of time (euros 1/1/02) per transport per hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low value raw materials and semi-finished goods</td>
<td>38</td>
</tr>
<tr>
<td>High value raw materials and semi-finished goods</td>
<td>49</td>
</tr>
<tr>
<td>Final products, loss of value</td>
<td>38</td>
</tr>
<tr>
<td>Final products, no loss of value</td>
<td>36</td>
</tr>
<tr>
<td>Containers</td>
<td>42</td>
</tr>
<tr>
<td>Total road transport</td>
<td>38</td>
</tr>
</tbody>
</table>
Value of Time and producer surplus

Besides the view of carriers as consumers that are willing to pay a specific price for travel time savings, another view is possible: the carrier as a supplier of a service that is willing to supply a specific quantity related to a specific price. In Figure 5-7 the supply curve of carriers is shown, which defines the quantity supplied for every possible price. The supply curve, in the short run, is equal to the marginal cost curve. If the price is set at level A, the quantity supplied is D. Similar to the consumer surplus, the suppliers left from D were willing to produce at a lower price, they save the money expressed by the grey triangle ACE.

Value of Time in cost-benefit analysis

For a cost-benefit analysis, the interesting part of the consumer- and producer surplus is the change in total welfare as a result of the different project alternatives. In Figure 5-8 the consumer surplus and the producer surplus are shown. The sum of the consumer surplus and the producer surplus can be seen as the total welfare. An alternative is only optimal if the total welfare is maximized.

In Figure 5-9, a situation is shown in which the marginal costs to supply a product have become less, which results in a shift of the supply curve, shown in dark blue. Because of this shift, the price drops. Because of the lower price A*, the demand increases to D*. The new equilibrium is C*. The shift of the equilibrium influences the consumer and the producer surplus. In Figure 5-9 the extra consumer as a result of the lower price is shown in light blue and the increase of producer surplus is shown in green. It is important to notice that a part of
the extra consumer surplus is a loss in producer surplus (the grey striped area). For the total welfare these two cancel out the effects. So for a cost-benefit analysis, only the gains or losses that are not cancelled out are relevant, because they contribute to the sum of the costs and the benefits.

Figure 5-9 Increase of consumer and producer surplus as a result of change in supply curve

In Figure 5-10 the consumer surplus and the producer surplus that are cancelled out are not shown, and the extra surpluses are divided into surpluses for the producers and consumers that already supplied and bought the product in the ‘old situation’ at the left of quantity D, and the surpluses for new producers and consumers between quantity D and D*.

These figures can also be applied on Delta Transway. Carriers receive guaranteed travel time and pay a little mount of money for it. However, they will only pay if Delta Transway results in lower costs by saving them time or by increasing reliability. For the ‘willingness to pay’ viewpoint the transport companies are the consumers. However from the viewpoint of welfare creation by lower costs as explained in Figure 5-9 the transport companies are the producers and the consumers companies that have goods they would like to have transported. Their marginal costs curve will shift down as shown in Figure 5-9 and Figure 5-10. The change in the curve is defined by the advantages expressed in euros minus the fee that has to be paid by the users.

A remark has to be made on the assumption that the marginal cost curve is equal to the supply curve, this only holds for the short term and if the price level is above the minimum point of the average variable cost curve.

Because there is strong competition on the market, carriers will lower the price for which they are willing to supply. Because of the lower prices, more consumers (companies that have goods to transport) are willing to pay which results in a demand shift. The new optimum C* is the where the new supply curve crosses the demand curve.
5.5.2 Estimated direct transport benefits

The main benefits of the implementation of one of the project alternatives are the direct transport benefits for the users of the infrastructure. They will have shorter travel times which they value positive. The value of the users for the minutes they save is expressed by the value of time which is explained in the previous sub section. In this sub section a model will be discussed that estimates the hours that are saved by the users.

First the method will be explained, then the results will be shown and last some discussion on the results is described.

**Method**

To be able to estimate the direct transport benefits of the project alternatives calculations with a simple model are made. The model is made by ARCADIS. To construct this model two existing models are used as input: the Nieuw Regionaal Model (NRM) and the Regionale Benuttings Verkenner (RBV), which were provided by the Noord-Brabant province. In the model extra capacity was added to the existing situation to see what the effect on the lost vehicle hours during rush hour on the road would be.

For the Delta Transway alternative the extra capacity added was 200 pae per hour in one direction. (pae is a measure for capacity, 1 pae is equal to the capacity of 1 car, a truck is two pae). The reason that 200 pae per hour per direction was chosen is that the number of trucks during rush hour is according to the above mentioned input models 100 trucks per hour which is equal to 200 pae. Cars are not allowed to make use of Delta Transway, so all the direct benefits that follow from the extra capacity are for the transport companies. The benefits are expressed in the difference in lost vehicle hours between the existing situation and the implementation of Delta Transway. The lost vehicle hours are the total time that vehicles spend extra on the road because of congestion. The less lost vehicle hours, the better. The saved lost vehicle hours because of the extra capacity multiplied by the Value of Time results in the direct transport benefits.

For the 2x2 alternative a similar calculation is made, however here the added capacity is similar to two standard lanes on provincial level, estimated as 1800 pae per direction per hour.

Some important remarks can be made on the method used:

- The model does not take into account the surroundings of the N279. This means for instance that traffic that now uses the A2 from Den Bosch via Eindhoven to the A67 is not taken into account in the model as potential users of an upgraded N279. It
turned out be very hard to get information on origin and destination traffic on national level, AVV explained that no such information was known of.

- The model uses intensities of 2004. The intensities did increase in 2005 and it is likely that they increase in the future. This is not taken into account.
- The model only takes the N279 from Den Bosch to Helmond into account, not the part between Helmond and the A67. Including this part could have a small positive effect on the difference in lost vehicle hours.
- Because the added capacity is not specific capacity for trucks, the advantage of better circulation due to separation of cars and trucks is not taken into account.
- The model only takes into account 2 morning rush hours and 2 evening rush hours per day, the other 20 hours of the day where not included.

**Results**

The results of the model are shown in the upper part of Table 5-9. The 2x2 alternative turns out to have a bigger decrease in lost vehicle hours than Delta Transway. This can be explained by the fact that the capacity added to the model for the 2x2 alternative is bigger, because the extra lanes can be used by all types of vehicles. The decrease in lost vehicle hours is multiplied with the Value of Time. For the trucks, the Value of Time of 38 euros is used, see also Table 5-8. For cars, the best method would be to analyse the exact ratios for the different motives of car users, but the information on the different motives is unfortunately not available for the N279. Therefore an average measure of AVV (2005) is used, which is 10 euro per hour. The results of the calculations (The decrease in lost vehicle hours as a result of the alternatives * the Value of Time) can be found in Table 5-9. A difference is made between benefits for cars and trucks.

**Table 5-9 Direct transport benefits**

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>2x2</th>
<th>Delta Transway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Results from traffic model:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decrease in lost vehicle hours relative to base case</td>
<td>3080 per day</td>
<td>1220 per day</td>
</tr>
<tr>
<td>Multiplied with the Value of Time:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working days per year</td>
<td>261</td>
<td></td>
</tr>
<tr>
<td>Value of Time for trucks</td>
<td>38 (Rand,2004)</td>
<td></td>
</tr>
<tr>
<td>Percentage trucks</td>
<td>20%</td>
<td>100%</td>
</tr>
<tr>
<td>Direct transport benefits for trucks</td>
<td>€ 6,109,000</td>
<td>€ 12,100,000</td>
</tr>
<tr>
<td>Value of Time for cars</td>
<td>10 (AVV, 2005b)</td>
<td></td>
</tr>
<tr>
<td>Percentage cars</td>
<td>80%</td>
<td>0%</td>
</tr>
<tr>
<td>Direct transport benefits for cars</td>
<td>€ 6,431,000</td>
<td>-</td>
</tr>
<tr>
<td>Direct transport benefits - one year</td>
<td>€ 12,541,000</td>
<td>€ 12,100,000</td>
</tr>
</tbody>
</table>

Delta Transway turns out to have fewer benefits than the 2x2 alternative. The difference however is only 3.8%. Interesting to see is that for Delta Transway all the benefits are for the freight transport while for the 2x2 alternatives only a bit less than half of the benefits is for the freight transport sector.

**Table 5-10 Net Present Value of the benefits until 2042**

<table>
<thead>
<tr>
<th></th>
<th>2x2</th>
<th>Delta Transway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct transport benefits</td>
<td>104 million euros</td>
<td>100 million euros</td>
</tr>
</tbody>
</table>
Following the same method as for the costs of the project alternatives, also the benefits of the project alternatives are calculated as Net Present Values (see also equation 5.1) using the same discount rate of 7%, also calculated until 2042. The results are used in the overview of costs and benefits that is given in section 5.7.

**Discussion on the results**

The results of the model are influenced by some assumptions that have been made when the model was created. The remarks that are made on the model earlier in this section are important to take into account when looking at the results.

Because the model does not take into account the surroundings of the N279, the number of trucks that might use one of the project cases might be bigger. The same holds for the fact that 2004 intensities were used. Furthermore the model takes not into account the part between Helmond and the A67 which leads to less saved vehicle hours and results of better circulation were not included and only rush hours were taken into account.

A last remark that can be made on the model is the capacity that is added for the alternatives. For the 2x2 alternative the standard capacity for a provincial road is added, for Delta Transway only 200 pae per hour per direction is added. This is the current intensities of trucks. However, when Delta Transway would be implemented, probably more trucks would use the system than that use the N279 now.

Besides the remarks on the model, also a remark can be made on the Values of Time chosen. Not taken into account is the fact that AVV expects the Value of Time to rise until 2020. (AVV, 2005b). This would increase the benefits of both the alternatives. However, if the Value of Time for freight transport will increase faster than the Value of Time for passenger transport, the benefits of Delta Transway could become more than the benefits of the 2x2 alternative. In general it can be said that the estimations made are very conservative, they define the lower boundary of the possible results.

