ROADIDEA-INCO

Comparing conditions for innovation and provision of mobility services in the EU, the USA and Canada

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Executive summary

ROADIDEA INCO - Road Map for Radical Innovations in European Transport Services – International cooperation aspects is a European Commission co-funded international cooperation project analysing and comparing transport information and service systems and innovation potential in the EU, the USA and Canada. The parent Project ROADIDEA (2007-2010) investigated the European transport system and Europe's ability to innovate new mobility services, showing that the major barriers in Europe are in accessibility, prohibitive pricing and standardisation of necessary data, and heterogeneous organisational structure of data providers in the EU countries.

ROADIDEA-INCO was carried out by three Partners from the ROADIDEA Consortium: Foreca Consulting Ltd (FORC) Finland (coordinator), Deutsches Zentrum für Luft- und Raumfahrt (DLR), Institute of Transport Research, Germany, and Amanova Ltd (AMA), Slovenia. In the USA and Canada the main partners were Federal Highway Administration FHWA and its Clarus initiative, A National Surface Transportation Weather Observing and Forecasting System; ITS Canada being responsible for the Regional Demonstration of Clarus in Western provinces of Canada – Yukon, British Columbia and Alberta, Transport Canada, and Environment Canada running operational road weather services and models.

Project took nine months from January to September 2010 and contained visits and meetings with partners and other key stakeholders the USA and Canada. Two innovation seminars were conducted in Washington D.C. and Montreal, producing new service ideas in IntelliDrive concept and management of transport services. The report presents analyses and comparisons of availability and content of road information, existing data policies, methods and models, and provision and innovation potential of mobility services. Conclusions include recommendations for common data standards and surface transport weather observing and forecasting systems in Europe and North America. The USA, Canada and the EU should commit to move forward together to take the practical steps necessary to establish internationally harmonized open and unrestricted data policies for all public sector information.

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1. Background and scope

ROADIDEA INCO - Road Map for Radical Innovations in European Transport Services – International cooperation aspects is an international cooperation project analysing and comparing transport information and service systems and innovation potential in the EU, the USA and Canada. The parent Project ROADIDEA (2007-2010) investigates the European transport system and Europe's ability to innovate new mobility services. Basic hypothesis is that effective accessibility to all kinds of useful background information combined with advanced data fusion methods and technological information platforms with high level of standardization are prerequisites for creation of innovative mobility services.

The key results of ROADIDEA showed that the major barriers in Europe are in the data layer: in accessibility, pricing, standardisation, and heterogeneous organisational structure of data providers in the EU countries. In the USA and Canada, similar information should be available more openly and basically free of charge due to different federal data policies. Does this affect local transport systems and provision of services?

ROADIDEA-INCO was carried out by three Partners from the ROADIDEA Consortium:
- Foreca Consulting Ltd (FORC) Finland (coordinator),
- Deutsches Zentrum für Luft- und Raumfahrt (DLR), Institute of Transport Research, Germany,
- Amanova Ltd (AMA), Slovenia.

Partners investigated the transport systems in the USA and Canada to find out the differences in data layer and in resulting methods and models, and provision of mobility services to various transport user groups. In the USA and Canada the main partners were:

- Federal Highway Administration FHWA and its Clarus initiative, A National Surface Transportation Weather Observing and Forecasting System,
- ITS Canada being responsible for the Regional Demonstration of Clarus in Western provinces of Canada – Yukon, British Columbia and Alberta,
- Transport Canada, and
- Environment Canada running operational road weather services and models.

Project's nine-month work plan from January to September 2010 contained visits and meetings with partners and other key stakeholders the USA and Canada in three phases:

1. Introduction and planning in January-February 2010 during TRB2010 in Washington D.C. and SIRWEC/PIARC in Quebec City, Canada,
2. Fact finding missions, and organising Innovation seminars with partners and stakeholders in the USA and Canada in April and June 2010,
3. Final seminars in September in Washington D.C., Ottawa and Montreal.

This Final Report contains analyses and comparisons of existing data policies, availability and content of road information, methods and models, and provision and innovation potential of mobility services. Conclusions include recommendations for common data standards and surface transport weather observing and forecasting systems in Europe and North America.

2. Summary of ROADIDEA Europe

Project ROADIDEA (2007-2010) studied in detail the European transport service system, and analysed its potential and barriers for new service innovations, also by concretely innovating and implementing new service pilots. Major barriers and facilitating factors for new transport service innovations were revealed, and guidelines offered for the next steps in an action plan to strengthen the potential for and lower the barriers to transport service innovations in Europe. The structure of European transport information systems and services were analysed in detail starting from the input data layer where raw and process data is ingested into the technical service platform, which then processes and integrates the data into end user services.

The innovation methods used in ROADIDEA were from the established Futures Research Discipline, and used in three Futures seminars in Europe. Similar methodologies were introduced in ROAIDEA-INCO for overseas partners. These were the Futures Workshop and Synectics, as defined by the Millennium Project (a global independent non-profit think tank and collaborative futures research initiative). The methods were used for group work, brainstorming, idea grouping, idea evaluation, and process evaluation. Emphasis was on the innovation process as part of idea refinement as well as initiation, and in catalytic effects across specialist disciplines to move towards fresh new service ideas.

In ROAIDEA, two innovation creation processes were conducted with 12 months' interval. Each innovation cycle started with a Futures Seminar involving over 30 participants working together for two full days to create new ideas and short-list the best ones for further development. The participants were project partners and invited experts from key stake holder sectors. Altogether more than one hundred ideas where created. The success of the innovation activities in ROADIDEA showed the benefits of systematic innovation activities among multi-disciplinary expert groups to accelerate the creation of service innovations and reduce their time to market in Europe.

The data survey revealed that the main problem in creating and implementing new mobility services in Europe is at its foundation, in the input data layer. The data needs for new services are numerous and the lack of necessary data is hindering the implementation of many potential new service innovations. One of the key problems is the heterogeneous availability of data for ITS in Europe with large differences e.g. between highly developed national transportation systems in middle- and northern European countries and the still less developed circumstances in South-Eastern countries. Conclusion was that due to the lack of the necessary data across Europe, today it is difficult or in most cases impossible to implement European-wide mobility service innovations. Thus, the necessity of a common European data catalogue for ITS became apparent and urgent. The recent political actions in the form of the PSI and INSPIRE Directives have somewhat improved the common data policy, but their influence is not yet evident in concrete service provision level.

Next step was to investigate models and methods to be used in processing of the input data. The methods focussed on data filtering and data fusion. Model development concentrated on forecasting traffic density in relation to weather phenomena, and developing new models for the most successful service ideas. Three ideas were developed into pilot services that were successfully demonstrated and very close to operational use, namely the "Pulp Friction" road surface slipperiness warning pilot in Finland, the Fog warning pilot in the Po Valley region in Northern Italy models, observation sensors and satellite information, and the "Do I get wet?" bicycle route planner in the Netherlands. The results show that weather clearly has an impact on traffic and also that it is possible to build new better models, which demonstrate the effects of poor weather to traffic. In developing forecast and traffic models the availability of flows of free data (in-situ observations from surface networks, vehicles, etc.) is of utmost importance, thus resulting in similar recommendations as above on the needs for more and better input data access. This was concretely demonstrated in ROADIDEA when some good new service ideas that were investigated further failed in operational implementation due to lack of data, such as the Gothenburg pilot in Sweden of combining traffic data and weather models, and the Port of Hamburg data for modelling the congested traffic in the city harbor.

ROADIDEA further analysed European transport services, existing systems, architectures and standards, describing the processes in generating new advanced information, utilising this information by private and public end users, technical requirements and specifications of driver and traveler support services, and documenting useful existing standards and standardisation requirements. Some visions for the future deployment of ITS in Europe are presented in project documents.

As it is also crucial to develop sustainable services out of the new and innovative ideas, ROADIDEA analysed, developed and assessed business models of transport information services. Identification of different stakeholders and their expectations and likely benefits was done and the potential business roles (for example information brokers) in the transport information service area defined. Generic business model approaches were applied to clarify the definition of the components of (potentially) different information service business models. Details of the users, benefits, value, stakeholders, and necessary data were included. Some new innovative business models were also presented. The analysis showed that not one business model was uniquely better than any of the others, and different business models are needed for different transport information services. Often mixed funding models are needed, including advertisements, sponsors, end user payments, etc. Linking transport information services to other information services adds further potential for larger audiences, which would help to secure the sustainability of such services. In public-private partnerships, public funding should not be terminated too early of the service's life cycle to reach a sustainable business. End users' willingness to pay for information services is generally quite low, but micro payments or low prices are better accepted especially if the user interface is a mobile phone.

In the concluding report of ROADIDEA, D1.9 The Road Map, the required actions to enhance the European innovation potential as seen in ROADIDEA and other ongoing projects and actions are considered, and in particular

- needs of developing the infrastructure,
- future needs of R&D of methods and models,
- future needs of R&D in European transport services,
- standardisation needs.

The Road Map as well as all other public documents of the project are available in ROADIDEA web site www.roadidea.eu.

3. Data and advanced ITS services in the US and Canada

Following the general ROADIDEA idea to combine road traffic and road weather models in order to innovate new road transportation services, the focus of the ROADIDEA INCO investigation of corresponding initiatives, services and application in the USA and Canada laid on the fields of road traffic and road weather monitoring and its combination. So, the following sub-chapters distinguish between road weather monitoring (describing mainly the CLARUS network) and road traffic monitoring projects. Within chapter 3.2 on road traffic monitoring projects, some remarkable research and implementation activities on a rather regional/national than local scale are selected in order to show the variety of given road site transportation services, applications and initiatives in the US and Canada.

However, as a minor extension to a European research project, it was not achievable for ROADIDEA INCO to get in contact with all existing both regional and national transportation projects, programs and authorities. Thus, the following exemplary overview is not claiming to be comprehensive and complete; it is not covering all US and Canadian federal states in a same extend. Nevertheless, it is describing some very interesting and innovative regional road transport services; but also one more global networking coalition covering a very important transportation corridor from Florida up to Maine is considered.

The ROADIDEA INCO team has participated in several US and Canadian conferences and workshops on ground transportation and road weather services. The goal of those so called 'fact finding missions' was to get a better insight view of available data sources, their implementation into real life applications and value added services, and the roles of involved stakeholders – but also to reveal barriers and issues.

3.1 Road Weather Monitoring – The CLARUS network

Clarus is an initiative sponsored by the Federal Highway Administration (FHWA). This initiative, as a critical component of the existing National Weather Observation System (NWOS), has three primary motivations.

- Surface transportation-based weather observations will enhance and extend the existing NWOS database supporting general weather forecasting enhancing the protection of life and property.
- National collection of real-time surface transportation-based weather observations will provide for unfettered access of data for support of operational responses to weather events and their impacts.
- Surface transportation-based weather observations integrated with existing NWOS observed data will permit broader support for surface transportation-specific models predicting impacts of weather on surface transportation safety and mobility.

The intent of the *Clarus Initiative* is to demonstrate how an open and integrated approach to observational data management can be used to collect, control the quality of, and consolidate surface transportation weather and pavement condition data to augment the existing NWOS. The *Clarus* Concept of Operations looks at the initiative from user perspectives, addressing the necessary infrastructure to consolidate the data from a multitude of independent data collection systems. This data fusion process offers the prospect of enhancing data coverage, improving the performance of meteorological support services, and providing guidance to owners of these data sources regarding the quality of their data and performance of their data collection systems. *Clarus* represents the next step in the union of weather data from disparate measurement sources and the first step in merging surface transportation weather data. Surface transportation weather data collected by the *Clarus System* will include atmospheric data, pavement data, and hydrologic (water level) data as shown in Fig. 3.1 presenting Clarus System data flows. [1]

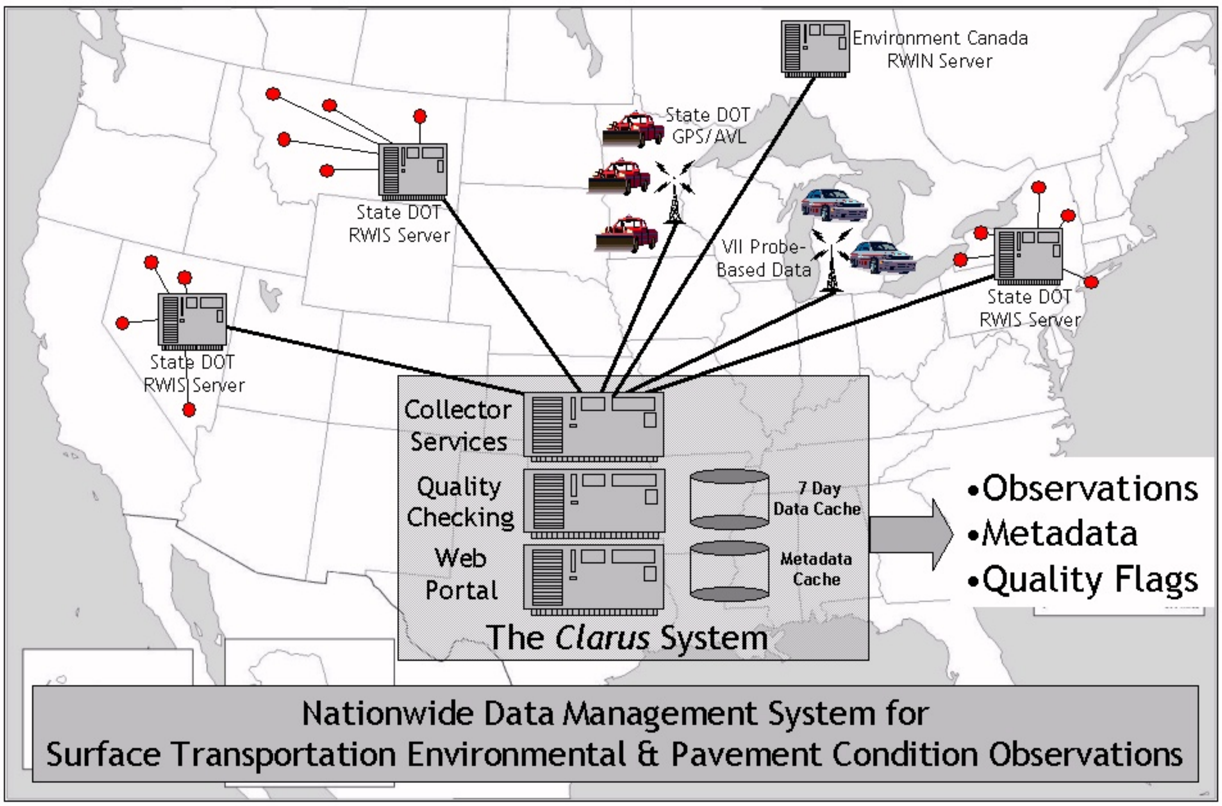

Figure 3.1 The Clarus system data flows. [1]

Clarus is providing clear benefits to everyone involved in weather and transportation:

- **Transportation managers** will have enhanced decision-making tools (e.g., the Maintenance Decision Support System (MDSS)) allowing them to more efficiently manage resources, more effectively maintain their roadways, and to give credible and precise travel advice.
- **Weather providers** will be able to provide high-resolution weather analyses and forecasts and real time travel conditions via radio, television, and the Internet. The accuracy of *Clarus* could tell a traveller about a specific route and the time bad weather is likely to arrive.
- And **travellers** will no longer have to engage in guesswork when it comes to driving in bad weather or place themselves and others at risk by driving on dangerous roadways.

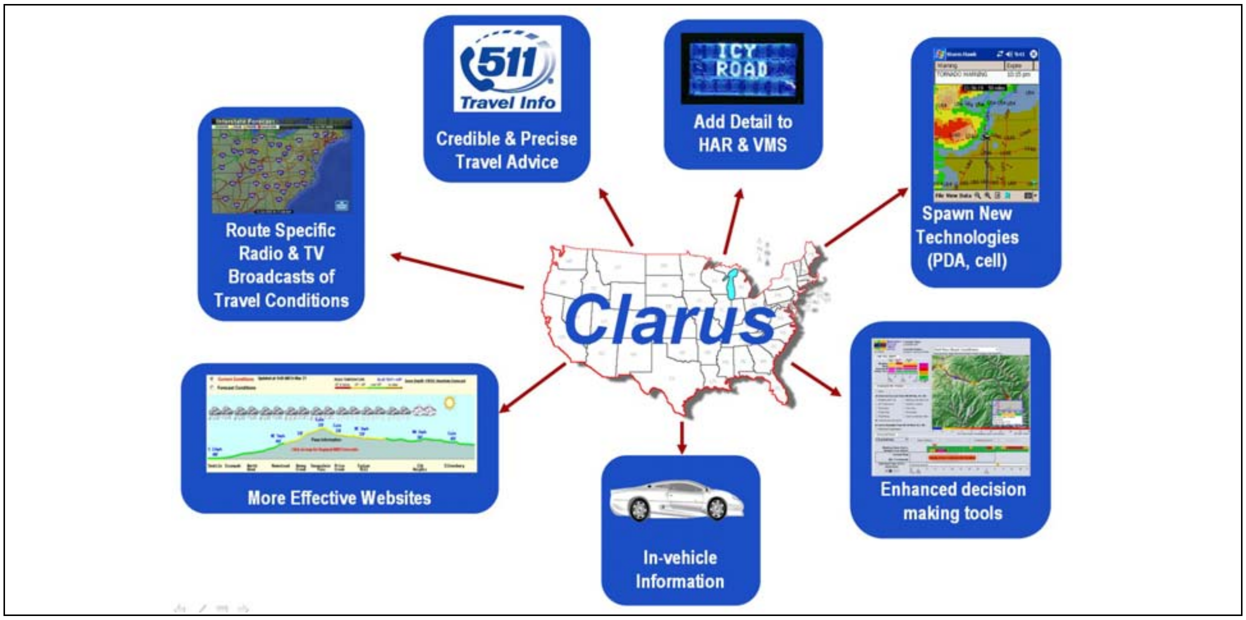

Figure 3.2 The Clarus system service opportunities. [1]

The main goal of the initiative is to create a robust data assimilation, quality checking, and data dissemination system that can provide near real-time atmospheric and pavement observations from the collective state's investments in road weather information system, environmental sensor stations (ESS) as well as mobile observations from Automated Vehicle Location (AVL) equipped trucks and eventually passenger vehicles equipped with transceivers that will participate in the Vehicle Infrastructure Integration (VII) Initiative.

Data

On the weather side, *Clarus* sources include **Doppler radar**, **personal observations**, **weather balloons**, **measurements of barometric pressure**, and **computer models** used by meteorologists. In transportation, it is the roadway surface information collected by the **over 2.500 weather stations** that gather data from sensors imbedded in the roadway, by **roadside weather sensors**, and in the future by **in-vehicle technology** as well.

Clarus data is implemented in the IntelliDrive system (chapter 3.2.1) and in RITIS (chapter 3.2.5.1).

Very enhanced data quality checks are carried out with the Clarus data. Figure 3.2 shows a corresponding data quality assessment for a specific road weather sensor. The following test routines can be applied:

- **Complete:** All tests that are going to be run have been.
- **Manual:** Set by DOT to indicate "Don't necessarily trust this value"
- **Sensor Range:** Observation compared to manufacturer's published minimum and maximum values
- **Climate Range:** Observation compared to climate minimum and maximum values per month by climatological region

- **Step:** Observation compared to previous observation to determine if the rate of change (plus or minus) was acceptable
- **Like Instrument:** Observation compared to the same observation types from the ESS
- **Persistence:** Observation compared to previous observation to determine if the values had changed over a period of time
- **Barnes Spatial:** Observation compared to neighbouring ESS to determine they are similar
- **Dewpoint:** Calculate a dewpoint value based on the temperature & relative humidity and then conduct a Barnes Spatial
- **Sea Level Pressure:** Calculate a sea level pressure from the station pressure and then conduct a Barnes Spatial

101008
Dane Co. US18/151 EB @ Sand Rock Rd.
Lat, Lon: 42.99399, -89.74561
Elevation: 334 m

Timestamp (UTC)	Observation Type	Value	Complete	Manual	Sensor Range	Climate Range	Step	Like Instrument	Persistence	Barnes Spatial	Dewpoint	Sea Level Pressure
2009-08-24 11:05	essAirTemperature (C)	10.40	●	–	●	●	–		●	●		
2009-08-24 11:05	essDewpointTemp (C)	10.20	●	–	●	●	–		●	●		
2009-08-24 11:05	essRelativeHumidity (%)	99.00	●	–	●	●	–		✗	●	●	
2009-08-24 11:05	essSubSurfaceTemperature (C)	22.90	●	–	●	●	–	–	✗			
2009-08-24 11:05	essSurfaceStatus	3.00	●	–	●							
2009-08-24 11:05	essSurfaceStatus	3.00	●	–	●							
2009-08-24 11:05	essSurfaceStatus	3.00	●	–	●							
2009-08-24 11:05	essSurfaceTemperature (C)	14.60	●	–	●	●	–	●	●	●		
2009-08-24 11:05	essSurfaceTemperature (C)	14.00	●	–	●	●	–	●	●	✗		
2009-08-24 11:05	essSurfaceTemperature (C)	14.30	●	–	●	●	–	●	●	✗		
2009-08-24 11:05	precipIntensity	3.00	●	–	●							
2009-08-24 11:05	precipType	3.00	●	–	●							
2009-08-24 11:05	windSensorAvgDirection (deg)	300.00	●	–	●		–		●			
2009-08-24 11:05	windSensorAvgSpeed (m/s)	0.56	●	–	●	●	–		●	●		
2009-08-24 11:05	windSensorGustDirection (deg)	297.00	●	–	●		–		●			
2009-08-24 11:05	windSensorGustSpeed (m/s)	1.39	●	–	●	●	–		●	●		

Figure 3.3 Data quality assessment table for Clarus station 101008. [1]

The European transport service sector would benefit significantly if pan-European data system similar to Clarus could be established. If thoroughly planned, efficiently managed and quality controlled, well accessible and containing versatile traffic and weather information, the system would remove the most important barrier – poor access to necessary data - for innovating and implementing new transport services, as concluded in the ROADIDEA project (see D1.9 The Roadmap).

However, to establish such a system is a long and cumbersome process and it would require very broad commitment from transport and weather administrators and other stakeholders in all European countries. In the USA, the initiative took seven years from the initial start to reach the current pre-operational phase (see Fig. 3.4). Most but not all North American States provide data to the Clarus system.

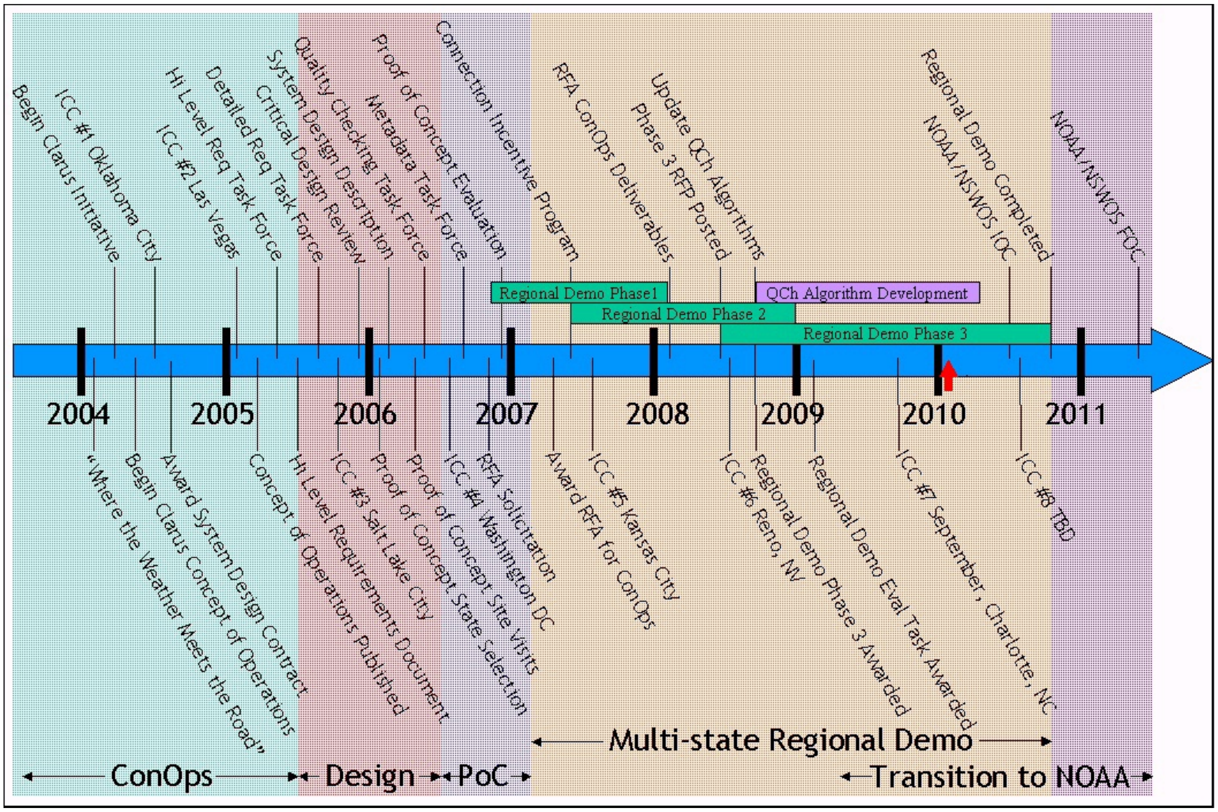

Figure 3.4 Clarus system Development Milestones. [1]

<u>Similar initiatives in Europe</u>

SIRWEC (Standing International Road Weather Commission) was originally set up in 1985 as SERWEC (Standing European Road Weather Commission). SERWEC became International in 1992 in the US, thus changing its name to SIRWEC accordingly.[2]

SIRWEC is operating as a forum for the exchange of information relevant to the field of highway meteorology. This shall include management, maintenance, road safety, meteorology, environmental protection and any other area of interest considered relevant by the Commission. From the information collected it is identifying those areas where increased and/or new research and development may yield improvements in practices, techniques, systems and methodology, to the general benefits of the art.
Furthermore, contact is to be initiated and maintained between the Commission and bodies such as COST, OECD, PIARC, WMO and other bodies so as to ensure that the work of the Commission is recognized.

To date, the following national and regional systems are set up in Europe:

- Baltic roads (Finland, Estonia, Latvia, Lithuania, Russia, Poland)
- Denmark
- Finland (Finnra Today)
- Germany (Federal Highway Research Institute)
- Iceland
- Lithuania

- Republic of Ireland
- Sweden
- Switzerland

Availability and provision of data, its penetration of the underlying road network, and the utilisation of data and derived information varies strongly between listed application areas. Especially data access is subject to national regulations.

Besides that, most European countries providing road weather data and aggregated information via public and private **weather data providers** (e.g. German Weather Services DWD in Germany). As stated above, national road weather provisions mostly underlie national regulations; no common level of service has been agreed on in a European scale so far.

3.2 Road Site Traffic monitoring – projects and initiatives

3.2.1 IntelliDrive

IntelliDrive is a multimodal initiative that aims to enable safe, interoperable networked wireless communications among vehicles, the infrastructure, and passengers' personal communications devices.

