Towards a suitable quick scan transport model

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adviseurs mobiliteit
Goudappel Coffeng

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www.goudappel.nl
goudappel@goudappel.nl

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Graduation committee

Chairman (TU Delft)	Prof. Dr. Ir. S.P. Hoogendoorn
Daily supervisor (TU Delft)	Dr.ir. J.W.C. van Lint
External daily supervisor (Goudappel Coffeng BV)	Ir. H. Palm
External support	Drs. V.L. Knoop
General support	Ir. P. Wiggenraad

Preface

This master thesis is a result of the study during my graduation at Technical University Delft, conducted at Goudappel Coffeng BV in Deventer. I studied the opportunities for developing a suitable quick scan tool for fast and coarse evaluations of transportation alternatives. Reading this document requires general knowledge of traffic simulation models.

First of all this report is written for the completion of my Master Transport & Planning on the faculty Civil Engineering. Also the report will be valuable for Goudappel Coffeng BV, because with the results of this research they can anticipate on the questions from customers. Finally the new developed quick scan method is an innovative method that is interesting for the Technical University of Delft.

Using this opportunity, I would like to thank several people who gave me support during my days at Goudappel Coffeng BV and during my graduation period. I want to thank Henri Palm for always being available when I wanted to discuss. A second word of thanks goes to Kobus Zantema who helped me with developing the new quick scan method. From the university I want to thank Hans van Lint for asking the right questions. Also the rest of my graduation commission deserve a word of thanks for their time and the meetings on the university.

Deventer, March 2012
Erica de Feijter

Summary

Nowadays traditional traffic simulation models are becoming more complex and more detailed. Often policy questions do not require this level of details and needs faster answers than can be reach with traditional models. Of course traditional traffic simulation models are necessary for the evaluations of transportation alternatives. It is relevant to have next to these complex models, simpler models, such as quick scan tools. With quick scan tools the effect of measurements/alternatives of infrastructure related projects in the strategic and tactical phase can be calculated. Among other things, there is need for quick scan tools for the acceleration of the reconnaissance phase in the "Meerjarenprogramma Infrastructuur, Ruimte en Transport" (MIRT) projects. According to the Projectdirectie Sneller & Beter there are at this moment no suitable quick scan tools for the MIRT-projects. From these findings the central problem follows that in current practice there is need for suitable quick scan tools for fast and coarse evaluations of transportation alternatives. In this thesis the objective is to develop a suitable quick scan tool for fast and coarse evaluations of transportation alternatives.

To develop a suitable quick scan tool, first the application and requirements of quick scan tools needs to be specified. Policy questions in the phase of mind setting and in the reconnaissance phase can be answered with quick scan tools. The application of quick scan tools is at a high level of time, space and travel behaviour simplification. The policy questions can be mostly answered by the calculation of measures focussed at spatial planning, price policy, mobility management, public transport and the changing and extending of infrastructure. These measures require certain output. Quick scan tools should provide at least information about mobility effects and a quick scan tool distinct from other tools and detailed models by also provide the economic, environmental and safety effects.

One of the requirements of a quick scan tool is that it should fit the application. These and other requirements can be divided in functional, performance, quality, output and input requirements and wishes. A quick scan tool differs from detailed models by the short computation time (performance requirement) and the low effort of the end users according to the interviewees. Low effort requires easy applicability and simple input. Other functional requirements are that quick scan tools should at least determine the direct behavioural changes of a measure and be able to assess different alternatives.

The quality requirements are transparency, fitting logical transportation relations, no conflicts with traffic flow theory and visualisation reliability of the output. The output should fit logical transport relations and should not be in contradiction with traffic flow theory. Also a quick scan tool should visualize the reliability of the output, because otherwise the tool will be used by the customers like the model can make accurate predictions.

One of the output requirements is that a quick scan tool requires a clear visualisation, so a tool can be used easily. Further more simple input and wide support for the input is

required. Next to this requirement, the desires of quick scan tools are the connection with existing models and not only calculated the effect on mobility, but also other traffic related effects, such as environmental, economic and safety effects.

Developing a new quick scan tool requires the overview of the existing quick scan tools to know the additional value of a new quick scan tool/method. Seventeen tools in the Netherlands and the United States are investigated. All the tools were in conflict with at least one requirement. The ScenarioVerkenner, Quick filter, Fast Simple Model and eventually also the Mobiliteitsscan are tools that meet almost all the requirements except visualisation of the reliability of the output. A new quick scan tool should provide inside in the reliability of the output. The calculation of the measures for mobility management are hard to determine with the existing quick scan tools. Also from the existing quick scan tools, it could conclude that no tool at this moment can calculate reliable travel times and because of this economic effects. Besides a tool that provides insight in mobility, environment, economy and safety is more likely to succeed, because the calculation of other traffic related effects is a large advantage of a quick scan tool compared to detailed models. Also the high level of time, space and behaviour simplification is often missing in the existing quick scan tools.

In a quick scan tool methods are used to meet the requirements of a quick scan tool. The methods can simplify the data of time, space and travel behaviour. Time simplification can be done by choosing some time periods or taking the sum of multiple time periods. For the spatial simplification, zone simplification, route, link and node simplification can be used. Simplification exists of the simplification, selection or reduction of data or model elements. Also Macroscopic Fundamental Diagrams (MFD) can show the network performance. The MFD is a graph that reflects the outflow of a network compared to the accumulation. Simplified methods can be used to model the travel behaviour; trip generation, modal split, period of day and route assignment.

Next to the simplification techniques some other methods can be used in quick scan tools, such as the incremental approach, elasticities, rules of thumps and demand and supply curves. With the incremental approach only the difference between the new situation and the reference scenario will be calculated without using an integral new equilibrium calculation. Another option is to calculated only the effects on roads with a certain traffic condition, such as congested roads. Elasticities and rules of thumb could make assumptions and so less calculation have to be made during the usage of a quick scan tool. With demand and supply curves the equilibrium between price and demand can be calculated.

From the application, requirements, existing tools opportunities and methods for the development of quick scan tools or method for fast and coarse evaluations of transportation alternatives follow. The high level of simplification can be reached by corridor models. Corridor models are models in which cities/regions are visualized by dots and vectors represent the flows between the dots. A corridor model requires simple input. Another opportunity that will decrease the computation time enormously is spatial simplification based on traffic states. This innovative method offers the chance to develop a quick scan tool that meets the requirements.

In this research the method of spatial simplification based on traffic states is developed. With this method the effect of measures that affects the total network or measures that effects changes in a specific area can be calculated. For the calculation of the measures that affects the total network, only the effect of the measure on the amount of trips is required. This can be determined by elasticities. The method works with an approximation of traffic assignment by interpolation between the traffic flows on a link for two assignments. When using the tool the choice can be made to simulate only certain traffic states. With this link categorization the high level of simplification can be reached. For the measures that affect a specific area, on forehand the advisor needs to define this area and assign the traffic from and to the area, so the distribution is known. With interpolation the effect of the measures in the area will be determined. A disadvantage of the method is that measures that affect certain links cannot be calculated, because this requires a new equilibrium.

The developed method meets the requirements. The method can be used under conditions for spatial planning, pricing policy, mobility management and the improvements of public transport. A disadvantage of the method is that it requires a detailed underlying model, so it could not be used when little data is available.

The model is assessed for spatial planning and pricing policy in the Nationaal Verkeers Model 2.0 (NVM 2.0). The categorization is divided in congested links, critical links or insignificant links. The computation time is less than ten seconds for the calculation of the congested links and 30 seconds for all the links instead of 5000 seconds with the traditional assignment. So the computation time is short and the calculation of only the congested links can be used when visiting a customer and direct results are required. When an advisor is writing a report in the office, the calculation of the other links can also be interesting, but the high level of simplification will be reached by the link categorisation. Certainly the implementation in a quick scan tool will require some extra time to visualize the results.

For the implementation of the method in a quick scan tool, some recommendations are made. To calculate also the travel times correctly, another model than the NVM 2.0, should be used. STAQ, the static assignment model of Goudappel Coffeng BV with the calculation of the effect of congestion and spillback, can be used. For a complete suitable quick scan tool the effect of all the measures should be calculated. The calculation of the effect on the link loads can be calculated with the same scripts as for spatial planning and pricing policy. The used linear function works in the NVM 2.0. It could be that another function will fit better the reality. So by the implementation in STAQ, the recommendation is to investigate this function. Also the opportunities for the calculation of measures that affects a certain link should be investigated. Overall the method of spatial simplification based on traffic condition with interpolation is a good basis of a suitable quick scan tool for fast and coarse evaluations of transportation alternatives.

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Introduction

1.1 Background

Policy makers together with model specialists need quick scan tools to make a quick, simple, but good comparison of alternatives in infrastructure related projects. Nowadays traffic simulation models give direction to political traffic decisions. Traffic models generate traffic data which policy makers use to answer their policy questions. The development of the models heads towards more detailed, complicated and dynamically models. The risk is to lose the connection with the political traffic questions, because the questions do not always requires this level of detail and the customers want to understand the calculation techniques (Kennisinstituut voor Mobiliteitsbeleid, 2010).

1.1.1 Trends traffic simulation models

Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek (TNO, technical research centre) and Dienst Verkeer en Scheepvaart (DVS, governmental department transportation and shipping) developed a roadmap for strategic national traffic simulation models (TNO, 2010). The report contains the insight in the expected future of these models by customers and suppliers of models. TNO expects four development directions; area orientation, indirect effects, traffic simulation and user-friendliness. The development of traffic modelling is especially focused on the dynamisation of static assignment models. The user-friendly innovation focuses on faster and more transparent results, such as quick scan tools.

Besides the dynamisation of the traffic simulation models, the trend is that traffic simulation models will be more complex over time with different consequences:

- Complex models require much time to build, but also to calculate the alternatives.
- Complex and detailed models are not transparent according to Martens & de Jong (2009). The result is a hard prediction of the uncertainties in a model.
- Customers have too high expectations of models. The models are more complex, but still cannot make exact and reliable predictions. Users use the models like they can make accurate predictions (Martens & de Jong, 2009).
- Also not always the complexity is required for a question (Kennisinstituut voor Mobiliteitsbeleid, 2010).

Of course traditional traffic simulation models are necessary for the prediction in infrastructural projects. Martens & de Jong (2009) think it is relevant to have next to these complex models, simpler models. Simpler models, such as quick scan tools, can be the solution for these disadvantages of the current trend, because:

- Quick scan tools requires much less calculation time.
- Quick scan tools are less complex than traditional traffic simulation models and by this they are more transparent.

Another reason for this research is the statement of the department of Transport and Environment about the unsuitability of the model instrumentation to make the integral considerations between economy, environment and safety. One of the causes of the delay is the reconnaissance phase in the "Meerjarenprogramma Infrastructuur, Ruimte en Transport" (MIRT)[1] projects. The commission founded the project direction "Sneller & Beter" to investigate the opportunities for acceleration. From the research it turns out quick scan tools are suitable in the reconnaissance phase of MIRT projects to filter multiple alternative to a few (ca. three). Besides the MIRT the "regionale gebiedsagenda's" and the "nationale markt- en capaciteitsanalyses" (NMCA) are also analyses at strategic level (Kennisinstituut voor Mobiliteitsbeleid, 2010) that requires quick scan tools. Goudappel Coffeng BV detects the demand for quick scan tools also at regional and urban level and wants to investigate the applicability of quick scan tools at tactic level.

1.1.2 Existing quick scan tools

At the moment there are some quick scan tools in development. At the end of 2009 four quick tools are known at DVS (Projectdirectie Sneller&Beter, 2010a):

- Urban Strategy (TNO)
- Fast Simpel Model (Significance)
- Mobiliteitsscan (KPVV/Goudappel Coffeng BV)
- Tiresias (Rijkswaterstaat)

These models are not completely useful for filter 1 in the MIRT-reconnaissance phases yet. Other companies also develop quick scan tools and quick scan applications based on detailed models. In this research the focus will be on the feasibility of traffic engineering principles for simplification of the models.

To summarise, there is need for quick scan tools for measurements/alternatives for infrastructure related projects in the strategic and tactical phase. At this moment the existing traffic simulation models are often too slow, complex and detailed for the strategic phase and sometimes at tactical level.

[1] The MIRT is an investment program of the Central government. She arrange more cohesion between investments in spatial planning, economy, accessibility and livability.

1.2 Problem definition and objective of research

In this section the problem definition and the corresponding objective of this research are defined.

1.2.1 Problem definition

The problem definition of the research is:

In current practice there is need for suitable quick-scan tools for fast and coarse evaluations of transportation alternatives.

A suitable quick scan tool is a tool that fits the expected application of the potential users and requirement of a quick scan tool. Also the model prediction needs to be consistent, so the selection of alternatives by the quick scan tool is the same as the selection of the more detailed underlying model. A suitable quick scan tool is also consistent. The consistency is keeping of the quality of the data by simplification (time, space, travel behaviour) from a detailed model to a quick scan tool.

1.2.2 Objective of research

From the answer of the problem definition, the object of the research follows.

The objective of this thesis is developing a suitable quick scan tool for fast and coarse evaluations of transportation alternatives.

A suitable quick scan tool can also be the development of a promising method for a new quick scan tool.

1.3 Research questions

To develop a suitable quick scan tool, first the application and requirements of quick scan tools needs to be specified, so the first research questions are:

What are typical application domains of quick scan tools?
What are the requirements for developing / using quick scan tools?

To develop a suitable quick scan tool, it is necessary to make a inventory which tools already exist and what their performance is.

Do existing tools meet the requirements and application of quick scan tools?

In a quick scan tool methods are used to meet the requirements of a quick scan tool, so the following question needs to be answered:

Which quick scan methods exist?

From the answers of the previous research questions, the opportunities for a suitable quick scan tool can be determined.

Which opportunities for a suitable quick scan tool exists?

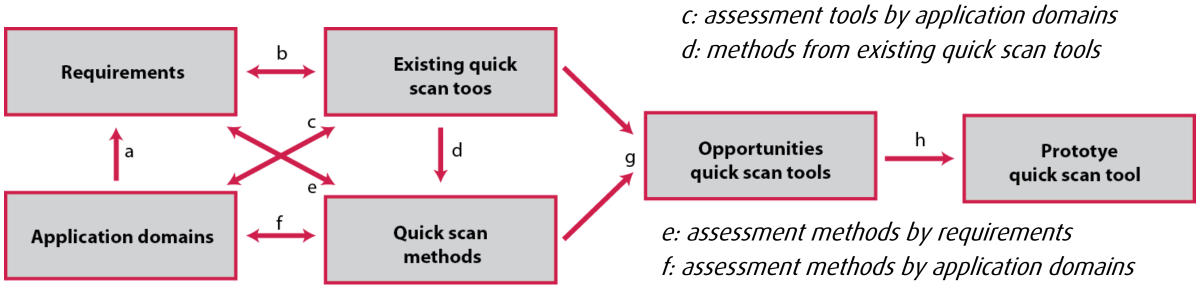
Finally an opportunity will be chosen to develop. This could be a full quick scan tool or a part of a quick scan tool, such as the method. Finally the last questions remain:

What is the approach of the chosen opportunity?
How does the developed quick scan tool/method works in a case study?

1.4 Approach

In this research the application of quick scan tools, the requirements, existing quick scan tools and quick scan methods will be indentified, so the opportunity for a quick scan tools can be determined and a prototype can be developed. Figure 1 illustrates the structure of the research. In the introduction of the chapters the approach of the elements (blocks in figure 1) will be described in details. The letters illustrate the order of the research elements. First the application domains of quick scan tools and the requirements will be determined. The requirements will partly follow from the application domains(a). The next chapter the existing tools will be assessed by the requirements (b) to determine which are actual quick scan tools. These quick scan tools will be judged at their application (c) and the used method (d) will be investigated. After that the quick scan methods will be described, whereby the methods will be assessed on the basis of technical requirements (e) and the application domains of quick scan tools (f). With the information of the methods and existing tools the niche in the market and the appropriate methods for a new tool will be determined (g). One of the opportunities will be chosen and described and finally a prototype will be tested in a case study (h).

a: requirements from application domains
b: assessment tools by requirements
c: assessment tools by application domains
d: methods from existing quick scan tools



e: assessment methods by requirements
f: assessment methods by application domains
g: determination opportunities quick scan tools
h: development of new quick scan tool

Figure 1 Research approach

1.5 Readers guide

In chapter 2 the application domains of quick scan tools will be described. Secondly the requirements will be summed in chapter 3 that shows that computation speed and less effort of the end users are important characteristics of quick scan tools. Chapter 4 will provide an overview of the existing tools and by comparison with the requirements only four tools are assessed as actual quick scan tools. The next chapter will described the quick scan methods from zone simplification to the incremental approach. From the first four chapters the opportunities for the development of suitable quick scan tools will be determined in chapter 6. From this the spatial simplification based on traffic states will be investigated in chapter 7 and will be applied in a case study in chapter 8. Finally the conclusions and recommendations for a suitable quick scan tool will be made.

2

Application domains of quick scan tools

In this chapter the application of quick scan tools will be investigated. The approach is described in section 2.1. To investigate the application of quick scan tools, the kind of traffic and transportation policy questions that can be answered by a quick scan tool have to be known (section 2.2). The traffic and transportation policy questions mentioned in this report can also be questions of companies or organisations. After the determination of the questions the associated political aspects are described (section 2.3). Then the dimensions domains where these questions occur will be shown (section 2.4) In section 2.5 the relevant measures and associated attributes, which need to be investigated according to the questions, will be formulated. Finally the conclusions about application will be made in section 2.6.

2.1 Approach

For determination of the application and requirements (chapter 3) of quick scan tools literature research is done and interviews are hold with model experts and advisors at national, regional and municipal level. The interview with the advisor at regional level will be partly used. According to this interviewee a quick scan tool can be a consideration between strategic alternatives or a quick scan tool as zooming tool. The drawings in the dimension graphs are based on the zooming tool. Most of the answers on the other questions can be used, because there are based on the strategic consideration tool.

First the application and requirements of quick scan tools according to the literature is determined, see figure 2. The information of the literature was used for the set-up of the interviews. The interviews were held to complete the literature research and to reflect the wishes of Goudappel Coffeng BV to provide a suitable quick scan tool according to the end users. The interviews consist of five parts; general questions, questions about the output, input and processing and finally the closer. Appendix A shows the set-up and will be discussed shortly. The general questions consist of questions about the customers of the interviewees and their expectations of a quick scan tool. In empty graphs they had to draw the dimension of quick scan tools for several level of details. The empty graphs are based on graphs in the basic book instruments (2005). The drawings of the interviewees are layered in figure 3, figure 4 and figure 5.

From the customer view there are wishes for the output of a quick scan tool to answer their traffic and transportation policy questions, so the second set of questions is about the required output. The visualisation and reliability of the output are part of the questions. The desired output requires input, so some questions about the input are asked. For the same reason questions about the processing of a quick scan tools are asked. During the interviews it was clear they had no ideas for the process and it was also not important when it fits the requirements. Finally the interview is closed by asking for a final word and the confidentiality of the given answers.

Together with the literature, the interviews lead to the traffic and transport policy questions, political aspects and the dimensions. The traffic and transportation policy questions are mainly based on a research of TNO about, amongst other things, the feasibility of quick scan tools. The political aspects follow from the traffic and transportation policy questions and are mainly based on the Platos Modelstelsel (Adviesdienst Verkeer & Vervoer, 2002). The application domains are mainly based on the filled graphs during the interviews, but also verified by the literature.

The traffic and transportation policy questions, political aspects, application domains and interviews result in a table with measures that are desirable to simulate with a quick scan tool. For this measures is investigated which behaviour changes normally primary and secondary should be simulated in a detailed model. Also the minimal desired output is determined. The required model elements for every measure are based on the application domains and the opinion of experts.

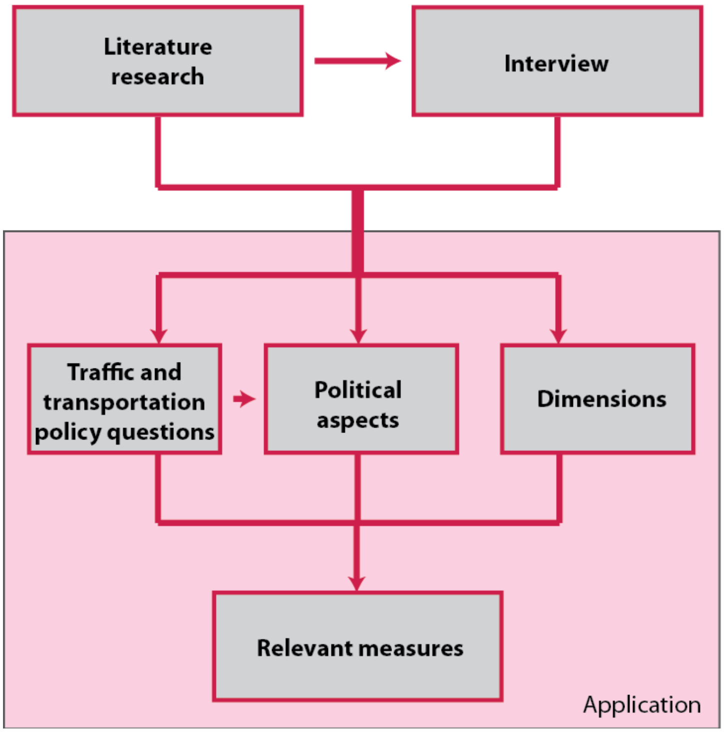


Figure 2 Process scheme application quick scan tools

2.2 Traffic and transportation policy questions

The kind of traffic and transport policy questions in which quick scan tools are suitable, have already been investigated by TNO and during the interviews confirmed by the experts. TNO (2004) did research on the connection of the methods of the AVV and the wishes and requirements of customers. Also the feasibility of quick scan tools by the improvement of the methods is determined. For this research fifteen interviews were performed with policy makers and planning bureaus. From the interviews a distinction was made between different types of traffic questions:

- **Questions in phase of mind setting:** quick consideration of proceeding tender.
- **Questions in reconnaissance phase:** identify promising directions of solutions.
- **Detailed questions:** substantiation of solutions and measures.
- **Reaction questions:** policy questions.

According to this research quick scan tools can be used in the phases of mind setting and reconnaissance phase. The detailed questions require detailed model runs and the reaction questions suffice by expert judgement. The mind setting occurs, among other things, in development of politic strategy document and additional documents. In this phase answers need to be given fast in a few days with as consequence less accurate answers. This results in directions of effects, such as positive, negative or no influence. This matches the demand, because a detailed breakdown is not required in this stage. Expert judgment is also suitable for the questions in the phase of mind setting, but the judgment of experts is not always consistently reproducible and as transparent as quick scan tools. More detailed models are also not the best option because of the duration and the costs of these studies. During two of the fifteen interviews the conclusion was that quick scan tools cannot be used as independent tool, but should be combined with expert judgement (TNO, 2004). In the interviews in this research this was also mentioned.

Also in the reconnaissance phase quick scan tools can be used. Nevertheless the reaction times in the reconnaissance phases are longer and the answers are more precise. With quick scan tools the calculation times can be improved a lot. An extensively substantiating of the answers is not needed, but the determination should not be a black box, so the made assumptions should be clear. In the reconnaissance phase there is often an assessment of different alternatives. In the mind setting phase expert judgement is also an acceptable method, but the use of quick scan tools is more reliable. The chances for quick scan tools are especially large in the reconnaissance phase. The need for quick scan tools in the reconnaissance phase in MIRT projects is already explained in the introduction.

2.3 Political aspects

In the reconnaissance phase alternatives with different measures needs to be calculated fast at global level. The questions in this phase can be divided by considering different polical aspects. In filter 1 of the reconnaissance phase the accent will be at the network performance and not at road sections. The comparison between the alternatives will be

made on link loads, I/C ratio, modal split and safety. The air quality will be rated by the NO_2 and PM10 values. The monitor of the Nationale Samenwerkingsprogramma Luchtkwaliteit (National Air quality Collaboration) provides concentration maps to easily simulate these values. The effect of the noise changes will be assessed by experts and rules of thumb in filter 1 (Projectdirectie Sneller & Beter, 2010b). Table 1 shows the range of application of traffic related political aspects and the function in models (Adviesdienst Verkeer en Vervoer, 2002).

Effects on mobility are direct output, while safety, environment and economy needs another calculation with the direct output(Adviesdienst Verkeer en Vervoer, 2002). According to the interviews the strength of quick scan tools is to have these calculations in the tool. So safety, environment and economy are also output of the tool. Economy can also be input for models, because independent of the measures or alternatives, the situation in the prediction years will be different from the current situation.

Table 1 Political aspects and their function in modelling and units (based on Adviesdienst Verkeer en Vervoer, 2002).

Political aspects	Function modelling	Units examples
Mobility	Output	Intensities, link loads capacity ratio, modal split, amount of trips, delay
Economy	Input/Post processing	Delay expressed in money
Environment	Post processing	NO_2 and PM_{10} and the noise in dB
Safety	Post processing	the expected number of (harm)accidents per road section

2.3.1 Mobility

If the required output is mobility, the effect on the mobility has to be determined. The mobility can be expressed in intensities, modal split and the Intensity Capacity ratio (I/C ratio). The representation of the network performance can also be expressed as the amount of completed trips toward the accumulation in a network or the delay. The I/C ratio influences the travel times and the accessibility of destinations and in general the performance of the network. I/C ratios larger than one are unrealistic, because it indicates a larger flow than the capacity. This indicates problem links, but does not reflect the network performance, because in case of congestion people choose another route and therefore the outflow of the network can dramatically increase.

2.3.2 Economy

The economic costs are often reflected against the costs of the measure in the cost benefit analysis (CE). In the more detailed "maatschappelijke kostenbaten analyse" (Societal cost benefit analysis, MKBA) more aspects are determined, such as safety and environmental impacts. For large infrastructural projects a MKBA is compulsory. For quick scan tools a first impression of the economic effects is adequate, so cost effectiveness analyses are feasible. Later in the project the MKBA can be made. In a CE the costs of the measure are relative easy to determine, but the determination of the effects of a measure expressed in money is more difficult. The profit can be expressed in the reduction of the delay expressed in money by a value of time variable (Meurs, Wee & Hoogendoorn,

2011).The delay is based on travel times, so the economic effects can only be shown if the travel times can be calculated accurate. With static assignment incorrect travel times will be calculated, because the spillback of congestion is not correctly simulated.

2.3.3 Environment

The environmental effects can be divided in effects on air quality and noise. The air quality is expressed in emissions of CO_2, NO_2 and PM10 and the noise in dB (Kennisinstituut voor Mobiliteitsbeleid, 2008). The noise pollution depends on the distance between the buildings and the road. A detailed model is a simplification of the reality. Often roads will not be part of the model and mostly these roads are not the roads with large noise pollution, but this assumption should be made. Also the type of assignment influences the correct distribution. Especially in case of all or nothing assignments there will be more traffic on the road than in reality. It is questionable if the amount of extra vehicles is negligible in the calculation of noise emissions. Fortunately in the reconnaissance phase details are not required and working with rules of thumb is admitted.

The assessment of externalities in transport is often done with effect models using the output of traditional detailed traffic models. Using the output of static assignment models is not appropriate. It has been proven that there is a relation between traffic dynamics and emissions of pollutants. This means the use of dynamic traffic assignment models with temporal information is better than static assignment models. In case of a narrowed two lane road to a one lane road, the congestion in a static model will be downstream of the bottleneck. In reality the congestion will be upstream of the bottleneck. In dynamic assignment this is better modelled.

The effect on the emissions is also different. First of all, because in the static model speed will be constant upstream of the bottleneck, while the speed in the dynamic assignment is lower and this will lead to an increase in emissions. Therefore the calculation of emissions in detail should not be done with a static assignment. In quick scan tools mostly a static or no assignment will be used, so the effects on air quality can only be approximated at network level (Wismans, van Berkum & Bliemer, 2010).

2.3.4 Safety

The safety is expressed as the expected (harm) accident per road section (Reurings & Janssen, 2007). This can be determined by a approximation of the intensities. Also the driving behaviour has influence on the safety, but this will not be simulated with quick scan tools, because driving behaviour is omitted of this thesis. Driving behaviour requires a high level of detail and in the interviews it was clear that this will not be part of a quick scan tool, see next section.

2.4 Dimensions

The policy questions are asked at different levels. For every political level a quick scan tool can be developed to make a simplified model, a meta-model, that approximates the behaviour of one or more models that are much more complex and detailed (van Grol, 2006). At which levels quick scan tools are applicable, will be determined in this section

based on drawn graphs in the interviews, the policy questions and aspects as written before.

One of the desired quick scan tool of the interviewee at regional level is a zoom application of a detailed model. This clarifies the different application of quick scan tools in the graphs. Because the research is focused at quick scan tools, the dimensions of quick scan tools will not be influenced by his answers.

2.4.1 Horizon and level of detail

At node, line and network level predictions can be made for a short and long prediction horizon. In figure 3 the dimension according to the model experts and advisors are shown from the interviews.

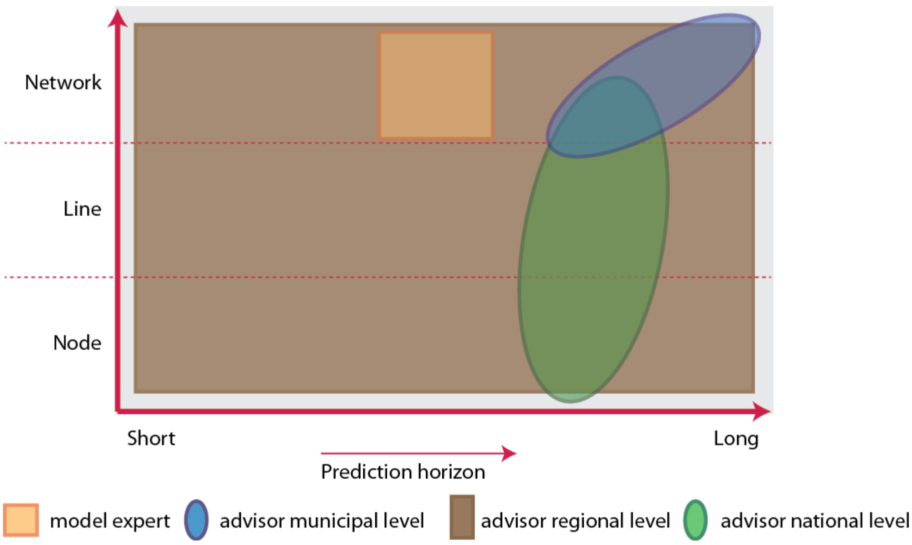


Figure 3 Dimension of quick scan tools according to the experts (prediction horizon and level of detail).

Prediction at node level generates more detailed answers which are not required in the reconnaissance phase. And the political traffic questions that need to be answered require predictions on longer term. According to the interviews the quick scan tools will mainly be at network level and on medium or long term. The same conclusion can be made on the requirements in the reconnaissance phase.

2.4.2 Effort and level of detail of questions

Figure 4 shows another dimension for quick scan tools. The y-axis in figure 4 reflects the level of policy questions and the x-axis the effort that the end user should make for using the tool. The decisions can be made at strategic, tactic and operational level. Models at strategic level are used for better insight into the development of the mobility in the future, when the policy does not change, and effects of new traffic policy. These models show a global, plausible, fast and flexible image of the future. The operational level obtains different requirements of the models. These models need to be more accurate, detailed, but also more informative, standard and uniform (Kennisinstituut voor Mo-

biliteitsbeleid, 2010). Because of the detail level of microscopic traffic models at operational level, quick scan tools probably will be too rough. According to the interviews, the quick scan tools will be usable at strategic and maybe tactical level.

Low effort of the users is an expectation of a quick scan tool, because the tools need to be easy to use. Remarkably, the effort of the end users don't have to be low according to the interviews. The interviewee at national level observed a relation between the level of detail and the effort of the user by his customers. A higher level of detail requires more effort of the user. It appeared that they expect that even in a quick scan tool the effort of the end users will be precisely present, because the end users need to give input for the model and set a lot of parameters in quick scan tools. Meanwhile they wish the effort will be as small as possible.

In the reconnaissance phase there should be the possibility to quickly and with little effort come from multiple alternatives to just three and the reconnaissance phase is at strategic level, so the results of the interviews correspond with the wishes in reconnaissance phases.

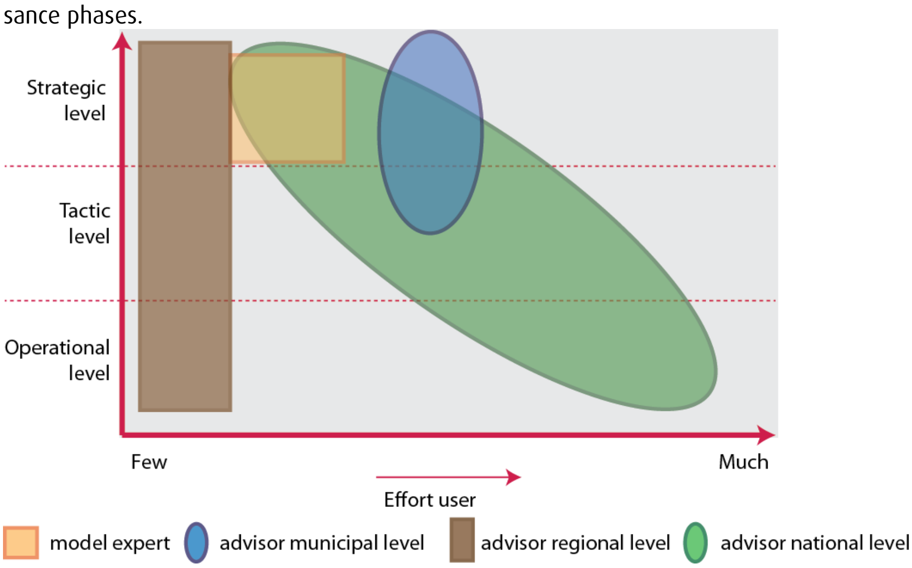


Figure 4 Dimension of quick scan tools according to the experts (effort of users and decision level).

2.4.3 Time and space

Quick scan tools are especially useful at lower level of detail (rough network) and a high time scale, see figure 5. A long prediction horizon requires also less detailed information (x-axis figure 5). It is not desirable to make an exact prediction of the future, because there are uncertainties in the further. At strategic level quick scan tools can also have input at yearly basis and the effect at national, regional and urban networks can be expressed in chances of crossing certain limits (green).