5.5.3 **External effects**

This section describes the external effects of the project alternatives. The term ‘external effects’ can be confusing. In this analysis it refers to the unintentional, non-priced effects on the well-being of others (OEI part II). Priced effects on third parties belong to the indirect effects. The external effects taken into account in this study are: safety, noise, air pollution and nature.

**External safety and road safety**

Safety is determined by the risks that are taken. The more risk is taken, the less safety. Risk can be calculated by multiplying the probability for a specific event and the result of this event. In this study, a distinction is made between external safety and road safety. External safety is in this study about the safety concerning companies and the road safety is about the risks on accidents.

For the external safety, the government has set boundaries on these risks to ensure a certain level of safety. Figure 5-11 shows the number of casualties and the probability of an accident. A low probability of an accident with a low number of casualties is acceptable, but if the probability becomes more than $10^{-6}$ per year (1 time in 1,000,000 year), risks reduction measures have to be taken, and if the casualties are more than 100, it is even unacceptable. With this guideline, areas around for instance industrial complexes can be drawn in which no houses are allowed to be build.

To have all the information about risks available, every province manages a map of all the risks the ‘Risicokaart’ (website Risicokaart). The maps can be found on internet and used by policy makers and disaster suppression teams.
Along the N279 some fuel stations cause risks because of the presence of flammable fuel and some companies cause risks because of the use of propane, ammonia or the storage of other dangerous substances. Figure 5-12 for instance shows for Veghel in red the places that cause extra risks because of dangerous substances and in green the vulnerable places like nursing homes and offices where a lot of people work. The risk contours are shown in black dotted circles. Risk contours show the chance of casualties with the risk source on a certain location.

The N279 does not fall into any risk contour (according to the ‘Risicokaart’. The procedure for the construction of new infrastructure is to discuss the new situation (one of the project alternatives) with the regional Fire Service and to analyse which risks should be dealt with. Sometimes changes in the design of the new infrastructure are made or extra fire extinguishing water possibilities are constructed. The costs for these extra measures are already integrated in the ‘other additional costs’, see also sub section 5.4.2. The above described procedure is the same for both project cases.

For road safety, in general the safety does become worse if the number of users of a road increases, which happens in both project cases. However, also some difference in safety between the two project alternatives can be mentioned. In case of the Delta Transway alternative, more trucks will drive at one side of the road, which will at some locations lead to more trucks near the buildings and in other cases to fewer trucks near buildings, dependent on the location of the buildings.

Another aspect, one in favour of Delta Transway is that it is not possible to overtake. This will decrease the probability of accidents, so lower the frequency of accidents. In Table 5-11 this results in a +/- for Delta Transway, a negative effect because of increased traffic intensities and a positive effect because of no options to overtake. The ‘-’ for the 2x2 project case is because of the extra traffic which results in a higher chance on accidents.
Noise

Noise has a negative influence on the quality of life for the people that are exposed to it. In the Netherlands, rules and regulations on noise emission are laid down a law called ‘Wet Geluidshinder’. This law defines when noise has to be tested and sets the standards for noise emission. When a new road is built, when changes in a road are made, or when houses are built, the new noise emission has to be estimated and measures to reduce this noise emission have to be taken. Compulsory calculation models are defined to use for the estimations.

From 1 January 2007 on, the calculation method will make a difference between noise during day, evening and night (until then it distinguishes only between day and night). For noise during the evening 5 dB is added, for noise during the night 10dB.

The increase in noise as a result of the realisation of the two project alternatives can be calculated with the SRM1 model, which stands for Standaard Reken Methode 1, see also appendix E in which the input factors of the model are shown. The output is the level of noise on the house fronts.

The kind of input data that is needed for the analysis is shown in figure 1 in which Nijland et al. (2003) explains ‘the factors leading to the (adverse) effects of noise’. The four blocks at the left side of the scheme are the four categories of data needed as input factors for the SRM1. Traffic volume is expressed in vehicles per hour, for which a distinction is made between day, evening and night, as explained before. The traffic speed is expressed in the maximum speed allowed on the road analysed. The technical characteristics of the vehicles are expressed in the difference that is made between cars, ‘light’ trucks and ‘heavy’ trucks. The technical characteristics of the road are expressed by for instance the dimensions of the road and the distance to a crossing. Of course also the distance between the houses and the road is an important input factor.
To be able to fill in this model for the project cases all this input data is needed. Unfortunately, not enough data on the project cases is available to fill in the model. In general because of the increase of capacity, both project cases influence the number of people exposed the noise negatively.

The project case Delta Transway is focused on freight transport, and since trucks do cause more noise than cars, this would have an extra negative effect on the noise level. Both project cases are given a ‘-’ in Table 5-12.

Table 5-12 Effect on noise

<table>
<thead>
<tr>
<th></th>
<th>2x2</th>
<th>Delta Transway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

0 = no effect, + = positive effect, - = negative effect

**Air pollution**

The indicator that is used for air pollution is the change in the number of people that suffer hindrance. Difference can be made in local and supra-local air quality. CO2 and NOx are supra-local and because this study only focuses on one road, CO2 and NOx can be let outside of the scope.

For local emissions, a model is available to calculate whether the standards that are set by the government are met. This model is called CARII and is available to use free of charge. The model calculates the emission on street level. To make use of the model, the following factors need to be specified:

- Road type (buildings, trees available, maximum speed)
- Tree factor, trees close to each other decrease the wind speed and therefore increase the concentration
- Distance to road axis

The model calculates the values of NO2, PM10, Benzeen, SO2, CO, and BaP (BaP is an indicator for the presence of PAKs (In Dutch: Polycyclische Armotische Koolwaterstoffen)). Because the standards that have to be met are also included in the model, the output of the model indicates whether the concentration of specific substances meets the standard or how
much deviation is expected. For the N279 and the above described project cases it is advisable to calculate the emissions at places where the road crosses residential areas. Because the increase of capacity for both roads more traffic will use the roads which will result in more air pollution.

Table 5-13 Effect on air pollution

<table>
<thead>
<tr>
<th>Air pollution</th>
<th>2x2</th>
<th>Delta Transway</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

0 = no effect, + = positive effect, - = negative effect

Nature

The indicator that is used for nature is the number of hectares of nature that is wasted. This includes both a quantitative and a qualitative factor. First the ‘nature’ has to be defined, which is expressed in ‘nature bottlenecks’, this is the qualitative factor. To define the nature bottlenecks guidelines described below are used. The quantitative factor is the number of hectares that is wasted.

To identify nature bottlenecks, it is necessary to analyse whether the area is part of the areas designated by the ‘EU Habitat and Bird Directive’ or the ‘Ecologische Hoofdstructuur’ (EHS).

Figure 5-14 Habitat areas (green areas).
Source: website Ministry of Agriculture, Nature and Food quality

The Ministry of Agriculture, Nature and Food quality provides an online ‘effect indicator’ in which per area that is part of the ‘EU Habitat and Bird Directive’ (European Commission – Nature & Diversity – website), per species (flora & fauna) and per disturbance factor the effects can be determined.
The region around the N279 does not include areas mentioned in the ‘EU Habitat and Bird Directive’ as can be seen in Figure 5-14 and Figure 5-15. Therefore both project cases get a zero. This does however not mean that the area around the N279 that is needed for the new lanes has no value.

| Table 5-14 Effect on nature |
|-----------------------------|-----------------|-----------------|
| Nature                      | 2x2             | Delta Transway  |
| 0 = no effect, + = positive effect, - = negative effect |

5.6 Indirect effects

Indirect effects are the consequences of an infrastructure project that do not have a direct relation with the project, but result from the direct effects of the project (OEI –part I, 2000). This implies there has to be a causal relation between the direct and the indirect effect.

5.6.1 New business activities

One indirect effect that is often mentioned is the positive effect from new infrastructure on the development of new business activities. According to research of TNO (TNO, 2001), accessibility by road is one of the five most important factors determining the location of a business (in Dutch: vestigingsfactor).

The ‘2x2’ alternative would result in a better accessibility of industrial areas near the N279 as well as the cities Den Bosch, Veghel and Helmond. The positive effects of Delta Transway are more focused on freight transport, so also the indirect effects do belong to companies that are related to freight transport. It is however difficult to estimate these effects. The better the base case is, the less the difference between the base case and the project alternatives. In Table 5-15, the positive effects on the development of new business activities is indicated by a ‘+’.

5.6.2 Technological spin-off

Because Delta Transway or a similar system that makes use of dedicated lanes and trip booking is not used before, the implementation of Delta Transway can have a positive effect on the image of the Netherlands as innovative economy and the competitive position of the companies concerned. These effects are however very difficult to forecast and to monetise. The expectation is that these effects will not influence the results of the analysis significantly.
5.6.3 Extra benefits for consumers

A third indirect effect that can be mentioned is the social welfare that is created for the consumers of services offered by transport companies, which are mainly companies that have goods that need to be transport. In section 5.5.1 the creation of extra social welfare, also for the consumers, is explained by Figure 5-10. If the accessibility is improved by new infrastructure, transport companies will have lower costs and because of the competitive characteristic of the transport market, the price for the consumers will be lowered, which results in extra consumer surplus. The effects on the consumers are however very difficult to forecast.

Table 5-15 Indirect effects

<table>
<thead>
<tr>
<th></th>
<th>2x2</th>
<th>Delta Transway</th>
</tr>
</thead>
<tbody>
<tr>
<td>New business activities</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Technological spin-off</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Extra benefits for consumers</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

0 = no effect, + = positive effect, - = negative effect

5.7 Overview social costs and benefits

In Table 5-16, an overview of the costs and the direct and indirect effects of the project alternatives is given. The data in the table is explained in the previous sections. All the values mentioned are Net Present Values until 2042.