IntelliDrive research is being sponsored by the U.S. Department of Transportation (USDOT) and others to leverage the potentially transformative capabilities of wireless technology to make surface transportation safer, smarter and greener. USDOT research is supporting the development and testing of IntelliDrive technologies and applications, to determine their potential benefits and costs. If successfully deployed, IntelliDrive will ultimately enhance the safety, mobility and quality of life of all Americans, while helping to reduce the environmental impact of surface transportation.[3]

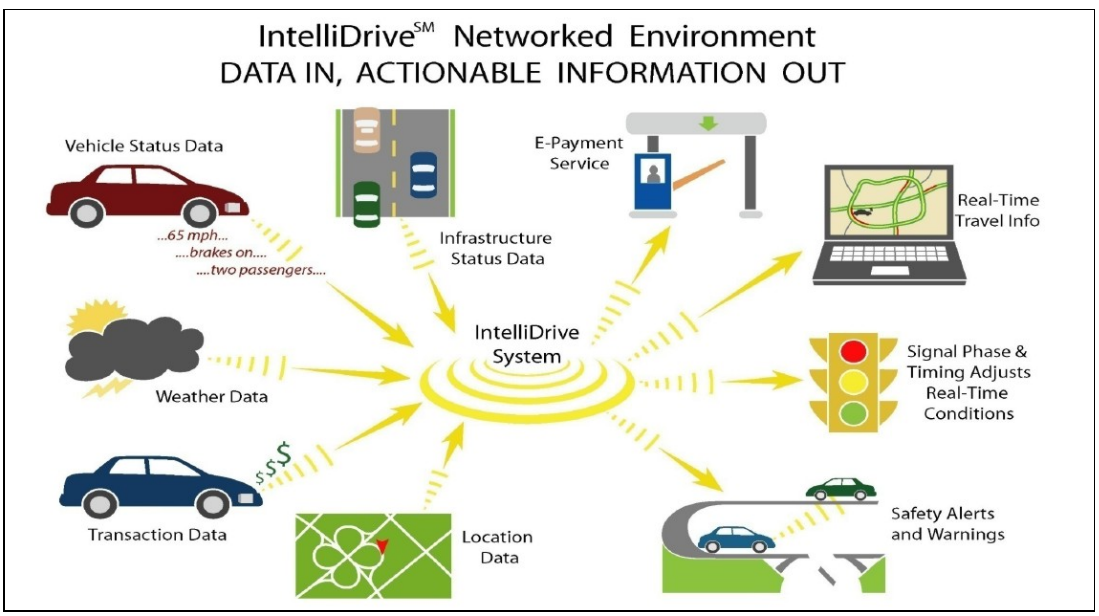

Figure 3.3 IntelliDrive Networked Environment

As shown in Figure 3.3 the IntelliDrive system is tapping several data sources on one hand side and on the other applications providing connectivity:

- Among vehicles to enable crash prevention;
- Between vehicles and the infrastructure to enable safety, mobility and environmental benefits; and
- Among vehicles, infrastructure, and wireless devices to provide continuous real-time connectivity to all system users.

IntelliDrive provides a starting point for transportation and information connectivity and is envisioned to ultimately encompass safety applications, mobility applications, and environmental applications.

IntelliDrive safety applications would enable vehicles to have 360-degree awareness to inform a vehicle operator of hazards and situations they cannot see. IntelliDrive **safety applications** have the potential to reduce crashes through advisories and warnings. For instance, vehicle operators may be advised of a school zone; sharp ramp curve; or slippery patch of roadway ahead. Drivers could also be advised of the presence of IntelliDrive-equipped bicycles and pedestrians around them, which would enhance the safety of pedestrians and bicyclists as well as motorists. Warnings could be provided more imminent crash situations, such as during merging operations put vehicles on a collision path, or when vehicle ahead stops suddenly.

IntelliDrive **mobility applications** are intended to provide a connected, data-rich travel environment based on information transmitted anonymously from thousands of vehicles that are using the transportation system at a particular time. This information could help transportation managers monitor and manage transportation system performance – for example, by adjusting traffic signals, transit operations, or dispatching maintenance crews or emergency services. This information could also help transportation agencies and fleet operators to manage crews and use resources as efficiently as possible.[1]

Under the IntelliDrive umbrella corresponding activities and projects are hosted and carried out. All of these are supporting the implementation of IntelliDrive’s overall goals and objectives. As being sponsored by the USDOT, it may also be considered as a strategic funding program for coordinated research, testing, demonstration and deployment activities. The program is working toward a future vision where vehicles and infrastructure are connected to enable crash less vehicles, and access to real-time data on the status of both vehicles and the roadway transforms transportation system management and operations to dramatically improve performance. The Federal research investment is targeted to areas that are unlikely to be accomplished through private investment because they are too risky or complex. Other stakeholders, including the States, the automotive industry and their suppliers, and consumer electronics companies, also are researching and testing IntelliDrive technologies and applications.

<u>Data</u>

To date the following data sources are used and applied within the IntelliDrive system:

- Vehicle Status Data: **Car CAN-bus data** (e.g. speed, wiper on/off, friction, lights on/off, etc.) is collected and exchanged with the system.
- Infrastructure Status Data: **Loop detectors and cameras** report the network status within observed regions and network segments. Given observations are analyzed and aggregated into travel time maps and status reports.

- Weather data: Using the **CLARUS system** (see chapter 2.2.1) road weather data is collected and exchanged with the system permanently.
- Transaction data: **Tolling information** is available. Analyzed and taking into special consideration.
- Location data: **Underlying network** topology is used for map matching given information and road status monitoring.

Currently IntelliDrive is investigating the possibility of leveraging existing vehicle fleets equipped with GPS and possibly with some CAN bus information (**FCD** – floating car data). Possible fleets include United Parcel Service (UPS), state DOT fleets (such as snowploughs), transit agencies, and various trucking companies. This is in addition to the small fleet of light vehicles that USDOT owns and operates in the Michigan test bed.

IntelliDrive data is to be provided and managed via the **Data Capture and Management Portal**. It is a USDOT prototype data environment that demonstrates how the collection, storage, and dissemination of real-time transportation data can occur in an operational environment. The resulting well-documented, distributed data resource will allow data captured from diverse sources to be integrated, shared, and leveraged by a broad range of researchers, private sector partners, and system operators. This prototype data environment will serve as a model for future data environments in motivating and defining emerging standards or data-related rule making.

Similar European projects

WiSafeCar is a Eureka-Celtic project involving partners from Luxembourg, Finland, France, Turkey and Spain. The overall aim of this project is to develop a reliable wireless traffic service platform to improve traffic safety, avoid traffic accidents and provide variety of new type of services to vehicles. This objective will be achieved by means of secure data collection from vehicles and fixed stations, secure dissemination of data between vehicles, and make use of such data for real-time transport service applications. The motivation of this project proposal came from Celtic's earlier project, CARLINK. The core members of WiSafeCar consortium have been working together in CARLINK, where intelligent way of creating wireless traffic platform for public transport services was researched and developed based on hybrid networking (Mobile WiMAX, WiFi, 2G/3G) and several innovative vehicular applications. It was realized in CARLINK that such platform should have some way to protect and authenticate data in order to provide reliable services in wireless vehicular communication environment [11].

eCoMove is another European Commission funded Integration Project (IP) under the seventh framework program of Information Society Technology, started April 2010. The eCoMove project will create an integrated solution for road transport energy efficiency by developing systems and tools to help drivers sustainably eliminate unnecessary fuel consumption (and thus CO2 emissions), and to help road operators manage traffic in the most energy-efficient way. By applying this combination of cooperative systems using vehicle-infrastructure communication, the project aims to reduce fuel consumption by 20% overall. This target can be achieved by:

- Saving unnecessary kilometres driven (optimising routes)
- Helping driver to save fuel (optimising driver behaviour)
- Managing traffic more efficiently (optimising network management)

The eCoMove concept rests on the idea that, for a given trip by a particular driver in a particular vehicle, there is some least possible fuel consumption that could be achieved by the "perfect eco-driver" travelling through the "perfectly eco-managed" road network. In reality, both drivers and traffic management systems fall short of this ideal, and much fuel is wasted and CO2 emitted un-necessarily. The eCoMove innovations will target the two sources of this avoidable fuel consumption: private trips and freight/logistics trips. Figure 3.4 shows the expected eCoMove benefit after implementing planned project integrations.

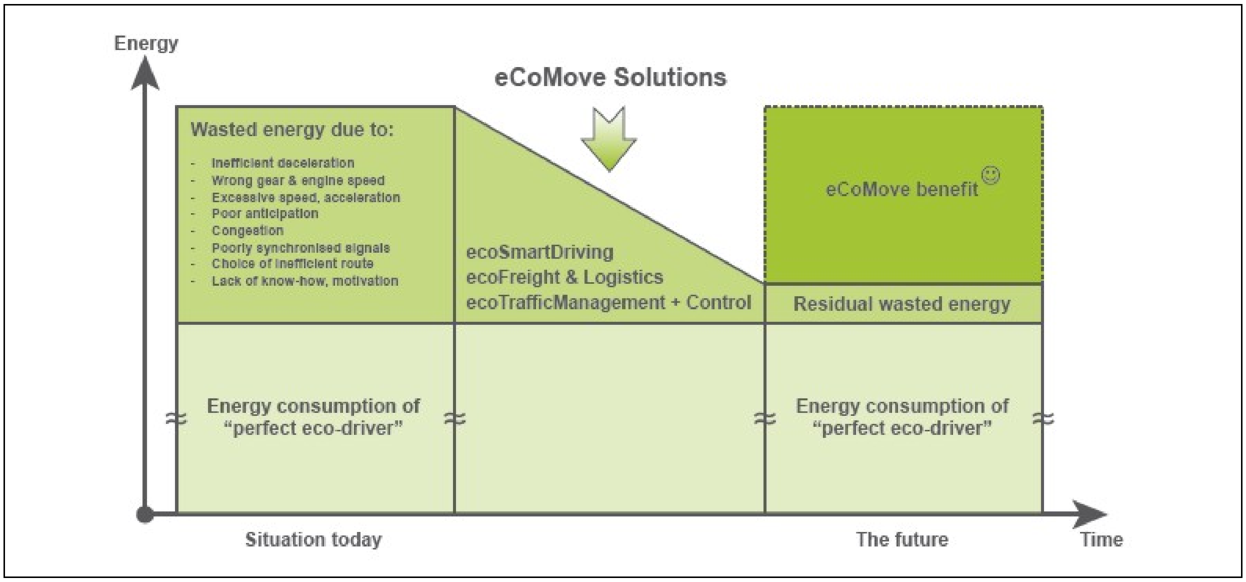

Figure 3.4 The expected eCoMove benefit

The aim of project **CARLINK** [12] was to develop an intelligent wireless traffic service platform between cars supported with WLAN transceivers beside the road(s). In this perspective also the WiMAX (Worldwide Interoperability for Microwave Access) network is analyzed. The primary applications are real-time local weather data, the urban transport traffic management, and the urban information broadcasting. CARLINK was conducted end of 2008.

The R&D project **CVIS** [13] co-funded by the European Union under the ICT (Information and Communication Technologies) priority of the 6th Framework Programme for Research aims to design, develop and test the technologies needed to allow cars to communicate with each other and with the nearby roadside infrastructure. CVIS' achievements will be applied in test sites in seven countries across Europe, to increase road safety and efficiency and reduce the environmental impact of road transport.

SAFESPOT, co-funded by the European Commission Information Society and Media and supported by EUCAR, is working to design cooperative systems for road safety based on vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. In order to prevent road accidents SAFESPOT developed a "Safety Margin Assistant" to detect in advance potentially dangerous situations and extend, in space and time, drivers' awareness of the surrounding environment. The Safety Margin Assistant is aiming to provide reactive driver support levels for 3 safety stages before the crash. In the Comfort Zone the system has to inform the driver, but the reaction needed (to avoid a possible accident, or to cope properly and safely with the given scenario for a specific application) is very comfortable. In the Safety Zone the situation is already relevant for safety and the driver has to react in a significant timeliness to safely comply with the road scenario. The Critical Zone is the zone just before a possible collision. In this zone, the driver has to react immediately and with the correct manoeuvre in order to avoid the accident.[14]

3.2.2 Portal

As it also applies to Europe, in the USA an uncountable amount of local and regional portals are online, providing information about traffic situations and related information such as road works, accidents, incidents, events, etc. The PORTAL system in Portland/Oregon is to be considered as a striking example, which offers a lot more than “only” traffic situation information.

The Portland Oregon Regional Transportation Archive Listing (PORTAL) is the official transportation archive for the Portland-Vancouver metropolitan region. The purpose of this project is to implement the U.S. National ITS Architecture's Archived Data User Service for the Portland-Vancouver metropolitan region. This system is being developed at Portland State University by students and faculty in the Intelligent Transportation Systems Laboratory.[4]

PORTAL was initially established in 2004 with a simple web interface and a single data source – freeway loop detector data from the Oregon Department of Transportation (ODOT). Since then PORTAL has grown into a large, complex system with a one-terabyte archive of transportation-related data and a web site with over 20 different pages featuring a wide variety of graphical and tabular displays of data. PORTAL is widely used by local transportation professionals; it has been used in the development of the Regional Transportation Plan, by the local news media, and in numerous research projects at the Intelligent Transportation Systems (ITS) Lab at Portland State University (PSU). PORTAL was originally developed as a research platform and has achieved its initial goals.

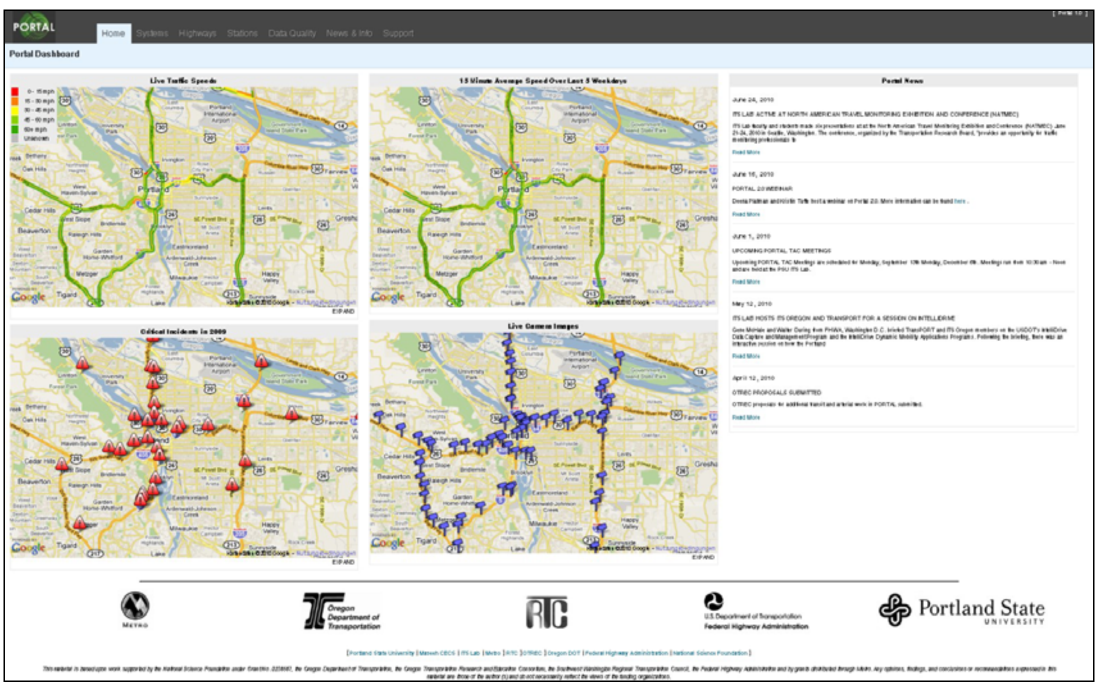

Figure 3.5 PORTAL Home Entry

As indicated with figure 3.5 PORTAL provides a unique opportunity to re-think the type of applications that can be made available to data archive users. Systems such as Portal 2.0 have a variety of users who have different needs and interests. Some users simply want to glance at current traffic conditions. Users such as traffic managers may wish for a more-detailed analysis or understanding of a current or recent traffic event. Users such as urban planners need trending and forecast information to help with the development of medium and long-term plans for the urban area. Finally, some users, including researchers and transportation department staff, wish to do in-depth, detailed analysis of the data, for example for research projects or performance reports [3].

While accessing aggregated information online, registered users may download raw data directly for their own analyses and applications. Results can be compared with PORTAL data aggregations; new applications are welcome to be included in the PORTAL. This collaboration aspect is making PORTAL a very special traffic information portal.

Data

PORTAL archives 20-second speed, count, and occupancy data from the approximately 600 inductive **loop detectors** in the Portland, OR and Vancouver, WA metropolitan region. Additionally, PORTAL stores other transportation-related data including data on **weather, incidents**, and variable message sign displays in addition to **bus AVL** and **truck weigh in motion records**. The ITS infrastructure in the Portland region also includes nearly **100 CCTV cameras**, 138 ramp meters, transit signal priority, advanced bus dispatch system, and an extensive fibre optics network. The regional transportation agencies (including Portland State University) are connected via a high speed (gigabit) ethernet ITS network that facilitates data sharing and interoperability [3].

Similar European Portals and Activities

There is a huge number of local and even regional multi-modal route planning and traffic state monitoring portals in Europe. Especially for metropolis regions it seems to be mandatory to provide multi-modal information about travel times (most commonly via color-coded maps), park-and-ride possibilities, construction sites information, and congestions. Some portals provide traffic forecasts; a few even implement weather information.

One outstanding example amongst thousands of portals in Europe is **www.anachb.at**, which collects and provides traffic information for road and public transport for the Austrian Vienna region. Figure 3.6 on the next page depicts the traffic situation using color-coded maps with special respect to ongoing road works, roadblocks and some more available information. It is also very common to add available cameras to such map views, in order to provide visual real time information by video.

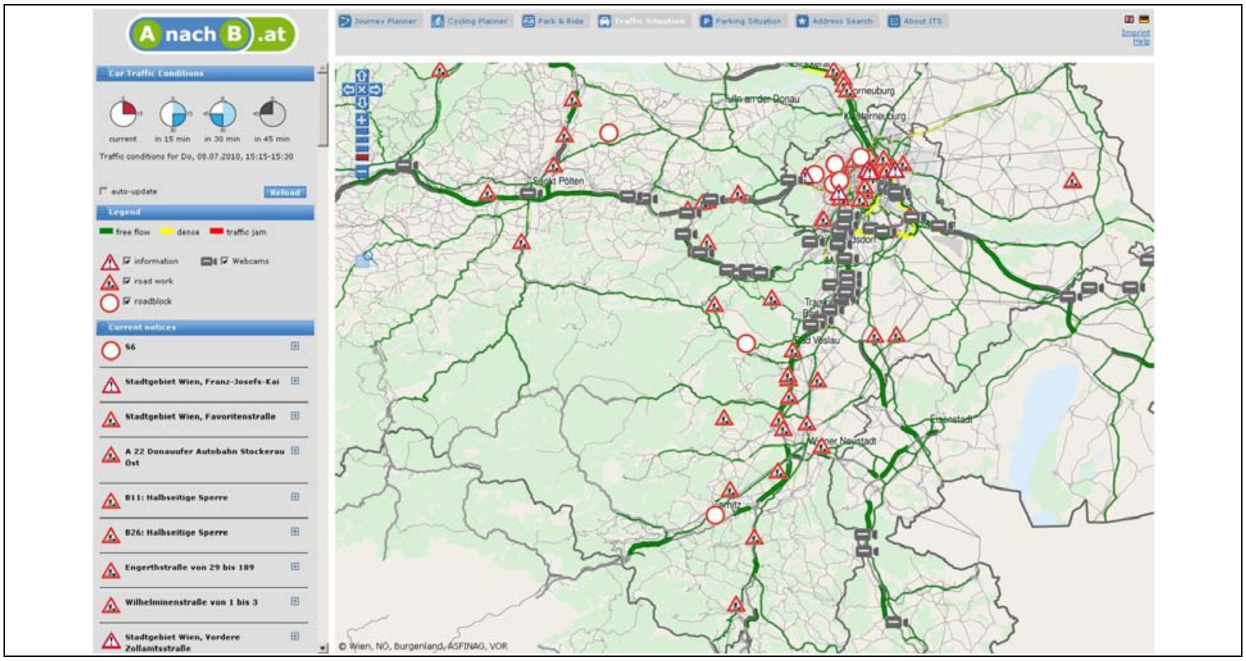

Figure 3.6 AnachB.at - Traffic Situation in the Vienna region

The calculation of link speeds, to be visualised as colored network elements, is based on loop detector data and floating car data (**FCD**). GPS equipped probe vehicle are permanently penetrating the traffic flow, sending their timestamp and position and, thus, allowing a calculation of link speed while taking into account actual data from high reliability and quality.

3.2.3 I-95 Corridor Coalition

I-95 Corridor Coalition is the only north-American initiative which has to be considered as a real global cross-border implementation for a number of similar traffic related local problems of different federal states in the U.S. 17 federal states from north-east Maine to south-east Miami are joining forces to follow the vision “that the transportation network in the region will be safe, efficient, seamless, and intermodal, and will support economic growth in an environmentally responsive manner”. [5]

Figure 3.7 I-95 Corridor Coalition Travel Time Information Application

The I-95 Corridor (for map visualisation see figure 3.7) Coalition is an alliance of transportation agencies, toll authorities, and related organizations, including public safety, from the State of Maine to the State of Florida, with affiliate members in Canada. The Coalition provides a forum for key decision and policy makers to address transportation management and operations issues of common interest. This volunteer, consensus-driven organization enables its myriad state, local and regional member agencies to work together to improve transportation system performance far more than they could by working individually. The Coalition has successfully served as a model for multi-state/jurisdictional interagency cooperation and coordination for over a decade.

The Coalition began in the early 1990's as an informal group of transportation professionals working together to more effectively manage major highway incidents that impacted travel across jurisdictional boundaries. In 1993, the Coalition was formally established to enhance transportation mobility, safety, and efficiency in the region.

During the 1990’s, the focus of the Coalition's program evolved from studying and testing intelligent transportation systems (ITS) technologies to a broader perspective that embraced integrated deployments and coordinated operations. The Coalition's perspective evolved from a concentration on highways to one that encompasses all modes of travel and focuses on the efficient transfer of people and goods between modes. Facilitation of regional incident management in areas such as pre-planning, coordination and communication among transportation and public safety agencies in the corridor remains a key part of the Coalition’s focus. Today, the Coalition emphasizes information management as the underpinning of seamless operations across jurisdictions and modes [5].

Figure 3.7 is depicting both the map visualisation of I-95 corridor and connected highway network stretches and the main usage of I-95 corridor data – namely for traffic status monitoring and travel time information purposes.

The system is supposed to support the following areas [5]:

- Travel Information Dissemination
  In addition to the development of a regional vehicle probe travel data collection and dissemination program, the Coalition's activities include promotion of integrated 511 Corridor-wide information, travel information coordination efforts, and operation of this website to facilitate rapid distribution of current information.
- Coordinated Operations
  Traffic management, law enforcement and other incident response personnel assist each other when major incidents occur by sharing information and equipment. They meet regularly to discuss how emergencies can be handled more effectively
- Intermodal Transportation
  The Coalition is working to facilitate safe, efficient and reliable movement of people and goods across all modes. This includes projects to improve information at connections between rail and airport stations, and to improve the flow of freight and passenger traffic in the region to and around port areas.
- Education and Training
  The Coalition provides training, best practices workshops/reports, and information exchange meetings related to improving management and operations for transportation.
- Electronic Payment Services
  The Coalition is supporting projects that advance interoperability between transit and toll agencies for bankcard/smart-card based fare payments
- Information Systems
  Development of both real-time and archived data sharing information systems is underway to assist member agencies with analysis, planning, long-distance travel information and incident management.
- Safety
  The Coalition serves as a vehicle for disseminating information about best practices and lessons learned from other safety initiatives in the region and assists members with identifying solutions to their safety needs.

The I-95 corridor coalition is linked with the IntelliDrive network and implemented in the SafeTrip-21 initiative, which is to demonstrate how ITS technology can improve safety and enhance the travel experience using readily available wireless communications devices. In addition, SafeTrip-21 will introduce new technologies designed to share valuable, real-time information to help prevent vehicle crashes and alleviate congestion in both urban and rural settings.

Data

Along 1.917 miles of corridor I-95 and up to 40.000 connected national highway system miles data is integrated and used for a huge number of applications and services in a local, regional and corridor scale. The primary source of data is **probe vehicle data**. There are a few regions in the multi-state coverage area (now spans from New Jersey to North Florida) that have some **loop detectors or radar detectors** provide by local public and private companies.

The **I-95 Corridor Coalition's Vehicle Probe project** is a collaborative effort among the I-95 Coalition, University of Maryland and INRIX providing comprehensive and continuous real-time travel information to members.

The Vehicle Probe Project

The University of Maryland has developed a probe technique to monitor the travel time on highways and arterials based on signals available from the point-to-point networking protocol commonly referred to as Bluetooth. The majority of consumer electronic devices produced today come equipped with Bluetooth wireless capability to communicate with other devices in close proximity. For example, many digital cameras use Bluetooth for downloading pictures to a laptop computer. It is also the primary means to enable hands free use of cell phones. Bluetooth enabled devices can communicate with other Bluetooth enabled devices anywhere from 1 meter to about 100 meters, depending on the power rating of the Bluetooth sub-systems in the devices. The Bluetooth protocol uses an electronic identifier, or tag, in each device called a Machine Access Control address, or MAC address for short. The MAC address serves as an electronic nickname so that electronic devices can keep track of who's who during data communications. It is these MAC addresses that are used as the basis for obtaining traffic information. The concept for deriving traffic information in this manner is illustrated in Figure 3.8.

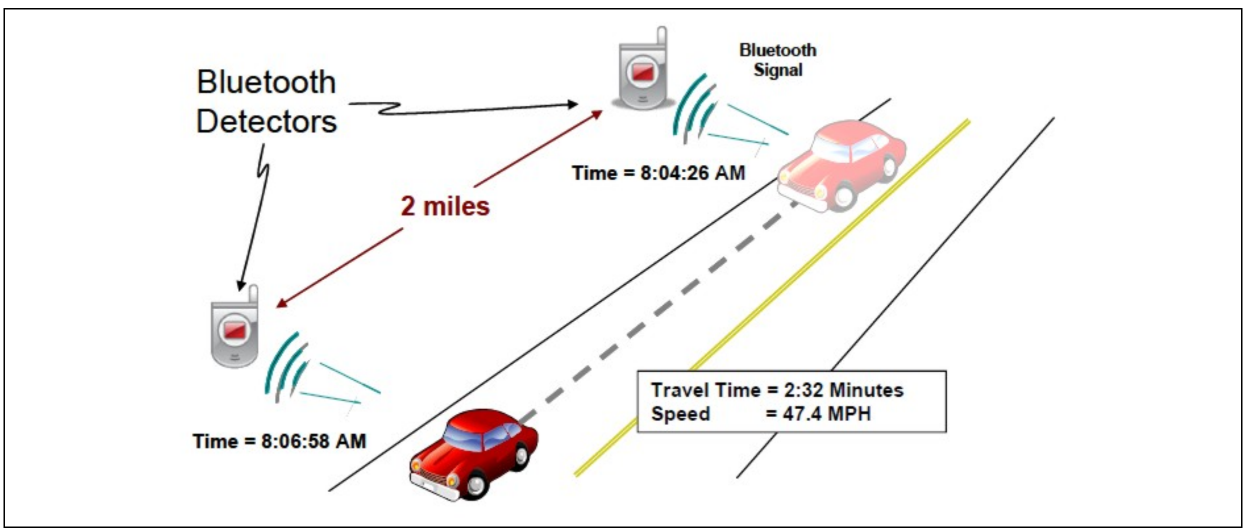

Figure 3.8 Bluetooth traffic monitoring operation concept

Figure 3.8 also shows that described Vehicle Probe Data (VPD) technology does not mean Floating Car Data (FCD) technology (also known as probe vehicle data in Europe) as widely in use in Europe. European FCD uses GPS-equipped vehicle as probes penetrating the traffic, sending their timestamp, position and nowadays vehicle parameters via UMTS or SMS to a server instance for mostly fleet disposition purposes. While technology and outcome (travel time per link/observed network element) can be compared, approaches differ in terms of implementation costs, penetration rate and reliability. (See also chapter 3.2.6 on General Conclusions and Remarks!)

I-95 Corridor Coalition member agencies benefit from the Vehicle Probe project by receiving travel time and speed data to support the dissemination of travel information using 511 and websites; display of travel times on variable message signs, traffic management during incidents and performance measurement. Coalition members are able to use this contract to expand travel data coverage within their jurisdictions, develop websites and interface with existing traffic management systems.

Similar European projects and coalitions

EasyWay is a project for Europe-wide ITS deployment on main TERN corridors driven by national road authorities and operators with associated partners including the automotive industry, telecom operators and public transport stakeholders. It sets clear targets, identifies the set of necessary ITS European services to deploy (Traveller Information, Traffic Management and Freight and Logistic Services) and is an efficient platform that allows the European mobility stakeholders to achieve a coordinated and combined deployment of these pan-European services.

EasyWay incorporates all current Euro Regions and facilitates the integration of new Member States and new areas such as the Baltic countries, Greece and Southern Italy. It reinforces the co-operation between the existing participating countries by providing a new integrated framework with clear objectives and reporting.[6]

EasyWay can be compared with the I-95 Corridor only partly. The levels of implementation of real end user services, common data acquisitions and public visibility are very different. While EasyWay is considering necessary technological prerequisites and supporting the definition of legal conditions and regulations, has the I-95 corridor to be considered as an operational system joining forces of several federal states in America in order to improve daily road traffic conditions and monitoring. The idea as such and its degree of implementation into real services should be taken as a how-to for an open European road networks solution.

