A TRAFFIC MANAGEMENT SYSTEM FOR BEIJING

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ABSTRACT

The paper describes the Decision Support System (DSS) that was developed as part of the Intelligent Traffic Management System (ITMS) of the Beijing Traffic Management Bureau (BTMB) to better manage vehicular traffic on the road network in Beijing. The system was designed, supplied and is being installed in Beijing.

The DSS comprises the following products and services:

- A Decision Support System for traffic planning, traffic control design & optimisation and traffic management. This system will eventually cover the total City of Beijing within and including the 4th Ring road and be implemented. It will become fully operational after the initial (pilot) system test proves to be successful;
- The initial implementation of the integrated network traffic control system was for a confined area in the north of Beijing including the area where most of the venues used for the Olympic Games are situated.

The development of the DSS has been completed and the system is currently being used by the BTMB to generate optimum traffic response plans based on traffic events taken from the Bureau's event data log. With the help of the DSS, coordinated traffic management strategies and incident response measures can now be implemented for the Beijing road network. For instance, the control of signalized intersections along arterial roads can be harmonized with traffic diversion schemes implemented on the City's ring road network. As a result, the Beijing traffic conditions can be improved through the application of effective incident management and route guidance techniques.

LIST OF ACRONYMS AND ABBREVIATIONS

BTMB	Beijing Traffic Management Bureau
CCTV	Closed circuit television
DSS	Decision Support System
ITMS	Intelligent Traffic Management System
ITS	Intelligent Transport System/Service
KBEST	Knowledge Based Expert System
MoE	Measure of effectiveness
OD	Origin Destination
SAGES	Scenario Analysis and Generation System
SCOOT	(Split Cycle Offset Optimisation Technique) is a tool for managing and controlling traffic signals in urban areas.
SIP	Simulation Integration Platform
TPB	Traffic Plan Builder
TPS	Traffic Plan Selector
TRP	Traffic Response Plan
VMS	Variable Message Sign

INTRODUCTION

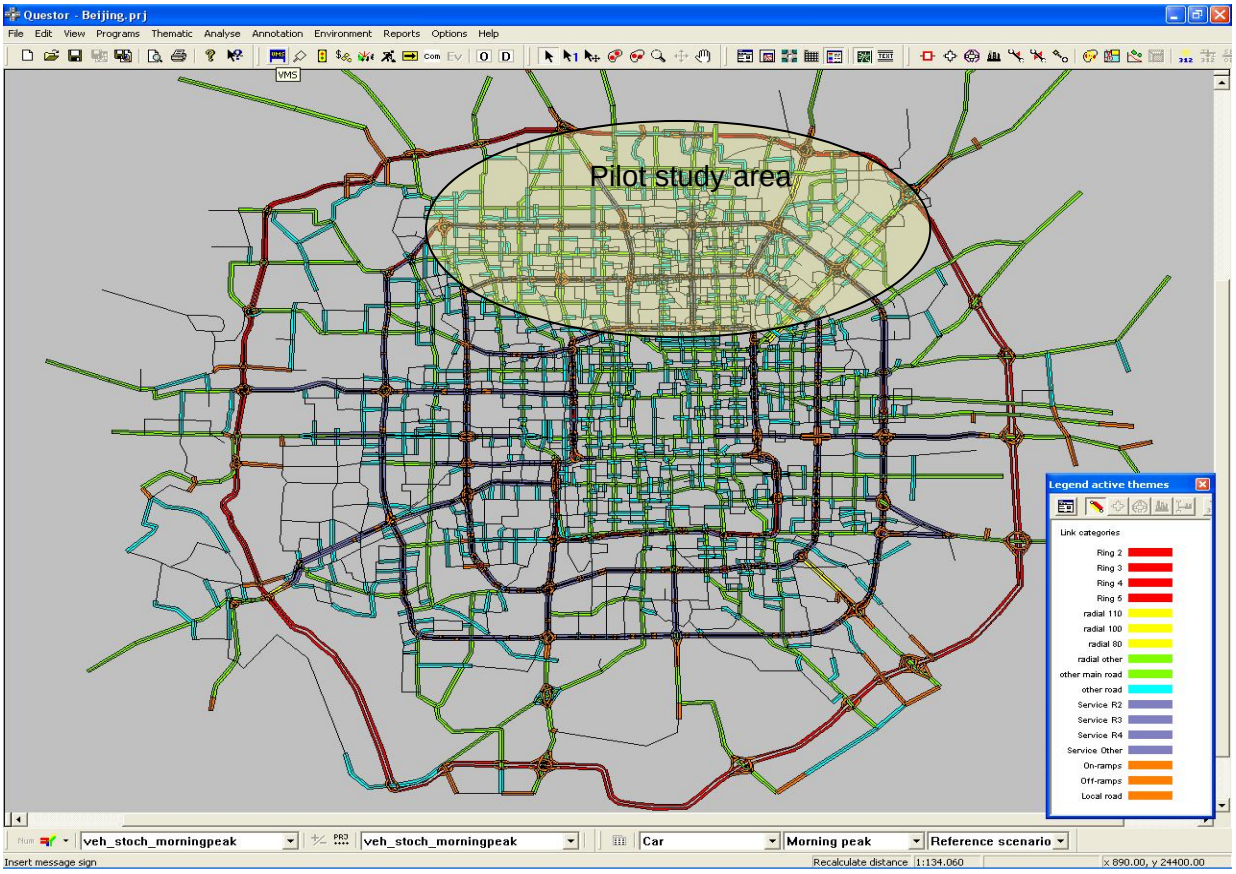
The DHV Group of Companies was appointed by The Beijing Traffic Management Bureau (BTMB) to design, supply and install a Decision Support System (DSS) for Beijing. The purpose of the DSS is to support BTMB (The Beijing Traffic Police who are in charge of traffic management in Beijing) in their management of the daunting task of managing traffic flow in Beijing.