Table 5-16 Overview of social costs and benefits (Net Present Values until 2042)

<table>
<thead>
<tr>
<th></th>
<th>2x2</th>
<th>Delta Transway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction, &amp; maintenance</td>
<td>199 million euros</td>
<td>204 million euros</td>
</tr>
<tr>
<td>Operational (8000 trucks)</td>
<td>n/a</td>
<td>2 million euros</td>
</tr>
<tr>
<td>Direct effects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport benefits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car users</td>
<td>53 million euros</td>
<td>0</td>
</tr>
<tr>
<td>Trucks</td>
<td>51 million euros</td>
<td>100 million euros</td>
</tr>
<tr>
<td>External effects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety</td>
<td>-</td>
<td>+/-</td>
</tr>
<tr>
<td>Noise</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Air pollution</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nature</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Indirect effects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New business activities</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Technological spin-off</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Extra benefits for consumers</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

0 = no effect, + = positive effect, - = negative effect

It turns out that the costs for Delta Transway are 7 million euros higher, and the benefits are 4 million euros lower than for the 2x2 alternative. So a logical conclusion is that the 2x2 alternative is a better alternative than Delta Transway is. However, some remarks can be made on that conclusion.

For both the costs and the benefits, the difference between the alternatives is small. Delta Transway will always be more expensive than the 2x2 alternative, because of the
investments specific for Delta Transway, but the difference is only 3.5% of the total costs. Knowing that the uncertainty of the estimations is 30%, this 3.5% difference is not that significant.

On the direct transport benefits, the remark can be made that the estimations of the benefits of Delta Transway are very conservative. As earlier explained the model that estimates the direct transport benefits included a lot of assumptions that were needed to be able to construct a simple model within a short period of time, but these assumptions do influence the outcomes, for Delta Transway in a conservative way. Also for the Value of Time used in the calculations of the direct benefits, the conservative assumption is made that users do not value time higher in the future. This assumption however holds for both the alternatives.

5.8 Investments and revenues for investors

In this section, the possibilities for private investors to invest in Delta Transway will be discussed. First the Internal Rate of Return will be explained, which is an economic measure used by investors to compare different possibilities to invest in. Second, some calculation will be made for Delta Transway to see what the Net Present Value and the Internal Rate of Return for investors would be. Last, the possibility of a construction in which the government invests together with private parties will be mentioned.

5.8.1 Internal Rate of Return

The Internal Rate of Return (IRR) is any discount rate (r) for which the Net Present Value (NPV) is zero. It can be seen as the expected return as a result on investment. So if the NPV of the benefits minus the NPV of the costs is zero, what will the value of r be? The answer on this question (a value for r) is the Internal Rate of Return. The benefit of the Internal Rate of Return is that it connects the returns to the investments. For instance: if a return is 20,000, it is not clear if this is a lot of return or just a small amount, this depends on the investments that had to be made to reach this 20,000 euros. The Internal Rate of Return for Delta Transway is calculated in the following section.

5.8.2 Net Present Value and Internal Rate of Return for Delta Transway

The Net Present Value can be calculated using the same method as explained in section 5.4.4 and the method to calculate the Internal Rate of Return is explained in the previous sub section. For the investments, the same figures as for the social costs are used, which results in investments of, expressed in NPV, 206 million euros, see also Table 5-17. The returns for the investors are defined by the number of users of Delta Transway multiplied by the fee they pay for the use of the system.

So before the returns can be calculated, it is necessary to make an estimation of the number of users.

To estimate the average number of users between 2013 and 2042 (which is the lifespan of the road) the trend of the number of ton kilometres transported on the road is analysed. Figure 1-3 shows the estimations until 2020. When the middle European scenario is taken, the ton kilometres increase with a factor 1.33 from 2000 to 2010 and also with a factor 1.33 from 2010 to 2020. In 2005 more than 4000 trucks were counted per day on several road sections. Following the factor 1.33 per ten years this would result in more than 12000 trucks per day in 2042, assuming that the increase in trucks on the N279 is the same as the average figures in the Netherlands. The average number that is used to calculate with is 8000 paying users. On the one hand maybe not all trucks are willing to pay for Delta Transway, on the other hand Delta Transway will attract trucks that now take the national road network. In the calculation in made in this section, 8000 vehicles is taken as a starting point. This is a feasible number of users; the capacity of Delta Transway can be 1800 per hour per direction, which is similar to 900 trucks per hour per direction, which is 1800 trucks per hour, so 5 hours per
day are needed to be able to reach the 8000 trucks per day. The capacity of a standard lane on provincial level is 1800 – 2000 pae per hour in one direction. Besides the number of users, also the fee has to be determined. For this estimation, the fees for the road pricing in the Netherlands have been analysed. No official fees have been mentioned by the government yet, but Cobouw (Cobouw online – news item) has made some estimations as mentioned in section 1.2.3. Unfortunately, no fees for trucks were mentioned. Cars have to pay, according to Cobouw, 3.4 eurocents during off-peak hours and 11 eurocents during peak hours. For trucks, fees are often higher, in this study 10 eurocents per kilometre is used, which 5 euros for the N279. The assumption is made that the 8000 users pay 5 euros each. In Table 5-17, besides the assumptions explained before, the Net Present Values and the Internal Rate of Return is shown. The NPV of the investments is 206 million euros; the NPV of the fees is 86 million euros which makes the total NPV 120 million euros negative. This results in an IRR of only 0.42%, which is very low.

Table 5-17 NPV & IRR for Delta Transway

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Delta Transway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount rate is same as for social costs and benefits NPVs</td>
<td>7%</td>
</tr>
<tr>
<td>NPV Investments same as NPV social costs</td>
<td>206 million euros</td>
</tr>
<tr>
<td>Fee per truck</td>
<td>€ 5 (€0.10 per km)</td>
</tr>
<tr>
<td>Number of trucks per day</td>
<td>8000</td>
</tr>
<tr>
<td>Days per year</td>
<td>261</td>
</tr>
<tr>
<td>NPV investments – cumulus 2042</td>
<td>206 million euros</td>
</tr>
<tr>
<td>NPV fees – cumulus 2042</td>
<td>86 million euros</td>
</tr>
<tr>
<td>NPV cumulus benefits minus costs in 2042:</td>
<td>-120 million euros</td>
</tr>
<tr>
<td>IRR</td>
<td>0.42%</td>
</tr>
</tbody>
</table>

5.8.3 Uncertainty

An increase of the number of users or the fee of 10% will result in an increase of the NPV of 10%, the same holds for a decrease of the number of users or the fee, according to the calculations. However, this calculation assumes inelasticity, i.e. no matter what the fee is, 8000 trucks will make use of Delta Transway. In reality, the number of users will be more elastic. A method to find out the elasticity would be to ask a significant number of freight transporters whether they would make use of Delta Transway for a specific price, and ask this for various prices. Besides the fact that in general, actual behaviour is somewhat different from the answers on this kind of surveys, this would give a better insight in the relation between the price of the fee and the number of trucks.

5.8.4 Conclusion & discussion

On the investments and returns for potential investors, the conclusion can be drawn that Delta Transway is not an interesting concept to invest in. However, some remarks can be made on this conclusion.

Construction of infrastructure is always very expensive. The high costs of the infrastructure can in this case, and not only in this case, not be invested only by private investors. It would be interesting to look at possibilities for investments by government and private parties together. More about this possibility is explained in the following sub section.
5.8.5 Investments by both government and private parties

In the above described scenario’s the assumption is made that the investors do want to earn back all the invested costs in the infrastructure. However, often the government invests in infrastructure without being paid back in a direct way. Besides the possibility that private investors design, build, finance, maintain and operate the infrastructure (called DBFMO), it is also possible that private investors design, build and maintain the infrastructure (DBM) and that after for instance 25 years the ‘concession’ ends and the government pays back a part of the investments. Getting paid back a part of the investments for sure makes it of course more interesting to invest for private parties.

Another way the investments could be shared is to see Delta Transway as a system that is not always used. When the system is not used, on times when no extra capacity is needed, the lanes can be used as normal roads. This needs some extra investments to make sure to the road users if they are allowed to make use of the lanes. The government could then pay for the part of the investments that belongs to the moments that everyone can make use of it and the private investors for the Delta Transway part. The possibilities mentioned in this subsection should analysed more in detail to see whether they are feasible solutions.
6 Conclusions & Recommendations

In this chapter the conclusions that can be drawn on the feasibility study of Delta Transway are described. After the conclusions are explained in section 6.1 some recommendations are given in section 6.2. The last section, section 6.3, contains some reflection on the research, content focussed as well as focussed on the process.

6.1 Conclusions

The aim of this report was to gain knowledge on the feasibility of Delta Transway. This was initiated by the formulating the following question:

“What are the social costs and benefits of the implementation of Delta Transway for freight transport on bottlenecks in the Dutch national and regional road infrastructure, and where and how can Delta Transway be applied in such a way that its positive results are maximized?”

To be able to answer these questions, the following sub questions were formulated:

1. What are the system characteristics of Delta Transway?
2. What can be learned from existing freight transport on dedicated lanes?
3. How can bottlenecks for freight transport be measured?
4. Which bottlenecks for freight transport can be identified?
5. How can Delta Transway be successfully applied on the bottlenecks?
6. What are the costs and benefits of Delta Transway when applied to a selected case?

First these research questions will be answered. Second, an overall answer on the main question will be given.

What are the system characteristics of Delta Transway?