Again, the main driver for I-95 Corridor Coalition success was and is that under the leadership of only one planning and administrative body (USDOT) it was possible the overcome administrative barriers and cross-border limitations.

As pointed out in several ROADIDEA reports, as long as no common availability of - at least the most necessary road traffic - data along main European road traffic corridors (TERN) is given under the governance of the European Commission, one can not expect a successful implementation of any cross border ITS services in Europe. The target for near future European service development has to be to apply similar services along long distance routes from for instance Sicily to the North of Sweden, as it is possible along 4000 miles of I-95 from Miami to Maine or even Montreal in Canada.

3.3 National Department of Transportation (DOT) and Federal Highway Administration (FHWA)

National and Federal Departments of Transportation (USDOT and xDOT) have to be considered as the main planning and administrating key role players within the overall U.S. transportation system. As part of DOT Federal Highway Administration (FHWA) is charged with the broad responsibility of ensuring that America's roads and highways continue to be the safest and most technologically up-to-date. Although State, local, and tribal governments own most of the Nation's highways, FHWA provide financial and technical support to them for constructing, improving, and preserving America's highway system. FHWA's annual budget of more than $30 billion is funded by fuel and motor vehicle excise taxes. The budget is primarily divided between two programs:

- Federal-aid funding to State and local governments;
- and Federal Lands Highways funding for national parks, national forests, Indian lands, and other land under Federal stewardship.[7]

FHWA pursue the mission and vision by focusing on four strategic goals:

- System Performance – The Nation's Highway system provides safe, reliable, effective and sustainable mobility for all users.
- National Leadership – FHWA leads in developing and advocating solutions to national transportation needs.
- Program Delivery – Federal Highway programs are effectively and consistently delivered through successful partnerships, value-added stewardship, and risk based oversight.
- Corporate Capacity – Organizational resources are optimally deployed to meet today's and tomorrow's missions.

FHWA is responsible for

- 46.934 miles (75.533 km) of Interstate highway,
- 116.813 miles (187.992 km) of other National Highway System roads and
- 3.884.777 miles (6.251.943 km) of other roads. [7]

xDOT and FHWA may be compared with transport ministries and road authorities in the European member states, whereas European countries are mostly further separated into federal states with its own authorities, local/federal regulations and responsibilities. In addition to that, the European Commission is acting as a roof authority, covering all European Commission member states and is applying additional regulation and frameworks. So, the regulative European system is far more complex than the U.S. DOT with its federal departments.

In terms of data one specific FHWA initiative (amongst a variety of others) is to be highlighted here. In cooperation with the private company Chaparral Systems Corporation, **TRADAS** (for TRAffic DAta System), as the only comprehensive traffic data collection management, quality control, and analysis software product available [8], has been developed in order for collecting, editing, summarizing, and reporting a wide range of traffic data. Its functionality includes:

- Calculation of site-specific HPMS statistics.
- Support for turning movement counts.
- New annual phase 4 "site AADT" calculations that maintain current-year statistics for all sites, regardless of count year.
- Enhanced support for the modification of site attributes.
- Optional Count Scheduler that provides a count schedule, field sheets, and up-to-date status information about the short-term count program.

It may be considered as a U.S. data collection and storing standard, which also includes advanced analyzing and quality control functions. Most U.S. applications and data warehouses dealing with automated data collection, storage and analysis are based on TRADAS backbone.

Another outstanding DOT initiative is **Clarus**, which is described in detail in chapter 3.1.

3.4 Latest University Research Activities

During ROADIDEA INCO's "fact finding missions" only a few visits of transport oriented research institutes at U.S. universities could be made within the very limited time frame. The following sub-chapters are intended to be considered as outstanding examples for university research on the field of acquisition, fusion and provision of transport related data. Besides those face-to-face meetings in Seattle (Washington University) and College Park (University of Maryland) a lot of valuable talks have been made with U.S. and Canadian researchers at different workshops and conferences. Corresponding conference proceedings and workshops minutes have been studied in order to get a better insight in ongoing and future data related research activities.

Another example for a lively cooperation between a public sector project, a private sector data provider and University research is described in chapter 2.2.2.3 I-95 Corridor Coalition with the I-95 Corridor Coalition vehicle Probe Project using Bluetooth vehicle probe technology developed at the University of Maryland.

3.4.1 CATT Laboratory at the University of Maryland

The University of Maryland's (UMD) Center for Advanced Transportation Technology Laboratory (CATT Lab) supports National, State, and local efforts to provide safe and efficient transportation systems through improved operations and management by means of research and development, technology implementation, training and education.[9]

The CATT Lab's research and development activities provide a bridge between the intelligent transportation systems (ITS) community, the information technology community, and other disciplines essential to the successful application of ITS. Though a complete list of our research initiatives can be seen in the research section of this website, the CATT Lab specializes in:

- data archiving
- data retrieval tools
- data visualization
- 3D modeling and simulation
- traveler information systems
- video image processing
- software development

<u>Regional Integrated Transportation Information System (RITIS)</u>

RITIS is an automated data sharing, dissemination, and archiving system. RITIS improves transportation efficiency, safety, and security through the integration of existing transit and transportation management data in Virginia, Maryland, and Washington D.C. The emphasis of RITIS is on data fusion and standardization, and their relationship to data collection, regional transportation systems management, regional traveller information dissemination, and system evaluation. RITIS automatically fuses, translates, and standardizes data obtained from multiple agencies in the region in order to provide an enhanced overall view of the region's transportation network. Participating agencies are able to view regional traffic information and use it to improve their operations and emergency preparedness. RITIS uses regional standardized data to enable traveller information, including web sites, paging systems, and 511. The two main RITIS functions include - the real-time fusion and exchange of regional transportation data; and data archiving.

With the 4D data visualisation application CATT offers a very intuitive and innovative way of mapping multimodal traffic, weather, accident, and incident data to a three-dimensional urban road network.

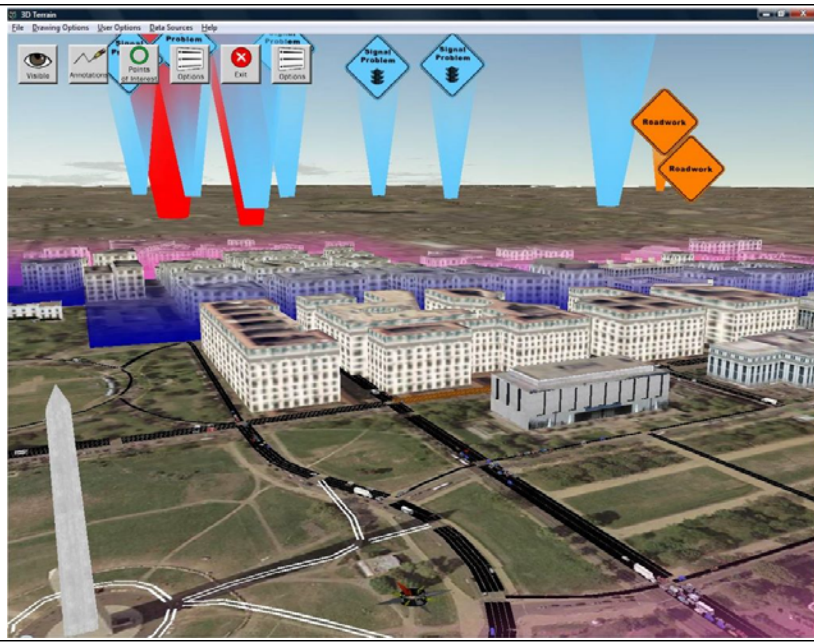

Figure 3.9 RITIS 4D data visualisation

Virtual road occupancy, calculated from actual road traffic observations, shows the actual traffic situation on road network stretches. Accidents, incidents and construction sights are highlighted with different and intuitive colour codes. Weather situations and given visibilities can be visualised; event data (e.g. parades) can be planned and managed; traffic cameras and public transport schedules are embedded.
Users can fly through the virtual scenery using a game controller, which gives a very realistic feeling of flying a surveillance helicopter. So, traffic managers and decision makers have a very good idea of the spatial environment of an event or incident and can see traffic situations, congestions and all kinds of traffic related issues very lively. This may support decision making and future traffic planning (e.g. construction planning) reliably.

<u>Data</u>

RITIS is applying a huge variety of transport and weather related data sources as well as a lot of infrastructure and points-of-interest data.

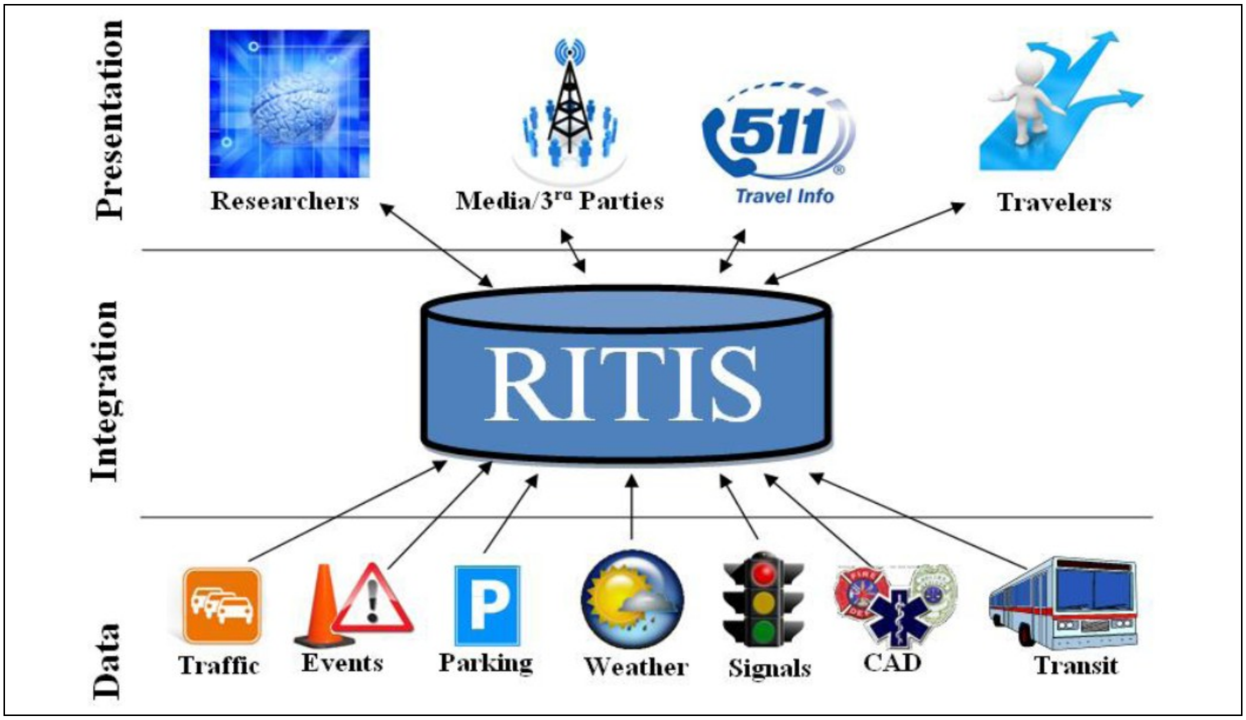

Figure 3.10 RITIS Diagram – From Data to Application

Following data sources are integrated into RITIS:

- Traffic
  Sensor types: Loop, RTMS, ATR, acoustic, microwave, probe vehicles
  Collecting: Speed, volume, occupancy, travel time
- DMS
  Sign types: Portable and permanent, incident management, and traffic control
  Collecting: Messages, message formats, time intervals, beacons
- Event/Incident
  Event types: Planned events, incidents, construction, weather
  Collecting: Location, severity, proposed and actual time intervals, fatalities/injuries, lane closures, responders and equipment, vehicles, hazmat, associated events
- Weather
  Weather types: Weather alerts, weather radar
- Transit
  Transit types: Bus and train AVL, scheduling, next arrival, detours, vehicle status, PID information
- FITM Plans
  Types: Freeway Incident Traffic Management Plans
  Collecting: Plans, plan invocation times
- GIS
  GIS types: Road network, terrain, evacuation routes
- Media
  Types: Images, video, sound, documents
  Collecting: Traffic cameras, radio communications

For the near future the implementation of the following data types is planned:

- CAD
  Types: Computer Aided Dispatch
  Collecting: Event information
- Signal Systems
  Types: Signal timing plans, signal status
- Flight Information
  Types: Aircraft locations, direction, altitude, speed

General public and private sector data consideration

As being in contact with several private data providers (e.g. INRIX, traffic.com, SpeedInfo, etc.) and implementing private data sources in RITIS, UMD/CATT has gained an expertise in data related real time operations and accesses.

When setting up RITIS and aiming at defining specific data use agreements correspondingly, on the public sector UMD's challenge was to deal with different DOT's data use agreements both within state and across state lines. Obviously, no common USDOT data access policy was given, which could have been taken as a regulative template for needed data use agreements. USDOT did not really make use or realising the true value of their right-of-way in terms of public funded data acquisitions so far.

When it came to an implementation of private sector data provider's data, specific use agreements had also to be arranged with those companies. Very restrictive data use regulations made data research possible but, partly, did not allow any publication of derived information such as performance measures. For instance, data from agency traffic.com could be used for internal real time operations, but – due to data use agreement - on CATT's website no actual speed could be displayed. Furthermore, it was not allowed to use the data for public studies and research publications, which effectively made the data worthless for research purpose and traveller information. Another data provider (only in the Washington D.C. region) had a reasonable data use agreement for displaying valuable information on websites. This company got no allowance to install measurement devices in adjacent states Maryland and Virginia. With INRIX, as the biggest traffic data provider in the U.S., a standard data use agreement for all I-95 coalition states (see chapter 3.2.3) could be defined, with which INRIX data is allowed to be used for real time operations, traveller info, displaying travel time of variable massage signs (VMS), and for archival functions such as performance measures and research purposes. The definition of a common data use agreement with INRIX could be achieved after a longer period of discussions and research, in which general elements have been identified and fixed. Finally, the creation of the data use agreement has been put out as a competitive process. (INRIX won and got the business.)

When defining common data use agreements, also different data access levels for different user groups and purposes had to be taken into account. Three groups of users have been identified:

- Agency users: i.) Real-time Operations, ii.) Travel Information, iii.) Planning, iv.) Performance Measures
- Researchers: University research with respect to whether they acting independently of on behalf of the DOT.
- Consultants: Performing studies for the DOT

The lesson learned from this process could also be from value for corresponding standardisation efforts of the European Commission. As defined as the major barrier when trying to get access to similar data sources all over Europe in ROADIDEA, EC as the regulative authority has to define common European data use, minimal availability and access regulations for all European Union member states – in order to pave the European way for common ITS services for road safety, security and mobility for travellers and goods.

3.4.2 Star Lab – University of Washington

The laboratory for Smart Transportation Applications and Research (STAR Lab) at the University of Washington (UW) was established in 2003 in order to enhance the strength of ITS research and education at the UW. Major objectives of the STAR Lab are:

- support advanced ITS research;
- cultivate ITS professionals;
- explore effective solutions to transportation problems;
- provide hand-on training instruments and software applications for students in ITS classes;
- and construct a bridge between the UW and agencies of transportation practice.[15]

From the great variety of ITS research topics in the following two projects dealing with transportation related data acquisition and provision are to be explained more detailed.

<u>Bluetooth based vehicle probe data acquisition</u>

This traffic data acquisition using Bluetooth vehicle probes relies on identifying and matching the median access control (MAC) address of each Bluetooth device carried by bypassing vehicles for travel time data collection. In this respect StarLab is focussing on a more general technological research regarding the inherent error rate of these data collection devices. Furthermore, the use of multiple devices in tandem to improve results is to be investigated. So, Bluetooth MAC address-based travel-time sensors developed by StarLab are being compared with the standard automatic license plate recognition (ALPR) devices for travel time data collection. Two types of antenna, omni-directional and directional, are in use to determine the effects of antenna selection on travel time data collection. Omni directional sensors were found to have a larger detection zone than the directional sensors and are subject to more noise and bigger spatial errors because a vehicle may be detected anywhere within the zone. Meanwhile, a larger detection zone also corresponds to a bigger sample size. Test results indicate that although the Bluetooth sensors tended to be biased towards slower vehicles, the travel time measurements obtained are representative of the ground truth travel-time data measured by the ALPRs.

StarLab researches see a great potential to apply this approach for cost-effective travel time data collection.

<u>Drive Net</u>

Drive Net is an open source platform for region-wide, web-based transportation decision systems which adopts digital roadway maps as the base and provides data layers for integrating multiple data sources. The system, named **Digital Roadway Interactive Visualization and Evaluation Network** (DRIVE Net), enables connections and interoperability of the separated database systems through properly designed and implemented ontology and taxonomy of the currently isolated data sets. The system allows exterior data to be plugged into an existing data warehouse, allowing for previously difficult multi-field data analyses to be undertaken through a user friendly, abstracted, interface.[16]

With figure 3.11 the web appliance of Drive Net is given. For the arterial network a color-coded real-time map is given. The menu on the left may give an impression of what can be made with the data collected and stored in the Drive Net data warehouse. Not all options could be shown graphically here. (See [16] for exploring Drive Net web site.)

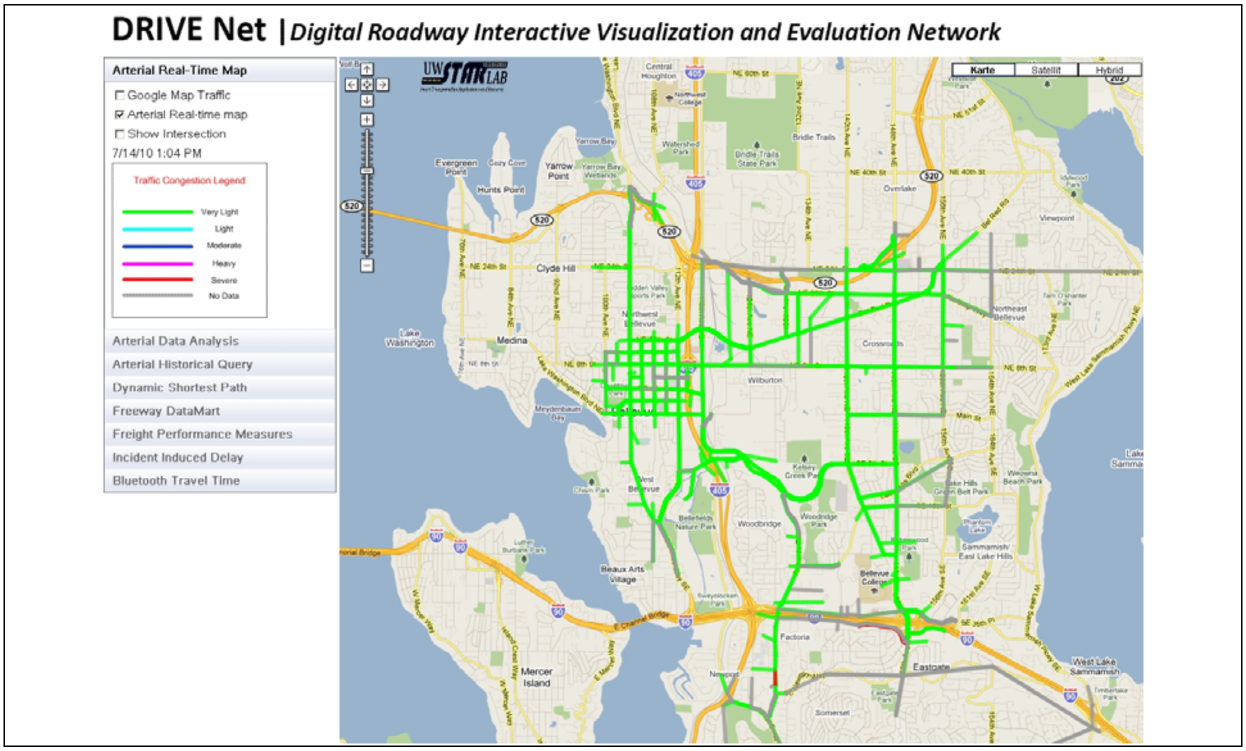

Figure 3.11 Drive Net data monitoring front end

DRIVE Net is accessing the following data:

- WSDOT (Washington State DOT) freeway loop detector data,
- City of Bellevue arterial traffic data,
- GPS data for truck fleets, and
- Washington State Incident Database

DRIVE Net can be used not only as a practical tool for various transportation analyses but also to help evaluate the benefit of a specific transportation solution. Currently, DRIVE Net allows users to access freeway and arterial data collected and hosted by the STAR Lab and its partners. Basic functionality includes the ability to select and download archives from the STAR Lab Data Mart, visualizing real-time and historical observations both spatially and temporally (e.g. user customizable traffic flow maps), optimized routing based real-time traffic and a modular framework that will be added to as needs arise.

Transportation agencies can benefit by using visualization to locate congestion areas under their jurisdiction. **Researchers** can have access to the stores of data behind DRIVE Net. The **public** benefits from trip planning and commuter route selection based on historical and real time data.

3.5 Development of ITS and mobility services in Canada

Due to its vast area and relatively small population, in Canada the provision of comprehensive mobility services and road maintenance in a sustainable manner is particularly challenging. Since 1999, Canada has offered co-funding to more than 150 projects to encourage the development and deployment of Intelligent Transport Systems. The results of 39 projects funded by Canada's ITS Deployment Plan for Canada are presented in [17], including services in traveler information, traffic management, public transportation management, electronic payment, emergency management, and information management.

Canada's ITS vision is to create an environment that will stimulate the collaborative development and deployment of ITS across urban and rural Canada to improve safety, maximize the use and efficiency of the existing multi-modal transportation system, and make Canada's ITS industry a leader by positioning it to meet future Canadian needs and to complete in the growing global marketplace.

ITS Architecture for Canada (version 2.0) was launched in February 2010 by Transport Canada. It is based on and highly compatible with the respective US ITS Architecture, providing the interfaces and technical standards for linking service areas and supporting technologies. It was the first one to introduce weather and RWIS into the architecture, which were then later added to the architecture in the US as well. Testbeds in V-to-V and I-to-V cooperative systems have been created. The architecture is available online at www.tc.gc.ca/innovation/its/eng/architecture.htm .

The Canadian RWIS network is operated across Canada by federal, provincial and territorial governments. All participants share raw data with Environment Canada, which conducts quality checks and ensures data integrity. However, the ownership of data remains within the originators, which are allowed to define their data delivery and licensing conditions independently. As a result, data policies differ from region to another, some being more liberal and some applying more restricted policy on the re-use of RWIS data.

Travelers are able to use various mobility services provided by public and private sectors. The 511 brand will be one of the key development areas, expanding from the well-know phone number to cover all major information platforms (TV, radio, Internet), and is expected to become the most recognizable face of ITS for the vast majority of the public. Location Based Services will be also an integral development area in 511. One example of 511 Web service for Quebec area is shown in Fig. 3.12.

Vision of Canadian ITS developers is that basic public information such as road weather should be given to the users free of charge, but viable business models should be developed to secure sustainability of services. Data collection by public sector should be free to private sector for service applications. Underserved sectors would need support from the public sector. The overall economic efficiency of ITS is the goal, aiming at seamless services which cover travelers' needs from one jurisdiction to another and one mode to another. Also the needs of travelers coming to Canada from other countries must be taken into account.

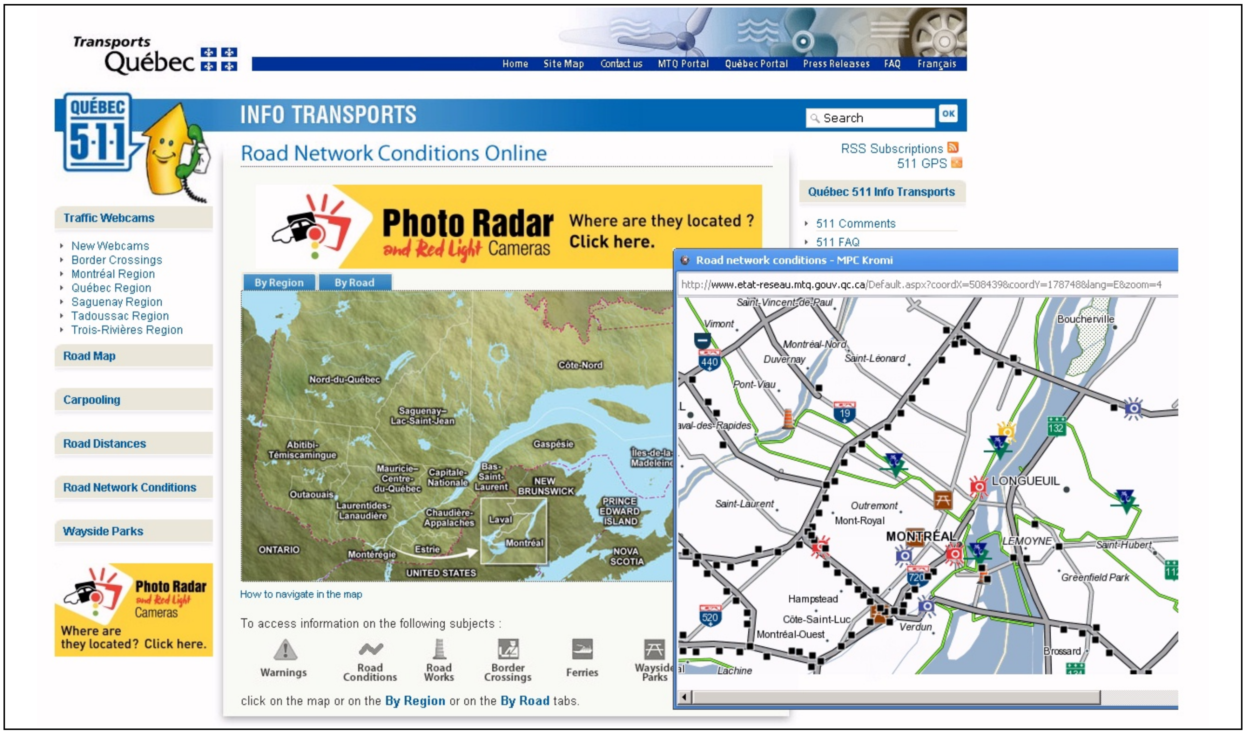

Fig. 3.12 511 traveller information for Quebec area.

3.6 Comparing data policies and service provision

ROADIDEA D4.5 Summary report on data processing and utilisation processes [18] contains a brief description of the EC data policy and its implications to transport services provision. The three main data Directives are

- Directive 2003/4/EC on the Public Access to Environmental Information,
- Directive 2003/98/EC on the Re-Use of Public Sector Information,
- Directive 2007/2/EC establishing an Infrastructure for Spatial Information in the European Community (INSPIRE).

The spirit of these Directives is generally promoting for open and free access to public sector information and to such data that is relevant also in the creation of new transport services. However, the directives do allow charging of data, giving the responsibility for final decision on pricing rules to Member States. The present licensing conditions and price levels, while being in contradiction to the general open data policy, also maintain a barrier for service provision and creation of new service provider companies in Europe. The general situation on spatial information in Europe is one of fragmentation of data-sets and sources, gaps in availability, lack of harmonization between datasets and formats at different geographical scales, and duplications of information collection. These problems make it difficult to identify and re-use the data that are available. However, in some European Union countries clear indications and actions towards more open data policy are observed at present.

Situation on the other side of the Atlantic is somewhat different. Federal information policy in the US is based on the premise that government information is a valuable national resource and that the economic benefits to society are maximized when taxpayer funded information is made available inexpensively and as widely as possible. This policy is expressed in the Paperwork Reduction Act of 1995 and in Office of Management and Budget Circular No. A-130, "Management of Federal Information Resources." This policy actively encourages the development of a robust private sector, offering to provide publishers with the raw content from which new information services may be created, at no more than the cost of dissemination and without copyright or other restrictions. [19] Similar Law on open access to federal information exists also in Canada. If data is acquired with public funding, it should be made available freely.

In the US, open and unrestricted access to public sector information has resulted in the rapid growth of information intensive industries particularly in the geographic information and environmental services sectors. Similar growth still remains to be seen in Europe due to the restrictive government information practices, which prevail in spite of the existing Data Directives.

