REGIONAL AND SUSTAINABLE TRAFFIC MANAGEMENT IN THE NETHERLANDS: METHODOLOGY AND APPLICATIONS

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1. INTRODUCTION

The transportation system is reaching the limits of its existing capacity due to the increasing demand for transportation caused by changes in activities, increasing prosperity and economic growth, not only in The Netherlands, but worldwide. For decades traffic signal control was the most important traffic management measure, especially in urban areas. Since 25 years traffic management systems on motorways are deployed. In a wider context, traffic signal control and other traffic management systems are part of the Intelligent Transportation System (ITS). Using ITS, the goal is to improve the transportation system by making it more effective, more efficient and safer.

Traditionally, traffic management is local: locally there is a problem and it is solved with a local traffic management measure, mostly without considering the effects on the rest of transportation system or other side effects. Also, in most cases, motorways and urban roads are operated and maintained by different road managers. In practise, these road managers are only responsible for their own part of the network and do not have the incentive to cooperate. In The Netherlands this problem has been recognised and a structure for cooperation has been developed. This cooperation becomes even more urgent if one realises that a major part of the delay experienced by road users is suffered on the rural and urban roads and not on the motorway network. For The Netherlands it was estimated for 1996 that the delays on the rural and urban roads are 2.5 times higher than on the highway network (Wilson, 1998).

This structure for cooperation is given in the Dutch National Traffic Management Architecture, which is described in the first paragraph, together with an introduction to regional traffic management. After that a separate paragraph is dedicated to the practise of regional traffic management, followed by a paragraph on the supporting tools. Finally, some conclusions are drawn and a perspective for further developments is given.

2. REGIONAL TRAFFIC MANAGEMENT IN THE NETHERLANDS

2.1 Transportation Policy

The development of ITS is part of the more comprehensive Dutch national policy to cope with the growth of traffic mobility while improving safety and the quality of life. The key instruments here are: enhanced use of existing infrastructure by means of ITS, expansion of infrastructure where bottlenecks persist despite improved utilisation and, on a longer term, price policy based on variable costs. From 1980 a large number of ITS techniques were introduced in the Netherlands (see table 1).

Table 1: ITS Measures taken in The Netherlands current situation (Rijkswaterstaat, 2004a)

	Number	Km.	Planned (2004-2008)
Motorway Traffic Management System		997	61
Monitoring		759	656
Dynamic Route Information Panels	103		38
Ramp Metering Systems	46		24
Tidal Flow Lanes	2	12	3/10
Truck Lanes	6	12	-
Plus lanes (small left lane)		6	134
Peak lanes (use of hard shoulder)		43	377
Bus Services	31	78	4/3
Overtaking prohibition for trucks		2413	27
Incident detection camera's	52		16
Cross-border management corridors	3		-
Regional Traffic Management Centres	6		3
National Traffic Management Centre	1		-
National Traffic Information Centre	1		-

An evaluation of the effects of these investments for the highway network in the period 1995-2000 showed a cost-benefit ratio of 1:2, i.e. the 1 billion euros that were invested in ITS in that period yielded total benefits of about 2 billion euros (see figure 1).

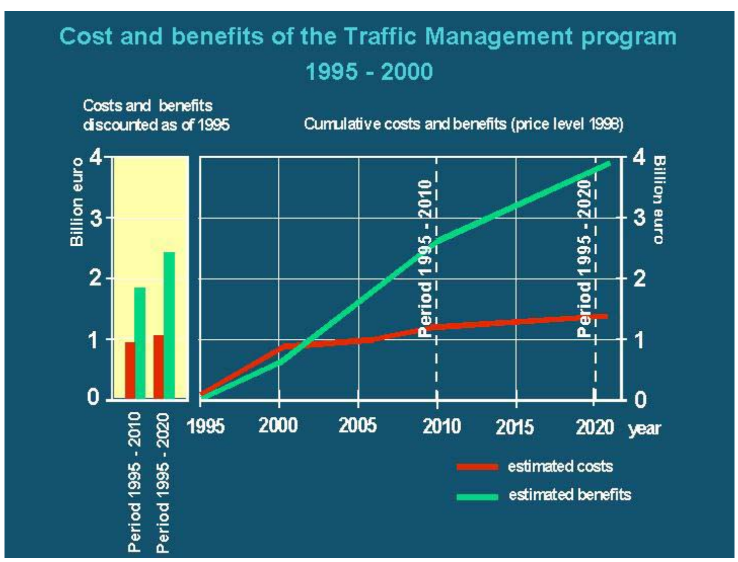

Figure 1: Investments and effects of ITS in the Netherlands on the highway network (Coëmet, 2003)

