Intelligent UMB Road Sensors and Advanced Road Weather Information System (ARWIS)

Karl E. Schedler[1] and Pavel Stingl[2]

[1] Consulting Office micKS MSR GmbH,
Alpgaustr. 22, Oberstdorf, Germany
Email: schedler@micks.de
[2] ChanGroup s.r.o,
Chebská 53, 356 33 Sokolov, Czech Republic
Email: sirwec@changroup.cz

ABSTRACT

A new modular fieldbus based technology was developped by LUFFT GmbH Fellbach, Germany. The UMB Technology offers all necessary sensor types for road and weather conditions as well as intelligent road pavement sensors and microwave radar based precipitation detection and present weather recognition. The technology was designed as a modular system with open interfaces at any integration level.

Reliable, easy to operate and cost effective monitoring stations on the roadside are the most important data source for advanced road weather information systems (ARWIS). As well as input for service operation platforms for traveller and traffic information.
In cooperation with the Czech Hydrometeorological Institute and The Road and Motorway Directorate of the Czech Republic, ARWIS, developed by ChanGroup s.r.o., became a common platform for road maintenance systems of the Czech Republic, aimed at highly specialized, very fast and precise exchange of information for decision support in winter road maintenance.
Currently, the system knows how to handle SH10, SH70 and BUFR meteorological data formats supplied by CHMI, RMD CR internal XML protocol for transmission of road weather stations data, and many other internal protocols used for direct communication between database servers including Oracle, MySQL, Interbase/Firebird, MSSQL etc. ARWIS is now part of system for winter road maintenance (JSMIS).

For Traveller and Traffic information a road weather service operation platform was developed by micKS MSR GmbH in cooperation with BMW and the consortium of the Bavarian Traffic Information Agency and in the framework of the eMOTION project supported by the European Commission. The platform processes data from intelligent road site sensors and various meteorological data sources and produces TMC messages according to the ALERT-C (RDS/TMC) standards.

Keywords:
- Intelligent Road Side Sensors with open protocol
- ARWIS Advanced Road Weather Information System
- MDSS (Winter-) Maintenance decision support System
- RWS-TTI Road Weather Information Service for Traveller and Traffic Information

1. INTRODUCTION

Road Weather information systems became more and more indispensable and important for supporting winter maintenance decisions. Winter maintenance decision support makes the highest demands on quality and range of measurements, information and forecasts. This highly sophisticated data should also be used for traveller and traffic information. Road weather information systems are part of the road infrastructure and the telematic field.