One might label the American and European approaches as 'open access' and 'cost recovery', respectively. In Europe, contrary to USA and Canada, the cost recovery policy also manifests in commercial activities of public sector bodies, resulting in several problems in the commercial market with accusations of abuse of dominant position and unfair competition. High prices for information ultimately lead to predatory and anticompetitive practices, like price dumping, and the creation of government owned corporations or joint ventures with preferred private sector entities that may serve to exclude others from the market. In the USA and also in Canada since 2000, these kinds of problems do not occur because the public sector does not engage into business operations, and is systematically working with the aim to help the private sector to success and fulfill its goal to provide innovative services. Public and private sectors cooperate actively and as an example, in the USA the fine line between public and private duties in weather services provision was defined more precisely for the mutual benefit of the two major information service sectors. [20]

The most sustainable solution also in Europe would be to separate public commercial activities into truly commercial entities, separate from the government and by adopting open access policies. Separation of commercial activities would be the basis not only for an open market in accordance with European competition law, but also guarantee market structures with maximum overall economic potential. Such development has slowly started, as some government agencies are willing to liberalize their policies, though at the same time fearing that they will suffer budget consequences.

The conclusions of [19], though almost ten years old, are still valid for information service sector in Europe. Recognition is slowly emerging that open access to government information is critical to the information society, the scientific endeavor, and economic growth. However, recent trends towards more "liberal" policies face opposition. This comes from treasuries as well as from entrepreneurial civil servants in charge of "government commercialization" initiatives, who are sometimes tempted to engage in anti-competitive practices. Therefore, these issues require consideration at the highest policy making levels of European governments.

In the USA and Canada, the principle of open and unrestricted access to public sector information works well with general weather information, which is operated by the federal administrative level. However, for some other key transport service data sources the situation is not so good at all, and is in fact very similar to that in Europe. As an example, for Road Weather Information Systems, the data accessibility in the USA and Canada is much more restricted due to the more local nature of the data and some liability concerns. [21]

The US states and Canadian provinces are mostly providing RWIS data and define the rules and conditions of access. In [21] four broad areas of liability concerns have been identified, involving scenarios in which e.g. a motorist might bring suit against a Department of Transportation (DOT) for damages resulting from a roadway accident. The identified liability concerns are:

- Dissemination of RWIS information directly to the traveling public, especially online;
- Providing RWIS information to the public indirectly, via a third party such as *Clarus* or a weather service provider that repackages and redistributes DOT data;
- A DOT's duty to respond to RWIS information that gives notice of weather-related roadway hazards; and
- Liabilities for not using RWIS technologies when they are expected or indicated.

Options for DOTs include making careful choices about how they implement, monitor, maintain, fund and use RWIS; what information is shared, how and with whom; and how they address RWIS-related issues with departmental policies, public outreach and risk management programs. The decisions DOTs make about which road weather information to make publicly accessible, to whom and through which media require careful assessment of which information is most relevant, useful and appropriate to share with the public. Another important consideration is whether other strategies are available to address liability concerns that arise from data dissemination. One strategy is to restrict the information sharing at least partially, and a more liberal one is to use on-line disclaimers for content provided on a public Web site.

System optimisation is important, as one of the most important protections against RWIS-related liability is to operate the best possible system — one that functions as intended, is meaningfully integrated into an overall road weather management program, provides accurate and timely information, and for which reasonable care has been demonstrated or exceeded in planning, deployment, maintenance and use.

In summary, recognizing the scale of the opportunity presented, and the speed of enabling technological change, the US, Canada and the EU should commit to move forward together to take the practical steps necessary to establish internationally harmonized, open and unrestricted data policies for all public sector information. One Canadian service provider formulates well what is at stake: ITS systems need open access to data to be powerful and gain momentum. Vehicle market is world market and the continent that opens the data first will be the world leader in ITS and mobility services.

4. Models and methods

4.1 Introduction

4.1.1 Objectives and goals of ICT and ITS

The main goal of EU ICT research of traffic on roads is to develop new tools for evolution of infrastructure based upon advanced information processing. Such evolution should provide for sustainable, smarter, safer, and greener traffic. The related tasks require optimal control of traffic flows, proper maintenance of infrastructure and efficient support to traffic agents by information transmission. With this aim new methods of information processing and corresponding algorithms or models with expressive intelligence are sought in various theoretical and applied works devoted to intelligent transport systems (ITS). Emerging results of research are published in international journals and conferences devoted to traffic, information processing, statistical modeling, optimal control, neural networks and intelligent systems. The most relevant ones that have been used in preparation of present INCO report are given in the References related to this section. Of much less international character is application of research results in development of new ITS units, their deployment and utilization by individual companies. Since individual companies quite often do not cooperate on an international level this discrepancy causes delay in a development of a uniform European traffic infrastructure. Consequently, the goal of EU commission is to provide support for a broad national and international cooperation in research projects devoted to traffic sector. This tendency also led to the EU project 215455 ROADIDEA (2007-2010) and cooperation at the research of methods and models utilized in ITS which are presented in this section of present report.

Partners in Roadidea are investigating Europe's ability to innovate new mobility services. Basic hypothesis is that effective accessibility to all kinds of useful background information combined with advanced data fusion methods and technological information platforms with high level of standardization are prerequisites for creation of innovative mobility services. The first results show that the major barriers in Europe are in the data layer: in accessibility, pricing, standardization, and heterogeneous organizational structure of data providers in EU countries. In the USA and Canada, similar information is available more openly and free of charge due to their open data policy. The main goal of INCO was to cooperate with the federal Clarus initiative in the USA and Canada in order to find out similarities and differences in data layer and in resulting methods and models, and provision of mobility services to various transport user groups. More specifically, Amanova partner in Roadidea project compared results obtained in this project to the information gathered on methods and models used for similar purpose in the USA and Canada. The "Maintenance Decision Support System" of U.S. Federal Highway Administration and "Model of the Environment and Temperature of Roads– METRo" project at the Environment Canada were in the focus of our interest.

4.1.2 Role of methods and models

From the engineering point of view the traffic is a stochastic dynamic process running in an extremely complex system that hardly permits a deterministic technical description that is needed for its engineering treatment. Consequently, technical description of roads traffic is based upon statistical treatment of data provided by traffic monitoring units, services characterizing environmental conditions, participants in traffic, police, and others mentioned in the previous section on data acquisition. Acquired raw data have to be verified and properly transformed or adapted to user needs before their transmission. In advanced information processing systems corresponding tasks are performed automatically by following various methods and algorithms derived from specific models of a relations between input and output data. The information flow in modern ITS either in EU or in USA and Canada (EUSCA) can be presented by the following scheme.

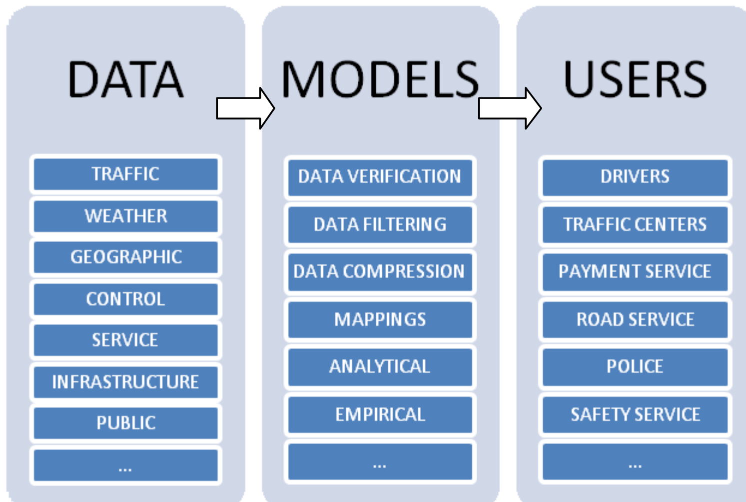

Fig. 4.1 Scheme of an ITS environment

The scheme indicates that information is provided in the ITS environment by various sources and transmitted over models taking place in some central intelligent system to various users. The processes that are running in the central intelligent system based upon some model of relations between input and output data are generally asynchronous and of stochastic character. Consequently the basic goal of ITS research in the framework of ICT is related to statistical modeling of relations between input and output data about traffic and environment.

The recorded and transmitted data most often represent stochastic time series, or still more generally dynamic fields. Therefore the most common basic problem of technical description is to formulate and create models that describe dynamics of corresponding phenomena. The next problem is then to apply these models in forecasting of driving conditions and properties of traffic flow, required service actions etc, while the final problem is to transmit resulting data over various channels to drivers, traffic information and other service centers, police, and other users.

In the past two decades very comprehensive fundamental research of traffic phenomena has already yielded good theoretical and empirical models for description of traffic flow dynamics. The corresponding research results have been thoroughly published by Springer in outstanding books such as: *D. Helbing: Verkerhsdynamik* and *B. S. Kerner: The Physics of Traffic* and are currently used by traffic experts in (EUSCA). However, the traffic is not an autonomous process since it is essentially influenced by changeable environmental conditions and traffic control and management actions. Since corresponding effects have not been accounted in the previous fundamental research of traffic dynamics the progress is now sought in a proper description of corresponding phenomena. The emerging results are mainly published in international journals and conferences. Our review of about 100 research articles from sources denoted in the References of this section and approximately the same number of individual communications with researchers from EUSCA during INCO activity have revealed that there are no essential differences in the approaches to modeling of treated phenomena in the EUSCA. In other words mathematical methods and objectives of modeling are similar while focuses of particular articles differ. Consequently we do not present here a detailed comparison of particular examples but rather try to describe common properties of traffic modeling in EUSCA while for the purpose of illustration we just present in the appendix some characteristic examples that have been considered during communication in the framework of INCO project.

4.1.3 Research of methods and models in the EU project Roadidea

Reviewing of research works performed on above mentioned problems has shown that there are mainly two approaches to their solutions utilized: either an existing method of modeling and information processing is adapted to the problem under consideration or a completely new method is sought by following various methods of innovative works. During the performance of the EU international project Roadidea it has been shown that a brainstorming carried out by a group of professionals at specifically oriented *Innovation seminars* could significantly contribute to the progress in the last case. Consequently, an idea emerged to spread this method also out of the EU that has finally led to the INCO project. In addition to new ideas, and with them related pilots that have been issued during brainstorming seminars, various concepts, methods, and models have been treated in the Roadidea Work Package 3 that are needed for data filtering and modeling of traffic flows or driving conditions based upon fusion of data provided by measurements and observations of road traffic and weather or other environmental variables.

Main results of research performed on methods and models of the Roadidea project are described in the web page www.roadidea.eu/documents/ as Deliverables of Work Package 3. The final goal of this research was to provide for an optimal joint quantitative description of the environment and traffic state that is needed for an efficient information support to participants in road traffic, traffic management and service centers and an advanced approach to the intelligent control of traffic flows. We also expect that this research will contribute to the solution of difficult problems related to development of autonomous driving.

A brief review of the research results of Roadidea project that were discussed in the INCO framework is the following:

- Filtering is considered as the process of defining, detecting and correcting errors in given data, in order to minimize the impact of errors in input data on succeeding analyses. The filters are presented as mathematical formulas or pseudo codes so that they could be implemented in a language of choice. Various examples of filters have been developed and examined on real data. In addition, a method for comparing and evaluating the filters was provided.
- For modeling of traffic properties and driving conditions many methods have been developed that generally pertain to parametric or non-parametric ones and use more or less similar building blocks. In the Roadidea project the fundamentals of traffic modeling was presented and most outstanding methods were examined, explained and applied. As typical examples of parametric methods the travel time prediction, friction and road surface condition estimation, traffic accidents characterization, and utilization of weather information were treated. Applicability of non-parametric methods the modeling of traffic flow field activity and its forecasting has been demonstrated. The same approach was also used in joining of weather and traffic data, and optimal estimation of missing data.
- The non-parametric approach directly yields an algorithm by which a structure of an artificial neural network is created from given data and hence represents most simple intelligent unit by which traffic models can be created. With respect to this property we included into appendix some examples that have been of interest to other partners in INCO. An outstanding advantage of the non-parametric method is that it provides for a simple approach to intelligent traffic control. For this purpose reinforcement learning can be included into the modeling.
- A method for evaluating the performance of the models based upon comparison of predicted and actually observed properties was also provided and exemplified.

- A specific problem at processing of traffic information represents a proper compression of overwhelming traffic and weather data before their storage. For this purpose an innovative approach was developed that is based upon minimization of information cost function that is formulated as the difference between the redundancy and information content of data. The corresponding algorithm represents a self-organized intelligent process of representative prototype data formation. These prototype data are normally much less numerous than the raw data and are consequently more proper for storing.
- Joining of traffic information with environmental and other data is especially challenging task because the character of data is rather different. In the Roadidea project weather data from different sources and with variation in spatial and temporal scales were treated together with traffic data. For this purpose various parametric, non-parametric, and classification methods were applied. The overall aim was to determine road conditions from available environmental data. Typical examples dealing with fusions of weather and traffic were:
    - route planning,
    - inclusion of weather data into general regression model,
    - alternative classifiers.
- The specific problem is to estimate the quality of data and how different data sources can be combined to increase the information. An innovation application of traffic flow variations to modeling of weather influences that are caused by precipitation and slipperiness was developed in the Roadidea and excited much interest abroad. The analysis showed how to characterize the impact of adverse weather on traffic and how to build a model by which negative effect of weather on traffic could be recognized. The treatment contained preprocessing, visualization of weather effects on traffic properties, modeling by decision tree classifier, etc.
    - The visualization was applied to build a dataset with classified samples such as "traffic disturbed by weather" or "normal traffic".
    - A decision tree classifier was used to form models that recognize the combinations of weather variables that lead to disturbed traffic. The visualization showed a distinct correlation between precipitation and changes in traffic pattern and the decision tree models exhibit a good and applicable performance.

The main goal of cooperation in the INCO project was to inform partners from USA and CA about the research conducted in the Roadidea project, to discuss applicability of results and to transfer acquired information back to the Roadidea framework. In addition the information about the "EU Intelligent Transport Systems Action Plan" (http://ec.europa.eu/transport/its/road/action_plan/) and related activities or projects was transmitted to other INCO partners. The plan was issued by the European Commission at the end of the year 2008 and at the start of 2009; the Commission took a major step towards the deployment and use of Intelligent Transport Systems (ITS) in road transport. The Action Plan suggests a number of targeted measures and a proposal for a Directive laying down the framework for their implementation. Similarly as in EU also in USA and Ca ITS are considered as a proper basis that can significantly contribute to a cleaner, safer and more efficient transport system. The common goal is to create the momentum necessary to speed up market penetration of rather mature ITS applications and services.

4.1.4 Complementing Roadidea research on methods and models by collaboration in the INCO project

In relation to our research on methods and models applicable to traffic information processing the partners of Roadidea project participated to various international conferences and events such as: Transport Research Arena – TRA, ITS World Congress, International Road Weather Conference – SIRWEC, Transportation Research Board Annual Meeting – TRB, various ITS conferences, etc. (More detailed review is given in References.) Numerous contacts with attendees from EUSCA have been established at these events and initially also led to formation of the INCO project. To the spreading of contacts, exchange of ideas, and enrichment of knowledge the participation to several INCO Seminars and visiting of home institutions of other partners has contributed most. Of greatest interest for our further research of methods and models were contacts established with researchers following the program of The National Academies in USA (www.national-academies.org) published by the National Academies Press (www.nap.edu) in the book *Where the Weather Meets the Road*. Most informative were contacts with researchers developing and deploying Maintenance Decision Support System – MDSS in USA and METRo in Canada as well as those joined with CLARUS initiative and ITS CANADA. Their basic characteristics that have attracted our interest are described in their web pages and are summarized as follows:

- The Maintenance Decision Support System (MDSS) project was initiated in 1999 by the U.S. Federal Highway Administration (FHWA) Office of Transportation Operations Road Weather Management (RWM) Program. A consortium of five national laboratories in coordination with state DOTs, academia, and the private sector have participated in the development and implementation of the project. These laboratories include:
    - Cold Regions Research and Engineering Laboratory (CRREL)
    - National Center for Atmospheric Research (NCAR)
    - Massachusetts Institute of Technology/Lincoln Laboratory (MIT/LL)
    - National Oceanic and Atmospheric Administration (NOAA) Forecast Systems Laboratory (FSL)
    - NOAA National Severe Storms Laboratory (NSSL)

  The MDSS capabilities were designed based on feedback received by the FHWA in 2001 from maintenance managers at a number of State Departments of Transportation (DOTs) as part of an initiative to capture surface transportation weather decision support requirements. The MDSS project goal is to seed the implementation of advanced decision support services provided by the private sector for state DOTs. This has been achieved by developing core software capabilities that serve as a basis for these tailored products. After the user needs assessment was completed, the MDSS program was extended with the objective of developing and demonstrating a functional prototype MDSS. The MDSS integrates state-of-the-art weather forecasting, data fusion, and optimization techniques with computerized winter road maintenance Rules of Practice (RoP) logic. The result is guidance aimed at maintenance managers that provides a specific forecast of surface conditions and treatment recommendations customized for individual plow routes. The MDSS project has several goals:

    - Demonstrate to the state DOTs that new technologies are available to assist maintenance managers with maintaining safety and mobility on roadways and provide for more efficient use of chemicals, equipment and staff.
    - Show the private sector road weather providers that there is a market for these new technologies. To aid this process, the FHWA is providing the core MDSS modules to

any company or organization using an aggressive technology transfer process with the expectation that the MDSS technologies will become commercialized.

Field demonstrations of the prototype MDSS were conducted in Iowa and Colorado from 2003 to 2005. Since we have estimated MDSS as the most advanced one and most interesting for transplantation to EU the properties of innovated MDSS guidance tool are described more in details in the Appendix.

- CLARUS is an initiative to develop and demonstrate an integrated surface transportation weather observing, forecasting and data management system, and to establish a partnership to create a Nationwide Surface Transportation Weather Observing and Forecasting System. The objective of CLARUS is to provide information to all transportation managers and users to alleviate the effects of adverse weather (e.g., fatalities, injuries and delays).
- Environment Canada (EC) is a diverse organization where programs and services are implementing the federal government's environmental agenda. EC is protecting the environment, conserving the country's natural heritage and providing weather and environmental predictions to keep Canadians informed and safe. EC tries to support sound environmental decisions and to repair the damage of the past, to collect and pass on knowledge, and to develop, implement and enforce policies to prevent future damage. EC works towards sustainable development.
- METRo is the road weather forecast software of EC. METRo is a program used on an operational basis since 1999 that together with the input of an atmospheric forecast, road composition and observations from a road weather station (RWIS), produces a local road forecast (temperature and road condition) for a 48-hour period on a simple desktop computer. All the input and output of METRo are in XML format. By distributing METRo as free and open source software, Environment Canada tries to help the public, private and academic sectors by providing a model that can be used, studied, modified and improved. Under the leadership of Environment Canada, the development model of METRo tries to catalyze the expertise of these different participants and produce benefits for citizens of the world by providing better winter road forecasts. With the help of observations provided by a road weather station (road weather information system, RWIS) and the atmospheric forecast, METRo can, amongst other things, predict the roads conditions with particular interest such as: freezing rain, accumulation of snow, frost and thaw.

At the activity inside INCO the task of Roadidea partner Amanova was to inform other INCO partners from US-CA about research conducted in the Roadidea project on methods and models and achievements on these fields. In the focus of our communication was the non-parametric modeling and possibilities offered by this approach. Simultaneously with activity inside INCO the information has been transmitted also back from INCO to Roadidea framework. In addition to participation to brainstorming events and the personal exchange of information, presentations of various posters, and exchanges of journal articles have been characteristic for our collaboration. Some examples of corresponding articles are presented l in the Appendix of this report. In order to provide for their understanding we briefly present basic common properties of modeling of traffic phenomena and corresponding influences in EUSCA that have been found during our cooperation in INCO or observed in related articles.

4.2 Common characteristics of modeling in ITS

4.2.1 The purpose of modeling

The basic purpose of application of a model is a mapping of some data into another form. If the primary form is represented by the multi-component variable X and the final by the variable Y, then the mapping relation is mathematically expressed by some function: Y=F(X). One of the basic tasks of traffic research in various projects of EUSCA is to find a proper method for formulation of the function F which is generally called modeling. For advanced modeling of mapping relations various methods of physical description of natural phenomena are most appropriate. Since weather and traffic phenomena are extremely complex and of stochastic character their treatment is generally supported by statistical methods. These methods generally include concepts of dynamic fields and networks while models are most often represented by mathematical relations.

4.2.2 Look-up table as a simple mapping

Basic information about the properties of traffic and related phenomena is provided by automatic measurements and human observations. Measurements generally yield quantitative data while observations most often provide qualitative information. The fundamental problem at joining of both data is therefore how to create a common data base which could be efficiently utilized at further processing that is needed when converting data into another more applicable or convenient form. For the purpose of processing of information by various mathematical models the qualitative data must be converted into a quantitative form, which is usually performed by a proper encoding. For this purpose a look-up table is quite often applied. Such a table in fact represents most simple model of mapping relation applicable for data transformation. The inverse problem to encoding is met when quantitative data obtained from mathematical-physical models are transmitted to users, which need qualitative information. These problems are treated by using various methods of classification, but until now they have not been solved univocally, and therefore, various data providers use different methods and with them related models that reside in their software. Consequently, it is very difficult to compare generally procedures utilized by various institutions. Some kind of standardization on an international level could provide for more user independent presentation of data and easier exchange of traffic information between various institutions and countries.

4.2.3 Types of models

The situation appears a bit less cumbersome when mathematical models of various researchers are considered. They can generally be classified as:

- analytical,
- empirical or statistical,
- hybrid.

Analytical models are derived theoretically based upon applications of fundamental physical laws and can be most often expressed in a compact form by a proper differential equation. Its mathematical form is generally not depending on its author or user. As a typical example one can mention the modeling of airflow by partial differential equations in meteorology or pavement heat balance model in traffic science. However, applications of models expressed by differential equations require initial and boundary conditions that have to be extracted from measurements and observations in a specific case. Due to the distributed character of weather or traffic phenomena, processing of related dynamic equations is very demanding, and in order to speed up corresponding calculations specific methods are developed and utilized or by various programmers. Communications with various researchers have revealed that also in this case some kind of standardization could provide for more flexible exchange of models on the international level.

4.2.4 Approaches to statistical modeling

Empirical or experimental models are used to describe relations between various measured quantitative data statistically. Due to stochastic character of weather and traffic variables experimental models are most generally formulated in terms of various regressions. There are generally two different approaches to formulation of regression model that are called

- parametric
- non-parametric.

The parametric approach is utilized when there is given certain indication or knowledge about the mathematical form of the relation between treated variables. In this case the relation between input and output variables is expressed by a certain function with included set of parameters that are adapted to the modeled phenomenon by optimizing some measure of model quality. For this purpose a database of certain number of joint measured data has to be provided. For the adaptation of parameters the minimization of mean square prediction error is most often utilized. As typical examples various polynomial, exponential, and logarithmic regressions can be mentioned. In addition to them various artificial neural networks could also be interpreted as regression models whose parameters represent properties of included memory cells or artificial neurons. In the first case the parameters most usually represent global properties of the modeled function while in the second case the parameters usually represent its local properties.

The non-parametric approach is usually applied when beside the experimental database there are given no indications about the form of the relation between variables under consideration. In this case the joint probability density function is first estimated based upon some kernel model. Most objectively the scattering function of the instrument used in experimental arrangement is applicable as the kernel. The estimated joint probability density function is further used to formulate an optimal relation between variables. In this case the minimization of the mean square error yields as an optimal estimator of the relation between input and output variables the conditional average. The model can then be objectively expressed without any ad hoc parameters by using joint data alone and is therefore called the non-parametric regression. This model corresponds to an associative recall of stored data from the database and represents the simple kind of learning from examples that is a basis of artificial intelligence. Since it can be executed automatically, the conditional average provides a valuable tool that could be simply included into various ITS.

Since traffic phenomena are generally of very complex character that is hardly described analytically, the non-parametric approach appears more convenient for modeling of relations between various traffic variables than the parametric one. However, application of parametric or non-parametric approach to modeling of traffic phenomena depends on the problem at hand and additional information about properties of the relation under examination. In both cases the mean square error is applicable for the description of model quality. For this purpose an additional testing database has to be provided.

Hybrid models are used when there is well known how the properties of certain sub-set of variables in the data base could be modeled analytically, while the properties of remaining set of variables could be specified just on the experimental basis. In such a case the modeling is most often very specifically adapted to the phenomenon under consideration and cannot be further generally described. Typical examples of this case are met when modeling influence on weather on traffic. In this case the modeling of weather dynamics includes analytical and parametric methods while the influence of modeled variables on traffic flows can be most simply performed based upon non-parametric approach.

4.2.5 Types of adaptation

At the adaptation of models to actual examples researchers in EUSCA most often apply two types that are called

- batch type
- adaptive or sequential type.

In the batch case certain set of sample data is given and the model is adapted to all of them simultaneously. Such approach is usually utilized when modeling general properties of traffic phenomena, as for example the relation between number of accidents and road slipperiness. In the sequential case the model is adapted to some changeable sub-set of more comprehensive set of sample data. When the subset of sample data is changed, the model properties are changed as well. As a typical example we can mention on-line modeling and prediction of driving conditions based upon current weather data. Sequential type of adaptation is very convenient for description of dynamic response of traffic phenomena on changeable environmental influences and is often met at modeling of traffic. It is also applicable at self-organized compression of overwhelming traffic data.

4.2.6 Performance measure

Since weather and traffic phenomena are time dependent and of distributed character the corresponding data generally represent multi-component time series. Their properties depend on specific geographic properties of environment and population. Consequently, it is possible just to compare approaches to modeling and qualities achieved, while comparison of specific model characteristics cannot be so generally performed. At the description of model quality the correlation coefficient between the variables predicted by the model and actually observed ones is usually utilized.

4.2.7 Fundamental problems of modeling in traffic information processing

Various regression models are applicable in processing of traffic properties when given data are of quantitative character, ie provided by measurements. However, human observations usually provide qualitative information that cannot be directly utilized in neither analytical nor empirical models. Consequently, there arises a fundamental problem: "How to extract models from qualitative information about observed phenomena?" As a typical example of a model hidden in the qualitative information we can mention the following expression: "Close the window of the car when the rain is falling, and open it when the sun is shining." The problem of modeling relations between qualitative data is not related just to traffic environment, but it is of much more general character. In fact, its solution could provide for development of really intelligent information processing devices whose operation could clone human thinking in details; or even surpass it. This problem must be properly solved if we want to proceed to efficient application of information provided by drivers or to develop vehicles capable of autonomous driving.

Analysis of approaches to processing of qualitative information that are utilized at present in EUSCA has revealed that there exist generally two typical cases. In the first one the qualitative data are converted into a quantitative data by a proper encoding. The encoding rule is created by operators and the model is built based on encoded data by using above mentioned possibilities of quantitative modeling. A model is sometimes simply represented by a look-up table or connection matrix. In the second example the qualitative information is interpreted and further related to some other qualitative datum by a human operator. However, this last case does not permit automatic treatment and awaits some fundamentally new theoretical approach. It appears reasonable that some future ICT projects should be devoted to the modeling of relations based upon qualitative information.

In addition to modeling of phenomena based upon qualitative information there appears as an outstanding problem the modeling of dynamics of interacting networks such as: roads, railway and air traffic, weather, energy supply chains, etc. The corresponding research works are now already in progress and their results appear in international literature.

4.3 Brief review of traffic and related phenomena modeling

Reviewing of articles presented recently at international conferences such as TRA, SIRWEC, TRB, ITS World Congress, etc has revealed that problems treated by models mainly stem from the following topics:

- Estimation of driving conditions from meteorological, geographic, infrastructure and other environmental data.
- Estimation of dynamic properties of traffic based upon driving conditions and roads properties and forecasting of traffic flows, travelling times, etc
- Description of congestion and finding a proper way of communication between vehicles.
- Optimization of service properties based upon weather, infrastructure and traffic flow data and prediction of influences of service actions on traffic state, safety, etc.
- Optimization of traffic control and management.
- Static and dynamic path optimization.
- Estimation of emergency, description of fog and smoke on crashes, prediction of accident probability and generation of proper traffic warning signals.
- Joining of data from various information networks and transmitting of transformed information back to them.
- Estimation of influences of control, warning signals and maintenance actions on driving behavior.
- Description of interaction between different networks, such as: traffic, weather, energy consumption, pollution distribution and prediction of effects caused by their interaction.
- Estimation of safety, economic and social impacts of traffic information support, control, management, regulations, etc.
- Estimation of data quality, data filtering, compression and optimization of traffic data storage.
- Classification of traffic flow, driving conditions, service actions, etc.
- Adaptation of traffic information to user needs.