Delta Transway is a system that assigns time slots on dedicated lanes to target groups. These target groups, for instance freight carriers, make a reservation for a certain time slot, which is called trip booking. These users arrive at the entry of the system, check in, and have a guaranteed travel time to the exit point of the system. Because of the trip booking, no congestion will occur. The main system characteristics are:

Trucks and buses on dedicated lanes

Delta Transway makes use of dedicated lanes. This can be existing bus and or freight lanes or new infrastructure. Because of the trip booking component, Delta Transway without dedicated lanes is not possible. A result of the dedicated lanes is that different vehicle types are separated. Buses and trucks that make use of Delta Transway are separated from cars. The cars drive on the ‘regular’ lane, the buses and trucks make use of the dedicated lane. The separation of these different types of vehicles has a positive effect on the circulation of the traffic.

Optimal use of capacity by trip booking
The advantages of trip booking are multiple. First it results in guaranteed travel time. The user knows that if he books a certain slot, he will be able to reach a certain location within a certain time. Second, the capacity can be used optimal. Another advantage is the possibility to give priority to target groups within the trip booking.

**Users pay for guaranteed travel time**

When the user makes a reservation for a time slots, he has to pay a certain amount of money. The amount of money can be differentiated to time and place. Also price advantages for users that book earlier can be applied.

**What can be learned from existing freight transport on dedicated lanes?**

To identify the lessons that can be learned from similar cases in which target groups make use of dedicated lanes, some of these situations have been analysed. The following lessons can be learned:

- Real travel time savings are likely to only take place during rush hours and even then maybe not always, and the impact on the car circulation might not be that significant. To handle with these problems, an analysis of the specific situation should be made.

- The situation of a dedicated lane with buses and trucks does, in general, not lead to unsafe situations

- The absence of a hard shoulder (in Dutch: *vluchstrook*) has a negative effect on the safety. It is recommended not to use hard shoulders to implement Delta Transway on, but dedicated lanes.

- The perceived advantages might be bigger than the real advantages. The question is whether perceived advantages are found important by policy makers. Perceived advantages are difficult to take into account when a cost-benefit analysis is made.

- Slow trucks (trucks that drive less than 80 kilometres per hour) on dedicated lanes have a negative effect on the (saved) travel time. Capacity planning has to deal with this problem.

- The longer the dedicated lanes, the more effective. Depending on the situation it should be considered whether the chosen section is long enough to gain significant travel time savings.

- If Delta Transway is implemented on a former bus lane, it is necessary to define in advance how much delay is allowed for busses compared to the initial situation. It might be necessary to have extra adaptations made to the design of the situation to ensure only limited delay.

**How can bottlenecks for freight transport be measured?**

During the research it turned out that several ways of expressing traffic intensities and congestion are possible. To get a clear overview Table 6-1 was constructed in which the different ways are compared. The table shows six ways that are used by road maintenance authorities which are compared on the variables.

In the table, variables that are used to express one of the six methods of measuring bottlenecks are rated with a ‘+’ or a ‘•’. A ‘+’ means that this method uses a certain variable,
a ‘•’ means it does not use that variable. The table gives an interesting overview of differences. Intensity takes into account the number of vehicles and sometimes also the type of vehicle expressed in a certain unit of time, often working days or weekdays, while the I/C-ratio adds the information of capacity to it. Therefore an I/C-ratio does tell more about the chance on a bottleneck, because high intensities alone are not a problem, only if the capacity lacks to cope with. The total severity of congestion does not take into account number or the types of vehicles; it looks at duration, length and frequency of the traffic jam as a whole. A disadvantage is that it is difficult to measure, because it needs to be defined where exactly the traffic jam starts and ends. EVO and TLN involve the individual vehicle again in the calculation of the economic losses by multiplying the total severity of congestion by the number of trucks because they are interested in freight transport especially. Also the Value of Time is included in the calculation, to make it possible to express the losses of time for freight transporters in euros. The lost vehicle hours and the travel time/free flow ratio are more focused on the user and the extra time the user has to spend due to delays. Lost vehicle hours are the extra hours spend by vehicles on the road. Travel time/free flow ratio is less focused on how many cars are impeded and for how long; it only takes into account the difference in speed and the result of this difference on the travel time.

Table 6-1 Comparison between methods to measure the bottlenecks for freight transport

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intensity</th>
<th>I/C-ratio</th>
<th>Total severity of congestion</th>
<th>Economic losses for freight transport sector</th>
<th>Lost vehicle hours</th>
<th>Travel time/free flow ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of vehicles</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Types of vehicles</td>
<td>+/•</td>
<td>+/•</td>
<td>+/•</td>
<td>+/•</td>
<td>+</td>
<td>+/•</td>
</tr>
<tr>
<td>Capacity of the road</td>
<td>•</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Time</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Duration of traffic jam</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Length of traffic jam</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Frequency of traffic jam</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Value of time</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Free flow speed</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>+</td>
</tr>
<tr>
<td>Actual speed</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>+</td>
</tr>
<tr>
<td>Distance</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>+</td>
</tr>
</tbody>
</table>

+ = variable is used
• = variable is not used
+/• = sometimes a distinction between cars and trucks is made

Considering these methods to measure bottlenecks for freight transport, the indicator ‘the economic loss for freight transport’ seems to be most useful for this study, because it focuses on freight transport (it makes a distinction between types of vehicles) and takes into account the consequences (losses) for the transport sector. The total severity of congestion does not take into account freight transport and is therefore less suitable. Lost vehicle hours are an appropriate alternative, but only if a difference is made between trucks and cars in the used intensities. If none of the calculations above can be made because of lack of data (for provincial roads this is often the case), the I/C-ratio and the rush hour/free flow travel time ratio can be calculated. These methods however do not give information about how many road users were influenced by the congestion or the duration of the congestion. One can only assume that the delay (in case of travel time/free flow ratio) causes congestion that affects a lot of vehicles or that the high I/C-ratio leads to congestion that affects a lot of vehicles. Intensity alone does not give enough information on
bottlenecks, because high intensities itself are not a problem, only when there is a lack of capacity to cope with the intensities.

**Which bottlenecks for freight transport can be identified?**

On national level, TLN & EVO regularly calculate the bottlenecks for freight transport that cause the greatest economic losses for freight transport on the basis of the severity of congestion of road sections on national level. In 2005, the A2 between Holendrecht and Oudenrijn was the number one with 32 million euro losses. The top 20 calculated by TLN & EVO is used as the answer on the question which bottlenecks can be identified on the national level.

On regional level, for the provinces that have to cope with the highest freight intensities, the bottlenecks for freight transport on regional level have been analysed. Two conditions have to be met to be in the list of bottlenecks for freight transport:

- The I/C-ratio has to be > 0.6
- The intensity of trucks has to be > 4000

For Zuid Holland the following bottlenecks meet these conditions: The N207, N211, N218, N466 and N470. These roads are defined as roads with bottlenecks for freight transport. In Noord-Holland especially the N201 and the N242 have both high truck intensities and ‘relatively high’ I/C-ratios. For Utrecht the N201, N210, the N230 and the N408 have been selected as bottlenecks for freight transport. The N279, the N284 and the N329 are regional roads in Noord-Brabant that all have intensities above 4000 trucks per day and I/C-ratios above 0.6. For Gelderland only the A325 and the N325 have more than 4000 trucks per 24-hours on a working day.

The bottlenecks mentioned above can be seen as bottlenecks for freight transport on the national and regional road network in the Netherlands.

**How can Delta Transway be successfully applied on the bottlenecks?**

In chapter 2, the system description resulted some success criteria for Delta Transway. These criteria are presented below.

- The target group that will make use of the dedicated lane has to be large enough. How large is large is a question that has to be decided upon by the investors in the infrastructure. Sometimes bus lanes are constructed which are only used by not so many public bus services. However, private investors will demand a certain return on their investments, which takes probably a larger target group.

- It needs to be desirable to give priority to a certain target group due to social or economical considerations. Social considerations can for instance be to give priority to public transport to support a modal shift, economic considerations can be to give priority to freight transport because of high Values of Time.

- The target group is brought past a bottleneck without causing a bottleneck downstream. If the ‘exit point’ of Delta Transway is a crossing that is the actual bottleneck, the implementation of Delta Transway does not improve the situation significantly.

- The more prohibitive physical barriers are located on the route of Delta Transway, the more difficult and therefore expensive the solutions are. So the route should preferable contain as few prohibitive physical barriers as possible.
There needs to be a possibility to construct a new dedicated lane or a dedicated lane should already be available. Delta Transway is not possible without a dedicated lane.

The congestion on the ‘normal road’ needs to a result of a lack of capacity that occurs regularly, for instance every morning during the peak hours. If the congestion is for instance a result of accidents, a better solution is to analyse why accidents happen, and to improve the safety of the road.

For dynamic capacity allocation, On Board Units are needed. Dynamic capacity allocation is preferred but not necessary.

Users need to be willing to pay for guaranteed travel time. If users are not willing to pay for Delta Transway, no matter what their reason is, the concept will not be a success.

The users of Delta Transway need to gain significant advantages by the use in terms of shorter travel times. The expectation is that users are only willing to pay for the concept if they gain significant travel times.

Obliged separation of vehicles is preferred from a circulation viewpoint but commitment will probably lack. Obliged separation of vehicle types means that trucks have to pay for the use of the road, without having an alterative.

Besides the criteria that followed from the system description, also criteria following from the analyses of the HOV-lane can be mentioned. These criteria have a more organisational character:

Make sure the data and methods used for analysis are relevant for the situation and accurate. If stakeholders agree on these choices there will be more commitment on the results of analysis.

Good communication to the press can prevent that only negative information is published. With good communication is meant that time and effort is spend on providing the right information.

Spend a lot of time in creating commitment, not only for the actual decision makers, but especially with stakeholders that are influenced by the project. More on stakeholders will be mentioned in the following section.

Be sure the juridical aspects are analysed as well. The system excludes users from using a certain lane which needs a juridical base. It could for instance be necessary that a juridical decision on road use (in Dutch: *verkeersbesluit*) is taken.