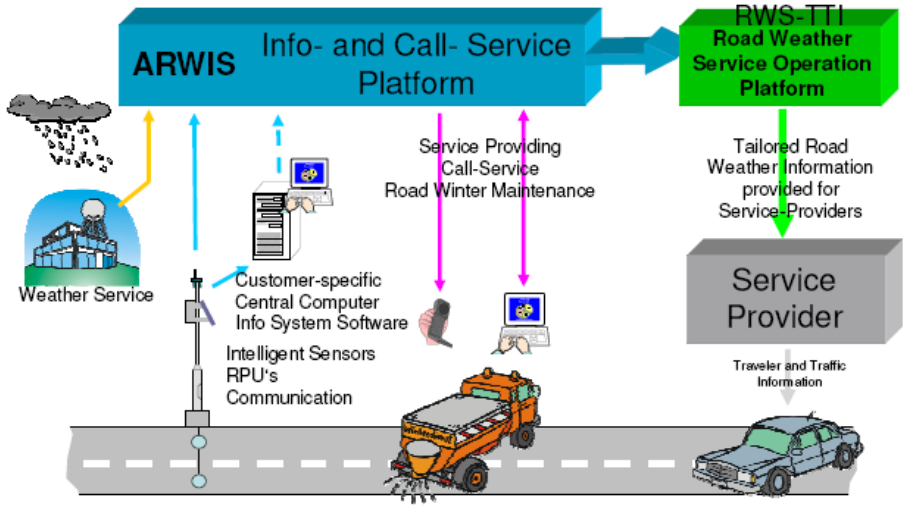


figure 1 Road Weather information Policy

The field of Road Weather Information comprises the following issues: Weather Services dealing with global atmospheric weather data and forecasts, the road weather remote stations acquiring all weather related road condition data, the road weather information central computers or comprehensive information and decision support services for the road maintenance organisations and also road weather content- and service- operation platforms for traveller and traffic information purposes. In the future extended data from moving vehicles could also enhance the coverage of the road network and improve the winter maintenance services.

2. INTELLIGENT SENSOR DEVICES

Reliable and precise data directly from the road pavement are an essential requirement for maintenance decision support. In order to make it affordable to densify the acquisition network on the road, easy to install, compact, intelligent and maintenance friendly devices are necessary. The German company LUFFT GmbH has developed intelligent devices both for road pavement condition detection and for atmospheric road side weather situation. A complete road weather remote station can therefore be composed of two sensor devices only – the minimum amount possible.

2.1 Combined sensor device for atmospheric weather

The atmospheric weather detector device WS600 comprises "all in one" the following measures:

- Type and Intensity of Precipitation with an innovative Doppler radar sensor (R2S see [2])
- Direction and Speed of wind, with a non-mechanical ultrasonic transducer (WS600)
- Air pressure with a an built in pressure transducer
- Air temperature and relative humidity within a protection shield, with an active ventilation in order to rise the response time and ensure accurate measurement of the surrounding atmosphere

figure 2 WS400 and WS600 "All in One" atmospheric sensor device (LUFFT GmbH)

The device has one serial interface where all measured data are reported. The communication protocol specification is open and can be easily implemented also in OEM solutions. A lot of applications are already realized by several OEM Partner. For example within Intelligent Vehicle Highway Systems for measurement of precipitation and aquaplaning situations it is used in environmental remote station.

2.1.1 Innovative microwave Doppler radar principle for precipitation measurement

Since about 4 Years when LUFFT introduces at first the R2S radar precipitation detector, the principle has proven its reliability in several evaluation tests in different institutions and has been approved in numerous installations on the field. The principle is predestined for operation in the environment of road traffic. Compared to optic sensor the disadvantages of getting dirty or being influenced by insects or light reflection effects are no longer a problem. The only precondition is heating during freezing temperatures in order to prevent forming of ice on the surface of the transducer cupola. The sensor is absolutely maintenance free. The Doppler Radar with a certain small microwave frequency at approx. 24GHz measures the speed and dimension of the falling precipitation particles and recognizes their type and calculates the equivalent intensity in mm/h. The resolution of the measurement is 0,01 mm and the reproducibility is more than 90%.

2.2. Combined sensor device for road pavement condition

In hundreds of installations the IRS series of road surface sensors from LUFFT was very successful in reporting accurate all important parameters appropriate to evaluate the condition of the road surface in order to support the decision of the maintenance people and for information of the car drivers.

One of the mechanical advantage is the possibility of easily removing the electronic transducer inlet in order to exchange it into a calibrated new device. Repair or recalibration can be done in a laboratory environment. Therefore the live time cost of an installation can be significantly reduced.

The road surface detector IRSxx ([3]) comprises "all in one" the following measures:

- Road surface Temperature in °Celsius
- Up to 2 Subsurface Temperature probes (e.g. for a depth of 30 cm)
- Waterfilm depth measurement by means of a microwave radar transducer

- Freeze Temperature in °C from the chemical concentration of the solution by their conductivity measured with gold electrodes and under consideration of the waterfilm thickness and the temperature
- Road surface condition (dry, ice, wet, slush) measured by the dielectric characteristics of the cover.

figure 3 Intelligent Road Surface Sensor IRS31 with housing and the inlet module itself

The complete device has low power consumption. The electronic in the inlet module provides the ready to use measures in the units necessary for the application. A serial interface with an open protocol specification makes it easy to implement into different OEM solutions.