The following problems were in the focus of our discussions during INCO meetings:

1. Joining of information from different sources in complex models.
2. Modeling and forecasting of driving conditions and traffic flows.
3. Optimization of traffic service activities.
4. Optimal management and control of traffic.

5. Description of congestion phenomenon and methods for its improvement.
6. Adaptation of traffic information to user needs.
7. Analysis of outstanding problems of modeling and development of methods for their solution.

In order to briefly illustrate the contents of our discussions we present in the Appendix some examples of the first three objectives.

4.4 Results of cooperation in the INCO project

During cooperation in the INCO project we have exchanged information about research conducted on methods and models in the framework of Roadidea project, and more in details about contribution of the company Amanova to this research. Simultaneously we have obtained information about similar research conducted in Canada and USA. Of greatest interest for us were applications of models in prediction of driving conditions, influence of traffic on pollution and environment, modeling of traffic flow dynamics, optimization of winter roads services, treatment of congestion problem and traffic information transmission to drivers. The results of our discussion are already considered at our present research and have been also transmitted to other partners of Roadidea project and institutions dealing with traffic in our country. At the corresponding communication we have observed great interest for a proper transplantation of MDSS to EU and more specifically to our country. At the same time we have found interest of researches, which are developing and deploying MDSS in application of non-parametric approach to modeling also in this system. The next problem of great interest for the future research in EU is a proper treatment of congestion phenomenon by methods of swarm intelligence that are now under very active development. At the same time we have met several outstanding problems of modeling which could be of great interest for the future research. Among them the most outstanding is the modeling based upon qualitative information and the modeling of dynamics on mutually interactive networks. We expect that proper solutions of these problems could significantly contribute to the progress on the processing of information by intelligent software in the traffic sector.

5. Innovation methods and idea creation

The innovation seminar methods that have been used in ROADIDEA have proven to be suitable to pursue to create new ideas on traffic and weather area. It has been an important way to bring together various stakeholders and researchers in the complex area of road weather. The innovation methods have allowed the tacit knowledge of various experts to be put into innovative collaboration. Therefore, the methods were also used in INCO project. In particular, the goal was to introduce the innovation method used in ROADIDEA, to give the overseas colleagues an opportunity to innovate their own activities and to reach better understanding of the overseas road weather systems.

5.1 Washington DC Innovation seminar

The first INCO seminar was held in Washington DC on 27 - 28 April 2010. Well before the seminar, background-reading material was sent to the participants. This material consists of information about ROADIDEA project, innovation methodology and the Millennium Project Scenarios 2008 (see annex for details). In the seminar, first the methods were presented to the audience. Under initial discussion it was pointed out that it is important to combine diverse views and expertise for innovation. Results of brainstorming cannot be forecast beforehand but the ideas unfold through deliberation among experts of different fields.

The methods used in this seminar are Futures Workshop and Synectics. The purpose is to gather together the tacit knowledge and personal understanding of experts and ensure vivid interaction between the experts. The very beginning of idea creation is to question the self-evident, to ask why, what, how and when about the issues of interest presented to the audience. It is important to note that the futures research assumes that there are always many possible alternative futures that can be considered either possible, probable, desirable or avoidable.

The scenarios used are taken from the Millennium Project's SOF 2008, as the have been used for innovation work in ROADIDEA project proper in 2008 and 2009. The definition of scenario "A scenario is a story with plausible cause and effect links that connects a future condition with the present, while illustrating key decisions, events, and consequences throughout the narrative." The three alternative scenarios are described in the annex of deliverable D5.3. In brief they are:

Table5.1. Scenarios in Brief - Alternative Worlds in 2030

Scenario 1: Business as Usual––The Skeptic Moderate growth in technological breakthroughs Moderate environmental movement impacts Moderate economic growth Moderate changes in geopolitics and war/peace/terrorism	**Scenario 2. Environmental Backlash** Moderate growth in technological break-throughs High environmental movement impacts Moderate economic growth Moderate changes in geopolitics and war/peace/ terrorism
Scenario 3: High-tech Economy – Technology Pushes Off the Limits High growth in technological breakthroughs Low environmental movement impacts High economic growth Few changes in geopolitics and war/peace/terrorism	**Scenario 4. Political Turmoil** Moderate growth in technological break-throughs Low environmental movement impacts Moderate/low economic growth Major changes in geopolitics and war/peace/terrorism

Of these scenarios the first, the Skeptic was not used but the three others were defined to be the basic futures image for each group in the seminar.

In addition, basic assumptions including megatrends and wild cards were discussed. It was noted that most of the wild cards are negative at first glance. It is indeed difficult to find positive wild cards, but most wild cards are contradictory - a positive happening can be negative to some people or communities and vice versa. Crises are also very often starting point of change and an opportunity to create something new or give way to something unforeseen to emerge. But learning by catastrophe many times seems to be the way humanity works. The basic assumptions and wild cards were as follows:

Basic Assumptions 2030
People on earth 8-10 Billion:
5 B in cities, 3-4 B rural
Climate change situation worse
Economic slow down
and great variances
Ecological immigration worse
Galileo / GPS systems work
Energy paradigm shift
Business models revamped

Wild Cards 2030
Pandemics
Sweet water scarcity
Superconducting in room
temperatures solved
Bioterrorism
Nuclear disaster
Changes in power politics
Security awareness higher
Life on exo-planet

At first the seminar agenda had focused on road weather questions only but it was decided in the discussion that the innovation should have a broader scope than road weather, i.e. deal with sustainable land transport development in general with the aid of ICT. The innovation process was as follows (for details, see Annex: Agenda)

1. The first session consisted of brainstorming of ideas on sustainable land transport in three groups, which took one of each alternative world scenario as the basic assumption. All ideas were documented on flip papers. The group leaders were Pirkko Saarikivi, Rene Kelpin and Auli Keskinen. Lulu Hyvätti took care of reporting.

2. Participants circulated around the flip papers and gave points (red stickers) to the ideas they liked best (each person allotted 10 points according to free will = evaluation cycle), and thus the three best ideas of each group were denominated. All the ideas are documented in the annex.

3. Then, the synectics session phase 2 was conducted in groups by asking about each idea: How can this idea be realised in practice? These ideas are documented.

Next, Jerome Glenn gave a presentation on the Millennium project and global scenarios for 2030. He has been the director of Millennium Project (started as a project of the American Council to the UN University, moved later over to WFUNA but is now independent non-profit global think tank) since it's beginning. He talked about the global scenarios, which the project produces and publishes annually as State of the Future (SOF) (see www.millennium-project.org). Importantly, he assured to us that: "The future will be more complex and change more rapidly… than most people think". But in organisational development, the new key question actually is: What is my or my organisation's improvement system and how do I improve that? (i.e. one must know what the system is through which improving of organisation's performance is recognised and what is one's role and possibilities to have an impact on that). The innovation methods used in this seminar are described in the Futures Research Methodology V3.0 2009 as compiled by the Millennium Project.

5.2 Montreal Innovation Seminar

The second innovation seminar was held in Montreal on 22 June 2010. Well before the seminar, background-reading material was sent to the participants. This material consists of information about ROADIDEA and INCO project, innovation methodology and a Jerome Glenn's video link explaining the futures ideas processed by the Millennium Project (see annex 3).

The innovation methods used in this INCO seminar are described. First the ROADIDEA and INCO projects were presented briefly to the audience. Then the methods for brainstorming were explained. Then, the video of Jerome Glenn was run to give food for thought for futures thinking (http://videolectures.net/forum2010_glenn_gcisd). Lastly, the issues which the Canadian colleagues considered important to be focused on in the brainstorming were discussed. The topics were chosen to be: 1) data issues especially data acquisition, and 2) institutional governance and organisational leadership. The innovation process was conducted as follows:

1. First, two groups were formed according to the two topics. The group leaders were Saarikivi and Keskinen. Hyvätti did the documenting.

2. Brainstorming was conducted for one hour when all ideas were written on the flip papers. After that there was a break, and a plenary was conducted were group leaders explained the results of brainstorming.

3. Next, the evaluation cycle was conducted so that each participant allotted points (red stickers) on the flip papers' ideas by giving two points to the best and 1 point to the second best idea in each group.

6. Innovation results

6.1 Washington DC

The three best ideas of the three groups were:

Group 1:

1. Personal transport IntelliDrive (everybody can take part in contributing to the data pool -> gain access to new services from the system)
2. Environmental data beyond traffic impact (other uses)
3. Repurposing existing infrastructure (needs money to build new)

Group 2:

1. Decision made by the system
2. Personalised trip planning
3. Advanced tele-presence systems (stay home)

Group 3:

1. Networks important to keep up, vulnerability is high
2. Data security
3. Profiled customised services commercially provided (routes)

More detailed of these explanations can be found in the annex 5 where all flip papers explaining all presented ideas are discussed.

6.2 Montreal

The two best ideas of the groups were:

GROUP 1. INSTITUTIONAL GOVERNANCE

- Find leaders to define shared secret
- Translink (a Canadian firm Translink) models needed, get all in the same room once

GROUP 2 . DATA ACQUISITION

- Total view of network (for planning, for traveller, for people and goods)
- System provides:
    - -suppliers need information for the planning
    - -Info to policy makers on sustainable demand management
    - -Policy feeds boundary conditions to optimisation scheme
    - -Selection: comfort, speed, accuracy of timing, facilities, parking lots, security, price

All the ideas created are presented in annex 6.

6.3 Comparison of ideas

The INCO project Washington seminar had similar background information as the 2nd innovation seminar in Dubrovnik, namely that the three futures scenarios for 2030 were used. The ideas that came out in the different worlds were generally speaking of similar nature although differences did occur. The Washington seminar in particular presented specifically global ideas that would focus on "using given infrastructure in a better way", noticing that a "paradigm change" of mobility and traffic is under way and that in future the global networking of stable and mobile gears will create the whole world to be a "networks of networks". The seminar in Montreal discussed two problem areas instead, namely institutional governance and data acquisition.

Some interesting comparison is presented in the following table. In general terms it can be noted, that the best ideas gather around two themes: first, data must be available for all stakeholders whatever the futures services might be - and they will develop towards more personalised profiles of users - and second, the public transport needs to be improved by every means so that it will run smoothly, efficiently, securely, multi-modally and in ecologically sustainable manner. Here both the EU and USA/Canada authorities readily agree and work towards these goals.

Table 6.1 on the next page presents Brief comparison of ideas of all ROADIDEA and INCO seminars.

Table 6.1 Brief comparison of ideas of all ROADIDEA and INCO seminars.

	Prague	**Dubrovnik**	**Espoo**	**Brussels**	**INCO/Washington**	**INCO/Montreal**
Source	D5.2	D5.3	D6.4	Final report D1.8	INCO-report D1.1	INCO-report D1.1
Evaluation method	evaluation survey	overall evaluation	evaluation by discussion	overall evaluation	group evaluation	group evaluation
Best idea	EUROADMAP	Semi-public transport	Pub Car-pooling	Lingua franca - automatic language translation on line	1. Personal transport IntelliDrive 2. Decisions made by the system 3. Networks important to keep up!	1. Improve institutional governance policies 2. Acquire total view of network for all purposes
Second best idea	FREEDATA	DYNAMOBI	Ubi-travel	Teleconference coffee breaks always open	1. Environmental data beyond traffic impact (other uses) 2. Personalised trip planning 3. Data security assured	1. Translink models 2. Prepare info to policy makers on sustainable demand management
Third best idea	Mobile sensor data aquisition	No-man driving Autonomous driving	eJames	Automated road No man driving	1.Repurposing existing infrastructure 2. Advanced tele-presence systems (stay home) 3. Profiled customised services commercially provided (routes)	-
Most radical idea (survey, evaluation)	EYEAR	LEGO block transport	Future solution for changing "roads to tubes".	-	-	-

	Prague	**Dubrovnik**	**Espoo**	**Brussels**	**INCO/Washington**	**INCO/Montreal**
Most radical idea (session)	My Route: personal filtering	Waste to energy	In-vehicle entertainment services	"The ticket" in universal public traffic bio-based	Repurposing existing infrastructure	User interface: you can wear it all!
Most radical idea / wp leader's pick	STAYHOME	Nanosurfacing - no ice, no snow	eHelmet as user interface in mobile offices	Automated road, no man driving	Advanced tele-presence systems (stay home)	Hospitals included and other new actors (police, events, etc.)
Best service idea	TOILET TOM-TOM	DYNAMOBI, travelling offices	Multi-lingual interfaces	Enhanced service promotion in media	Profiled customized services commercially provided (routes) & Your-secure-route	Just price for just service
Best data-based idea	Friction data	Friction used as energy in roads	Tracking location of users and vehicles	-	Personalised trip planning	Distributed data loading
Best business idea	Freedata	Low cost energy, e.g. compressed air as driving force	eBilling fully automatic	-	Expanded environmental observation Intellidrive	Role of big info companies (Google) vs. public authorities, who can afford to keep up the system?

7. Conclusions

The ROADIDEA INCO team has investigated and analysed the US and Canadian transport systems and compared the existing data policies, availability and content of road information, methods and models, and provision and innovation potential of mobility services.

While attending several meetings, workshops and conferences in the U.S. authors have been in contact with a considerable number of high-quality and partly very innovative ideas, projects, initiatives and portals. Latest technologies are in use in order to inform users about the traffic state and corresponding roadside conditions, whereas data collection methods and technologies are partly old-fashioned and loop detector oriented.

First of all, it has to be pointed out, that the transportation systems as such and, thus, corresponding data aspects of the U.S. and Europe as a whole can hardly be compared.
While U.S. federal states can easily create cooperation networks and apply ITS initiatives and programs under the 'umbrella' of different public managing, planning and funding authorities – such as U.S. Department of Transportation (USDOT) or Federal Highway Agency (FHWA) – without cultural and regulation triggered barriers, European Union still exists of 27 separated member states with more than 20 languages and – even more important – a huge amount of different cultural, historical and political backgrounds, and – when it comes to transport related data aspect - regulative policies. Nevertheless, the ROADIDEA INCO data consideration, as described with chapter 2 of this report, tried to compare given trans-regional ITS systems, taking U.S. mainland states and EU member states as two comparable entities in terms of transportation.

Special respect has been laid on cross border ITS services applying and merging data from different sources with innovative methods and sophisticated models in order to improve road safety and driving conditions – and so, decreasing road traffic fatalities, congestions and delays. In the following, some general data related and other key conclusions of the ROADIDEA-INCO study are presented.

<u>No 'free data' for transport services</u>

Even after getting familiar with only a few aspects of the U.S. and Canadian transportation systems, authors observed that the original assumption of 'free data' policy in transport data was not correct. This is due to the fact that in the US, the Freedom of Information Act covers only federal data sources, whereas most data sources that are necessary when implementing transport services originate from state of private organisations. Thus the accessibility has similar restrictions and barriers as observed in ROADIDEA data analysis for Europe.

<u>Metrics</u>

When talking about and comparing transport data, its quality, its quantity and the estimation of impacts of data related applications for the performance of the entire transportation system, clearly defined metrics are needed. While well-defined metrics for road weather data are given, quality, precision, and reliability of traffic data acquisitions very often cannot be described in intuitive metrics. This is challenging data related initiatives and projects but also traffic databases and warehouses. Big efforts and expenditures are made in North America as much as in Europe. Corresponding planning and managing bodies and authorities should join forces and synchronize standardisation initiatives in order to create a common set of reasonable metrics beyond what is exchanged on a research level on conferences.

Local Solutions for local problems

A lot of local solutions for local problems are given in both the U.S and Europe. Conversely, this means that an operational trans-regional approach to tackle similar issues globally is mostly missing on both sides of the Atlantic Ocean, even though lessons learned in other regions are widely taking into account when setting up new local solutions and research communities are well networked. However, corresponding activities and initiatives are under consideration.

Federal and National data acquisition

Data acquisitions focuses differ from state to state in Europe and the U.S. – following national and federal strategic decisions. In Europe no minimal availability of data necessary for elementary ITS services is given in a continental scale. So, cross border implementation of services along long distance routes throughout Europe are barely applicable. The same only partly applies to the U.S. Nowadays a more strategic direction towards common data coverage is given by regulative authorities (USDOT, FHWA, etc.). While corresponding decisions are made by only a few authorities, these decisions are more reliable but also less flexible. Once pursued strategic directions can not be easily corrected. Due to different national strategies in Europe, development paths are more diverse and competitive.

Data regulations and policies

The issue of data related regulations are important in the U.S. and Europe similarly. As for the U.S., there is definitely no "free data policy", as it is rumoured from time to time outside the U.S. With the USDOT CLARUS initiative on road weather data one aspect of transport related data can be considered as "freely" available. But, this advantage is lightly used up by regulations, public and private road traffic data providers (have to) saddle their data with. The European Commission, as the roofing European body, is working on corresponding recommendations, which could clarify data access regulations for EC member states. But, to date it is unknown how to implement those recommendations and how to convince member states to make those recommendations to national law.

Networks of data networks

As also for transport data, the "Networks-of-Networks" idea has to be matured and applied generally and globally. A variety of data generating and applying networks, which providing quiet good local solutions for different local problems (traffic and weather) while tapping several data sources, have to be combined globally and interdisciplinary. Corresponding networking funding schemes in the U.S. and Europe have to be developed, combined and synchronised.

Actual versus historical data

The authors, attending several data related workshops and conferences in the U.S., got the impression that a different focus is given whether to use real-time (online) or historical data. While latest European research activities are relying mainly on the combination of real-time road traffic observations (FCD, cameras, satellites, etc.) and large historical data bases, collected from the same or similar data sources, U.S. research only now starts to consider real time data acquisitions (Bluetooth FCD, camera imaging). In the U.S., mostly average travel time and performance measurement figures, derived from large historical databases, are in use for traffic monitoring and supporting decision-making. The drawback of this approach is that actual events can hardly be observed while using only historical data. For "normal" road conditions average patterns may the best choice, but, in order to enable for instance Traffic Management Centres (TMC) to notify and react automatically on actual events (e.g. accidents and incidents), also real-time roadside observations are essential.

FCD versus Probe Vehicle Data

FCD (floating car data) is used intensively in Europe's large cities and agglomeration areas where GPS equipped fleets (Taxis, delivery trucks, buses, etc.) are producing a fairly good ground truth for up-to-date traffic monitoring. Nowadays first implementations allow sending back information, based on FCD merged with a variety of corresponding data, to the fleets. So, the operational circuit is closed, which could be (and partly is) used for next generation ITS services using C2C (car to car) and C2I (car to infrastructure) technologies.

U.S. FCD is very often equated with Vehicle Probe Data. When visiting research laboratories and considering large data initiatives (I-95 Corridor Coalition) Vehicle Probe Data are collected using Bluetooth MAC addresses of mobile devices such as phones and PDAs. The technology is described in the corresponding paragraph of chapter 3.2.3. The most obvious limitation of the technology is that only on observed road network elements data collection is possible. Large efforts and technique-based expenditures are needed, while new cars are more and more equipped with GPS hardware. An exhaustive observation using "Bluetooth FCD" is hardly achievable.

GPS FCD is only used with very small pilot fleets for feasibility studies (USDOT fleet with a dozen of cars, snowploughs).

Clarus Initiative

As described more deeply in chapter 3.1, a big step towards free data availability has been made with the CLARUS system on road weather data covering a major part of the U.S. and a minor but augmenting part of the Canadian road network. Data are freely available both offline and online. For data research purposes offline data sets may be downloaded; for implementing online data into value added services and applications several data base interfaces are defined and intensively used by a variety of public and private service providers.

CLARUS has to be considered as a 'success story' when implications of 'free data policy' are to be considered in North America. With the USDOT, a roofing authority was successfully joining forces and donating financing for a standardized way of collecting the same type of data in an over-regional scale. There is an urgent need to start implementing a similar network of road weather data networks also in Europe.

Unfortunately, when considering the transportation system as a whole, road weather data is an important but minor aspect when targeting a comprehensive and reliable description and monitoring of daily road traffic conditions. Much more work needs to be done to achieve open and free data access to all necessary transport data for the innovative transport services of the future.

Models and methods

During cooperation in the INCO project we have exchanged information about basic research conducted on methods and models in the framework of ROADIDEA project and similar works in USA and CA. The results of our discussion are already considered at our present research and have been also transmitted to other partners of ROADIDEA project and several institutions dealing with traffic in the EU. At the corresponding communication we have also talked about possibility of transplantation of MDSS from USA to EU. At the same time we have found interest of researches, which are developing and deploying MDSS in application of ROADIDEA results in this system. Similarly as in USA and CA, of great interest for the future research in the EU is a proper treatment of congestion phenomenon by methods of intelligent control and swarm intelligence that are now under very active development. Among them the most outstanding problems identified during our collaboration in the INCO are the modeling based upon qualitative information and the modeling of dynamics on mutually interactive networks. We expect that a proper stimulation by EU funding could contribute to solutions of these problems and to a progress on the processing of information by intelligent software in the traffic sector.

Enhancing innovation and international cooperation

It is hard to draw definite conclusions of the innovation potential of European and North-American transportation sectors after a relatively short study such as ROADIDEA-INCO. Innovation methods applied in the project worked well with all partners regardless of their origin and resulted in many interesting and realistic ideas that can be developed further.

We observed that differences, though not as extreme as initially assumed, do exist in the data layer and in the data policies, but also other societal differences play a role in establishing a thriving information service sector (e.g. general attitude towards entrepreneurship, financing available to start-ups and growing companies, financing to R&D). There are also many different system constraints (e.g. central DOT vs. European, national, federal regulations in Europe, language and cultural issues and barriers).

Nevertheless, road traffic problems tend to be the same here and there. And also the impacts of adverse weather conditions are being considered more and more. Even though technology and regulative trends differ, the main direction of development has to be the same, i.e. greening of transportation, lower fuel consumption, decreasing road traffic fatalities, emissions, accidents, congestions, environmental impacts of traffic, etc. Research and technological development strategies and topics and standardization processes have to be synchronised and harmonised between Europe and the rest of the world – not only between Europe and the US.

The scientific exchange is already taking place through a few high-quality transport related annual World Conferences such as TRB and ITS. A similar exchange of research and technological development paths and strategies should also be established on an administrative level. ROADIDEA-INCO was one of the first projects that used a new kind of funding scheme to enhance international cooperation within ICT in transport. We urge EC to continue establishing and increasing such activities. This is an effective way to strengthen and weave new networks of experts to work together towards more innovative and sustainable global transport system.

8. Next steps and recommendations for actions

During the active period of ROADIDEA-INCO in 2010, the EU-US Cooperation was active in several Steering groups, Technical groups and working groups, and the Joint Declaration of Intent on Research Coopeartion in Cooperative Systems was signed. Potential applications with joint interest of developement were identified, harmonisation of standardisation continued and other coordination areas such as assessment tools identified. In order to strengthen this trans-Atlantic co-operation and knowledge exchange, ROADIDEA-INCO project recommends several new cooperation ideas that are brought to the attention of the existing working groups and actors in the European Commission. The following steps and actions are recommended:

- **Integration of ROADIDEA INCO results, expertise and partnerships into existing co-operation activities, working groups and task forces (e.g. *EU-US Co-operation steering group, technical groups and working group*).**

  Eventhough the ROADIDEA INCO team had a relatively short time and limited resources to complete its study, it was able to establish valuable contacts to the US and Canadian transport authorities, and gained insight in the most current developments that have potential for continued cooperation. The team is keen on presenting major project results and discuss possible co-operation fields and knowledge exchange channels with the European Commission. Strengths and weaknesses of considered transportation systems may be analysed, discussed and balanced.

- **Pro-active continuation and fostering of established contacts with concrete pilot and co-operation projects.**

  When presenting projects results to the DOT officials in Washington special attention has been raised with the description of European FCD based applications. The need and concrete implementation aspects of GPS-based FCD (Floating Car Data) have been intensively discussed. This could be taken as a first concrete co-operation project as FCD plays a very little role in the US IntelliDrive initiative – even though the technology is available and easily applicable.

- **Establishment of special interest sessions at international ITS Conferences (e.g. TRB Washington, ITS World).**

  Different aspects and unsolved problems are under consideration in the EU and US similarly, such as Metrics, Data Description and Exchange Standards for mobile ITS application, Data Policies, Models and Methods and many more. Latest interdisciplinary research activities and findings should be exchanged and discussed with special respect to trans-Atlantic co-operations and synchronisation of research directives. US partners will be invited to European conferences (e.g. ITS Europe) to get to know latest European research activities and results. Corresponding financing schemes and research exchange programs are to be set up.

- **Innovation seminars joining EU and US researchers and decision makers.**

  The success story of creating radical innovations for the transport system is to be continued in a trans-Atlantic scale. New service ideas are to be created using ROADIDEA innovation procedures taking into account urgent global issues and latest research topics in the EU and the US. Experts must discuss possible solutions on complex issues using interdisciplinary approach. Results may be integrated into new research and implementation funding schemes and strategic development paths.

- **Synchronisation and harmonisation of European and US research agendas and directives**

  Above-mentioned activities have to be governed and financed by administrative bodies in Europe and the US. In this respect, only a top-down-approach is applicable.

- **ROADIDEA-INCO project recommends several project proposals that require further actions and could be issued by the EC in the coming R&D calls under international cooperation actions**

For instance, large historical databases in the US are to be completed by European online data approaches (FCD) for detecting actual events and accidents automatically.

The centralised approach and advanced data quality checking routines of the US DOT CLARUS system for road weather data is to be adapted and applied to Europe. CLARUS should be used as a model and a benchmark. The implementation of such an initiative is discussed in more detail in the ROADIDEA Roadmap document D1.9.

Transplantation of MDSS (Maintenance Decision Support System) from USA to EU could be of benefit as well. It would require adaptation of the existing system to Europe. Results of Roadidea project would be applicable for this purpose.

One of the most outstanding characteristics of transport and related phenomena is the tremendous complexity and rather weak review of running activities on the related research field. In order to improve the situation an efficient source of corresponding international information is needed. Maybe TRANSPEDIA is a proper world for such an information source.

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Annexes

Annex 1: List of meetings and participants

Date	Place	Topic	Participants
09.01. – 13.01.2010	Washington, USA	Kick-off, local partner's meeting, first fact finding (TRB2010 conference), Clarus Work Shop by FHWA, Committee on Surface Transport Weather.	Pirkko Saarikivi (FORECA), Rene Kelpin, Marcus Mehlin (DLR). Workshop 20 and the Committee 30 local experts.
14.01. – 15.01.2010	New York, USA	Visiting TMC New York, fact finding, discussions	Pirkko Saarikivi (FORECA), Rene Kelpin, Marcus Mehlin, Julius Menge (DLR). Head of TMC and Traffic Police +2.
05.02. – 11.02.2010	Quebec, Canada	Canadian fact finding (SIRWEC2010 and PIARC conferences), local part-ner's meeting with ITS Canada.	Pirkko Saarikivi (FORECA), Franc Svegl (AMA), Rene Kelpin (DLR). Leader Environ-ment Canada, some 80 partici-pants in SIRWEC, 700 in PIARC.
21.03 – 27.03.2010	Stockholm, Swe-den	Workshop Road to Excel-lence + INCO topic - ex-change of experience with Canada (Quebec and Alberta) and USA (Minne-sota)	Franc Svegl (AMA), + 50 par-ticipants.
25.04. – 28.04.2010	Washington, USA	US innovation seminar by FHWA. Theme: Intel-liDrive	Pirkko Saarikivi, Auli Keskinen, Lulu Hyvätti (FORECA), Igor Grabec (AMA), Rene Kelpin (DLR). 24 participants from FHWA and road sector stake-holders
29.04. – 01.05.2010	College Park, Maryland, USA	Several fact finding meet-ings at the University of Maryland	Igor Grabec (AMA), Rene Kelpin (DLR) + local research experts.

