STEP Short Term Prediction

WP2: User Requirements

July 2012

Mott MacDonald
KU Leuven
Fileradar

This project was initiated by ERA-NET ROAD.

Project Nr. 832564

Project acronym: STEP

Project title: Short TErm Prediction

Deliverable Nr 2 – User Requirements

Date of deliverable: 11 July 2012

Start date of project: 01.10.11 End date of project: 31.12.2012

Author(s) this deliverable:

Mark Finer, Mott MacDonald, United Kingdom

Chris Tampere/Rodric Frederix, KU Leuven, Belgium

Version: Draft 02

Executive summary

This report summarises the consultation exercise initiated as part of the STEP project to gain a better understanding of the operational short term prediction requirements of traffic managers at Interurban and Urban Traffic Control Centres (TCC's) in Europe. One of the key objectives was to explore the gaps between the state-of-the-art and requirements of operators in terms of functional application, interfacing and the success of existing tools that are currently being used by TCCs.

During the period January to March 2012 a series of meetings and discussions took place with Traffic Control Centre contacts in the UK, Netherlands and Belgium to understand how real-time traffic controllers are setup, including practical operational and data requirements as well as to gather views on traffic prediction tools that are currently available to improve network performance and how these are used in practice. Our main objective was to understand the key issues that need to be addressed when developing practical traffic prediction tools and to maximise the potential for their application to support traffic control centre operations.

An online questionnaire was developed. We also distributed hard copies to key contacts, which elicited a total of 15 responses from TCCs. A summary of the key points from this feedback is provided below.

Tasks, Goals and Measures Of Traffic Control Centres

- Overall TCCs agree on the importance of improved journey time reliability and reduced disruption in the case of major incidents;
- TCCs are mainly concerned about the efficiency of the system (i.e. the throughput of the road network) that they manage, mostly in irregular situations;
- The most important measures that they apply during their daily operations to influence traffic operations are providing information and incident management; and
- Concerns about to deal with irregular situations (eg. random incidents on the network etc.) also indicate a potential application area for short-term prediction model.

General Response of TCCs To The Issue of Short-Tern Prediction

- A total of 80% of TCC respondents stated that they were optimistic about the use of short-term predictors to address problems of congestion; and
- TCCs indicated that the staff in many cases is unaware of the possibilities of traffic prediction, and that they should be taught about the application more fully.

User Requirements For Short-Term Prediction

- Just over half respondents stated that the accuracy of the predictions themselves was a key issue;
- Nearly 75% or TCCs stated that they wanted to see evidence of successful application by other TCCs and also experience of real-life trials; and
- 75% of respondents stated that the cost of setting up short-term traffic predictors in their daily operations was a key consideration.

Visualisation of Short Term Prediction

- In terms of how to present information to users the use of colour-coded links overlaid on a map view was most popular response, accompanied by alerts or alarms in case of abnormal conditions; and
- It was considered important that the level of manual intervention when using the tool should be kept to a minimum, and automation should be provided to help the operators.

Scenario Generation

- Predictors should be linked to traffic management scenario generation, so that the system can predict the traffic conditions that will arise with and without traffic management intervention.
- The use of short-term prediction without scenario generation is already seen as an important asset by many TCCs.
- Still, over 50% of TCC respondents felt that predictors that have the ability to apply scenario generation are considered most useful.

Horizon and Accuracy of Short Term Prediction

- A total of 40% of respondents felt that in terms of the accuracy of outputs of prediction tools and information on future travel times and the speeds a target of 80% was desirable;
- It was noted that the desired horizon for prediction tools depends on both the user and the specific situation, as for traffic controllers a shorter horizon is required, while for traffic engineers a long horizon is needed; and
- In the case of inter-urban incidents or peak periods, a 1 hour look-ahead was considered as appropriate, while for urban networks a period of 15-30 minutes was seen as a good horizon. This is because in urban environments the traffic flows can change much more quickly.

Experiences With Short Term Prediction:

- Only 4 of the 15 TCCs interviewed have any experience with short term prediction tools, and the feedback provided revealed that they are only partially dissatisfied with their current systems; and
- Early stages of development and application – dissatisfaction with accuracy of the system. However, in some cases it was too early to evaluate their systems fully.

Overall Conclusions

The Traffic Control Centres (TCCs) and their staff that responded to the STEP User Questionnaire revealed a positive attitude towards the use of short-term prediction models. Nevertheless, the experience of TCCs with the practical use and application of these models during their daily routine/operation is certainly limited.

It is worth noting that the TCCs that already have experience with short-term prediction tools are still trying to identify how best to install a workable system. Therefore, a key conclusion is that all TCCs are still searching for successful experiences elsewhere, which supports the benefits and importance of STEP project and its objectives of understanding the success factors associated with short term prediction in a real TCC environment. The pilot projects in WP4A and WP4B will provide enormously valuable feedback on the use of a prediction tool in a real operational setting.

The use of short-term prediction without scenario generation is already seen as an important asset by many TCCs. Given the high importance that is given to accuracy of traffic prediction, it is reasonable to conclude that it is beneficial to focus on such easier applications as a first stage, so that the TCCs can gain some positive experience with short-term prediction. Only after successful results have been identified, should we proceed with developing predictors with scenario generation, which of course is the ultimate objective of the development of a predictive system. Our suggestion is to consider a future ERANET project that develops and tests such scenario generators

The TCC representatives are interested in short term predictions in regular conditions, which is seen as a means to deal with variability/reliability of traffic conditions. Ultimately however, and consistent with most TCC's considering management of their networks in irregular conditions one of their prime objectives, predictions of irregular conditions would be most useful, as one can then rely less on experience. This raises particular challenges to developers of such tools, since the state-of-the-art does not provide readily applicable traffic prediction tools with proven predictive power in incidental conditions. Obviously, the reason for this is the inherent conceptual difficulty of predicting unforeseen events, as well as drivers' response (demand side) to non-repetitive irregular traffic conditions.

Other TCC operations and systems in Europe show a desire to see a standardised approach which are seen as essential for the extension and roll-out to other urban centres and cities. In the case of Dusseldorf and Berlin as well as Turin, communication between Traffic Management Centres is supported by standards that are currently being developed and established at a national level. In this context, the transferability of any software components to other conurbations will be an essential consideration in terms of future development of any predictive tool. Finally, the manner of presenting the traffic prediction results is an important aspect, but should be further explored in a later stage in the development of prediction tools during the pilot phase of the project.

Research work undertaken for the UK Highways Agency on the Optimum Real-Time Co-ordinated Management of Congestion (CoMoCo) project revealed a number of key issues that local authorities would like to see addressed in the development of Network Management Systems (NMS). These included the development of decision making protocols in the development of systems, the desire for automated systems to reduce the burden on already overloaded traffic control centre staff and the development of standards for communications link and data share across systems. All of these have relevance for the STEP project and the development of specifications for prediction tools.

WP3 focuses on the development of the proposed User Interface that will be presented to potential users of the short term predictors in the UK Pilot (WP4A) that will enable more detailed assessment and evaluation to be undertaken on how potential users might use the interface to support decision making in their strategic management of the road network.

On the basis that we have canvassed a number of potential users of short term prediction data on key attributes that they wish to see incorporated into the specification of prediction tools it is important to ensure that these are reflected in the development of draft specifications that will be used in the development of the prediction tool and interface for both UK and Dutch trials (WP4A andWP4B).

Whilst users appear somewhat divided on the type of different user interface there is interest in developing an alerting type interface as well as graphical representation of the predictions that are made. In developing and testing the tool and interface both the UK and Dutch trials aim to investigate both mechanisms. In terms of visualisation, in general the feedback identified that the use of colour-coded links overlaid on a map view was a popular option, accompanied by alerts or alarms in case to show abnormal conditions. Importantly, TTC operators revealed the level of manual intervention when using the tool should be kept to a minimum and a degree of automation should be provided to help the operators in their daily operational duties.

As part of the work to develop user interface specifications within WP3A it is envisaged that an alerting type mechanism to advise operators when traffic conditions are predicted to be different from usual, with minimal disruption to operators duties. The primary objective is to develop a user interface based on the short term prediction mechanisms required by operators, as opposed to the development of new tools to support the trials themselves.

Table of content

List of Tables

List of Figures

1 Work Package 2 – User Requirements

1.1 Introduction

This work package aims to confirm the detailed operational requirements of traffic managers at control centres in the UK, the Netherlands and Belgium. Through this engagement activity we have sought to gain a good understanding of gaps between the state-of-the-art and these operational requirements. In order to obtain information on potential TCC user requirements, a programme of face-to-face interviews/phone discussions were held with traffic managers at control centres in the UK, Belgium and the Netherlands to gain a full picture of the detailed operational requirements of traffic managers at control centres, drawing on the wider knowledge of the start-of the-art approaches to traffic prediction researched in WP1.

The STEP partners understand the importance of strong engagement with our respective highways partners in delivering this research project. During the period January to March 2012 meetings were arranged with Traffic Control Centres in the UK, Netherlands and Belgium to raise awareness of the STEP project and to obtain information on a wide range of issues concerning Short Term Prediction. The feedback from this research has helped inform and guide delivery of the WP4A and 4B pilot projects in terms of traffic management tools and development of appropriate user specifications. This information has included information on the reliability of the forecasts, user interfaces required to enable operators to understand the predictions as well as assessment of the importance of potential interventions.

During the Inception phase of the project the partners discussed the best mechanisms for obtaining the information from the Traffic Control Centres (TCCs) and it was agreed that a tailored progress of engagement/surveys including face-to-face meetings with key representatives of the Roads Agencies (in the Netherlands at the Rijkswaterstaat) as well as the UK (Highways Agency). During November/December 2011 a detailed questionnaire was developed to elicit views from the TCCs that was distributed to key contacts during the period from January to March 2012. In addition, a number of other means were progressed to try and encourage TCC representatives to share their views with us. This included:

- Use of LinkedIn to target key individuals, particularly through the established Traffic Management Group and those members registered from Europe; and
- Use of dedicated web pages to share/exchange information on the project including presentation of an online questionnaire. Web pages on the STEP project have been developed by KU Leuven to support the project; and

The partners recognise that by engaging with TCCs early on in the project (particularly those staff responsible for operational aspects of the TCCs) we are able to learn more about:

- The key priorities and objectives of the TCCs in terms of their operational objectives and existing systems for collecting data, as well as how this data is used to manage networks efficiently;
- Options that offer a potential application within TCCs that supports their business objectives and ensure that outcome is something that is useful/valuable for them; and
- 'Unlocking' more detailed ideas from them that can inform the STEP project.

1.2 Survey Approach and Questionnaire Design

In considering the key issues of interest to us from the TCCs, a detailed questionnaire was developed, which is included in full in Appendix A. This was broken down into a number of distinct sections including the following:

- *Understanding the Goals and Tasks of the TCCs*

We were particularly keen to gain a better understanding of the key objectives of traffic control centres and how traffic control centres operate. Similarly, information on what types of traffic control measures are currently used in traffic management plans were also considered useful to highlight particular functions that would help inform about most effective trial application(s) and also improve our understanding of how valuable traffic prediction tools are likely to be.

- *Structure Of Traffic Control Centre*

This was aimed at obtaining information on the size of the workforce within each TCC that we engaged with, roles and tasks of different types of employees, as well as other corporate information including yearly budgets.

- *Data And Information Sources*

We were keen to understand more about current practices in data collected approaches by traffic control centres and current issues and problems that are experienced in surveying and measuring performance.

- *Software*

This was aimed at understanding any existing software that is currently used for managing traffic information or any software tools that are currently actively being used for traffic management decision support.

- *Short Term Traffic Predictions*

Adaptive traffic control technology currently offers good opportunities to manage and reduce traffic congestion on networks and we are keen to understand more about whether existing traffic control centres currently use prediction tools as part of their current operation.

Taking into account initial feedback during early engagement with the TCCs, an online version of the questionnaire was developed to help TCC representatives to share their views with us.

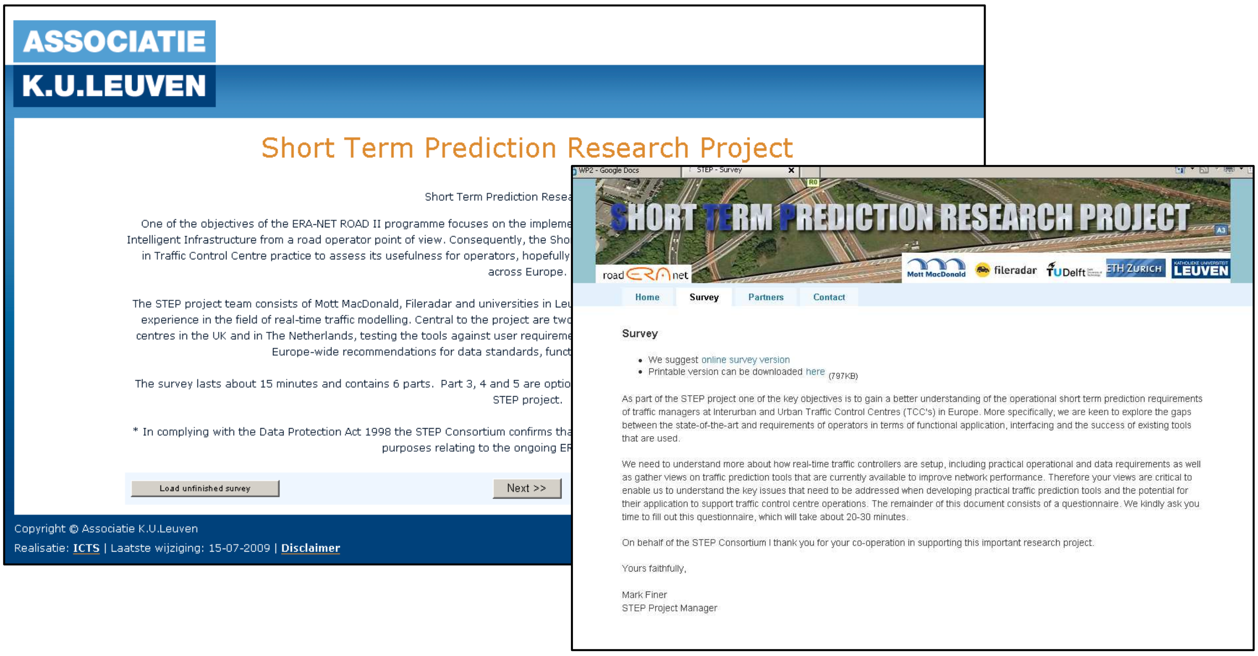


Figure 1 STEP Website and Online User Survey Questionnaire

1.3 Consultation with Traffic Control Centres

The following Traffic Control Centers (TCC) provided feedback by face-to-face meetings, and by filling in the designed questionnaire:

- Lancashire County Council, UK
- Newcastle City Council (Tyne and Wear), UK
- ROMANSE, UK
- Transport Scotland, UK
- West Sussex County Council, UK
- City of Edinburgh Council, UK
- Transport for Greater Manchester, UK
- Ministerie van het Brussels Hoofdstedelijk Gewest, Belgium
- Vlaams Verkeerscentrum, Belgium
- Rijkswaterstaat Dienst Utrecht, The Netherlands
- Verkeerscentrum Nederland, The Netherlands
- Verkeersmanagementcentrale Zuid-Nederland, The Netherlands
- Società Autostrade Meridionali, Italy

As can be seen, responses were obtained from different countries (UK, Belgium, the Netherlands, and Italy). Other TCCs from Germany, France, Finland, Greece, Romania, and Czech Republic were also contacted, but did not respond to filling in the questionnaire (either hard copy or online version), despite being contacted several times in the hope that they would share their views with us. It is disappointing that a greater number of responses weren't received but given the niche field, a total of 15 responses have certainly provided us with good level of information on which to assess the current level of understanding and use of short-term prediction tools and attitudes towards this.