2.3 Proof of the Quality and calibration certification

To ensure the quality of data acquisition every sensor is tested and calibrated before delivery. This should become a standard. Every sensor at LUFFT will be delivered together with a calibration certificate which shows the calibration characteristic of the sensor.

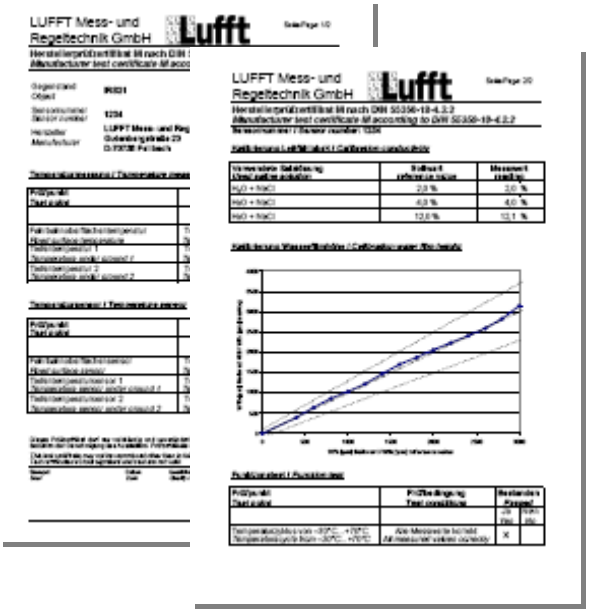


figure 4 calibration certificate with waterfilm depth characteristic

2.4 Modular remote stations with UMB Technology

Road Weather and environmental remote stations should be well arranged and arbitrarily extendable. The UMB Technology provides – among others - these sophisticated features. The Technology also is designed for low power consumption – which allows – under certain conditions - solar or/and fuel cell power supply assembly.
Each top hat rail plugged UMB Module can control one Sensor or a complex sensor device. A mobile Phone network communication can be established by adding a GPRS Module. National or international line communication protocols, such as TLS or NTCIP can be supported by adding a LCOM Module (a small top hat rail mounted IPC). More about UMB Technology can be obtained from [1].

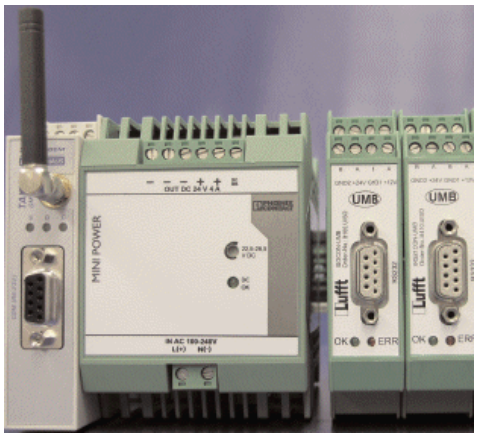


figure 5 Two UMB Technology modules, with Power Supply and Modem sufficient for a complete remote station with atmospheric and road surface sensors

3. STAND ALONE CENTRAL COMPUTER SOLUTIONS: SMARTVIEW

On a central computer the SmartCom collector software controls the data acquisition from remote stations. Supporting different communication media makes it easy to choose the optimal and cost effective way for the application. The data were directly stored in a SQL standard database.