From about 2000 it became more and more recognized that more investments in even more advanced ITS techniques is not the fundamental solution to the increasing traffic problems. From that time a change was made in The Netherlands from a technique-oriented to a result-oriented approach of traffic management. In other words, the focus of traffic management was no longer (mainly) on the ITS techniques but (more and more) on the ultimate quality of the trip experienced by the road users.

For this the Dutch national traffic management architecture was developed. One of the basic assumptions for this architecture is a three-layered approach, which makes a distinction between policy makers, business managers, and system engineers. The idea behind this three-layered approach is that the right people, given the right information, will be able to make the right decisions. In this way, it is aimed to achieve the right balance between user needs en technology push. This layered approach differs from the European KAREN architecture and the US National Architecture, which are (still) more focussed on the technical aspects of ITS.

2.2 Traffic Management Architecture

The Dutch Traffic Management Architecture (TMA) is a structured description of the complex system of traffic and traffic management measures. It can be used to develop and implement a consistent and accepted (in terms of political objectives) set of traffic management measures and the necessary technical and information infrastructure (figure 2).

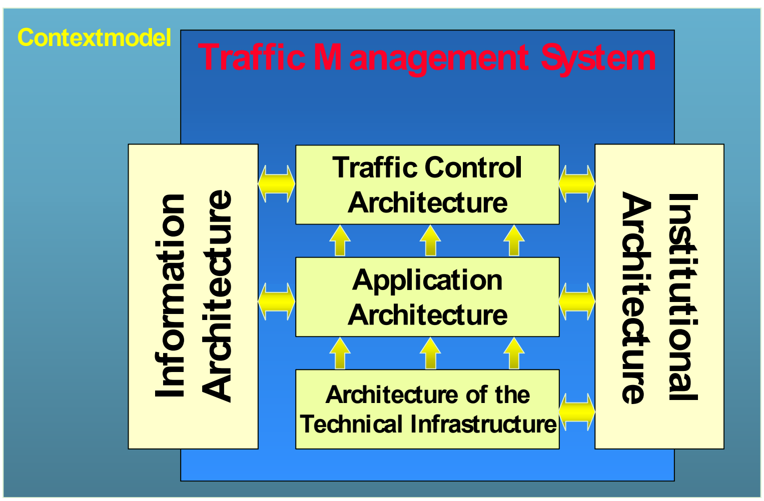

Figure 2: Traffic management architecture

The TMA consists of five sub-architectures, each describing one aspect of traffic management. For defining and using a consistent set of traffic management measures the Traffic Control Architecture is used. For the integration of the hardware and software an Application Architecture is defined. The Architecture of the Technical Infrastructure describes the general ICT services in traffic management systems. The Information Architecture should harmonise the exchange and use of information and finally the

Organisation Architecture gives a picture of the organisation required to facilitate traffic management. Of these five sub-architectures, the Traffic Control Architecture is the most developed one and plays a leading role in the design, implementation and operational use of traffic management (Rijkswaterstaat, 2001).

2.3 Traffic Control Architecture

The Traffic Control Architecture (TCA) provides the user with a framework for setting up and using traffic management. Unlike other ITS Architectures, which are more technology-oriented, the TCA covers the entire process of traffic management, from the initial intent to improve a local traffic situation right up to an integrated traffic management concept. The process starts with defining the common 'traffic management targets' for a specific region, indicating the problems to be tackled using traffic management, and translating these into a solid network vision. This regional network vision is called a *traffic control strategy* and constitutes the common basis of all activities of the participating organisations with respect to traffic management in that region.

The traffic control strategy should unite the separate targets the participating organisations (mainly road authorities) want to achieve in that region. In this respect it balances the needs from all road users, such as a safe trip with an acceptable and reliable travel time, given certain (financial and environmental) restrictions and the objectives of all road authorities. After this, the traffic control architecture describes the steps to link this traffic control strategy to the choice of traffic management measures. In doing this, TCA continuously focuses on helping the users to cooperate with the various parties involved.