During the consultation period, comments were received about the length of the questionnaire itself and the it was observed that there was greater interest from the TCC's to respond to questions about short–term prediction, the tools most likely to be used as part of daily operational routines and so the results presented here.

1.4 Other Relevant Research

The Transport Research Laboratory (TRL) has developed the Motorway On-Line Advisor (MOLA) tool for the Highways Agency (HA) which is a tool that is used by traffic operators in the event of an incident on the network. More specifically, it assesses alternative diversion plans for the incident using a CONTRAM traffic network model, and informs the operator on the best plan(s) available to minimise congestion. The HA commissioned the Optimum Real-Time Co-ordinated Management of Congestion (CoMoCo) project to address the issue of communication between different NMS to achieve better co-ordination.

In 2008, as part of the CoMoCo project, a questionnaire was designed aimed at getting a better understanding of problems encountered when co-ordinating network management systems. The questionnaire aimed to understand what stage stakeholders had reached in considering such systems and what technical issues were had identified that affected implementation. A total of 37 responses were received (out of a total 169 questionnaires sent out via e-mail to UK local traffic authorities).

The survey revealed that some facilities are in place ready for use in a MOLA-like system, although no such automated real-time systems have been uncovered in this survey. The local authorities understand the importance of real-time traffic management, although in many cases the need is not (yet) great enough to justify the cost.

In some areas, real-time automated systems are in development, but are mostly still in early stages. In the near future it is likely that such systems will become more common as the rising cost of congestion demands more advanced technology.

Respondents were asked at what stage they were currently at in considering or implementing an automated real-time Network Management Strategy (NMS). The results revealed that a significant majority of local authorities are at the early stages of implementation, with only 13% of responses (six organisations) commenting that they were at the roll-out phase of their strategy. A total of 31% (14 organisations) answered 'none', identifying they were not at any stage in considering implementing an automated real time NMS due to a variety of reasons:

- Some were looking at the possibility of developing joint solutions with other (neighbouring) local authorities;
- Some felt that NMS was not directly relevant of benefit/value to areas which comprised significant rural traffic networks; and
- Issues relating to the costs and resources required for implementing such systems.

Respondents were also asked to share their views on any technical issues affecting the implementation/performance of NMS systems, with 33% (10 organisations) commenting that a range of common problems have been identified including the following that will affect implementation/performance of a real-time NMS:

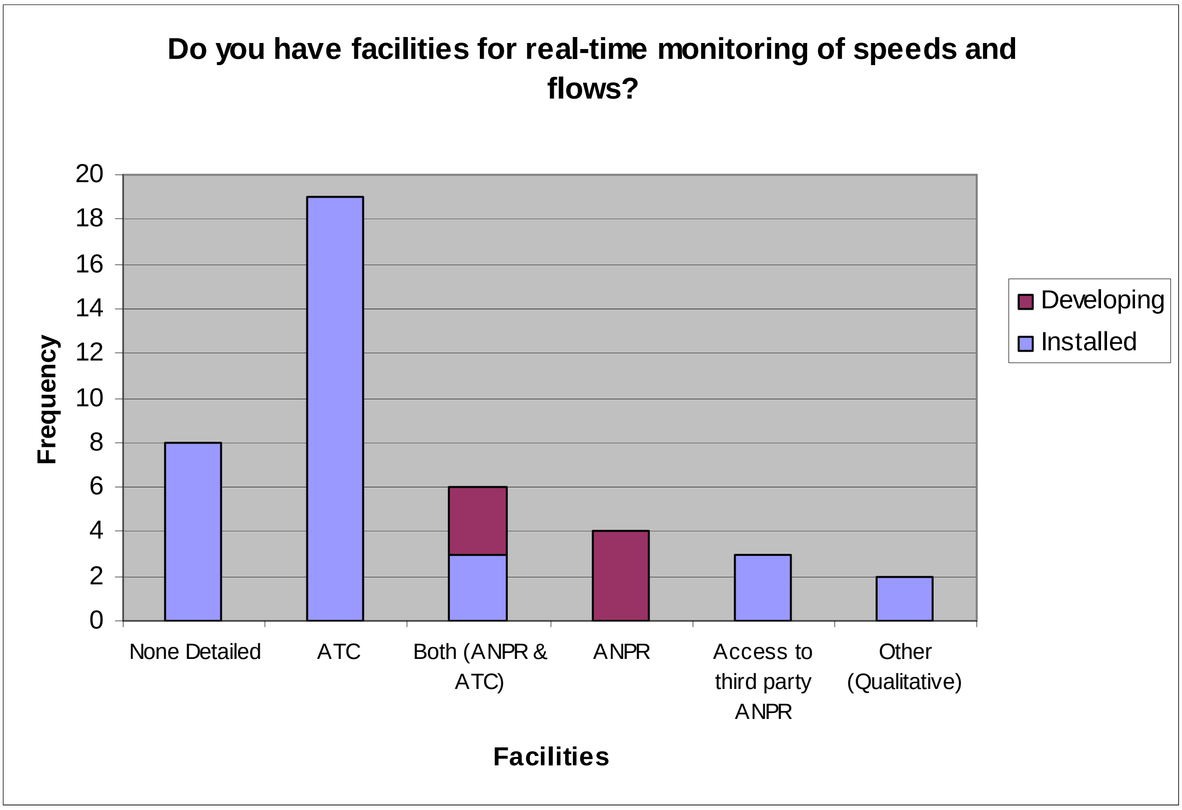
- Potential incompatibility of data sets made available from different sources;
- Communication and migration problems when dealing with UTMC protocols;
- Adapting existing systems to integrate new data sources;
- Differing standards;
- Inflexibility of current generation of Variable Message Signs (VMS);
- Ageing signals stock and built-in obsolescence,
- Level of resources required, such as staff and associated capital and on going revenue & maintenance costs; and
- The need for an interface to link Common Database to Network Management Systems.

Whilst it is understandable that a significant number of local authorities have not identified or addressed any technical issues (obviously related to the fact that most authorities are still in the early stages of developing and implementing NMS strategies), further review of the responses for local authorities that have highlighted and addressed technical issues provides valuable insight. The results revelead that a significant number of local authorities are anticipating issues with enhancing and interfacing existing systems and require a standard set of guidelines for how this can be achieved.

Over 20% of responses – reported that they had no current quantitative methods or mechanisms in place for measuring real time traffic behaviour. Of the local authorities responding positively on real-time monitoring, the vast majority are based on the use of automatic traffic counts (three organisations stated that they had enhanced these ATCs with ANPR systems). In addition, three organisations highlighted they had mechanisms in place for access to third party ANPR systems.

It is also apparent that, of the authorities currently developing mechanisms for real-time traffic monitoring, no organisations are basing their future monitoring system on automatic traffic count technologies alone. As a result, it seems that the implementation of new real-time traffic monitoring systems is likely to be based around ANPR systems (with these systems enhanced by additional ATC systems). It is worth noting that two of the organisations that do not have quantitative mechanisms for real time traffic monitoring have developed qualitative mechanisms in place. While one of these organisations has developed a relationship with the local police to obtain information regarding real-time traffic behaviour on an ad-hoc basis, the other has obtained access to traffic monitoring CCTV to receive real-time images.

Figure 2 Local Authority Responses on Facilities for Real-time Monitoring



Source: TRL, Co-ordinated Network Management Systems: Stakeholder Survey Analysis Report, CPR378, 102(387) HTRL, June 2008

Respondents were asked to comment on what issues would need to be addressed to enable a co-ordinated framework for congestion management to be developed to further improve management of the highway network. Examining the responses TRL found that a number of themes were clear including the following issues:

- *Decision Making Protocols*: The framework should provide a set of protocols for when, how and which network management strategies should be implemented;
- *Automation*: The framework should provide a mechanism for implementing an automated process (to ease the burden of overloaded traffic control centre staff);
- *Event Prioritisation*: The framework should provide a facility for event prioritisation to ensure that the network is optimised in the occasion of simultaneous events;
- *Standards / Compatibility Issues / Recommendations*: The framework should provide detailed recommendations and standards for the communications link and data share across systems;
- *Provision of RTTI to the travelling public*: any framework should provide protocols for dissemination of real time traffic information (RTTI) to the public (VMS, Website, Radio);
- *Cross Boundary Themes*; The framework should provide a methodology for how the cross boundary communications link and data share is provided; and
- *Links to Other Systems (i.e. streetworks):* The framework should include consideration of other systems.

The most common theme identified was the provision of RTTI to public: without informing the public of traffic conditions, it would be impossible to attempt to manage and influence the network. Of the remaining themes, the next most highlighted themes all correspond to aspects of research included within the CoMoCo project, covering the issues recognised within the responses centring around the key themes “Standards / Compatibility Issues / Recommendations” (with seven responses) and “Cross Boundary Links” (five responses) but also addressing issues such as “Decision Making Protocols” (four responses) and “Automation” (two responses). The CoMoCo project aims to provide a standard protocol for how this co-ordination can be provided addressing these issues highlighted. As part of the questionnaire, respondents were asked to share their views on those improvements and innovations that they would like to see in terms of the co-ordinated management of congestion. A wide variety of responses were given including those relating to the provision of real-time information and better use of information to inform incident management strategies. A selection of these comments are summarised in Table 1 below.

Table 1 Local Authority Feedback on Future Innovation to Solve Congestion (TRL Study)

Respondent	Comment
Borough of Poole	*'Real time information on anticipated journey times on major routes and advice on restraints and alternatives.'*
Leicester City Council	*'Shared use of live traffic flow data to inform Air Quality and Noise Monitoring, Modelling and Public Information.'*
North Tyneside Council	*'Better ability to react to emergency situations, less disruption to public transport.'*
North Somerset Council	*'The ability to accept information from different systems to provide a network wide view of all data on a real time basis. This will allow the traffic flows, unplanned event and works data to be viewed simultaneously.'*
Solihull Council	*'Ultimately an automatic system that notifies our systems which subsequently can respond automatically with some form of action/plan.'*
South Gloucestershire Council	*'Real time data provision / Active Traffic Management.'*
Southampton City Council	*'A system that provides you with "what if" scenarios and suggested alternative routes. It also needs to be able to be updated regularly with closures/banned turns are alterations.'*

Source: TRL, Co-ordinated Network Management Systems: Stakeholder Survey Analysis Report, CPR378, 102(387) HTRL, June 2008

The conclusions of this research that have a direct relevance on the STEP project include the following points:

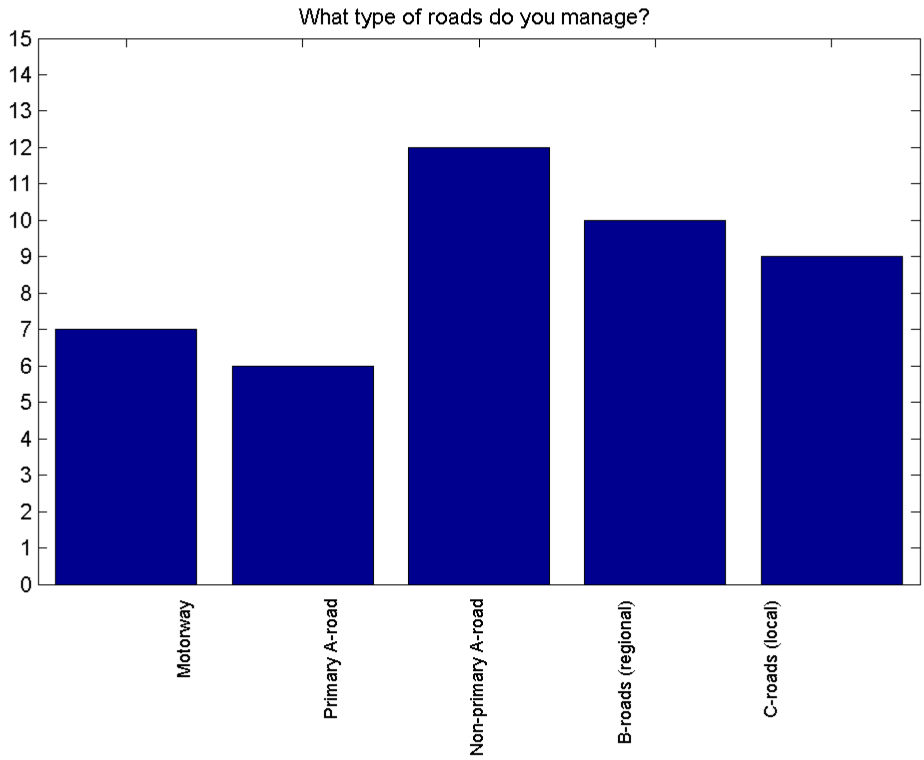
- There is a desire from authorities to see the development of decision making protocols in the development of systems, particularly focusing on providing a set of protocols for when, how and which network management strategies should be implemented;
- The development of systems should be automated to provide a way of reducing the burden on already overloaded traffic control centre staff;
- Authorities wanted to see the development of standards and compatibility Issues to be addressed with system frameworks providing detailed recommendations and standards for the communications link and data share across systems;
- Within metropolitan areas it is important to address cross boundary themes and provide a sound methodology for how the cross boundary communications link and data share is provided between neighbouring authorities and agencies; and
- It is important to establish links to other systems (i.e. streetworks) and consider the practicalities of doing this.

2 Results of Traffic Control Centre (TCC) Survey

2.1 TCC Management of Roads

The TCCs that were included in the survey programme manage a broad range of road types, so the conclusions presented in this report are not restricted to any one type of road. It should be noted that the number of TCCs that manage road types with uninterrupted flow (no interruption of the flow due to traffic lights etcetera) is very small based on the feedback we manage to obtain. However short-term prediction models on the other hand are most appropriate for this type of roads. Therefore, care should be taken when interpreting the results. On the other hand, the variety of types of roads provides a more generic overview of the experiences and requirements of different traffic operators.

Figure 3: TCC Response on Management of Roads



2.2 Understanding Traffic Control Centre (TCC) Tasks & Goals

Before focusing on the vision and experiences of TCCs on issues relating to short-term prediction, it is important to understand the main goals and tasks of the TCCs themselves, as this helps to understand how short-term traffic prediction can support the delivery of these objectives and also facilitate TCC daily operations. The questionnaire included a number of objectives/goals as summarized in Table 1 below and respondents were asked to rate the relative importance of these.