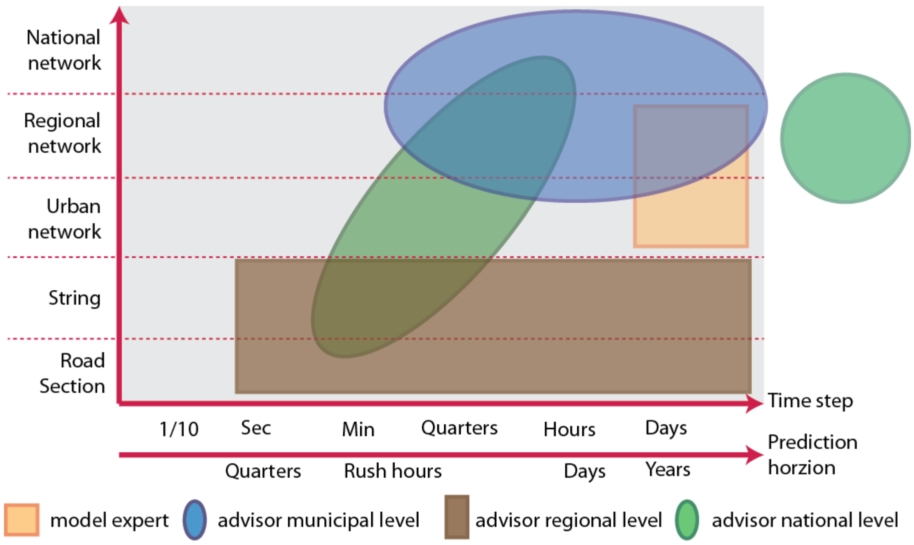


Figure 5 Dimension of quick scan tools according to the experts (Time and space).

Because of the required level of detail the dimensions of quick scan tools are not at local level, so the driving behaviour (characteristics of individual vehicles, such as braking) will not be simulated in quick scan tools (Adviesdienst Verkeer en Vervoer, 2002). According to the experts the driving behaviour was also an element that should not be simulated with a quick scan tool.

According to the dimensions of quick scan tools, the tools will not fit the short horizon at operational node level market section. The result is that microscopic simulation and the accompanying use of the infrastructure will not be part of quick scan tools, because when modelling the use of infrastructure, driver behaviour is needed as input. Aalbers (2011) mapped modelling in the traffic and transport system based on the traditional movement, transportation and traffic model. The quick scan tools definitely simulate patterns in time/space and can simulate use of a network, see figure 6.trip frequency, destination choice and modal choice can be simulated with patterns in time and space (+mode). the simulation of departure time choice and route choice requires the use of the network. the driving behaviour was already excluded for quick scan tools. therefore quick scan tools can use patterns in time/space and the use of the network, but will not simulate the use of the infrastructure. so quick scan tools will not be used at microscopic level.Trip frequency, destination choice and modal choice can be simulated with patterns in time and space (+mode). The simulation of departure time choice and route choice requires the use of the network. The driving behaviour was already excluded for quick scan tools. Therefore quick scan tools can use patterns in time/space and the use of the network, but will not simulate the use of the infrastructure. So quick scan tools will not be used at microscopic level.

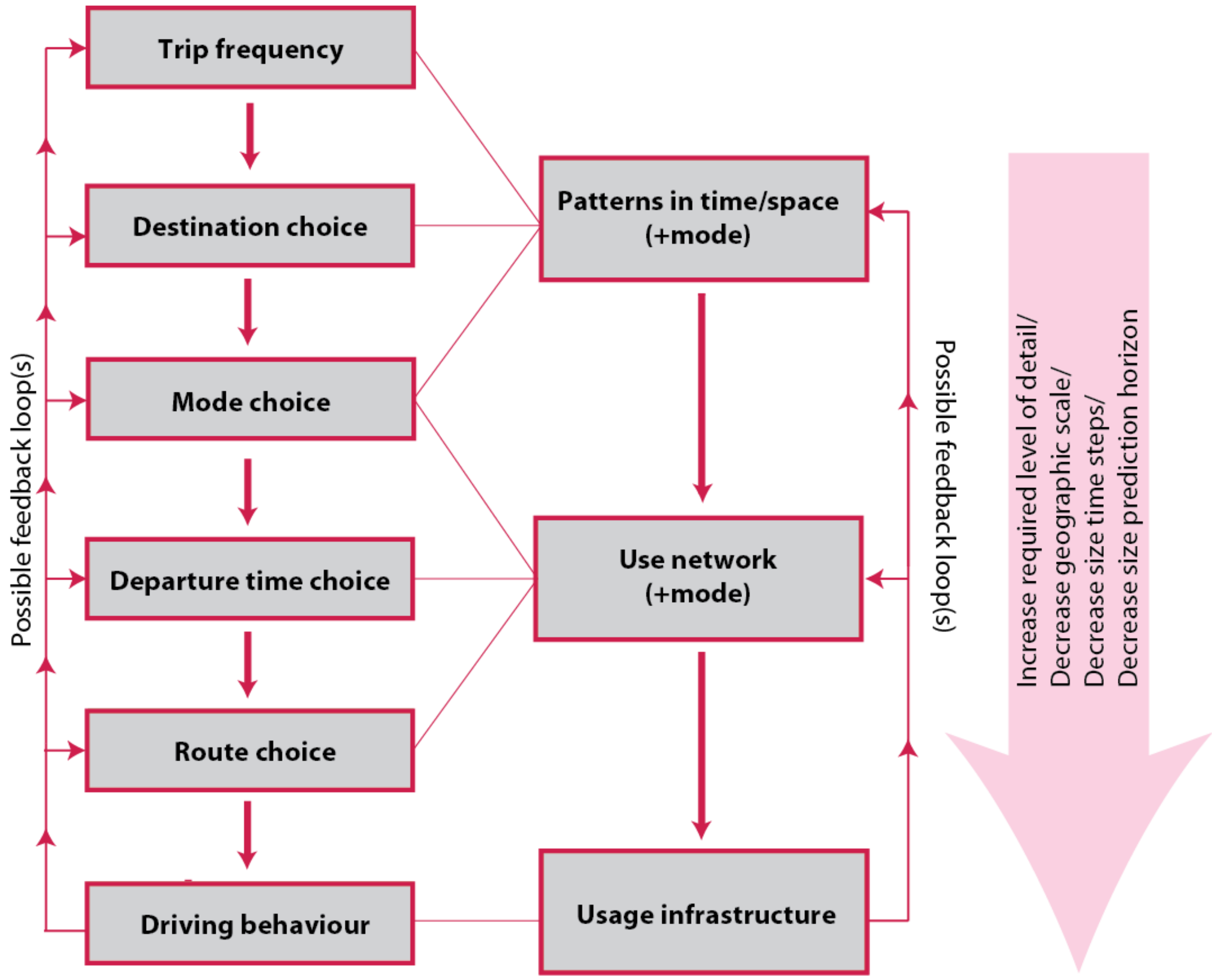


Figure 6 Overview model elements (Aalbers, 2011).

In conclusion, quick scan tools are usable at a low level of details (rough network), long prediction horizon and will simulate the travel behaviour at a macroscopic level. These three directions need to be at the same level of simplification. For example a model with a long horizon prediction horizon and large time steps should not make a prediction at a high level of detail and simulated driving behaviour. In the case of quick scan tools a high level of simplification is required for fast and coarse evaluation of transportation alternatives.

2.5 Relevant measures

The different traffic and transportation policy questions will be allocated to six different kind of measures to anticipate on relevant scenarios. The measures are based on the "ladder of Verdaas" (Hop et al, 2010), literature (Litman, 2011a), interviews and expert opinions. The associated effects on behaviour and required input and output of the quick scan tool, can be different per measure. In this case the measure will be split in multiple

specifications. Table 2 reflects the effect of measures on behaviour changes and the required model elements and required output. This table is based on literature, logical assumptions and is reviewed by experts. The table is made for models in general, but the effect on the behaviour changes is divided in primary and secondary effects. A quick scan tool will minimal calculate the primary effects (Projectdirectie Sneller&Beter, 2010a).

Spatial planning measures illustrate the development of new areas, e.g. living area's, which causes transportation. Price measures reflect the effects of introduction of charges at road sections, time periods or emission of individual vehicles.
Definitions of mobility management and traffic management can overlap, so the definitions will be made clear. Mobility management includes all the measures that directly try to intervene at all pretrip strategic and tactical choices at the movement and transportation market. The trip frequency, destination choice, period of day and mobility are part of these choices. Traffic management reflects all the measures that intervene at the traffic market and at the system and the use of the infrastructure. This includes the route choice and the exact departure choice (Aalbers, 2011). The dimension, figure 4, shows that quick scan tools are not desired at operational level, so the use of the infrastructure in traffic management is not relevant for quick scan tools. (Traffic management) measures that influence the route choice with capacity changes can be part of a quick scan tool. In this thesis capacity measures will be included in change infrastructure measures.
The improvement of public transport by decreasing prices or increasing frequency or speed is another measure. Also physical changes can be made at the existing infrastructure by for example a rush hour lane or traffic management measures that affects the capacity. Or the decision can be made to build new infrastructure, e.g. a new road.

2.5.1 Effect on behaviour changes

For every specification the effects on behaviour are determined, see Table 2. The behaviour changes that will be influenced depends on the kind of measure. The behaviour changes that need to be part of a quick scan tool depends on the measure. This was also concluded from the interview question about the procession.

A distinction between primary effects and secondary effects is made. Primary effects are effects that directly follow from the measure. Secondary effects are a result of the primary effects and sometimes require iterations to reach equilibrium in traditional models, which often increase the computation time. The effects at very long term, such as moving to another location of buying a car will not be visualized in the table, but can be part of a quick scan tool. As mentioned before, the driving behaviour is not part of the research.

2.5.2 Required model elements and output

For every measure the need of patterns in time/space and the usage of network is visualized in table 2. The use of infrastructure is excluded from the table, so only the use of the network and patterns in time and space will be visualized. The desired model elements as input depends on the behaviour changes that will change primary. The table is filled based on trip frequency, destination choice and modal choice can be simulated with patterns in time and space (+mode). the simulation of departure time choice and route choice requires the use of the network. the driving behaviour was already excluded for

quick scan tools. therefore quick scan tools can use patterns in time/space and the use of the network, but will not simulate the use of the infrastructure. so quick scan tools will not be used at microscopic level..

Table 2 shows also the desired output based on the requirements. The kind of measure determine the minimal required output. For example, the price policy is a financial instrument, so the output also requires the economic effects. The effect on safety can be interesting, but is not necessary. The effects on the mobility are always important when using quick scan tools. The economic, environmental and safety effects are desirable, but not required, see next chapter.

Table 2 Measures, effects on behaviour changes and required output for models.

P = direct effect
s = derived effect
✓ = minimal required
× = not required

		Behaviour changes					Model element		Output model (Effects)			
Measures	**Specification**	Trip frequency	Destination choice	Mode choice	Departure time choice	Route choice	Patterns in time/space	Use network	Mobility	Economy	Environment	Safety
Spatial Planning	Effect at network	p	p	s	s	s	✓	×	✓	×	×	×
Price policy	Fixed charge (€/km)	p	p	p	s	s	✓	×	✓	✓	×	×
	Charge per time (high/low charge)	s	s	p	p	×	✓	✓	✓	✓	×	×
	Charge per location	p	p	p	s	p	✓	✓	✓	✓	×	×
	Charge per car emission	s	s	p	s	×	✓	×	✓	✓	✓	×
Mobility management	Effect time shift (e.g. "nieuwe werken")	p	×	s	p	s	✓	✓	✓	✓	×	×
	Effect modal shift (e.g. car pooling)	p	×	p	s	s	✓	×	✓	×	✓	×
Public transport	Improve quality (reliablity, freq,speed)	×	s	p	×	s	✓	✓	✓	×	✓	×
Change infrastructure	(Dynamic) capacity by changing infrastructure (rush hour lane)	s	s	s	s	p	✓	✓	✓	✓	✓	✓
Extend infrastructure	Create capacity by building infrastructure	p	p	s	s	p	✓	✓	✓	✓	✓	✓

The strength of quick scan tools is the short computation time. To reduce the calculation time, the processes with a long calculation time should be improved, such as simplification of the network and use of rules of thumb, see the chapter about quick scan methods. Another possibility is to excluded the small indirect effects of a measure in a quick scan tool. So a quick scan tool should simulate the primary effects and when it is possible, the secondary effects.

2.6 Conclusions

In conclusion, quick scan tools are useful for policy questions in the phase of mind setting and reconnaissance phase according to a research of TNO (2004) and projectdirectie Sneller & Beter (2010).

The associated required output of a quick scan tool is mobility aspects and desirable is the effect on the environment, economic effect and safety according to interviewees and potential users. With these output elements the political traffic and transportation policy questions can be answered. Each measure that needs to be calculated with a quick scan tool requires different output. Also measures effects certain behaviour changes, such as trip frequency, destination choice, mode choice, departure time choice and route choice. This can be a direct effect or a derived effect. A quick scan tools should at least improve the primary effects (direct effects). The behaviour changes that will be effected will require model elements: patterns in time and space and/or use of the network.

In literature and between interviewees the perception of quick scan tools differs. To overcome this problem, the first questions in the interviews were focussed on the point of view of the customers of the interviewee. Therefore it was known if the point of view matches the purpose of the research; developing a suitable quick scan tool for fast and coarse evaluation of transportation alternatives. Overall conclusions about quick scan tools could be made, because of the overlay between the interviews and the literature. The perception can be different of the reader of this report, but the described application domains in this chapter fits the purpose are is used as basic for this thesis. Quick scan tools needs to be applied at a high level of simplification on time, space and travel behaviour, because quick scan tools make predictions quick and at the strategic (or tactical) level, so a high level of details is not needed.

3

Requirements

In this chapter all requirements of a suitable quick scan tool, for the application described in previous chapter, will be shown. If possible these are formulated in a specific, measurable, acceptable and realistic way. The requirements are divided in functional, performance, quality, output and input requirements. A distinction between the requirements (need to have) and the desires (nice to have) is made. The desires related to a requirement will be written together with the requirements. The desires not related to requirements are summarized at the end of the sections. First the functional requirements will describe what the tool should be able to do (section 3.2). The performance requirement focus on one of the most important characteristics of a quick scan tool, the computation time (section 3.3). In section 3.4 the requirements about the quality of a quick scan tool are formulated. Then some output and input requirements will be given. Finally in section 3.7 the conclusion about the requirements will be made.

3.1 Approach

According to Projectgroup Sneller & Beter (2010a) quick scan tool distinguishes of detailed models by the short computation time (section 3.3). Another characteristic of a quick scan tool is the low effort of the end users according to the interviewees. This results in easy applicability and less required input of the end user. According to the interviews quick scan tools will not be used when they do not have enough support, so this is a general condition besides the requirements and wishes in this chapter.

The requirements are divided in functional, performance, quality, output and input requirements. The functional requirements reflect the requirements about the functionality of the tool. The performance requirement is focussed on the computation time. The quality requirements are devised to reach enough quality in the quick scan tool. Also requirements about the output and input are introduced to win broad support.

Figure 7 reflects the process scheme of the requirements. The requirements are based on literature, interviews and the application of quick scan tools determined in previous chapter. The set up of the interviews is already discussed in the introduction previous

chapter. Finally the requirements are verified during an interview by the requirements of the developing of the Mobiliteitsscan.

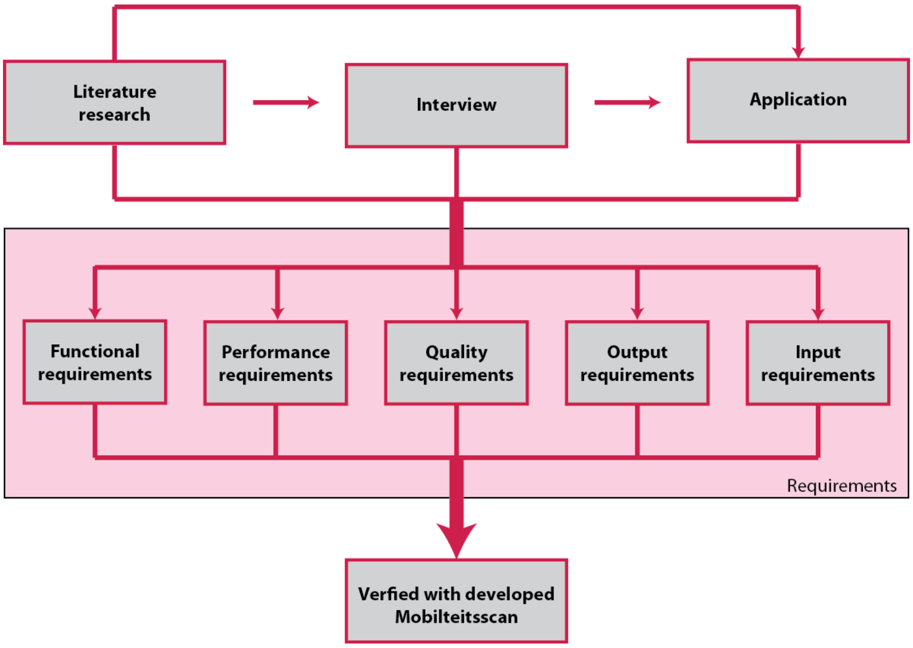


Figure 7 Process scheme requirements quick scan tools

3.2 Functional requirements

In this section the functional requirements of quick scan tools are formulated.

- **High level of simplification.** In section 2.4 is determined that a quick scan tool should have a high level of spatial, time and behaviour simplification. A detailed model has a low level of simplification. For example all roads are shown in the network and the zone categorization is based on detailed zip codes. A quick scan tool could, for example, only shows the highways and every city reflects a zone.
- **Reproducible.** With the same input, the same output should be generated. This is the strength of a quick scan tool compared to expert judgement (TNO, 2004), see also section 2.2.
- **Easy applicable.** The effort of the end user for working with the quick scan tool should be much less than the effort when using traditional models, see subsection 2.4.2.
- **Assessment of alternatives.** A quick scan tool is able to compare multiple alternatives. Alternatives can be different measures, but also different demographic developments. The specific measures and developments differ per tool. During the interviews this was an important criterion for quick scan tools. In addition it is a pro if it can generate alternative suggestions. Preferably is the simultaneously presentation of the results of the different alternatives, but this is not a requirement.

- **Determination primary effects.** At least a quick scan tool determines the primary direct effects (Projectdirectie Sneller&Beter, 2010a), see also section 0. If the secondary effects can be calculated without harming the other requirements, they can be part of the quick scan tool. Secondary effects often require iterations and this will increase the calculation time. The short computation time is one of the main characteristics of a quick scan tool. When a quick scan tool has no iterations, there will not be a new equilibrium calculation. The improvement of the calculation time needs to be made with the primary effects of a measure.

3.3 Performance requirement

One of the characteristics of a quick scan tool is the short computation time. This performance requirement is described below.

- **Short computation time (<10 min).** One of the most important characters of a quick scan tool is a shorter computation time than traffic simulation models. The calculation time is the time the user has to wait for the results of the tool excluding building alternatives. The interviewed advisors want to have a fast interactive tool that is applicable in workshop sessions. The desired computation time is less than ten minutes. Projectgroup Sneller & Beter (2010a) opines quick scan tools have high potential in reconnaissance phases because of the short calculation time.

3.4 Quality requirements

The quality requirements are the requirements related tot the quality of the calculation of the quick scan tool and the output.

- **Transparent.** A quick scan tool should be transparent, the relation between input and output should be clear (Hop, Turpijn & van der Waard, 2010). The details of the calculation should not necessarily be explained in detail, but at least there should be a story telling, so the process is explainable and it is clear how the tool works (Kennisinstituut voor Mobiliteitsbeleid, 2010).
- **Fits logical transportation relations.** In the interviews is asked for the logical transportation relations that a quick scan tools needs to fit. The results where examples, such as when the welfare improves, the amount of vehicles kilometres should increase and the average travel time per head will not increase over the years (BREVER lay). Also when the amount of inhabitants and work spaces increase, the mobility (amount of trips) will increase. And when the travel time ratio between modalities change, there should be a modal shift.
- **Visualisation reliability output.** Output cannot be exact, so exact results should not be presented. The unreliability of results of a model are caused by changes in the future, incorrect input and the assumptions in the calculation method of the tool. The mobility in models in the future, such as 2020, are not predictable precisely and can only be made with a large bandwidth. A fake impression will be made and is not scientifically acceptable to present exact values (Kennisinstituut voor Mobiliteitsbeleid, 2008). So first of all, quick scan tools should use bandwidths or rounded values with

margins as output. The determination of the bandwidths can be done by experience in detailed models or by experts. Secondly if the bandwidth is too broad caused by the inaccuracies in the model, the results should not be used. By simplification the uncertainty will increase. Depending on the effect of the quick scan method on the quality of the output, some results will be too unreliable to make predictions for certain element, such as the effects on air quality, see subsection 2.3.3. Important is that not every traffic related question can be correctly answered with traffic simulation models or quick scan tools. Another improvement of the visualisation of the output reliability is just showing relative results between alternatives and the reference scenario. By doing this the unreliability that occurs on the account of other elements than the quick scan method, such as demographic developments, will be excluded.

- **No conflicts with traffic flow theory**. The network fundamental diagram reflects the outflow by accumulation in a network. In free flow conditions the outflow increases by the increase of the accumulation. When the accumulation increases more, there will be a critical accumulation where the outflow (amount of vehicles per hour) is maximal. It would be logical when the accumulation increases more and more, the outflow will decrease, because of spillback and gridlock (Hoogendoorn, 2007). In quick scan tools more traffic should lead to a decrease in the outflow. This requirement comes together with the requirement about fitting logical transportation and traffic relations.

3.5 Output requirements

The literature, interviews and application of quick scan tools, chapter 2, leads to requirements for the output.

- **Clear visualisation.** During the interviews is determined that a good user interface is required to make the tool easy applicable and to clearly presenting the results. Tables and maps are experienced as clear. An internet tool is a desire, not a requirement. It will increase the support of the users and the saleability. Also an internet tool has the ability to monitor the users and the use of the tool which is attractive for Goudappel Coffeng BV.

- **Not only generate the effect on traffic (desire).** The demand of quick scan tools is often the determination of other effects than the effect on traffic. The effect on traffic will be used for continued studies, such as accessibility, environment studies and cost benefits analysis (Projectdirectie Sneller&Beter, 2010a). The strength of a quick scan tool, according to the experts, is the direct calculation of these continued studies. For determination the indirect effects the correct output should be generated. For example if the tool has to generate effects on emissions, a distinction of the impacts of cars and trucks should be taken into account (Duijnisveld & Schrijver, 2009). The required output should fit the measure that will be simulated according to table 2. Also reliable output is required, such as precisely calculated travel times for the calculation of the economic effects.

3.6 Input requirements

The input requirements depend on the other requirements. The needed input also depends on the used quick scan methods and underlying detailed models.

- **Simple**. DVS (Projectdirectie Sneller&Beter, 2010a) requires simple input for quick scan tools. The input during the use of the tool should not be too extensive; low level of detail and using existing information. The input for the development of the model should also be simple to implement. This can be done by the input of simple data for the development, for example in a country with less data, or the tool should be based on an existing detailed traditional model. The data of the existing model can be simplification to a high level of simplification. One or more of the measures of table 2 need to be simulated by the tool, so there should be enough input. This connects with the statement that output should meet the requirements of a tool.
- **Wide support**. The support of a tool depends partly on the input, so the input should have a wide support. For example the input should connect with the predictions of the future, such as the social-economic developments.

- **Connection with existing models (desire).** To generate faster models the connection with existing models is a pre (van der Hoeven, 2011). Especially for the municipality market the tool should not contradict existing models from the customer according to a interviewee. To use the quick scan tool for filter 1 in the MIRT-reconnaissance phase, the quick scan tool should be able to implement the OD-matrices and network of the Nieuw Regionaal Model (NRM, New Regional Model) (Projectdirectie Sneller&Beter, 2010a).In the Netherlands a lot of information and existing models are available. In foreign countries these are not always available, so in this case quick scan tools generate relative reliable output with little information. Hence, the connection with existing models depends on the available information.

3.7 Conclusions

The expectations of quick scan tools differs per person. In this chapter the requirements are based on literature, interviews and the application domains to abut to requirements of quick scan tools. The main characteristics of a quick scan tool is the short computation time and the low effort of the end users. The low effort can be translated in easy applicability and less required input for the end user. Also the connection with the application is required, so the high level of simplification and the improvement of the primary behaviour changes are required. In the next chapter the existing quick scan tools will be assed on the requirements and in chapter 5 the methods to reach the requirements are described.

4

Existing quick scan tools

In the previous chapter the requirements of quick scan tools are determined. In this research a tool is only defined as a quick scan tool when the tool meets the requirements. Otherwise it will be called a tool. The existing tools will be assessed in this chapter. First an evaluation of the tools meeting requirements will be made. With this a selection of at first sight accurate quick scan tools is made. The selected potential quick scan tools will be assessed in the second section to determine which tools satisfy the application and which methods are used.

4.1 Approach

Figure 8 illustrates the process scheme of the existing tools. All known so called quick scan tools in the Netherlands are inventoried by conversations with experts and research in literature. This inventory generated an overview of the tools in the Netherlands. For comparison another country with a lot of tools is selected, the United States. R. L. Bertini of the Portland State University helped selecting tools. Also countries that has high potential for quick scan tools according to Goudappel Coffeng BV are considered. These countries, such as Brazil, do not have existing tools, so these could not be assessed. The tools in the Netherlands and the United States are assessed on the requirements of quick scan tools in this thesis. This is based on the available information on internet and literature. Mostly not enough information was public available to assess the tools completely. The tools that meet almost all the requirements are marked as potential quick scan tools. These quick scan tools are described in detail to investigate the applicability and the used method based on the available information.

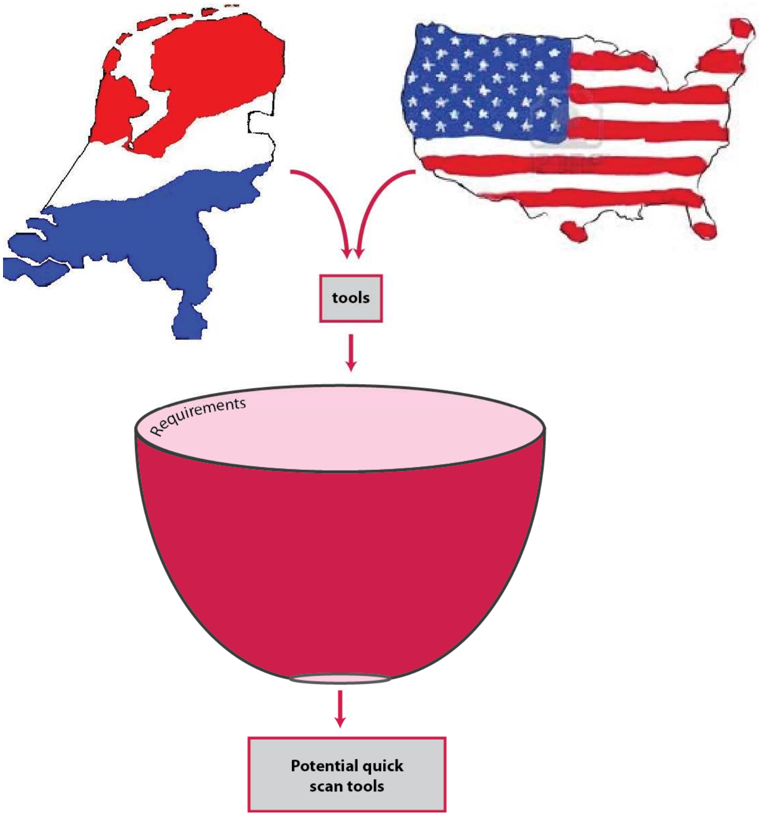


Figure 8 Process scheme existing tools.

4.2 Tools meeting requirements

Table 3 shows a selection of tools. It is a reflection of the tools in the Netherlands. Also a few tools from the United States are selected. First the tools will be described shortly and then the tools will be compared with the requirements and the remarkable results will be described. During the inventory of quick scan tools the amount of available data per tool varied a lot. Because of this it was hard to determine the quality of the tools. With the available data the tools are assessed in functional, performance, quality, output and on their input requirements.

The relative old models ScenarioVerkenner and the mobiliteitsverkenner use elasticities to make predictions for the mobility. The ScenarioVerkenner calculates the effects of scenarios and the mobiliteitsverkenner forecasts trips.

The ToeKan method was developed to show the effect of road works on the capacity of a road. Tiresias is an instrument for regional policy makers to compare the effects of measures and developments (Rijkswaterstaat, 2003). On European level the Fast Simple Model calculates sustainable transport policies (van Grol, Walker, de Jong & Rahman, 2006).

Quick Filter is a zooming tool based on the NRM that can calculate different scenarios. In the zoomed area the effects will be determined. A similar zooming application is used in the Mobiliteitsscan. The Mobiliteitsscan calculates the effects of measures on the mobility, spatial elements and the environment (Kennisplatform Verkeer en Vervoer & Transumo, n.d.). Another tool that calculates the effects of measures is the Regionale BenuttingsVerkenner (Rijkswaterstaat, n.d.).

Urban strategy is an instrument that shows the effects at spatial planning. In this model also the effects of changing infrastructure can be simulated (TNO, n.d.). Which is unlike the strategic multimodal model of Significance that runs without spatial computation component. It's a promising tool at first sight, but unfortunately more information about the tool is not available for this thesis. Another promising method is the incremental approach to assess alternatives with Marginal Computation (Corthout, Tampère, Frederix & Immers, 2011). This method is very experimental and the calculation time is still high, but it has high potential and will be discussed in 5.5.1.

Besides the car traffic models, there are other models that focus on public transport, such as De Kast and OV-light. De Kast is a forecasting model of the public transport demand in the future (de Keizer, B., de Vries, B. & de Bruyn, 2009). OV-light is a public transport model that calculates the changes in the skim matrix of the variant and uses these relative changes for the elasticities to show the change of the OD-matrix. After this a new assignment can be made. With the modal split tool the modal shift in case of different measures can be determined (Mestrum, 2011).

COMMUTER Model, Rapid Fire and Surface Transportation Efficiency Analysis Model (STEAM) are promising tools which have wide support in America. COMMUTER Model is a spreadsheet-based model that estimates the effects (focused at commuting) of transportation on travel and air quality (United States Environmental Protection Agency, 2005). The Rapid Fire Model is a model that evaluates climate, land use and infrastructure investment policies at national and regional level (Calthorpe Associates, 2011). STEAM is a tool for estimating impacts of multi-modal transportation alternatives in planning context (Federal Highway Administration, 2000).

The described tools are compared with the requirements in table 3. If a tool suffices a requirement according to the literature a green tick is shown and a red cross is shown if the tool does not meet the requirement. Sometimes there was not enough information available to assess a tool (?) or the requirement does not apply (n/a) for a tool. If a tool had limited information (*) a small article or a presentation was available. In case of Significance only an announcement on the website was available. With medium amount of information (**) a long article or multiple literature is meant, but not enough to know most of the details of the tool. Also not enough information could be available (***).

The desires are omitted, because they will not be part of the assessment of the tool as quick scan tool, but are an advantage of the tool. Also not all the requirements are part of the first selection. The requirement about the calculation of the primary effects depends on the measures that the tool can simulate. This will be discussed when a few tools are chosen for further explanation. The requirement about the high level of simplifi-

cation depends on the method and will be discussed when the method of some tools will be investigated in more detail (section 4.3). Also only the first impression of the computation time of the tool is known and will be shown. However the calculation time depends on the used method, but also on the size of the network and the problem. If known, during the detailed explanation of a couple of tools an assessment of the computation time will be made.

Table 3 Tools meet requirements

*	= limited information	
**	= medium amount of information	
***	= enough information	
✓	= meet requirement	
×	= do not meet Requirement	
n/a	= requirement does not apply	
?	= not enough informa-	

	Functional			Performance	Quality				Output	Input	
Tools	Reproducible	Easy applicable	Assessment of alternatives.	Short computation time (<10 min)	Transparent	Fits logical transportation relations	Reliable	No conflicts with traffic flow theory	Clear visualisation.	Simple	Wide support
COMMUTER Model (United States Environmental Protection Agency)**	✓	✓	✓	✓	✓	?	×	?	✓	×	?
de Kast (Nederlandse Spoorwegen) **	✓	✓	✓	?	✓	n/a	×	n/a	✓	×	✓
Fast Simpel Model (Significance)**	✓	✓	✓	✓	✓	?	×	?	✓	✓	✓
Marginal Computation (R. Corthout)**	✓	✓	✓	×	✓	?	✓	✓	n/a	×	?
Mobiliteitsscan (KPVV,DVS, GC)***	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓
Modal split tool (Witteveen+Bos & Universiteit Twente)***	✓	✓	✓	✓	✓	✓	✓	?	✓	×	?
MOVE, mobliteisverkenner (DVS)**	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓
OV-light*	✓	✓	✓	×	✓	✓	×	n/a	✓	✓	✓
Quick Filter (DHV)*	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓
Rapid Fire Model (Calthorpe Associates)**	✓	✓	n/a	✓	✓	✓	×	×	✓	✓	?
Regionale BenuttingsVerkenner (RWS)**	✓	✓	✓	✓	✓	?	×	?	✓	×	✓
ScenarioVerkenner (DVS)**	✓	✓	✓	✓	✓	✓	×	?	✓	✓	✓
STEAM (Federal Highway Administration U.S. Department of Transportation)**	✓	✓	✓	?	✓	?	×	?	✓	×	✓
Strategische multimodale model (Significance)*	?	?	?	✓	?	?	?	?	?	?	?
Tiresias (RWS ZH)***	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓
ToeKan method (RWS)*	✓	✓	✓	✓	✓	?	×	n/a	✓	×	?
Urban strategy (TNO)*	✓	✓	✓	?	?	?	×	?	✓	×	✓

4.2.1 Functional requirements

All the researched tools are reproducible, because they generate the same results every time. And all the tools are developed for easy application when experts use them for a customer. In Urban strategy the use by experts is especially mentioned.

Also all the tools can assess alternatives. However sometimes only one alterative can be measured and sometimes more. The Mobiliteitsverkenner and de Kast are demand forecasting models and cannot determine the effects of measures. Overall the functional requirements are met by the existing tools.

4.2.2 Performance requirement

Almost all the tools meets at first sight the short computation time requirement. OV-light and Marginal Computation need more than ten minutes to calculate the effect of alternatives or measures.