Also the operational side of traffic control, such as defining, testing and implementing control scenarios for road works, incidents, football matches, etc., is part of the TCA. In the operational part, the use of models to assess different control scenarios becomes very important (Schuurman, 2003). To structure the process to come to a widely accepted traffic control architecture the Handbook Sustainable Traffic Management was developed.

Figure 3: Handbook Sustainable Traffic Management

3. HANDBOOK SUSTAINABLE TRAFFIC MANAGEMENT

3.1 Introduction

The entire process following the principles of the TCA, is described in the Handbook for Sustainable Traffic Management (Rijkswaterstaat, 2003). This handbook is published in Dutch, English and also in Chinese.

The handbook has been developed based on numerous real-life applications in the Netherlands, varying from projects that were previously technologically oriented to large-scale projects with more than twenty-five participating road authorities. Currently the methodology is applied in some 50 projects in The Netherlands (see figure 4).

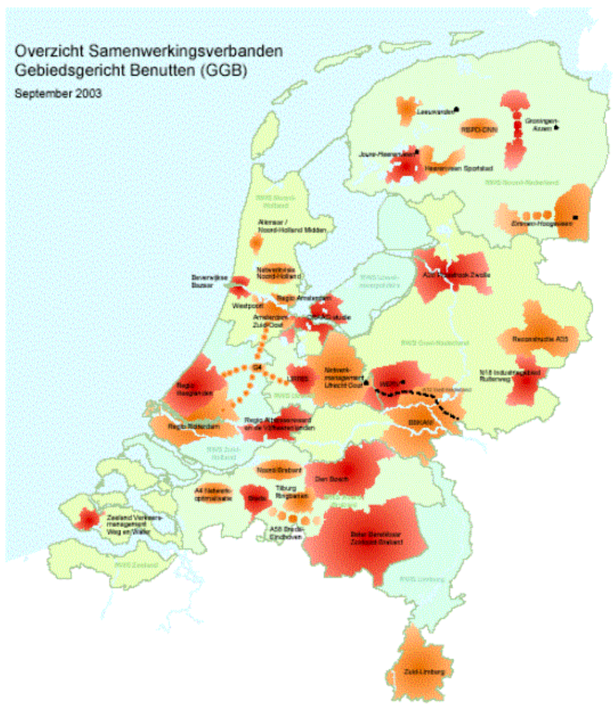

Figure 4: Local applications of Sustainable Traffic Management (Rijkswaterstaat, 2004b)

3.2 Contents

The Handbook for Sustainable Traffic Management is subdivided into nine steps. Each of these steps comprises a number of self-contained actions. These actions result in 'intermediate products' (reports, analyses). At certain points, coinciding with executive meetings, 'products', in the form of memorandums laying down the agreed arrangements and the results of the discussions that were held during the step(s) under review, are presented.

Generally speaking, the process as described in this workbook is as follows. The first step (step 1) is to initiate and organise the project, bringing together the relevant parties, which are needed to work collectively on Sustainable

Traffic Management. Together, these parties will define the ‘traffic management targets’, indicating the problems that need to be tackled using traffic management (and perhaps other means). Also setting up a proper project organisation structure is very important.

With all parties together, the following three steps need to be taken to formulate the common goals more precisely. First, the traffic management targets into a network vision need to be elaborated (step 2). Clear and unambiguous objectives state the target situation. In a control strategy (step 3), the contingency priorities need to be set. These priorities are to be used conflicting targets cannot all be fully met. The frames of reference constitute the third element of the network vision and these include measurable criteria (travel time, noise levels, etc.) as well as thresholds to indicate what is acceptable and what not (step 4).

Now the target situation can be compared with the actual current or projected situation (step 5) to determine the locations and severity of bottlenecks (step 6). After this, ways to deal with these bottlenecks can be proposed by defining services (step 7). A service is a general description of actions intended to achieve the desired effect for certain traffic flows, locations, or roads (e.g. limit the flow of incoming traffic, increase the capacity at the bottleneck). In doing so, the priorities defined for the control strategy, can be taken into account. This is the step where logic, consistency, and coherence is created.