Table 2: Understanding TCC Key Objectives

	Level of Importance					
	Not Applicable	**Not Important**	**Slightly important**	**Important**	**Very Important**	**Critical**
Improve journey time reliability	**0**	**0**	**2**	**9**	**4**	**0**
Reduce road casualties and accidents	**4**	**3**	**2**	**1**	**3**	**2**
Reduce disruption caused by major incidents	**0**	**0**	**1**	**8**	**5**	**1**
Provide alternative route advice to minimise the effect of congestion	**4**	**1**	**5**	**1**	**3**	**1**
Minimise delays due to roadworks	**0**	**1**	**6**	**4**	**4**	**0**
Influence road users' decisions before they set out on a journeys	**0**	**3**	**1**	**7**	**3**	**1**
Keeping the ITS Infrastructure Operational	**1**	**4**	**0**	**3**	**3**	**4**

The most popular category in terms of goals and objectives is to reduce the level of disruption caused by major incidents, with more than 60% of TCCs questioned rating this as important and a further 33% considering it an even higher priority. Examining the views of TCC's on the importance of journey time reliability as a key objective, more than 50% of respondents commented that it was an important objective with a further third highlighting that it was very important to their operational requirements.

Perhaps surprisingly, the issues of congestion and providing advice on alternative routes did not score highly among respondents, with 25% of TCCs considering this objective as not being applicable to them, and a further 33% considering it as only slightly important to them. Of those who did consider it important as a priority/objective, only 32% felt that it was important or higher.

Another popular objective amongst TCCs is the need to influence road users' decisions before they set off on their journeys. Nearly 50% felt that this was important with a further 32% considering it to be even more important as an objective. Similarly, keeping ITS infrastructure operational is a popular objective amongst TCC respondents with 25% indicating that it is critical to them and a further 50% said that it was important/very important. Just over 25% felt that it wasn't a priority objective for them.

Road casualty reduction is not considered as important as other objectives, with over 25% of respondents commenting that it isn't applicable to their operation/business, with a further 33% stating that it was either not important or of only slight importance to them.

From the list of respondents just under 50% were from TCCs managing motorways and a similar figure also manage inter-urban Trunk Roads.

In terms of views about the potential of short-term prediction to address problems of congestion, 80% expressed a positive response on this. More than 60% of TCCs already have used some form of traffic prediction already, with a fairly even set of responses concerning the use of predictions across the following categories:-

- Understanding general picture of congestion delay per month;
- Providing a general picture of congestion hours; and
- Evaluation of management scenarios.

The overall attitude of TCC staff towards the use of short-term prediction is quite ambivalent, with 60% revealing neither a positive or negative response on the topic of short-term prediction in general.

As can be seen in the Table 1, the TCCs agree on the high importance of improved journey time reliability and reduced disruption in the case of major incidents. The latter task is mainly considered important by TCCs that manage motorways. The other TCCs consider it at most important. Also minimised delays due to road works are considered important, and again there is a clear distinction between TCCs that manage motorways and the other TCCs. For TCCs that manage motorways, minimising delays due to road works is deemed important to very important, while for the other TCCs it is at most considered important. In general, this can be summarized as increased interest of TCCs, mainly those that manage motorways, for a reduction of the travel time experienced by vehicles, and maintaining the throughput in case of abnormal situations.

So this clearly relates to the efficiency of the system that needs to be preserved during irregular conditions. Influencing road users' decisions before they set out on a journey is also deemed important by most TCCs, while this is less the case for providing alternative route advice to minimise the effect of congestion. This can be interpreted as a focus on the operational level only in irregular situations. In regular situations, they want to have an influence on the tactical level (e.g. influencing road users' decisions before they set out on a journey), not on the operational level (e.g. providing alternative route options in regular congested situations). Concerning reducing road casualties and accidents, there is again a clear distinction between TCCs that manage motorways and the other TCCs. The latter group considers it at most slightly important, while the former group considers it slightly important to critical. On the role of keeping the ITS infrastructure there was no overall agreement amongst respondents, as it was considered as being critical by some, and not important by others. Other tasks that were identified by some TCCS are:

- Providing extra traffic information for road users in case of a crisis;
- Reducing disruptions caused by major events or weather circumstances;
- Maintaining safety, livability & pollution standards; and
- Acting as a centralized contact point for all signal and ITS queries.

During January 2012 a number of Traffic Control Centre representatives from the UK UTMC CDMF (Common Database Management Facility) User Group were also consulted on the issues relating to short term prediction through a face-to-face discussion. In terms of key objectives a number of goals were raised by representatives the primary one being to keep traffic flowing (the “expeditious movement of traffic”), and also ‘preserving’ or improving journey times. There was a view amongst CDMF representatives that achieving CO2 emission reduction wasn’t necessarily a primary objective, but would be ‘nice-to-have’ if it could be achieved.

In term of the key objectives for the development of a short term prediction system there was a general consensus that getting up-to-date info to the public is an important objective, particularly to support the goal of keeping traffic flowing. However, a number of other key themes areas were also raised including:

- Fault Management: responding to and managing incidents that occur on the network;
- Maintaining traffic flow conditions; and
- Providing information to the traveling public.

There was some agreement that the overall goal is not necessarily to reduce journey times, but to ensure *reliable* journey times is a priority for TCCs.

2.2.1 Objectives of TCCs in Other EU Cities

Information obtained on the objectives of other Traffic Control Centres (TCCs) in Europe is presented in Table 3 below.

Table 3 Summary of TCC Objectives in Europe

Location-	Organisation	Objectives
Berlin, Germany	Berlin Traffic Management Centre (VMZ Berlin Betreibergesellschaft	• To provide information: monitoring and improving the mobility by providing free of charge traffic information to the State of Berlin and the general public.
North Rhine-Westphalia	Ministry of Transport, Energy and Spatial Planning of Nordrhein-Westfalen.	• To provide information: Informing the road users fast and efficiently about the current and future traffic states. • Improving throughput of traffic by coordinating traffic with active traffic management; • Avoiding network overload by traffic flow regulation at junctions and interchanges, as well as temporary use of the hard shoulder at peak periods; • Increase safety and decrease the number of accidents by reducing critical traffic situations; and • Using most suitable alternatives, often recommending alternative routes and inform
Duseldorf,Gemany	Dusseldorf Department for Traffic Management	• To provide information including estimating and predicting future traffic states (including travel times). • To control and management of the traffic system.
London - UK	Transport for London (TfL) Program supported by Transport for London and the Directorate of Traffic Management.	• Information provision: Estimating and predicting future traffic states (including travel times). • Control and management of the traffic system.
Turin,Italy	5T 5T manages the Traffic Operation Centre in the metropolitan area of Torino, integrated with the Public Transport real-team Monitoring System (AVM).	To achieve a range of traffic management objectives including: • To improve the traffic fluidity in the urban area and reduce congestions; • To improve real time information services for the mobility; • To improve quality and performance of monitoring services for the public transport fleets; • To reduce air pollution caused by traffic.
Naples / Italy	Work supported by The European Commission Information Society Technologies (IST) Program	• To provide information: Estimating and predicting future traffic states (including travel times). • To detect incidents
Helsinki, Finland	VTT Technical Research Centre of Finland funded by Ministry of Transport and Communications andFinnish Road Administration.	• To provide information: Predicting future traffic flows based on current traffic flows, weather and road conditions.

Source: STEP Project Work Package 1 Report, State-of-the-Art: Review of Best Practice (Nov 2011)

2.3 Available Traffic Management Control Measures to TCCs

In this section, we aim to inquire some information on the types of traffic control measures that are used in traffic management plans. This will provide a useful baseline of current functions that can help assess how valuable traffic prediction tools are likely to be. We distinguish between 6 categories of control measures:

- General traffic information;
- Traffic flow measures;
- Route guidance;
- Traffic control measures;
- Incident management; and
- Infrastructure management.

For each measure in a specific category, we ask for the importance of that measure in the daily operations to influence traffic operations. Table 4 below summarises the different traffic management control measures that are used by the TCCs that were surveyed.

Table 4: TCC Views on Availble Traffic Control Measures

Traffic Management Approach	Specific Measure	Level of Importance					
		Not applicable	Not Important	Slightly Important	Important	Very Important	Critical
General traffic information provision	Road traffic conditions (speeds, queues)	0	0	3	6	3	3
	Travel times	1	0	2	8	3	1
	Multimodal travel information (e.g. P+R)	3	3	5	3	1	0
Traffic flow measures	Variable speed limits	8	3	1	1	1	1
	Lane management	6	4	1	2	1	1
	Overtaking prohibition	8	5	1	1	0	0
	Fog warning	8	3	4	0	0	0
Route guidance	VMS route information	2	1	3	4	4	1
	Traffic restrictions	1	2	6	4	2	0
	Diversions	5	2	2	4	1	1
	Toll info	10	3	1	0	0	1
Traffic control measures	Ramp metering	9	4	0	0	2	0
	Access management (e.g. trucks, HOV, HOT,…)	9	4	1	0	0	1
Incident management	Incident detection and verification	0	1	2	7	1	4
	Organizing incident response	2	2	3	4	1	3

	Informing incident response teams	**7**	**3**	**0**	**0**	**3**	**2**
Infrastructure management	Tunnel surveillance	**7**	**3**	**0**	**2**	**3**	**0**
	Bridge openings	**8**	**3**	**1**	**3**	**0**	**0**
	Tidal flow / flexible infrastructure	**11**	**3**	**0**	**0**	**0**	**1**

In relation to the traffic management control measures used in daily operation, the user survey revealed that approximately 80% of respondents use travel times as part of their operations and consider this as important. Only 7% stated that this measure does not apply to them. Similarly, multi-modal travel information is also a popular control measures with the TCCs with 60% stating that they felt it was an important measure at their disposal.

2.4 General Traffic Information

Providing general traffic information is considered as one of the most important set of measures to influence traffic operations. General traffic information provision (provision of information on traffic speeds/queues) is seen as important by 40% of TCCs, with a further 40% also considering the measure to be even more significant or critical to their daily operation. Especially information on the traffic conditions and travel times is considered an important tool that is also available in most TCCs. Apart from the measures listed in the questionnaire, a few TCCs also mentioned the provision of information on incidents, road works and diversions as an important measure. As to the relation between these measures and the goals and tasks of the TCCs, it is not clear to which aim these measures are directed. Given the high importance that is given both to these measures and to maintaining the efficiency of the system, it is possible that TCCs hope to influence traffic conditions by general traffic information provision. It is also possible that providing information itself is seen as one of the main tasks of the TCCs.

2.5 Traffic Flow Measures

The number of TCCs that make best use of traffic flow measures is limited and those that t can make use of such measures are mainly those TCCs that manage motorways. Among these TCCs there is not much agreement on the importance of these measures in their daily operations. The traffic flow measures can be seen as partially related to safety, and partially related to increasing the throughput of the system. While both are considered important, especially by the TCCs that manage motorways, there is no consensus among them regarding the importance of these measures. This can indicate that some of them believe that these measures have an important effect, while others do not believe this.

In terms of traffic flow measures (including variable speed limits), this is considered a unpopular measure by respondents with nearly 50% commenting that it doesn't apply to their daily operation and a further 20% stating that they considered it not to be an important measure. Only 27% of TCCs consider this be important as part of their daily activities. A similar pattern of response was also evident with the response to the use of traffic lane management, with over 65% considering it not applicable to their operation and only 30% considering it an important control measure.

Overtaking prohibitive measures are not considered a priority for TCCs with a significant number of respondents (80%) indicating that this has little relevance to their operation and only 13% thinking that this type of measure is important. With fog warning measures, there was very little consideration amongst the TCCs of this measure being important as part of their daily activities. Only 7% considered this intervention to be important, with the majority of TCC's (66%) stating that it was not important or not relevant to their business.

2.6 Route Guidance

With respect to use of route guidance as a traffic control measure, the most popular response from TCCs concerned Variable Message Signing (VMS),with nearly 70% considering it an important traffic management measure as part of their operational activities, whilst half of those who supported the use of this measure commented that it was either very important or critical to the operational tasks. The second most popular response from TCCs was for traffic restrictions with the survey revealing that 50% of TCCs consider this to be an important or very important part of their operational activities. Nonetheless, there were still 20% of respondents who stated that this measure was either unimportant to them or not applicable as part of their remit. Route diversions and guidance were considered quite popular with the TCCs with nearly 50% of them viewing these measures as important or a higher priority, As with the use of traffic restrictions, 20% of respondents still considered it either unimportant or not applicable as part of their operational activities.

Other route guidance measures such as diversions or toll info are less frequently available, but when available, they can play an important role (especially diversions). However, the provision of toll information was considered the least popular category of route guidance measures, with the majority of respondents (67%) stating that it was not applicable to their daily operation. There is no real difference here between TCCs that manage motorways and the others.

2.7 Traffic Control Measures

Traffic control measures are not available to most TCCs, and even when available, there is no consensus on the importance of these tools. Given the importance attributed to improved journey time reliability, and in general the efficiency of the system in irregular situations, this is a remarkable finding. A possible explanation is that some respondents filled in 'Not important', while they meant 'Not applicable'. Another possible explanation is that some TCCs are not aware of the advantages of traffic control measures, because the algorithms that steer these measures and that determine the successful application of these measures are not well known.

With traffic control measures and the aims of all the different measures presented, the survey results revealed very little support for these, with only 20% of TCC respondents stating that measures such as ramp metering were important. In the case of access to access management measures (for example, tunnels, High Occupancy Vehicle (HOV) lanes) only 7% of TCCs consider these as important interventions. In both cases, more than 50% of TCCs consider these types of measures as being not applicable to their operation.

2.8 Incident Management

Incident management is clearly considered very important in daily operations, especially the detection of incidents and the organization of the incident response. This is in line with the high importance that is given to the task of reducing disruptions caused by major incidents. The TCCs were not asked about incident-related traffic management, but given the importance given to reducing disruptions, it is expected that incident-related traffic management is also considered important. This would be an interesting path for short-term prediction models: they can play a role in the prediction of the consequences of incidents, possibly with various scenarios.

Incident management was considered by the TCCs to be a popular traffic control measure, with use of incident detection and verification securing considerable support from TCCs, with 80% of respondents committed to this as an important measure, with over 30% viewing it as a higher priority, in terms of either very important or critical as a daily operational measure.

Dealing with incident response was also seen as a popular measure amongst TCC, with over 50% considering it to be important as a daily activity, with half of these respondents commenting that it was very important or critical to their operational activities. Closely linked to this is the provision of information to incident response teams, which saw over 30% of TCCs commenting that this was very important or critical to their activities. However, there were a considerable amount of negative views on this, with two-thirds of respondents stating that this measure was either unimportant or not applicable to them, and so a wide range of views is evident on this particular measure.

2.9 Infrastructure Management

Within the category of infrastructure management, the survey revealed little support for measures such as tunnel surveillance and bridge openings, as in both cases 50% of TCCs indicated that such measures aren't applicable as part of the their daily operational tasks. Therefore not many TCCs make use of corporate infrastructure management measures. There is also no agreement on the importance of these measures among TCCs that do dispose of them. Indeed, just over 25%of respondents commented that bridge openings were either important or very important with no-one revealing that it is critical as part of their business.

There was a more positive response from TCCs on the topic of tunnel surveillance, which revealed that 35% of TCCs saw this as an important measure or even higher priority within their daily operational work. Responses on the topic of tidal flow/flexible showed a wide variation of views, with two-thirds of TCCs considering it not applicable to them and a further 20% that it wasn't an important part of their operational activities. However, two respondents did comment that it was either very important or even critical to them as an option for traffic control and management. Other important measures that were reported by the TCCs are rush hour lanes, and setting traffic signals by area traffic control.

2.10 Conclusions

From the responses to the questionnaire, it can be concluded that the TCCs we surveyed are mainly concerned about the efficiency of any system (i.e. the throughput of the road network) that they manage, mostly in irregular situations. The most important measures that they dispose of during their daily operations to influence traffic operations generally relate to providing information and also concentrating on incident management.