On the base of the actor analysis, some advise is given in how to deal with the actors. For the dedicated critical actors with contrasting perceptions, it is useful to think of possibilities to change the project in such a way that the goals of the critical actors become less contrasting. Of course, if the project changes it has to be in such a way that the former actors with equal perceptions still have equal perceptions. An example is to make Delta Transway only accessible for clean trucks, which might make the concept more interesting in the light of environmental-friendly policy.
The non-dedicated non-critical actors with equal perceptions are actors that do not need attention in the first place. Later in the project, however, they can be interesting allies. It is advisable to elaborate this analysis if more specific details on the location and the location dependent actors (for instance local authorities) are known.

**What are the costs and benefits of Delta Transway when applied to a selected case?**

For the case study the regional road N279 is chosen. This road is seen as an alternative to accommodate traffic of the A2 between Den Bosch and Eindhoven which would give the N279 a more national function. Two project cases were compared on the social costs and benefits. One project case was to change 2x1 lane into 2x2 lanes, the other project case the implementation of Delta Transway in two directions.

| Table 6-2 Overview of social costs and benefits (Net Present Values until 2042) |
|---------------------------------|----------------|----------------|
| Costs                           | 2x2            | Delta Transway |
| Construction, & maintenance     | 199 million euros | 204 million euros |
| Operational (8000 trucks)       | n/a            | 2 million euros |

**Direct effects**

<table>
<thead>
<tr>
<th></th>
<th>2x2</th>
<th>Delta Transway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport benefits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car users</td>
<td>53 million euros</td>
<td>0</td>
</tr>
<tr>
<td>Trucks</td>
<td>51 million euros</td>
<td>100 million euros</td>
</tr>
</tbody>
</table>

**External effects**

<table>
<thead>
<tr>
<th></th>
<th>2x2</th>
<th>Delta Transway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>-</td>
<td>+/-</td>
</tr>
<tr>
<td>Noise</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Air pollution</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nature</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Indirect effects**

<table>
<thead>
<tr>
<th></th>
<th>2x2</th>
<th>Delta Transway</th>
</tr>
</thead>
<tbody>
<tr>
<td>New business activities</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Technological spin-off</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Extra benefits for consumers</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

0 = no effect, + = positive effect, - = negative effect

This resulted in the overview shown in Table 6-2. All the effects were calculated as Net Present Values until 2042. The transport benefits were calculated by multiplying the Value of Time for cars and trucks by the saved lost vehicle hours following from a small traffic simulation model.

Also the external effects of the two cases have been analysed. On road safety, the increase in users of the road has a negative effect on the frequency of accidents, but a positive effect of Delta Transway is that it is not possible to overtake. Noise and air pollution will increase due to the increase of traffic intensities. The N279 and its surroundings do not belong to special areas mentioned in the EU Habitat and Bird Directive which results in a ‘neutral’ effect for the indicator nature.

Indirect effects that were taken into account are ‘new business activities’, ‘technological spin-off’ and ‘extra benefits for consumers’. Both the project cases offer the possibility to develop new business activities on the industrial areas along the N279 as they are ‘opened up’ better.
by the new infrastructure. For Delta Transway the focus will be on business related to freight transport, for the 2x2 alternative the business activities have a more general character. Because Delta Transway is an innovative concept, it can have a positive effect on the image of the Netherlands as innovative economy and the competitive position of the companies involved. The third indirect effect is the lower price that the consumer pays for transport if the transport sector benefits from guaranteed travel times.

On the costs of the alternatives the following can be concluded:

Delta Transway turns out to be more expensive. The difference is 7 million euros, which is only 3.5% of the total costs. The extra costs are caused by:

- Extra building costs for the connections with the industrial estates which are also the entry and exit points of Delta Transway
- Extra engineering costs, other additional costs and unforeseen project costs because of the extra building costs (these costs estimations are a percentage of the building costs)
- Operational costs

Because the differences in costs between the project alternatives are all extra costs for Delta Transway, Delta Transway will always turn out to be more expensive then the 2x2 alternative. It is however questionable whether a difference of only 3.5% is significant. Interesting is that 2/3 of the construction costs (which is 97% of the total costs) is caused by the building costs, and these building costs only differ 3 million euros as a result of the connections of Delta Transway with the industrial estates.

On the direct transport benefits of Delta Transway, the conclusion can be drawn that Delta Transway turns out to have fewer benefits than the 2x2 alternative. The difference however is only 3.8%. Interesting to see is that for Delta Transway all the benefits are for the freight transport while for the 2x2 alternatives only a bit less than half of the benefits is for the freight transport sector.

Concerning the results of the direct transport benefits, some remarks can be made on the model: Because the model does not take into account the surroundings of the N279, the number of trucks that might use one of the project cases might be bigger. The same holds for the fact that 2004 intensities were used. Furthermore the model takes not into account the part between Helmond and the A67 which leads to less saved vehicle hours and results of better circulation were not included and only rush hours were taken into account.

A last remark that can be made on the model is the capacity that is added for the alternatives. For the 2x2 alternative the standard capacity for a provincial road is added, for Delta Transway only 200 pae per hour per direction is added. This is the current intensities of trucks. However, when Delta Transway would be implemented, probably more trucks would use the system than that use the N279 now.

Besides the remarks on the model, also a remark can be made on the Values of Time chosen. Not taken into account is the fact that AVV expects the Value of Time to rise until 2020. (AVV, 2005b). This would increase the benefits of both the alternatives. However, if the Value of Time for freight transport will increase faster than the Value of Time for passenger transport, the benefits of Delta Transway could become more than the benefits of the 2x2 alternative. In general it can be said that the estimations made are very conservative, they define the lower boundary of the possible results.

It turns out that the costs for Delta Transway are 7 million euros higher, and the benefits are 4 million euros lower than for the 2x2 alternative. So a logical conclusion is that the 2x2 alternative is a better alternative than Delta Transway is. However, some remarks can be made on that conclusion.
For both the costs and the benefits, the difference between the alternatives is small. Delta Transway will always be more expensive than the 2x2 alternative, because of the investments specific for Delta Transway, but the difference is only 3.5% of the total costs. Knowing that the uncertainty of the estimations is 30%, this 3.5% difference is not that significant.

On the direct transport benefits, the remark can be made that the estimations of the benefits of Delta Transway are very conservative. As earlier explained the model that estimates the direct transport benefits included a lot of assumptions that were needed to be able to construct a simple model within a short period of time, but these assumptions do influence the outcomes, for Delta Transway in a conservative way. Also for the Value of Time used in the calculations of the direct benefits, the conservative assumption is made that users do not value time higher in the future. This assumption however holds for both the alternatives.

Besides these social costs and benefits, also the benefits for the potential investors have been analysed. It turns out that with 8000 paying vehicles per hour and a fee of 5 euro per paying truck, the Net Present Value of the benefits minus the costs in 2042 is 120 million euro negative and the Internal Rate of Return 0.42%. See also Table 6-3. On the investments and returns for potential investors, the conclusion can be drawn that Delta Transway is not an interesting concept to invest in. However, some remarks can be made on this conclusion. Construction of infrastructure is always very expensive. The high costs of the infrastructure can in this case, and not only in this case, not be invested only by private investors. It would be interesting to look at possibilities for investments by government and private parties together.

One way the investments could be shared is to see Delta Transway a system that is not always used. When the system is not used, on times when no extra capacity is needed, the lanes can be used as normal roads. This needs some extra investments to make sure to the road users if they are allowed to make use of the lanes. The government could then pay for the part of the investments that belongs to the moments that everyone can make use of it and the private investors for the Delta Transway part. This possibility could be analysed more in detail to see whether it’s a feasible solution.

Table 6-3 NPV & IRR for Delta Transway

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Delta Transway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount rate is same as for social costs and benefits NPVs</td>
<td>7%</td>
</tr>
<tr>
<td>NPV Investments same as NPV social costs</td>
<td>206 million euros</td>
</tr>
<tr>
<td>Fee per truck</td>
<td>€ 5 (€0.10 per km)</td>
</tr>
<tr>
<td>Number of trucks per day</td>
<td>8000</td>
</tr>
<tr>
<td>Days per year</td>
<td>261</td>
</tr>
<tr>
<td><strong>NPV</strong></td>
<td></td>
</tr>
<tr>
<td>NPV investments – cumulous 2042</td>
<td>206 million euros</td>
</tr>
<tr>
<td>NPV fees – cumulous 2042</td>
<td>86 million euros</td>
</tr>
<tr>
<td>NPV cumulous benefits minus costs in 2042:</td>
<td>-120 million euros</td>
</tr>
<tr>
<td><strong>IRR</strong></td>
<td>0.42%</td>
</tr>
</tbody>
</table>
Main question

The answers on the sub questions above provide the answer on the main question: “What are the social costs and benefits of the implementation of Delta Transway for freight transport on bottlenecks in the Dutch national and regional road infrastructure, and where and how can Delta Transway be applied in such a way that its positive results are maximized?”

On the one hand, it is difficult to draw general conclusions. On the other hand, the case study shows that the social costs are high and the social benefits do not go beyond the social benefits of regular capacity improvement. However if the policy is explicitly to give priority to freight transport, Delta Transway has the advantage that all the direct transport benefits are given to this sector and the costs are not significantly higher. In this study some bottlenecks for freight transport on which Delta Transway might be a feasible solution are identified, these bottlenecks however should be analysed more in detail before conclusions can be drawn. The criteria following from the system description, from similar concepts and from the actor analysis should be taken into account for a successful analysis and implementation of Delta Transway.

6.2 Recommendations

In this section several recommendations are made to ARCADIS concerning the future development of Delta Transway. Some recommendations follow directly from experiences with analyses that have been carried out in this study, other recommendations follow from broader experiences during this research.