4.2.3 Quality requirements

The transparency of the models is often acceptable, because there are detailed manuals that explain the relation between the input and the output. The transparency of the Kast is also assessed as good. In "de Kast" different drawers are integrated, so the causes of the growth of the trips can be split in percentages by different elements, such as demography, congestion and the timetable. This level of transparency creates value and cannot be found in other models.

At first sight the tools fit logical traffic and transport relations, such as demand growth by grown car ownership. The ScenarioVerkenner even has a causality test to prevent contradiction with traffic and transportation relations.

Remarkably most of the tools do not visualize the reliability of the output according to the description of the requirement. The output often exists of exact values, but the used methods result in more uncertain values. In addition, the use of exact values as results for modelling the future is doubtful. Tiresias visualizes his results in absolute values, functions scores and maps. With function scores the results are shown with a value between 1 and 10. The function scores is a form of reliable output when it is used the right way. Presenting results on a map is done by multiple quick scan tools. An indication with colours for the I/C-value can be reliable, because the results are given in bandwidths. A bandwidth for every calculated value separately would be more suitable, but also hard to determine. The modal split tool has calculated the margin of error (5%) for all the municipalities in the Netherlands.

The conflict with traffic flow theory is hard to determine. It is clear, if a model use static assignment spillback and gridlock cannot occur. This is in conflict with traffic flow theory. From a few models it is known they use a static assignment and there is no compensation or other method to prevent conflict with traffic flow theory. The advantage of the Marginal Computation (MaC) is that dynamic network loading is applied, so there is no conflict with traffic flow theory. Unfortunately the calculation time was still more than 2 hours for a case study, but improved ten times compared to the reference situation (Corthout, Tampère, Frederix & Immers, 2011).

This implies the method is good for the calculation time, but in combination with a dynamic network loading it is still time consuming on the current computers.

In traditional models the output is also often not reliable because the output is too exact. So if a tool only conflicts with this requirement, the tool will be discussed in the next section.

4.2.4 Output requirement

For the same reason as the requirement about the easy application, all the tools have a clear visualisation. Many tools are built in Microsoft Excel and often easily applicable and also the results are easy to export. The mobiliteitsscan en Quick Filter also generate the results on a map.

4.2.5 Input requirements

The required input is not always simple. Sometimes special data is required or for every OD-pair the amount of trips should be filled manually (COMMUTER). The ToeKan method requires manually filled in capacities and Urban strategy requires a lot of information about the urbanisation, especially for the 3D output.

Most of the tools have wide support, because they are approved or developed by the government or built on an existing detailed model. For example Quick Filter is built on the NRM.

4.2.6 Conclusion

From table 3 it is clear that no tool meets all the requirements. As written before, the requirement of visualisation reliability output will be released, because traditional models also do not always meet this criteria and it is relative easily to make the translation from exact values to bandwidths. This requirement needs to be valid for the development of a new quick scan tool. The potential quick scan tools that are selected without this criteria are the Fast Simple model, Quick Filter and ScenarioVerkenner.

4.3 Potential quick scan tools

The tools selected in the previous section are marked as potential quick scan tools and will be discussed in detail. Also the Mobiliteitsscan will be described, because this tool is developed by Goudappel Coffeng BV and a new version will be developed with more iterations, so there will be an improvement. The potential quick scan tools will be further investigated in this section and it will be determined if they can be called reliable good quick scan tools. Every tool will be assessed at application and method. During the assessment of the application, the purpose of the tool and the simulation of measures and output will be shown. After this the used method will also be discussed in relation to the application. Finally an conclusion will be drawn.

4.3.1 ScenarioVerkenner

The ScenarioVerkenner calculates the effects of scenarios on the traffic demand and by this effects on traffic and transport. Figure 9 shows the input screen of the ScenarioVerkenner to give an indication of the user interface.

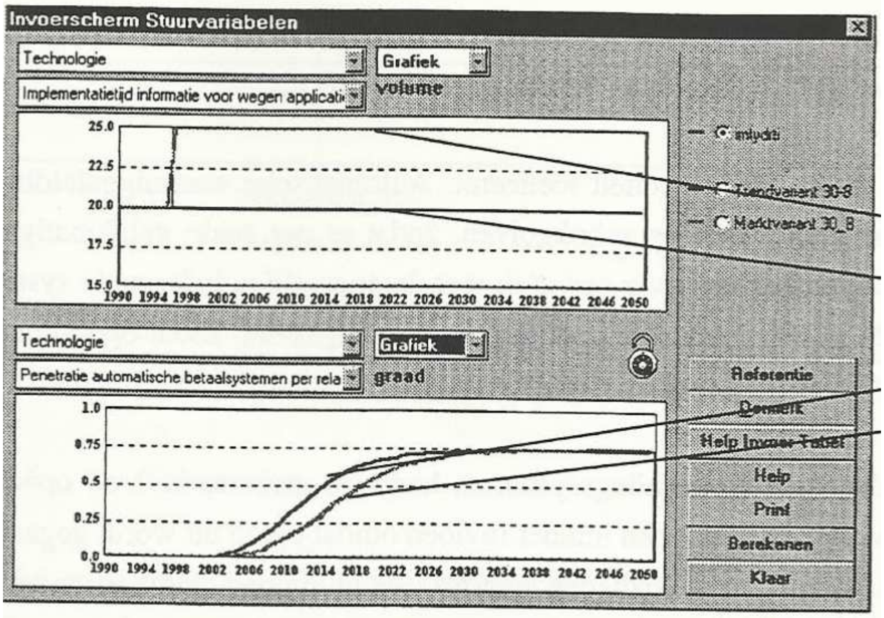


Figure 9 Quick scan tool "ScenarioVerkenner" input screen

Application

The aim of the ScenarioVerkenner is to calculate the effects of scenarios. The tool will not measure the traffic at one link, but makes predications at national level. So will visualize the general development in the next years. The tool is developed for prediction at long horizon (15-60 years), so the time and spatial simplification are at the same level. With elasticities the simplification of travelling behaviour will be simplified. In conclusion, the level of simplification is at all three simplification directions, as a quick scan tool should be according to the chapter application.

The ScenarioVerkenner is focussed at general developments, such as economic, price policy developments, the quality and capacity of infrastructure. The calculation of just a few measures of table 2 is a disadvantage of the tool.

The ScenarioVerkenner calculates the output elements mobility, economic, environment and safety with simple rules of thumbs, but more details are not available, so an assessment of the calculations of the output cannot be made.

Method
In the ScenarioVerkenner, scenarios are built that describe the development of the transportation system in its environment. In the second phase the effects of the developments on the demand are calculated. Finally, the effects are evaluated on their consequences at society and the goals of the government.

A scenario exists of an integral description of the future, events in the future and an analysis of the current situation and the link with the future events. With subvariables and elasticities the variables of the scenarios are determined. For example a subvariable is the amount of immigrants and the scenario variable is the size of the population. The building time of scenarios is half a day. In a few minutes a scenario can be calculated. The ScenarioVerkenner distinguishes seven themes for the scenarios, such as demography, social economy and infrastructure.

The scenario variables are input for the traffic demand model. The traffic generation model makes predictions of future demand. An equilibrium between demand and supply will be reached. In the spatial distribution model the determined demand will be distributed over the zones. An explicit network does not exist and the amount of zones is limited, a form spatial simplification. The amount of trips per motive and mode will be reflected by the I/C ratio and the parking capacity per OD-pair. Also a functional spatial classification is made because of the characteristics of these areas, such as large city Randstad, suburb of this area and country area outside the Randstad. Finally, the calculated traffic and transportation effects will be evaluated on the consequences for the political aims.

Conclusion
The design of the ScenarioVerkenner is promising, because the elasticities generate a large acceleration of calculation of effects at national level. The tool is outdated and by now no longer in operation. The model is built on elasticities and these can change in the future, as described in subsection 5.5.2. TNO (1999) already showed large changes between the predictions of the model and the actual trend. So calibration of the model is necessary. Also the assumption is made that the functional spatial classification will not change in the future. Also only a few measures can be calculated with this tool. Concluding the ScenarioVerkenner is a good example of a quick scan tool at a high level of simplification, but at this moment the elasticities are outdated and cannot make correct predictions.

4.3.2 Quick Filter

Quick Filter is developed by Dwars, Heederik and Verhey (DHV). Quick Filter is an instrument for policy makers. It can be used by the end users with support of traffic engineers. Figure 10 illustrates the interface of Quick Filter for an impression of the quick scan tool.

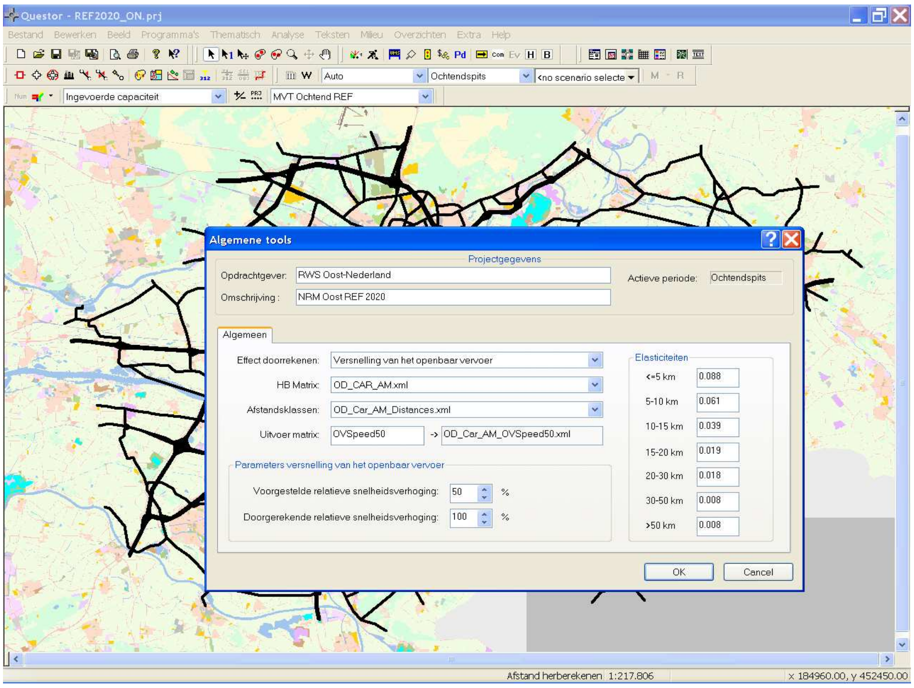


Figure 10 Quick scan tool 'Quick Filter' of DHV (PLATOS Colloquium 2011)

Application

The purpose of the tool is to use the filter to make a choice between available alternatives. Quick Filter is based on the NRM, so the level of detail is the same. At link level results are presented in a map. The prediction are made for the years 2020 and 2030. The expectation of a quick scan tool is to get the overview and network performance. Presenting results at link level for the year 2030 by zooming into a small area does not fit this expectation.

All the measures of table 2 expect mobility management and charge per car emissions can be simulated with the Quick Filter. The required output for mobility is delivered by the intensities at the network, the I/C ratios, section speeds and travel times, vehicle kilometres travelled and the delay. The economic effects of measures can be calculated limited. The profit of toll can be calculated, but the travel time revenue translated in money cannot be made. Also the calculation of environmental impacts are not part of the tool. Those are drawbacks of Quick Filter as quick scan tool. According to table 2, the economic effects and the environmental effects are often desirable. On the other hand for example calculation of the economic effects requires correct travel times. So if this could not be calculated correctly, it is not desirable to present economic effects.

Method
Quick Filter calculates alternatives at small areas. Alternatives are created on forehand based on elasticities. The details of the chosen values are not publicly. Quick Filter zooms in a small area of the NRM with all regional alternative routes inside the area. By doing this the calculation time of the assignment is less than one minute. The zooming improves all calculations of the behaviour changes, see subsection 5.5.1. So the primary behaviour changes by the measures can be simulated by the Quick Filter.

By zooming the link loads at the tailored roads should be known. To have accurate information the NRM should be run and be in (almost) equilibrium. The disadvantage of this method is the restriction to the small area. The generated information, is just for the specific area. In the case of travel time, kilometres travelled, delay and intensities the effect at alternative routes outside the area are also relevant. For example by a capacity reducing measure, the travellers will maybe use a route outside the selected area in reality. In the model they cannot, so they have to choose the congested link or an alternative route which are less desirable than the alternative route outside the area. The choice of the zooming area has to correspond with the measure and the desired effects for a specific area.

Conclusion
Concluding, the method is useful for the determination of the desired effect on mobility by measures, but only inside a smaller area. The risk is to make the wrong cut and exclude important alternative roads. Quick Filter reflects the effects at the small area, but the effect on the rest of the network is leaved out the model. The other effects than mobility cannot be calculated by the tool, while this is a large desire of quick scan tools according to the requirements. The model requires the underlying model NRM, so it is a meta model and has the same or less quality as the NRM.

4.3.3 Mobiliteitsscan
The Mobiliteitsscan is developed by Goudappel Coffeng BV and ECORYS. The scan provides insight in the interaction between mobility, environment and space. Figure 11 shows the interface of the mobiliteitsscan.

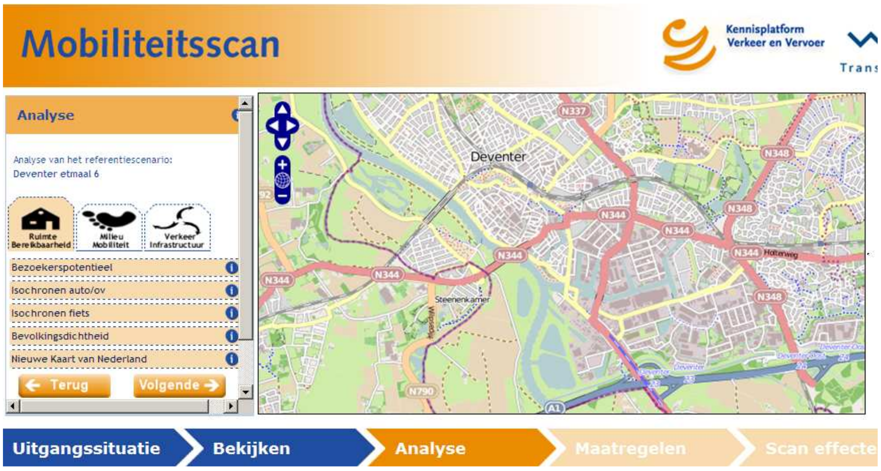


Figure 11 Quick scan tool 'Mobiliteitsscan' (http://mobiliteitsscan.bereikbaarheidskaart.nl)

Application
The mobiliteitsscan shows at local and regional level the spatial, transportation and environmental effects. The results in the tool are presented in maps with the results per link or location. The effects on the total network are missing to provide at ones inside as expect of strategic quick scan tools. The tool can only make predictions of the future if an underlying model exist of the further situation and is already run. The time steps are not part of the tool, because the mobiliteitsscan uses speeds at links to predict the throughput and the new measures are also expressed in improvement of speeds. The behaviour changes are also expressed by the speeds or the customer makes a prediction of the effect on the OD-matrix. In conclusion the simplification of the behaviour is at a high simplification level, the time simplification does not apply and the spatial simplification differs, so the simplification levels are corresponding, but the level of spatial simplification is sometimes too detailed.

The mobiltiteitsscan can be used for modelling new spatial plans and the effects on mobility. The effect on the time shift and price policy cannot be simulated with this tool. The effect of working at home and carpooling can be simulated (effect of mobility management), but the effect of the measure on the percentage reduction in trips should be manual filled in. By carpooling an indication is given for the reduction by different groups. The improvement of the quality of the public transport can be simulated, but the user should fill in the improvement of travel time. New infrastructure can be created in the tool by drawing a new line and give the capacity. The capacity can be changed, only expressed in speeds and circulation speed on roads, so extended infrastructure cannot be correctly simulated.

The Mobiliteitsscan calculates the effects on the mobility, by visualizing the intensities, I/C ratios and modal split. The scan does not present results of the delay, because just one iteration is used and the effect of a congested road at the rest of the network cannot be determined. The scan also calculates the effect of mobility on the environment. The pollutions calculations of the CO2, PM10/NOx/NO2 are based on the Saneringstool. The Saneringtool 3.0 provides reliable results (van Breugel & Molenaar, 2009), but depends

on the input, so depends of the underlying model in the Mobiliteitsscan. The intensities and traffic composition are input for the calculations of the Saneringtool. Besides reliability of the scan is based on underlying models, the Mobiliteitsscan bases the intensities on one iteration, so not definitely reliable. This makes it hard to adjudicate the calculation of the pollutions. The economic effects and the effects on safety will not be calculated in the Mobiliteitsscan. Because of this calculating the effect on the modal shift, improvement of public transport and extend infrastructure could be improved. This measures desire economic effects and the extension of infrastructure desires also the safety effects. An advantage of the tool is that in case of unavailable data, the roads will be visualized gray, so unreliable results will not be shown.

Method

The short computation time of the tool is caused by the usage of speeds on links, one iteration and the zoom function. The scan use traditional models of customers whereby in the Mobiliteitsscan the traffic demand will be assigned based on the speeds per link of the traditional model. The traffic will be assigned just ones by an all-or-nothing assignment. The error is neglected for the purpose of the tool according to the makers. But the results are exact (intensities) visualized and with this method the results can be totally different when applying a measure. To determine the problem links it will give a first indication, because at such a link more people want to use the link than the capacity of the link.

The Mobiliteitsscan has a zoom function. In the zoomed area the effects will be determined. The rest of the Netherlands will be simplified with an origin per city or province. By zooming out, the network will less detailed and by this the calculation time will stay reduced. The zooming method provides a simplification on the behaviour changes trip frequency (less zones), destination choice (less zones), mode choice (less OD relations) and route choice (all-or-nothing assignment). By this the primary changes can be improved for all the measure the tool is designed for.

Conclusion

The mobiliteitsscan present a interesting method by using the speeds (the throughput) of links from detailed models. The throughput determine the quality, so this choice is clever, but depends on the quality of the underlying model. The mobiliteitsscan is a meta model, like Quick Filter.

The economic effect is hard to determine, because the travel times cannot be calculated correctly. So leaving out this element, the effect on the mobility and environment can be determine of spatial planning, effects on the model spit, improvement of public transport and the extend infrastructure. The effects on link level does not fit strategic quick scan models.

Overall the expectation of the users is high. They needs to know what the effect will be on the travel time or speed to calculate the effects. Besides prediction of the further can only be made when in a detailed model the speeds on the roads are already know. But the mobiliteitsscan is useful to determine the effects of an improvement of a road, whereby later in the process the measure to reach this improvement can be determined.

4.3.4 Fast simple model

The Fast Simple Model (FSM) can assess transport policy measures of the European Commission's White paper and other policy measures. Figure 12 illustrates the introduction window of the Fast simple model.

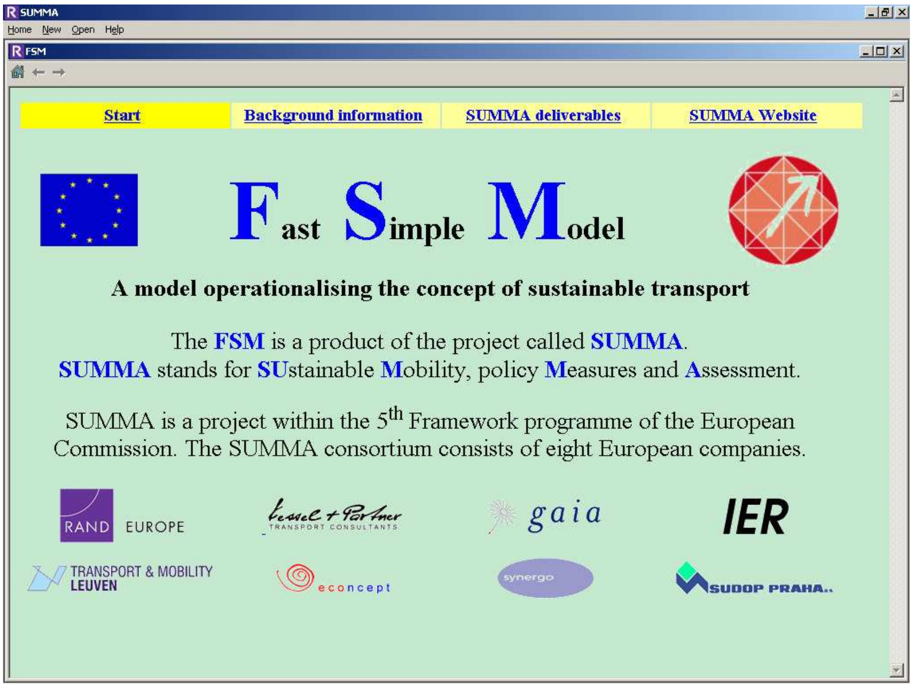


Figure 12 Quick scan tool 'Fast Simple Model' introduction window (van Grol, Walker, de Jong & Rahman, 2006).

Application

The FSM has been developed for assessment of transport policies with respect to environmental, economic and social sustainability for selected regions and cities in Europe. The tool calculates the effects of policies and not measures, so comparison with table 2 is not proper. FSM is applicable to calculate spatial planning and price policy. Infrastructural changes or new infrastructure cannot be simulated by this tool.

The output is split in economic effects, such as infrastructure cost, environmental effects (e.g. emissions and land take) and the social effects (e.g. car independence and trip length). The economic effects are visualised in detail. The trip lengths are one of the social indicators and is part of the mobility output as formulated in the chapter application. The other elements belonging to the output mobility are not indicators in the FSM. The accident related fatalities and serious injuries is a social indicator and reflects the safety.

Method
The FSM is based on the reference scenario from a existing model. This model EXPEDITE is already a meta model of detailed models, such as the Dutch National Model System. FSM works without a network, like underlying model EXPEDITE.

In the FSM a policy can be selected and run. The presentation can be in tables, charts and maps. To generate the output the model exists of three parts: demand generation, impact assessment and policy assessment.

The Demand Response Module (DRM) generates forecasts of the passenger and freight transport demand based on the reference scenario and policy changes. The number of vehicle kilometre generated by EXPEDITE will be divided to vehicle types, modes, motives, person types and distance class by the database TRENDS. The dissimplification of total vehicle-km to individual vehicles types in 2020 is derived by a choice model. This model is based on variables, such as the usage costs and purchase of vehicles.

The output of the DRM is input for the Impact Assessment Module (IAM). In this module 34 economic, environmental and social indicators can be calculated. The used methods are unknown.

The last module is the Policy Assessment Module (PAM). In the PAM the policy measure (or multiple) can be evaluated and assessed in monetary terms. The results of an indicator can be presented in graphs, tables and maps. The complete assessment will be done by the DynaRankDecision-Support system. In this sheet the output is shown in scorecards. The values are percentages changes between the reference case and the political run. At every row a policy is shown, so policies mutual can be compared (van Grol, Walker, de Jong & Rahman, 2006).

Conclusion
FSM is a tool that can measure the effects of political measures at the environmental, economy and society. The model is based on the meta model EXPEDITE and by this there is wide support, but also the quality depends on the underlying models of EXPEDITE. The use of elasticities will be discussed in chapter 5. Regrettably the quality of the elasticities and the calculation of the effects is not assessable, because of the amount of available information.

4.4 Conclusion

None of the seventeen tools meets all the requirements. Without the requirement reliable output, four tools meets the all the other requirements. These four tools are the ScenarioVerkenner, Quick filter, Fast Simple Model (FSM) and eventually also the Mobiliteitsscan. In the next chapter the methods in these existing quick scan tools and other quick scan methods will be discussed to finally in chapter 6 the opportunities for the development of a new quick scan tool will be established.

5

Quick scan methods

In chapter 4 already some quick scan methods are mentioned from the existing quick scan tools. In the chapter requirements is determined that an import quality of quick scan tools is the short computation. This short calculation time can be achieved by simplification or other so-called acceleration methods. In this chapter simplification can be the simplification, the selection or reduction of data or model elements. In the chapter 'application', the need of spatial-, time- and travel behaviour simplification similarly is already set by the application domains. In this chapter the quick scan methods in these three fields will be discussed. First of all, the spatial simplification at different levels will be described. Then a description of time simplification will be given in the second section and simplification of the travel behaviour in the next section. There are also some other methods that can be applied at two or more of the elements (spatial, time and behaviour simulation). These will be explained in the fourth section. Finally, the described methods will be assessed by the requirements and the measures, the model elements and the output.

5.1 Approach

Literature research and logical reasoning resulted in simplification methods for time, spatial and behaviour simplification; see figure 13. These three simplification directions needs to be at the same level, so they are related. Besides there are other methods that can be used in quick scan tools. These are often related on one of more simplification directions. After the overview of the quick scan methods, the methods will be assessed by the requirements of chapter 2. Finally the behaviour changes that can be improved by the method, the required model input elements and the output that can be generated by this technique, will be determined. By the simulation of measures, the required behaviour changes, model elements and the output are determined in table 2. The suitable methods by the measure can be determined in this chapter.

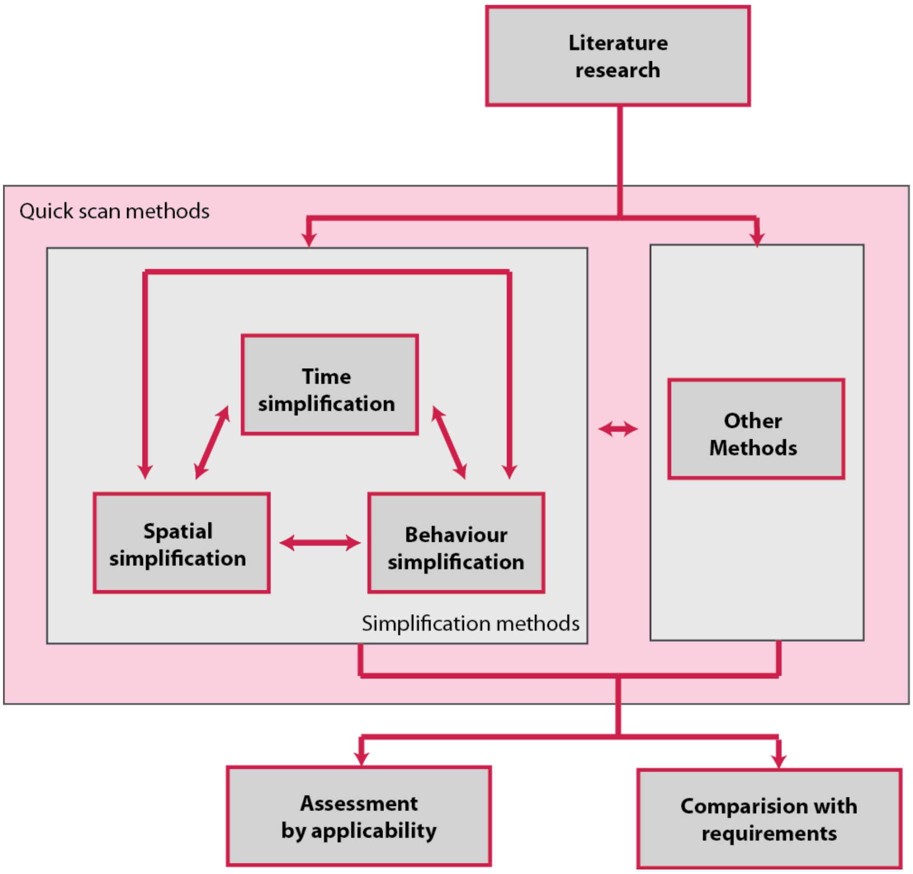


Figure 13 Process scheme quick scan methods

5.2 Spatial simplification

One of the three ways of simplification is spatial simplification. An efficient method is zone simplification (5.2.1). Often related is the simplification of network elements, such as routes, links and nodes (par 5.2.2). A larger simplification is to assess at network level with network fundamental diagrams (5.2.3).

5.2.1 Zone simplification

Zone data is already an simplification of the data per household or individual. In traditional models, zone data will be determined by existing area definitions, such as zip codes, because information is already available for these complete areas. Simplification of households or individuals requires clustering methods (Kim, 2009). In this research the zone simplification is defined as simplification, selection or reduction of zones (clustered household/individual data). To make the network coarser and improve the calculation time, the amount of zones can be reduced. This can be done by deleting zones or combining zones. The assumption is made that the smallest zones can be deleted or combined. The definition of a small zone can be expressed by the characteristics of a zone, such as size of the area, amount of inhabitants or workplaces.

Methods
Zones can be deleted or merged. The merging of zones is hard or flexible, also called fuzzy in the literature (Xu & Wunsch II, 2005). The merging can also depend on the place of the connection of the zones to the network.

- **Deleting zones.** By deleting zones, the smallest zone will be removed and the area will not be filled, see figure 14 (left). This does not automatically means that the zone cannot contain network elements. The zone can still have links for transit traffic, but the zone is no longer a origin or destination. Also the associated OD-pairs will be deleted (right figure 14).

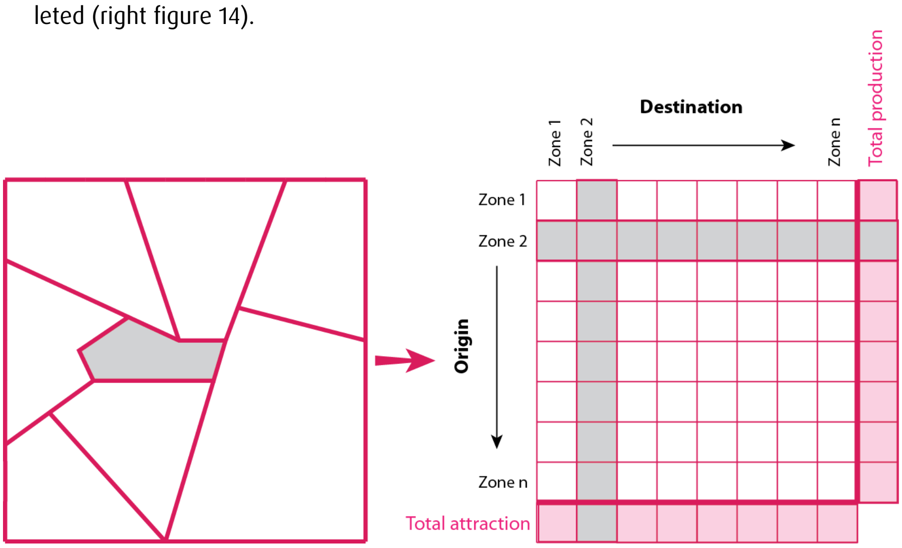


Figure 14 Deleting zone (gray) for simplification at spatial level. Deleted small zone(left) and the effect at OD-matrix (right).

- **Hard zone simplification.** Zone simplification can be done by merging complete small zones to bigger zones, this is called hard zone simplification. This can be done automatically by merging with the largest shared border or with the largest area automatically. When the first option is applied, the largest shared border of the smallest zone will be deleted and by doing this, the small zone will be combined with a bordered zone, see figure 15 middle image.

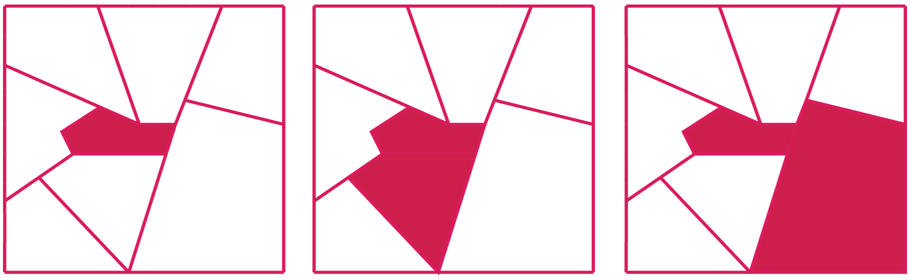


Figure 15 Hard zone simplification for spatial simplification by merging zones. Reference situation (left), merging longest border (middle) and merging largest bordered area.

In the case of the largest area, the smallest area will be combined with his largest bordered area, see figure 15 right image. Then the second smallest area will be combined and so on until the definition of small area is reached. For this, the eliminate-function in ArcGIS can be used (ArcGIS1, n.d.). Normally this function is used to eliminate the zones that exist by combining different maps with polygon overlay.

- **Flexible zone simplification.** When applying flexible zone simplification, a zone will be allocated to several clusters. In the example of figure 16, the smallest zone is split into two smaller zones and after that merged with two bordered zones. For example the splitting can be based on physical obstacles. The distribution of the smallest zone can be done over two or more zones. By merging with just one zone it becomes the same as hard zone simplification.

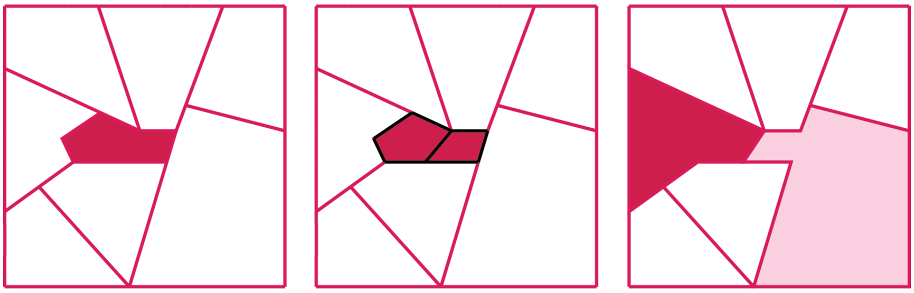


Figure 16 flexible zone simplification for spatial simplification by splitting (middle) the smallest zone and merging it with two bordered zones (right).

- **Connection link-dependent zone simplification.** In traffic simulation zone characteristics are important, but the assignment of the generated traffic to the network is also important. In traditional traffic simulation models, zones will be connected with the network at a node. This point illustrates a place where the vehicles enter the network. Simplification of zones by entry place is a good option, because it can be applied independent of the characteristics of the zones. The distance between the entry points determines the clustering of zones. This can be done geographically, by using the smallest direct distance between the connection points (middle figure 17). A more logical way of doing this is by using the closest connection point at the network (right figure). The distance over the road from the connection point of the zone that has to be aggregated to the connection point of the left zone is smaller than the distance to other zones.