It is evident that not too many TCCs incorporate measures that actively aim at improving the throughput of traffic, facilitated through traffic control measures, and in this context it is unclear whether they consider these measures important. These findings can already give an indication towards possible areas of application of short-term prediction, since providing information is considered important, short-term prediction can help providing more accurate information (e.g. travel times). Furthermore, concern about irregular situations also indicates a potential application area for short-term prediction models.

Prediction models are most valuable in irregular situations, but they also experience most difficulties in such situations, because of the uncertainty on the irregularities (e.g. incident duration, severity) and uncertainty on the drivers' response (i.e. change in demand and/or routing). In order to deal with these difficulties, predictors that can evaluate different scenarios can generally be expected to be the most useful for TCCs.

3 Traffic Control Centres and Short-Term Prediction

3.1 General Attitude Towards Short-Term Prediction

As part of our research we wanted to understand the views of traffic control operators on short-term traffic prediction, independent of their experience with it. Such an understanding is important, since it can have a large impact on the acceptance by the traffic operators, and thus on its subsequent success.

Figure 4 TCC Attitudes towards Short-Term Prediction

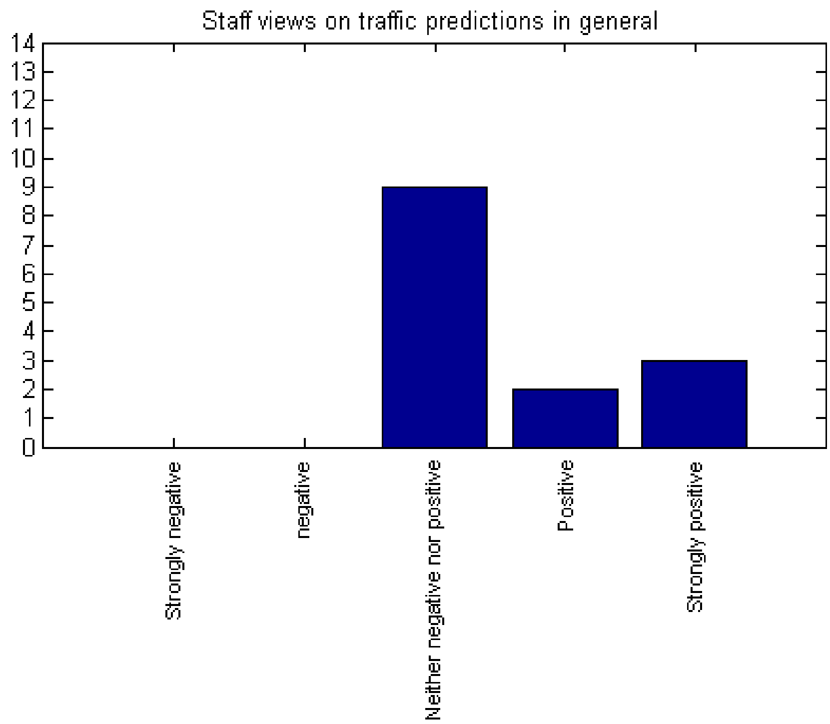
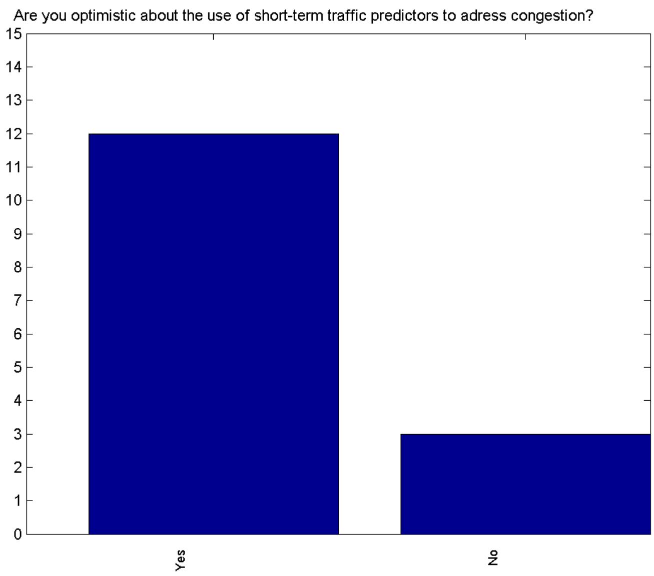


Figure 5 Views of TCCs on the Use of Short Term Predictors to Address Congestion



Figures 4 and 5 above indicate that, traffic operators are generally positive about traffic prediction. The primary question is whether this attitude is based on realistic expectations, or whether it is based on rather naïve expectations. In the latter case, developers of short-term prediction models should put effort in providing realistic expectations towards their product, to ensure that a naively positive attitude does not turn into a negative attitude due to disappointing experiences.

The TCCs also indicated that the staff in many cases is unaware of the possibilities of traffic prediction, and that they should be taught about this. Furthermore, the system should be ripe with an easy interface before implementation in the operator room.

The UK CDMF User Group were asked how they felt the development of a short term prediction system may help their traffic control/management capability. There was some genuine concern expressed about potential issues of keeping any given model up-to-date. At the same time some of the users commented that using historical data could prove valuable in helping to decide which specific traffic management strategies to implement to address particular congestion issues.

There was some concern that the introduction of yet another tool would potentially take away valuable resource that is currently employed to make sure SCOOT functions properly, particularly given there are currently insufficient resources available to keep SCOOT working at an adequate level. Overall, there was a concern about potentially introducing another high maintenance system when resources are already stretched to capacity.

3.2 User Requirements For Short-term Prediction - Key Factors

The TCCs were asked about the key factors that influence the choice of whether or not to use short-term traffic predictors in their daily operations.

Figure 6 TCC Views on the Key Factors Required for Short Term Prediction

	Response				
	Strongly Disagree	**Disagree**	**Neither Agree of Disagree**	**Agree**	**Strongly Agree**
European standards of how to successfully integrate traffic predictions in TCCs	**0**	**6**	**6**	**2**	**0**
Evidence of successful application by other TCCs and real-life trials	**0**	**1**	**0**	**11**	**0**
The accuracy of the predictions	**0**	**0**	**0**	**6**	**8**
Acceptance of new systems by the TCC workforce	**0**	**3**	**6**	**3**	**2**
Cost of setting up	**0**	**0**	**3**	**10**	**1**

Focusing on the key factors that influence choice of whether to use short term prediction in their daily operations, a total of 40% of respondents stated that they disagreed about the need/importance of following European standards of how to integrate traffic predictions within TCCs. A further 47% did not feel able to respond positively o this, neither agreeing nor disagreeing with this and only13% confirming that it would influence their choice. Therefore, the presence of European standards is not a priority for most TCCs.

Clearly, the accuracy of the predictions is seen as most crucial, with the survey revealing that 47% of TCCs stated that this would significantly influence their choice, and even (53%) more strongly agreed with this approach.

Of course, the cost of a traffic prediction system is also seen as a key issue for TCCs when it comes to establish a short-short term prediction system. Nearly three quarters (73%) of respondents stated that this would affect their choice of short-term traffic prediction system, with a further 7% strongly agreeing with this.

The acceptance of any new system by the TCC staff is also seen as important, but only plays a role when the requirements on the level of accuracy are met. In this case, the acceptance of new prediction systems by TCC staff revealed a lower level of positive response with only 40% of TCCs either agreeing/strongly agreeing that this would influence their chose of system, whilst a further 40% could neither agree or disagree on this. The interface can play an important role here. Of course, the accuracy itself can also partially result in a positive attitude of the TCC workforce.

Evidence of successful application of real-time prediction is also considered a key element, as it can be an indicator for the accuracy of the predictions from these tools, and evidence of successful application by other TCCs as well as real-life trials, revealed that 8% of them agreed with this and a further 11% strongly agreed. This probably relates to issue of ensuring that TCCs have a good understanding and appreciation of the benefits and operation of such systems before proceeding.

The discussion amongst the UK CDMF representatives considered that the following would be influential in terms of establishing a system for short-term prediction within TCCs:

- Low up-front cost and ease of set-up, as there is simply not enough available resources to accommodate complex initial configurations of such systems. The size of the area being monitored also has a bearing on this;
- The importance of having low-cost licences as well as low cost maintenance (in the form of time from personnel, and not requiring expensive external resource to maintain); and
- Reference to wider savings was also made in terms of the benefits of such a system and the importance of conducting adequate cost/benefit analysis on the implementation of systems, particularly looking at the time savings that may result.

3.3 Details About User Requirements

The TCCs were asked a series of questions on aspects relating to the user interface with short-term prediction systems to gauge views on what would work best in a practical setting. Overall, responses to the issue of user interface revealed that across most of the aspects of the question no answer was provided, most likely due to a lack of detailed knowledge/understanding of traffic prediction approaches overall, as well as specific issues relating to user interfaces themselves.

- Only 13% commented that their user interface is actually integrated with their existing traffic management system;
- A similar response was given by those TCCs who use spreadsheets to see the predictions they have; and
- A total of20% of TCCs confirmed that their traffic prediction tools have their own separate visualization approach/structure.

In terms of response to the experience of TCCs with their existing traffic prediction systems, whilst the majority of TCCs didn't feel able to respond (due to their lack of knowledge/ experience with such systems, of those that did respond:-

- A total of 20% of TCCs stated that they were dissatisfied with the overall accuracy of their system;
- 20% expressed an indifferent attitude about the cost of systems; and
- 20% are dissatisfied with the installation of their system.

The TCCs were asked if they would have installed the same system, had they the opportunity to adopt a fresh approach. The majority felt unable to respond to this, however a total of 20% stated that they would have installed the same system, and only just under 8% said that they would start afresh.

When linking predictors to traffic management scenario generation, for predictions without scenario generation – 40% of TCCs feel that this is a useful option, with a further 45% commenting that this approach would in fact be very useful or even essential (13%).

For the option of predictors in parallel, evaluating different traffic management scenarios, this resulted in a positive response from TCCs, with two-thirds indicating that this approach would be considered very positive, and 20% of TCCS commenting that it would in fact be essential.

3.4 *Visualisation of Short Term Prediction Outputs*

The TCCs were asked for their views on the presentation of prediction outputs and the best options for this.

Table 5 Views on Visualisation of Prediction Outputs

	Response				
	Strongly Disagree	**Disagree**	**Neither Agree of Disagree**	**Agree**	**Strongly Agree**
Through colour-coded quantities in a tabular list	**1**	**0**	**10**	**3**	**0**
Through colour-coded links overlaid on a map view	**0**	**0**	**3**	**8**	**3**
Through colour-codes and figures on a dialog for the status of a single selected link or section	**0**	**3**	**9**	**2**	**0**
Through alerts or alarms for abnormal conditions	**0**	**1**	**3**	**6**	**4**

The options presented included the use of colour coded information, with the most popular option amongst TCCs being the use of colour coded links overlaid with a map view. This option was supported by 80% of respondents, with 20% expressing a strong desire to see this used support prediction outputs. .

The option of presenting information through use of alerts or alarms for abnormal conditions was also popular amongst TCCs, with 40% of respondents stating that they agreed with this option, and a further 26% revealing a strong preference for this approach. In addition, using a graph showing historical, current, and predicted conditions would be useful. So the interface should be more in a visual form than in a tabular form.

The amount of manual intervention should be kept to a minimum, and automation should be provided to help the operators in their tasks. Some TCCs report that the visualisation needs are dependent on many factors (user, time horizon), and wonder whether it is relevant at this stage to specify them. A user survey with all operators would be useful to identify each of their needs in this instance.

The was some wide debate amongst the CDMF User Group with several attendees suggesting using coloured links on a GIS map, where link colouring shows expected conditions in the desired horizon. That said, the problems of showing this at the same time as existing conditions was also noted. Some attendees recommended the use of graphs and charts, which would enable both historical and actual data to be presented, with predicted deviations from the norm also able to be highlighted.

Some representatives suggested the use of ‘dashboard’, providing an ‘at-a-glance’ view of potential issues and also pop-up alerts to operators to ensure that notifications are easily observed. There was also support for the use of text/email alerts, which would be particularly useful for those operators who have staff who work out-of-hours.

3.4.1 Visualisation in Other EU Cities:

A summary of the visualisation used by other TCCs in Europe is presented in Table 5 below.

Table 6 Summary of Interventions and Control Measures used by Other TCCs in Europe

Location-	Traffic Management Operator	Interventions
Berlin, Germany	Berlin Traffic Management Centre (VMZ Berlin Betreibergesellschaft	• All messages that are provided to public, based on either the information received or the predictions made by the system, are available to the editor who is supported by an automatic system to ensure that all the outgoing messages are consistent. The users can get varied information from the website (www.vmzberlin.de) including a summary of congestion problems, current parking situation, traffic forecasts, or traffic conditions via cameras. • The public can also use an inter-modal dynamic route finder to plan journeys based on up-to-the-minute traffic information and different transport modes. Dynamic roadside information panels are used to inform the drivers of the traffic conditions ahead. o Every half an hour Radio Berlin 88.8 broadcasts the current traffic situation directly from the TMC. o The project focuses on providing information and not on developing control strategies, therefore, only a prediction (based on current state) is made.
North Rhine-Westphalia	Work initiated by the Ministry of Transport, Energy and Spatial Planning of Nordrhein-Westfalen. The development and tests were done in the framework of a research project at the University Duisburg-Essen	• A public website (www.autobahn.nrw.de) is designed to offer traffic information to the general public. It offers a map of the motorways of the region of North Rhine-Westphalia. Its different parts are colored according to their specific traffic state: o Light green for free flow o Dark green for dense flow o Yellow for stop and go traffic o Red for a traffic jam • The user of the website can select whether he wants to see: o The current traffic state o 30 minute forecast o 60 minute forecast
Duseldorf,Gemany	Dusseldorf Department for Traffic Management	• There is currently nothing available to the public yet, as the whole system is still being tested. The existing website does not provide forecast information yet (http://www.duesseldorf.de/vid/).
London - UK	Transport for London (TfL) Program supported by Transport for London and the Directorate of Traffic Management.	• There is nothing on-line yet, as the different software are now being tested.
Naples / Italy	Work supported by The European Commission Information Society Technologies (IST) Program	• During the trials, no information was served to the users of the road. No information was found regarding the current procedure.

Source: STEP Project Work Package 1 Report, State-of-the-Art: Review of Best Practice (Nov 2011)

3.5 Scenario Generation

Predictors can be linked to traffic management scenario generation, so that the system can predict the traffic conditions that will arise with and without traffic management intervention. The TCCs were asked about the importance of this aspect of predictors.

Table 7: TCC Views on Scenario Generation

	Response				
	Not useful	**Somewhat useful**	**Useful**	**Very useful**	**Essential**
Predictors without scenario generation – predicting with the assumption that no traffic management action is taken.	0	1	6	6	2
Predictors in parallel evaluating different traffic management scenarios	0	0	3	9	3

Predictors with the ability for scenario generation are considered most useful. Nevertheless, also predictors without scenario generation are seen as useful, so it is not seen as an essential requirement. This can be seen as corresponding with the fact that providing general traffic information is seen as an important issue. As such, the development of predictors without scenario generation is already an important first step in the process. The development of predictors that can evaluate multiple scenarios is also considered an important secondary stage designed to meet all user needs.