BACKGROUND

The City of Beijing has a population of approximately 14 million and covers an area of about 17 000km². It has 170 000km of roads, 190km of which are freeways. In the year 2000 it already had 1.6 million vehicles which number was growing at a rate of 18% per annum. As a result Beijing experiences serious traffic problems.

Beijing possesses a sophisticated Traffic Control System housed in a Traffic Control Centre in the middle of Beijing. Beijing has about 1450 traffic signals, of which 280 are linked to a SCOOT system. It also has various other traffic control systems and a number of signals that are not linked to any system. It also has about 1485 loop detectors, a number of radar detectors, many CCTV cameras, variable message signs, mainly providing information and a number of pilot projects such as lane control, dynamic speed control etc.

Figure 1: Beijing's road network



The project scope covered the major roads (i.e., ring roads, expressways, highways and major arterials) in the northern part of the Beijing roadway network within the 5th Ring Road. This area covers several major facilities, such as Olympic Park, and the Beijing International Airport, as well as fast growing suburban areas.

THE AIM OF THE PAPER

The aim of the paper is to report on the design, supply and installation of the DSS software at the traffic Control Centre in Beijing and to discuss possible applications in South Africa.

PROBLEM STATEMENT

Prior to this project, BTMB already had a sophisticated Traffic Management Centre which was primarily linked to the VMS system on the main highways and was mainly used for advisory information, and a police dispatching system to detected incidents. Like many systems of its kind, the traffic Control Centre was not linked to the secondary road network control systems, nor the traffic signal systems. As a result it has limited possibility of traffic demand and congestion

management. The effectiveness of the traffic management is based on the experience of the management centre operators. This means that it does not have the capability of answering any "what if" questions. It therefore operates on rule based reasoning, rather than any case based analysis and certainly no model based reasoning.