07.06-11.06.2010	Brussels, Belgium	TRA2010 and International Innovations Seminar	Pirkko Saarikivi, Auli Keskinen, Lulu Hyvätti (FORECA), Igor Grabec (AMA), Rene Kelpin (DLR). 23 European and international participants + 131 web cast viewers.
14.06. – 20.06.2010	Ottawa and Montreal, Canada	ITS Canada 2010 Conference, meeting with Environment Canada and local road weather service provider AMEC.	Pirkko Saarikivi (FORECA), 300 conference participants, 2 in Environment Canada, 2 in AMEC.
21.06. – 25.06.2010	Seattle, USA	Conference participation TRB NATMEC 2010, visiting Washington University	Rene Kelpin (DLR), several hundred conference participants, local research experts.
21.06. – 23.06.2010	Montreal, Canada	Innovations Seminar with ITS Canada, Bureaux du Ministére des Transports du Québec, AQTR, Association québécoise du transport et des routes	Pirkko Saarikivi, Auli Keskinen, Lulu Hyvätti (FORECA), Igor Grabec, Franc Svegl (AMA), 19 local participants.
24.06. – 26.06.2010	Ithaka, USA	Cornell University technical visit	Igor Grabec, Franc Svegl (AMA), local research experts.
25.07. – 02.08.2010	Stockholm, Sweden	Final meeting - Road to Excellence + INCO topic - exchange of experience with Canada (Quebec and Alberta) and USA (Minnesota)	Franc Svegl (AMA), 8 participants
21.09 – 25.09.2010	Ottawa and Montreal, Canada	Results presentations in Transport Canada and Environment Canada	Pirkko Saarikivi (FORECA), 9 experts in Ottawa, 18 in Montreal.
26.09. – 29.09.2010	Washington, USA	Results presentation and discussion with local partners	Pirkko Saarikivi (FORECA), Rene Kelpin (DLR), FHWA 4 experts.
21.10.2010	Brussels, Belgium	Final project review meeting	Pirkko Saarikivi, Auli Keskinen, Lulu Hyvätti (FORECA), Rene Kelpin (DLR), Franc Svegl (AMA)

Annex 2: Examples of modeling for ITS

Our aim in this section is to represent some typical examples of methods and modeling related to ITS in Canada, USA, and EU project Roadidea. As has been mentioned above the main results of research performed on methods and models of Roadidea are described in its web page www.roadidea.eu/documents/, therefore we present here only some characteristic examples of non-parametric modeling that appears most generally applicable. For this purpose we have arbitrary selected results of the study performed by Amanova.

In the Roadidea project Amanova studied applicability of non-parametric approach to modeling of statistical relations between various observables characterizing properties of traffic and environment. The information required by the modeling is extracted directly from measured quantitative data. The modeling performance is characterized by the correlation coefficient between observed and predicted data. Examination of the correlation coefficient dependence of utilized variables indicates how the method can be tuned to a specific case of modeling. The method is demonstrated the following characteristic examples:

- estimation of road surface slipperiness in winter from weather data,
- forecasting of traffic flow rate at a single point or a network of points,
- estimation of missing traffic data.

Examples, such as estimation of missing data, optimal compression of traffic flow data, application of non-parametric method in approach to intelligent control of traffic flow, measurement of residual salt on road surface, are described in other articles as indicated in the web page www.roadidea.eu/documents/. These works have also been presented at various international conferences and with them related Roadidea events, as for example at *SIRWEC Conference, Quebec, TRA Brussels, etc.* In addition to this the results have also been presented by posters at INCO Seminars. Beside these examples we describe here also some representative examples of models used by non-EU partners in INCO.

Example 1: Prediction of adverse driving conditions in winter

Basic steps of non-parametric modeling of driving conditions

Driving conditions on a road are influenced by weather and road surface states that are changing rather stochastically.[E1.1,2,3] Consequently, we treat driving conditions as non-autonomous stochastic phenomena and describe their properties statistically by a general, non-parametric model.[E1.3,4-10] Information for the creation of the model is extracted from joint records of variables describing driving conditions and environmental properties quantitatively. The applicability of the method is demonstrated in the subsequent section by predicting variables representing slipperiness and concentration of particulate matter that influences visibility on a road surface. The final goal of our approach is to provide for a quantitative prediction of driving conditions from weather forecasts.[E1.5]

Our aim is to proceed to a general description of a relation between environmental and driving conditions on a particular point of a road. Both types of conditions are represented by vectors X, Y which comprise components of the state vector Z=(X,Y) that is further considered as a stochastic variable. We next assume that a series of measurements has yielded N joint statistical samples $\{Z_n=(X_n,Y_n);\ n = 1,..., N\}$ comprising a data base and that a calibration has provided the scattering function *g* of the instruments comprising the traffic and weather observation system.

In our description we want to avoid any a priori suppositions about the properties of the observed phenomenon as is usually done in a parametric statistical modeling of relations between stochastic variables. Consequently, we follow previously mentioned non-parametric approach and estimate the relation between X and Y by the conditional average [E1.4,6,7]: Y=E[Y|X]. If we want to predict driving conditions Y we just have to provide some data X about environmental conditions and the data base containing joint samples obtained by previous observations of the same phenomenon. Execution of arithmetical operations indicated in the expression of conditional average then yields the predicted value. The performance of the proposed estimation is quantitatively described by the correlation coefficient *r* between predicted and measured values.[E1.4] For this purpose we usually split the data base into two portions and subsequently use the first one for modeling and the second one for testing. Such cross-validation method was applied also in cases presented in the next section.

Prediction of pavement slipperiness

The pavement slipperiness describes the most important road property during winter in Scandinavian and Alpine countries as well as in Canada and certain regions of USA.[E1.5,11] It is well known that living beings have a well developed sense for estimation of slipperiness and that slipperiness essentially depends on the past and present weather conditions. However, it is not easy to characterize this property technically since the friction coefficient is subject to large fluctuations when measured as a ratio of horizontal and vertical force acting on a moving vehicle. Therefore, the idea is to join the information about slipperiness estimated by a fleet of expert drivers driving in different conditions with the information provided by various kinds of sensors in vehicles and weather observation stations. Based upon joined information an intelligent system should be developed that could learn from the acquired data to predict slipperiness from weather data. Such projects started recently in various Scandinavian countries. In order to demonstrate applicability of conditional average estimator for this purpose we utilize here data published by Swedish Slippery Road Information System - SRIS (**www.sris.nu**).[E1.11]

Figure E1.1 shows a record of the following joint variables: temperature - T, precipitation - P, and slipperiness - S that was estimated by a fleet of expert drivers. Although these variables appear independent, their dependence is in fact hidden in the joint PDF. If we apply several components of past and present weather data together with the slipperiness to describe the state vector Z, then the non-parametric modeling renders possible to predict the slipperiness from weather data and past records. Figure E1.2 shows records of predicted and actually observed slipperiness in dependence of time.

To characterize the accuracy of the slipperiness prediction we apply the correlation plot shown in Fig. E1.3. A point in this Figure is determined by the really measured value X and the corresponding predicted value Xp*.* The correlation coefficient of the predicted and actually observed slipperiness is calculated from all points in the graph and equals *r* = 0.77.

It is instructive that this result could be essentially improved. For this purpose we first determine the maximal value of measured slipperiness Xm and arbitrary select its half value 0.5 Xm as a critical level of slipperiness. Based on the critical value we define a transformed slipperiness variable by a unit step function U: Xtr = U(X - 0.5 Xm). Its value vanishes for slipperiness below the critical value and equals 1 for slipperiness above it; hence the transformed variable Xtr is applicable to roughly indicate critical conditions.

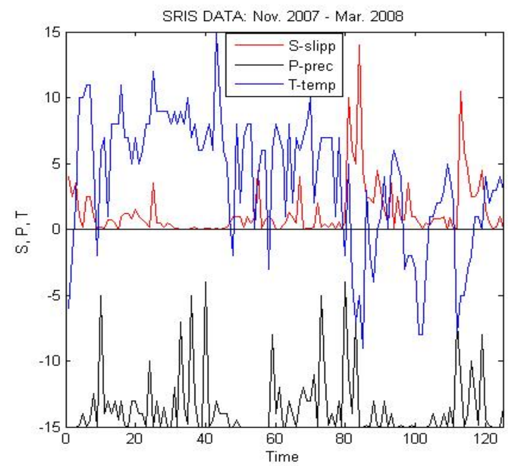


Figure E1.1. Record of joint weather and slipperiness data as published by www.sris.nu.

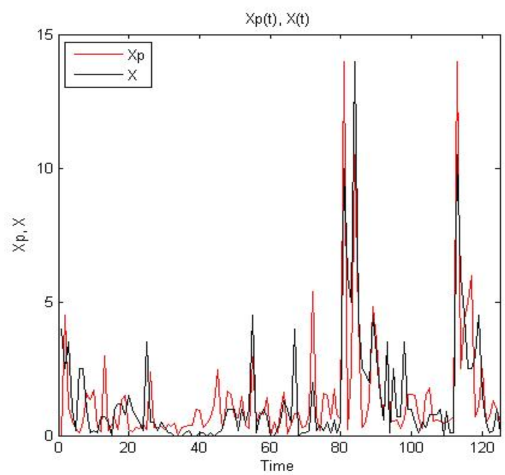


Figure E1.2. Slipperiness X as measured (black) or predicted (red) by the conditional average estimator from weather data.

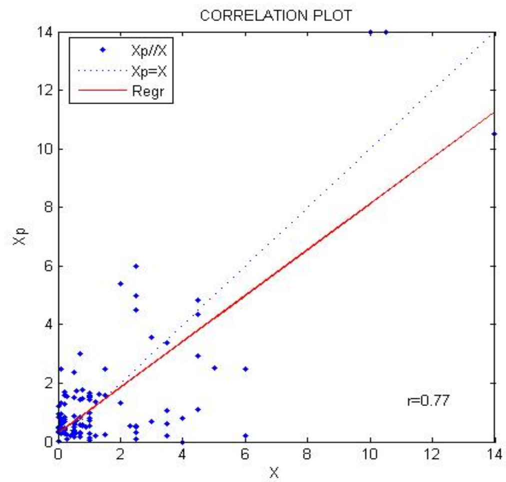


Figure E1.3. Correlation plot of measured and predicted slipperiness X from weather data.

The correlation coefficient of predicted and actually observed transformed variable Xtr is in *r*~1. This means, that a proper processing of data can significantly support and improve the statistical method.

It is important that forecasting of weather is well developed and that corresponding weather variables could be further utilized to forecast the slipperiness. Joining of traffic and weather data is needed for this purpose. This possibility is now a basis for development of an intelligent system for prediction of driving conditions.

The demonstrated example of slipperiness prediction indicates that non-parametric statistical modeling is applicable in the development of intelligent information processing systems that resemble properties of human experts. Such systems could substitute operators at various stations for traffic management and control. For this purpose the prediction method has to be included into more complex method of intelligent control.[E1.4,12]

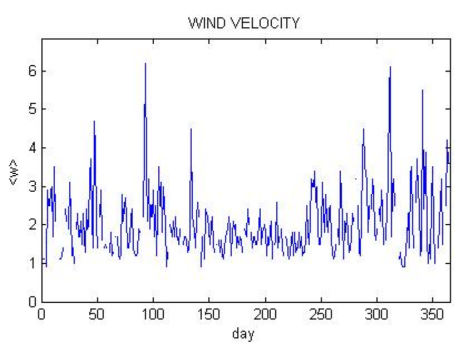
Prediction of pollution indicator PM10

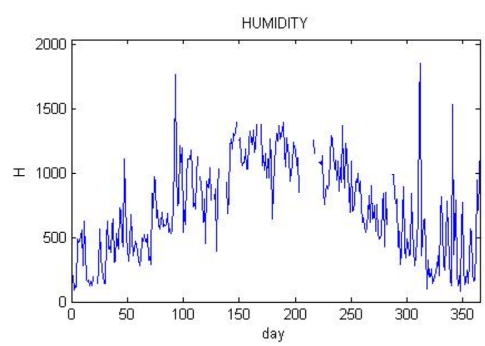
Beside slipperiness the air pollution is very important for characterization of driving conditions.[E1.5] It essentially depends on concentration of microscopic particles in the air which is described by pollution indicator PM10. This variable describes the concentration of solid particles having diameter in the range between 0 and 10 um and significantly influences visibility and development of fog. Our goal was to develop a method for prediction of P=PM10 from given data about other environmental variables describing the average air temperature - T, humidity – H , and the average wind velocity – W. For the testing of the non-parametric modeling and forecasting we utilized the data base provided by ARPV - Centro Meteorologico, Teolo, Italy. It contains data obtained by measurements in the Po valley in Italy. A portion of the data base is presented in Fig. E1.4. From this data base records of the state vector components Z= (W,H,T,P) have been then extracted. They are shown in Figs. E1.5a,b,c,d. Here the time is next used as the sample index n.

Microsoft Excel - Arpv_data

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1		Percentage of wind calm <0.5 m/s	Average wind speed	Average wind speed (without values<0.5 m/s)	Average wind direction	Hmix rural	Hmix urban	Stanford Index	Average radiation	T minimum	Average T	Total precipitation	Equavalent potetial temperature	Concentration PM10 Air Quality Station in Arcella	Concentration PM10 in Air Quality Station in Mandia	Concentration PM10 in Air Quality Station. Average Mandria and Arcella				
2	date	% wind calm	vv_m	vvc_m	dv_m	zi_r	zi_u	stan_u	rmed	tmin	tmed	ptot	thte	PM10_arc	PM10_man	PM10_tipo		aa	mm	gg
3	1.1.2003	17	1	1 1	289,1	156	206	0,54	81	277	280	0	296	63	62	63,0		2003	1	1
4	2.1.2003	12	1	1 1	352,9	46	90	0,69	7	278	278	0,2	294	55	54	55,0		2003	1	2
5	3.1.2003	25	1		85,2	74	126	1,37	17	277	278	0	293	53	46	50,0		2003	1	3
6	4.1.2003	17	0,8	0 9	75,1	93	117	2,74	50	274	276	0,2	289	62	46	54,0		2003	1	4
7	5.1.2003	8	2,7	2 9	299,5	266	491	0,39	31	276	278	5,8	293	44	40	42,0		2003	1	5
8	6.1.2003	8	2,3	2 5	326	262	464	0,05	42	274	276	8	288	48	36	42,0		2003	1	6
9	7.1.2003	0	2,5	2 5	338,2	245	471	0	19	274	275	5	287	33	25	29,0		2003	1	7
10	8.1.2003	0	2,9	2 9	336,4	271	521	0	12	274	275	0,2	285		41	41,0		2003	1	8
11	9.1.2003	0	3	3	334,6	285	553	0,02	28	273	274		301		32	32,0		2003	1	9
12	10.1.2003	12	1,5	1 7	337,2	188	284	0	51	273	274	0	289					2003	1	10
13	11.1.2003	0	3,5	3 5	323,2	347	623	0,03	87	272	274	0	298					2003	1	11
14	12.1.2003	4	2,1	2 1	357,9	257	391	0,36	100	269	272	0	302					2003	1	12
15	13.1.2003	37	0,7		57,1	136	178	2,75	83	267	271	0	311		130	130,0		2003	1	13
16	14.1.2003	62	0,5		41	119	156	1,81	84	269	273	0,2	314		152	152,0		2003	1	14
17	15.1.2003	62	0,5		14,4	125	166	5,1	80	270	273	0,2	315		188	188,0		2003	1	15
18	16.1.2003	8	1	1 1	12	91	126	4,98	46	270	274	0,2	305		196	196,0		2003	1	16
19	17.1.2003	17	0,9	1 1	41,7	120	163	3,54	72	272	276	0	300		127	127,0		2003	1	17
20	18.1.2003	17	1,1	1 2	34,8	84	124	1,43	39	272	277	0	291	128	103	116,0		2003	1	18
21	19.1.2003	0	1,4	1 4	68,7	156	198	4,08	105	271	274	0,2	318	76	67	72,0		2003	1	19
22	20.1.2003	33	0,7		78,4				93	271	275	0,4	306	101	97	99,0		2003	1	20
23	21.1.2003	4	2,3	2 4	312,2				17	276	278	15	293	83	87	85,0		2003	1	21
24	22.1.2003	17	1,8	2 1	39,8				31	275	279	2	294	49	50	50,0		2003	1	22
25	23.1.2003	37	0,8		70	112	141	2,39	56	273	277	0,2	296	84	73	79,0		2003	1	23
26	24.1.2003	0	1,9	1 9	339,7	170	258	2,17	107	274	279	0	291	67	52	60,0		2003	1	24
27	25.1.2003	0	3,1	3 1	326,3	331	566	1,22	108	277	279	0,2	290	49	37	43,0		2003	1	25
28	26.1.2003	0	2,3	2 3	335,9	268	365	2,23	111	275	278	0	288		47	47,0		2003	1	26
29	27.1.2003	4	1,1	1 2	66,4	192	245	3,29	96	273	277	0	294		86	86,0		2003	1	27
30	28.1.2003	12	1,2	1 4	0,4	141	200	2,63	87	272	276	0	303	148	134	141,0		2003	1	28

Figure E1.4. Data base used in modeling and forecasting of PM10.





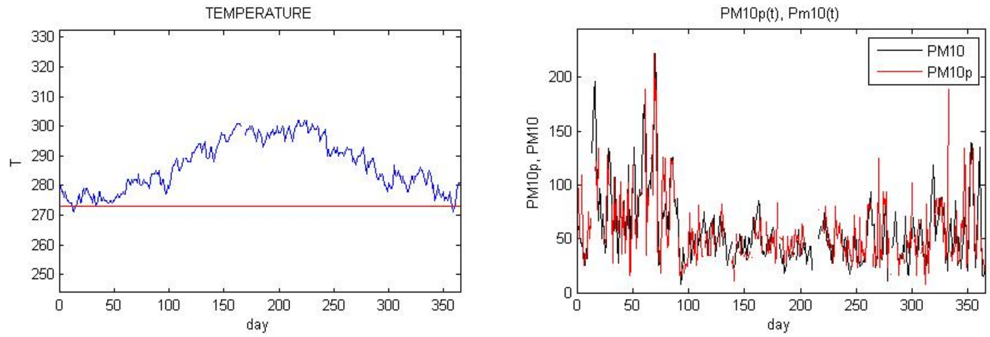


Figure E1.5. Records of variables used in modeling and prediction of PM10

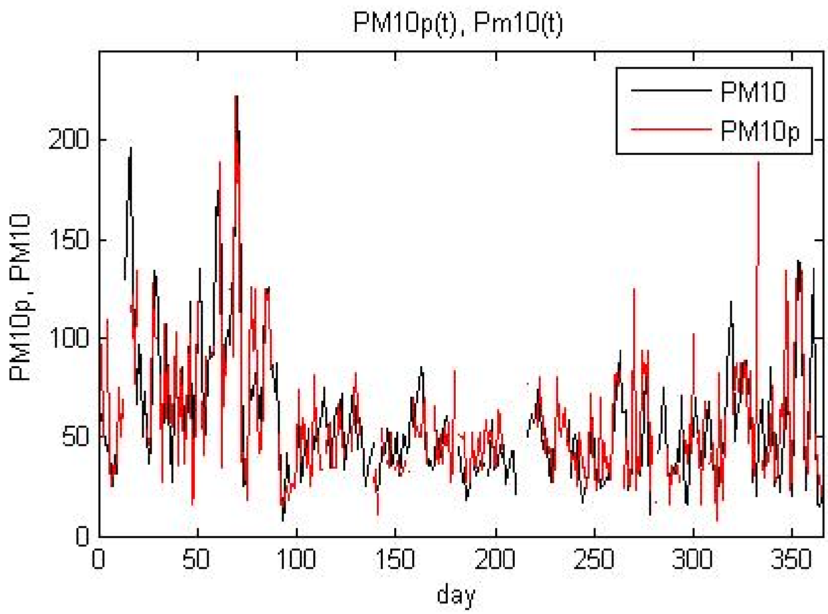


Figure E1.6. Records of predicted (red) and measured (black) PM10.

Based upon data from joint records shown in Fig. E1.5 we created statistical model of the relation P=F(W,H,T) as described by the conditional average. By using the model we then predicted hidden concentration P from given data of W,H,T. The result of prediction is shown together with corresponding measured data by the records in Fig. E1.6.

Agreement between predicted and really measured details are described by the correlation coefficient r and shown in the correlation diagram in Fig. E1.7. Similarly as in the case or slipperiness also in this case the value of correlation coefficient r=0.74 indicates an applicable prediction of variable under consideration.

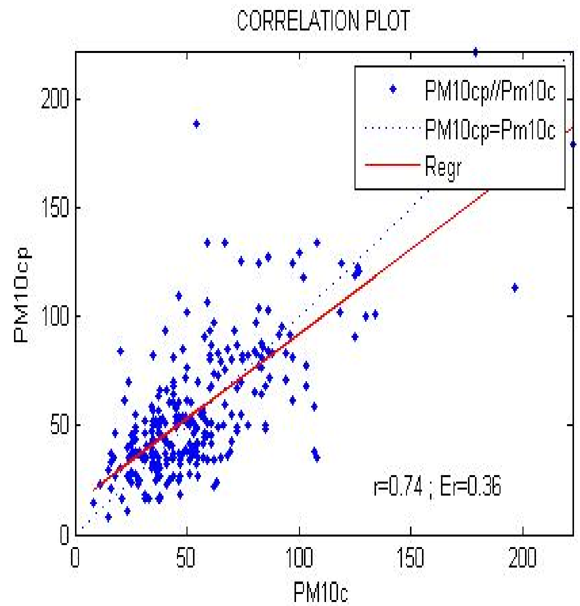


Figure E1.7. Correlation diagram of predicted and measured PM10. The agreement of both values is characterized by the linear regression line (red) while the diagonal line corresponds to an ideal agreement.

Conclusions about modeling of driving conditions

In this section the focus is on a general statistical modeling and forecasting of winter driving conditions.[E1.5,13] Consequently, non-parametric statistical approach is considered since it is completely based upon measured data.[E1.4] In spite of the complexity of driving conditions on roads, the non-parametric statistical modeling of relations between characteristic variables by conditional average estimator renders possible their forecasting based on environmental data. The information generated by forecasting can be transmitted to participants in the traffic over existing communication devices such as mobile telephones or internet.[E1.5] Beside this it is also applicable at the optimization of road service actions in winter.[E1.13] An important advantage of the non-parametric statistical modeling is that the governing algorithm is formulated rather generally and can be executed practically automatically without essential modification at its adaptation to a specific case. It can be therefore easily used for ITS support.

In addition to modeling of driving conditions the proposed method can be used to predict traffic flow distribution and related variables such as path integral of traffic activity and an optimal travelling time interval. It could also provide information about possibility of congestion development in a selected travelling time interval, etc.[E1.5,14] Beside this, non-parametric approach renders possible a simple joining of weather and traffic flow data and related prediction of critical states. Related to the modeling of traffic flow it also renders possible modeling of pollution generated by the traffic and forecasting of corresponding critical states. The non-parametric approach also renders possible consideration of traffic control variables in the modeling and thus provides also a basis for an intelligent control of traffic by ITS.[E1.4,14]

Example 2: Modeling and forecasting of traffic flow

The problem and approach to its solution

The aim of this section is demonstrate development of a graphic user interface – GUI by which the traffic flow on the network of roads could be predicted and presented to a user. The model was developed in the framework of Roadidea Work Package 3 and is now used in the Traffic information center of Slovenia. At the modeling the road traffic is considered as a driven chaotic phenomenon that can be characterized by the flow rate. Its dynamics is modeled statistically by following non-parametric approach. Basic information for the modeling is extracted from time series of the traffic flow rate recorded by a network of centers. An optimal predictor of the flow is formulated non-parametrically in terms of conditional average estimator explained in the previous Example 1. The condition is comprised of the hour and the day-code that together represent the driving. The model is further employed in the Matlab GUI that forecasts the traffic flow rate as specified by a user. GUI is adapted for application on web pages and cell phones. Potential users are participants in the traffic, road services, various agencies, government, etc.

Statistical background

The traffic is described by the flow rate Q and driving variables V influencing it. The traffic state vector is represented by the time series: $\mathbf{S} = (Q(t),Q(t-1),\ldots,Q(t-\tau);V(t), V(t-1),\ldots,V(t-\tau))$. N measured records comprise the statistical data-base: $\{\mathbf{S}_n ; n=1,\ldots, N\}$. The dynamic generator of the flow is described by a mapping relation:
$Q(t)=F(Q(t-1),\ldots;V(t), V(t-1),\ldots)$.
To estimate the function F we consider the vector in the parenthesis on the right as the condition X, and the variable $Q(t)$ on the left as the predicted value Y. At a given time t the flow rate $Q(t)$ can then be predicted from the past flow rate $Q(t-1)$... and driving variables $V(t)$, $V(t-1)$... by the conditional average estimator given in Example 1. In the most simple treatment we consider as driving variables the *hour* and the *code* of the day. It is not known in advance how many past values have to be utilized in modeling. For this purpose we quantify the prediction performance by the correlation coefficient r between predicted and measured traffic flow rate Q. By evaluating the performance at different numbers of components, we find an optimal composition of the condition.

Traffic flow forecasting

The forecasting was tested using records of traffic flow rate on the network of Slovenian roads from the year 2007 with 1h intervals. The time datum is transformed to hour of the day (0-24) and the day-code by the rule: Monday – 1, day after holiday or weekend – 2, normal working day – 3, Friday – 5, day before holiday or weekend – 6, Saturday – 7, Sunday – 9, holiday – 10. Fig. E2.1 shows a record of the traffic flow rate Q over the year at some representative point. Fig. E2.2 shows the corresponding distribution of the day-code, while Fig. E2.3 shows the hour variable in dependence of time. Fig. E2.4 shows result of forecasting for some normal representative week of a year. The agreement between predicted (red line) and original data (dotted line) is demonstrated in Fig. E2.5 by blue points. The dotted line in Fig. E2.5 represents an exact prediction. A bit worse prediction than in a normal week is obtained in weeks containing holidays. From the plot the correlation coefficient r and the linear regression line (red) were determined. The mean value of the correlation coefficient over the year is $\langle r \rangle \sim 0.96$ in average over all points of observation. At the presented modeling just the day-code and hour variable are used to describe the condition. If the present value of traffic flow $Q(t)$ is included into the condition, the mean performance is slightly increased and more stable over the year. Inclusion of weather variables into condition does not represent any problems.

