REPORT OF A PILOT
DATABASE ORIENTED PRODUCTION OF STYLIZED TRAFFIC MANAGEMENT MAPS

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SUMMARY

One of the needs for dynamic traffic management is a system that gives an operator quick and precise access to actual traffic and road data. These data can be presented in tables, diagrams and maps. A traffic management map has to be clear and simple, so a stylized map seems a good approach, especially when combined with the possibility to show different levels: an overview of the road network in the whole country as well as a detailed view of traffic lanes. Other requirements for the map are actuality and maintainability.
In this pilot is studied how such a stylized map for traffic management can be produced. Starting with digital data sources, a map database was filled and processed to construct the map objects, reflecting the user requirements. The next step was putting the data into a presentation system that also handled the process of stylizing the map. With these steps, the process was completely designed and followed, some needs for further developments were defined and a set of example maps was produced.

MOTIVES FOR THE PILOT

Traffic Management Systems

In consequence of the growing traffic, congestion is increasing and therefore delay and hindrance are felt by more and more people. In a lot of urban areas with a high density of economical activities and households, there is not enough space to take care of the traffic problems by building new roads. What is needed is traffic management: for better and safer use of the available infrastructure. The traffic management of such an area depends on several systems that give the road user information, guidance and instructions. Although a lot of traffic systems are working automatic, an operator is needed for handling special situations. Also if actions are needed to avoid foreseen traffic problems, the operator is the one to set the right measure.

System Operator Tasks

Two major tasks for traffic management, in relation to the road lay-out, are dynamic information and incident management. With dynamic information the driver is guided and directed trough the road network. With incident management the negative effects are limited and the normal traffic flow can recover. The traffic management systems are doing basic things like gathering information about traffic flow and speed and putting maximum speeds or congestion-warnings on the panels above the road. In addition, the operator is responsible for giving specific information to the road users, closing lanes if an accident has happened or rerouting the traffic.

Real Time Traffic Representation

For these traffic management tasks, a good real-time representation of traffic and road on a map is needed. Such a map should also give an orderly overview to identify, judge and apply measures for the traffic management. The need of actuality and completeness of this map, asks for the use of several sources of digital data about roads, traffic objects and land use. Although the map hasn't to be geometric correct, it is important to make it possible that a person or object on the road is represented on the right position to an operator who can only look at the map. A car that sends its GPS position to the operator, must be drawn on the map precise on the road.

A Pilot to Develop Traffic Management Maps

To study the feasibility of the database oriented production of stylized traffic maps, a pilot project was started by the Dutch Ministry of Transport, Public Works and Water Management. Several parties were involved: Oranjewoud (engineering compagny), Carto (information technology), PSB (database technology), Tenet UK (software development), Informaat (user requirements) and EDS (system management).

OPERATOR TASKS IN TRAFFIC MANAGEMENT SYSTEMS

Examples of Traffic Management Systems

On the Dutch Motorway network, various traffic management systems are available. The main system is that of matrix-signs above each lane, on a regular distance. On these signs a maximum speed can be shown, arrows can be shown and also a cross is possible. The greens arrow steers the traffic to another lane, the red cross closes a lane. Another system is that of dynamic route information: a panel above the road that displays text

with information about rerouting or connections to public transport or availability of parking space. Furthermore, tunnels and bridges often have their own set of matrix signs, traffic lights or even barriers to regulate the traffic.
All these systems have a component to give information to the road user, a component to gather traffic information for performing their own process and a component with consoles in a traffic center to be used by the operator.

Functional and Lateral Integration

Although the traffic management systems are involving in functionality as well as in diversity, it is clear that integration is becoming more and more important. All the different systems have their own set of operator tasks with increasing overlap and influence. So there are two ways of integration needed. The first is called functional integration, the second lateral integration.
Functional integration is needed to combine the different systems and create one user-interface for all the tasks. This gives an operator a uniform entry for all the functions of the underlying traffic systems. Functional integration asks for a map that can show different themes together as well as separately, concerning traffic as well as road.
Lateral integration is needed to connect the regions for which a separate Department has its maintenance responsibility. At least a map of the whole Netherlands is needed for a quick overview of the road network, with the possibility to zoom in on spots that can give further information for traffic management. As an example, figure 1 gives the national Motorway network on a stylized map on which several themes like congestion, road works or mist areas can be shown.