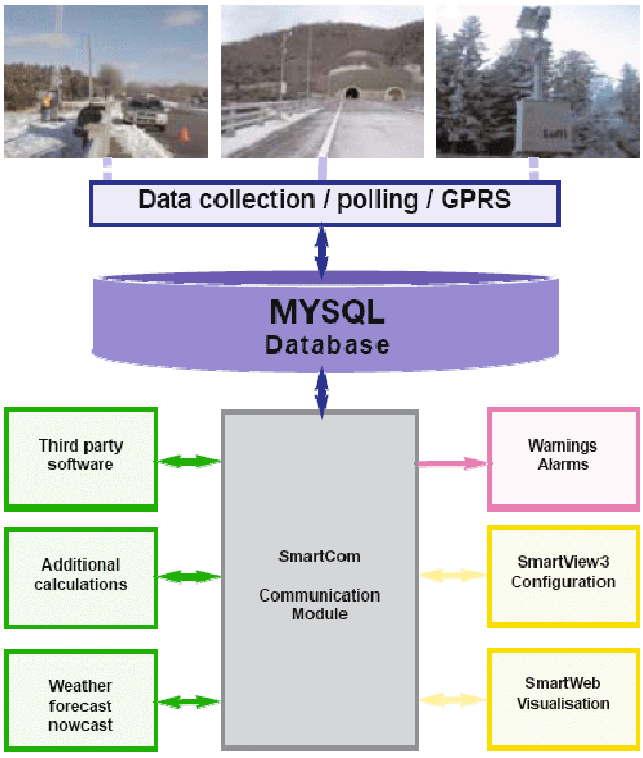


figure 6 Structure of the SmartView RWIS central computer software

Around the database application specific modules can be installed. For winter maintenance users it is important to view the information with standard tools from different places within a computer network. SMARTVIEW therefore has a WEB Interface. The display adapts itself to the setup of the remote station. More about the software modules can be found in [4].

3.1 Camera pictures help maintenance people in assessing the road condition

Visual inspection of the road condition is the most informative way. Together with accurate measured data experienced people can gain a full knowledge about the actual situation on site. Still pictures can be taken in certain intervals (1 … 15 minutes) and together with the measured data transferred to the central computer or to the service platform.

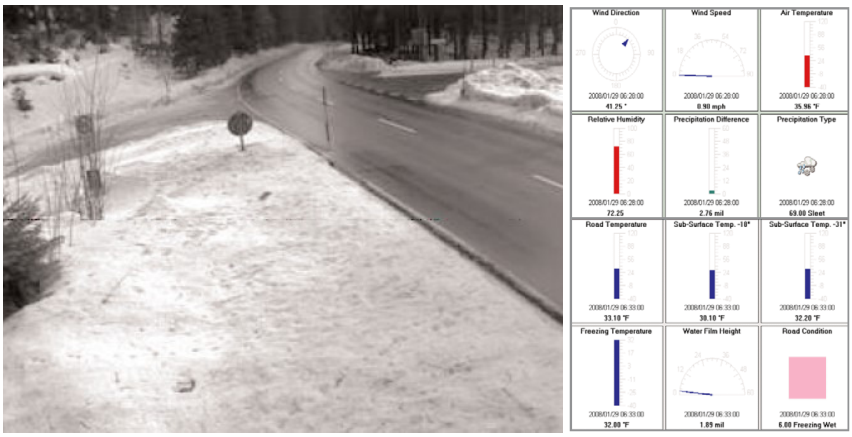


figure 7 Example picture and indicator display of data from a road site in Bavaria

4. ADVANCED ROAD WEATHER INFORMATION SERVICE (ARWIS)

ARWIS is a well established system for processing and on-line presentation of road weather stations data. It's history begins in the year 1998, when ChanGroup s.r.o. started the development of a system for viewing data from LUFFT road weather stations. At 2004, in cooperation with Czech Hydrometeorological Institute and The Road and Motorway Directorate of the Czech Republic, ARWIS becomes a common platform for road maintenance system of Road and Motorway Directorate of the Czech Republic, aimed at highly specialized, very fast and precise exchange of information for decision support in winter road maintenance. Data in the system are not limited by road maintenance relevant data only, but there are functions of the system, which are serving for sharing data between all parts of Integrated Rescue System (police, fire rescue service, emergency medical service). At this time, ARWIS is part of JSDI (Unified System of Traffic Information), developed in cooperation with Cross and VARS companies. Maintenance and further development of Arwis is handled by IT Developers s.r.o. company .