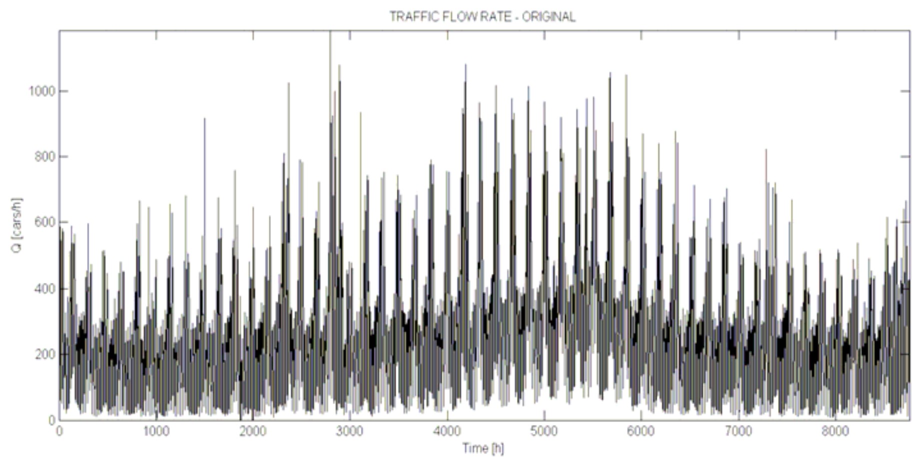


Fig. E2.1. Record of flow rate

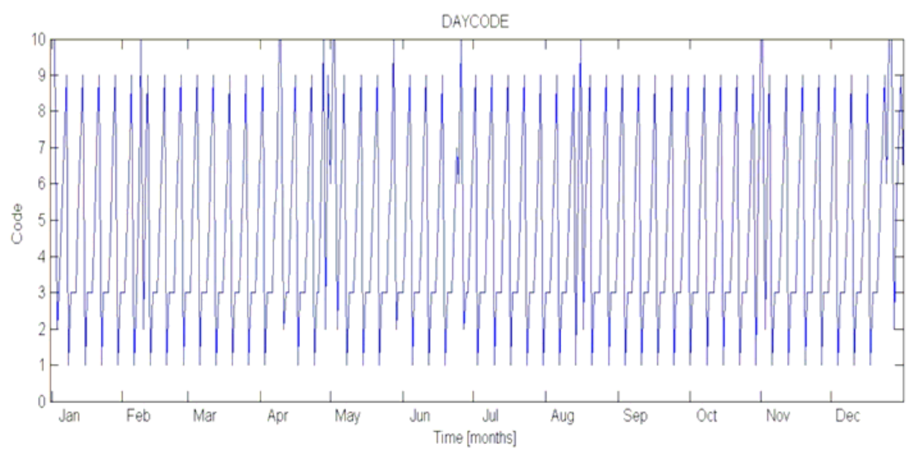


Fig. E2.2. Record of day-code

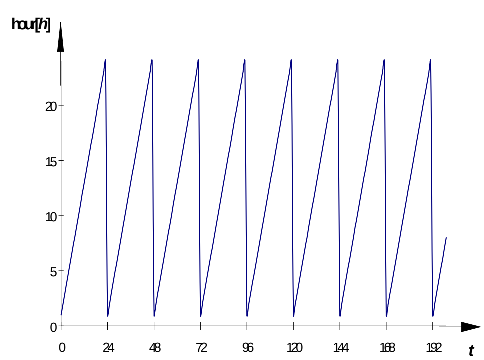


Fig. E2.3. Hour variable

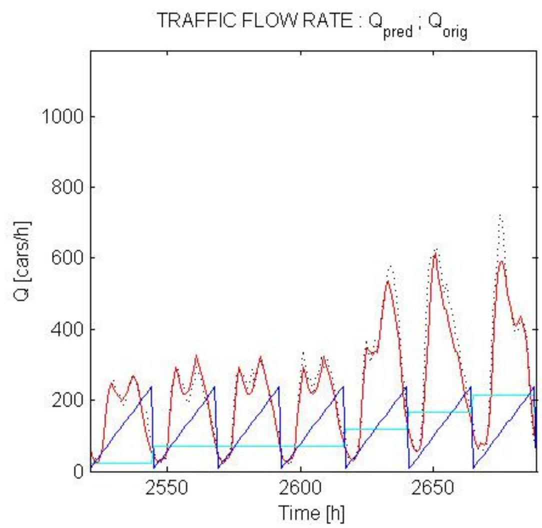


Fig. E2.4. Flow prediction for a week of normal days

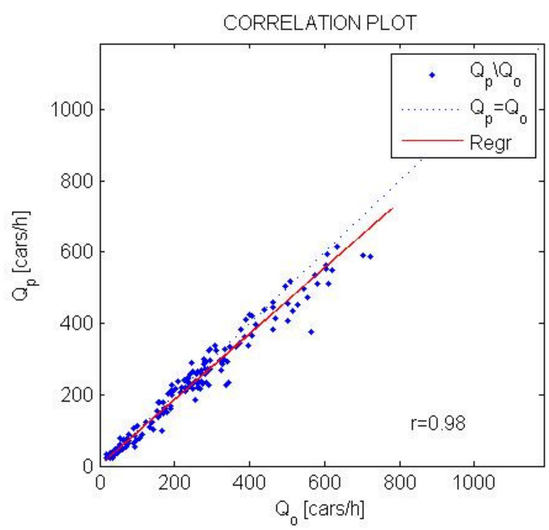


Fig. E2.5. Correlation plotof traffic flow prediction

Properties of the Graphic User Interface – GUI

The prediction code was incorporated into matlab GUI shown in Fig. E2.6. At an application a user sets time (day and hour) of prediction, and selects an observation point from the pop-up menu. GUI displays the field of traffic flow rate from the start of the selected day to the selected hour in the top graph of Fig. E2.6 and displays the distribution of predicted traffic flow over the selected day in the bottom graph. The selected place and hour of prediction are marked in the graphs. Prediction can be repeated with varied time and place and the display can be printed.

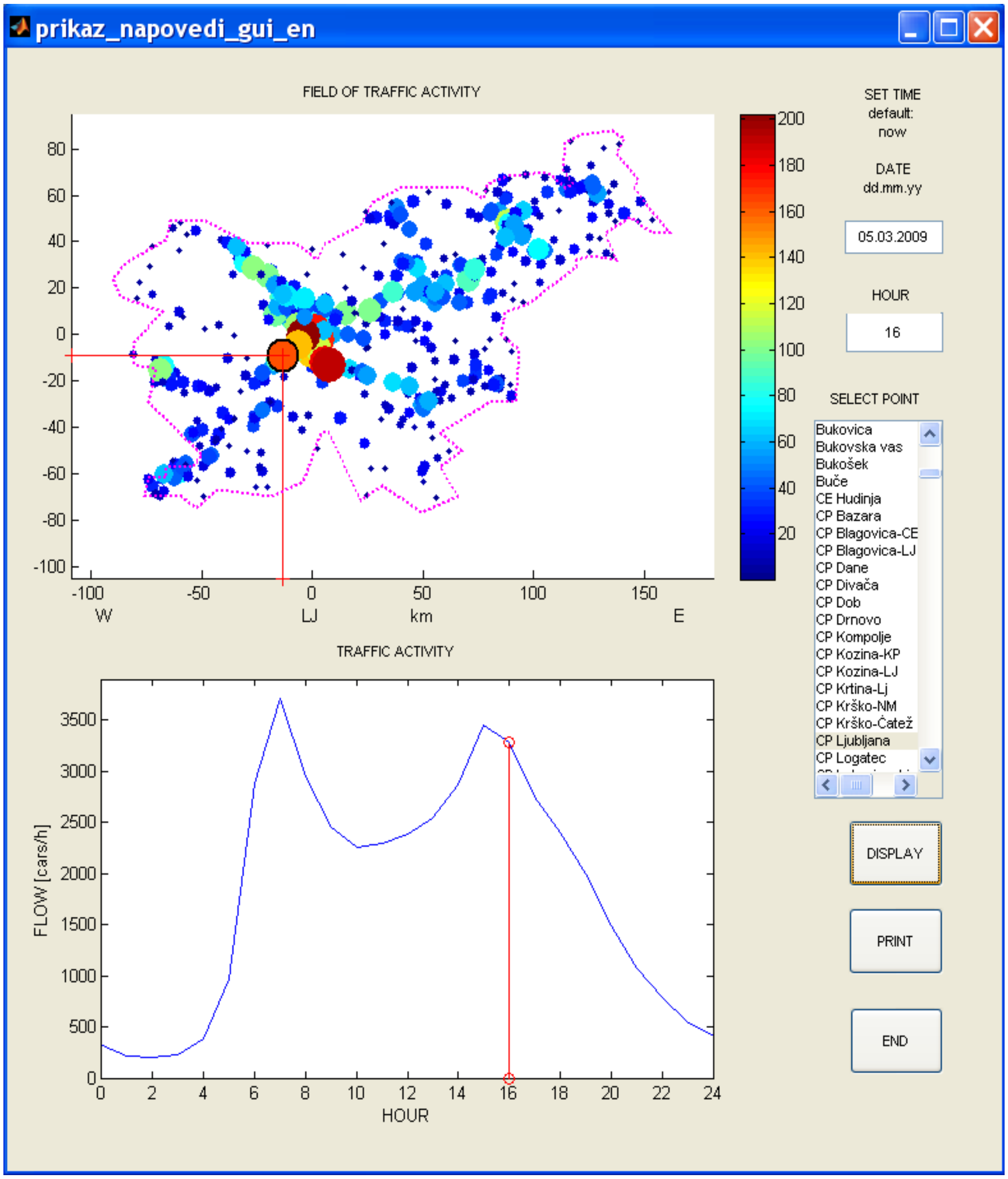


Fig.E2.6. Graphic user interface for presentation of predicted traffic flow field in Slovenia.

Additional application of flow prediction

Predicted traffic flow rate renders possible to estimate the traffic load passed during travelling on a predetermined route by integrating *Q(t)* from the start to the end of travelling. Fig. E2.7 shows the dependence of such integral on the starting time of travelling between two extremal points on the most loaded high-way in the country. The traffic load essentially depends on the starting time, therefore its value could provide for a selection of a proper time of travelling. Beside this it can be compared with the critical value of load (red line) at which formation of congestions coud be expected.

By using predicted data of the traffic flow rate one can also proceed with modelling of congestion at a bottleneck of a road. For this purpose the normal driving conditions and a proper distribution corresponding to the predicted rate have to be accounted. Fig. E2.8 shows the result of such a modelling. A blue bottom-up line corresponds to a car driving trough the bottleneck. The graph reveals four characteristic phases of traffic flow over the bottleneck known as: a free flow far before, backward formation of a congestion in front of, synchronized flow inside, and a free flow afterwards. Such a hybrid model could be utilized by a road service when planning reconstruction works.

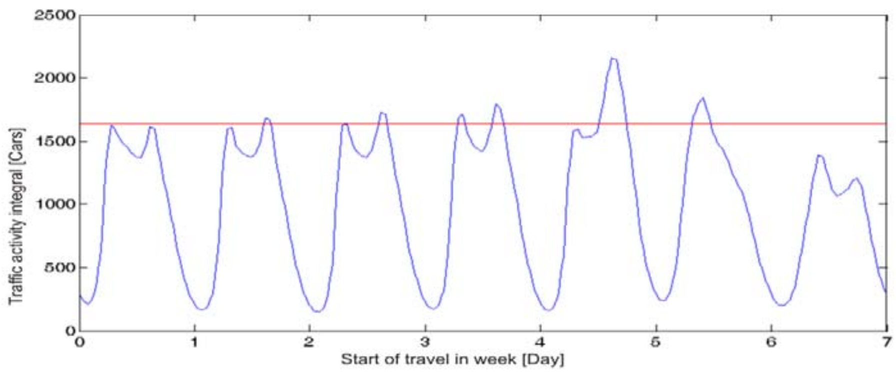


Fig. E2.7. Prediction of the critical flow (red) on a selected route

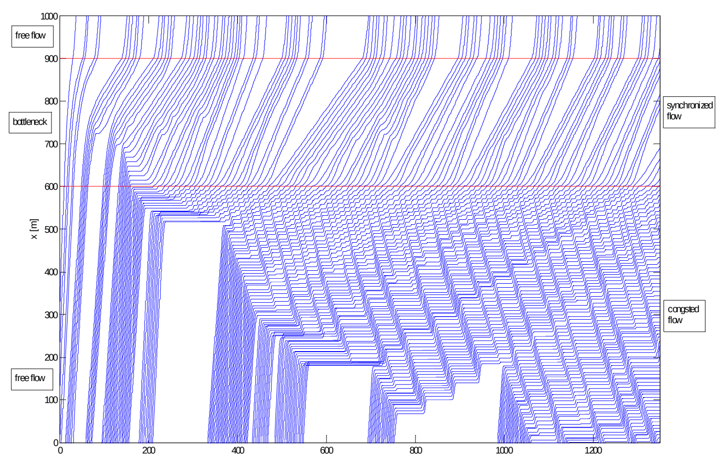


Fig. E2.8. Modeling development of congestion on a bottleneck

Acknowledgment

Research of presented examples was supported by EU 7 FP project Roadidea and with it related INCO, iCAR - EU Thematic Network, EU COST MP801 and Slovenian Agency for Roads. Data used in modeling were provided by collaborating companies Semcon and Klimator in Göteborg in Sweden and ARPV Centro Meteorologico, Teolo, Italy.

Example 3: MDSS guidance tool

The MDSS guidance tool (www.rap.ucar.edu/projects/rdwx_mdss/) provides winter maintenance professionals with route specific weather forecast information and treatment recommendations. For this purpose the MDSS applies weather forecast data at locations important to the user's operations as input to the pavement heat balance model (e.g., METRo) to predict the road surface conditions, such as subsurface temperatures and the snow depth at each forecast lead-time. Based upon these conditions treatment plans at each site are generated based on Rules of Practice guidelines. The MDSS includes a graphical user interface (GUI) display for road maintenance managers. By this display a maintenance manager can generate treatment plans and seeing the resulting predicted road conditions. The GUI contains a set of windows that describe the interconnection of basic modulus, each of which contains a specific model indicated by the window text. The models span from simple look-up tables, over empirical models to analytical ones. In addition to the especially demanding composition and programming of modules, the development of the MDSS has been supported by sophisticated programming of complete network performance that provides for on-line supply of weather information and interactive work of maintenance managers. The structure of the MDSS is graphically represented by the following set of pictures that clearly represent the main functional modules of the environment.

The basic structure of MDSS is shown schematically in the Figure E3.1. The weather and supplementary data are obtained from National Weather Service and RWIS and used in Road Weather Forecast block that includes several modules for generating variables that are needed as input to Road condition and treatment module. This module contains the model for prediction of road temperature, the model with chemical concentration algorithms and a module with rules of practice for anti- and de-icing. The output from Road condition and treatment module is used as input to the Road Weather Predictions and Plow Route Specific Treatment Recommendations module where suggestions of proper road treatment are created based upon predicted weather and selected road state data.

For the operation of the MDSS the most important is the model that converts weather variables into road treatment recommendations. Its structure is schematically represented in the Figure E3.2 while the variables describing the pavement state and used in modeling are indicated in Figure E3.3.In addition, the influence of terrain properties on variables characterizing pavement state is indicated in Figure E3.4. From the weather variables the snow depth and pavement temperature are first estimated based upon a hybrid model. The pavement temperature is used together with rules of practice to estimate the chemical concentration of the pavement and to estimate a proper chemical application as well as the recommendations for optimal plowing.

In order to provide a graphical support to maintenance operators, the MDSS environment also contains various windows containing geographical and weather information such as selected maintenance arc (Figs E3.5 E3.6.), event summary (Fig E3.7), treatment selector (Fig E3.8), and other properties of interest along the selected maintenance arc (Figs E3.9- E3.10.).

The structure of the MDSS provides for rather simple expansion of the network of locations and is very convenient for application. With respect to this some preliminary steps have already been done in order to transplant this system also to EU countries. In addition, various possibilities to include non-parametric modeling and prediction of traffic flows into further versions of MDSS have been discussed during INCO Innovation seminars. The possibilities to upgrade MDSS by a module for diminishing of congestions and traffic management at critical events have also been discussed.

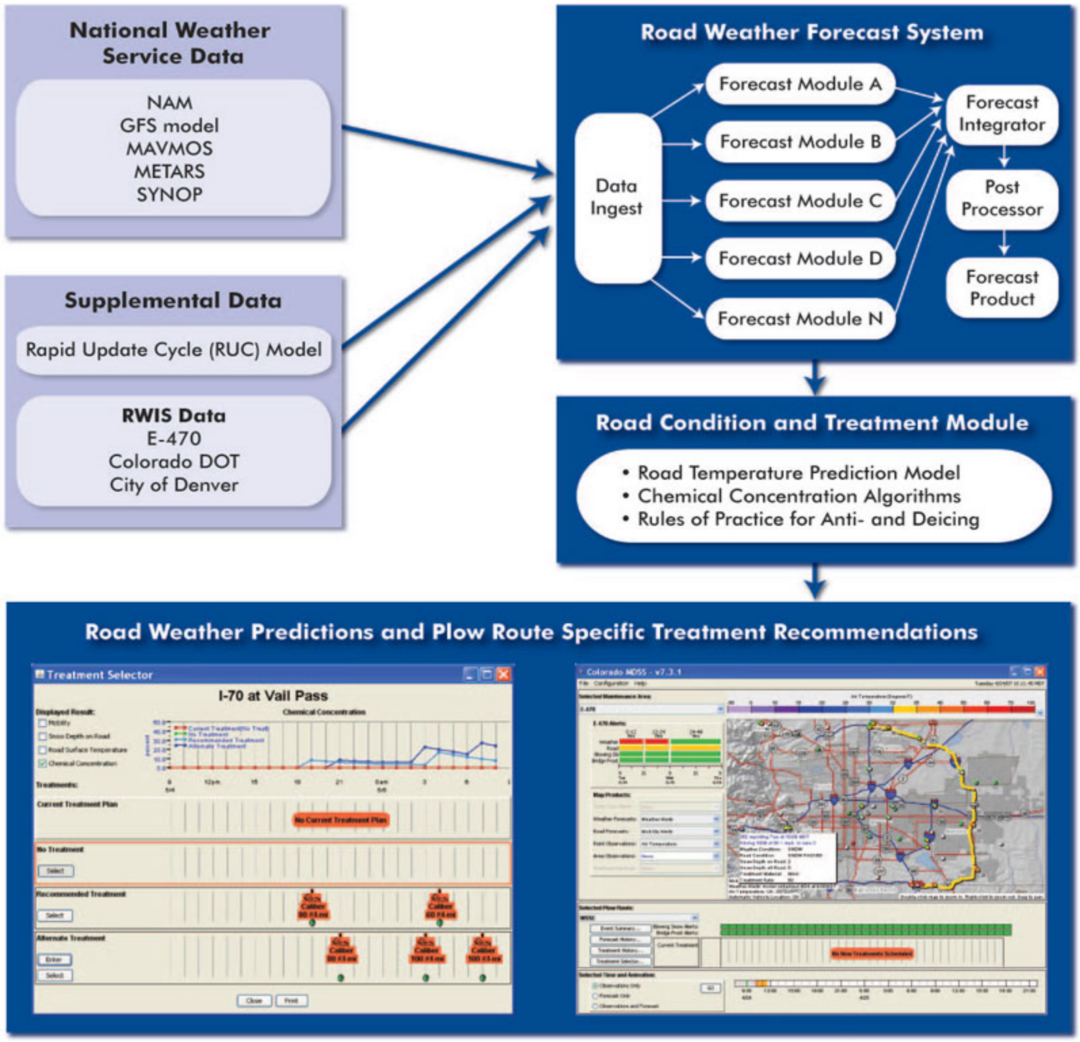


Figure E3.1. System architecture used in current MDSS winter demonstrations.

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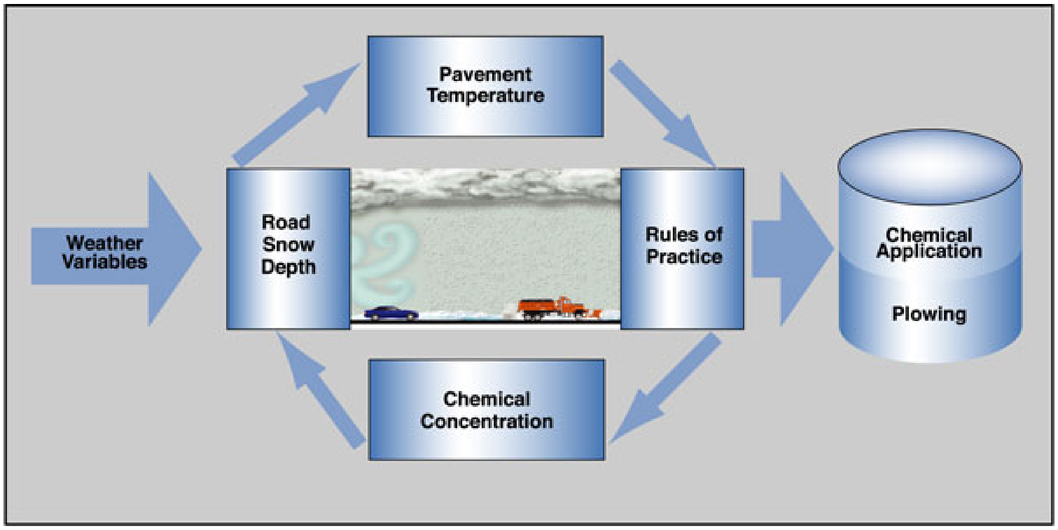

Figure E3.2. Structure of the hybrid model for creation of service recommendations

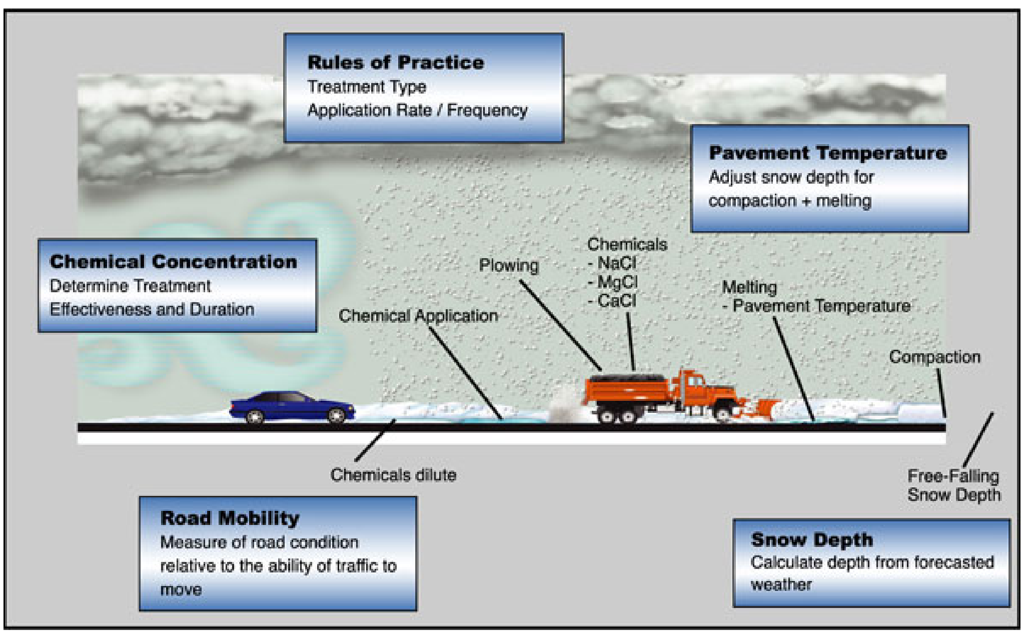

Figure E3.3. Variables utilized in modeling of pavement state and service recommendations

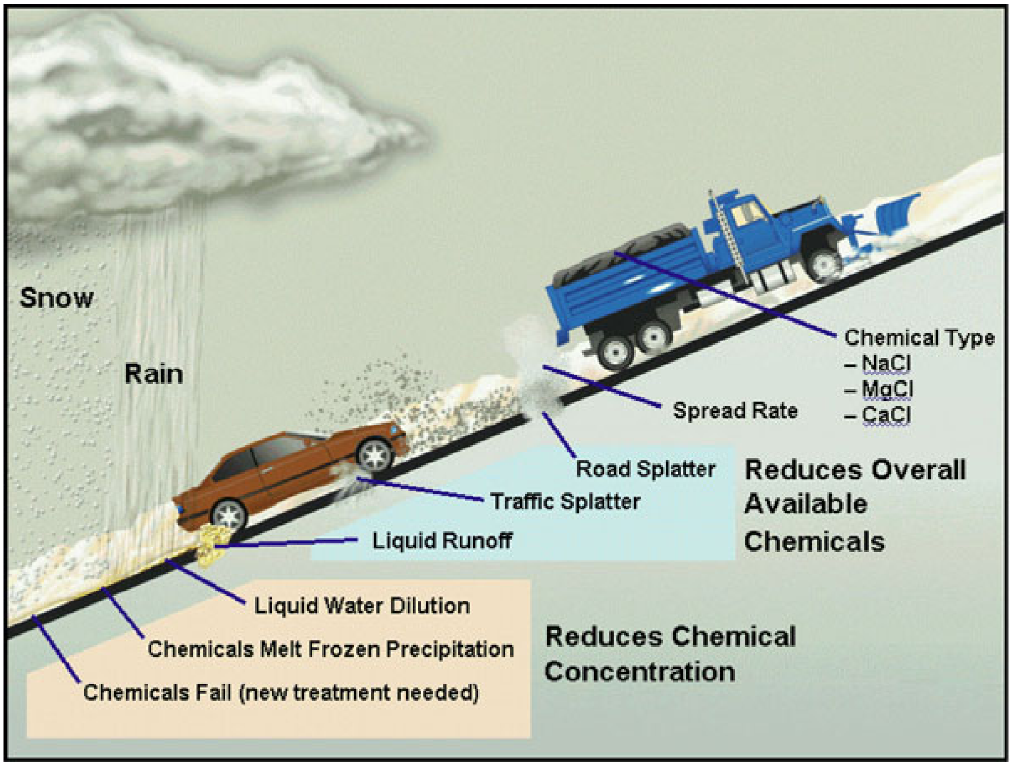

Figure E3.4. Influence of terrain properties on variables characterizing pavement state.

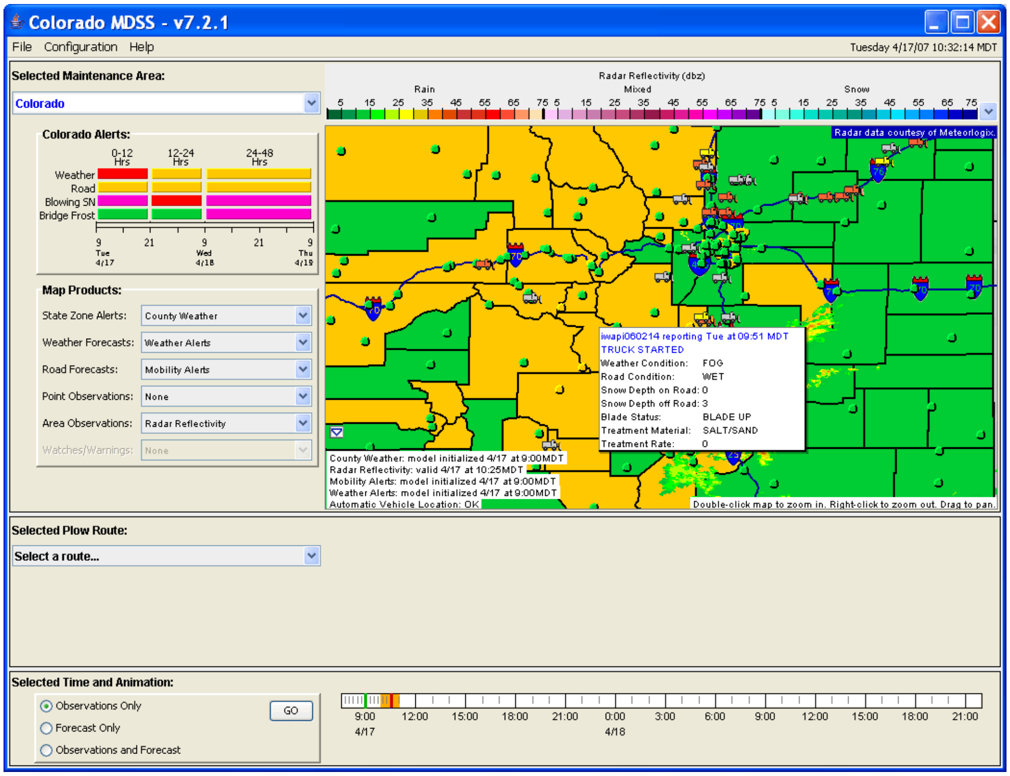

Figure E3.5. Window for presentation of selected maintenance arc and weather alerts.

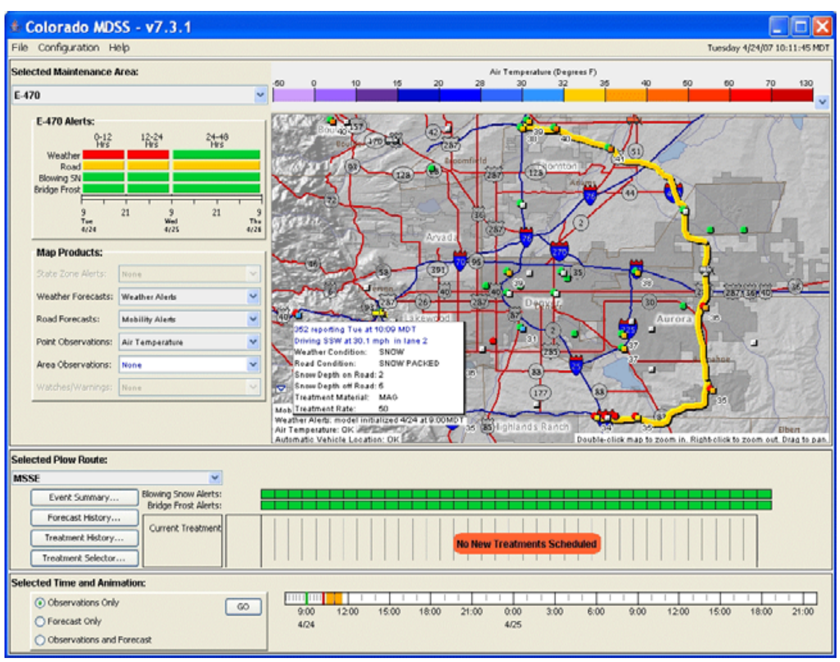

Figure E3.6. Window for presentation of selected maintenance district.