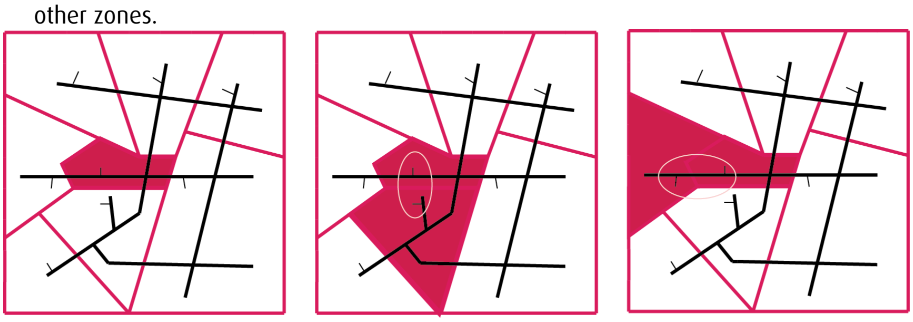


Figure 17 Connection link dependent zone simplification by the distance between the connection links geographically (middle) and by network (right).

Of course, a combination can be made between the zone simplification methods. For example: the zone with the least inhabitants merges with the zone that has the least direct distance to the entry points.

When applying hard, flexible or network dependent zone simplification, the OD-matrix will change. If two zones are combined, automatically the trips will be summed. The total attractions and productions will automatically become larger. Figure 18 shows the schematic effect of zone simplification at the OD-matrix. In reality, zone 1 and 2 do not necessarily need to be summed up, it could also be zone 1 and 4 for example or the production and attractions of zone 1 can be split into two other zones.

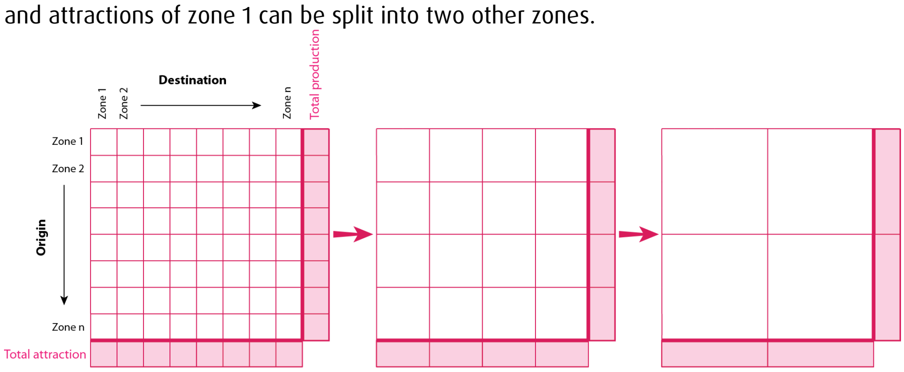


Figure 18 Effect of zone simplification at OD-matrix

Calculation of door-to-door travel times also requires the travel time from the original zone to the border of the connecting point of the aggregated zone (pre- connection figure 19).

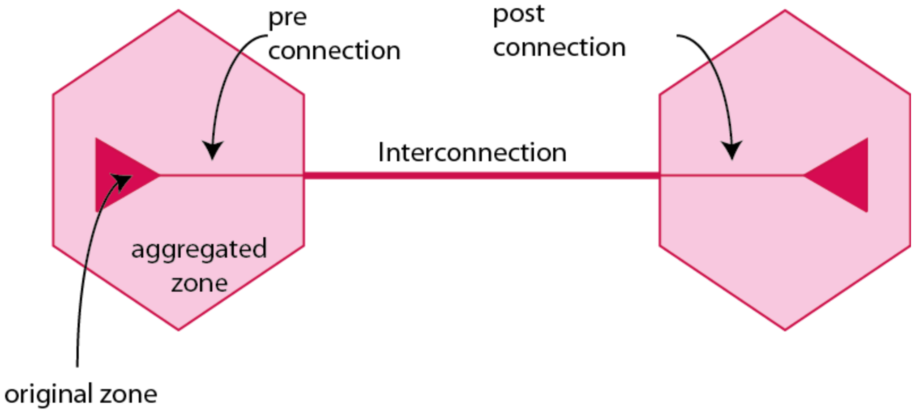


Figure 19 Travel time elements when applying zone simplification (Raadsen, Schilpzand & Mein, 2009)

To calculate the travel times, the shortest path from all original origins to all border nodes (pre connection) should be measured first. The same for the destination aggregated zones (post connection). After that, the shortest path between the two aggregated zones (interconnection) should be calculated. Finally the pre interconnection, interconnection and post interconnection compose the door-to-door travel times (Raadsen, Schilpzand & Mein, 2009).

Application

In this chapter at the end of the (sub)sections the use of the method will be shown in the pink blocks. The pink blocks will be summarized in subsection 5.6.2. Green text colour means that the method applies for an element, red means that it does not apply and gray means that the method applies at certain constrains or following from the method, but does not change in essential.

For example if you look at zone simplification the route choice is gray, because by zone simplification vehicles will leave the aggregated zone from a different point and there are less connection points to the network, so the route choice has to change. The calculation time of the route choice will be improved because there is less data needed, but the calculation method will not be improved and remains the same.

Use zone simplification

Improvement computation time of behavior changes:

- ✓/× Trip frequency
- ✓ Destination choice
- × Mode choice
- × Departure time choice
- ✓/× Route choice

Model elements required input:

- ✓ Patterns in time/space
- × Use network

Useful for output:

- ✓ Mobility
- ✓ Economy
- ✓/× Environment
- ✓ Safety

Zone simplification has impact at the behaviour changes trip frequency, destination choice and route choice. The merging or deleting of zones effect the OD-matrices and because of this also the trip frequency. Deleting zones will reduce the trip frequency and merging zones will lead to a change in an indirect increase of trip frequency. Destination choice is coloured green, because in essential the destination choice automatically changes by the reformulation of the zones.

In the ScenarioVerkenner some zones will not be used by the assignment or zones will be aggregated, see hard zone simplification. Zone simplification is an effective method to reduce the computation time. The simplification affects the OD-matrices, and by this the amount of trips (interzonal) can be reduced. Merging areas result in larger zones. If a traffic and transportation policy question requires simulation of short distance trips, the zones can't be too large, because then some trips will not be simulated. Also if public transport is an important issue, the zone subdivision needs to be extra fine because the use of public transport strongly depends on the characteristics of the local access and egress transport (Bovy, Bliemer & van Nes, 2006). So the choice of zone simplification should meet the required level of detail for the public transport.

Theoretically zone simplification only requires patterns in time and space. Often generated traffic of the zones will be assigned to a network. Zone simplification is useful for all the output. When concerning the economy, the aforementioned door-to-door travel time is a critical element. In the aggregated zones, the impact to the noise emission cannot be determined, because the distance to the roads is unknown or only the transit traffic will be used in the calculation.

5.2.2 Network simplification

By applying zone simplification, automatically some links will not be part of the network, such as connection links from the disappeared zone to the rest of the network. Besides, it's possible to delete links or nodes in order to simplify the network. Routes exist of multiple links and nodes, so by route simplification the network could also be simplified.

Methods

Figure 20 shows in the upper situation the simplification of one OD-pair with three routes (left) to two routes (middle) ad one route (right). By multiple OD-pairs in a detailed network (below left) an simplification to a simplified network can be made to delete some links and nodes (middle) and result in one shortest route per OD-pair (right). The new network with less links will be the input for a quick scan tool and with the application of network simplification, the calculation time will decrease.

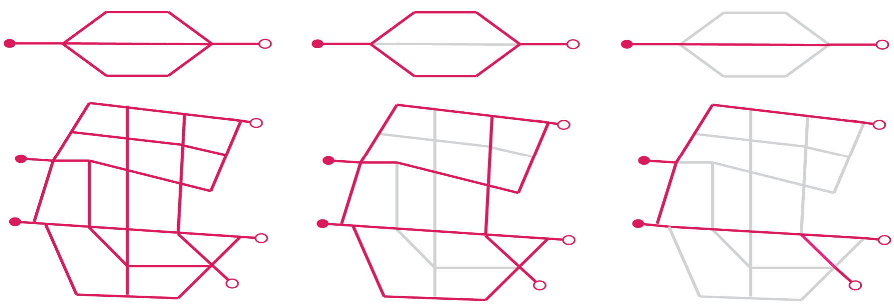


Figure 20 Simplification at link level for one OD-pair (on top) and multiple OD-pairs (below) by deleting links (gray).

The choice of deleting links or routes can be made using the following criteria:

- **Least traffic flow.** The links with the least traffic flow in traditional models in (almost) equilibrium disappear. The same can be done for routes. Another option is deleting all the OD-pairs with low flows, so the "important" flows remain. This will not reduce the amount of links, but decrease the calculation time substantial.
- **Not shortest route.** Also all the routes longer than the shortest route could be deleted and result in just one travel possibility per OD-pair. The shortest route is mostly defined as the route with the shortest path (least travel time). This results in a network with only the shortest routes. The traffic at the "deleted link" should use the remaining links, but the links will not be really be deleted in reality. This would result in an overload at the remaining links that does not fit reality.
- **Short distance to other link.** Geographically combining links which have a small distance between the two links. Links with a smaller distance with another link than the tolerance value, should be combined. In geographic information systems this simplification can be done easily (ArcGIS2, n.d.). On the other hand: with this method an incorrect combining can be made by combining country routes with an important corridor.

To prevent the wrong merging, the combining can be done by category. The combining can be split into the highway network and then the underlying network or the local roads can be merged with the highways. This results in a highway network.

Besides link- and route simplification, also node simplification can be done. Nodes with just two connecting links can be deleted from a network or a roundabout with a lot of nodes can be turned in a one node intersection. When applying node simplification, automatically the amount of links decreases and also the possible places to connect a zone to the network will reduce. The calculation time will not decrease drastically, because the amount of OD-pairs will remain the same.

Link simplification can end in a simplification where cities are points and vectors indicate the flows between the cities. These models are called 'corridor models'. The vectors are unrealistic links with for example weighted average travel time and a weighted average distance. In these models, there is almost no choice between routes, because one corridor reflects mostly all flow between two cities. So corridor models do not need a detailed assignment method. A model based on traffic flow theory, such as a bottleneck model, can be useful.

In the previous subsection the topic of zone simplification was discussed. A combination of the total network simplification is made in spatial simplification by using the traffic states of the network elements. In this innovative method, a distinction between uncongested, critical and congested states can be made. This is a variation of the incremental approach, see section 5.5.1. For example uncongested links and nodes can be combined into a lower layer. A layer on top of that will contain the critical network elements and finally, the congested links will form the upper layer. This categorization can correspond to the traditional simplification, e.g. living area's, underlying network and highway network, but is not necessary. When applying quick scan tools, the lowest layer is not very interesting, because of these uncongested links do not contain problems. At the two upper layers, bottlenecks occur and therefore, the highest costs are at these links.

Application

By link/route simplification the network structure will be influenced and because of this, also route choice. The assumption is made that people don't change their destination and crucial links to destinations will not be deleted. This means that the shortest route to the destination will always containes.

Network simplification at link level improves the calculation time. A disadvantage is the irreversibility of the simplification method, so the application should be used precisely.

The abolition of OD-pairs with low flows, will not attack the amount of links. The disadvantage is that large increase of flows at deleted OD-pairs will not be part of the simulation in the tool.

Use network simplification

Improvement computation time of behavior changes:

- × Trip frequency
- × Destination choice
- × Mode choice
- × Departure time choice
- ✓ Route choice

Model elements required input:

- ✓ Patterns in time/space
- ✓ Use network

Useful for output:

- ✓ Mobility
- ✓ Economy
- ✓/× Environment
- ✓ Safety

Spatial simplification by traffic state is promising, because it faces the essential elements of a network. Meanwhile it is a new method, so there is a need to investigate this method further.

Network simplification effects the route choice and take place at network elements, so the network is required input. Automatically the patterns in time/space are required

Almost all the output elements can be calculated by network simplification. A warning is in order by the application of spatial planning and noise nuisance. In tools the simplified network can be used as a new network, otherwise there's no benefit compared to a simple traditional model. A difference is that, by developing a new area, deleted links (existing roads in reality) should be part of the shortest route, but cannot because they are deleted. The result is that the dilation of the new area to a destination will be larger. However, experts can manually determine the connection at the new network by using experience. So the simplification of the links by spatial planning needs attention and for the same reason building a new road.

If two routes are combined to a new, non-existing road, the effect of noise nuisance cannot be calculated, because the distance to the road is relevant. In this case the road is situated on an unrealistic place. A simpler model, such as queuing model, is suitable by this simplification by network simplification.

5.2.3 Macroscopic fundamental diagram

In quick scan tools, the effect of a measure in the network needs to be measured. This can be done by assignment to an simplified network (see last sections). Another way is to show the network performance immediately by the Macroscopic Fundamental Diagram (MFD). The MFD is part of a requirement (chapter 3), but it is also be used as a method to simplify the spatial element of modelling. The fundamental diagram reflects the dynamics on a homogeneous road section.

The dynamics of the total traffic network are visualized in the MFD (also called Network Fundamental Diagram). In this diagram, the state of the network is shown by the relation between the amount of vehicles in the network (accumulation) and the production (effectiveness) of the network. This simple relation reflects the dynamics of a network and a small amount of variables is needed, only the accumulation and outflow are required.

Method

To understand the MFD first the theory of fundamental diagrams needs to be clear. The relations between macroscopic characteristics of a traffic flow are shown in fundamental diagrams (FD). FD's model the average relation between time headway (1/intensity) and distance headway (1/density). The relations between the intensity and density, speed and density, speed and intensity are usually plotted in graphs (see figure 21). The fundamental diagram reflects the conditions of a road section (Hoogendoorn, 2007).

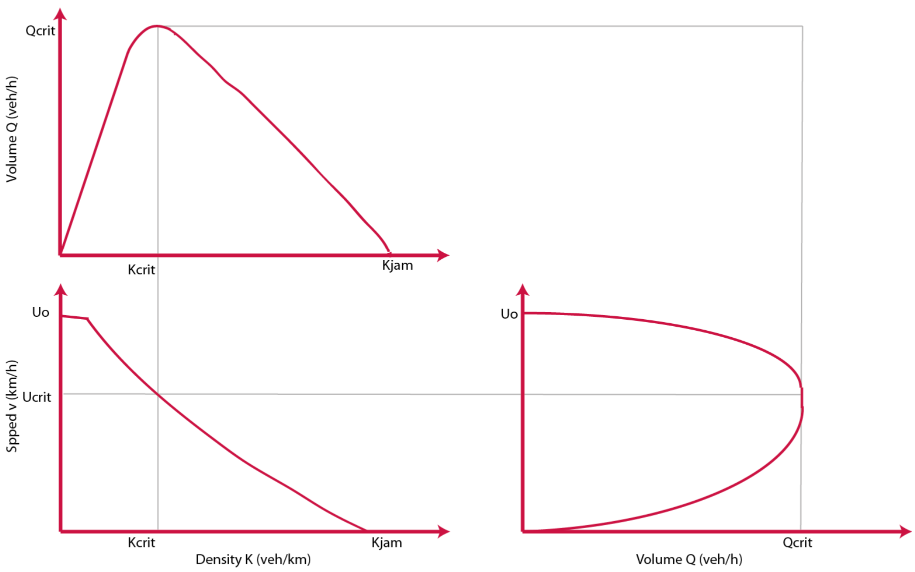


Figure 21 Fundamental diagram illustrates relations between density, speed and intensity.

Fundamental diagrams do not have the same shape for every road (Ji, Daamen, Hoogendoorn, Hoogendoorn-Lanser & Qian, 2010). The location of the collectors and dramatic changes in the traffic situation influence the shape of the FD(Buisson & Ladier, 2009).

Also the shape of a fundamental diagram depends on the characteristics of the road (amount of lanes, grades etc), drivers, vehicle composition and conditions such as lightning and weather. Also, measures such as speed limits, influence the (M)FD (Hoogendoorn, 2007). By simulation at macroscopic level weather conditions and drivers are not important. The road characteristics, vehicle composition and speed limits are relevant.

A network has other characteristics than a road section. In a network traffic processes such as route choice and spillback, are integrated. The average driving behaviour of a whole network is shown in a MFD. The state of the network is illustrated by the relation of accumulation and production or accumulation and output (figure 22). Output is the amount of vehicles finishing their trips per time unit. Accumulation is the amount of vehicles travelling in a network. Accumulation and travel production are observable quantities, output is not. There is a linear relation between the production and output, so the (unobservable) output can be approximated by the traffic production (Geroliminis & Daganzo, 2007). The MFD can also reflect the total distance travelled by all vehicles travelling (x-axis) in a network and the amount of vehicle hours travelled (y-axis).

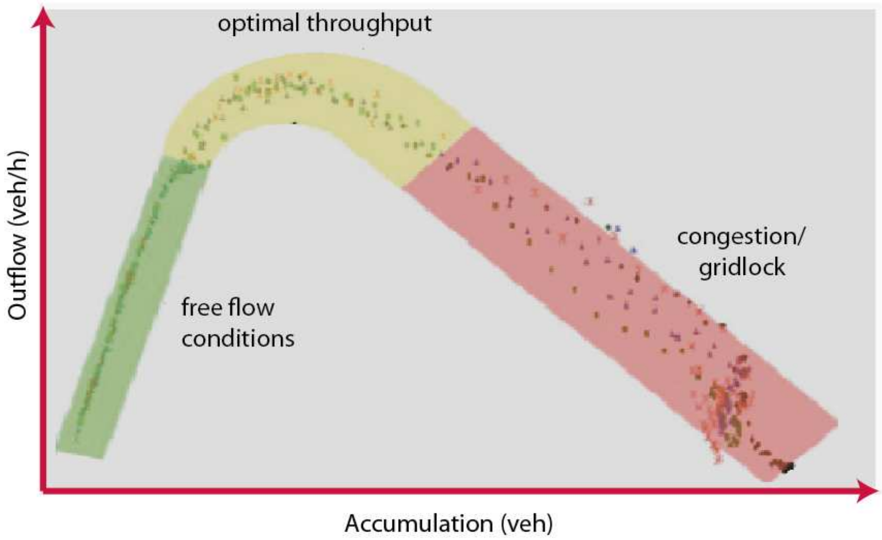


Figure 22 Macroscopic fundamental diagram reflects the relation between the accumulation and the outflow (Geroliminis & Daganzo, 2007).

The up-sloping line represents the free flow conditions where the travel production increases with increasing accumulation. The down-sloping line shows the congested state. Between these lines, the optimal throughput can be achieved (yellow) (Geroliminis & Daganzo, 2007).

Determination (M)FD

For determination of the shape of the MFD, information about the effects of network conditions on the shape are needed. The determination of the MFD can be done by determination of the average density and intensity or by summation of fundamental diagrams of roads.

- The average weighted network flow, also called production, (q^w) is the sum of the flows at the link (q_i) multiplied by the link length (l_i) divided by the total link length (sum of l_i). For determining the average network density of vehicles, also called occupancy, (o^w) the occupancy at the detector on link I (o_i) multiplied with the link length (l_i) devided by the total link length (sum of l_i) (Geroliminis & Daganzo, 2008).

$$q^w = \sum_i q_i l_i / \sum_i l_i$$
$$o^w = \sum_i o_i l_i / \sum_i l_i$$

Where:

$q^w = average\ weighted\ network\ flow, production$

$q_i = flow\ link\ i$

$l_i = lenght\ of\ link\ i$

$o_i = Occupancy\ of\ link\ i$

- Another possibility is to take the vector sum of the different fundamental diagrams. The vector sum leads to the MFD. The shape of the FD's of roads can be input for the MFD. The FD can be observed from data measured by loop detectors. The input data should be filtered before usage, because of bias. This results in less data and because of this it will be harder to construct the fundamental diagram (Cassidy, Jang & Daganzo, 2011). Also missing or broken detectors can be a problem and the accuracy of the loop detectors has to be proven. Another possibility is to use the aggregated flow and density by virtual loops in a simulation model (Courbon & Leclercqa, 2011). The advantage is that predicted changes of a road and traffic will be included in the results. On the other hand, there should be a model of the study area and the accuracy of the output can deviate from reality. To derive a complete MFD, data of all the three traffic states are required. Therefore, peak and off-peak data should be collected. Also the time periods need to be long enough to simulate total traffic light cycles and small enough to prevent averaging and by this missing the optimal throughput.

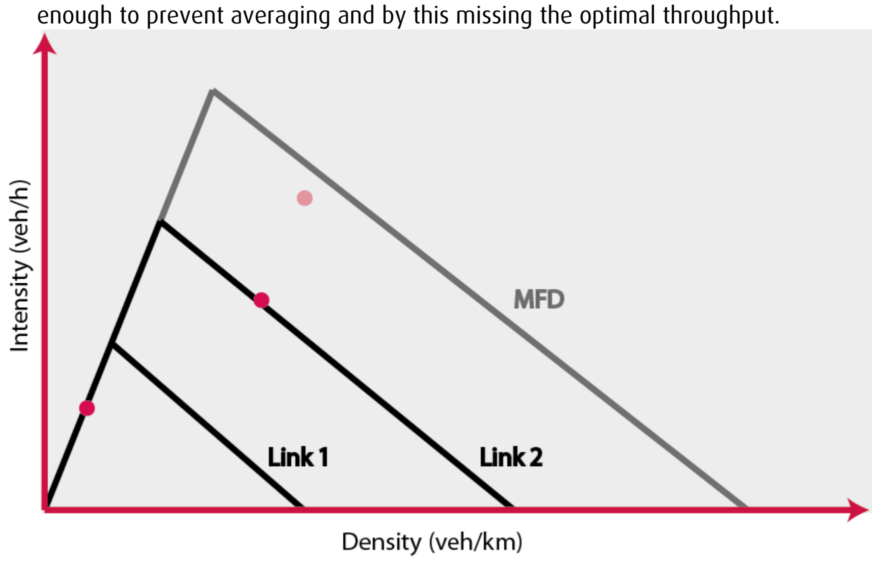


Figure 23 Summation of fundamental diagrams of links to a macroscopic fundamental diagram.

The vector sum of FD’s of roads forms the MFD (figure 23). If the situation on the two links differs, (uncongested and congested) the point will lie under the MFD (pink point). The relationship is only valid when traffic states are similar for all the links in the network (Daganzo, Gayah & Gonzales, 2011). Otherwise it is necessary to know which conditions at the different roads occur at the same time, as this results in different MFD’s. In figure 23 the sum of the fundamental diagrams is shown. (Cassidy, Jang & Daganzo, 2011) In this case also the assumption of triangular MFD’s is made.

Network performance
A network performance can be expressed in the relation between the amount of vehicles in a network and the amount of completed trips. Another indicator of the network performance (veh/h) is the function of the variation in densities over the links. The higher the variation, the lower the performance will be. The performance can be measured in the average density per subnetwork, because the relation between the variation in cell density and the variation in subnetwork accumulation is mainly linear (Knoop, van Lint & Hoogendoorn, 2011).

Application
In quick scan tools an assessment of the shape of the MFD of that network can be made to assess the network performance or the quality of a sub network (pink dot) can be determined, by comparing it to the average MFD of comparable roads (see figure 24). These average MFD can be determined by using information of microscopic models. The effect of a measure at the MFD will be displayed in the new MFD for a subnetwork and can be assessed.

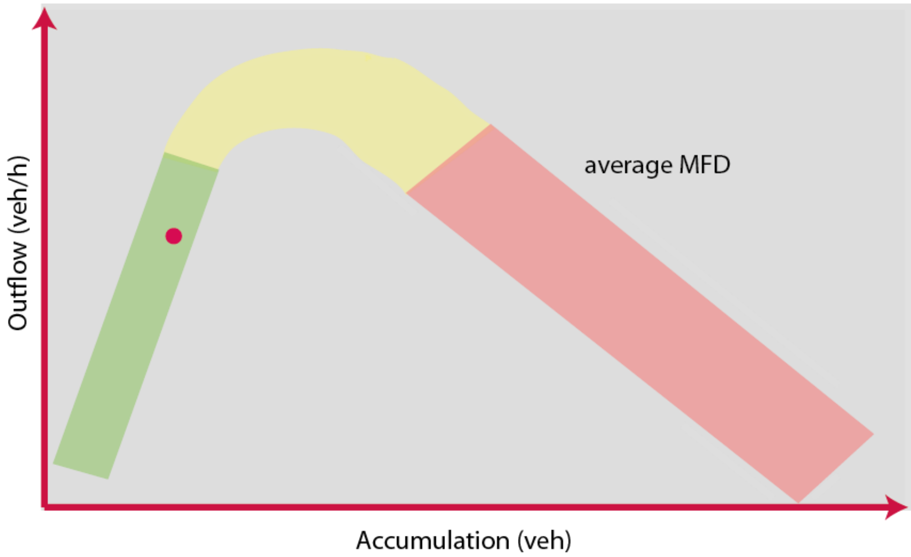


Figure 24 Example comparison situation with MFD of comparable roads.

By the use of MFD's, the route choice will be simplified, because it is generalized in the network performance. Advantages are that the assignment to a network is not required, unlike detailed models, and less data is needed. The output can be given at global level.

For example the MFD can be used to easily determine the effect of forty thousand more cars at the (sub)network. The biggest advantage is the small amount of required data and that the location of the new area that generates the forty thousand extra cars is unnecessary to know.

The problem is the determination of the MFD. Ideally the MFD can be determined by the characteristics of a network; network structure, network load and used measures. Nowadays the research of these elements is in progress. The MFD is a conceptual idea and is gradually tested at simple networks. Assumptions such as triangle MFD's are made. So it demands more research to generalize and apply the theory. This research will be out of scoop of this thesis. However the use of MFD's in quick scan tools has high potential in the future. The use of MFD in the assessment of tools by the requirements is suitable. When a network has a high accumulation, the outflow should decrease, see requirement section 3.4.

Use macroscopic fundamental diagram

Improvement computation time of behavior changes:

- ✗ Trip frequency
- ✗ Destination choice
- ✗ Mode choice
- ✗ Departure time choice
- ✓ Route choice

Model elements required input:

- ✓ Patterns in time/space
- ✗ Use network

Useful for output:

- ✓ Mobility
- ✓ Economy
- ✓/✗ Environment
- ✓ Safety

5.3 Time simplification

In quick scan tools, a good interaction between spatial and time simplification is needed. With a high level of time prediction, a high level of spatial simplification is required, because the at long horizon the future is more unpredictable, especially at a detailed network. figure 5 and trip frequency, destination choice and modal choice can be simulated with patterns in time and space (+mode). the simulation of departure time choice and route choice requires the use of the network. the driving behaviour was already excluded for quick scan tools. therefore quick scan tools can use patterns in time/space and the use of the network, but will not simulate the use of the infrastructure. so quick scan tools will not be used at microscopic level. show the parallel relation between the large prediction horizon and the size of time steps. When there is a large prediction horizon, the effects for 5 minutes are irrelevant, so the time steps can be increased. For a detailed network small time steps are desired, because detailed results are required.

Because of the low level of detail in case of spatial simplification, the time steps also do not have to contain a high level of detail. The translation from small time steps to larger time steps is called time simplification. Time simplification is a simple simplification method. It can be done in two ways. Small time intervals will be summed up to larger time intervals. Another method is to select time interval depending on the required output. By implementing one of these two approaches the calculation time will decrease.

Method
The choice of time simplification depends on the availability of the data, the required data for the output and the network dependent elements. The available data is especially for quick scan tools very important, because according to the requirements, the input should be simple.

A method is to add up time intervals. By this method of merging time intervals, the associated data should be summed up. The original data are the trips in the OD-matrices. The OD-matrices should be summed up to form a new OD-matrix, see figure 25.

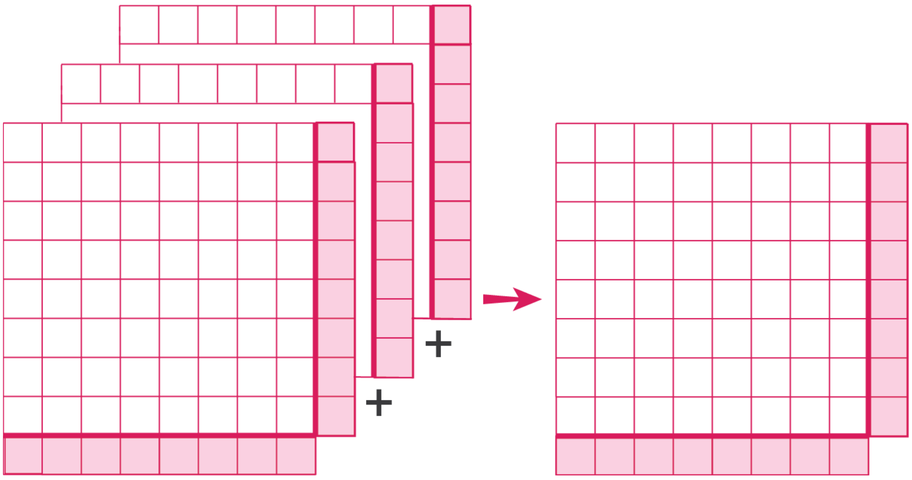


Figure 25 Time simplification by enumeration of the data of original OD-matrices of different smaller time intervals to a new OD-matrix.

Another possibility is to selection of just a few time intervals when the output does not require all of them, is a form of time simplification. The indicative time step (e.g. rush hour) intensity is needed to determine the bottlenecks for the accessibility. For environmental impact the daily intensities satisfy.

Dynamic assignment models use an OD-matrix for every time period, e.g. 5 min periods. In this case, the sum of time steps or a selection of time steps can be made. With the sum of time steps, the strength of a dynamic model will be tone down, because it will be more similar to a static model. By certain time simplification, the time shift cannot be simulated any more. Static assignment models use just one time period, e.g. rush hour or total day. Of course this model can be run for different periods. The interval that is required for the output can be chosen.

The correct simplification step depends on the required output and on the network depending elements. For example the interval size for route travel times is higher than the intervals for link travel times when forecasting travel times. The best simplification interval size for forecasting route travel time is a function of the traffic dynamics. So the choice of time simplification needs to be adjusted to the situation (Park, Rilett, Gajewski, Spiegelman & Choi, 2009). The time simplification depends on the spatial simplification and the simplification of travel behaviour.

Application

Time simplification influences the OD-matrices. The calculation time will be effected by the amount and size of OD-matrices that are used. By changing the OD-matrices, the trip frequency changes, but the amount of trips do not change over time. It does not matter if the there are six OD-matrices of 10 minutes containing hundred trips or one OD-matrix of an hour containing six hundred trips. There are still six hundred trips per hour. This is the reason the trip frequency is marked orange.

When less time periods are used, the time shift will also be less detailed simulated, because there are larger time frames. When a departure time first is situated in a five minute frame and will change to ten minutes later, this change will not be observed in a new one hour frame. Changing frames is the indirect result of time simplification and by this departure time choice is indirect changed.

Use time simplification

Improvement computation time of behavior changes:

- ✓/× Trip frequency
- × Destination choice
- × Mode choice
- ✓/× Departure time choice
- × Route choice

Model elements required input:

- ✓ Patterns in time/space
- × Use network

Useful for output:

- ✓/× Mobility
- ✓ Economy
- ✓/× Environment
- ✓ Safety

Time simplification influences the patterns in time and not directly change the network structure. The choice of time simplification affects the reliability of the output. For example the bottlenecks are not correctly determined by the use of day intensities, because the input will be averaged and because of this the output will also be averaged. For the same reason the environment cannot always be calculated correctly. Mostly the averaged output is not interesting when performing a global analysis. Working with worst/best case scenarios is more appropriate for quick scan tools.

5.4 Simplification of travel behaviour

One of the main forms of simplification, besides spatial and time, is simplification of travel behaviour. The level of spatial elements and time elements will be input for a model. The model can also be improved, to accelerated the calculation of behaviour changes. The acceleration of behavioural changes of traditional models will be discussed in this section. The choice of simulation of travel behaviour needs to be done properly towards the chosen spatial and time level. For example a static route assignment should not be applied at a network with a high level of detail. The driving behaviour is excluded for quick scan tools in the chapter ‘application’, so it will not be further discussed in this section. The choice of driving behaviour simulation should correspond to the chosen simplification levels.

5.4.1 Trip generation

In trip generation the amount of trips will be determined. This can be done in detail or in a simplified manner. For example the amount of extra trips that a new area will attract can be calculated in detail, but also an assumption can be made based on elasticities (subsection 5.5.2). Besides, the amount of trips can be chosen by characteristics such as the selection of data points (zones), modes and time steps, see previous sections. The size and the amount of OD-matrices can be chosen. Smaller matrices mean less origins and/or destinations and will decrease the calculation time. Less matrices will result in time simplification. At the same time it will also decrease the reliability of the calculation.

5.4.2 Trip distribution

The trip distribution can be determined by a simple gravity model. In this model, the amount of trips between a specific origin and destination depends on the attraction ability of the destination zone, the production ability of the origin, the accessibility between the two zones and a measure of average trip intensity in the area.

Another way of trip distribution is the use of distribution functions. Continuous distribution functions can be used. This function depends, with a mathematic relation, on costs of the route between origin and destination. A simplification is the discrete distribution function.

For quick scan tools a simpler form of simulation of trip distribution can be chosen. A simplification will be to choose a less data intensive distribution method with less calculation time, such as the gravity model or discrete distribution function, instead of the disaggregated choice models.

Another very fast model is the growth factor model. By this method the cells in the base year OD-matrix will be multiplied by a growth factor. This model is quick and simplified the reality and requires an existing OD-matrix, so applicable in meta-models. In Furness and Fratar the growth factor is applied per zone.

5.4.3 Modal split

If a quick scan tool is not used for the determination of the modal split, it is not necessary to use all the data of other modes. By selecting just one mode, the calculation time will improve. Also the use of simpler formulas is an option.
In the "verplaatsingstijdfactor" (distance time factor) the relation is given between the dependant variable (the modal split between two modes) and the independent variable (the rate between the travel times) of the two modes.

5.4.4 Period of day

Simulating the choice of period of day requires information of the whole days. For the correct simulation of time shifts, a dynamic assignment model should be used. If a model will not calculate the time shift a detailed time steps is not required. In section 5.3 more information is given about time simplification. The distribution of the departure time over the different periods can be quickly determined by using a split factor based on the data in transportation researches, for example Dutch Mobility Research, 'MON data'.

5.4.5 Route assignment

There are different types of static route assignment, see table 4. The choice of the assignment method depends on the wish of modelling congestion effects and/or random utility route choice. For example: if the congestion effect should not be simulated and there are no individual differences between travellers, an all or nothing assignment method is suitable. The maximum simplification of the calculation can be tuned when desired.

Table 4 Static route assignment methods

		Congestion effect modeled	
		No	Yes
Random utility route choice modelled	No	All-or-nothing	Deterministic equilibrium
	Yes	Stochastic	Stochastic equilibrium

The choice of the route assignment depends on the aims of a quick scan tool. A useful variation for quick scan tools is to use different methods in one tool. For example: a deterministic equilibrium assignment method can be used in the problem area and for the rest of the model an all-or-nothing assignment can be used. The place where the effect should be calculated can be determined in more detail and the tool is fast. Besides, also the choice of amount of runs one wants to perform can be based on the required output.