A question that is left unanswered in this study is what the exact effect is of separate freight lanes on the circulation of traffic. This question could be answered by making a detailed traffic model, which was not possible within the scope of this research, but could be useful for a more detailed insight in the transport benefits of Delta Transway.

Because of limitations in models and data, it was not possible to include the surroundings of the N279 into the model that was made to estimate the transport benefits. These limitations however do influence the output of the model, and therefore it is recommended to use more detailed models when analysing cases.

To get a better idea on the benefits of Delta Transway is would be useful to investigate the number of freight transporters that would use Delta Transway and their willingness to pay. The willingness to use the system determines the success of the concept. A stated preference study in which freight transport companies can express their choices in specific situations could be a method to analyse this.

Another aspect of Delta Transway that can be investigated in more detail is the design of the ICT system behind Delta Transway: for instance the system that registers the users, an enforcement system and the back office. Designing this system element would give a better insight in the specific costs and needs for Delta Transway.

In the previous section the conclusion was drawn that for private investors alone Delta Transway is not an interesting concept to invest in. However, as mentioned also in the conclusions combinations of private and public investments could be an interesting possibility. This possibility has to be analysed more in detail however. It is recommended to study on feasible options in which both public and private investments are made.
A last recommendation is to investigate what the effect would be of the use of Delta Transway by business travellers by car. Interesting would be the effect on the circulation and on the financial feasibility of Delta Transway. The original concept Delta Transway separates the trucks from the cars, this however reduces the target group.

6.3 Reflection

This reflection is a review on the study that is described in this report.

Early on in this project, during the lunch meeting with the advisory panel in which potential stakeholders of Delta Transway were present, it turned out that everyone has other ideas on what Delta Transway is and how it should be implemented. This emphasized the need for a clear system description on what Delta Transway is in this study. The choice was made to focus on Delta Transway as it could be implemented with existing proved technology. Looking back, that choice resulted in a case study that is linked very closely to reality.

One of the sub questions was to identify the bottlenecks for freight transport on national and regional level. On national level the severity of congestion figures make it possible to compare road sections, on regional level it turned out to be much more difficult to get an overview. This took more time than planned and resulted in the more theoretical section 3.3. about the ways of measuring bottlenecks for freight transport.

The selection of a suitable case for the case study was more difficult than expected. A lot of information on the location and the situation is necessary to make a proper choice. This information is hard to obtain and difficult to specify. Finally the N279 was chosen above a number of other bottlenecks mainly on the argument of commitment by authorities. This resulted in stakeholders that were willing to provide extra information on the situation, which was necessary to complete the case study. Looking back, the argument on commitment was a smart one to use because the extra information was valuable and the commitment improved the relevance of the case.

The expectation was that an existing transport model could be used to estimate the transport benefits. However, this model turned out to make assumptions on the situation in such a way that the results were influenced significantly. However, no other model was available, and finally conclusions could be drawn, but with some important side notes.

Six months is not much time to spend on discovering all the ins and outs of an innovative transport concept, talking with stakeholders, writing a research proposal, making a system description, identifying bottlenecks in the Netherlands, doing a cost-benefit analysis and writing a report. Fortunately it was possible in eight months. Looking back, it is the cost-benefit analysis that offered the most concrete picture on the feasibility of Delta Transway. The other chapters however were partly necessary to come to the cost-benefits analysis. If more time could have been spent on the study, a more thorough analysis of the possibilities of public and private investment could have been made, this is now recommended for future research.
References

ARCADIS
Several non-published reports and impressions on Delta Transway are used which are property of ARCADIS INFRA B.V.

AVV Transport Research Centre, 2004 “Ontwikkelingen verkeer en vervoer 1990-2020” Probleemverkenning voor de Nota Mobiliteit”

AVV Transport Research Centre, 2005a
“Het Vrachtverkeer in de Spitsperioden op het Hoofdwegennet”, pp 22.

AVV Transport Research Centre, 2005b
“Kengetallen Value of Time personenvervoer, basisjaar 2005”

AVV Transport Research Centre, 2006 “Methodewijziging Fileregistratie”
Website last visited on May 17th 2006

Bruijn, J.A. de, Heuvelhof, E.F., ten, Veld, R.J. in ‘t, 2002
“Procesmanagement, over procesontwerp en besluitvorming.” Tweede herziene druk Schoonhoven: Academic Service

Cobouw online – New item
Published on September 30th 2006
Website last visited on October 4th 2006
http://www.cobouw.nl/cobouw.nieuws/toonnieuwsartikel.jsp?di=263670


Enserink, B, Koppenjan, J.F.M., Thissen, W.A.H., 2002 “Analyse van complexe omgevingen” Diktaat voor TB211. Delft University of Technology, Faculty of Technology, Policy and Management

European Commission – Nature & Diversity – website
“EU Habitat and Bird Directive”
EVO – website
Last visited on July 28th 2006
www.evo.nl

Gelderland Province, data provided by Freek Peul on May 22th 2006

GOVERA - website
Website last visited on July 28th 2006
www.govera.info

GOVERA, 2006. “Kwaliteitsnetwerk Goederenvervoer Randstad”
Available for download at www.govera.info

EU Habitat and Bird Directive – effectenindicator
Website last visited on October 10th 2006


INCODELTA – website
Website last visited on September 21st 2006
http://www.incodelta.nl/projecten/kwaliteitsnet.html

Ingenieur, de (2005, June 10th) “Reserveren op de snelweg”

Manshanden, W.J.J., Jonkhoff, W., Bruijn, P.J.M. de, Newrly, S.B., Koops, R.M., 2005
“Randstad Holland in internationaal perspectief” TNO (Bouw en Ondergrond) pp. 77

Ministry of Agriculture, Nature and Food quality – website
Website last visited on October 10th 2006

Ministry of Economic Affairs - website
Website last visited on July 27th 2006
http://www.minez.nl

Ministry of Housing, Spatial planning and the Environment - website
Website last visited on July 27th 2006
http://international.vrom.nl/pagina.html?id=7319

Ministry of Transport, Public Works and Water Management - website
Website last visited on July 27th 2006
http://www.verkeerenwaterstaat.nl/english/

Ministry of Transport, Public Works and Water Management – News item
Published on September 15th 2006
Website last visited on October 4th 2006
http://www.verkeerenwaterstaat.nl/actueel/nieuws/kosteninvoeringkilometerprijsdal
Ministry of Transport, Public Works and Water Management – Van OEEI naar OEI
Website last visited on November 9th, 2006
http://verkeerenwaterstaat.nl/onderwerpen/mobiliteit%5Fen%5Fbereikbaarheid,080% 5FOverzicht%5FEffecten%5FINfrastructuur%5Fachtergrond%5F5Fgeschiedenis#2

Ministry of Transport, Public Works and Water Management
Onderzoeksprogramma Effecten Infrastructuur (OEI)
Website last visited on July 17th, 2006
http://www.minvenw.nl/cend,bei,wiatiseenoei,eenoverzicht,index.aspx

MIT projectenboek 2006 (Meerjarenprogramma Infrastructuur & Transport)
Website last visited on August 11th 2006
http://www.minvenw.nl/dgp/mitprojectenboek/2006/projectenboek.html

“Costs and benefits of noise abatement measures” Transport Policy Volume 10 pp. 131-140

MOBIS,
Figures from website, last visited on May 29th 2006
http://www.mobis.databank.nl/

Noord-Brabant Province
“Wegenkaart Provincie Noord-Brabant” Beheersituatie 1 september 2005

Noord-Holland Province, “Verkeersgegevens”
Website last visited on May 30th 2006

Noord-Holland Province, “Wegenkaart Noord-Holland”

NOS - website
Website last visited on July 26th 2006


Nota Ruimte, 2006. Ministry of Housing, Spatial Planning and the Environment
http://www2.vrom.nl/notaruimte/

OEI part I – Onderzoeksprogramma Effecten van Infrastructuur, 2000
“Evaluatie van Infrastructuurprojecten; Leidraad voor kosten-baten analyse”
Deel I hoofdrapport

OEI part II - Onderzoeksprogramma Effecten van Infrastructuur, 2000
“Evaluatie van grote infrastructuur projecten; Liedraad voor kosten-baten analyse”
Deel II capita selecta
Website last visited on July 26th 2006
http://www.delta.tudelft.nl/archief/j27/15140

Chapter 2 – 4

Port of Rotterdam Authority - website
Website last visited on July 28th 2006
www.portofrotterdam.com

Rand Europe, SEO & Velkamp NIPO, 2004
“Hoofdonderzoek naar de reistijdwaardering in het goederenvervoer”
Report TR-154-AVV in commission of AVV

Reader spm9421, ‘Risicobeheersing en Management’ 2005
Compiled by J.A.A.M. Stoop

Rietveld, P., 2002

Risicokaart – website
Website last visited on October 8th 2006
www.risicokaart.nl

Schiphol Group - website
Website last visited on July 28th 2006
www.schipholgroup.nl

Sloot, M. van der, 2002. “Van A naar B met ΔTransway” ARCADIS

Smits, W., 2002. “Stakeholder Analysis of a Guided Transport System” Master Thesis Faculty of Technology, Policy and Management, Delft University of Technology

In: Bijdragen Vevoerslogistieke werkdagen 2004 Deel I

Stiller Verkeer – website
Website last visited on October 9th 2006
http://www.stilerverkeer.nl/index.php?section=rmv&subject=RMW02&page=SRM1

TLN – website
Last visited on July 28th 2006
www.tln.nl

TLN – figures ‘economische schade’
Website last visited on May 17th 2006
http://www.tln.nl/media/PDF/Rapporten/Hoofdstuk_Infrastructuur.pdf
TNO, 2001
“Core centra en vestigingskeuze” TNO-report 01 R 007 51091