In terms of the utility of modelling traffic management interventions, during discussions with UK CDMF TCC representatives, there was general agreement that this would be useful to help assist in determining which interventions can be used, although the difficulties of doing this in an urban environment were also acknowledged too. There was some debate on whether existing operator knowledge provided an adequate proxy for this, as once a scenario begins to unfold, operators generally work from a set of responses that have previously succeeded. Where a response has previously failed, or it is recognised that it could be improved, that response will usually be modified to attempt to address the issue.

3.5.1 Scenario Generation in Other EU Cities

Details of scenario generation used by other TCCs across Europe is presented in Table 8 below.

Table 8 Information on Scenario Generation for Other TCCs in Europe

Location-	Traffic Management Operator	Scenario Generation
Berlin, Germany	Berlin Traffic Management Centre (VMZ Berlin Betreibergesellschaft	• The focus is on providing information and not on developing control strategies, and therefore only a single prediction based on current state is made.
North Rhine-Westphalia	Work initiated by the Ministry of Transport, Energy and Spatial Planning of Nordrhein-Westfalen.	• As above.
Dusseldorf,	Dusseldorf Department for	• The operator can simulate in real-time the effects of an event,

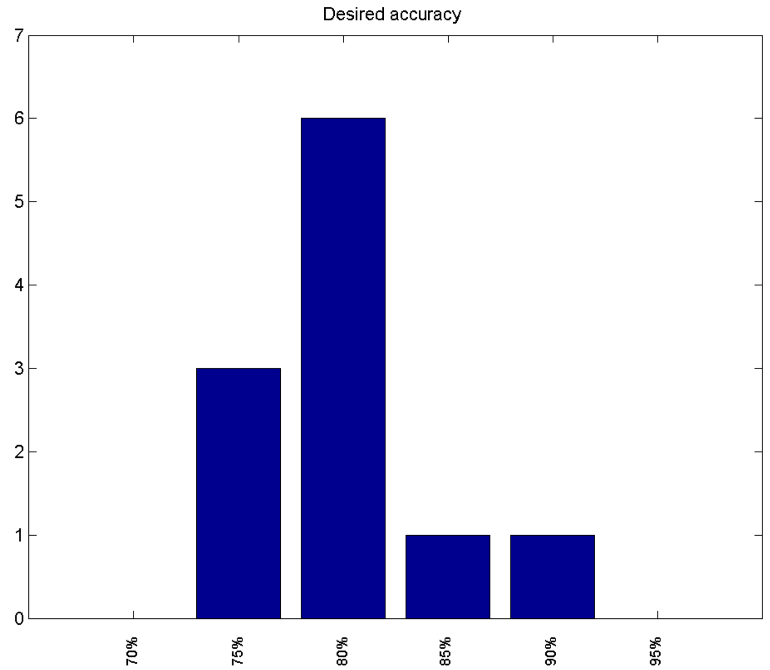
Germany	Traffic Management	accidental or generated as a control measure, by clicking into the link and inserting the type of event (already predefined), and choosing day and time of the beginning and the end of this event.
London - UK	Transport for London (TfL) Program supported by Transport for London and the Directorate of Traffic Management.	• Scenarios are designed based on specific events, demand patterns, or signal plans and are currently manually selected. This includes tests undertaken where TCCs design different scenarios by proposing different combinations of signal settings/plans. • For that they employ pre-defined signal plans using the adaptive traffic control system SCOOT. SCOOT optimizes the performance of the network, in almost real-time, by changing traffic signal times according to the traffic conditions.
Naples / Italy	Work supported by The European Commission Information Society Technologies (IST) Program	• Project focuses on providing information and not on developing control strategies. Hence, only a single prediction (based on current state) is made.
Helsinki, Finland	VTT Technical Research Centre of Finland funded by Ministry of Transport and Communications and Finnish Road Administration.	• Project focuses on providing information and not on developing control strategies. Hence, only a single prediction (based on current state) is made.

Source: STEP Project Work Package 1 Report, State-of-the-Art: Review of Best Practice (Nov 2011)

3.6 Desired Horizon and Accuracy

The respondents were asked about the desired horizon and minimum accuracy of the predictor, and these both for the travel times and the speeds at measurement sites. For the travel times, a desired horizon from 30 till 90 minutes was generally considered reasonable. For one respondent, a horizon between 1 and 48 hours was desired. For the speeds, the same horizon was desired.

Figure 7 TCC Views on the Desired Accuracy from Short Term Predictions



Regarding the accuracy, both for the travel times and the speeds an accuracy of around 80 percent was desired. While the given answers were all quantitative, they mainly indicate an order of magnitude. The fact that no overly high accuracies (more than 95%) were expected indicates that the TCCs do not have unrealistic expectations. On the other hand, an 80 percent accuracy on the travel times is rather high when it is interpreted as a maximum error of 20 percent on the travel times. It should be noted that in general, no explanation is provided on the meaning of this responded required accuracy. Therefore these responses can be seen as being more qualitative than quantitative. The responses can therefore be interpreted as a first, possibly premature opinion that should be reviewed after gaining more experience with short-term prediction.

Other outputs that were desired are flows and delays, and location of traffic jams. It was also noted that the desired horizon is depending on both the user and the specific situation. For controllers, a short horizon is required, while for engineers a long horizon is needed. In urban networks, traffic conditions. In case of incidents or peak periods, a 1 hour look-ahead would be needed, while for urban networks, 15-30 minutes is likely to be a good horizon (since everything changes so fast).

The majority of representatives at the UK CDMF User Group commented that having predictions for an hour ahead would be the best option. There was some concern about local authority control rooms not being manned over a 24-hour period, which means they any system may be reliant on shift patterns such that abnormal circumstances can be recognised prior to end of manned periods.

3.7 Cost of Short Term Prediction Systems

The TCCs were asked what would be an acceptable budget for implementing a system with short-term traffic prediction capability.

Table 9: TCC Views on Cost of Short Term Prediction

Cost Of System	**Response**				
	Strongly Disagree	Disagree	Neither Agree of Disagree	Agree	Strongly Agree
€10,000 per year	1	1	3	2	8
€20,000 per year	1	0	3	6	5
€50,000 per year	2	1	5	5	2
€100,000 per year	6	3	4	2	0
€200,000 per year	9	3	2	1	0
€500,000 per year	11	1	3	0	0

In terms of costs of introducing short-term prediction systems, arrange of cost (annual costs) options were presented to the TCCs in terms of what they would consider to be an acceptable budget for implementing such a system. As one might expect, a significant proportion of respondents supported the lower cost options with 60% and 67% agreeing to budget figures for £10,000 and £20,000 per year, respectively. When presented with the option of £50,000 per year, the level of positive response fell significantly with only 49% of TCCs agreeing that this budget level was acceptable.

Low levels of acceptance were evident when it came to understanding the level of acceptance of budgets ranging from £100,000, £200,000 or £500,000 – only 7% of TCCs commented that this was acceptable. These results indicate that the upper limit for most

TCCS ranges between 50.000 and 100.000 euro. Many TCCs stress that an acceptable budget depends on the benefits of the system and therefore more detailed cost-benefit analysis work is needed to answer this question. Furthermore, a distinction should be made between one-off costs (implementation/ installation), and yearly costs (licenses, maintenance).

Within the CDMF TCC engagement there was an acknowledgement that as local authorities, budgets are generally universally tight, and therefore the view was that relatively small budgets would be available and so any system implementation/maintenance costs would need to take account of this. The cost/benefit argument above is also relevant and would be central to any business case for implementation.

3.8 Experiences with Short-Term Prediction

A total number of 4 out of 15 TCCs already has some experience with short-term prediction, although one of these four only has off-line experience with them. We were not able to deduce any useful information from the questions on the use of the predictions, and on the set-up of the user interface. A more interesting question asked about their satisfaction with the short-term prediction model they used.

Table 10: TCC Experience with Short-Term Prediction

	Response				
	Strongly dis-satisfied	**Dissatisfied**	**Indifferent**	**Satisfied**	**Strongly satisfied**
Overall Accuracy	0	2	2	0	0
Cost of Implications	0	0	4	0	0
Maintenance issues	1	0	3	0	0
Installation Issues	0	2	2	0	0

All 4 TCCs were at least partially dissatisfied with the current system. The TCC that tested the traffic prediction tool off-line was dissatisfied with the accuracy, and decided to no longer continue with traffic prediction. One of the problems was that the prediction tool did not do a good job in predicting the consequences of an incident, which is seen as the most useful application.

Two TCCs were still developing their system and testing it, and therefore they cannot yet properly evaluate the system. A fourth TCC was also dissatisfied with the accuracy, and mainly the labour-intensiveness to make a prediction every shift of 4 hours. It can be concluded that the use of short-term prediction models by TCCs is still in an early stage. The TCCs that already have some experience with it had their share in the difficulties regarding the development of these models, instead of disposing of readily applicable tools. This explains their partial dissatisfaction. None of the respondents from the UK CDMF User had any experience of short term prediction.

3.9 Case Studies of TCCs in Europe

As part of the study a short review was undertaken of other TCCs in Europe to gain a better understanding of how they are structured to collect and analyse traffic data and utilise short term prediction to help manage highway networks more effectively. Systems in Turin, Berlin and Dusseldorf were examined, with a summary of these systems summarized below.

3.9.1 Case Study: City of Turin 5T Traffic Operation Centre

Within the Metropolitan area 5T manages the Traffic Operation Centre (TOC) in the metropolitan area of Torino, integrated with the Public Transport real-time Monitoring System (AVM), in order to get smoother traffic and to improve the performance of Public Transport. More specifically, the primary objectives of the TOC are to design, develop, implement and manage ITS solutions and info-mobility services, aimed at achieving a number of key objectives including:

- To improve the traffic fluidity in the urban area and reduce congestions;
- To improve real time information services for the mobility;
- To improve quality and performance of monitoring services for the public transport fleets; and
- To reduce air pollution caused by traffic.

The Traffic Operation Centre uses variable message signs panels (VMS) to provide information about traffic conditions and parking availability in the metropolitan area. The Urban traffic Control (UTC) system seeks to improve traffic conditions and provide "green light" priority to public transport across the city. Other features of the TOC include the use of a limited traffic zone (ZTL) that controls vehicles access in the Torino city centre, video-surveillance on buses and at bus stops, as well as an internet trip planner that provides citizens real arrival times at bus stops, best path calculation, real time availability in the parking areas.

At the regional level 5T is one of the main stakeholders supporting the Regional Infomobility Plan which seeks to manage regional transport and mobility, through an open technological infrastructure that enables the collection, integration, processing and certification of data in real time to regulate the exchange of information on traffic and transport. Through achieving better integration with existing systems, the above mobility and environmental objectives will be achieved. Based on previous experience with the Traffic Operation Centre of the Winter Olympic Games in Torino 2006 (TOC), 5T managed the development of the extension of the traffic monitoring and information system to the whole regional territory.

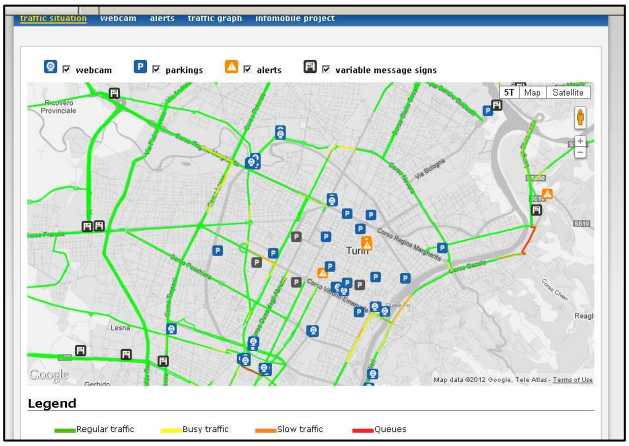


Figure 8 5T Traffic Operation Centre in Turin, Italy

Source: 5T Website

The traffic control system managed by 5T includes a total of 330 traffic signals within the network boundary with the system reducing waiting times at traffic-lights, and contributing to total trip time reductions of up to 20%. The 5T system also offers many advantages to other vehicles including bus vehicles which can be includedin the priority system to reduce travel times and maintain schedules more easily. Camera technology has been installed at twenty of the major junctions across thecity, to enable constant monitoring of traffic conditions and to relay the real-time transmission of images to the 5T System Control Room as well as the Traffic Police Operations Centre.

One of the main innovative elements of the project is the "City Mobility Supervisor", a control and management system over the metropolitan traffic area. As well as providing near real-time traffic information and short and middle term forecasts about traffic conditions, this also supports an overall general strategy for other 5T regional sub-systems. One of 5T's key features is the high quality of its real-time information services in terms of information on traffic conditions, the availability of parking as well as journey times of public vehicles (ie.buses).

The www.5t.torino.it website provides city residents with a wide range of useful services for pre-trip planning and to facilitate more efficient movement around the city. The information covers the metropolitan area of Turin although it is intended to expand this to include a larger part of the Piedmont region. The site fulfills a number of functions including:

- calculating the best route to their destination via public transport or by private car;
- providing information on the availability of free places at city parking lots;
- checking the time of arrival of a bus vehicles at specific bus stops; and
- verifying traffic and road conditions through the use of maps and alerts.

To date, the site has been very successful, with nearly 150,000 route calculation requests each month requested by city residents.

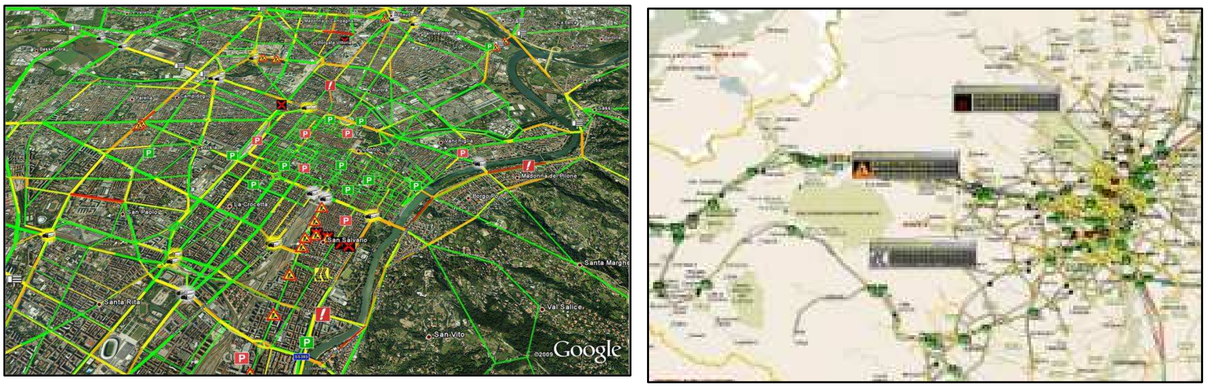


Figure 9 Graphical Outputs from the 5T Traffic Operation Centre

Source: 5T Website

In Italy the use of integrated information and communication technologies in the transport sector has enabled cities and urban centres to develop systems for tracking and fleet management, traffic control and regulation of traffic light cycles, addressing problems of air pollution, as well as providing traffic services to road users. These systems, although as yet little developed and coordinated with different results, have highlighted the strategic role of communication technologies in solving problems related to mobility. Indeed the evolving experience of the 5T system in Turin is seen as one of the earliest and most significant examples of EU-wide monitoring and control of traffic in urban locations.