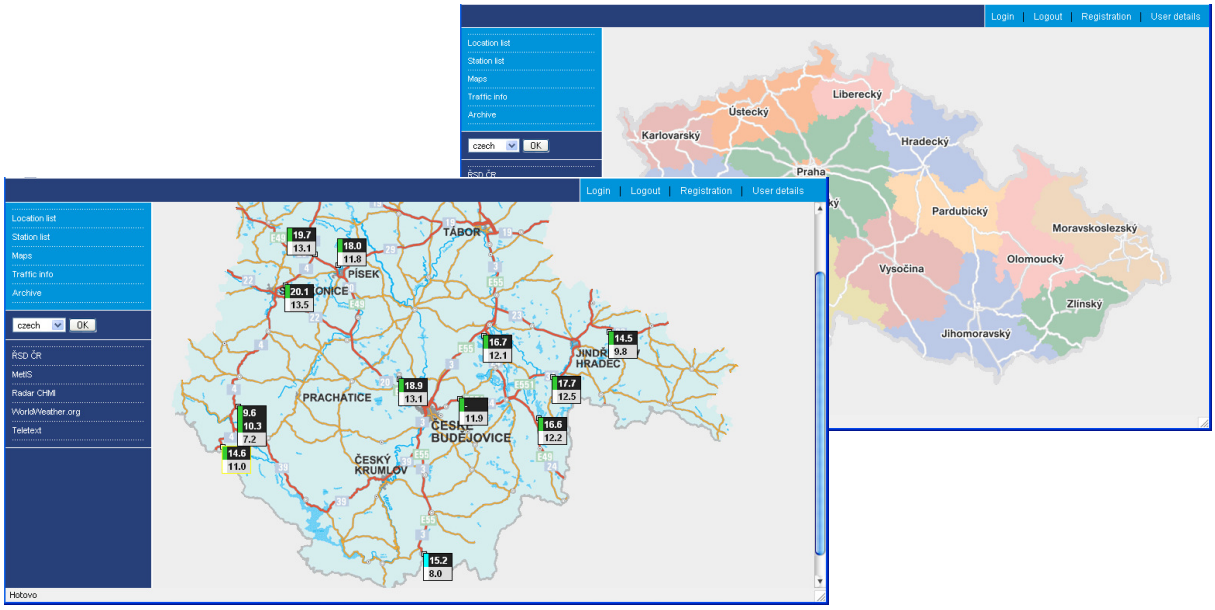


figure 8 Screenshot of ARWIS WebSide: main map and regional map

ARWIS is a highly modularized, object oriented system developed on the Linux/Unix (C++ and Apache/PHP) platform, as data source independent system. This means that the import subsystem can be very quickly reorganized to accept new data source, by supplying of new import module, which converts the data delivered on data channel to the internal system protocol, which can be interpreted by the system like any other data source. Currently the system knows how to handle SH10, SH70 and BUFR meteorological protocols supplied by CHMI, RMD CR internal XML protocol for transmission of road weather stations data, and many other internal protocols used for direct communication between database servers including Oracle, MySQL, Interbase/Firebird, MSSQL etc. The same situation is with the export modules of the system.