Bottlenecks and spillback influence the route choice. Static assignments cannot simulate this proper. Dynamic assignments can approximate the route choice, including bottlenecks and spillback, much better. Dynamic assignment models can simulate variations in time by using multiple OD-matrices. This requires more input than static models, but generates more reliable travel times and the place of congestion can be better determined. The calculation time of dynamic assignment is very long compared to static models, so dynamic models are in the traditional form mostly not applicable in quick scan tools. Static models with a more correct calculation of travel times, such as Static Traffic

Assignment with Queuing (STAQ) and QBLOK are better. QBLOK is an assignment technique used in the LMS. QBLOK use another calculation of the travel times on the links. The flow of the previous links will be take into account. In the case of congestion on the previous links, because there is a capacity is reached, the inflow on a link will be less. In this case there will be a queue modelled. Also blockades on links on the next link will be take into account, because this will influence the outflow of a link (Dienst Verkeer en Scheepvaart, 2009). STAQ is a link transmission model that only requires calculations on the nodes. STAQ consists of two phases: squeezing and queuing. By squeezing all the traffic demand is put on the network along paths derived from a earlier performed route choice model. A link with more demand than capacity is a bottleneck link. The traffic flow on all paths with bottleneck links will be reduced (squeezed) from the bottleneck links to the destination. The surplus will be stored in vertical queue at the start of the bottleneck link. With the second phase (queuing) the vertical queues are translated in horizontal queues by using traffic flow theory and the fundamental diagrams. The queuing phase yields flow conditions on any given location on any given link on the network. Based on cumulative flows, travel times and link speeds can be derived (Brederode, Bliemer & Wismans, 2010).

In the last three sections the directions of simplification are discussed. Spatial simplification can be done by zones, network elements simplification and assessment of network performance. With spatial simplification the calculation time can be improved much. Especially at network level with the fundamental diagram. If a high level of spatial simplification is chosen (rough network) a high level of time simplification (larger time steps) is required. Also a long prediction horizon requires large time steps and a more rough network. The simplification of travel behaviour is relative wide usable, because all the model steps can be simplified. The level of travel behaviour simplification can be chosen by the level of spatial and time simplification and vice versa. In a quick scan tool a high level of simplification at all three elements is expected.

5.5 Other methods

Besides the three simplification directions mentioned in the previous sections, there are other quick scan methods that can be applied at more directions. The first section describes the incremental approach that can be applied at the spatial and time element. The second section describes elasticities that are applicable at all three simplification directions. The supply curves are also at time and space, so the supply and demand curves are also in this section described.

5.5.1 Incremental approach

In the incremental approach, only the difference between the new situation and the reference scenario will be calculated without using an integral new equilibrium calculation (Projectdirectie Sneller&Beter, 2010a). By using this approach, for example the measures and the demographic development can be simulated separately. In the tool called "Applicator", small political changes can be calculated with an incremental approach. The Applicator does not use new iterations and there will be no equilibrium, but it rather works with the detailed calculations of the detailed underlying model (TNO, 1993). Using this, the calculation time will be greatly reduced. When only calculating the changed situation, only the influenced route trees should be investigated.

Another form of incremental calculation with iterations is Marginal Computation. When using Marginal Computation, only the active part where the traffic flows differ from the base flows will be calculated in the second iteration. The active part of the network and active time period that changed in the second iteration will be calculated in the next iteration and so on (Corthout, Tampère, Frederix & Immers, 2011).

Another possibility is to cut a small area, where the adjustment for the quick scan tool is made. At the intersection of the edges of the area and the roads leaving, the travel times and remaining distance of these links should be calculated. The distance of the edge to the end of the link can be expressed as a percentage of the total link length and by this a percentage of the travel time. The risk is that it is possible to cut a link containing congestion. Another risk is that the percentage can be unsuitable or the place of the congestion is not correct. The amount of inaccuracy that exists should be further investigated. The cutting of a small area of a detailed model will simplify all the behavioural changes, because the amount of trips, amount of route choices etc will reduce.

Application
The incremental approach is one of the most effectiveness methods, because only the important network elements will be used and not the complete network. With the zooming incremental approach (cut small area) all the behaviour changes will be improved because the network will be simplified and by this the OD-matrix. For the new area, all the output elements can be calculated. Also in the matrix incremental approach can occur. In this case only the patterns in time and space are needed.

With the Marginal Computation method, the route choice will be improved, because only the changed links will be used in the next iteration. The incremental approach is used in the existing models Quick Filter and the Mobiliteitsscan.

Use incremental approach

Improvement computation time of behavior changes:
- ✓ Trip frequency
- ✓ Destination choice
- ✓ Mode choice
- ✓ Departure time choice
- ✓ Route choice

Model elements required input:
- ✓ Patterns in time/space
- ✓ network

Useful for output:
- ✓ Mobility
- ✓ Economy
- ✓ Environment
- ✓ Safety

5.5.2 Elasticities
An elasticity reflexes the impact of a change in an independent variable on a dependent variable (Hague Consulting Group, 1999). Elasticities can for example be used to make a first-order estimation of changes in demand to price changes.

Next to elasticities, rules of thumbs exist. Rules of thumbs are simple rules that will be used to reflect the relationship between two or more variables. This could be a linear relation between two variables, but could also be a simple other formula. Often an elasticity is more based on an actual relation between two variables and rules of thumbs are more based on rough assumptions. An example of the use of rules of thumbs is the traffic generation in the online traffic generation tool. The publication CROW 256, Verkeersgeneratie woon- en werkgebieden” and “ 272, verkeersgeneratie voorzieningen” are used and contain rules of thumb. Other publications of the CROW can be used to formulate rules of thumb.

Methods
There are different kinds of elasticities; Point, arc and cross elasticities and shrinkage ratios.

Point elasticity. Point elasticity is directly derived from the economic definition of elasticity. Elasticity is roughly speaking the slope of the demand curve at a given point.

Point elasticity:

$$\eta_\rho = \frac{dQ}{dP}\ x\ \frac{P}{Q}$$

Where:

η_ρ = elasticity

P = price

Q = quantity

Arc elasticity. Arc elasticity is similar to point elasticity. Arc elasticity gives the change in consumption resulting from each 1% change in price, calculated in infinitesimally small increments. Arc elasticity computes the percentage change between two points in relation to the average of the two prices and the average of the two quantities instead of the change from one point to the next. The logarithmic formulation results in a closely approximation by a midpoint. For example: -0,5% price elasticity for traffic applied to 10% price increase, leads to 0,5% reduction of consumption (e.g. trips taken, kilometres driven). A variation to arc elasticity is mid-point (linear) arc elasticity. When applying this method, the change in percentage is calculated relative to the midpoint (Litman, 2011a).

Log arc elasticity:

$$\eta_\rho = \frac{\Delta \log Q}{\Delta \log P}$$

Mid-point arc elasticity:

$$\eta_\rho = \frac{\Delta Q}{\frac{Q_1 + Q_2}{2}} + \frac{\Delta Q}{\frac{P_1 + P_2}{2}}$$

- **Shrinkage ratio.** A simplistic form of the arc elasticity is the shrinkage ratio, using a linear function to calculate how prices changes affect consumption. The shrinkage ratio occurs in the "rule of thumb" formulation and is defined as the change in demand relative to the original demand divided by the change in price (Litman, 2011a).

Shrinkage ratio:

$$\eta_\rho = \frac{\Delta Q / Q_1}{\Delta P / P_1}$$

- **Cross elasticity.** The cross-elasticity refers to the change in percentage in consumption of a good as a result of the price change of another good. Modal shift is an example of this phenomenon. If the prices of public transport increase, the usage of bicycles will improve (Litman, 2011a).

Concerning point and arc elasticities, the absolute elasticity value greater than 1.0 indicates an elastic relationship and less than 1.0 indicates an inelastic relationship. For shrink ratio's this is not always the case. When a relation is inelastic, the relative change in demand is smaller than the relative change in price. The elastic relations are most valuable for quick scan tools.

In general also inelastic relations close to 1 are interesting. In quick scan tools only large changes in the independent value are remarkable, because there is enough influence on

space, time and travel behaviour. These three direction has less details than traditional models, so small changes will not be noticed.

The Australian governmental department of infrastructure and transport owns a database with 400 elasticity tables from 200 sources (Elasticities Database Online). Some tables contain information from different countries. Elasticities can be different for different countries and some sources are out of date, so direct application in a Dutch quick scan tool is risky.

Application

Elasticities can be determined from the output of models or can be used as input elasticities to simplify the calculations in models (van der Waard, 1990). In quick scan tools elasticities are useful as input, especially to make the translation of transportation output into other effects (environment, economic and safety). For the modal shift cross elasticities are helpful to improve the calculation times a lot. Also, elasticities can be used to make predictions of the future OD-matrices and destination choices.

Elasticities are only reliable when correlation between the variables is shown. Also, elasticities are static over time. If the relation between two variables changes over time, elasticities will not change. Therefore elasticities are only useful when the relation is stable.

Use elasticties

Improvement computation time of behavior changes:
- ✓ Trip frequency
- ✓ Destination choice
- ✓ Mode choice
- ✓ Departure time choice
- ✓ Route choice

Model elements required input:
- ✓ Patterns in time/space
- × network

Useful for output:
- ✓ Mobility
- ✓ Economy
- ✓ Environment
- ✓ Safety

Elasticities can be used for all the behaviour changes. The elasticities influence the patterns in time/space and is widely usable to calculated all the output elements. In the existing quick scan tools ScenarioVerkenner, Quick Filter and the Fast simple model elasticities are used to decrease the computation time.

5.5.3 Demand and supply curves

One of the methods that use elasticities is the use of demand and supply curves. It excludes the network and time element and determines the equilibrium between price and demand. In static assignment demand and supply curves are used. The traffic assignment is based on the supply curves. After iterations the first principal of Wardrop will be approached.

Demand and supply curves will be illustrated with an example. A road will be extended from one lane to two lanes, because the capacity is not suitable for the projected traffic

growth. This can result in generated traffic demand with induced travel[2] and maybe additional trips,

By improving a road, e.g. road extension, travel costs will decrease and therefore demand will increase. This effect is indicated by the demand curve. Another relation between the travel time/cost and the demand is if the demand increases, the travel time/cost will increase, because the high I/C-value of the road section influences the throughput and will lead to larger travel times (Litman, 2011b).

Method

The supply curve (left figure 26) reflects the traffic flow in travel time/costs as a function of the demand. The supply curve is in transportation formed by the link performance function that often is simulated by using the BPR-function. In traditional static assignment models, the BPR-function is already used. The simplification step in quick scan tools should be to determine the supply curve for each OD-pair or for each network individually.

The demand curve (right figure 26) shows the amount of travellers that is willing to make a trip when certain travel times/costs are involved. For example the distribution function of the gravity model. If the trip length is 10 minutes, traveller x, who is willing to pay more (20 min) for a trip than the duration of the trip, has a profit of 10 minutes, which he can use for other activities and results in more economic value. The area under the demand curve is the, an indication of the benefits of a certain trip (10 min), the consumer surplus.

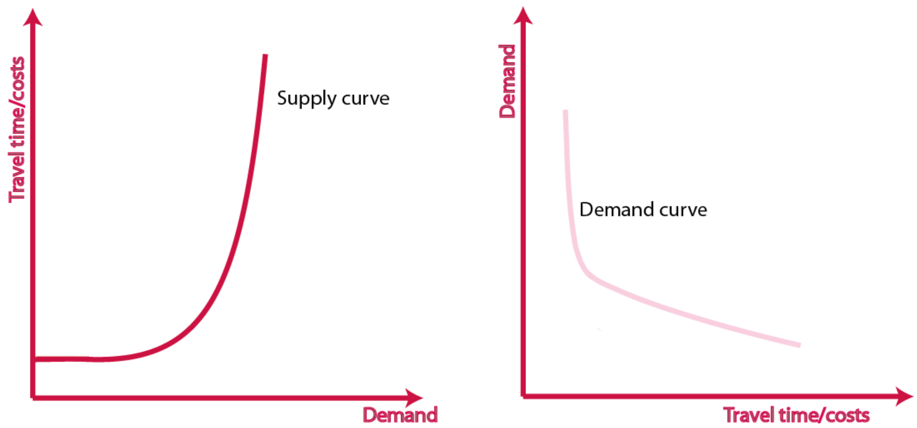


Figure 26 Supply (left) and demand (right) curves (Federal Highway Administration, 2002).

The supply and demand curves can be plotted in one graph by rotating and mirroring the demand curve. In economics, the intersection of the supply and demand curves indicates

[2] Induced travel is the increase of trip frequency and distances that occurs by improvements of the network. Additional trips when travel conditions improve are called latent demand (Litman, 2011b).

the equilibrium point. In figure 27 the equilibrium represents the average state where no travellers are willing to pay more for their trip than the equilibrium price.

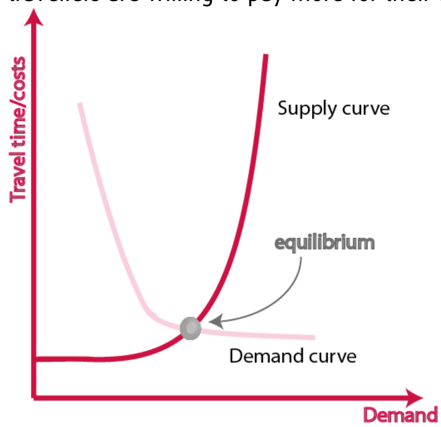


Figure 27 Equilibrium between supply and demand curves

A problem in this theory is the fact that travellers often do not know the travel time/costs before they make the trip. They make their decision about the trip based on experience and information of the traffic situation at the moment of departure, so the amount of travellers in reality will be different than the equilibrium. The decision of travellers (route choice) in the network is too detailed for quick scan tools at strategic level, but the assumption of them reaching an equilibrium in the long horizon can be made.

In most of the researches, a distinction is made between short (<2 years) and long horizon (>10 year) elasticities for traffic demands. A short horizon demand elasticity graph is in usually steeper than one of the long run, because at long horizon there are more opportunities to increase or reduce the consumption. Quick scan tools make predictions for long term, as determined in chapter ‘application’. The demand curve will therefore be less steep (Federal Highway Administration, 2002).

Application

There are traffic related measures that result in a change in the demand or supply curve. The movement of the intersection of the demand and supply curve can be used to provide insight in the introduction of measures such as price policies or extension of the network capacity. Application at link level is no option for a quick scan tool, because this is already used in static assignment models. Simplification of the spatial element or the curves should be made at network level or at least per OD-pair.

Use supply and demand curves

Improvement computation time of behavior changes:

- ✓ Trip frequency
- ✓ Destination choice
- × Mode choice
- × Departure time choice
- × Route choice

Model elements required input:

- ✓ Patterns in time/space
- × network

Useful for output:

- ✓ Mobility
- ✓ Economy
- ✓/× Environment
- × Safety

Simulation of the supply curve can be done by determining a function for the total network or for an OD-pair. The variables in the BPR-function at link level are the free flow travel time, volume of traffic and capacity per unit. Because it's not possible to speak of the free flow travel time, volume of traffic and capacity of a total network or OD-pair, the average BPR-function should be estimated. There is a difference between using the average of the variables of different BPR-functions to create a new BPR- function and using the average travel time (result of BPR-functions). Besides, the BPR-functions of some roads can be more important than the BPR-functions of other roads. The averaging of BPR-functions should be investigated when using this method. It is doubtful if the summation of BPR-functions is possible, because different conditions at links can occur at the same time, for example less demand on one link and too much demand at another link. The problem is similar to the problem of summing FD's to an MFD. Supply curves reflect the amount of demand that can be handled by a link pretty well, however, at relatively high demand (congestion), the supply curve (BPR-function) is not very realistic. So, as is the case when converting FD's to MFD's, the supply curve cannot be a sum of supply curves and needs to be determined by using existing models.

The demand curve reflects the amount of vehicles that want to make a trip at a certain travel time/cost. The demand curve per OD-pair influences the choice of trip frequency. The trip costs differ for every OD-pair, because of the different lengths of the trips and willingness to pay per kind of trip (short, long, business, recreational). Demand curves are realistic at crowded links and can be used as input for quick scan tools. They can be different per group.

The theory has potential, but the effects of measures at the curves needs more research. Like the MFD, the supply and demand curves are too experimental for this research, but have high potential, because they are fairly easy to apply.

The supply and demand curves are already used in the NRM (and also in another form in the Landelijk Model Systeem, National Model System (LMS)) in the fictional cost method. The calculation of the equilibrium will be approximated by loops of choice models. The method uses a curve of the traffic demand as function of the accessibility and a curve of the accessibility as function of traffic demand. Traffic demand of a basic year will be assigned and leads to an accessibility . This accessibility results in a new traffic demand. The equilibrium (U_e) will be at the intersection between two straight lines that approximate the curves, see figure 28. Using straight lines will accelerate the process and less storage space is necessary (RAND Europe, 2006), but is still a approximated solution method.

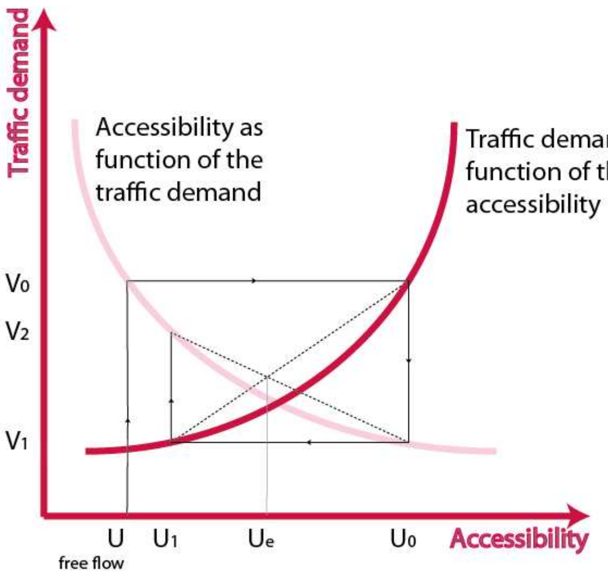


Figure 28 Fictional cost method

5.6 Assessment of considered methods

This section described the assessment of the methods. In the first section, the described methods in this chapter will be tested by the related requirements. In the second subsection the methods are assessed on their application.

5.6.1 Methods meets requirements

In table 5, methods are approved if they always contribute to the requirement. It could also be that they do not contribute, but are also not in conflict. Sometimes the methods are not in conflict with the requirements under conditions. In this case the method is not always in conflict with the requirement. On the top of the table the method related requirements are shown. In a quick scan tool, a combination of quick scan methods can be used to fit all requirements. For example zone simplification needs detailed data of zones, so therefore, the input is not simple. A combination with different elasticities can form a total tool, because with less data predictions of the generated trips can be made.

Table 5 Assessment quick scan methods according the requirements.

✓ = Always contribute requirement
\- = not in conflict with requirement
✓/× = not in conflict under conditions
× = in conflict

Methods	Requirements related to methods: Reproducible	Assess alternatives	Short computation time (<10 min)	Fits logical transportation and traffic relations	Output does not conflict traffic flow theory	Simple input
Zone simplification	-	-	✓	-	-	✓/×
Network simplification	-	-	-	-	-	✓/×
Macroscopic Fundamental Diagram	-	-	✓	-	✓	-
Time simplification	-	-	✓	-	✓/×	✓/×
Simplification of travel behaviour	-	-	✓	-	✓/×	✓/×
Incremental approach	-	-	✓	-	-	✓/×
Elasticities	-	-	✓	-	×	-
Demand/Supply curves	-	-	✓	-	×	-

All the methods are reproducible, because the calculation methods generate the same results every time they are applied. Also all methods can be used to assess multiple alternatives, but not all measures can correctly be determined with all the methods. Sometimes important elements will be removed when analyzing a measure. For example, the effect of adding links between the original zones is not measurable by zone

simplification, because they are situated inside the new aggregated zone. By the MFD or demand and supply curves, the shape will change minimum at network level by one changed road.

The computation time depends on the size of the network. Quick scan methods improve the calculation time, but the required way of simplification should be determined and depends on the size of the network. Zone simplification improves the calculation time much, because the amount of OD-pairs will drastically decrease. For example; deleting one zone is often faster than deleting one OD-pair at a large network. Because zone simplification improves more than network simplification, a – is given to network simplification. The MFD and the demand and supply curves can be used without a new network and because of this, the calculation time is relatively short.

None of the methods conflict with logical transportation and traffic relations, at least they do not conflict more than traditional models. If a method is built at a traditional model, the tool would fit also the same relations as the underlying model. Besides the relations, a method should also not be in conflict with traffic flow theory. Static assignment conflicts with traffic flow theory, because the spillback of congestion is not correctly simulated. Time simplification of dynamic models, multiple OD-matrices for different time periods transferred in just one OD-matrix will result in conflict traffic flow theory. The same can occur by travel behaviour simplification. Elasticities and demand and supply curves will always conflict traffic flow theory, because the traffic situation in congestion cannot be simulated correctly with this methods.

With the simple input requirement, the methods are assessed if the method requires no extra information at the moment it is used. The input of creating the method, e.g. elasticities needs much input, is leaved out of account. The incremental approach, travel behaviour, zone, network and time simplification all need specific information about the situation at the moment the tool is applied. The needed input to generate the tool is large for elasticities, expert judgement, the demand/supply curves and MFD's. By usage the general elasticities etc are already generated and by this easier to use. Building these models will cost more time, but the development of the tool should not be quick, the usage of the tool should be easy.

5.6.2 Application of the methods

Table 6 shows the application of the quick scan methods. If a method improves a behaviour change or a model element, a tick is given and a cross by no changes. If the improvement only occurs by certain conditions a tick and cross are given. A green tick by the model elements means that the element is required as input. If a method contains a green tick at an output element, it can be used for those outputs. The assessment is already done and explained at the end of the sections in this chapter and summarized in table 6. In general, the incremental approach is a very good method to improve the traditional model steps. Also elasticities are efficient quick scan instruments. The method to improve the simulation of the travel behaviour scores well at all the elements, because it includes all the behaviour changes.

Looking at the output incremental approach, elasticities and route/link simplification are suitable methods. MFD's illustrated quickly the network performance with few variables.

Table 6 Application of quick scan methods

✓ = yes
✗ = no
✓/✗ = yes, under conditions

	Improvement computation time of behaviour changes					Model elements required input		Useful for output			
Methods	Trip frequency	Destination choice	Mode choice	Departure time choice	Route choice	Patterns in time/space	Use network	Mobility	Economy	Environment	Safety
Zone simplification	✓/✗	✓	✗	✗	✓/✗	✓	✗	✓	✓	✓/✗	✓
Network simplification	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓/✗	✓
Macroscopic Fundamental Diagram	✗	✗	✗	✗	✓	✓	✗	✓	✓	✓/✗	✓
Time simplification	✓/✗	✗	✗	✓/✗	✗	✓	✗	✓/✗	✓	✓/✗	✓
Simplification of travel behaviour	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Incremental approach	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Elasticities	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓
Demand/Supply curves	✓	✓	✗	✗	✗	✓	✗	✓	✓	✓/✗	✗

Dependent of the measures that have to be simulated, certain methods can be used to improve the calculation time. A tool can consist of multiple methods and so all measures can be simulated using quick scan methods. With table 2 the required input and output is shown. Also the primary effects in behaviour changes are described for a measure. With this information the appropriate methods can be found in table 6.

The described quick scan methods are in general feasible according to the requirements. The correct use needs attention. This chapter showed that not all the methods can be used for the calculation of all behaviour changes. By this a method is not feasible for the evaluation of all the measures. Multiple methods can achieved a correct evaluation. The restrictions of the methods will be part of the assessment of existing quick scan tools. The next chapter will show the opportunities for the development of quick scan tools from the existing tools and the quick scan methods.

6

Opportunities for the development of quick scan tools

The previous chapters showed existing (quick scan) tools and the different quick scan methods compared to the requirements and the application of quick scan tools. In this chapter the conclusions of the previous chapter will be summed to determine the opportunities for the development of quick scan tools. In the first section of this chapter the opportunities for quick scan tools, based on the existing quick scan tools, will be discussed. In section 6.2 the opportunities for quick scan methods will be described. And finally the choice of developing a new tool will be made.

6.1 Existing quick scan tools

In chapter 4 the ScenarioVerkenner, Quick filter, Fast Simple Model (FSM) and finally the Mobiliteitsscan were assessed as quick scan tools. Quick filter and the Mobiliteitsscan are meta models, because they are based on detailed underlying models. Meta models are not suitable for countries where little data is available, because detailed models are required and these models require much information. Also the FSM uses a meta model called EXPEDITE to calculate European policy indirectly and the ScenarioVerkenner is outdated.

Projectdirectie Sneller & Beter (2010a) has selected four suitable quick scan tools that could be partly used in the reconnaissance phase in MIRT-projects, see the introduction of this report. Urban Strategy, Fast Simple Model, Mobiliteitsscan and Tiresias were selected. In this research Urban Strategy is mainly eliminated because of the required detailed input and Tiresias because of the contradiction with traffic flow theory. The other two quick scan tools were also selected in the chapter existing quick scan tools, so this confirm the conclusions of projectdirectie Sneller & Beter.

6.1.1 Application and requirements

The selected quick scan tools in chapter 4 state they can calculate the effects of certain measures. During the inventory in chapter 4 calculation process of these tools are assessed by the required output and the used methods as determined in the previous chapters. Some measures could not correctly be assessed because often there was too few information available.

Quick Filter and the Mobiliteitsscan simulate at a high level of detail and predict mostly at link level. In the chapter application the determined application domain was a rough network, long prediction horizon and simulation at macroscopic level. Quick Filter and the Mobiliteitsscan do not fit this profile, the FSM and ScenarioVerkenner do.

As mentioned before, the ScenarioVerkenner is outdated and cannot calculate measures correctly nowadays. The FSM calculates the effect of spatial planning and pricing policy and other policy measures. The Mobiliteitsscan simulates spatial planning, effects on the model split, improvement of public transport and the construction of new infrastructure. Quick filter models all the measures from table 2 except mobility management and price policy in form of charge per car emissions.

From table 2 mobility management related measures cannot be easily simulated with the existing quick scan tools, especially the effect in time shift. The comparison of existing tools and the 'ladder van Verdaas' also show the demand for good simulation of mobility management in utilization of the network in the reconnaissance phase (Projectdirectie Sneller&Beter, 2010a).

A lot of the tools are in contradiction with traffic flow theory and this result in unreliable travel times and because of this in unreliable economic effects. In a case study of Goudappel Coffeng BV, at the highway A12 in the Netherlands, travel time calculated with static models leads to deviations up to 70% from the measured travel time. With models that simulate spill back (STREAMLINE, Qblock, STAQ) the deviation is maximal of 27%. So simulating the effects of bottlenecks is required to approximate the travel times correctly.

6.1.2 Opportunities based on existing tools

From the seventeen tools a few lessons for the development of the new quick scan tool can be learned. Almost all the tools presenting the results like they can predict exact values, because of the calculation method, the used data. In the new quick scan tool, this should be remedied. The visualization of the relative results, like in Tiresias, or bandwidths are options. In the tool de Kast the effect of different elements that creates the output are separated shown, which increases the transparency.

In conclusion from the existing quick scan tools the need for a new quick scan tool is mainly for calculating the effects of the network utilization. It is desirable to measure all the measures and all the output elements described in table 2. For the output a reliable calculation of travel times is desired, especially to calculate the economic effects. For the application the quick scan tools need to make predictions at network level, on long horizon and at macroscopic level.

6.2 Quick scan methods

From the quick scan methods in chapter 5 not all the methods meet all the requirements. Sometimes a combination of methods is necessary to meet all the requirements. The

incremental approach and elasticities are relative good quick scan methods because of their wide application. For the other methods the functionality of the method depends on the kind of measure, so for each measure the suitable method needs to be determined. For this thesis innovative methods can be interesting to find an opportunity for a suitable quick scan tool. Also the technical developments must bear in mind to develop a suitable quick scan tool in the future.

6.2.1 Innovative methods

Innovative methods are the use of demand and supply curves and the Macroscopic Fundamental Diagram. Unfortunately, research at and implementation of these methods is not feasible in this thesis. In the existing tools these were also not applied, but for future quick scan tools very promising because of the global overview, calculation speed and less required input. Another innovating method is to make network classification based on the traffic states, because it is focussed on the problems in a network. Also the Marginal computation method (Corthout, Tampère, Frederix & Immers, 2011) is focussing at the important elements that will have traffic during the assignment. It is a promising method that can be used in quick scan tools to improve the calculation time.

6.2.2 Technical developments

During the interviews and according to other experts the expectation is that the computers will improve enormously and by this the calculation time of detailed models maybe will decrease. When the calculation time will decrease over time, the compensation in simplification of space, time and behaviour changes is less important. Also dynamic models could be run faster than currently. This would accelerate the process at long term, but there is still need for quick scan tools. First of all because the computers at this moment and the next years will still have high calculation time for detailed models. Secondly the models will be more complex over time, so this will compensate the profit of the calculation time. Thirdly the required input for detailed models will still be much. A quick scan tool should require less detailed data from the end user and also the measures should be simple to implement. A major benefit would be to calculate the effect with just a small amount of information, such as a new area at the network without knowing the exact location. The MFD would be very suitable for problems like this. If less data is required, the tool could have potential at the international market.

6.2.3 Opportunities based on methods

The incremental approach and the elasticities are widely deployable. Depending on the function of a tool, other methods are also proper. From the innovated methods the Marginal Computation and spatial simplification based on traffic states are possible methods that improve the calculation time with conservation of quality. Bearing the technical development of computers in mind, the focus of a new quick scan tool should be a tool with less input data.

6.3 Choice developing new tool

Concluding from the existing tools the potential for a successful quick scan tools is to simulate measures for mobility management. Most desirable is to calculate multiple

measures. For the output the calculation of the travel times seems to be calculated incorrectly and by this the additional output. Besides a tool that provides insight in mobility, environment, economy and safety is more likely to succeed, because this is a large advantage of a quick scan tool compared to detailed models. Also the high level of time, space and behaviour simplification is often missing in the existing quick scan tools.

The high level of simplification can be achieved by using the quick scan methods described in chapter 5. To approximate a high level of spatial simplification, corridor models have high potential. Corridor models are models in which cities/regions are visualized by dots and vectors represent the flows between the cities/regions. A corridor model requires simple input; this has potential at the international market.

Another opportunity is to choose an innovative quick scan method and determine the potential of this method. Marginal Computation and spatial simplification based on traffic states are realistic options. Marginal Computation is an acceleration of the assignment and at first sight it looks it will not reach the desirable calculation times for a quick scan tool. Marginal Computation uses new assignment of the traffic and spatial simplification based on traffic states do not have to. Spatial simplification based on traffic states is a new method that has to be investigated, but looks promising because of the incremental approach.

Also an existing tool could be chosen and be improved to develop a suitable quick scan tool. In this thesis the challenge of developing a new model or technique will be chosen. So the two accomplishable opportunities are the development of a corridor model or research at spatial simplification based on traffic states. Because of the innovated character of the new form of spatial simplification, this will be developed during the rest of the research. The approach of the further research will be discussed in the next chapter.

7

Spatial simplification based on traffic states

In chapter 6 the spatial simplification based on the traffic states was marked as innovative and promising. The methodical description of spatial simplification based on traffic condition will be given in this chapter. First the approach will be explained in general in section 7.1. The elements of the method will be explained in detail in the following sections. Link categorization will be described in section 7.2 and the measures that can be simulated with this approach in section 7.3. The measures that affects the total network (section 7.4) and specific areas (section 7.5) will be explained. Finally the conclusion of the method will be made.

7.1 Approach

The assumption of spatial simplification based on traffic states is that for a first investigation with a quick scan tool only the problem links or critical links are important. Also there are links that are not critical or have a high chance to be critical from the effect of a measure. In the method multiple scenarios will be calculated (+/- x% amount of trips). Before it is possible to determine the categories, the total traffic is assigned to the network with the detailed model system, see figure 29. Also the amount of trips for another situation is assigned for the determination of the link loads with interpolation.

By using the new quick scan method the effect of measures should be calculated. Based on the conclusions of previous chapters, the measures that can be investigated with this method will be determined. These measures can be divided in three categories; measures that influence all trips in the network, a specific area or specific links.

The effect of the measures on the amount of trips will be determined with elasticities. This change in amount of trips will affect the link loads. With interpolation between the link loads in the scenarios the effect on the total network can be determined. For a specific area the distribution of the traffic over the network will remain the same as the existing trips in the specific area. So in this case the route choice of new vehicles will not be part of the method.

The measures that effect specific links will not be simulated. The use of a capacity change on just one link is not correct, because multiple links will be affected. People could choose other routes and this primary requires a new assignment of the traffic. By a new assignment the method is equal to traditional models. The measures that affect the total network or a specific area do not primary affect the route choice, see table 2 and table 7.