The ongoing development of the system is seen as a way to consolidate and extend the city's existing transport telematics platform across a wider geographical area where the innovative features and applications of ITS (Intelligent Transport System can be applied at a regional level. This new technology is being shared with other cities across the country to share the wider benefits in terms of resources and expertise and to try and standardise approaches elsewhere as a common outcome (ie. in terms of platforms, interfaces, standards, etc.). The City of Turin Municipality supported by the Piedmont Regional Authority is therefore working closely with the Municipality of Genoa, Bologna Municipality, the Province of Florence and the Province of Cagliari in the continued development and roll-out of the project.

Starting from the existing local operating platforms, the city is looking to implement a system that supports decision-making to enable the management of personal mobilit. This includes allowing the measurement, evaluation and adoption of different traffic management policies measures to control of mobility and access (ZTL systems and electronic gates) to the city. Information provision providing citizens with accurate information on these measures. To achieve this,the city is using vehicle fleets as data loggers (ie.through the use of Floating Car Data) to increase the extent and detail of the existing system to enable more accurate tracking data to be obtained and the required infrastructure to support this as well as improving the frequency and relevance of the data shared with the travelling public.

The innovative element of the project/system relates to the approach to managing the complexity of integrating different sources of data arising from the integration of innovative sources of data (eg, floating car data sensors or innovative land) from systems of different types. A major objective is to develop and implement a national standardisation of services and related information services management models to ensure interoperability between vehicles and Traffic Operation Centres (TOC) and mobility management centres in metropolitan areas. More specifically, the ongoing development of the traffic control system seeks to achieve a number of operational goals, primarily relating to the scheme 'architecture including:

- standardising communication protocols between different agencies across the region;
- developing the telematics platform for the city in terms of extending the mobility management system and its integration with simulation tools to prepare useful real-time database services for motorists; and
- developing and integratiing the platform as a decision support system for controlling access to areas of land and related services to citizens.

It is anticipated that the use of this technology will continue to develop and be integrated with other initiatives proposed within the individual Infomobility Regional Plans to ensure there is consistency of approach when expanding traffic monitoring in metropolitan areas and also regional areas. The traffic operation centre will be able to utilise data made available from the floating vehicles to obtain information on traffic flows and speeds across the road network, which is then used by applications in the traffiic control/mobility centres to estimate traffic information for the entire network.

3.9.2 Case Study: Berlin Traffic Management Centre (TMC) (or VMZ Berlin Betreibergesellschaft in German)

The Traffic Control Centre is of particular importance for the work of the Berlin Traffic Control. By collecting all traffic information in one place, the Berlin Traffic Control is able to directly influence the traffic situation in and around Berlin and to minimise or even completely avoid disturbances. Traffic monitoring is undertaken 24-hours a day, to ensure that any incidents are dealt with immediately to ensure the smooth operation of the city' highway network

The Traffic Control Centre monitors and when indicated manually activates the traffic lights (also "light signal systems") in Berlin at about 2000 junctions, as well as nine Variable Message Sign Systems (VMS) mainly on the Berlin motorways. It monitors the traffic situation on more than 1500 km of roads, and transmits traffic information of the regional reporting office (TMC procedure). The Berlin centre is one of the biggest state-of-the-art traffic control centres in Europe. The traffic management and control system was developed and delivered by a consortium assisted by a number of partners including: BMW, BVG, VBB, IVU Technologies, ZLV, OneStepAhead, PTV AG.Specific objectives are as follows:

- Prediction of current and future travel times for car traffic in Berlin;
- Information system for construction sites;
- Dynamic parking information;
- Traffic guidance on via programmable road signs and Internet;
- Multi-modal traffic information; and
- Information platform for separate traffic control center (VKRZ)

Figure 10 Images of Berlin Traffic Management Centre (TMC)

Source: Senate Department for Urban Development and the Environment, Berlin Traffic Control - Management (VKRZ)

VMZ is divided in two departments:

- Business to Administration division: which focuses on providing services to the public sector by assisting local and federal authorities in the development and implementation of future-oriented traffic management concepts; and
- Business to Business division: which is geared towards companies from a variety of industries.

The free traffic information services of VMZ are made possible by a new type of cooperation between public and private partners. The initial investment costs for the setup of VMZ were financed by the Senate Department for Urban Development of Berlin, whilst VMZ is responsible for the continued operation and further development of the traffic management system.

The regional reporting office is integrated into VKRZ, and by means of TMC procedures (Traffic Message Channel) transmits latest information on special events such as roadwork sites, or demonstrations to the associated radio stations and navigation systems. The system aims to achieve the following:-

- Provide a Quality Management System for major roads in Berlin as a prerequisite for environment oriented Traffic Management;
- Montoring System for real time traffic information;
- Monitoring System for real time air pollution and noise (specifically addressing how the city can meet EU-limit values for PM10, NO2 and noise); and
- Support situation adapted traffic management strategies to address critical situations and ‘hot spots’ (planned).

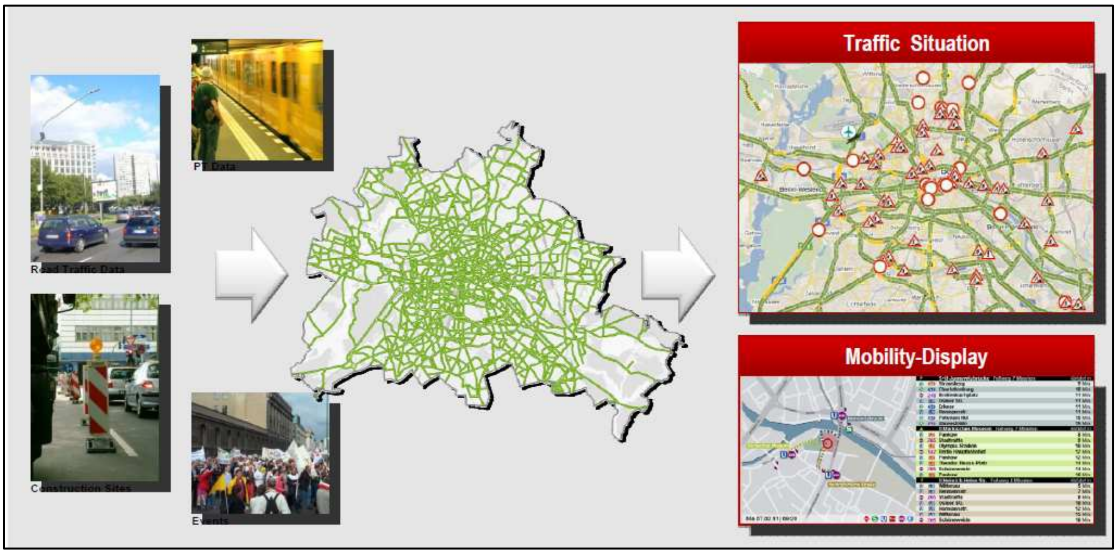


Figure 11 The Berlin Traffic Management System Provides Up-to-date Information on Traffic Conditions Across the City

Source: VMZ Berlin Belreibergesellschaft mbH Website

Approximately 250 detectors have been installed across the city for traffic monitoring, the equipment comprising autonomous overhead detectors supplied by solar power which transmit measured values to the control centre by mobile radio (Traffic Eyes developed by Siemens). Traffic volume and mean speed are acquired in 5-minute intervals, although transmission to the control centre is only triggered when the acquired parameters undergo major changes. The dedicated detectors are also complemented by a series of inductive loop detectors that have been introduced on some motorway sections of Berlin on which section control systems are also being operated. This particularly applies to the southern part of the motorway ring-road which is covered completely by inductive loops (with more than 150 installed in total). Other data is also collected including:-

- Data from the public transport systems (BVG, S-Bahn Berlin GmbH, and VBB);
- Data provided from a total 20 webcameras across the city; and
- Floating car data (FCD) from buses and taxis.

Information about the travel speed on individual links of the network model is provided from these sources. As thedata is collected in periods of 15 minutes in order to forecast the following 15 minutes in the same link, the coverage of the network with this kind of information is variable, depending on the availability of FCD.

The system integrates a wide range of data sources and utilises this to create a platform of information for individual (car) travel) as well as public transport in terms of current situation and also forecasts. This then informs a service platform which enables the TMC to provide a wide range of information on which to base future traffic management decisions.

With traffic control systems and through the use of Variable Message Signs (VMS) on the Berlin motorways traffic data such as speed, traffic volume, moisture and visibility are also automatically collected and evaluated by the TMC. Depending on the traffic situation the computers send instructions to the Variable Message Signs (VMS) which can then automatically activate speed limits, initiate prohibitions or emit warning notices as "Traffic Jam" and "Slippery Road" to ensure that the traffic flows more smoothly and effectively. It is also possible to close tunnels automatically by means of signals in case of fire danger should the need arise. In addition, the TMC has the option to manually activate traffic notices and also other notices such as "Danger", "Construction Site", or "Danger of skidding due to ice or snow", and lane closures.

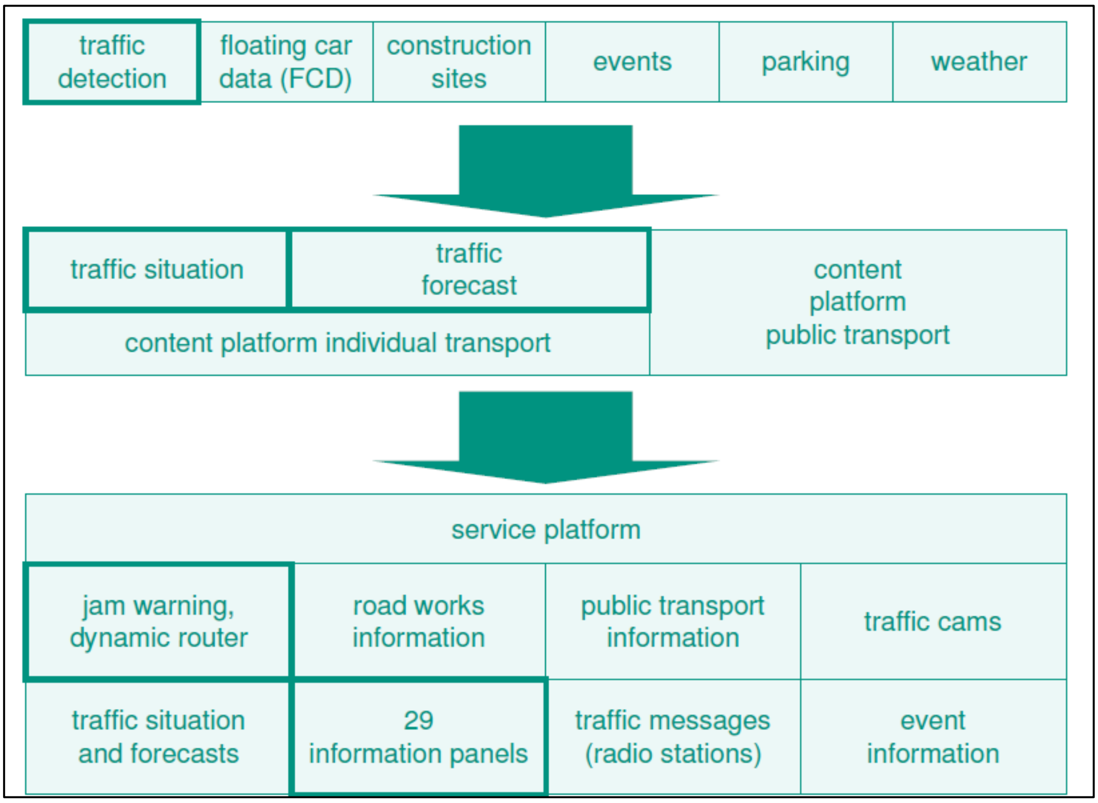


Figure 12 Overview of Berlin Traffic Management Centre Database and Service Provision

Source: VMZ Berlin Belreibergesellschaft mbH

A comprehensive Traffic News and Information on up-to-date Traffic service is provided to support the system which includes the provision of traffic and environmental data for the city as a whole, daily traffic forecasts provided through media, and comprehensive information on mobility characteristics to the general public and care drivers through information presented on the VMZ website (www.vmz-info.de) as well as numerous info panels that are installed acround the city. Working in tandem the Traffic Control Centre with the information systems available seeks to improve the traffic situation through optimised traffic control.

In order to be sucessful and efficient the complete system relies on the co-ordinated management of actions of a number of different agences including airport agencies, rail and road operators, the public transport control centre, taxi operators, police etc.

All messages that are provided to the public are, based on either the information received or the predictions made by the system that are available to the operator. This process is supported by an automatic detection of information, to ensure that all the outgoing messages are consistent. The users obtain information from the website (www.vmzberlin.de), which includes:

- traffic congestion problems issues;
- details on construction sites;
- information on current parking situation; and
- information on traffic forecasts, or traffic conditions via web cams.

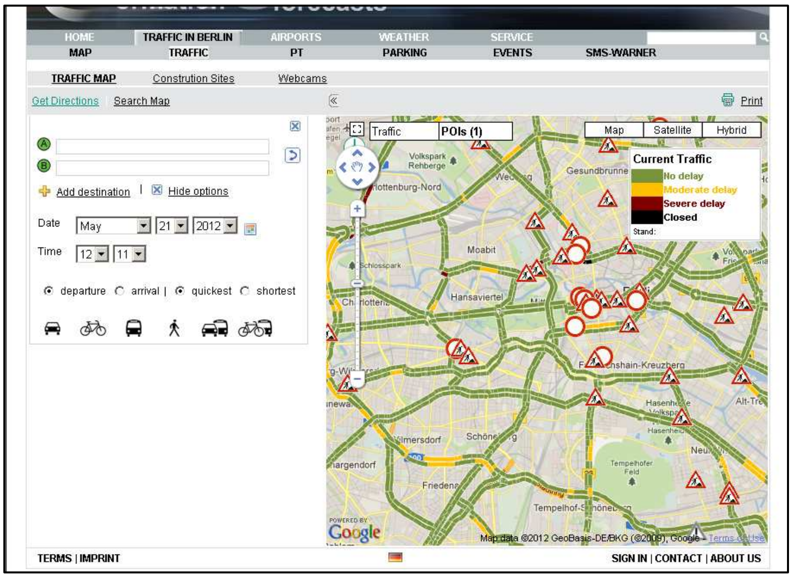


Figure 13 A User-Friendly Interface is Provided to Show Incidents on the Network

Source: VMZ Berlin Belreibergesellschaft mbH

The public can also use an inter-modal dynamic route finder to plan journeys based on up-to-the-minute traffic information and different transport modes. Dynamic roadside information panels are used to inform the drivers of the traffic conditions ahead. Every half an hour Radio Berlin 88.8 broadcasts the current traffic situation directly from the TMC to the travelling public.The project focuses on providing information and not on developing control strategies, therefore, only a prediction (based on current state) is made.