Utrecht Province, facts and figures
Website last visited on May 30th 2006
http://www.provincie-utrecht.nl/prvutr/internet/verkeerenvervoer.nsf/all/20.0.0?opendocument

“Pilot N408, van busbaan naar doelgroepstrook”.
Report commissioned by the Ministry of Transport, Public Works and Water Management

“Kosten-baten analyse van verkeersveiligheidsmaatregelen, een methodische verkenning”
SWOV-publication, R-2003-32

European Communities, pp. 70

Zuid-Holland Province, “Wegen en Vaarwegen in Zuid-Holland”
Appendices
A. Advisory panel

The organisations that act as an Advisory Panel are:

- Port of Rotterdam (Havenbedrijf Rotterdam)
- Schiphol Airport
- Dutch Flower Auctions Association (Vereniging van Bloemenveilingen (VBN)).
- EVO, an association for the interests of shippers and companies who take care of their own transport (Eigen Vervoorders Organisatie)
- TLN, an association for the interest of transport companies and logistic service providers (Transport & Logistiek Nederland)
- VNO NCW West, the employers’ organisation for the provinces Noord-Holland and Zuid-Holland
- Ministry of Transport, Public Works and Water Management
- Connexxion, a public transport company
- INCODELTA, a cooperative body in which the provinces Limburg, Noord-Brabant, Zuid-Holland and Zeeland, the regional departments of the Directorate-General of Public Works and Water Management, environmental organisations and industry develop projects together.
- GOVERA, a cooperative body in which the provinces Noord-Holland, Zuid-Holland, Utrecht and Flevoland, the regional departments of the Directorate-General of Public Works and Water Management, the Bureau for inland shipping (BVB), EVO, TLN, the communities of Amsterdam, Rotterdam, Den Haag and Utrecht and the chambers of commerce develop projects together.
- Logica CMG, business process and IT consultant
- Bouwfonds, international property company
- National Platform Anders Betalen voor Mobiliteit, a committee who advised the government on road pricing
- Environmental organisations (Zuid-Hollandse Milieufederatie)
B. Regional bottlenecks for freight transport - figures

The road sections that are crossed out do not meet the following conditions that have to be met:
- The I/C-ratio has to be > 0.6
- The intensity has to be > 4000

Zuid-Holland

Table C-0-1 Sections N-roads with more than 4000 trucks per 24-hours in Zuid-Holland (GOVERA, 2006)

<table>
<thead>
<tr>
<th>Road</th>
<th>Description</th>
<th>From</th>
<th>To</th>
<th>Trucks on working days per 24-hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>N207</td>
<td>Provinciale weg</td>
<td>N210 Goenjanverwe</td>
<td>4040</td>
<td></td>
</tr>
<tr>
<td>N209</td>
<td>Gemene weg</td>
<td>N455 Dorpstraat</td>
<td>4062</td>
<td></td>
</tr>
<tr>
<td>N209</td>
<td>Gemene weg</td>
<td>Dorpstraat</td>
<td>N11</td>
<td>5178</td>
</tr>
<tr>
<td>N211</td>
<td>Nieuweweg</td>
<td>N211 Madepolderweg</td>
<td>4070</td>
<td></td>
</tr>
<tr>
<td>N211</td>
<td>Zuidwestelijke randweg</td>
<td>N466 A4</td>
<td>4929</td>
<td></td>
</tr>
<tr>
<td>N213</td>
<td></td>
<td></td>
<td>5812</td>
<td></td>
</tr>
<tr>
<td>N218</td>
<td>Hartelweg</td>
<td>A15 N493</td>
<td>4786</td>
<td></td>
</tr>
<tr>
<td>N466</td>
<td></td>
<td></td>
<td>4574</td>
<td></td>
</tr>
<tr>
<td>N470</td>
<td>Oostweg</td>
<td>Berckelseweg</td>
<td>Scheglaan</td>
<td>5607</td>
</tr>
</tbody>
</table>

Noord-Holland

Table C-0-2 Sections N-roads with more than 4000 trucks per 24-hours in Noord-Holland (Noord-Holland Province)

<table>
<thead>
<tr>
<th>Road</th>
<th>Description</th>
<th>From</th>
<th>To</th>
<th>Trucks on working days per 24-hours</th>
<th>I/C-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>N201</td>
<td>Kruisweg</td>
<td>V.H. Goedhartlaan</td>
<td>Rijksweg A4</td>
<td>8352</td>
<td>0,41</td>
</tr>
<tr>
<td>N201</td>
<td>Kruisweg</td>
<td>Aalsmearerderweg</td>
<td>Fokkerweg</td>
<td>7581</td>
<td>0,74</td>
</tr>
<tr>
<td>N201</td>
<td>Kruisweg</td>
<td>Fokkerweg</td>
<td>Aalsmeerderdijk</td>
<td>7456</td>
<td>0,61</td>
</tr>
<tr>
<td>N201</td>
<td>Burg. Kasteleinweg</td>
<td>Aalsmeerderdijk</td>
<td>V.Cleefkade/Oosteinderweg</td>
<td>6448</td>
<td>0,52</td>
</tr>
<tr>
<td>N201</td>
<td>Burg. Kasteleinweg</td>
<td>V. Cleefkade/Oosteinderweg</td>
<td>Zwarteweg</td>
<td>6448</td>
<td>0,52</td>
</tr>
<tr>
<td>N201</td>
<td>Kruisweg</td>
<td>Rijksweg A4</td>
<td>Aalsmeerderweg</td>
<td>5692</td>
<td>0,56</td>
</tr>
<tr>
<td>N242</td>
<td>Provincialeweg</td>
<td>N244 Westdijk</td>
<td>N243 N.vaart/Omval</td>
<td>5122</td>
<td>0,69</td>
</tr>
<tr>
<td>N242</td>
<td>Ommering</td>
<td>Diamantweg/Bestevaerstraat</td>
<td>Leeghwaterbrug</td>
<td>4811</td>
<td>0,65</td>
</tr>
<tr>
<td>N242</td>
<td>Ommering</td>
<td>Leeghwaterbrug</td>
<td>N244 Westdijk</td>
<td>4811</td>
<td>0,65</td>
</tr>
<tr>
<td>N242</td>
<td>Westerweg</td>
<td>N243 N.vaart/Omval</td>
<td>N508 Huygendijk/N508 Nollenweg</td>
<td>4520</td>
<td>0,61</td>
</tr>
<tr>
<td>N207</td>
<td>Leimuiderweg</td>
<td>Rijksweg A4</td>
<td>Verbindingsweg Hoofdvaart</td>
<td>4208</td>
<td>0,27</td>
</tr>
</tbody>
</table>
Utrecht

Table C-0-3 Sections N-roads with more than 4000 trucks per 24-hours in Utrecht (2004) (Source: Utrecht Province, facts and figures)

<table>
<thead>
<tr>
<th>Road</th>
<th>Description</th>
<th>From</th>
<th>To</th>
<th>Trucks on working days per 24-hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>N201.01</td>
<td>Mijdrechtse Zuwe</td>
<td>Provinciegrens</td>
<td>Piet Heinlaan</td>
<td>4008</td>
</tr>
<tr>
<td>N210.29</td>
<td>Provincialeweg</td>
<td>Utrechtseweg/estelijke toe/afrit A2</td>
<td>oostelijke toe/afrit A2</td>
<td>4813</td>
</tr>
<tr>
<td>N230.03</td>
<td>Zuilense Ring</td>
<td>noordelijke toe/afrit A2</td>
<td>Utrechtseslag</td>
<td>4181</td>
</tr>
<tr>
<td>N230.05</td>
<td>Zuilense Ring</td>
<td>Utrechtseslag</td>
<td>Amsterdamse slag</td>
<td>4048</td>
</tr>
<tr>
<td>N408.03</td>
<td>Plettenburgerbaan</td>
<td>Houtenseweg (N409)</td>
<td>Ravenswade/Ravensewering</td>
<td>4001</td>
</tr>
<tr>
<td>N408.05</td>
<td>Laagravenseweg</td>
<td>Ravenswade/Ravensewering</td>
<td>Rijksweg A2</td>
<td>5346</td>
</tr>
</tbody>
</table>

Noord-Brabant

Table C-0-4 Sections roads on province level with more than 4000 trucks per 24-hours in Noord-Brabant (MOBIS)

<table>
<thead>
<tr>
<th>Road</th>
<th>Description</th>
<th>Percentage freight transport on working days [%]</th>
<th>Trucks on working days per 24-hours</th>
<th>I.C.-ratio [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>N261</td>
<td>Loon op Zand - Efteling</td>
<td>10,6</td>
<td>4232</td>
<td>0,42</td>
</tr>
<tr>
<td>N279</td>
<td>Berlicum - Dungense brug</td>
<td>20,1</td>
<td>4941</td>
<td>1,03</td>
</tr>
<tr>
<td>N279</td>
<td>Dungense Brug - Ind. terr. De Brand</td>
<td>21,9</td>
<td>5756</td>
<td>1,33</td>
</tr>
<tr>
<td>N279</td>
<td>Heeswijk - Middelrode</td>
<td>21,4</td>
<td>4643</td>
<td>0,87</td>
</tr>
<tr>
<td>N279</td>
<td>Ind. terr. De Amert - Dinther</td>
<td>21,2</td>
<td>5047</td>
<td>0,88</td>
</tr>
<tr>
<td>N279</td>
<td>Ind. terr. De Brand - Rijksweg A2</td>
<td>19,1</td>
<td>5990</td>
<td>1,17</td>
</tr>
<tr>
<td>N279</td>
<td>Middelrode - Berlicum</td>
<td>21</td>
<td>4682</td>
<td>0,91</td>
</tr>
<tr>
<td>N279</td>
<td>Veghel - NCB-Laan</td>
<td>25,8</td>
<td>4684</td>
<td>0,69</td>
</tr>
<tr>
<td>N284</td>
<td>De Stuiver - Rijksweg 67</td>
<td>14</td>
<td>4239</td>
<td>1,48</td>
</tr>
<tr>
<td>N329</td>
<td>Rijksweg 50 - Oss</td>
<td>18,8</td>
<td>4179</td>
<td>0,89</td>
</tr>
</tbody>
</table>