Next, each service can be linked to one or more measures (step 8). Measures are the means to implement the services (e.g. ramp metering, traffic lights, rush hour lane). The cost, effectiveness, and completion date of this set of measures can be calculated. This will result in a proposal for an action scheme (step 9). Once the scheme has been ratified at the political level, the implementation of the measures, the design of control scenarios and, finally, the operational traffic management can be started. For an overview of the Sustainable Traffic Management steps and their products, see figure 5.

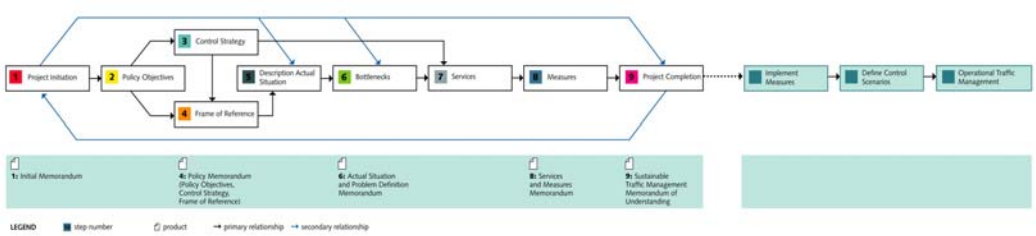

Figure 5: Sustainable Traffic Management Process Diagram (Rijkswaterstaat, 2003)

3.3 Practical Application: Network Vision and Control Strategies

The point of departure of the method of Sustainable Traffic Management is a solid network vision. This vision, also called the traffic control strategy, describes the desired performance level of the network and prioritises traffic flows in the network in case the quality level is too low. For example, if problems occur on the network, problems on priority 1 roads are solved at the expense of roads with a lower priority. In the previous two years, control strategies have been developed for the whole Dutch highway-network. All highways and main roads have been prioritized area oriented. This has resulted in 9 regional control strategies and three national control strategies (for peak-hour traffic, for economical traffic and for recreational traffic). On a regional level, the traffic control strategies are defined for a more detailed network. As an example, figure 6 shows the regional traffic control strategy for the network of South Holland (including the city of Rotterdam).

The cooperating areas, shown in figure 4, use the network vision for their region to decide on their own investments in traffic management measures. In various regions this has already resulted in the development of large scale region wide traffic management programs, financed by, developed by and implemented by the participating road authorities, but aimed at one specific and common objective.

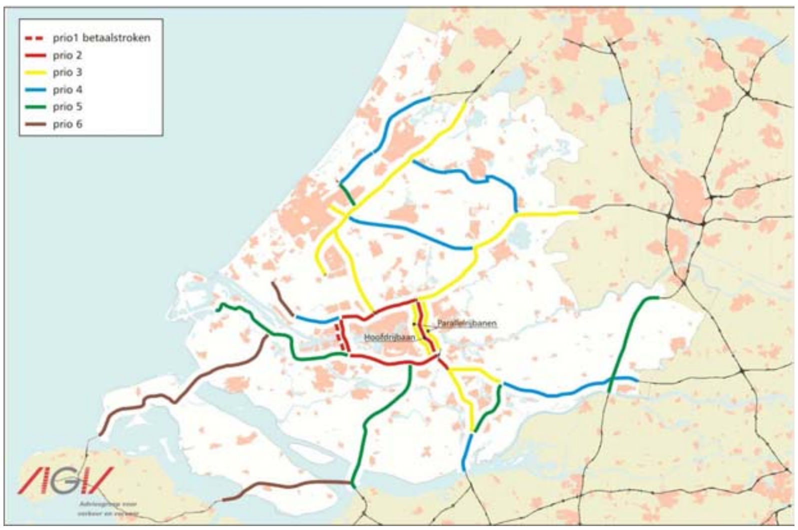

Figure 6: Regional control strategy

3.4 Practical Application: Road Works

Once a traffic control strategy has been formulated and agreed upon, this constitutes a solid basis for common traffic management in a regional area between the road authorities involved. Departing from this common basis, the various road authorities can work on their own implementation of traffic management, knowing that their efforts will coincide once they will become operational. Moreover, this basis constitutes a common and network-wide point of departure for dealing with different disruptions, such as major road constructions, incidents and special events.