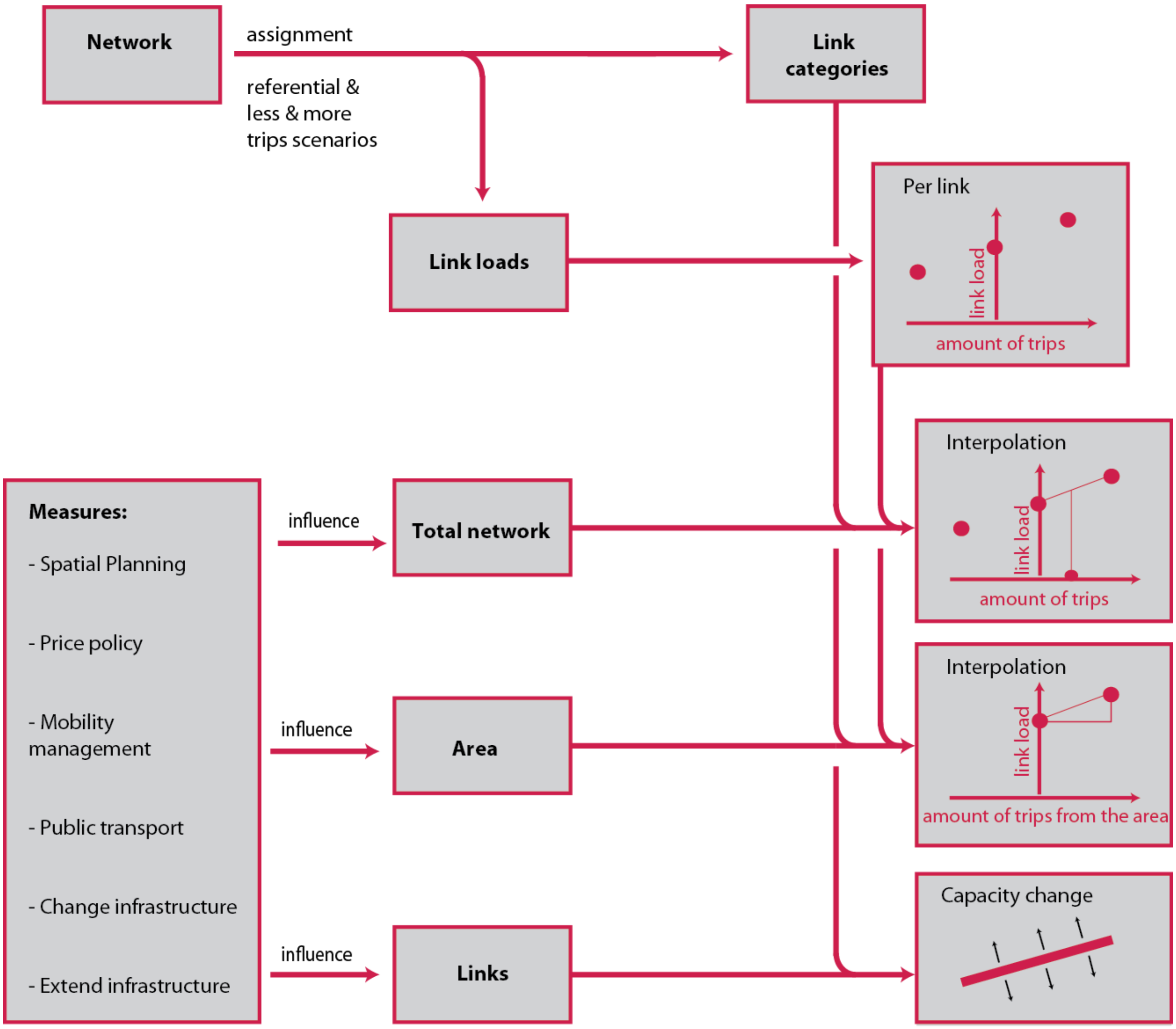


Figure 29 Process scheme of the method simplification based on traffic states

7.2 Link categorization

The network simplification strategy in this quick scan method is calculating only the important links during the use of the quick scan tool. Whereas the assumption is made that important links are the links with a high chance of problems, now or in the future. For these links, only the change of flows is investigated. This incremental approach and network simplification are discussed methods in chapter 5. This section will discuss the categorization of the links.

The categorization will be done per link. First the traffic needs to be assigned to the network to know the situation on the links. Some links will have another category if more or less traffic will be assigned. Also at least two points are necessarily for interpolation. So the traffic will, besides the reference scenario, be assigned for at least one other situation.

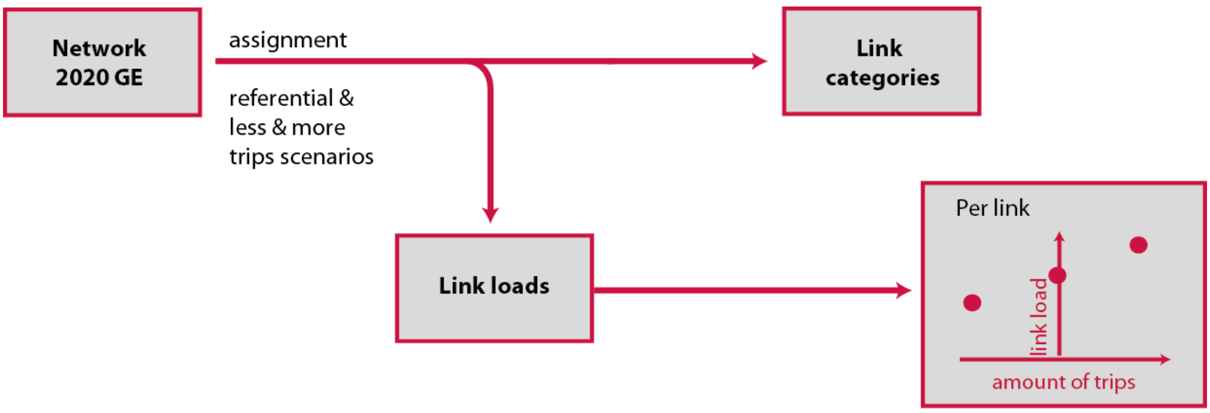


Figure 30 Process scheme link categorization

7.2.1 Categories

Spatial simplification based on traffic states is based on the characteristics of links. This can be the flow or density on the link or the I/C ratio. Flows or density categories can be used for environmental studies, under the condition that the intensities and densities can be calculated precisely. Another categorization is to base the categories on the conditions on the roads, such as bottlenecks, spill backs and queues.

In theory the method can be used in many models, but the categorization can differ in models. In static models the intensities and I/C ratio can be used. For the calculation of travel times a static assignment is not useful. Building a dynamic assignment model for a quick scan tool will be too time consuming and will be out of the scope of this research. So a static assignment with simulation of the effects of bottlenecks, such as STAQ and QBLOK, can be used. When applying STAQ the categorization can be: Squeezing start node (I), queuing at link (II) and otherwise (III). In the case of QBLOK the bottleneck, spill back and queue values determine the categories.

7.3 Measures

The method of spatial simplification based on traffic states introduced in this chapter uses an incremental approach and network simplification. In table 5 these methods do not conflict the requirements.

The incremental approach and the network simplification can improve the calculation time of certain behaviour changes and can generate some kind of output. This can be compared to the required behaviour changes and output of measures. Whether these measures actual can be modelled correctly by the underlying detailed model should be critically assessed.

Looking at the application of this method, the network simplification simplified of the route choice (table 6). The broad applicability of the incremental approach improves all of the behavioural changes and by this the computation time will improve enormously. The network simplification influences the use of the network and the incremental approach influences the patterns in time and space. Not all methods of network simplification can generate reliable environmental output. In case of merging roads noise pollution cannot be calculated correctly. As this is not the case in this research, so the environmental effects can be calculated as well. At this moment this is not integrated in the method, but this can be developed in the further. The underlying detailed model needs to generate reliable output. When there is no calculation of the links which are not critical, the effect on these links cannot be calculated. For the economic effects the free flow travel times can be used on these links with the assumption that the travel times are not influenced on these links.

With the described method the change in the amount of trips caused by a measure will be determined with elasticities. The route choice will not be calculated again, but will be approached by the interpolation between the reference situation and another situation(s). Table 7 illustrates the measures of table 2 and their application at the total network, area or link. The influence area can be the total network in case of the area or link. The red marked measures cannot be simulated by the developed method and should be calculated another way. The charge per location requires a new assignment and the charge per car emission requires the total overview of emission categories divided over the network. For example the composition of the traffic at highway can be completely different. The assumption in this model is an average driver. The effect of building new infrastructure or change existing infrastructure cannot be calculated with this tool, because this would require a new assignment.

The effects in time shift can be calculated, but only the shift between periods (morning peak, evening peak or off-peak) and not within a period. Also general improvements for all public transport, such as charge changes, can be simulated, but improvements at specific lines cannot.

Table 7 Measures and their application area

Measures	Specification	application area
Spatial Planning	Effect at network	Area
Pricing policy	Fixed charge (€/km) Charge per time (high/low charge) Charge per location Charge per car emission	Total network Total network
Mobility management	Effect time shift (e.g. "nieuwe wer-ken") Effect modal shift (e.g. carpooling)	Total network/area Total network/area
Public transport	Improve quality (reliablity, freq,speed)	Total network/area
Change infrastructure	(Dynamic) capacity by changing infrasture (rush hour lane)	Link
Extend infrastructure	Create capacity by building infrastructure	Link

For the calculation of the effects of the measures scripts are made. The first part of the scripts is meant for the effect on the total network (subsection 7.4). The second part calculates the effect of measures in a certain specified area (subsection 7.5). The capacity changes will not be determined in this research as explained in section 7.1.

7.4 Measures effecting total network

Some measures affect all links in a network. From table 7 pricing policy, mobility management and the improvement of public transport can influence the total network. For measures that influences the total network a script is written to determine the effect on the link loads by interpolation between the reference scenario and the other two scenarios.

To measure the effect on the total network the method exists of two parts. First the effect of a measure on the amount of trips chance needs to be calculated. Than by interpolation the effect of the chance in amount of trips can be translated in the chance in link loads, see figure 31.

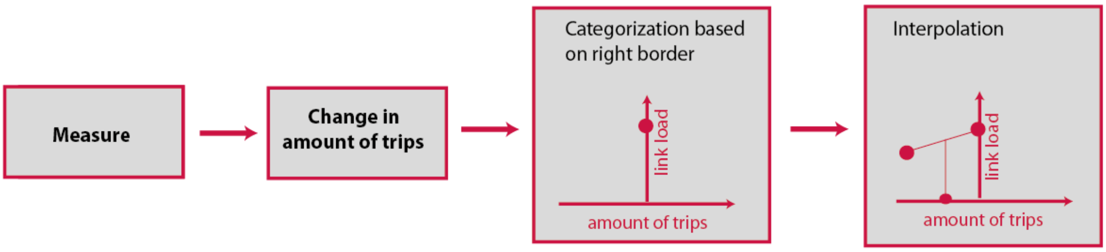


Figure 31 Process scheme measures that effects the total network

For every measure that affects the total network, the percentage change in trips is calculated with elasticities and rules of thumb. This percentage will situated between two assigned situations, for example between the reference situation and 5% extra trips. The amount of assigned situations will be determined based on the underlying model. The two scenarios that will be used for interpolation will be called left and right border.

The categories that will be shown will be based on the link load of the right border for car traffic, because this will place the links in the highest ranking category, since the right border has almost always a higher link load than the left border. The slope between the left and right border, will determine the change per percentage change of trips. The slope is calculated by reducing the link load of the right border with the link load of the left border, divided by the difference in trips between the borders. The change in amount of trips (%) will be multiplied with this value and the new load for the measure can be shown.

In the method the categories that needs to be displayed can be selected, mostly this will be the congested category and maybe the critical category. This process will be repeated for every link in this category separately. If the detailed model in which the method is implemented can visualise the results on a map, the difference to the reference load can be shown on the network for the links in the selected categories. The information on the other links will not be shown because these are not adapted by the measure and will be deceptive. If the model only calculates the effects in values and cannot visualise these on a map, the results needs to be shown in bandwidths.

7.5 Measures effecting specific area

Some measures changes only a specific area and not the total network. In this case the change should be applied in the area, but the effect of this measure should be calculated in the total network.

For the calculation of the effects of measures in a specific area, the area needs to be defined on forehand. All the trips generated from this area (multiple zones) to all the zones and attracted to the area need to be assigned. This will be used for the determination of distribution of the traffic over the network from and to the area. It is important that all the other traffic is also assigned to the network. Then the traffic from the area to each link on the network can be determined. These percentages are needed to calculate the effect of measures that influence the amount of trips departing from an area. This will also be determined for the arrivals per period. Area's with existing trips and without existing trips needs a different approach.

7.5.1 Area with existing trips

If an area already has trips in the zones, the slope is the part of the link load at a link caused by the area divided by the amount of trips from the area, see figure 32.

The amount of added trips will be multiplied by the slope and added by the total load of a link (includes all trips, right point). It is also possible to calculate the effect when less trips will be generated by the area than predicted for the year 2020. In this case the decrease will be subtracted of the total link load. The same needs to be done for the arrivals. An area with existing trips uses in case of extension of the area extrapolation. Because of the almost linear relation between the amount of trips and link load in a static assignment (subsection 8.3.2), extrapolation can be used for small changes, but is not desirable.

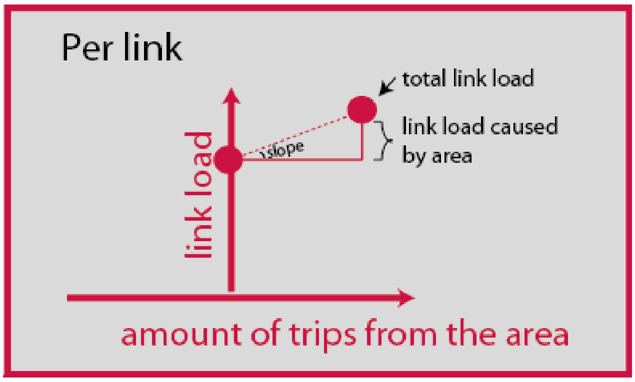


Figure 32 Determination slope factor by measures in a specific area with existing trips.

7.5.2 Area without existing trips

When the zones in the area does not generate trips, another approach is required, see figure 33. The destinations of the new inhabitants will be based on a zone with inhabitants next to the area. For the new area an amount of fictive trips will be distributed over

the zones in the area to have a reference point for the calculation. The amount of trips needs to be estimated on the high side, so interpolation will be used and not extrapolation. Similarly as by existing trips the slope factor will be calculated, but the extra trips caused by the area will be added by the left point (total link load). This will also be done for freight traffic and for different time periods.

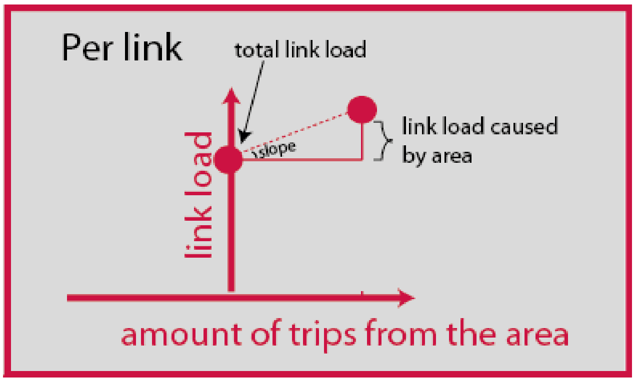


Figure 33 Determination slope factor by measures in a specific area without existing trips.

The input for the method is the categories and period that needs to be shown and also the extra new car and freight trips in the zone that are required. Than the effect of new trips or loss of trips in a specific area at the network can be calculated.

7.6 Conclusions

The quick scan method described in this chapter (spatial simplification based on traffic states) can calculated the effect of measures that affects the total network or measures that effects changes in a specific area. Measures that effects the capacity on a link cannot be simulated, because a new assignment is required to calculate the effect on the other links. The method can be used under conditions for spatial planning, pricing policy, mobility management and the general improvements of public transport.

At this moment the effect on mobility can be determined. If the method will be used in STAQ, also reliable travel times can be simulated. Also the effect on environment can be implemented in the future. The effect on safety can be determined with a method based on the traffic flows (Reurings & Janssen, 2007).

The method is compared with the requirements of chapter 2. The computation time will be determined in a case study in the next chapter. A high level of simplification is reach due the choice of showing only the important links (critical and/or congested). The method is also reproducible and transparent, because the method is based on elasticities that calculated the effect on the amount of trips. A disadvantage of the method is, it still the method requires an underlying detailed model.

The easy applicability depends also on the interface that is not built in this research, but the small amount of required input does not conflict easy applicability. The results can be shown in comparison plots, which are visualise the output reliable, because not the ac-

tual values will be shown. If the method is used in a quick scan tool, the calculation of other effects will not be hindered by this method.

The method can assess multiple alternatives, because different scenarios can be calculated. Also the method fits logical transportation relations and by using STAQ it will also not be in conflict with traffic flow theory.

In conclusion the method meets the requirements and could be the basis of a suitable quick scan tool. To change the method in a tool all the measures and output elements should be integrated and a way to calculated the measures that effects the capacity of a link should be developed.

8

Case study

To test the methodology spatial simplification based on traffic states, a case study is chosen for the 'Randstad' area. The used model and network are described in section 8.1. The chosen link categorization for the underlying detailed model will be discussed after the network description. To illustrate the method, the effect of the measures spatial planning and pricing policy (one charge for every place and time) are chosen in this research. Pricing policy influences the total network (section 8.3). Spatial planning can influence the entire network, but it's effect will be focussed in a specific area. In this thesis the emerging area Almere Pampus and the developed port area the Second Maasvlakte are chosen to calculate the effects of spatial planning in section 8.4. Finally the method will be validated and conclusions will be made.

8.1 Model and network

The Nationaal Verkeersmodel 2.0 (NVM 2.0), developed by Goudappel Coffeng BV, is chosen to run a case study in this research. The main reason to choose this model is that the NVM operates at a strategic level. Also for a large network the improvement of calculation time will be clearly visible. The NVM 2.0 reflects all of the Netherlands. The four provinces that include the economic region the "Randstad" are selected to test the method, see figure 34.

Figure 34 Four provinces that include the Randstad.

The model is based on the year 2008 and contains a forecast for the year 2020. The method is developed for the year 2020, because the users of the tool want to see the effect measures in the future.

Four economic scenarios for the social economic development are made by the 'Welvaart en Leefomgeving' (WLO). For this research the assumption is made that the Global Economy (GE) scenario for 2020 is suitable, because this scenario is used most often in forecast modelling and therefore also by the NVM 2.0. This scenario has the highest growth for economy and population so will predict the highest level of mobility of the four scenarios and there will be less risk of underestimation.

The NVM 2.0 is a multimodal model (car, freight, public transport and bicycles). In this research car and freight transport are simulated for the morning peak (07:00-09:00), evening peak peak (16:00-18:00) and the off-peak period.

In the model the flows on the links will be determined. These flows will be called link loads and a link is a road in one direction. A road can have two links, because of the two directions. The link loads are expressed in PCE (passenger car equivalent), in this value trucks are expressed in person cars, because trucks needs more space on the road.

The NVM 2.0 is a static assignment model. According to subsection 2.3.2 reliable travel times cannot be computed by static assignment. In order to calculate travel times the developed quick scan tool will have to be used with a model, such as QBLOK or STAQ. STAQ predicts much more reliable output (section 6.1.2) and Goudappel Coffeng BV is the owner, so this would be a logical choice for Goudappel Coffeng BV. As STAQ is still under construction, it is unavailable at this time of research.

8.1.1 Amount of iterations

The off-peak period and all the periods for the trucks are assigned by an all-or-nothing assignment. For cars in the morning and evening, the traffic is assigned with volume averaging with ten iterations. The NVM 2.0 uses 10 iterations for the assignment of cars in peak hours. In this thesis is the deviation between 10 and 100 iterations investigated. The assumption is made that with 100 iterations the network is almost in equilibrium, so the links loads by an assignment of 10 iterations are compared with the equilibrium (100 interations). The scenario 2020 GE is calculated with 10 and 100 iterations. Only the links with enough traffic (>100 PCE) are investigated. At these links the absolute difference of link loads between 10 and 100 iterations is calculated and divided by the link load of 100 iteration. The result is that 4,90% of the links have more than 10% difference link loads by 10 iterations than 100 iterations. The calculation of iterations is time consuming, so in the NVM 2.0 the choice for 10 iterations is understandable. In the new method the traffic only needs to be assigned once during the development of the tool, so for the tool 100 iterations are chosen for modelling the car traffic in the peak periods.

8.2 Link categorization

There will be a distinction between three categories; congested (I), critical (II) and insignificant (III) links. The assignment to the categories will be based on the I/C ratio. This will be done per direction, so a road can have two different categories. According to traffic flow theory a certain I/C ratio apply by congestion (low speed) and by free flow (high speed). By static assignment not the actual amount of PCE, but the amount of PCE that want to use the link is shown, so low intensities always visualize free flow and not congestion. Because of the static assignment in the test network, I/C ratio's above the 1.0 can occur. These will be assigned to category I.

The I/C ratio categorization of the NRM will be used:
Category I: I/C>0,9
Category II: 0,8<I/C≥0,9
Category III: I/C≤0,8

8.2.1 Assigned scenarios for interpolation

The categorization is based on traffic states on the links after assignment of the traffic in the reference scenario. For interpolation minimum one other assignment is required. The expectation is that measures will not have a larger effect than a change of 20% in the amount of trips. Pricing policy will have a high effect on the amount of trips up to 17%, see section 8.3. To approximate also the small changes correctly by interpolation, interpolation between the reference scenario and -20% or +20% is too rough. So the method will use interpolation between scenarios with steps of 5% from -20% to +20%.

8.2.2 Categories for assigned scenarios

The categories for all links (divided per direction) are determined for the nine scenarios. For all the scenarios the traffic flows and capacities of the links and the associated I/C ratio are established. The flows are the link loads on the network after the assignment described in the previous section. The flow is expressed in PCE and the capacity is the lowest capacity of the car or truck on the lane. In this way a link will be placed in the most critical category. The final I/C ratio is the highest of the I/C ratio in the evening or the morning. Based on the final I/C ratio, a link is assigned to a category. The amount of links in the categories for the referential scenario and +/-10% extra trips scenario's are shown in table 8. As expected more links will be critical or congested if the amount trips increase with ten percent and with a decrease of ten percent more links will be in a lower category.

Table 8 Amount of links in link load categories for three scenarios.

Scenario	Cat I	Cat II	Cat III
2020GE (0%)	3271 (100%)	2105 (100%)	57465 (100%)
-10% trips	2164 (66%)	1612 (77%)	59065 (103%)
+10% trips	4594 (140%)	2504 (119%)	55743 (97%)

Figure 35 illustrates all the links with category I during reference scenario. The bigger cities The Hague, Rotterdam, Utrecht and Amsterdam have a lot of congested links (busiest period of the day).

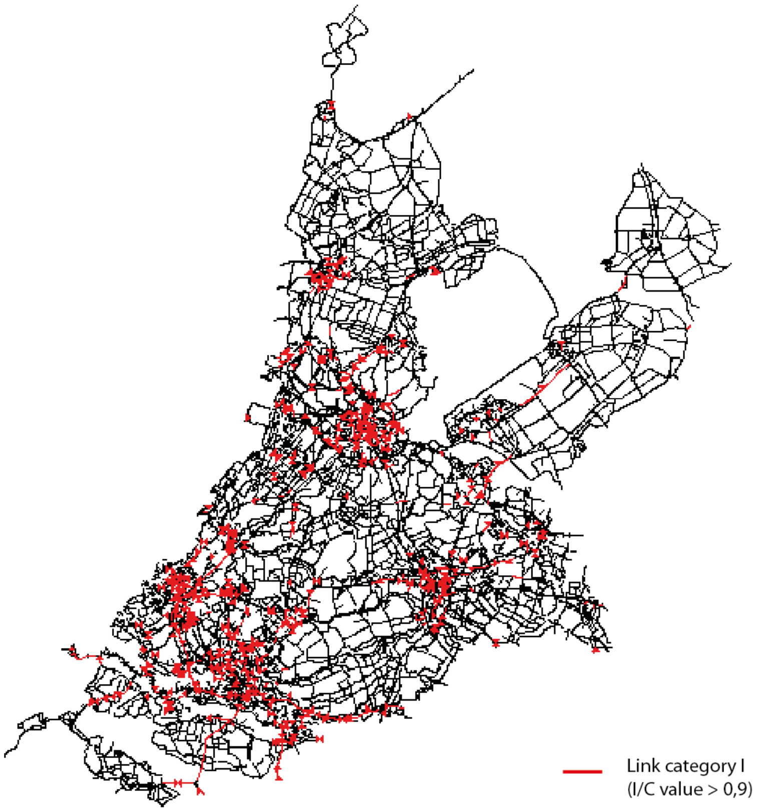


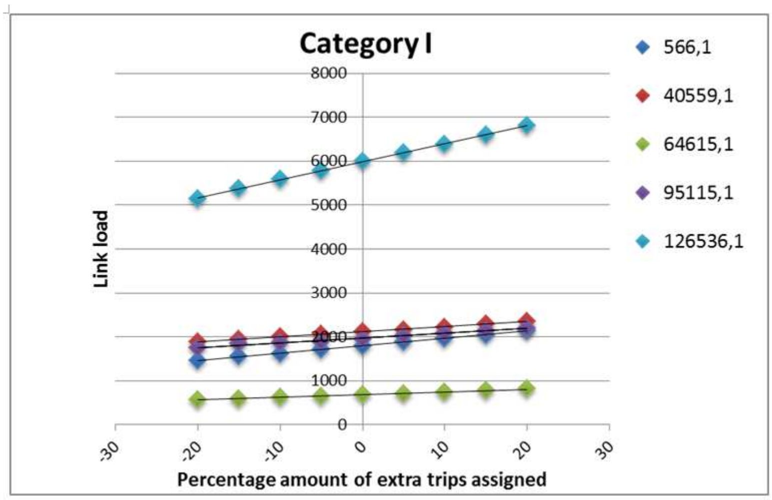
Figure 35 Links with category I (red) during reference scenario 2020; 3271 links.

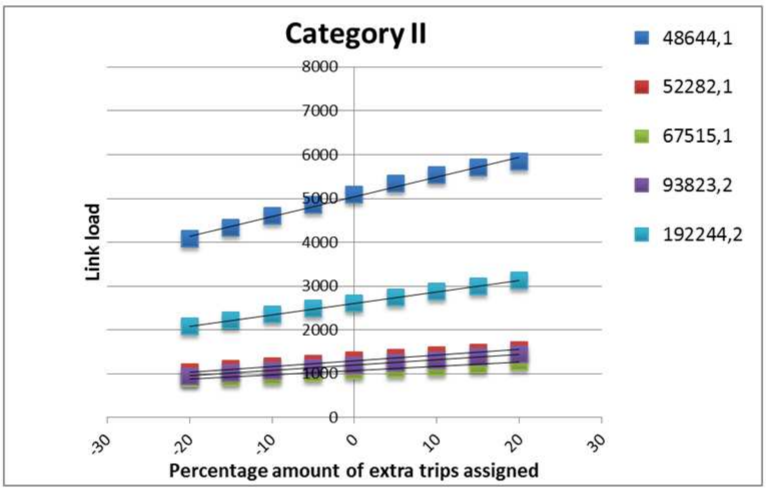
8.3 Pricing policy effecting total network

In this section the effect of pricing policy will be calculated to illustrate measures that effects the total network. The approach described in section 7.4 is used. In this approach interpolation is used and will be first described in this section.

8.3.2 Interpolation

To determine the effect of a measure interpolation will be used. Interpolation is the prediction of the values between two or more calculated values. The values between the calculated values can be approximated with a function. In this thesis the function fitting the relation between the amount of trips and the link loads is determined based on the assignment of -20%, -15%, -10% and so on to +20% extra trips. Figure 36 shows the link loads of five random chosen links for every category and their linear regression line in case of 100 iterations and in the morning peak.





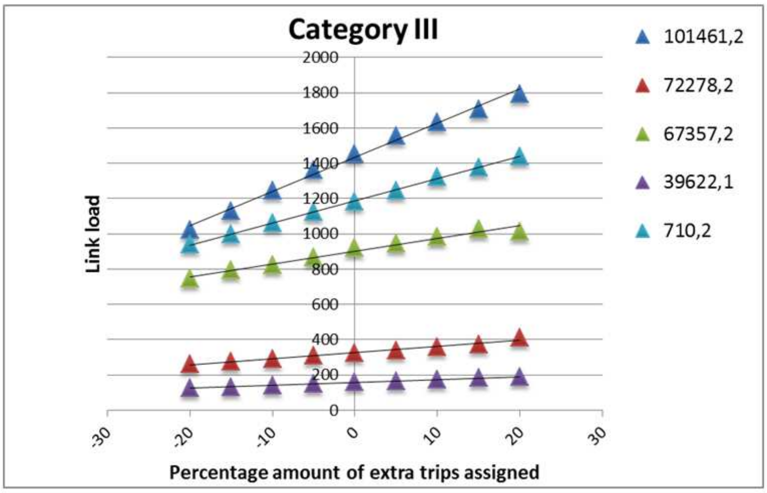


Figure 36 The link loads and their linear regression line for different scenarios (x% extra trips) of five random chosen links (link number, direction) in the three categories.

At first sight it looks like there is a linear relation between the percentage extra trips assigned to the network and the link loads. This conclusion will be supported by the R square.

The R square is a good indication or the data points can be approached with a linear function. The R square is determined between the percentage amount of trips and percentage change in link load. A R^2 larger than 0,9 indicates a linear relation. In table 9 the average R square is 0,95, so a linear assumption is good. Most of the links (88,7%) a linear relation is found. The average R square of links in category III is lower than the links in the other categories, but still above the 0,9.

Table 9 R square and slope per category.

	Average R^2	$R^2 \geq 0.9$ (#)	$R^2 \geq 0.9$ (%)	Average slope regression line
all categories	0,952	47075	88,7%	0,053
cat I	0,971	3070	5,8%	0,008
cat II	0,973	1979	3,7%	0,009
cat III	0,950	42026	79,2%	0,058

The average slope of the linear regression lines are also visualized in table 9. Remarkable is the large slope of the links in category III compared to the slope of the other categories. This could be explained by the fact that more traffic results in a shift of the traffic in higher categories to category III, because of route choice. Because the function reflects the relative change, the effect of one extra vehicle is larger on a link with a low link load than a link with much traffic. The links in category III has often a small link load, so the effect of extra vehicles is larger.

Because of route choice links can have large difference in link load for different amount of trips. To approximate the assignment of the detailed model as much as possible with the method a linear step function will be chosen.

Also the amount of links that will deviated much from the estimated value are visualised. For every assignment, except the reference scenario, for every link the link load of an assignment will be compared to the link loads of the assignments next to this assignment. Figure 37 shows the example of 5% extra trips. This will be compared to the link loads in the reference scenario and the scenario of 10% extra trips. If the link load of 5% is between the link loads of the reference and +10% scenario, this will be assessed as good.

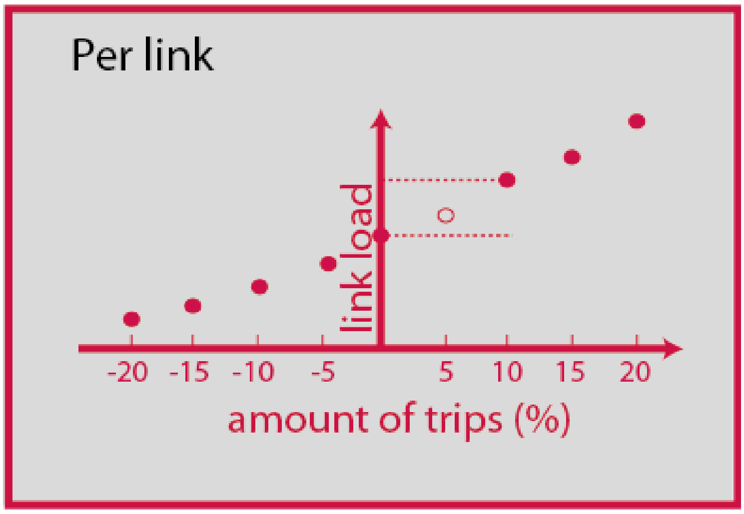


Figure 37 Method of determination of the amount of deviated links.

Figure 38 shows the percentage links that will not have a link load between the link loads of the bordering assignments in case of 100 iterations. These links will be called deviated links. For every scenario this is calculated, from -15% extra trips compared to -20% and -10% to the link loads of +15% compared to the 10% and +20% scenarios. It turns out that in general how more extra trips are assigned, how higher the percentages of deviated link loads. This can be explained by the fact that with more traffic, more route changes will take place. In the worst calculated assignment (+15%) 4,15% of the links have a deviated link load. Also a division is made between the categories. Regarding the results from figure 38 the links in category II deviated more than the other two categories. This could be explained with the fact that routes in cat III are often in free flow state and the links in category I almost always in congested state. The extra trips will not influence the state. A link in category II reacts more on route choice.

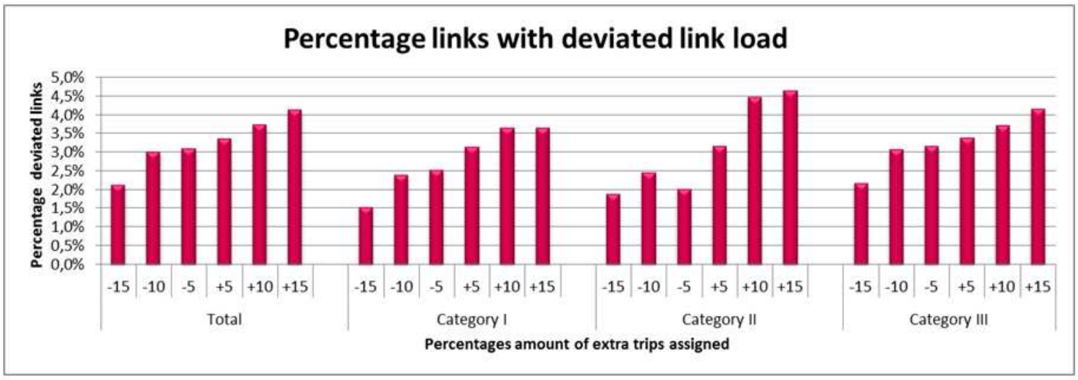


Figure 38 Percentages links with deviated link loads than the bordered scenarios for different assigned scenarios (x% extra trips).

A linear functions fits the data points almost. For a more suitable result a linear steps function will be chosen. The assumption of linear needs to be investigated when it will be implemented in another model, such as STAQ.

8.3.3 Approach

the categorization is based on the right border, because almost always the right border category is higher than the category of the left border. In the NVM 2.0 a maximum of fifteen of the 62.841 links will be assigned to the incorrect category, see appendix B, so the assumption that the right border is higher than the left border is acceptable.

The assumption is made that the introduction of a standard price per kilometre influences the amount of kilometres travelled for every location and time in an equal way. Ministerie of Verkeer en Waterstaat (2005) researched the traffic related effects of pricing policy. Ten alternatives are calculated with the LMS for the year 2020 for the Randstad. Within this research the European Coordination scenario is used instead of the GE scenario in the NVM 2.0. The assumption is made that the same effect on travelled kilometres will occur.

The sub variants 1a (Motorrijtuigenbelasting (MRB) + 25% Belasting voor Personenauto's en Motorrijwielen (BPM) will be transferred in a charge per kilometer) and 1b (MRB + 100% BPM will be transferred in a charge per kilometer) are used for determination of the effect per charge. The mobility (vehicle kilometres) reduction is 11% by a charge of 3,4 eurocent (all charges in this section per kilometre) in sub variant 1a and 17% by 5,7 eurocent in sub variant 1b. The assumption within this thesis is that distribution of the trips will remain the same. This way the percentage of travelled kilometres can be used to correct the link loads. For example a road of 200 meters with a link load of 120 PCE with a decrease of 11%. In total 24.000 travelled metres will be corrected by multiplication with 0,89 (11%), will result in 21.360 vehicle kilometres. This value turned into link loads is 106,8, is the same as 120 PCE multiplied by 0,89.