Figure 1: National motorways on a stylized map

Both ways of integration have in common the need for transforming and stylizing the map for optimal use of the screen and combining overview with details.

Map Requirements

The operator needs a good real-time representation of traffic and road on a map, eventually extended with information about weather or even traffic flow prognoses. The map must be able to show the complete environment for which the operator is responsible as well as details about situations he has to act on. The map should also give an orderly overview to identify, judge and apply measures for traffic management.
To meet the operator tasks, there will be three levels of presentation: at the highest level the Motorway network, then the Carriageway network and at the lowest level the Lane network. These three networks must be usable for the different poly-thematic presentations of the same traffic and road data.

GPS aspects

Although the operator doesn't need a geographic correct map, he needs the possibility to know about the position of road and traffic. It is also necessary to have the possibility to combine position-information from different sources: relative as well as absolute. A road-worker or a policeman can describe his position in relation to a traffic light or a junction: '25 meters after – seen in traffic direction – a traffic sign'. Also absolute coordinates will be used, mostly in case of fixed objects and often sampled in the terrain by the use of GPS equipment. Another possibility is the use of the 'road-picket' that belongs to each road and has a road number, a distance and sometimes a character to indicate its unique position (1). To make a connection to the map, even the road-picket position will have to be know in coordinates, so it will be measured with GPS equipment, because sometimes the position of the road-picket will have a small change by a maintenance road-worker. In the future, when GPS in cars and in cellular phones is becoming more available, the traffic management map has to be ready for projecting incoming GPS data.

MAP MODELLING

The Conceptual Model of the Map

To be able to develop the map and process the data, as a first step a conceptual model of the map was constructed. This was done with the use of Express, a formal information modeling tool. Express gives an international standardized (ISO) method for specifying complex information models, often used in petrochemical and CAD environments. The use of all kind of traffic and road objects from different sources, justified the choice of Express as the less specific tool for constructing the conceptual model.
Starting with the Carriageway heartlines as primary source, two related networks were derived. First, the heart-lines of the Motorway's were constructed by generalizing the network. Second, the Lane network was derived by constructing lanes out of Carriage-ways with the attribute 'number of lanes'. So there are three essential concepts: Motorway, Carriageway and Lane for modeling a network, based upon the same road network. Beginning with these essentials, a complete conceptual model was developed.

The Production Model

One of the starting points in the map production process was that the map data should be stored in a database. This is the same database that forms the heart of all the separate traffic management systems.

This database also handles all the dynamic information between traffic objects along the road and the operator system in the traffic management center. This database has good facilities for authorization, replication and real-time processing.
Another reason for relying on the database is that the source data will come on different moments from different sources and have to be prepared before they can be processed by the presentation system. The production model describes the process that start with the digital data from different sources, the pre-processing of the Carriageways, the filling of the map database and the connection with the presentation system.

DATABASE ORIENTED MAP PRODUCTION

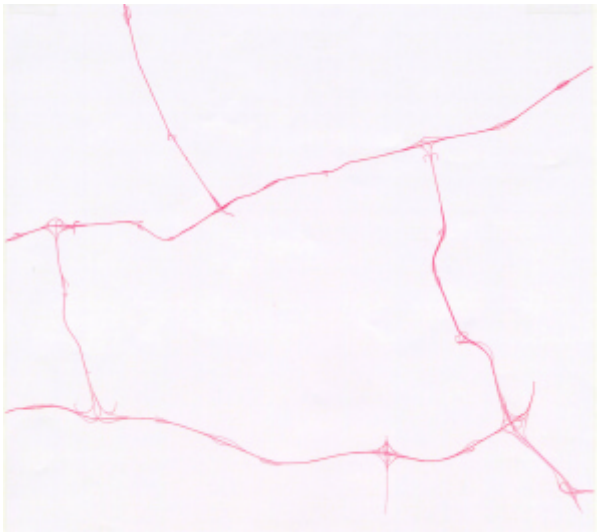
Digital Data Sources for Map Information