THE PURPOSE OF THE PROJECT

The purpose of the project was to develop a DSS that could be used by the BTMB to generate optimum traffic response plans based on traffic events taken from the Bureau's event data log. With the help of the DSS, the following traffic problems can be implemented for the Beijing road network:

- Coordinated traffic management strategies. These are normally events that recur on a weekly basis at a specific time of day;
- Incident response measures. Incidents cannot be predicted. Once detected on a real time basis, an incident-specific measure needs to be implemented for the duration of the incident and then removed, once the incident has been cleared;
- Event management. These are "incidents" that can be predicted;
- Road closures. These are normally planned capacity reduction events that take place at a prescribed time;
- etc

For instance, the control of signalized intersections along arterial roads could be harmonized with traffic diversion schemes implemented on the City's ring road network.

Through integrated control measures, the management of the whole network now becomes achievable. This is done by building up control scenarios and storage into a knowledge bank. Previously this was a complicated task for the operator who faced a number of problems:

- Data interpretation problems
- Lack of insight into network dynamics (non-recurrent situations)
- Complex interactions between measurements

To alleviate the operator's problems, a cased base reasoning, such as is provided by the DSS, is required.

THE DECISION SUPPORT SYSTEM FOR INCLUSION INTO THE INTELLIGENT TRAFFIC MANAGEMENT SYSTEM (ITMS) OF BEIJING

The project objective was not only to develop the DSS, but also to supply and install a traffic management system for a pilot area in the north of Beijing (see map) that will support the Bureau to better manage traffic in Beijing in response to traffic congestion, incidents, road works and events such as the Olympic Games. The DSS is to identify major traffic problems on the complex ring road network in Beijing. It is to be used to design possible traffic solutions, evaluate the effect of the identified solutions, and finally store selected solutions in a database from where they could be retrieved for implementation. The system had to be integrated into the existing BTMB Intelligent Traffic System (ITS) architecture and also take its future implementation plan into account.

Development of the DSS

The main task was the development of a Decision Support System that had to be integrated into the existing ITMS.

The Decision Support System that was developed takes advantage of advanced simulation modelling techniques such as:

- integrating microscopic and mesoscopic traffic forecasting and simulation
- dynamic traffic simulation
- latest high speed computer processing capabilities
- dynamic OD calibration

After the successful development of the DSS, it had to be thoroughly tested in an off-line simulation environment. The major steps to test the system were:

- Identify major traffic problems
- Develop control scenarios to solve these problems
- Evaluate and test these scenarios
- Select the best control scenarios for implementation and store in a specially developed database

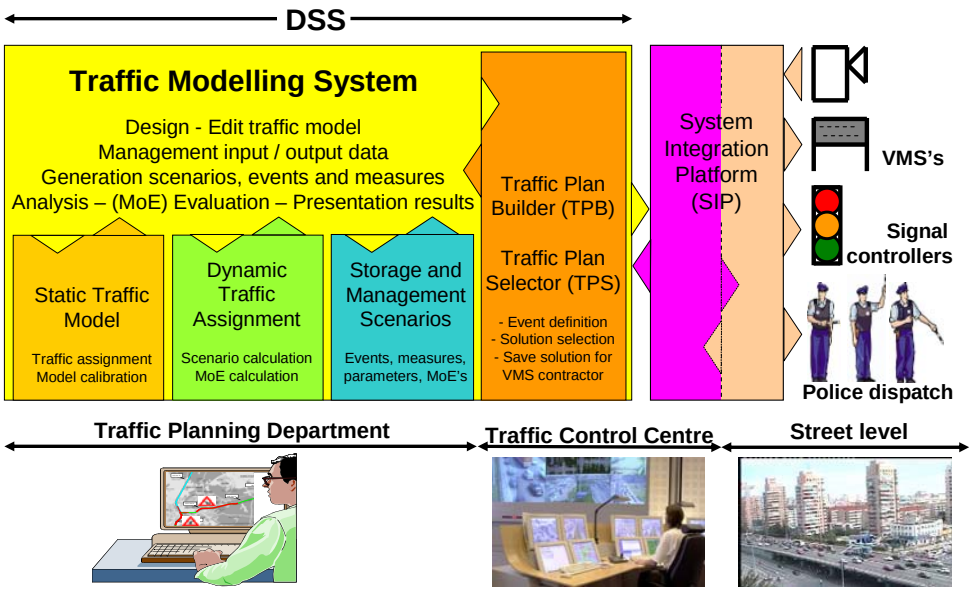
Once comfort had been reached that the scenarios will indeed improve traffic flow, the system was ready for implementation in the field. The major implementation steps were to:

- Integrate the systems to allow the implementation of integrated control scenarios
- Design and implement the initial incident management system that will:
- Identify incidents
- Trigger measure implementation procedure
- Select scenario (in a semi automated fashion)
- Implement a KBEST Scenario selected from the database
- Return to normal once incident has passed

Components of the DSS

The DSS that was specifically developed for Beijing consisted of a Traffic Modelling System, a Traffic Plan Builder, and a Traffic Plan Selector as shown in the figure below:

Figure 2: Traffic Modelling System



The DSS is linked to the street hardware and other systems via a System Integration Platform that was specially developed to cater for all the interface requirements.

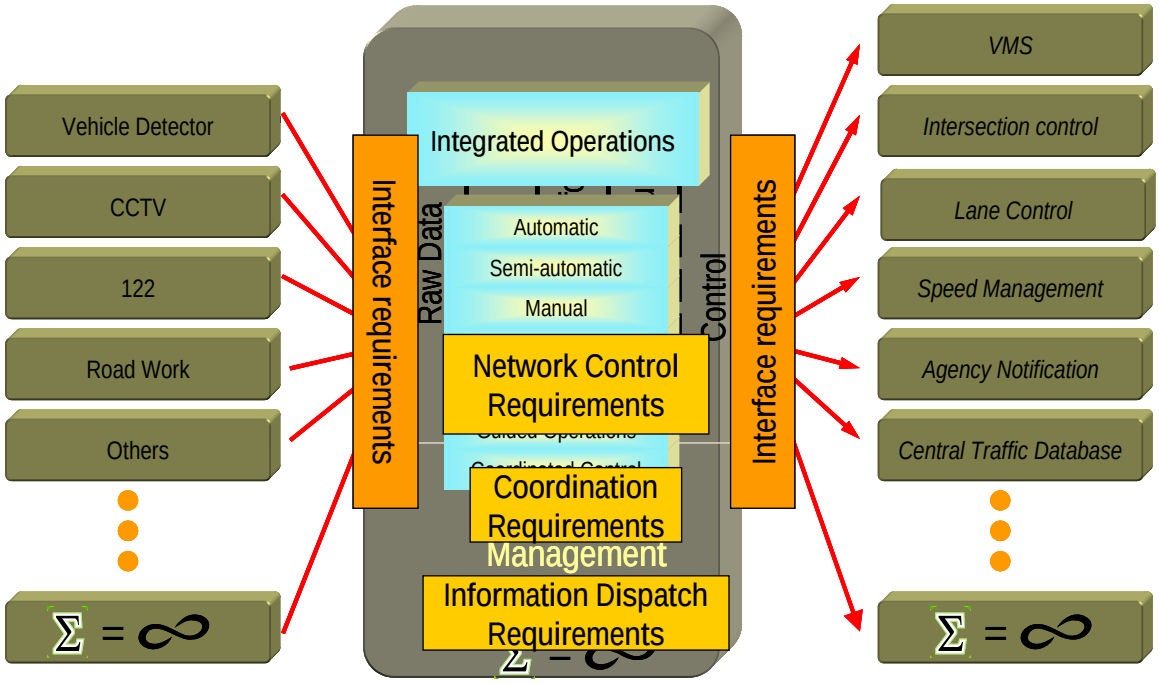
The Traffic Model

A special traffic simulation model was developed for Beijing. Because of the unique application in terms of the size of the Beijing traffic network and dynamic detail required, it was decided to opt for a mesoscopic model. The specific mesoscopic model that was used is called Questor Dynamic and was specially developed by DHV to simulate ITS applications in a dynamic environment. A mesoscopic model has the advantage that it can simulate large dynamic traffic systems which in practice prove a challenge to microscopic models. Macroscopic models on the other hand, have problems to simulate dynamic conditions. Using the latest computer high speed processing capabilities, it is now possible to simulate large dense networks such as the Beijing traffic network dynamically at speeds far in excess of real time. The modelling system consists of a static traffic