Interpolation can be use to determine the reduction by charges between the 3,4 and 5,7 eurocent for cars, see figure 39. Per cent increase, the effect will differ -2,61% per euro-

cent next to the 11% of the lowest charge. Extrapolation will not be used, because of the expected inaccuracy. The expectation is that introduction of a small charge, such as one cent will be different than the effect of the increase of one cent by a higher charge. As shown in table 10 the function to calculate the decrease in link loads for cars per eurocent between 3,4 and 5,7 eurocent will be:
decrease cars = -11+(-2,61(charge-3,4))*

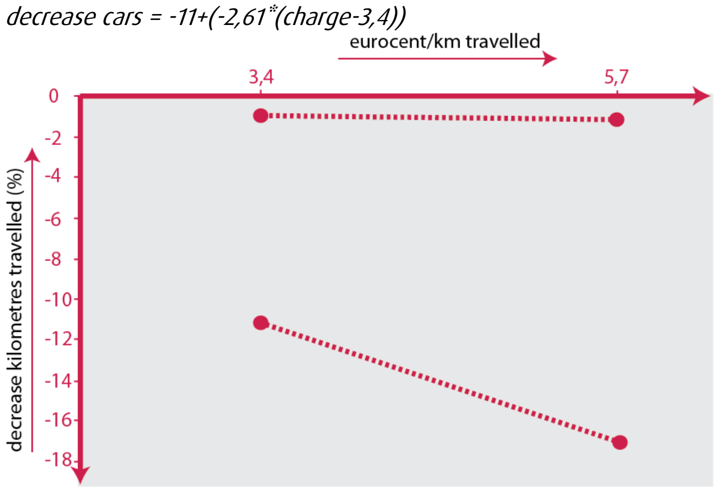


Figure 39 reduction kilometres travelled (%) by a charge per kilometre.

The reduction of freight travelled kilometres is calculated in the research of Verkeer en Waterstaat (2005) in percentages for the highways and the rest of the network. For a charge of 3,4 eurocent per kilometre this results in a reduction of 0% at the highways and 2% on the rest of the network. The reduction of freight travelled kilometres will be 0% at the highways and 3% on the rest of the Randstad by a charge of 5,7 eurocent per kilometre. To determine a general charge for all the links the weighted average reduction percentage needs to be determined. This result in a general percentage of -0,71% for 3,4 eurocent and -1,06% by 5,7 eurocent. Per cent increase, the effect will differ -0,15% next to the 0,71 of the lowest charge. The function, see table 10, to calculate the decrease of the link loads for freight per eurocent between 3,4 and 5,7 eurocent per kilometre will be:
decrease freight= -0,71+(-0,15(charge-3,4))*

Table 10 Decrease kilometres travelled for different charges and modes.

	Charge		Decrease between 3,4 and 5,7 eurocent	
	3,4 euro-cent/km	5,7 euro-cent/km	Decrease per cent	Decrease function
Cars	-11%	-17%	-2,61%	*-11+(-2,61*(charge-3,4))*
freight	-0,71%	-1,06%	-0,15%	*-0,71+(-0,15*(charge-3,4))*

8.3.4 Results

The situation of a morning peak with and without pricing policy will be shown for all the links in category I. The charge is set on 4 eurocent per kilometre. The categorisation is based on the highest category in the morning or evening peak, see subsection 8.2.2, so some links without a high I/C ratio are shown in figure 40. The reverses situation does

not happen. The computation of the link loads for all the links of category I takes less than ten seconds.
In the next figures the roads around the Hague and Rotterdam are shown for the two situations with and without pricing policy and finally the comparison is made. The widths of the coloured area reflects the link loads and the colour shows the I/C ratio on the links. Sometimes just one direction is shown, because only one of the directions has category I.

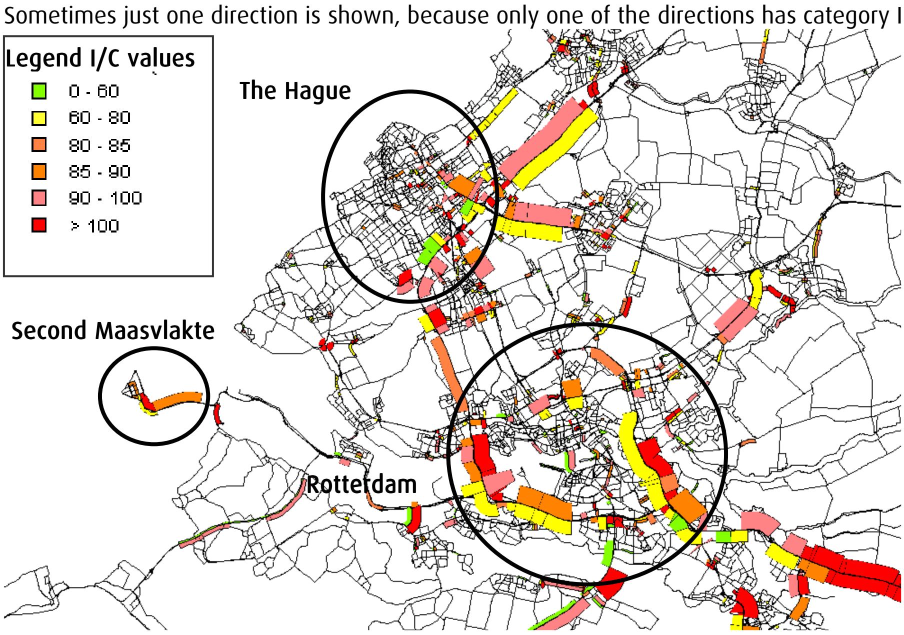


Figure 40 Links of category I in the Hague and Rotterdam area for the reference scenario 2020 in the morning peak.

The highways around the Hague and Rotterdam will have a high I/C ratio in the morning peak. When applying the pricing policy almost all the roads will have a lower I/C ratio. Sometimes this will result in another category, for example the road to the Second Maasvlakte.

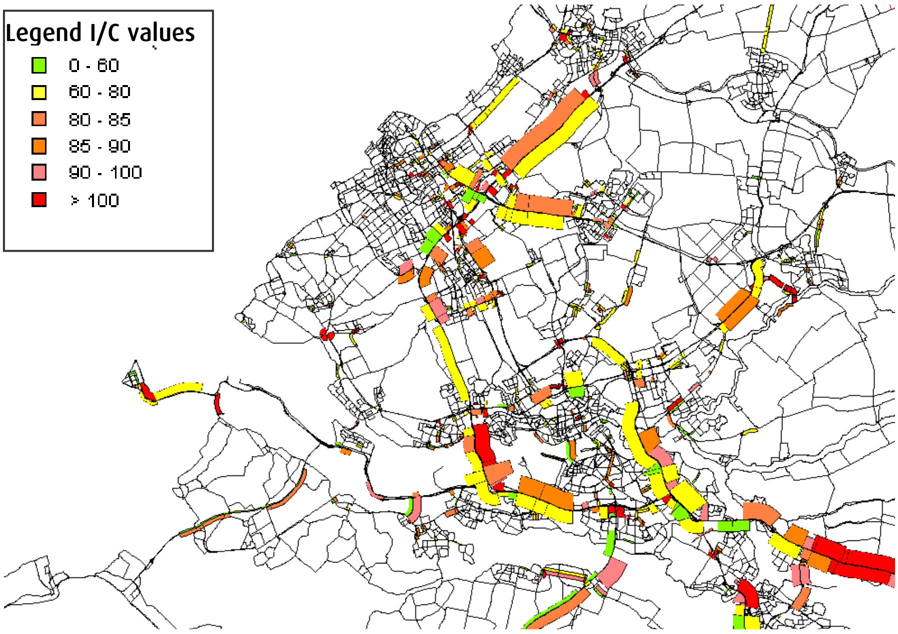


Figure 41 Links of category I in the Hague and Rotterdam area by the implementation of pricing policy (€0,04/km) in the morning peak.

In the comparison plot, the loads of both situations is shown. The largest part of the loads will exist in both situations (yellow). The blue parts illustrate the link load that the reference situation has more than by the introduction of pricing policy. There are a few links where the link load of the reference scenario is smaller than the load by pricing policy scenario. This will occur when the link load in the reference scenario is higher by the -15% scenario than the -10% scenario for cars.

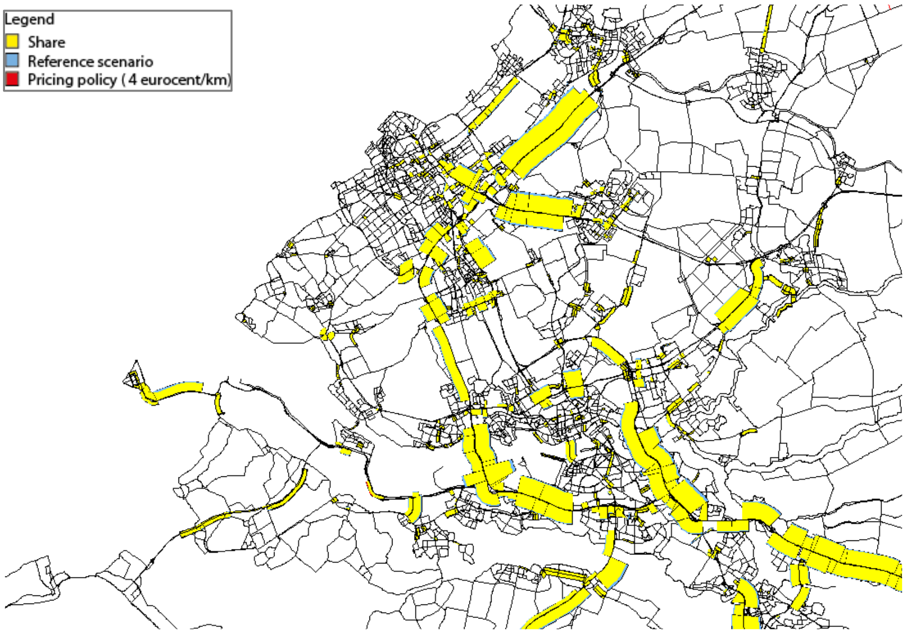


Figure 42 Link loads of links in category I in the Hague and Rotterdam area by the implementation of pricing policy (€0,04/km) in the morning peak compared to the reference situation.

8.4 Spatial planning effecting specific area

As described in section 7.5 measures that effects a specific area can be divided in areas with and without existing trips. In this case study the effect of spatial planning is illustrated by the Second Maasvlakte (area with existing trips) and Almere Pampus (area without existing trips).

8.4.1 Second Maasvlakte, area with existing trips

The Second Maasvlakte is chosen to simulate the development of an area with trips in 2020 in the NVM 2.0. In this model the Second Maasvlakte consists of two zones. By developing a Third Maasvlakte (extension of Second Maasvlakte) the assumption is made the traffic will enter the network at the same two zones and the generated traffic will increase with 50%. The extra traffic due to more employment is visualized in figure 43. Further away of the Second Maasvlakte the traffic is more distributed over the network, so the link loads are lower.

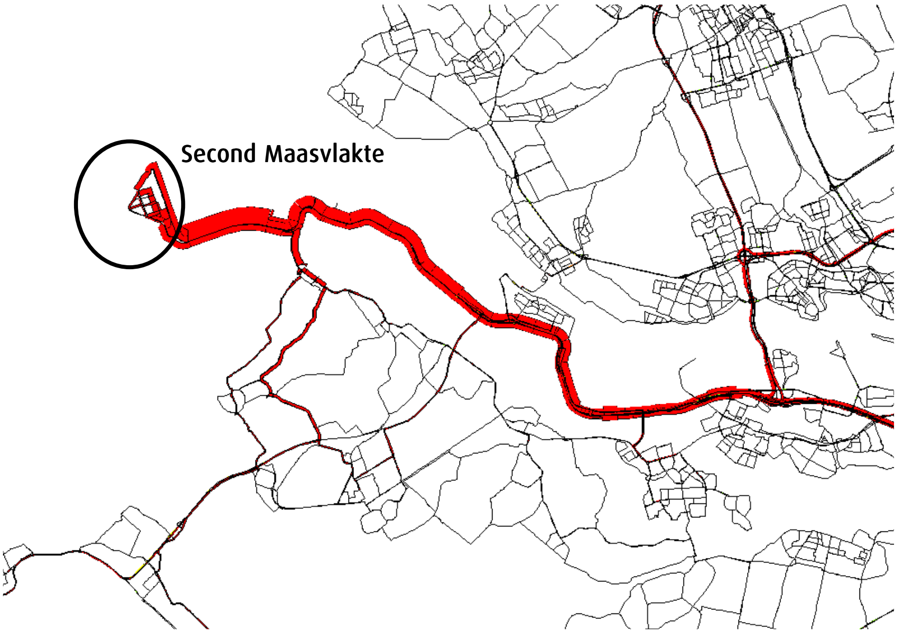


Figure 43 Distribution of extra traffic from and to the Second Maasvlakte in the morning peak caused by the extension of the Second Maasvlakte.

The effect for the morning peak is visualized in the difference between figure 44 (reference situation) and figure 45 (extension Second Maasvlakte). Some links will changes from I/C category, such as parts of the N15 and the N218.

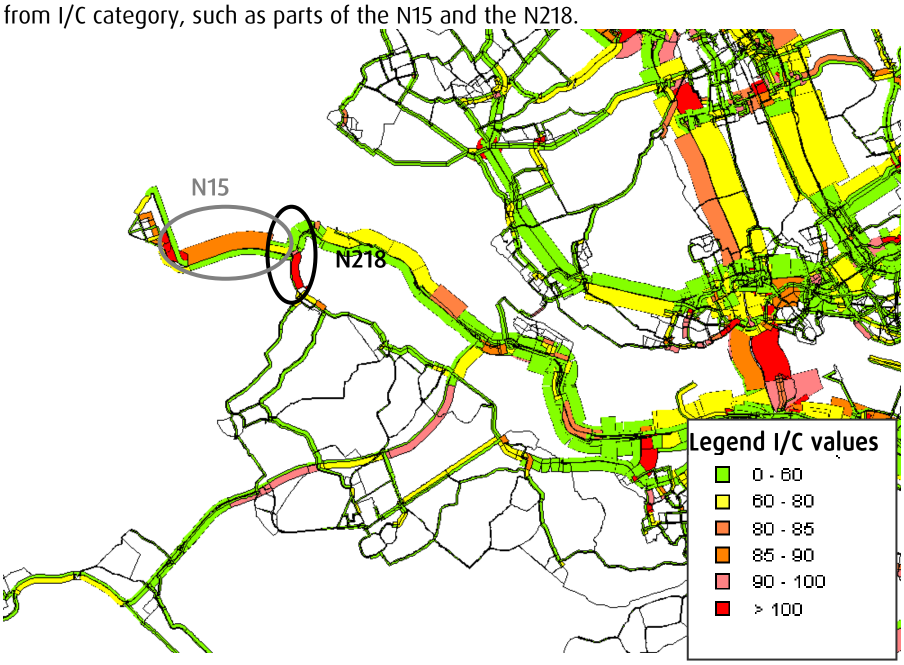


Figure 44 Link loads on roads around the Second Maasvlakte in the reference situation for the morning peak.

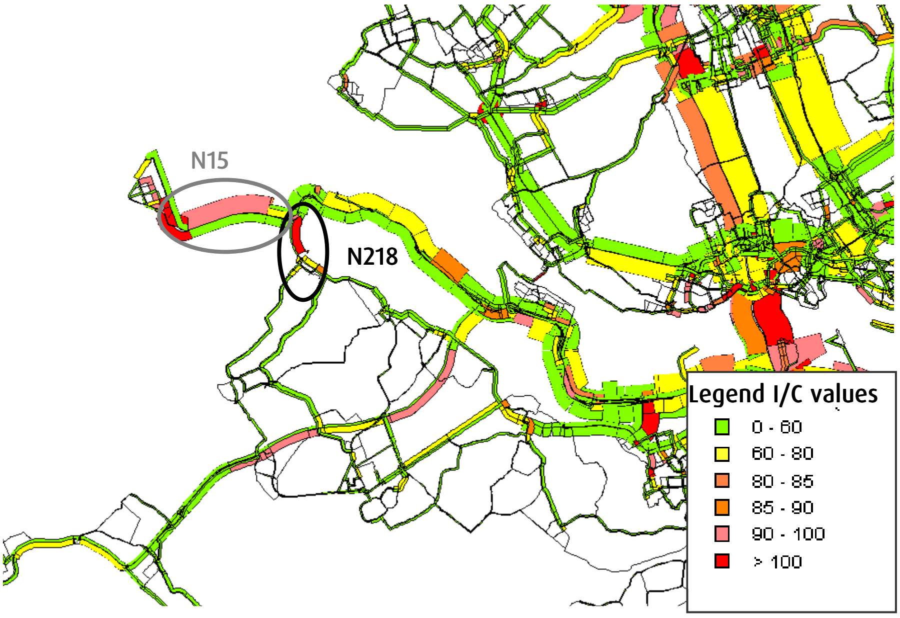


Figure 45 Link loads on roads around the Second Maasvlakte by an extension of the Second Maasvlakte for the morning peak.

Figure 46 shows the comparison between reference scenario and the extension of the Second Maasvlakte. The N15 and A15 will mainly be affected by the extension.

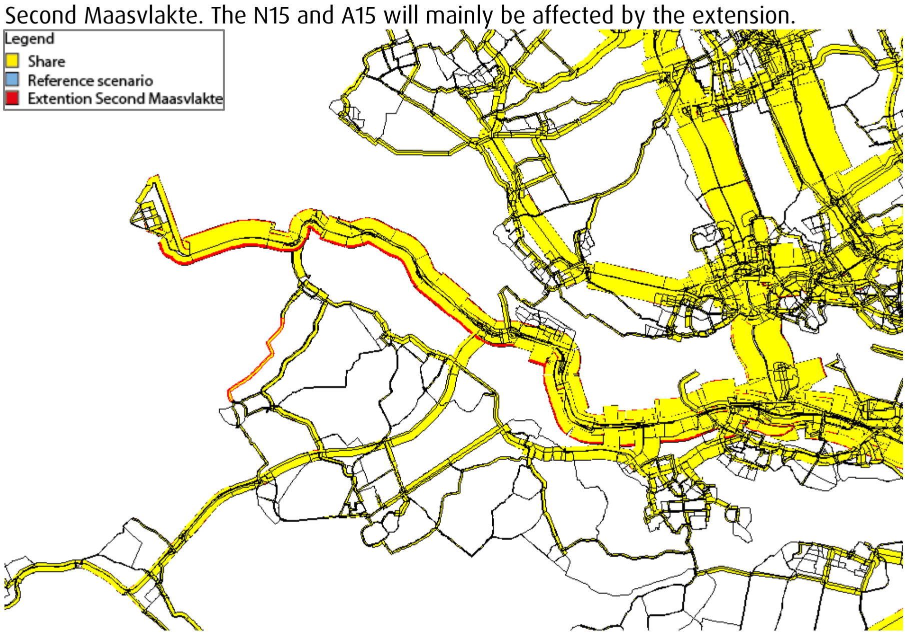


Figure 46 Comparison of the link loads between the reference situation and an extension of the Second Maasvlakte for the morning peak.

Another scenario is that the sale of terminals will be disappointing, so just half of the terminals will be sold and just 50% of the trips will be generated and attracted. Figure 47 shows the link loads on the roads around the Second Maasvlakte for the evening peak.

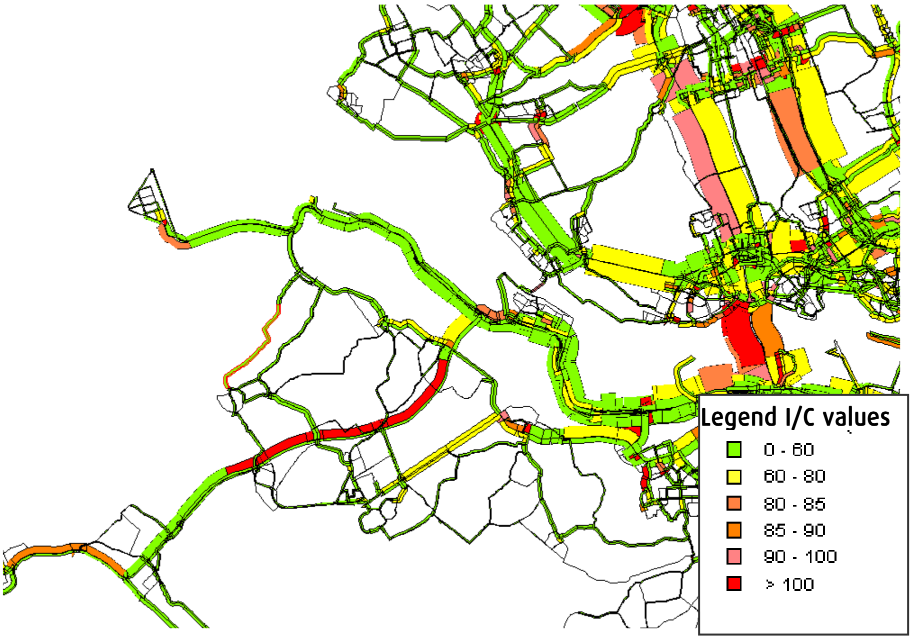


Figure 47 Link loads of the roads around the Second Maasvlakte in the evening peak by less sold terminals in the Second Maasvlakte.

Figure 48 shows the difference of less sold terminals in the Second Maasvlakte compared to the reference situation. The link loads will be less than the reference situation. The figure shows that less traffic will result in a route choice, more traffic will use the southern route.

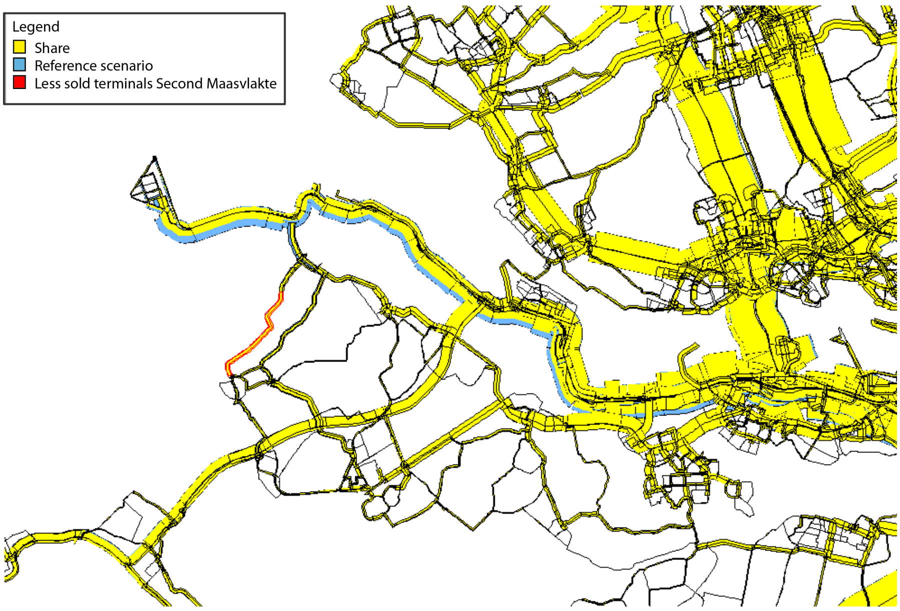


Figure 48 Comparison of the link loads between the reference situation and less used terminals in the Second Maasvlakte in the evening peak.

8.4.2 Almere Pampus, area without existing trips

To illustrate the calculation of an effect in a specific area without existing trips, the area Almere Pampus (figure 49) is chosen. This area is part of the metropolis Randstad, but has space for development. In Almere Pampus 20.000 new houses will be build (Gemeente Almere, 2009). Until the year 2020, 8.000 houses will be construct. Based on publication "Verkeersgeneratie woon- en werkgebieden" (CROW, 2007), the amount of trips generated by new houses will be determined. The amount of generated trips depends on the living environment. For Almere this will be 24.800 trips per day. This is based on the living environment "outside city centre, high urbanism". For a peak period (morning/evening) 10% of the amount of day trips will be taken. Freight traffic will be 0,02 trip per house.

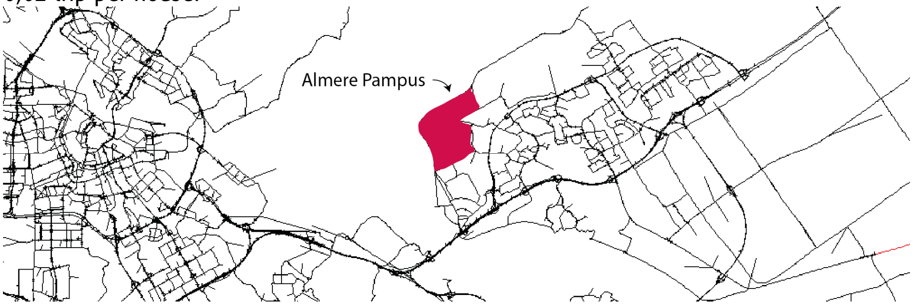


Figure 49 Almere Pampus; new developed area in 2020

With the described script in section 7.5.2 the links that will have traffic from Almere Pampus can be determined. This distribution is based on the distribution of the area next to Almere Pampus. The distribution of the traffic of 10.000 fictive trips is chosen, so during the advice with the client the amount of new houses up to 10.000 can be used.

Figure 50 shows the link loads caused by the 10.000 new houses in the new developed area in the morning peak. From a living area mainly cars will departure from this area.

Figure 50 Link loads of the traffic from Almere Pampus in the morning peak caused by the development of 8000 houses.

The script will added the traffic from figure 50 by the existing link loads. Figure 51 shows the comparison of the link loads in the reference situation and with the new developed area. In red the added traffic is showed. As expected especially the roads near to the new area will have more traffic than in the reference situation.

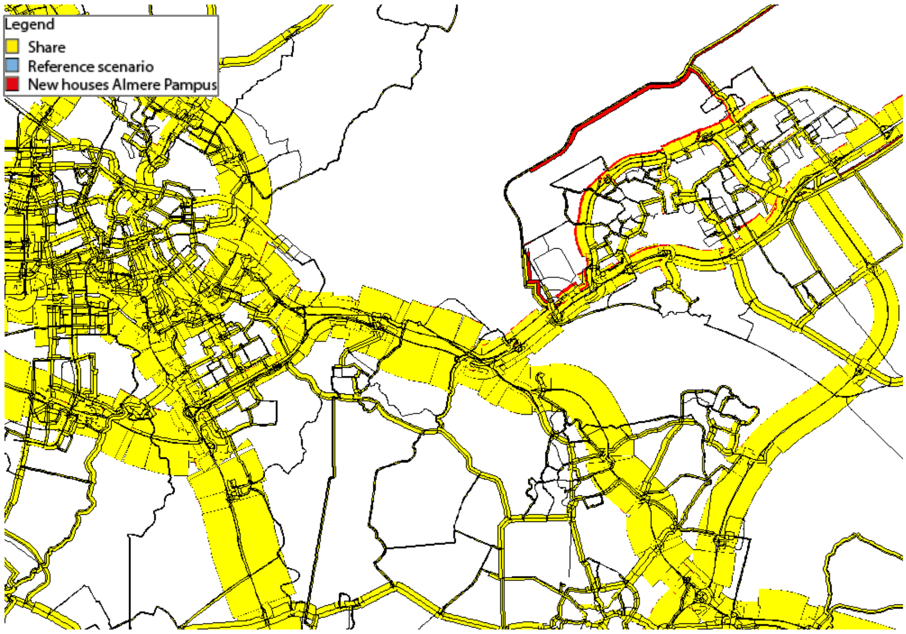


Figure 51 Comparison of the link loads between the reference situation and 8.000 new houses in Almere Pampus in the morning peak.

In the evening, the people living in the new houses will return to their houses. *Figure 52* shows the situation nearby Almere Pampus for the evening peak in the reference situation.

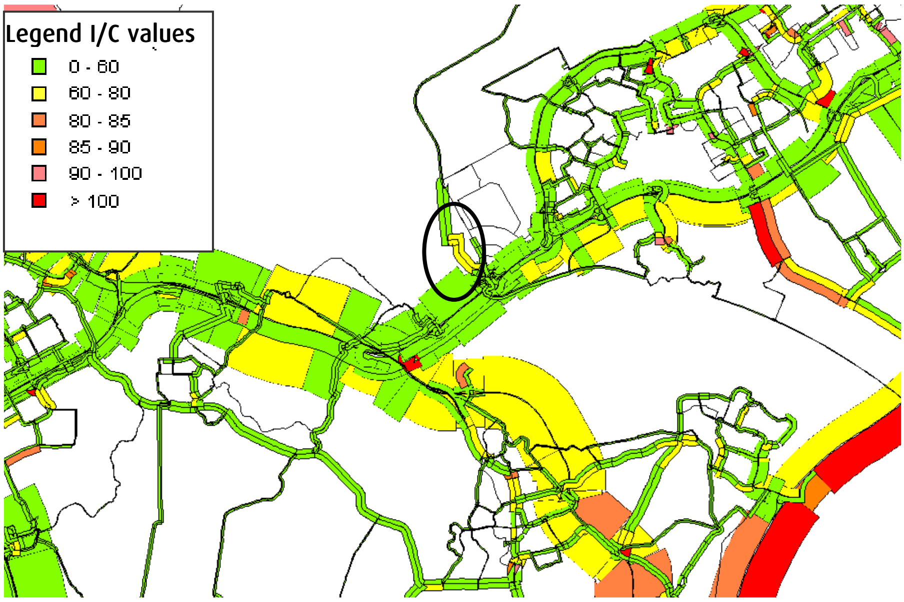


Figure 52 Link loads of the roads around Almere Pampus in the evening peak in the reference situation.

In figure 53 the roads close to the new area will not be critical or congested, but the roads from the exit of the highway do. In the reference situation there were no problems on these links. The capacity of these link should be improved, to process all the traffic in the evening peak to the new developed area.

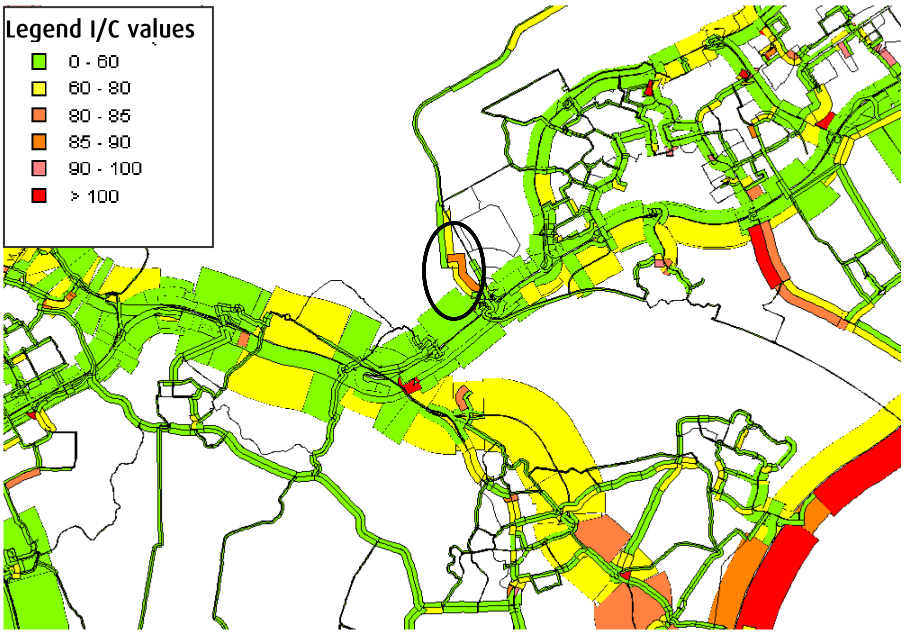


Figure 53 Link loads of the roads around Almere Pampus in the evening peak when the new houses are built.

8.5 Validation

The scripts result in the possibilities to measure other amount of trips than the measured amount of trips (-20% to +20%) because of the interpolation. It is important to verify the deviation of the results of the method with the calculation of the exact amount of trips as a result of a measure with the NVM 2.0. In this section also the computation time of the method will be described.

The method will be assessed by the average absolute and relative deviation between the link loads of the method and the actual assigned amount of trips. The relative deviation will be determined only for the links with a link load of more than hundred vehicles. This is done because small difference of amount of vehicles on a link with a small link load will have a large relative deviation and will disturb the results.

Next to this absolute and relative deviation, also the root mean square will be determined. With the root mean square the larger absolute deviations will be more taking into account than the small deviations. For the validation of this method larger deviations are worse than smaller deviations, because large deviations indicates a incorrect prediction of the method.

$$absolute\ difference = \frac{1}{n}\sum_{1}^{n} \left| X_{assigned} - X_{method} \right|$$

$$relative\ difference = \frac{1}{n_{>100}} \sum_{1}^{n_{>100}} \frac{\left| X_{assigned} - X_{method} \right|}{X_{assigned}}$$

$$root\ mean\ square = \sqrt{\frac{1}{n}\sum_{1}^{n} (X_{assigned} - X_{method})^2}$$

Where:
n = amount of links
Xmethod = the link load determined with the developed quick scan method
Xassigned = the link load determined with assigned traffic

This is done for the morning and evening peak, because the measures are also calculated for these periods and these are most critical periods.

8.5.1 Measure total network

The effect of measures that affects the total network was illustrated by the example of pricing policy of 4 eurocent per kilometre. This effect is calculated with the method, as showed in subsection 7.4. The calculated link loads needs to be compared with the actual link loads when 4 eurocent per kilometre will be applied. The method exists of the translation of price policy to reduce of amount of trips and the translation of the amount of trips to the change in link loads. In an ideal situation the effect of pricing policy could be calculated with the NVM 2.0. This is not the case and the elasticities are based on another model (LMS), so the elasticities element will not be part of the validation. Only the change of the amount of trips on the link loads will be validated. The actual link loads will be calculated by adjusting the amount of trips between the zones and will be assigned again. The amount of trips will reduced by the calculated decrease for cars and freight separated by the introduction of pricing policy of 4 eurocent per kilometre:

Decrease cars = -11%+(-2,61%(4-3,4 cent))=-12,57%*
Decrease freight= -0,71%+(-0,15%(4-3,4 cent))=-0,8%*

The adjusted trips between the zones will be assigned to the network. The link loads that follow from the assignment are called the actual link loads. The link loads determined by the method will be compared to these actual link loads by the absolute, relative deviation and the root mean square, see table 11.