One example of a traffic control strategy for road works is a recent application in the east of the Netherlands. On one of the main highways baffle boards were to be installed next to the road over a length of 2.5 kilometres. During the 6 months of construction major delays were expected (and predicted with models). Both (inter)national and regional traffic would suffer unacceptably. Computer models showed that if measures were only implemented on the highway, the problems would shift to the local roads and that, considered from a network-wide perspective, total delays would even increase. This was the reason for the involved road administrators, i.e. the national government, the province of Gelderland, six local authorities and the police, to start their preparations using the Sustainable Traffic Management approach.

Following the steps of Sustainable Traffic Management, the process started with the definition of the objectives during the construction works. Discussions were about which traffic flows should be disrupted minimally and where would traffic queues be most accepted. These objectives were all combined into a control strategy (Kock and Van den Hoogen, 2002). Subsequently the (temporary) traffic management measures to reach these defined network-wide objectives were defined. These considered of both traffic management measures services near to the construction works (see figure 7) and measures to re-route the international traffic coming from Germany via a parallel connection. Some of the required measures were temporary one's. Others were existing measures, but used differently than in the regular situation. Examples of these measures are ramp metering, variable message signs, re-routing information, a barrier to separate traffic flows, decreased speed limits and altered tuning of the traffic signals and incident management patrols. These measures were implemented by the various participating road authorities and by the police. An evaluation during the construction process showed that the major traffic delays were prevented and that, in fact, traffic delays were acceptable and were kept under control.

Figure 7: Control strategy and implemented measures

3.5 International

As stated in the paragraph 2.1 of this paper, the Dutch approach of the Traffic Control Architecture slightly differs from other ITS Architectures, such as the US National Architecture, the European KAREN Architecture and the

Japanese HIDO Handbook. The main difference is the more user-oriented approach of the Dutch architecture and the more technological-approach of the other architectures. In a paper for the 9th World Congress on ITS (Berghout *et al.*, 2002) it is shown that the Dutch approach aligns with the European KAREN architecture and that in fact it could have an added value to the KAREN architecture. It is therefore proposed to use the Dutch approach as a 'first step' before the other existing ITS architectures. That's why the Handbook was also published in an English version.

4. REGIONAL TRAFFIC MANAGEMENT EXPLORER

4.1 Introduction

In order to facilitate the process of Sustainable Traffic Management, the Regional Traffic Management Explorer (RTME) was developed. This sketch planning and modelling tool supports the steps needed for STM and makes it possible to determine the effects of proposed traffic management services and measures. These effects can then be compared to the formulated policy objectives or other sets of measures.

4.2 Development

Before the development started, functional requirements were formulated based on an inquiry among potential users and modelling experts. The following five activities were found to be of importance to the user:

- Import of data;
- Modification of data;
- Building different traffic management scenarios;
- Calculating the effects of the scenarios;
- Presenting the results of the calculations.

Based on these activities the following limiting conditions were specified:

- It should be possible to apply the tool in a workshop, which means a lot of effort for the preparation and minimal effort for composing the scenarios, running the simulation and presenting the results. For back office applications the model should be able to produce a dynamic equilibrium.
- The tool should be applicable to regional networks, including motorways, rural roads and urban streets.
- It should be possible to compare the results of the different scenarios in an easy way, which means simple and fast presentation possibilities.
- Modelling the effects of services and traffic management measures should be realistic, giving a reliable outcome of the model, on which implementation plans can be based.
- The development should lead to a national tool, which is available to everybody and with which it is possible to apply it independent of a consultant.

After a thorough exploration of the available transport planning software and dynamic traffic assignment (DTA) models, it was decided to build the RTME as a plug-in of the OmniTRANS transport planning software, which is build and maintained by OmniTRANS International. First choice for the DTA model was METANET, which was extended with a model for urban links and a DTA module. But during the development it became clear that the run time of METANET would to be too long for the regional networks to be studied. A number of potential DTA models (DYNASMART, VISUM, MaDAM, MARPLE) was evaluated. For several reasons, it was decided to switch to the DTA model developed by Henk Taale for his PhD research, called MARPLE (Model for Assignment and Regional PoLicy Evaluation).

4.3 MARPLE

MARPLE was developed to study the interaction between route choice and traffic signal control. The problem under research is how to control traffic taken into account route choice. For this a fast traffic simulation and assignment model was needed and because five years there weren't too many of these models around, it was decided to develop such a model.