Traffic management has started on the Motorways around bridges and tunnels but is now spreading over lager parts of the network. That is the reason for the assumption that traffic maps have to be made for the whole Motorway network in the Netherlands.
This means that the process of map production must be automated and will be centered around a database with map data.
To fill and maintain this database, good sources for digital geographical data are needed. The usability of data is judged by criteria like: available features, coordinate system, object-identification, scale, accuracy and actuality. As sources are used:

- For the Carriageway heartlines: the National Road Data File from the Ministry of Transport, Public Works and Water Management (in standard CEN/GDF format (2));
- For the land use: the Topographical data from the 1:10.000 map from the Ministry of Defense (in the special DXF and E00 formats, in the future in CEN/NEN (3)(5));
- For the road details: the Digital Terrain Data (in the special DXF format) from the Ministry of Transport, Public Works and Water Management;
- For further road features: the administrative Motorway database from the Ministry of Transport, Public Works and Water Management (in ASCII format).

An example of the main Road data is shown in figure 2 with the raw source lines representing the heart-lines of the Carriageways.

Figure 2: Motorway Ring of Rotterdam, raw source lines

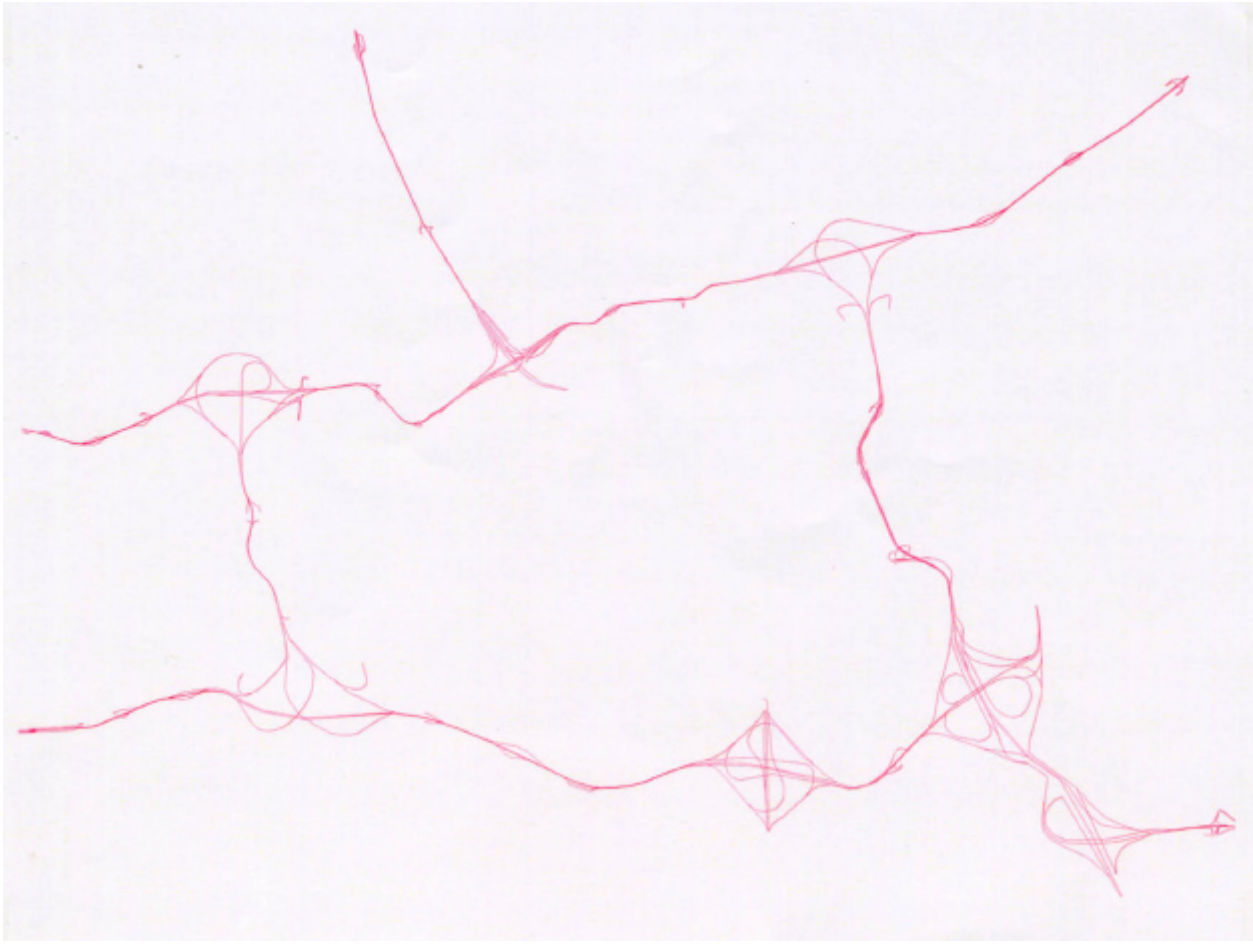


Transformation of Map Data

An important step to reach optimal use of the screen with the lines representing the network, is to transform the original data. In figure 3 an example of this kind of transformation is given: the distances between the heart lines of the source data are widened by a transformation of the network. Depending on the parameters used, it is possible to construct variants of this network

The need for transformation comes from the whish to draw each Carriageway with a certain breadth without overlapping each other. Furthermore, the background has to be transformed in the same way to keep the network in a relative equal position. By example: if a road with a bridge moves to another place after transformation, is its necessary that the river on the background also moves to the same new position.

Figure 3: Motorway Ring of ROTTERDAM source data after transformation



The result after transforming, rendering and filling in the colors, is shown in figure 3, where a lot of the road objects and traffic indicators are still hidden. By using the same transformation process for the coordinates of all these objects, their position in the map will stay accurate. Even dynamic objects, sending in their GPS-data, can be drawn on their correct position on the map with the transformation rules.

Stylizing of Map Data