Table 11 Relative and absolute deviation and root mean square by implementation of pricing policy (4 eurocent per kilometre).

		total network	
		morning peak	evening peak
links with linkload >0 vehicles	Amount of links	52737	53026
	Root mean square (#)	17	16
	Average absolute deviation (#)	6	2
links with linkload >100 vehicles	Amount of links	44862	46555
	Average relative deviation (%)	0,82%	0,77%

The root mean square, the absolute and relative deviation seems to be acceptable. To verify this, the average absolute difference between the -10% and -15% is determined. This is around the fifty vehicles in the morning peak, so the average absolute deviation of six vehicles is good.

The method requires a lot of scenarios to calculate during the development of the tool, so it is tested if the method suffices with fewer situations. A method with three scenarios; reference scenario, -10% and +10%, is chosen to compare the link loads in the morning peak. Between these values linear interpolation (section 8.3.2) will be used and extrapolation outside the borders. The links with more than 100 vehicles in the assigned scenario are investigated. In the method with three situations is the average deviation 4,46% for links which has in the method a smaller link load than the assigned scenario.

On the other hand this method overestimates more (25,47% of the links). In the case of method with nine assigned situations the underrated and overestimated are more equal distributed and much lower (around 1%).

In conclusion the method with steps of 5% is much more reliable than the method with three scenarios in case of price policy in the morning peak. The expectation is that smaller changes in the amount of trips will deviate more. Also it is more preferable to use only interpolation and not extrapolation. So this should be implemented in the method based on an underlying static assignment model.

8.5.2 Measures effect specific area

The measures that effect specific area (multiple zones) can be split up in zones with and without existing trips generated or attracted of an area. In subsection 8.5.2 Almere Pampus is used for the example of a zone without trips and the Second Maasvlakte for a zone with existing trips.

In Almere Pampus 8.000 new houses will be developed. The validation of these kind of measures depends on the chosen calculated amount of extra trips, in case of Almere Pampus the amount of trips caused by 10.000 new houses. The effect is calculated with the method and with a new assignment. The link loads determined by these two approaches are compared. Table 12 shows the results of the validation. The absolute deviation is lower than by pricing policy. This can be explained by the fact that less links will be affected with the development of Almere Pampus.

Table 12 Relative and absolute deviation and root mean square by 8.000 new houses in Almere Pampus.

		Almere Pampus	
		morning peak	evening peak
links with linkload >0 vehicles	Amount of links	53079	53562
	Root mean square (#)	18	19
	Average absolute deviation (#)	1	1
links with linkload >100 vehicles	Amount of links	45814	47544
	Average relative deviation (%)	0,10%	0,11%

Half of the links will not be affected by the development of the new area, so in table 13 only the affected links are visualized. The relative deviation is a little bit worse, but the absolute deviation is still around one vehicle, so this does not affect the conclusion that the effect of the development of Almere Pampus can be approached with this method. The root mean square is larger than in case of pricing policy. This could be explained with the fact that measures that effect a specific area do use the distribution of the traffic of just one assignment.

Table 13 Relative and absolute deviation and root mean square of the affected links by 8.000 new houses in Almere Pampus.

		Almere Pampus	
		morning peak	evening peak
links with linkload >0 vehicles	Amount of links	33600	36949
	Root mean square (#)	23	23
	Average absolute deviation (#)	1	1
links with linkload >100 vehicles	Amount of links	619	836
	Average relative deviation (%)	0,14%	0,14%

The effect of the extension of the Second Maasvlakte which causes 50% more trips is described in subsection 7.5. More links will be affected by the extension of the Second Maasvlakte than by the development of Almere Pampus. The relative and absolute deviation and root mean square of the affected links are showed in table 14 and are good. The morning peak is better approached with the method than the evening peak. This can be explained that in the evening peak more traffic is at the network and especially more traffic from and to the Second Maasvlakte. And more traffic can caused more route changes and so more affected links and a larger root mean square.

Table 14 Relative and absolute deviation and root mean square of the affected links by extension Second Maasvlakte.

		Tweede Maasvlakte extension	
		morning peak	morning peak
links with linkload >0 vehicles	Amount of links	44708	44708
	Root mean square (#)	14	14
	Average absolute deviation (#)	1	1
links with linkload >100 vehicles	Amount of links	1605	1605
	Average relative deviation (%)	0,19%	0,19%

For the situation that less terminals will be sold, the results of the affected links are also determined and good, see table 15.

Less sold terminals will cause less trips, so there will be route changes, but less than in case of an extension of the Second Maasvlakte.

Table 15 Relative and absolute deviation and root mean square of the affected links by less sold terminals in the Second Maasvlakte.

		Tweede Maasvlakte less sold terminals	
		morning peak	morning peak
links with linkload >0 vehicles	Amount of links	44296	44296
	Root mean square (#)	15	15
	Average absolute deviation (#)	1	1
links with linkload >100 vehicles	Amount of links	1568	1568
	Average relative deviation (%)	0,21%	0,21%

8.5.3 Computation time

The computation time is determined on a Intel® Core ™ i7 CPU 860 @ 2.80GHz 2.79 GHz, 3,18 GB of RAM computer. The computation time is less than 10 seconds for the calculation of the effects on links of category I. For the effect on all the categories the computation time is around 30 seconds. The new assignment will takes 8 minutes and 20 seconds for all the links. The method is 166,7 times faster than the traditional method with an assignment with hundred iterations for the car traffic in the peaks.

8.6 Conclusions

The method can be used under conditions for spatial planning, pricing policy, mobility management and the improvements of public transport. The effect of pricing policy and spatial planning are calculated in this chapter. Scripts are written in which with a few input elements the effects on the link loads can be determined.

During the validation the effect of pricing policy and spatial planning can be good approximated by this method. The average relative deviation is for both measures less than 1% for the links with more than hundred vehicles. The average absolute deviation is in the morning peak six vehicles and is acceptable compared with the difference of fifty vehicles between the two scenarios in which interpolation take place. The average absolute deviation of the spatial planning measures is around one vehicle. The root mean squares are also good.

The computation time is less than ten seconds by calculation only the effects on the links in category I. For all the categories the computation time is around 30 seconds instead of more than 80 minutes in a traditional assignment. So the method is quick enough to used in a quick scan tool. If an advisor is round the table with a customer, only the congested (and critical) links can be calculated, because these links are the most important to visualize the results of a quick scan tool. When an advisor is writing a report in the office, the calculation of the other links can also be interesting. Certainly the implementation in a quick scan tool will require some extra time to visualize the results.

9

Conclusions & recommendations

In this chapter the conclusions will be made from the previous chapters to show how the objective of this thesis is accomplished:
The objective of this thesis is developing a suitable quick scan tool for fast and coarse evaluations of transportation alternatives.

Next to the conclusions the recommendation for further research will be given.

9.1 Conclusions

The answers on the research questions will be given in this section to reach the objective of this thesis.

9.1.1 Application domains and requirements

To develop a suitable quick scan tool it is necessary to know the application and the requirements of quick scan tools. A quick scan tool is distinguished from detailed traditional models by the short computation time and the low effort of the end users. Quick scan tools are suitable for policy questions in the phase of mind setting and the reconnaissance phase, because for this questions fast answers are required an a loose in accuracy is allowed. To answer these kind of questions the quick scan tool should provide information about mobility effects. A quick scan tool distinct from other tools and detailed models when it provides the economic, environmental and safety effects. The policy questions in transportation can be answered with the calculation of the effects of measures. These measures are focussed at spatial planning, price policy, mobility management, public transport and the changing and extending of infrastructure. To make a quick scan tool fast a tool should improve the computation time of the direct behaviour changes following from the measures. For this the patterns in time and space and the use of the network could be required. Quick scan tools needs to be applied at a high level of simplification on time, space and travel behaviour, because high level of details is not required at strategic and tactical level, where quick scan tools needs to be applied.

9.1.2 Existing tools

For the development of a quick scan tool with additional value, the existing tools are analysed. None of the seventeen investigated tools from the Netherlands and the United States meets all the requirements. Without the requirement visualisation of the reliability of the output, the tools ScenarioVerkenner, Quick filter, Fast Simple Model (FSM) and Mobiliteitsscan meets all the other requirements. From the existing tools can be conclude that no suitable quick scan tool for the calculation of mobility management exists. Also the high level of time, space and behaviour simplification is often missing in existing quick scan tools.

9.1.3 Quick scan methods

The methods in a quick scan tool helps to meets the requirements and application of quick scan tools. Some measures require multiple methods. Elasticities and the incremental approach are wide deployable approaches for multiple measures. An interesting method with incremental approach is Marginal Computation, which can generate more reliable travel times. On the other hand, this method requires new iterations.

The suitable methods can simplify the data of a detailed model (time, space and travel behaviour) or are new methods to approximate the traffic situation. An efficient simplification method of space is zone simplification, because the amount of OD-pairs will drastically decrease. Another option of spatial simplification is the simplification of routes, links or nodes. Time simplification can be done by choosing a time period or taking larger time steps by addition of time periods. The simplification of travel behaviour can be achieved by using a faster method of determination of the behaviour changes. Ways to approximate the traffic in a network are the Macroscopic Fundamental Diagram or the demand and supply curves.

9.1.4 Opportunities quick scan tools

The missing high level of simplification in the existing models can be achieved by corridor models in which cities/regions are visualized by dots and vectors representing the flows between the spots. Further the determination of the travel times and the additional economic effects in a new quick scan tool will be an improvement compared to the existing tools. A quick scan method that can contribute to the missing elements in existing models, is the innovative method spatial simplification based on traffic states. So next to improving an existing model, the opportunities are the development of a corridor model or investigate the innovative method spatial simplification based on traffic states.

9.1.5 Chosen opportunity

In this research the method of spatial simplification based on traffic states is developed. With this method the effect of measures that affects the total network or the change caused in a specific area can be calculated. For the measures that affects a specific area, on forehand the advisor needs to define this area and assign the traffic from and to the area, so the distribution is know. A disadvantage of the method is that measures that affect certain links, cannot be calculated, because this requires a new equilibrium.

The developed method does not conflict the requirements. The method can be used, under conditions, for spatial planning, pricing policy, mobility management and the im-

provements of public transport. A disadvantage of the method is that it requires a detailed underlying model, so it could not be used in when little data is available.

9.1.6 Case study

The model is assessed for spatial planning of Almere Pampus and the Second Maasvlakte that change a specific area. Also pricing policy of 4 cent/km is assessed as measure that affects the total network. One of the important requirements of quick scan tools is the computation time. With spatial simplification based on traffic states the computation time is less than ten seconds for the calculation of the congested links and 30 seconds for all the links instead of 5000 seconds with the traditional assignment. So the computation time is short and the calculation of only the congested links can be used when visiting a customer. The high level of simplification will be reached by this link categorisation. Certainly the implementation in a quick scan tool will require some extra time to visualize the results. In conclusion the method meets the requirements and could be the basis of a suitable quick scan tool.

9.2 Recommendations

The conclusion was that the method of spatial simplification based on traffic states could be a good basis for a suitable quick scan tool, but is not yet a full quick scan tool. The used linear step function is suitable for a quick scan tool based on a static assignment. It is interesting to do further research to the boundaries of the quick scan method to know if the linear assumption still exist by extreme amount of trips. It could be that another function will fit better the reality. So by the implementation in STAQ, the recommendation is to investigate this function. To change the method in a tool all the measures and output elements should be integrated.

9.2.1 Calculate all measures

Not every measures can be calculated with the method. At this moment only the elasticities for the measures spatial planning and pricing policy are calculated to measure the effect of the measures on the amount of trips. For a suitable quick scan tool also the other measures should be calculated. The calculation of the effect of the change in amount of trips on the link loads can be calculated with the same scripts as for spatial planning and pricing policy.

Measures that affect a specific area do use the distribution of the traffic of one assignment. In case of extension of an area with existing trips even extrapolation is used. It is interesting to investigated of the use of more assignments, like the measures that affects the total network. The expectation is that with even one more extra assignment measures that will be implemented in a specific area will be calculated more precise, because route choice of the new vehicles is part of the method. Also only interpolation will be used.

To complete the tool the effect of measures that affects a certain link should also be calculated correctly. This occurs by the measures that influence the capacity of a road or the effect of a new road. The effect of capacity changes can be calculated roughly with the method in the NVM 2.0, because the capacity element of the I/C ratio will change. Route choice would not be the result of the capacity change, but only the I/C ratio will be lower. To calculated the route choice it is necessary to know the connection between the link and the origin destination pairs. Route trees can be used for this. The calculation of the effects of the measures that affects a certain link request further research. The effect of measures cannot be calculated without a good calculation of the output elements.

9.2.2 Calculate all output elements

At this moment the new method is used in the Nationaal Verkeers Model 2.0. The method can be implemented in other detailed static models if the flows and capacities can be calculated and the affected links by an area can be determined. With the static assignment in this model no accurate economic effects can be calculated, because the calculated travel times are not reliable. The method should be implemented in a model such as STAQ, the static fast assignment model of Goudappel Coffeng BV, to provide reliable travel times.

Also the effect on environment can be implemented. This could require other categories, because other units are important, such as flows instead of Intensity/Capacity ratios. The effect on safety can be determined with a method based on the intensities from Reurings & Janssen. Overall spatial simplification based on traffic states needs further research, but is a good basic for a suitable quick scan tool for fast and coarse evaluations of transportation alternatives.

10

List of sources

- 4cast (2008). *Handboek kalibratie (handbook calibration).* Delft: Ministerie van Verkeer en Waterstaat, in Dutch.
- Aalbers, C. (2011). *Mobiliteitsmanagement en verkeersmanagement in MIRT-verkenningen (mobility management and traffic management in MIRT reconnaissance phases).* Delft: Dienst Verkeer en Scheepvaart, in Dutch.
- Adviesdienst Verkeer en Vervoer (2002). *Platos modelstelsel (PLATOS Model system).* Delft: Adviesdienst verkeer en vervoer, in Dutch.
- ArcGIS1 (n.d.). *Elimination function ArcGIS.* Retrieved November 18, 2011 from http://resources.esri.com/help/9.3/arcgisdesktop/com/gp_toolref/data_management_tools/eliminate_data_management_.htm
- ArcGIS2 (n.d.*). Integration function ArcGIS.* Retrieved November 18, 2011 from http://resources.esri.com/help/9.3/arcgisdesktop/com/gp_toolref/Data_Management_tools/integrate_data_management_.htm
- Australian Government, Department of Infrastructure and Transport (n.d). *Elasticities Database Online.* Retrieved November 4, 2011, from http://www.bitre.gov.au/tedb/
- Bovy, P.H.L., Bliemer, M.C.J. & van Nes, R. (2006). *Transportation Modeling.* Delft: TU Delft.
- Brederode, L., Bliemer, M. & Wismans, L. (2010). *STAQ: STATIC TRAFFIC ASSIGNMENT WITH QUEUING.* Deventer: Goudappel Coffeng BV.
- Buisson, C. & Ladier, C. (2009). *Exploring the Impact of the Homogeneity of Traffic Measures on the Existence of Macroscopic Fundamental Diagrams*. Washington, DC: the 88th Aunnal Meeting of Transport Research Board.
- Calthorpe Associates (2011). *Rapid Fire Model*. Berkeley: Calthorpe Associates.
- Cassidy, M.J., Jang, K. & Daganzo, C.F. (2011). *Macroscopic Fundamental Diagrams for Freeway Networks.* Washington, DC: the 90th Aunnal Meeting of Transport Research Board.
- Corthout, R., Tampère, C.M.J., Frederix, R. & Immers, L.H. (2011). *Marginal Dynamic Network Loading for Large-scale Simulationbased Applications.* Washington, DC: the 90th Aunnal Meeting of Transport Research Board.
- Courbon, T. & Leclercqa, L. (2011). *Cross-comparison of Macroscopic Fundamental Diagram Estimation Methods.* Procedia Social and Behavioral Sciences, 20, 417–426.
- CROW (2007*). Verkeersgeneratie woon- en werkgebieden (traffic generation living and working areas).* Ede: CROW, in Dutch.

- Daganzo, C.F., Gayah, V.V. & Gonzales, E.J. (2011). *Macroscopic relations of urban traffic variables*. Transportation Research Part B, 45, 278–288.
- de Keizer, B., de Vries, B. & de Bruyn, M. (2009). *Nieuw prognosemodel "De Kast" als beleidsinstrument (new prediction model "De Kast" as government instrument).* Antwerpen: Colloquium Vervoersplanologisch Speurwerk, in Dutch.
- Duijnisveld, M. & Schrijver, J. (2009). *Visie op de toekomst van de nationale personenvervoermodellen (vision of the future of national person transportation models).* Antwerpen: Colloquium Vervoersplanoligisch Speurwerk, in Dutch.
- Federal Highway Administration (2000). *Surface Transportation Efficiency Analysis Model (STEAM 2.0).* Washington, DC: Federal Highway Administration.
- Federal Highway Administration (2002). *Highway Economic Requirements System-State Version 2.* Washington, DC: Federal Highway Administration.
- Gemeente Almere (2009*). Structuurvisie Almere 2.0 (Plan Almere 2.0)(concept).* Almere: Gemeente Almere, in Dutch.
- Geroliminis, N. & Daganzo, C.F. (2007). *Macroscopic modeling of traffic in cities.* Washington, DC: the 86th Aunnal Meeting of Transport Research Board.
- Geroliminis, N. & Daganzo, C.F. (2008). *Existence of urban-scale macroscopic fundamental diagrams.* Transportation Research Part B, 42, 759–770.
- Hague Consulting Group (1999). *Trace*. The Hague: Hague Consulting Group.
- Hoogendoorn, S.P. (2007). *Trafic Flow Theory and simulation*. Delft: TU Delft.
- Hop, J., Turpijn, B. & van der Waard, J. (2010). *Verkeer in verkenningen (traffic in reconniassances).* Delft: Dienst Verkeer & Scheepvaart, in Dutch.
- Ji, Y., Daamen, W.,Hoogendoorn, S., Hoogendoorn-Lanser, S. & Qian, X. (2010). *Investigating the Shape of the MFD Using Simulation Data.* Transportation Research Board of the National Academies, 2161, 40-48.
- Kennisinstituut voor Mobiliteitsbeleid (2008). *Milieuschattingen in planstudies (milieu predictions in planning studies)*. Den Haag: Ministerie van Verkeer en Waterstaat, in Dutch.
- Kennisinstituut voor Mobiliteitsbeleid (2010). *Rekenen met beleid (calculation with policy).* Den Haag: Ministerie van Verkeer en Waterstaat, in Dutch.
- Kennisplatform Verkeer en Vervoer & Adviesdienst Verkeer en Vervoer (2005). *Basisboek instrumenten (basic book instruments)*. Deventer: Goudappel Coffeng BV, in Dutch.
- Kennisplatform Verkeer en Vervoer & Transumo (n.d.). *Mobiliteitsscan (Mobility scan).* Retrieved November 18, 2011 from http://mobiliteitsscan.bereikbaarheidskaart.nl/, in Dutch.
- Kim, W. (2009). *Parallel Clustering Algorithms.* Atlanta: GeorgiaStateUniversity.
- Knoop, V.L., van Lint, H. & Hoogendoorn, S.P. (2011). *Data requirements for Traffic Control on a Macroscopic Level.* Australia: 2nd International Workshop on Traffic Data Collection & its Standardisation.
- Litman, T. (2011a). *Transportation Elasticities.* Victoria: Victoria Transport Policy Institute.
- Litman, T. (2011b). *Generated Traffic and Induced Travel.* Victoria: Victoria Transport Policy Institute.
- Martens, M., & de Jong, M. (2009). *Governance verkeersmodellen: uitdagingen voor de toekomst (governmental transport models: challenges for the furture).* Antwerpen: Colloquium Vervoersplanologisch Speurwerk , in Dutch.

- Mestrum, D. (2011). *De ontwikkeling van een quickscanmethodiek om de modal split van personenverkeer te bepalen (the development of the quick scan method to determine the modal split of person transport).* Enschede: Witteveen+Bos & Universiteit Twente, in Dutch.
- Meurs, H., van Wee & Hoogendoorn, S.P. (2011) *Kosteneffectiviteit inzichtelijk gemaakt (providing insight in cost effectiveness) (concept).* Den Haag: NM Magazine, in Dutch.
- Park, D., Rilett, L.R.,Gajewski, B.J., Spiegelman, C.H. & Choi, C. (2009). *Identifying optimal data simplification interval sizes for link and corridor travel time estimation and forecasting.* Transportation, 36, 77–95.
- Projectdirectie Sneller&Beter (2010a). *Zinvolle effectbepaling (ZEB) Verkeer (meaningful effect determination).* Den Haag: Projectdirectie Sneller&Beter, in Dutch.
- Projectdirectie Sneller & Beter (2010b). R*WS handreiking MIRT (RWS guide MIRT).* Delft: Rijkswaterstaat, in Dutch.
- Dienst Verkeer en Scheepvaart (2009). *QBLOK_2004 toedelingsprocedure LMS/NRM (assignment procedure LMS/NRM)*. Den Haag: Dienst Verkeer en Scheepvaart, in Dutch.
- Raadsen, M., Schilpzand, M. & Mein, E. (2009). *Applying inter regional shared routes in detailed multiregional dynamic traffic models*. Deventer: OmniTRANS.
- RAND Europe (2006). *Documentatie van OGM 4 (documentation of OGM 4).* Leiden: Adviesdienst Verkeer en Vervoer, in Dutch.
- Reurings, M.C.B. & Janssen, S.T.M.C. (2007). *De relatie tussen verkeersintensiteit en het aantal verkeersongevallen voor verschillende wegtypen (the relation between link loads and the amount of traffic incidients of different road types).* Leidschendam: Stichting Wetenschappelijk Onderzoek Verkeersveiligheid, in Dutch.
- Rijkswaterstaat (2003). *Tiresias, onderbouwing van strategische keuzes (tiresias, argumentation of strategic choices).* Rotterdam: Ministerie van Verkeer en Waterstaat, in Dutch.
- Rijkswaterstaat Adviesdienst Verkeer & Vervoer (2005). *Verkeerskundige effecten Anders Betalen voor Mobiliteit (traffic related effects of pricing policy)*. Den Haag: Ministerie van Verkeer en Waterstaat, in Dutch.
- Rijkswaterstaat (n.d.). *Benuttingsverkenner.* Retrieved November 18, 2011 from http://www.benuttingsverkenner.nl/, in Dutch.
- van Breugel, P.B. & Molenaar, R. (2009*). Eindrapport-vergelijking-saneringstool 3.0 (final report comparison saneringstool 3.0).* Schiedam: DCMR Milieudienst Rijnmond, in Dutch.
- TNO (1993*). De ontwikkeling van de APPLICATOR (the development of the APPLICATOR)*. Delft: Ministerie van Verkeer en Waterstaat, in Dutch.
- TNO (1999). *De TNO trend in de ScenarioVerkenner (the TNO trend of the ScenarioVerkenner)*. Delft: TNO, in Dutch.
- TNO (2004). *Beleidsanalyse verkeer en vervoer op maat (adjusted policy analysis traffic and transportation).* Delft: TNO, in Dutch.
- TNO (2010). *Roadmap verkeers- en vervoersmodellen (Roadmap traffic and traonsport models)*. Delft: TNO, in Dutch.
- TNO (z.d.). *Urban strategy*. Retrieved November 18, 2011 from www.tno.nl/urbanstrategy
- United States Environmental Protection Agency (2005). *COMMUTER Model v2.0.* Washington, DC: United States Environmental Protection Agency.

- van der Hoeven, W. (2011). *Verkeersmodel op maat: sneller en beter (adjusted traffic simulation model; faster and better).* Nieuwegein: Nationaal Verkeerskunde Congres, in Dutch.
- van der Waard, J. (1990). *Concept elasticiteitenhandboek (concept elasticities book)*. Rijkswaterstaat, in Dutch.
- van Grol, R., Walker, W., de Jong, G. & Rahman, A. (2006). *Using a Meta-Model to Analyse Sustainable Transport Policies for Europe.* Iceland: RAND Europe.
- Wismans, L.J.J., van Berkum, E.C. & Bliemer, M.C.J. (2010). *Modeling externalities using dynamic traffic assignment models a review*. Washington, DC: Paper prepared for the 89th 31 Annual Meeting of the Transportation Research Board.
- Xu, R. & Wunsch II, D. (2005). *Survey of clustering algorithms.* Rolla: IEEE Transactions on Neural Networks.

Appendix A

Set-up interviews

Het project team Sneller en Beter heeft onderzocht hoe de verkenningsfases versneld kunnen worden. Één van de maatregelen waarvan ze verwachten dat zal bijdragen aan het versnellen zijn quick scan tools. Het doel van mijn onderzoek is het ontwikkelen van zo'n quick scan tool waarmee een versimpeling van gedetailleerde modellen wordt gemaakt doormiddel van versimpelingstechnieken waarbij de waarde van de data zoveel mogelijk behouden wordt. Hierbij wil ik me richten op strategische fasen van infrastructurele projecten. Ik wil de toepassing en eisen opstellen voor deze quick scan tools. Hiervoor wil ik o.a. dit interview gebruiken als input. Ik hoop hiermee de eisen van de klanten van Goudappel Coffeng BV. goed in beeld te brengen. Bij het beantwoorden van de vragen wil ik u vragen om in het achterhoofd te houden dat ik bezig ga met het ontwikkelen van een versimpeld model en het dus ook niet onoverkomelijk is om bepaalde elementen niet mee te nemen in de quick scan tool.
Ik deel het interview op in de algemene verwachtingen van quick scan tools, de vereiste output, input en verwerking.

Algemeen (wat is een quickscan tool en wat zou het moeten kunnen?)

1. Voordat we beginnen is het handig om te weten wie uw klanten zijn, zodat ik weet vanuit welke deel van de markt uw de vragen beantwoord.

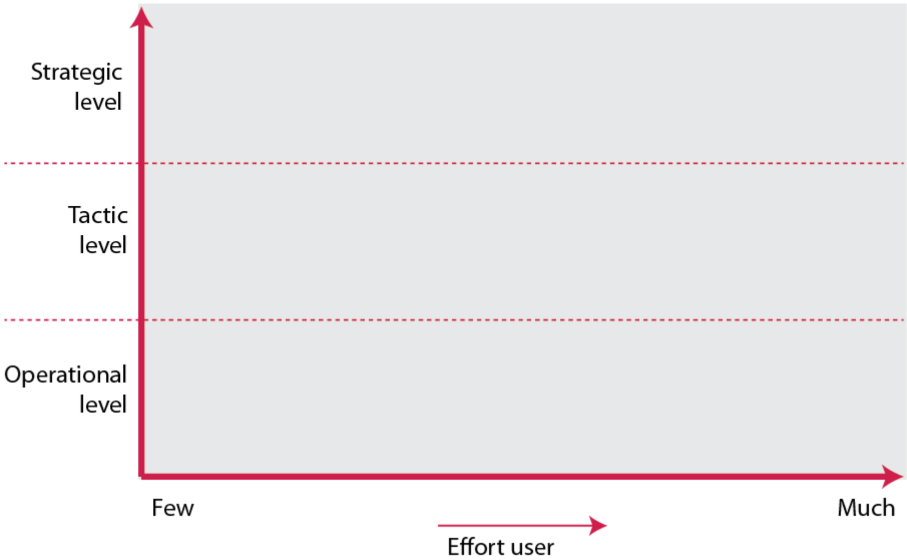
2. Welke rol spelen verkeersmodellen in uw advisering aan klanten?

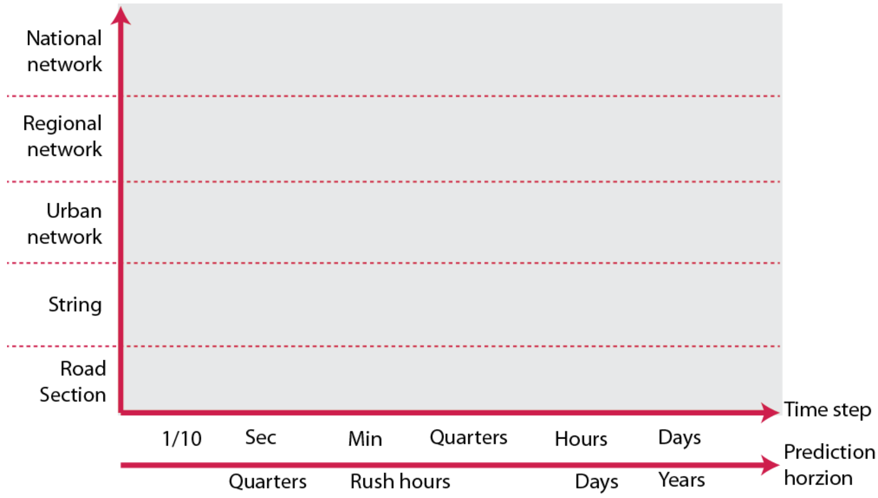
3. Voor welke problemen/beleidsvragen met de verkeersmodellen moet in uw werk een quick scan model een antwoord zijn? (Bijvoorbeeld vraagstukken op het gebied van bereikbaarheid, leefbaarheid, locatiebeleid, verkeersintensiteit, prijsbeleid, gedragsbeïnvloeding, (maatschappelijke) kosten).

4. Wat verwacht de markt van een quick scan tool? Wat zijn de eigenschappen van een quick scan tool? B.v. transparent (en wat is dan transparent), simpel, snel (zie vraag 6) en flexibel.

5. Voor welk detailniveau zijn quick scan tools geschikt. Kunt u in onderstaande grafieken tekenen waarvoor quick scan tools geschikt zijn en dit toelichten.


Network
Line
Node
Short
Long
Term


Strategic level
Tactic level
Operational level
Few
Much
Effort user



6. Wat is het verschil tussen een quick scan tool en een gedetailleerd traditioneel model? Waarom prefereert een klant een quick scan tool boven een model? (waar is de winst? tijd, geld, informatiebeschikking).

7. Welke consistenties zijn relevant bij de overgang van gewone verkeersmodellen naar quick scan modellen?

8. Binnen welke termijn worden antwoorden op de beleidsvragen verwacht ie met een quick scan tool beantwoord moeten worden? (Bijvoorbeeld binnen een uur, binnen een halve dag, binnen een dag, binnen een week, binnen een maand) Wat is maximaal toegestane rekentijd van een quick scan tool?

Output

1. Moet de quick scan tools alleen in te zetten zijn voor het berekenen van de verkeerseffecten of zijn andere effecten (b.v. op de omgeving (geluid/lucht)) ook van belang om mee te nemen?

2. Betrouwbaarheid. In mijn onderzoek ga ik uit dat de output van quick scan tools zo veel mogelijk met de realiteit overeen moeten komen. Hiervoor wil ik gebruik maken van verkeerskundige afbakening. Bijvoorbeeld als een netwerk een hoge I/C waarde heeft en het verkeer verdubbeld, zal de gemiddelde reistijd niet kunnen afnemen. Welke verkeerskundige principes of relaties zal ik zeker mee moeten nemen om een betrouwbaar model te krijgen? (b.v. I/C altijd < 1)

3. Daarnaast wil ik de toegestane afwijking van de output in kaart brengen? Wat is de maximale afwijking van de output? (b.v. 50%, 0,05% of niet anders dan een ander model zou doen?)

4. En op aanvulling daarvan: Hoeveel mag de afwijking van andere gedetailleerdere modellen zijn om een betrouwbare tool te behouden?

5. Welke output wordt verwacht door de klanten/adviseurs?

6. Zijn er verwachtingen/eisen van de klant over de visualisering van de output van de modellen? (b.v. rapport, tabel, internettool, efffecten presenteren (opdelen in deeleffecten), kaartje)

7. Zijn er nog andere eisen aan de output die van belang zijn om mee te nemen in het programma van eisen?

Input

1. Wat zijn de eisen aan input van een quick scan tool?

    - We hebben de gewenste output bepaald, wat is het gewenste detailniveau van de input?

    - Bestaande data?

    - Aansluiting met welke andere modellen is wenselijk? Zelfde input of juist de output van die modellen?

    - Voorbeelden? Intensiteiten, HB-matrixen of iets heel anders?

2. DVS zou graag zien dat alle maatregelen uit de Zevensprong van Verdaas meegenomen worden in quick scan tools. Aan de andere kant vraagt dit wel een hoog detailniveau van je quick scan tool. Zijn de zeven oplossingsgebieden volgens u geschikt om met quick scan tools door te rekenen?

3. Als we het hebben over input van quick scan tools, zijn er dan nog andere zaken die ik mee moet nemen?

Verwerking

1. Ik had het eerder al over een verkeerskundige afbakening om de betrouwbaarheid te behouden. Welke van de volgende elementen moeten zeker meegenomen worden in de verwerking van de data in de quick scan tool?
    - Keuze wel of niet reizen (trip choice)
    - Bestemmingskeuze
    - Vervoerswijzekeuze
    - vertrektijd keuze
    - routekeuze
    - rijgedrag (b.v. snelheid).

2. Aan welke knoppen wil een klant kunnen draaien?

3. Meerdere scenarios kunnen vergelijken?

4. Heeft u nog suggesties voor verwerkingstechnieken van de tool? (b.v. elastiteitsmodel)

Afsluiting

1. Is er nog een onderdeel van quick scan tools die we nog niet besproken hebben tijdens het interview? Heeft u nog iets toe te voegen?

Dan wil ik u graag bedanken voor uw input voor mijn onderzoek. Ik zal het interview op grote lijnen uitwerken en uw een terugkoppeling geven. Zijn de antwoorden die u heeft gegeven vertrouwelijk?

Appendix B

Category shifts

Table 16 Category shifts between the reference scenario and the -10% trips.

		-10% scenario categorization		
		I	II	III
Reference scenario categorization	I	2159	1073	39
	II	5	532	1569
	III	0	7	57458

Table 17 Category shifts between the reference scenario and the +10% trips.

		+10% scenario categorization		
		I	II	III
Reference scenario categorization	I	3266	5	0
	II	1283	812	10
	III	45	1687	55733

Vestiging Deventer
Snipperlingsdijk 4
7417 BJ Deventer
T +31 (0570) 666 222
F +31 (0570) 666 888
Postbus 161
7400 AD Deventer

www.goudappel.nl
goudappel@goudappel.nl

adviseurs mobiliteit
Goudappel Coffeng