For the traffic simulation MARPLE uses travel time functions and propagates traffic through the network based on these functions, taking blocking back effects into account. For different road types, different state-of-the art travel time functions are used:

- Normal links – travel time function of Akçelik (Akçelik, 2003);
- Controlled links – travel time function of HCM 2000 (TRB, 2000);
- Roundabout and priority links – capacity formulas of Wu (Wu, 2003) and travel time function of Akçelik.

Based on the travel times on the different routes between each OD pair in the network with sufficient demand, a deterministic or stochastic assignment is used to distribute the demand on the available routes. The deterministic assignment uses the variational inequality approach to come to a solution (Bliemer, 2001). The stochastic assignment takes overlap in routes into account (Cascetta *et al*, 1996). The available routes between an OD pair can be maximized and are determined using a Monte Carlo simulation with the free flow travel times and Dijkstra's algorithm for the shortest path.

In an iterative process with the simulation and the assignment the model converges to a true dynamic deterministic or stochastic user equilibrium. The outcome of the model consists of indicators on network level (total distance travelled, total delay, etc.), on route level (flow, travel time and delay per time period) and on link level (flow, speed and density per time period). The model is not validated, but gives reliable results.

4.4 Use of the RTME

The RTME provides tools to formulate policy objectives and a general traffic management strategy. The objectives are quantified in a so called frame of reference (step 4) and a user can input reference values for different (flexible) criteria, such as average speed on links, or (parts of) routes, travel times between origins and destinations, etc (see figure 8).

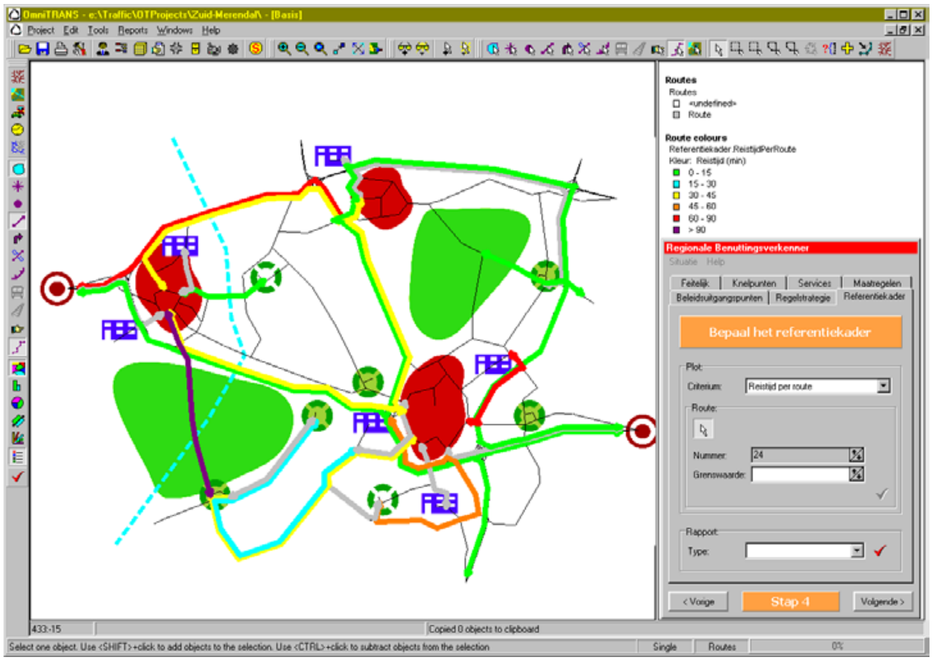

Figure 8: Frame of reference (step 4)

When policy objectives are confronted with the actual situation (step 5, see figure 9), bottlenecks can arise for the different criteria (step 6, see figure 10).