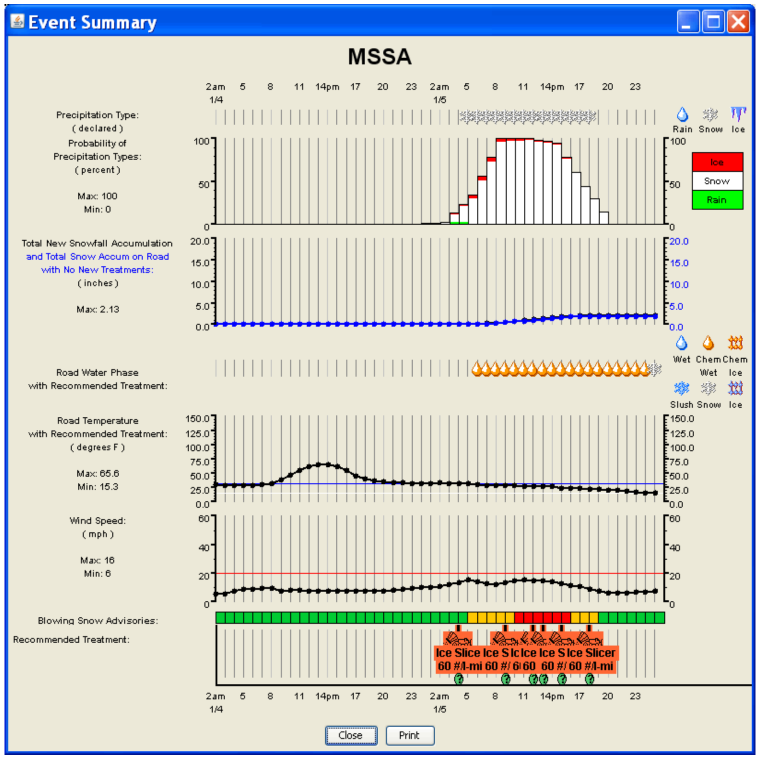

Figure E3.7. Window for display of event summary.

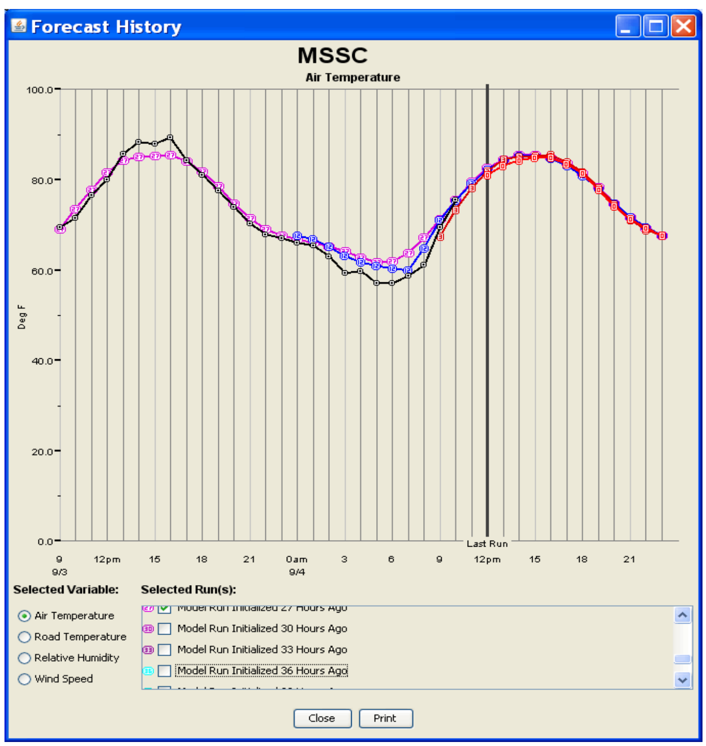

Figure E3.8. Window for presentation of forecast history plot.

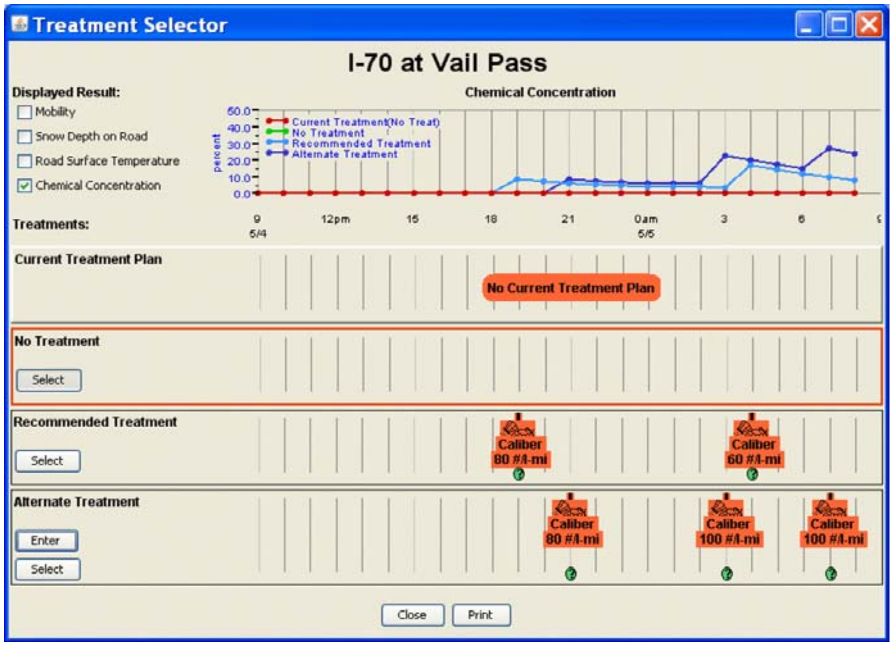

Figure E3.9. GUI for treatment selection.

Figure E3.8. Window for presentation of weather forecast variables.

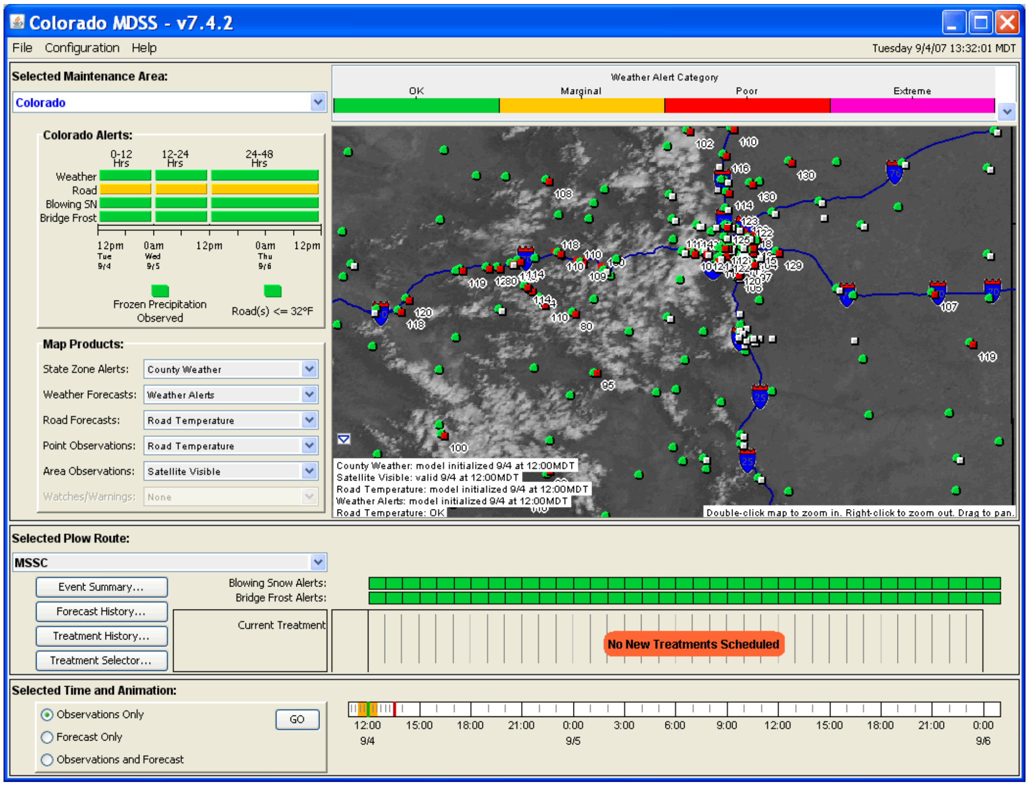

Figure E3.9. Window for presentation of weather variables in the region containing selected maintenance arc.

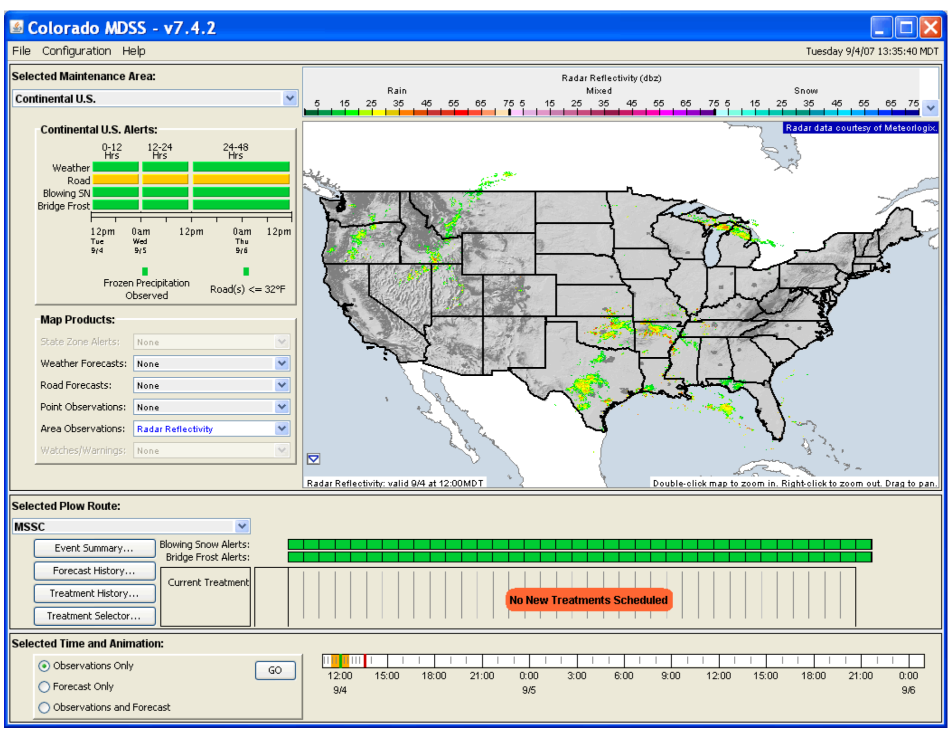

Figure E3.10. Window for presentation of weather variables in the state containing selected maintenance arc.

Annex 3: Background Reading ROADIDEA-INCO SEMINAR, 27 - 28 April, 2010

Place: **German Aerospace Centre - DLR, Washington, D.C.**
1776 I (Eye) Street, NW, Suite 1000
Washington, D.C. 20006
Date: **Tuesday 27 April**

Agenda:

Time Issue

13-14 Welcome - Dr. Drescher, DLR
Introduction of participants - Paul Pisano
Presentation of ROADIDEA - INCO project - Pirkko Saarikivi
Innovation process; Scenarios of 2008 - Auli Keskinen

14-18 Innovation seminar, 1st session (brainstorming, evaluation cycle) on IntelliDrive road weather topics:

- Data acquisition from vehicles
- Data translation
- Linking new data to Mesonets (Clarus etc.)
- Applications for new data

Conducted by Auli Keskinen and Pirkko Saarikivi, Foreca Consulting, Rene Kelpin, DLR Germany
(Coffee breaks as needed)

18 Cocktails & snacks

Wednesday 28 April

9-10 Millennium Project; Scenarios; What's globally new
Jerome Glenn, Millennium Project, Washington, D.C.

10-13 Innovation seminar, 2nd session (synectics session)
Conducted by Auli Keskinen, Pirkko Saarikivi, Rene Kelpin, Lulu Hyvätti
(Coffee breaks as needed)

13-13.30 Conclusions, closing remarks, further actions

Annex: Rationale and workplan. Problem solving by Synectics Method

ROADIDEA-INCO - Rationale and Work Plan

Rationale

Project 215455 ROADIDEA (2007-2010) is investigating Europe's ability to innovate new mobility services. Basic hypothesis is that effective accessibility to all kinds of useful background information combined with advanced data fusion methods and technological information platforms with high level of standardization are prerequisites for creation of innovative mobility services. The first results show that the major barriers in Europe are in the data layer: in accessibility, pricing, standardisation, and heterogeneous organisational structure of data providers in EU countries. In the USA and Canada, similar information is available openly and free of charge due to their open data policy. This study is cooperating with the federal Clarus initiative in the USA and Canada to find out the differences in data layer and in resulting methods and models, and provision of mobility services to various transport user groups.

Work Plan

In the USA, road information systems and services are analysed, with main emphasis on the Clarus initiative managed by the US Partner Federal Highways Administration. Its Multi-state Regional Demonstration project is extending to Canada, covering Yukon, British Columbia and Alberta. The responsible Partner is ITS Canada. The visits will also include innovations session, as in ROADIDEA but somewhat simplified and shorter. US and Canadian partners invite their key experts and stakeholders to the events which are conducted following the Synectics method of brainstorming.

Problem Solving by Synectics Method

Synectics* is a problem solving method where a group of experts from wide range of fields can produce innovative ideas under guidance using a reasonable allocation of resources. The Synectics session suits best for a group of 10 to 20 people and can last from three to 6 hours.

The Synectics session is conducted in two phases using as starting point the results of a brainstorming and evaluation process where 3 best ideas have been short-listed for further discussion. First, for each idea a Problem Owner (PO) who knows intimately the issue is selected and the Process Engineer (PE) who knows the method well is assigned. The group of experts makes the innovating audience (A).

This process insists to maintain the individual sovereignty and dignity by forbidding criticism, but the new ideas may be drawn from already stated ones, i.e. the "riding on others' ideas" is invited to form an "innovation hyper-cycle". The PO and the PE can make further questions if the A seems to fall silent.

The Synectics is run for each 3 ideas as follows:

Phase 1: The PO explains the idea to the A. Then PO makes the question: How can this problem be solved? or: How can this idea be realised? The A is free to throw in ideas and the PE makes notes by writing them on one flip paper for all to see. Thus, this is a "trialogue" among PO, PE and A.

Phase 2: When all ideas have been gathered the PO selects 2 or 3 best ones (also if possible some of the ideas may first be combined). The PE writes this short list on second flip paper. Each idea is then further discussed. The PO starts by asking: How can this idea be realised in practice? The A creates ideas for practical realisation and the PE writes these on a third flip paper.. Thus in the end, the PO selects the best ideas (no limit) for each problem. (Depending on the time available the discussion can go even to more details, otherwise these best ideas are the result of the session).

*for details, see Synectics at http://creatingminds.org/articles/synectics.htm).

Background reading (sent beforehand to eventual seminar participants)

EU Fp7 R&D Roadidea Project, www.roadidea.eu

ROADIDEA studies the innovation potential of the European ITS sector by analysing available data sources, revealing existing problems and bottlenecks for data utilisation and service build-up. ROADIDEA also makes an effort to develop better methods and models to be utilised in different service platforms.

- Project Leader: Dr Pirkko Saarikivi, Foreca Consulting Ltd

Futures Workshop Innovation Method

Apel, Heino (2004), *Future Workshop,*
http://www.die-bonn.de/esprid/dokumente/doc-2004/apel04_02.pdf
Innovation work in ROADIDEA Project, Deliverables D5.1, D5.2, D5.3
http://www.roadidea.eu/default.aspx

- ROADIDEA D5.1 Innovation Plan
- ROADIDEA D5.2 Results of the First Innovation Seminar
- ROADIDEA D5.3 Results of the Second Innovation Seminar

SIRWEC Standing International Road Weather Committee, www.sirwec.org

SIRWEC exists to encourage meteorologists, weather forecasters, highway engineers, road masters and others, who are interested in road weather problems, to exchange ideas to make our roads safer to drive on in all weather conditions.

- President 2010-2012: Mr Miguel Tremblay, Canada
- Vice-Presidents 2011-2012: Mr Yrjö Pilli-Sihvola & Mr Pertti Nurmi, Finland
- SIRWEC was originally set up in 1984 as SERWEC (Standing European Road Weather Commission, among founding members: John Thornes, Auli Keskinen, Erkki Nysten).

The Millennium Project, WFUNA, www.millennium-project.org

Executive Summary for State of the Future 2009,
http://www.millennium-project.org/millennium/SOF2009-English.pdf
The Millennium Project (founded in 1996) is an independent non-profit global participatory futures research think tank of futurists, scholars, business planners, and policy makers who work for international organizations, governments, corporations, NGOs, and universities. The Millennium Project manages a coherent and cumulative process that collects and assesses judgments from over 2,500 people since the beginning of the project selected by its 33 Nodes around the world. The work is distilled in its annual "State of the Future", "Futures Research Methodology" series, and special studies.

- Director Jerry Glenn, http://www.youtube.com/watch?v=cFlkaRMCqlg

The energy scenarios of the Millennium Project on 2008
(handed out as separate file to eventual participants beforehand - this is the same background information as in ROADIDEA Dubrovnik innovation seminar, 5/2009, and explained in Deliverable D5.3)

Annex 4: ROADIDEA - INCO Washington DC seminar

All Ideas of Three Groups (collected on flip papers in the seminar)

Group 1 Leader P. Saarikivi

World 2, Environmental backlash 2030

General discussion: cars will be more environmental friendly

Ideas:

1. Energy influences transport (scaled down?) optimised smart grid for transport (multisource)
2. Efficiency, optimal system (civil liberties)
3. Repurposing existing infrastructure (needs money to build new)
4. Encourage telecommuting (Financial impact)
5. Redefine commerce (work) and logistics and way of moving (e.g. golf carts)
6. Land use
7. Reduced winter maintenance -> "sleigh cars"
8. Meter the "essentialness" of transport
9. Environmental data beyond traffic impact (other uses)
10. Personal transport IntelliDrive (everybody can take part in contributing to the data pool -> gain access to new services from the system)
11. Flow control -> revolutionise traffic controls

Three best ideas were (quite equal number of points):

4. Personal transport IntelliDrive (everybody can take part in contributing to the data pool -> gain access to new services from the system)
5. Environmental data beyond traffic impact (other uses)
6. Repurposing existing infrastructure (needs money to build new)

Synectics session results on the second day providing more practical information on question: HOW CAN THIS BE REALISED? (phase two) on the three best ideas

1. Personal transport IntelliDrive (everybody can take part in contributing to the data pool -> gain access to new services from the system). Is there too much data? Interpretations might get confused? Quality of data and the differences result on need for more quality checks.

- Much data, but computers take care of integration
- Many obs. may contribute to one data point -> consolidated reporting (can be done locally)
- Needs sophisticated quality checking
- Need to decide where "the brains" of the system are. Centralized vs. distributed, find optimum
- Training of users needed, so that people use it, "marketing", give people incentive to contribute voluntary.

- Sensor development needed, tailored to different modes
- Is there a limit in available band width?
- Suburban and rural have different needs
- Results used to control transport actions (pollution level…)
- First: more sophisticated routing using IntelliDrive

2. Environmental data beyond traffic impact (other uses)
- Using data for other applications
- New sensors are needed, pollution obs.
- Viruses, pollen ->service: route planning
- Pollution also coming from the vehicle
- Cars/bicycles/pedestrians on the same lane: collision avoidance (radar, infrared)
- Sensors on helmets, clothes, jewellery
- Interact with the system by voice/thoughts

3. Repurposing existing infrastructure (needs money to build new)
- Innovation need: new type of rails and tires!
- Design the highway lines to new modes (bicycle lanes needed), multi-purposes roads
- Logistics need
- Repurposes also the data spectrum
- Must have back-ups and plan b's
- Use of electricity, need rationalizing
- More rails!
- Must re-plan road maintenance actions: Better designed bike roads, less need for asphalt-> need magnetic asphalt!

Group 2 Leader: R. Kelpin

World 3, Technology break through

General discussion: New kind of connectivity pushes through. All people, vehicles, incidents, etc. all information available for all wirelessly. Highway trust fund is financing the transport. The tax has been fixed not indexed. Tax increase is not possible…?

PROBLEMS:

Haves vs. have not's (or in Washington DC have not's vs. have Yachts)
1. Vehicle miles travel is increasing, population is increasing at the same time the network is fixed not growing and Haves vs. have not's (or in Washington DC haves vs. have Yachts)
2. Transportation financing
   Advanced Tele-presence systems (decreases traffic volumes, and pollution) (stay@home) Flexible working time
   Freight distribution policies improve efficiencies, improve goods tracking

INTELLIDRIVE: WHAT THE SYSTEM CAN BRING TO OUR WORLD:

1. Personalized trip planning (multi –modal, optimized) assuming full access to all information. Special respect to personal mobility budget (when I can personally upgrade my mobility) daily/predefined trips get mode and routing suggestion, with respect to road weather and other events).
2. 100% crash avoidance, technologically supported
3. Driver or system making routing decisions? Technology steers the system, is there driver making routing systems? Technology steers the system, user has to follow otherwise fined
   Human forecasting (behavioural)
   Personally and systemically
4. Ground sourcing of data

The three best ideas were:

4. Decision made by system
5. Personalised trip planning
6. Advanced tele-presence systems (stay home)

Synectics session results on the second day providing more practical information on question: HOW CAN THIS BE REALISED? (phase two) on the three best ideas

1. Decision made by system

- Data and information system
- Networks of networks
- Systems of systems
- Data
- Observation and surveillance
- Data and data modes
- Reliable d to d relation
- Data privacy?
- Computer and methods…advancements
- Communication (wireless) backbone
- Functional understanding, maths, optimisation
- Dramatic policies changing
- Primary vs. secondary network
- System optimisation
- Self learning, neuronal networks

2. Personalised trip planning

- Information dissemination
- Historical traffic patterns database
- Personal optimization
- Logistics (personal itinerary planning)
- Psychological backgrounds
- Social networks
- Changing paradigms
- Communication system I to car, car 2 user
- Internet 3.0

3. Advanced tele-presence

- Bandwidth challenges
- 3D TV
- Communication challenge
- Privacy
- Advanced personal tele-presence
- First: more sophisticated routing using IntelliDrive
- Virtual sandwiches
- Virtual reality (pub session, beach session)
- Holographic (?)
- Direct brain communication

GROUP 3 Leader A. Keskinen

World 4, Political turmoil

PROBLEM AREAS THAT NEED ATTENTION:

1. Security issues (personal, equipment)
2. Area security
3. Data security
4. Enhanced personal security service
5. Communication (V to I, I to V, V to V)
6. Wearable IT
7. Networks important to keep up, vulnerability is high
8. Unequal distribution of resources
9. Telework? A solution in crises?
10. Commercial toll-roads (routes) profile-based services
11. No public private partnership possible

The three best ideas were:

- Networks important to keep up, vulnerability is high
- Data security
- Profiled customized services commercially provided (routes)

Synectics session results on the second day providing more practical information on question: HOW CAN THIS BE REALISED? (phase two) on the three best ideas

1. KEEP UP THE NETWORKS. Networks important to keep up at all times, vulnerability is high, must have contingency plans

- Assure a type of redundancy
- A budget, federal, state, city levels
- Critical to national, security designation
- There must be a tested contingency plan
- Reroute
- Multimodal flexibility
- Upkeep maintenance plan
- Parts lifecycle
- Education of the public

- re-organizing hubs/networks

2. Data security General discussion: Michigan test bed 63 million dollars
There must be comparison between satellite data and mobile-data

- Contingency plan needed if data missing
- privacy laws
- Risk management plan
- Data sharing arrangements (private, government)
- Encryption methods
- Data management policies (incoming information)
- Privacy laws
- Levered satellite technology infrastructure

3. Profiled customized services commercially provided for road / routes

- Toll routes
- Emergency management should have more weather data for emergency
- Different tiers with services and cost, requires access to data
- Rules for data distribution
- Security services has to be vedded (vetted=security service clearance)

Annex 5: Background material for Montreal

Agenda: ROADIDEA-INCO SEMINAR, June 22nd, 2010

Place: AQTR, Montréal, Québec, Canada

Draft Timetable and Agenda

Tuesday June 22nd, 2010

Time Agenda

9-10 Welcome and introduction of participants
(Lise Filion, MTQ and Director for ITS Quebec AQTR)

Presentation of ROADIDEA-INCO project (Pirkko Saarikivi)
Purpose: To collect and share ideas on data fusion methods and technological information platforms for creation of innovative mobility services. Access to data: key factor for innovative transport services?

Innovation process, goals and methods (Auli Keskinen)

10-11 Introductions to Global Scenarios 2030 by Jerry Glenn, Director of Millennium Project (45 minutes), slide collection to be sent later
http://videolectures.net/forum2010_glenn_gcisd

11-12 **Acquisition des données par le biais de véhicules / Data acquisition from vehicles**

Le véhicule multifonction (titre à confirmer)
Yves Savard, direction du laboratoire de chausses, *MTQ*

Interprétation des données / Data translation

Gestion de réseaux en temps réel / Real-time Road Management
Yves Lebel, chef des opérations / chief, operations, *MTQ*

Utilisations de nouvelles données / Applications for new data
Titre à confirmer
Michael De Santis, coordonnateur STI / coordinator, ITS, *AMT*

12-13 Lunch

13 -15.30 Brainstorming Conducted by: Auli Keskinen, Foreca Consulting, Pirkko Saarikivi, Foreca Consulting, Franc Svegl, AMANOVA

Method: Brief two-phase synectics session

13 -14 Division into groups (if less than 30 participants make three groups, group leaders: Auli, Pirkko, Franc)

Start the synectics session: create ideas for **ITS services for the future** (say 10 years ahead), group leader writes the ideas on flip papers

14-14.30 Select three best ideas in each group by giving red points
Coffee break
Evaluation cycle: all participants cycle around and give red points

14.30-15.15 Confirm the best idea and continue:
Take the first best idea and create ideas on: **How would this idea be realised?**
Document the results (Lulu)

15.15-15.30 Presenting the results of brainstorming in plenary
Conclusions, closing remarks, further actions

Annex as in Washington seminar (see annex 1 of this report):
ROADIDEA-INCO - Rationale and Work plan
Problem Solving by Synectics Method

Annex 6: All ideas of Montreal Innovation Seminar

GROUP 1 Leader AULI KESKINEN

INSTITUTIONAL GOVERNANCE

- Find leaders to define shared/ secret information [14]
- Linking data -> different providers (we are dealing with networks of networks)
- Hospitals included and other new actors (police, events, etc.)
- Distributed data loading [4]
- Superimposing data on map (all the data you need in superimposed format)
- Business models must re-thought (competitiveness of private firms to be considered) [4]
- Physical and logical networks can be separately organised
- Translink models needed, get all in the same room once [7]

GROUP 2 Leader PIRKKO SAARIKIVI

DATA ACQUISITION

- Utilization of network
- Road works
- Optimized mode
- Total view of network (for planning, for traveller, for people and goods) [7]
- Total picture of the network (including supply and demand)
- User sees real cost of service on-line
- System suggests the mode based on urgency.
- Just price for just service
- Put in your need and the system pops up the optimised way to travel
- System provides: [6]
  -suppliers need information for the planning
  -Info to policy makers on sustainable demand management
  -Policy feeds boundary conditions to optimisation scheme
  -Selection: comfort, speed, accuracy of timing, facilities, parking lots, security, price
- Information needs [5]
  - all transportation modes(how much, where, when)
  - disruptions (road works, accidents, weather, events)
  - emissions per mode (costs of each mode)
  - parking lots, tolls
  -estimated time of arrival (based on history)
  -seat availability, first and second class...
  -terminal amenities
  -wi-fi...
  -accessibility
  -cost for the user
  -reliability
  -maps

- Scalable; local to continental
- Public security needs:
  -evacuation routes
  -advice to users
  -automatic info at the accident place
- Privacy issues?
  -is anything private in transport?
  -surveillance cameras
  -social networks as sources of data
- Role of big info companies (Google) vs. public authorities, who can afford to keep up the system?
- Main goal efficiency , sustainability
- Urban <-> suburban <-> rural (all have different needs, costs etc. balance is needed)
- User interface: all you can wear it! In the future all are connected, it can be used in every language everywhere [5]