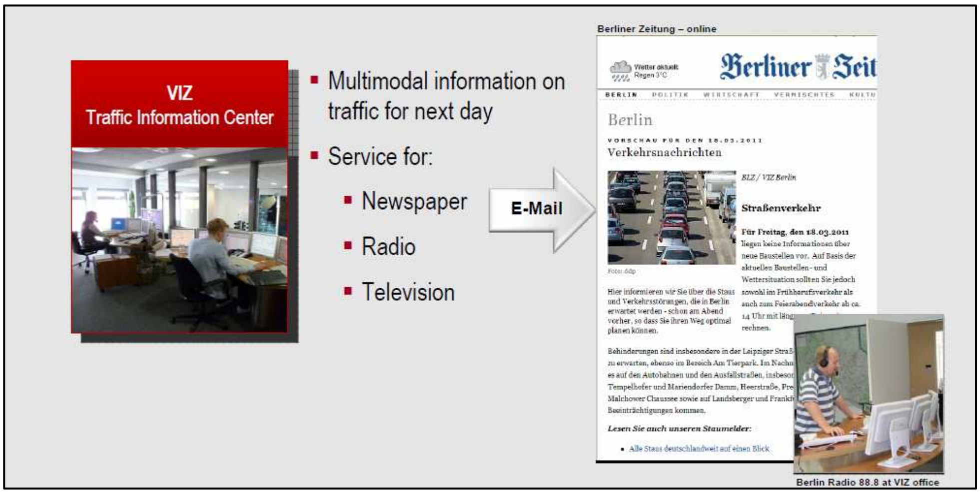


Figure 14 The Berlin TMC System is supported by a Comprehensive Media/Communications Strategy

Source: VMZ Berlin Belreibergesellschaft mbH Website

In summary key aspects of the system are that the Traffic Management Centre is the fundamental mechanism for ensuring mobility management within an extensive conurbation such as Berlin. The provision of traffic information in advance of trips is viewed by the city to be a very useful way to influence the traffic demand. By informing car drivers in advance, driver behaviour can be altered/adapted to using other routes, other time (away from peak period), other destination (ie retail) or even, other mode (public transport). In addition, the system also brings a number of environmental benefits as a result of lower levels of congestion and vehicle emissions.

3.9.3 Case Study: Dusseldorf Traffic Management and Control (D-Motion)

Dmotion is a German research project within the VM 2010 (Traffic Management 2010) research initiative funded by the German Ministry of Economy and Technology (BMWi). The aim of Dmotion is to develop and implement an integrated traffic management system for the conurbation of Düsseldorf. The system is based on a comprehensive data, information and strategy network for both regional and local authorities, as well as for private service providers. A key objective of the system is to generate a consistent and comprehensive report on traffic conditions for Greater Düsseldorf, which can then help inform corrective actions.

Dmotion provides a data, information and network strategy for the Dusseldorf region and the city itself. Each day more than 400,000 commuters travel to Düsseldorf by car with many people making these trips from surrounding areas outside the city. Presently a motorway 'ring' surrounds Düsseldorf comprising motorways A57, A44, A46 and A3. The A3 and A57 are also well used by supra-regional traffic. Consequently, there was a view that such a network structure provided a good opportunity for the development of a comprehensive traffic management system that links between national and city-level traffic.

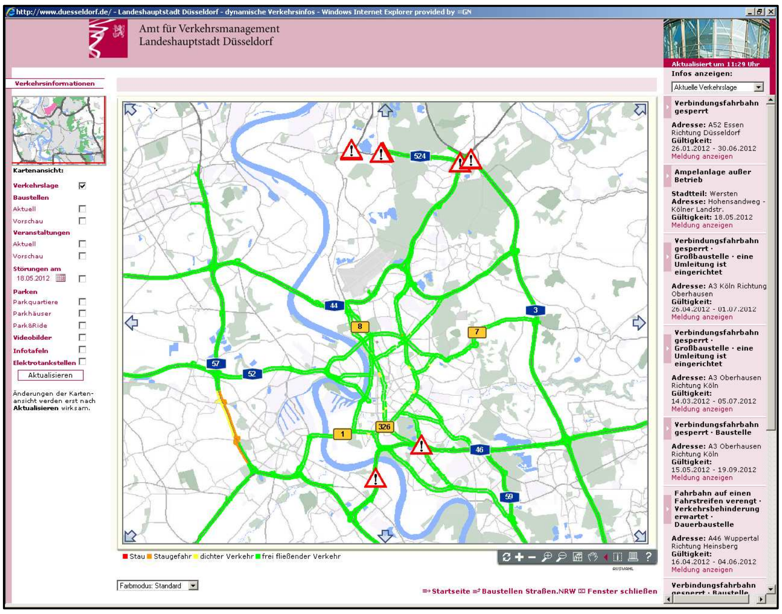


Figure 15 In Dusseldorf a User Friendly Interface provides details of any traffic incidents on the network

Source: *Dmotion – An Overview Of The German Research Project. The Process Chain From A Comprehensive Data And Information Network To A Strategy Conform Routing (**Andreas Budde, City of Düsseldorf, 2010***

The motorways are operated by the Federal State of North Rhine-Westphalia with the traffic control centre situated in Leverkusen whereas the urban road network is operated by the City of Düsseldorf with its urban traffic management centre. Each road authority is responsible for traffic control within its own territory, using different control and information systems, and therefore to ensure an effective traffic management it is important to integrate these systems into a coordinated strategy management approach.

More specifically, Dmotion has the following objectives:

- Providing an integrated report on traffic conditions and identifying co-ordinated strategies for the optimal use of the network;
- Implementing a communication interface between urban and highway traffic control centres to establish an integrated and coordinated strategy and information management solutions;

- Integrating private service providers into the management strategy to ensure consistency and continuity of information; and
- Applying general standards to ensure transferability and interoperability of the overall concept to other locations.

The aim of Dmotion is to generate a uniform, cross traffic management report for the region of the state capital Dusseldorf. Through the strategic connection of traffic signals and variable message signs, road users can be diverted to alternative routes or made aware of incidents on the network. All information is being provided through internet access to get the maximum exposure to the travelling public.

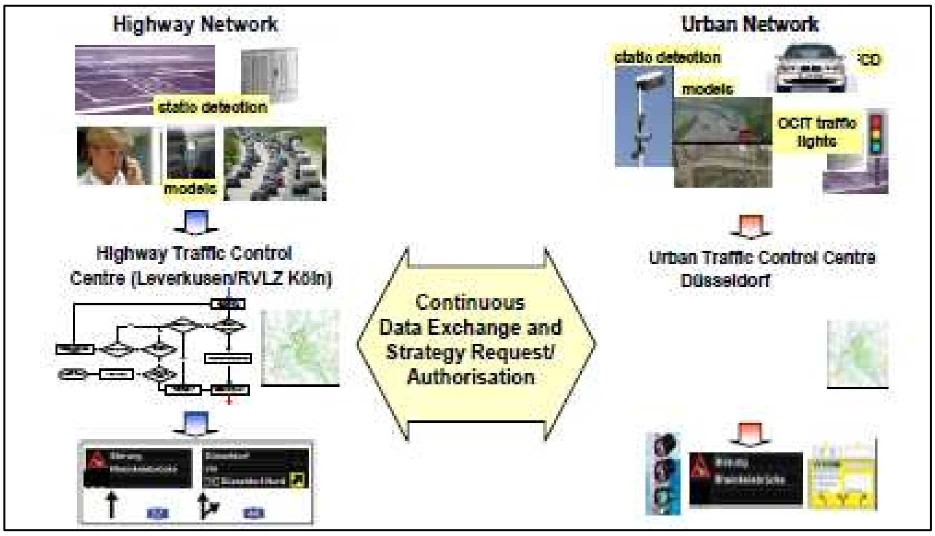


Figure 16 Continuous Data Exchange Underpins the Success of the DMotion Project

Source: *Dmotion – An Overview Of The German Research Project. The Process Chain From A Comprehensive Data And Information Network To A Strategy Conform Routing (****Andreas Budde, City of Düsseldorf, 2010***

For the Düsseldorf region a real-time estimation of traffic conditions is being provided to eve an overview on current traffic conditions on urban main roads and the surrounding motorways. Therefore, an information network of local and regional authorities was required. The distribution of high quality coherent traffic information to road users is a main objective of Dmotion. In order to guarantee the transferability of the developed aspects, the use of standardised interfaces is an essential subject. Within the project Dmotion the communication between the traffic management centres is ensured by standards which are currently developed and established in Germany.

Within the city centre, traffic data that is collected is brought together (comprising data from static detectors, video, infra red and inductions loops) as well as floating car data (FCD) . A process of geo referencing helps support the exchange of traffic data between the service provider and the traffic management centres. Based on the data gathered the city use a real-time model called DINO (Dynamic Network Monitoring) to provide an estimation on current traffic conditions for the network of the City of Düsseldorf as well as a short-term prediction for the urban network.

At the regional level within the motorway management centre the traffic state estimation and the short-term prediction are performed by using the MARZ algorithms and the online model OLSIM for motorways.

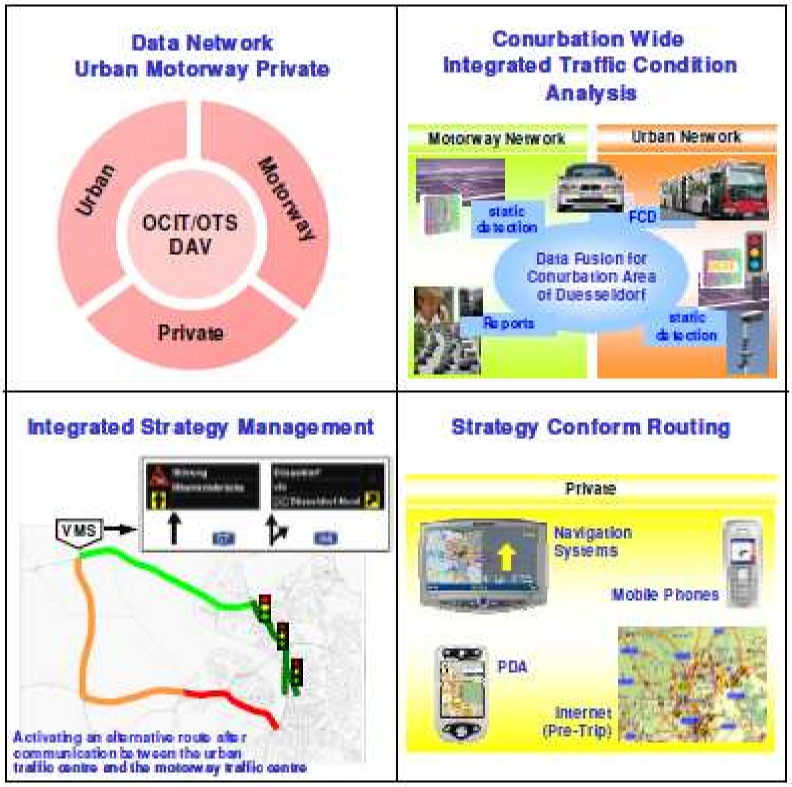


Figure 17 Columns of the Dmotion Project

Source: Dmotion – An Overview Of The German Research Project. The Process Chain From A Comprehensive Data And Information Network To A Strategy Conform Routing (**Andreas Budde, City of Düsseldorf), 2010**

Both the urban and regional information on both current and forecast traffic conditions are combined to forms a source for the traffic management operators as a basis for decisions for dynamic strategy management. Traffic management operators and planners are able to monitor how the network performs, to identify weak points and to monitor and evaluate the effects of influencing and controlling measures. The information on current traffic conditions is published to road users across the region via internet and to the private service provider who is also then able to provide high quality traffic information services.

Coherent traffic management strategies are selected based on the network wide traffic state analysis from the system. A workflow based strategy management is being set up in the TMCs in Dusseldorf City as well as the Federal State of North Rhine-Westphalia, which will reflect both operational and strategic requirements of those involved. It was considered important that each authority was able to determine the appropriate measures required for any intervention and maintain their own approach for when they would activate dynamic traffic signals, variable message signs and related roadside equipment within their own networks. Once interventions have been identified and selected, the system is able to check and verify whether this can be introduced (in terms of assessing the capacity of alternative routes etc.) as well as assessing if any contradictory strategies are being implemented.

The system also has a strong information network established between the private service providers and the highway authorities, as high quality, easy to understand traffic information to road users is a critical part of the project. In collaboration with the public utility company of Düsseldorf, a traffic information service is being designed and tested to take account of certain user needs of both local and regional operators.

4 Conclusions

The Traffic Control Centres (TCCs) and their staff that responded to the STEP User Questionnaire revealed a positive attitude towards the use of short-term prediction models. Nevertheless, the experience of TCCs with the practical use and application of these models during their daily routine/operation is certainly limited. This lack of experience in the use of prediction systems is reinforced by the responses received on the level of accuracy required with prediction systems, as a general view was provided, rather than a set of definitive detailed requirements.

It is worth noting that the TCCs that already have experience with short-term prediction tools are still trying to identify how best to install a workable system. Therefore, a key conclusion is that all TCCs are still searching for successful experiences elsewhere, which supports the benefits and importance of STEP project and its objectives of defining the success factors for short term prediction in a real TCC environment. The pilot projects proposed under WP4A and WP4B will identify such specific requirements and feedback on the use of a prediction tool in an operational setting.

The use of short-term prediction without scenario generation is already seen as an important asset by many TCCs. Given the high importance that is given to accuracy of traffic prediction, it is reasonable to conclude that it is beneficial to focus on such easier applications as a first stage, so that the TCCs can gain some positive experience with short-term prediction. Only after successful results have been identified, one should proceed with developing predictors with scenario generation, which of course is the ultimate objective of the development of a predictive system.

The TCC representatives are interested in short term predictions in regular conditions, which is seen as a means to deal with variability/reliability of traffic conditions. Ultimately however, and consistent with most TCC's considering management of their networks in irregular conditions one of their prime objectives, predictions of irregular conditions would be most useful, as one can then rely less on experience. This raises particular challenges to developers of such tools, since the state-of-the-art does not provide readily applicable traffic prediction tools with proven predictive power in incidental conditions. Obviously, the reason for this is the inherent conceptual difficulty of predicting unforeseen events, as well as drivers' response (demand side) to non-repetitive irregular traffic conditions.

Other TCC operations and systems in Europe show a desire to see a standardised approach which are seen as essential for the extension and roll-out to other urban centres and cities. In the case of Dusseldorf and Berlin as well as Turin, communication between Traffic Management Centres is supported by standards that are currently being developed and established at a national level. In this context, the transferability of any software components to other conurbations will be an essential consideration in terms of future development of any predictive tool. Finally, the manner of presenting the traffic prediction results is an important aspect, but should be further explored in a later stage in the development of prediction tools during the pilot phase of the project.

Research work undertaken for the UK Highways Agency on the Optimum Real-Time Co-ordinated Management of Congestion (CoMoCo) project revealed a number of key issues that local authorities would like to see addressed in the development of Network Management Systems (NMS). These included the development of decision making protocols in the development of systems, the desire for automated systems to reduce the burden on already overloaded traffic control centre staff and the development of standards for communications link and data share across systems. All of these have relevance for the STEP project and the development of specifications for prediction tools.

WP3 focuses on the development of the proposed User Interface that will be presented to potential users of the short term predictors in the UK Pilot (WP4A) that will enable more detailed assessment and evaluation to be undertaken on how potential users might use the interface to support decision making in their strategic management of the road network.

On the basis that we have canvassed a number of potential users of short term prediction data on key attributes that they wish to see incorporated into the specification of prediction tools it is important to ensure that these are reflected in the development of draft specifications that will be used in the development of the prediction tool and interface for both UK and Dutch trials (WP4A andWP4B).