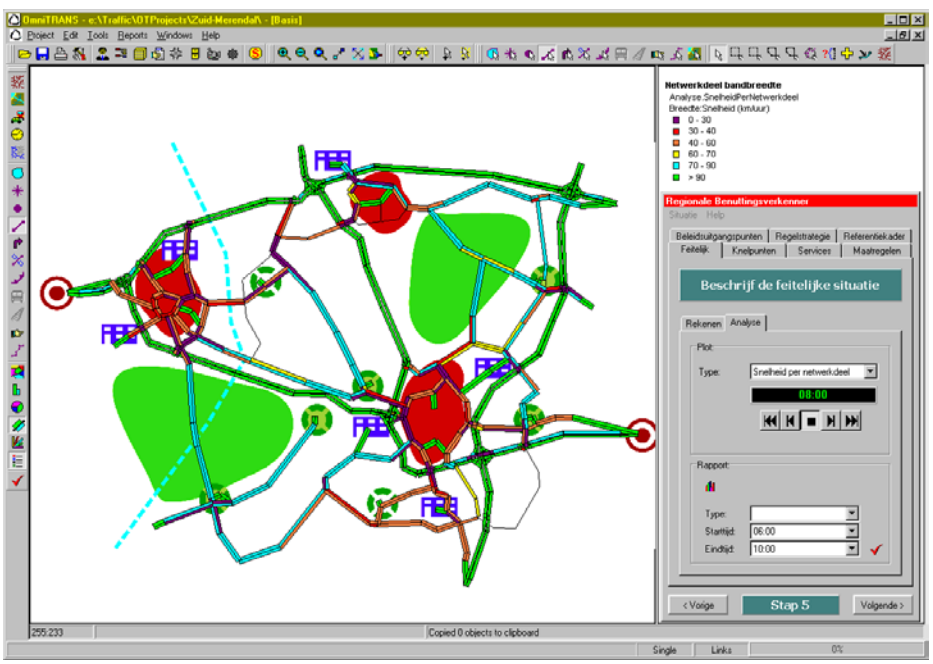

Figure 9: Current situation (step 5)

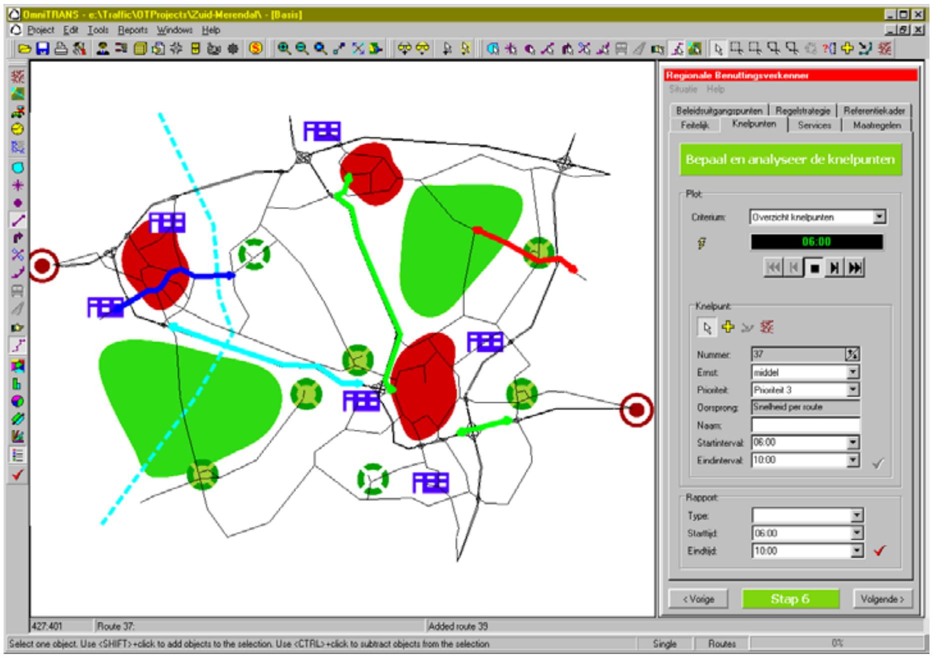

Figure 10: Bottlenecks (step 6)

The objective in the remainder of the STM process will then be to eliminate as much of these bottlenecks as possible. The RTME facilitates this in two steps. In the first step, called services, resolving the bottlenecks is thought of in general terms, such as reduce inflow, restrict speed and increase capacity. In the second step these services are translated into actual measures, such as ramp metering, tidal flow lanes, speed limits, etc (see figure 11). The effects of services and measures can be calculated using MARPLE.