The presentation system can use the map data from the database for further processing and stylizing the map. As can be seen in figure 4, the roads from figure 3 are presented in a stylized map. For this presentation all the Carriageways have been generalized along the main motorway with leaving out the details of all the exits and entries. These variants of the stylized map are just two examples of what can be done by the processing with certain parameters. Depending on the user requirements, the angels, distances and stretches can be changed.

Figure 4: Motorway Ring of ROTTERDAM: two variants of a stylized map

The stylized map is one step further away from a geographic correct map. But, the same as with the transformations, the map still can be used for positioning traffic objects in the right place. In case a dynamic traffic object, by example an emergency vehicle, sends its GPS position, the presentation system can calculate what the correct position on the map should be to show the vehicle on the map.
To decide about the map layout, the complete map, also with its traffic and road themes, has to be tried and judged by the operators in accordance to the tasks they have to perform.

PILOT RESULTS

Database Oriented Production

In this Pilot different sources for digital geographical information are used to fill a common database with information about all the traffic and road objects. Within this database the starting Carriageway level is extended to the Motorway level as well as the Lane level, so three different presentation levels for the map are constructed from one and only one database. It might be clear that this is very important for production as well as maintenance of the map.

Stylized Maps

At the same time, the geographical information from the sources is transformed, based upon the underlying connection, to produce stylized maps. In these maps, data from different sources about roads and even land use, is combined in such a way that the existing dependencies aren't disturbed. By example: a bridge is still over a river, even in the stylized version of the map. Also the police car that sends its GPS-information to the traffic management center can be located correctly on the map. In this Pilot was proven that the automated production of a stylized map for traffic management is possible and even necessary to meet the operator requirements.

Further Developments

The Pilot has shown that automated production of a stylized map from existing sources for the whole of the Netherlands is within reach (4, 6, 7 & 8). Although a lot of activities are needed to set up the production process and to make sure that the correct data in the right format can be delivered, some suitable examples of the map for a traffic management center have been produced. So, a good basis is given for further development of stylized maps. Most important is that the maps can be constructed to meet the operator requirements and therefore can help simplifying traffic management.

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