Gelderland

Table C-0-5 Road sections on province level with more than 4000 trucks per 24-hours in Gelderland (Gelderland Province)

<table>
<thead>
<tr>
<th>N-road</th>
<th>Description</th>
<th>Trucks on working days per 24-hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>A325</td>
<td>Aansluiting A15 noord</td>
<td>5964</td>
</tr>
<tr>
<td>A325</td>
<td>Matsersingel</td>
<td>4421</td>
</tr>
<tr>
<td>N325</td>
<td>Ir. Molsweg</td>
<td>6845</td>
</tr>
</tbody>
</table>
C. Regional bottlenecks for freight transport - maps

Zuid-Holland

Figure D-0-1 Bottlenecks for freight transport in Zuid-Holland on regional level (Zuid-Holland Province)
Figure D-0-2 Bottlenecks for freight transport in Noord-Holland on regional level (Source: Noord-Holland Province)
Noord-Brabant

Figure D-0-3 Bottlenecks for freight transport in Noord-Brabant on regional level (Source: Noord-Brabant Province)
Actors and Stakeholders

Ministry of Transport, Public Works and Water Management
The main interests of the ministry are to “protect the Netherlands against the negative influences of water and providing it with safe, world-class connections”. (Website Ministry of Transport, Public Works and Water Management). These interests are specified (in goals) in the Nota Mobiliteit (2004). One of the important goals is the accessibility of the economic centres in the Netherlands, which implies the need for well functioning infrastructure networks. The ministry is interested in the development of concepts like Delta Transway if it turns out it can optimize the capacity use on the national roads with relatively low costs.

Ministry of Housing, Spatial planning and the Environment
The main interest of the Ministry of Housing, Spatial planning and the Environment is a permanent quality or the living environment (Website Ministry of Housing, Spatial planning and the Environment). To specify these interests in goals, the Nota Ruimte is published. In this policy document, the policy goals of the ministry are set. For Delta Transway, this ministry is important because of the ‘MER-procedure’ and the ‘Tracewet’ which is legislation on the construction of new infrastructure.

Ministry of Economic Affairs
The interest of the Ministry of Economic Affairs is to stimulate sustainable economic growth in the Netherlands (Website Ministry of Economic Affairs). One of the goals of the ministry is to stimulate innovation. Because Delta Transway is an innovative transport concept that can have a positive effect on the economy by offering guaranteed travel time, this ministry is also included in the list of actors.

Province and cooperative bodies in which provinces participate
The provinces have an important interest in the accessibility and reliability of its road network. They are responsible for the regional road network. Besides this responsibility the province also is an important actor in the spatial planning of activities. Provinces that facilitate a lot of freight transport cooperate in organisations that, together with companies, environmental organisations, and Rijkswaterstaat, work on joint solutions for freight transport problems in these provinces. For Noord-Holland, Zuid-Holland, Utrecht and Flevoland, this is GOVERA (see also the website of GOVERA), for Limburg, Noord-Brabant, Zeeland and Zuid-Holland this in INCODELTA (see also the website of INCODELTA). Because provinces are obviously searching for the best ways to keep their cities and industrial areas accessible, they are interested in concepts like Delta Transway.

Local authorities (communities as well as cooperative bodies in which they participate)
The main interest of the local authorities is the quality of living of its residents. Often freight transport is therefore seen as undesirable, it should not use the local roads. On the other hand, local authorities want to attract companies to create employment and stimulate the local economy. For Delta Transway it will differ strongly per local authority what their specific goals are. Often local authorities cooperate in regional bodies to solve problems that are relevant for several authorities or to develop the region together. The perceptions, interests and goals are strongly related to those of the local authorities.
Trucking companies and branch organisations

The interest of trucking companies is to maximise their profits and the continuity of their company. Congestion means for them that they need more time to deliver, which can usually not be passed on to the customer. Extra travel time is expensive because of labour costs, one of the most important factors in the total transport costs. These companies have two main branch organisations that take care of the interests of the transport sector, EVO and TLN.

The organisation EVO (Eigen Vervoerders Organisatie) takes care of the interests of 30,000 shippers, receivers and transporters (also companies that do their own transport) in the Netherlands and wants to increase the return of the members by stimulating accessibility solutions and increasing the efficiency of freight streams. From this accessibility view, EVO is interested in the developments around Delta Transway. (See also the website of EVO). TLN is a branch organisation for freight transport and logistic services with focus on road transport (see also the website of TLN). As well as EVO they are interested in the developments around Delta Transway because the guaranteed travel time that Delta Transway offers might be interesting for the transport sector.

Public transport companies

These companies offer a transport service to the customer and want to maximise their profit. Because of the system of contracting out by the government, also the quality of the service is very important. For these companies, a trip booking system can be an advantage, because of the guaranteed travel time. However, if Delta Transway is implemented on a lane that used to be a bus lane, only in use by buses, the public transport company will not like the idea of sharing space with other road users.

Developers of hardware and software for Delta Transway

Potential implementation of Delta Transway would be interesting for companies that can develop the ICT system behind it. After this is implemented it has to be operated and maintained, which is also potential work for the developers. The main interest of these companies is to maximize their profits.

Mainport authorities

With the mainport authorities, the Port of Rotterdam Authority and the Schiphol Groups are meant. The port of Rotterdam Authority is the organisation that exploits the port, coordinates the processes and provides services to the companies located at the port and their customers. It facilitates economic activities and wants to develop the port to a world-class port with a strong competitive position in Europe (see also the website). Therefore it is important to make sure the accessibility of the landside of the port, especially to the hinterland, is up to certain standards. It because of this interest, the Port Authority is willing to think along with ideas that might improve this accessibility. Depending on the potential location of Delta Transway the port authority might be interested in implementation.

The Schiphol Group has shares in several airports, but it is also responsible for the exploitation of the biggest airport in the Netherlands, Schiphol (seen also the website). By creating extra services to passengers and companies, a dynamic environment around the multi modal interchange is created. One of the main interests of the Authority is to retain and strengthen the competitive position of the airport. For this competitive position the accessibility of the airport is of major importance, which explains their willingness to participate in initiatives that might increase this accessibility, just like the Rotterdam port authority wants for the Port of Rotterdam.
**Investment companies**
For the realisation of Delta Transway it is necessary to do investment in the infrastructure that is needed. These investments can be done by the government, but an alternative is to involve investment companies. Their interests are to maximise profit, and their analysis on the feasibility of making profit will define whether they want to take part in a consortium. They do not have direct interests in a potential realisation of Delta Transway.

**Environmental organisations**
Depending on the location of Delta Transway, environmental organisations might disagree with the construction of extra infrastructure. The use of Delta Transway does imply dedicated infrastructure which is often seen as ‘extra’ infrastructure. Their interests are to preserve the nature in the Netherlands which can be contradictory to the interests of the implementation of Delta Transway. Another aspect that environmental organisations mention is that Delta Transway might attract more traffic which causes more pollution and noise.

**Residents of potential locations of Delta Transway**
Residents in generally do not like to get new infrastructure ‘in their backyard’. This can result in a lot of resistance against plans and therefore a lot of delay. It depends on the specific location whether residents will have inconvenience of noise and pollution. This resistance is probably not against Delta Transway in itself, but against extra traffic.
D. Preferential alternative BOSE

Figure G-0-4: Preferential alternative (Source: ARCADIS)
E. Standard Calculation Model (SRM1) – Noise

**SRM1 in RMW2002**

<table>
<thead>
<tr>
<th>Verkeersgegevens:</th>
<th>Dag:</th>
<th>Avond:</th>
<th>Nacht:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personenwagens per uur</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Snelheid personenwagens</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Lichte vrachtwagens per uur</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Zware vrachtwagens per uur</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Snelheid zwaar verkeer</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

| Wegdeeltype               | DAB 11/16 (referentie) |

**Omgevingskenmerken:**

<table>
<thead>
<tr>
<th>kenmerk</th>
<th>waarde</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoogte weg</td>
<td>0</td>
</tr>
<tr>
<td>Horizontale afstand tot midden van weg</td>
<td>25</td>
</tr>
<tr>
<td>Hoogte van waarnemer</td>
<td>5</td>
</tr>
<tr>
<td>Zichthoek (127 graden = volledig)</td>
<td>1.27</td>
</tr>
<tr>
<td>Fractie absorberend oppervlak (0=hard; 1=zacht)</td>
<td>0</td>
</tr>
<tr>
<td>Percentage reflectie van overzijde (0=geen; 1=volledig)</td>
<td>0</td>
</tr>
<tr>
<td>Afstand tot reflecterend oppervlak overzijde</td>
<td>0</td>
</tr>
<tr>
<td>Hoogte van reflecterend oppervlak (minstens 5m)</td>
<td>0</td>
</tr>
<tr>
<td>Afstand tot kruispunt (0=geen kruispunt)</td>
<td>0</td>
</tr>
<tr>
<td>Afstand tot minirotonde (0=geen minirotonde)</td>
<td>0</td>
</tr>
<tr>
<td>Afstand tot drempel (0=geen drempel)</td>
<td>0</td>
</tr>
</tbody>
</table>

**Resultaten:**

| Berekende geluidniveau in $L_{eq}$ | 0 |
| Berekende geluidniveau in $L_{den}$ | 0 |
| Berekende geluidniveau in $L_{night}$ | 0 |

*Figure I-0-5 SRM1 (Source: website 'Stiller verkeer')*