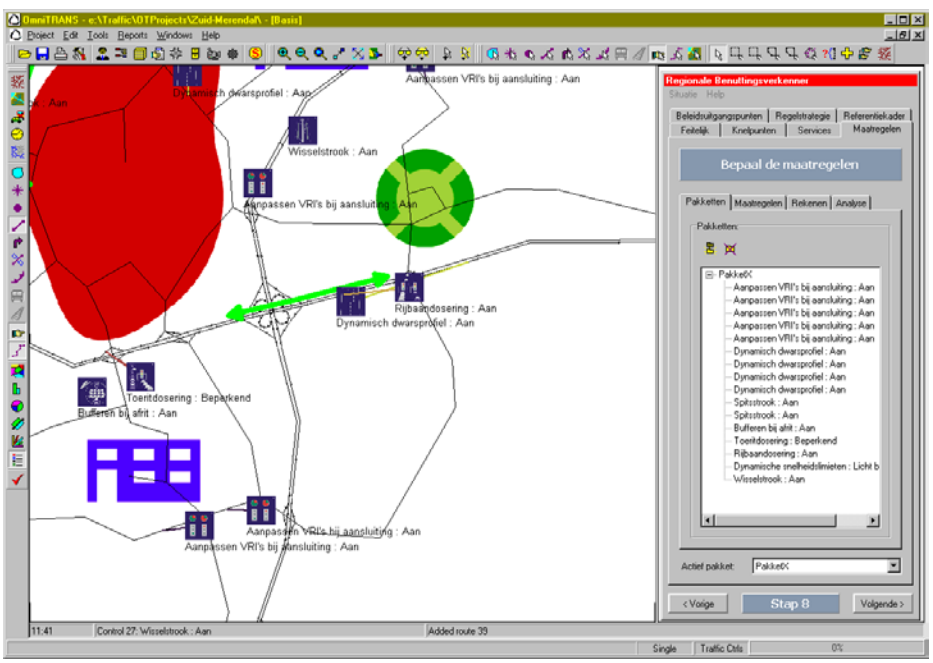

Figure 11: Traffic management measures

4.5 Case Studies

The development of the RTME started in 2003. In June 2004 a first version was ready for testing. The different parties involved raised three important issues: the RTME should be tested thoroughly, such that all potential users have enough confidence in the tool and the underlying traffic model, all relevant consultants should be able to gain experience with the tool to create an equal starting position as compared with the developer of the tool and all regional offices of Rijkswaterstaat wanted to use the RTME as part of their STM processes.

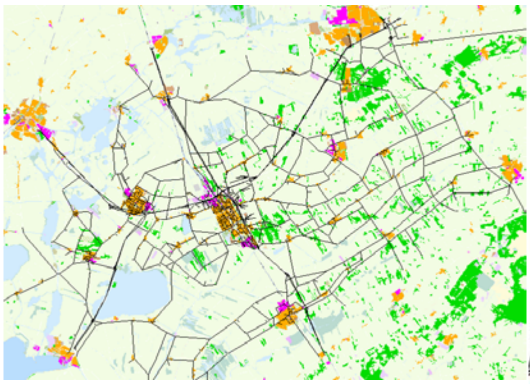

Figure 12: Example networks for case studies

It was therefore decided to start 9 pilot studies for 9 different areas in 9 different regional offices of Rijkswaterstaat with 9 different consultants (see figure 12 for example networks). AVV Transport Research Centre coordinates these pilots and if necessary solves software problems. Also the interaction between the different pilots is coordinated by AVV. For this a website (www.benuttingsverkenner.nl) with all relevant documents, downloads and a forum was created.

The pilots will give information on the use of the RTME, possible improvements and gives the consultants the opportunity to learn to work with the tool. The planned end date of the pilots is October 2004.

5. CONCLUSIONS

The Traffic Control Architecture has been introduced successfully in the Netherlands as an approach to set up integrated traffic management plans on a regional level. In several major conurbations the methodology has been adopted now as a guide for the development of cooperative regional traffic management enabling different road authorities (state, province and municipalities) to work together effectively.

A handbook for Sustainable Traffic Management was produced (also available now in the English and Chinese language) as a guide for adopters of the new traffic management approach. The authors welcome initiatives that lead to an application of the handbook on an international level.

To support the STM process at different stages a software tool was developed based on a dynamic traffic assignment model, called the Regional Traffic Management Explorer. With the dynamic traffic assignment model MARPLE the RTME computes the effects of combined traffic management measures on the network and confronts them with the control strategies and with the objectives. At this moment nine case studies are done to test the RTME and gain experience working with it.

Acknowledgement

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