model that is used to build the network and calibrate the model using normal static techniques. The output of this model is used to calibrate a dynamic mesoscopic model that then in turn is used to simulate various traffic scenarios over time and determine various measures of effectiveness. The system also has a Scenario Analysis and Generation System (SAGES) module in which various management scenarios can be tested. The best performing scenarios can then be selected and stored in a Knowledge Based Expert System called KBEST for future use based on case based reasoning.

A flow chart of how the various traffic plans are generated, selected and finally used on the ground is shown in the figure below.

Figure 3: The input and output elements of the Beijing DSS



Traffic Management Measures linked to the DSS

The DSS software has been successfully installed at the writing of this paper. In future number of traffic control and other management measures will potentially be linked to the DSS (The exact scope is still under negotiation). These include:

- Signal control
- Ramp metering control
- Dynamic traffic information: For example VMS could be linked to form part of a dynamic traffic information system and the incident management system
- Preparation/evaluation control scenarios for non-recurring situations
- Road works: capacity impact schemes
- Special events: For example sports events

Scenario generation and analysis system

The scenario module simulates and analyzes the traffic operations of various traffic control schemes for a given a traffic event (i.e., an incident or a work zone) and provides the quantitative evaluation results for these alternatives. The operator can select the traffic control scheme based on the results of the evaluation and stores the scheme into an expert system knowledge database for the Traffic Plan Builder (TPB) to retrieve.

Traffic Plan Builder and Traffic Plan Selector

TPB is a tool that assists the operator to prepare traffic response plans, including event information, traveller information (VMS signs and corresponding messages), urban traffic signal control (i.e., traffic signal controllers and signal timing plans), and police dispatch, ready to be implemented for the real-time system. TPB provides several easy-to-use features to help the operator to select the needed traffic measures (traffic diversion, entry gating, promoting traffic flows of diversion routes, etc) in response to a specific event and automatically suggests the corresponding traffic control aspects. TPB interfaces with SAGES to request the best traffic control scheme for a specific event and to send pre-built traffic response plans to SAGES for evaluation.

DSS operation

It can easily be shown that most traffic problems have a localised effect, particularly if the size of the Beijing network is taken into account. The process is therefore started by selecting a specific area in Beijing for dynamic traffic simulation to analyze traffic conditions and identify traffic problems. The operator, in this case BTMB, can also define future events such as road closures, construction works in order to predict the future dynamic traffic impact. The operator then defines the traffic management measures that he would like to use in the simulation model to manage the event. The simulation model is then run. The output of the model predicts the associated traffic behaviour, and evaluates the results. The best traffic management measures are identified using several model runs and stored in the KBEST database. Using the TPB coordinated traffic responsive, management plans are built for future retrieval done by Beijing Traffic Management Integration System (i.e., a real-time traffic management system).

POSSIBLE APPLICATIONS FOR SOUTH AFRICA

There are many potential applications in South Africa for such an intelligent traffic management tool in South Africa. Beijing has a very complicated road network. Each major road such as the ring roads consist of a grade separated road with a parallel one way service road on each side and a cycle path next to this. Each interchange therefore consists of 3 or 4 levels, partly with at grade crossings and partly grade separated. Although none of our cities possess such a complicated road network as Beijing, there are many applications where the integration of various traffic control systems that are currently functioning independently, could be integrated. As the system can operate under either a laboratory (off-line) or a real life (on-line) condition, or both, the number of possible applications is many. In South Africa, basically every large city possesses freeways and local networks that are not currently being managed as a system although some are in the process of being installed.

Many of our larger cities are currently contemplating the possible implementation of a number of ITS systems. We have found this tool to be ideal to test the usefulness of such systems on a network-wide basis rather than a local basis such as is normally done with the assistance of microscopic models.

ACKNOWLEDGEMENTS

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