Whilst users appear somewhat divided on the type of different user interface there is interest in developing an alerting type interface as well as graphical representation of the predictions that are made. In developing and testing the tool and interface both the UK and Dutch trials aim to investigate both mechanisms. In terms of visualisation, in general the feedback identified that the use of colour-coded links overlaid on a map view was a popular option, accompanied by alerts or alarms in case to show abnormal conditions. Importantly, TTC operators revealed the level of manual intervention when using the tool should be kept to a minimum and a degree of automation should be provided to help the operators in their daily operational duties.

As part of the work to develop user interface specifications within WP3A it is envisaged that an alerting type mechanism to advise operators when traffic conditions are predicted to be different from usual, with minimal disruption to operators duties. The primary objective is to develop a user interface based on the short term prediction mechanisms required by operators, as opposed to the development of new tools to support the trials themselves.

Sources

STEP Project – Work Package 1, State-of-the-Art: Review of Best Practice Report, Institute for Transport Planning and Systems ETH Zurich, Katholieke Universiteit Leuven (KUL), TU Delft, Nov 2011

TRL, Co-ordinated Network Management Systems: Stakeholder Survey Analysis Report, CPR378, 102(387) HTRL, June 2008.

Dmotion – An Overview Of The German Research Project. The Process Chain From A Comprehensive Data And Information Network To A Strategy Conform Routing (Andreas Budde, City of Düsseldorf, 2010

Appendix A – User Questionnaire

SHORT TERM PREDICTION RESEARCH PROJECT

QUESTIONNAIRE

Understanding Traffic Control Centre Needs and Benefits of Real-Time Prediction

One of the objectives of the ERA-NET ROAD II programme focuses on the implementation of short term prediction aimed at getting the most out of Intelligent Infrastructure from a road operator point of view. Consequently, the Short TErm Prediction (STEP) project seeks to test short term prediction in Traffic Control Centre practice to assess its usefulness for operators, hopefully leading to improved standards and guidance for implementation across Europe.

The STEP project team consists of Mott MacDonald, Fileradar and universities in Leuven, Delft and Zurich, who combine extensive and complementary experience in the field of real-time traffic modelling. Central to the project are two real-life trials that will be conducted in operational traffic control centres in the UK and in The Netherlands, testing the tools against user requirements. A key intended outcome of the project is the development of Europe-wide recommendations for data standards, functional specifications and user interfacing.

As part of the STEP project one of the key objectives is to gain a better understanding of the operational short term prediction requirements of traffic managers at Interurban and Urban Traffic Control Centres (TCC's) in Europe. More specifically, we are keen to explore the gaps between the state-of-the-art and requirements of operators in terms of functional application, interfacing and the success of existing tools that are used.

We need to understand more about how real-time traffic controllers are setup, including practical operational and data requirements as well as gather views on traffic prediction tools that are currently available to improve network performance. Therefore your views are critical to enable us to understand the key issues that need to be addressed when developing practical traffic prediction tools and the potential for their application to support traffic control centre operations. The remainder of this document consists of a questionnaire. We kindly ask you time to fill out this questionnaire, which will take about 20-30 minutes.

On behalf of the STEP Consortium I thank you for your co-operation in supporting this important research project.

Yours faithfully,

Mark Finer

STEP Project Manager

Mark.finer@mottmac.com

Tel: +420 221 423 924

1. GOALS AND TASKS OF YOUR TRAFFIC CONTROL CENTRE (TCC)

We are keen to gain a better understanding of the key objectives of traffic control centres and how traffic control centres operate. Similarly, information on what types of traffic control measures are used in traffic management plans will provide a useful baseline of current functions that can help inform us on the most effective trial application and assess how valuable traffic prediction tools are likely to be.

(a) What is/are the main goal(s) and task(s) of your TCC?

	Level of Importance				
	Not Important	**Slightly important**	**Important**	**Very Important**	**Critical**
Improve journey time reliability.	1	2	3	4	5
Reduce road casualties and accidents	1	2	3	4	5
Reduce disruption caused by major incidents.	1	2	3	4	5
Provide alternative route advice to minimise the effect of congestion	1	2	3	4	5
Minimise delays due to roadworks.	1	2	3	4	5
Influence road users' decisions before they set out on a journeys	1	2	3	4	5
Keeping the ITS Infrastructure Operational					
Other (please specify)	1	2	3	4	5
....	1	2	3	4	5

Please provide comments here:

....

....

....

(b) What types of roads do you manage?

TYPE OF ROUTE	Please Tick Correct Box(es)
Motorway	
Inter-urban Trunk Road (Primary A Road)	
Non-primary A-Road	
B-Roads (regional)	
C-Roads (local)	
Other (Please specify)	

(c) What is the size of the area that you manage?

Please provide comments here:

....

....

(d) Can you provide a map of the roads that you manage (please include it as attachment while returning your answers?

Yes	No

Please provide comments here:

....
....
....
....

(e) What kind of management/control measures can you use in your daily operations to influence traffic operations?

		Level of Importance				
		Not				Critical
General traffic information provision	Road traffic conditions (speeds, queues)	1	2	3	4	5
	Travel times	1	2	3	4	5
	Multimodal travel information (e.g. P+R)	1	2	3	4	5
	...	1	2	3	4	5
	...	1	2	3	4	5
Traffic flow measures	Variable speed limits	1	2	3	4	5
	Lane management	1	2	3	4	5
	Overtaking prohibition	1	2	3	4	5
	Fog warning	1	2	3	4	5
	...	1	2	3	4	5
	...	1	2	3	4	5
Route guidance	VMS route information	1	2	3	4	5
	Traffic restrictions	1	2	3	4	5
	Diversions	1	2	3	4	5
	Toll info	1	2	3	4	5
	...	1	2	3	4	5
	...	1	2	3	4	5
Traffic control measures	Ramp metering	1	2	3	4	5

	Access management (e.g. trucks, HOV, HOT,…)	1	2	3	4	5
	…	1	2	3	4	5
	…	1	2	3	4	5
Incident management	Incident detection and verification	1	2	3	4	5
	Organizing incident response	1	2	3	4	5
	Informing incident response teams	1	2	3	4	5
	…	1	2	3	4	5
	…	1	2	3	4	5
Infrastructure management	Tunnel surveillance	1	2	3	4	5
	Bridge openings	1	2	3	4	5
	Tidal flow / flexible infrastructure	1	2	3	4	5
	…	1	2	3	4	5
	…	1	2	3	4	5
Other categories	…	1	2	3	4	5
	…	1	2	3	4	5
	…	1	2	3	4	5

Please provide comments here:

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

2. STRUCTURE OF TRAFFIC CONTROL CENTRE

(a) What is the size of the workforce in your TCC?

Number of Staff	Please Tick Correct Box
0-5	
6-10	
11 – 25	
More than 25	

Please provide comments here:

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

(b) Could you provide a brief description of the tasks of each type of employee?

Please provide comments here:

....
....
....
....
....
....
....
....
....

....

(c) What is your yearly budget? *(Optional)*

Budget	Please Tick Correct Box
Up to €100,000	
€100,001 to €250,000	
€250,001 to €500,000	
€500,001 to €1,000,000	
Above €1,000,000	

Please provide comments here:

....
....

....

(d) What part of your budget is allocated to projects or innovation? *(Optional)*

Budget	Please Tick Correct Box
Up to €100,000	
€100,001 to €250,000	
€250,001 to €500,000	
€500,001 to €1,000,000	
Above €1,000,000	

Please provide comments here:

....
....

3. DATA AND INFORMATION SOURCES

We are keen to understand more about current practices in data collected approaches by traffic control centres and current issues and problems that are experienced in surveying and measuring performance.

(a) What kind of (real-time or historic) data do you use in your TCC?

Data Type	Measurement interval
Speeds	*(i.e. 1 min)*
Flows (intensities)	
Occupancies	
Travel times	
Densities	
Route/OD-samples	
Traffic composition (vehicle types)	
Incident detection	
Weather parameters	
Other (please specify)	
....	
....	

Please provide comments here:

....
....
....
....

(b) Which fraction of the total network links are equipped with sensors? What is the positioning strategy (e.g. measure on/off-ramps, redundant placement of detectors)

Please provide comments here:

....
....
....
....

(c) What kind of measurement equipment is used to gather these data?

Types of Equipment Used	Level of Use				
	Never	Scarcely	Regularly	Mostly	Everywhere
Inductive loop	1	2	3	4	5
Magnetic Loop	1	2	3	4	5
Pneumatic Road Tube	1	2	3	4	5
Active Infrared	1	2	3	4	5

Passive Infrared	1	2	3	4	5
Microwave Radar	1	2	3	4	5
Ultrasonic	1	2	3	4	5
Passive Acoustic	1	2	3	4	5
Video Image Processing	1	2	3	4	5
License plate reidentification	1	2	3	4	5
Bluetooth	1	2	3	4	5
Toll booths	1	2	3	4	5
Floating car data	1	2	3	4	5
Other (please specify)	1	2	3	4	5
....	1	2	3	4	5

Please provide comments here:

....

....

....

(d) Is the measurement equipment owned by the government or do you (also) use privately owned data sources (i.e. GPS devices, telephone signals, etc.)?

Equipment	Government owned	Privately owned
Inductive loop		
Magnetic Loop		
Pneumatic Road Tube		
Active Infrared		
Passive Infrared		
Microwave Radar		
Ultrasonic		
Passive Acoustic		
Video Image Processing		
License plate identification		
Bluetooth		
Toll booths		
Floating car data		
Other (please specify)		
....		

(e) How is the data that you use formatted?

Please provide comments here:

....

....

....

(f) What kind of digital map do you use for the description of the roads of your area (for visualisations, computations, etc)?

Please provide comments here:

....

....

(g) Is the digital map freely available for commercial use or is it proprietary to you or someone else?

Please provide comments here:

....

....

4. SOFTWARE

(a) What kind of software / visualisation tools do you use for managing traffic state information + what do you use it for (main functions/role)?

Please provide comments here:

....

....

....

....

....

(b) Please provide a list (or screenshots if possible) of all kinds of visualisation that you use during daily operations.

Please provide comments here:

....

....

....

(c) Have you developed your own software / tools or do you use (a) commercial product(s) (please state which one(s))?

Please provide comments here:

....

....

....

(d) Do you use any software tools for traffic management decision support?

Please provide a description:

....

....

....

5. SHORT TERM TRAFFIC PREDICTIONS

Adaptive traffic control technology currently offers good opportunities to manage and reduce traffic congestion on networks and we are keen to understand more about whether existing traffic control centres currently use prediction tools as part of their current operation.

(a) Are you optimistic about the use of short-term traffic predictors to address congestion?

Yes	No

Please provide comments here:

....

....

....

(b) Have you, do you or will you use any form of traffic predictions already?

Yes	No

Please provide comments here:

....

....

If you have not used a traffic prediction yet, please go to (h)

(c) In your experience with traffic prediction, what are the predictions used for and which prediction horizon do you consider in your application:

User Interface	Yes/No	Prediction horizon
General picture of coming days/months		
General picture of coming hours		
Evaluation of management scenarios		
Real-time incident management		
Other (Please specify)		

(d) In your experience with traffic prediction, how is the user interface set up (how can you see the predictions):

Uses of	Yes/No
Integrated with existing traffic management system	
Prediction tool has own, separate visualisation	
Spreadsheet	
Other (Please specify)	

(e) In your experience with traffic prediction, how satisfied are you with your current system?

	Response				
	Strongly dis-satisfied	Dis-satisfied	Indifferent	Satisfied	Strongly satisfied
Overall Accuracy	1	2	3	4	5
Cost of Implications	1	2	3	4	5
Maintenance issues	1	2	3	4	5
Installation Issues	1	2	3	4	5
Other (please specify)	1	2	3	4	5
....	1	2	3	4	5

Please provide comments here:
....
....
....

(f) In your experience with traffic prediction, please provide a description of the prediction model(s) and your positive and negative experiences:

Model(s) used:
....
....
....
....

Positive experiences:
....
....
....
....

Negative experiences:
....
....
....
....

(g) In your experience with traffic prediction, with your current knowledge, would you have installed the same system if you had the opportunity to start again?

Yes	No

if no, what are the minimal requirements for an alternative system to be more acceptable for you?
....
....
....

(h) What is your opinion about the required prediction horizon and level of accuracy over that horizon for the predictor to be worthwhile for your needs?

	Response	
	Desired horizon [minutes]	Minimum % accuracy for a predictor to be useful (over stated horizon period)
Measured travel times vs predicted travel times		
Measured vs predicted speeds at measurement sites		
Other (please specify)		

Please provide comments here:

....

....

....

(i) How would you like the traffic predictions to be presented to you?

	Response				
	Strongly Disagree	Agree	Neither Agree of Disagree	Agree	Strongly Agree
Through colour-coded quantities in a tabular list	1	2	3	4	5
Through colour-coded links overlaid on a map view	1	2	3	4	5
Through colour-codes and figures on a dialog for the status of a single selected link or section	1	2	3	4	5
Through alerts or alarms for abnormal conditions	1	2	3	4	5
Other (please specify)	1	2	3	4	5
....	1	2	3	4	5

Please provide comments here:

....

....

....

(j) What are the key factors that influence your choice of whether to use short-term traffic predictors in your daily operations or not?

	Response				
	Strongly Disagree	**Agree**	**Neither Agree of Disagree**	**Agree**	**Strongly Agree**
European standards of how to successfully integrate traffic predictions in TCCs	1	2	3	4	5
Evidence of successful application by other TCCs and real-life trials	1	2	3	4	5
The accuracy of the predictions	1	2	3	4	5
Acceptance of new systems by the TCC workforce	1	2	3	4	5
Cost of setting up	1	2	3	4	5
Other (please specify)	1	2	3	4	5

Please provide comments here:

....

....

....

(k) In terms of overall costs of establishing short-term traffic prediction capability within TCCs what do you consider to be an acceptable budget for implementing such a system?

Cost Of System	Response				
	Strongly Disagree	**Agree**	**Neither Agree of Disagree**	**Agree**	**Strongly Agree**
€10,000 per year	1	2	3	4	5
€20,000 per year	1	2	3	4	5
€50,000 per year	1	2	3	4	5
€100,000 per year	1	2	3	4	5
€200,000 per year or more	1	2	3	4	5

Please provide comments here:

....

....

....

(m) Independent of any experience with traffic predictions in your TCC, what is the staff's (especially the traffic operators) attitude towards traffic predictions?

	Response				
	Strongly Negative	**Negative**	**Neither Negative or Positive**	**Positive**	**Strongly Positive**
Staff views on traffic predictions in general	1	2	3	4	5

Please provide comments here on the reason why (especially if their attitude differs from yours):

....

....

....

(n) Do you have any other comments to make about the content of this questionnaire? Please comment below.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

6. YOUR CONTACT DETAILS

Title: Mr/Mrs/Ms/Other
First name ____

Surname ____
Address ____
____
Postcode ____
E-mail ____
Daytime telephone number ____

Should you wish to discuss the questionnaire or any other issues relating to the STEP project please don't hesitate to contact me at the following address:-

Mark Finer –
STEP project Manager
Mott MacDonald Limited
Narodni 984/15
110 00 Praha 1
Czech Republic
Tel: +420 221 423 924
Mobile: +420 724 884 259
E-mail: mark.finer@mottmac.com

In complying with the Data Protection Act 1998 the STEP Consortium confirms that it will process personal data gathered from this form only for the purposes relating to the ongoing ERANET STEP project.