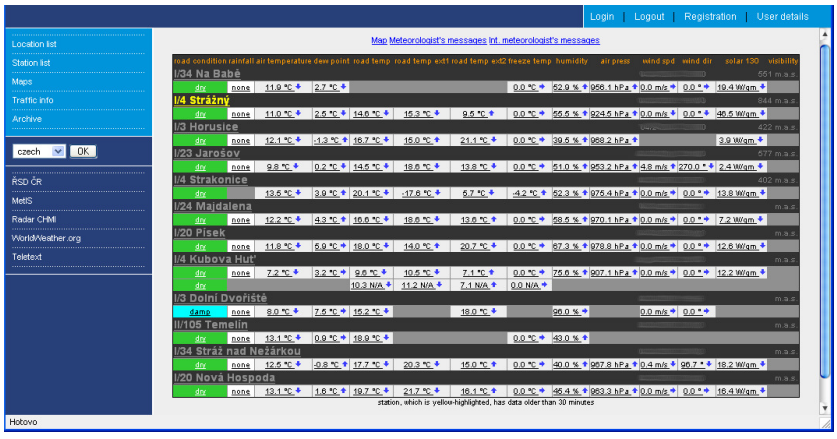


figure 9 Screenshot of ARWIS Webside: Regional stations overview

We can export anything, anywhere.
The interface of the system is brief, without worthless features, aimed for quick orientation and interptetation of information issued by the system. Main system display is a map of Czech Republic, which is separated in parts by regions of CR, where all stations are displayed in that region as boxes with basic, quick information of road state, road surface temperature, precipitation intensity and air temperature, with quick display of alarms set on station values. By clicking on this box, you can switch to detailed view with a history graph of selected sensors, and detailed view of all sensors and values, supplied by station. The system can interprete data from a number of road sensors. As key part of the system serves a “Monitor”, which is a configurable table of desired stations in the region with actual data display, displaying alarms, and with access to history graphs for all measured sensors.

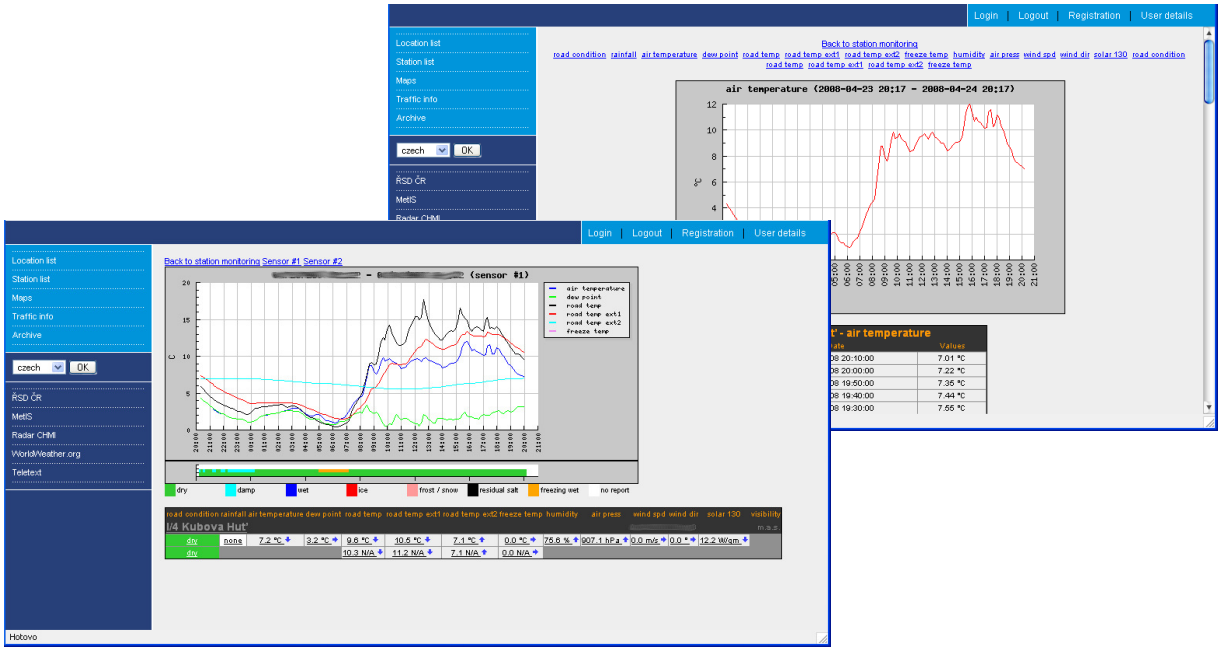


figure 10 Screenshot of ARWIS Webside: Detailed history graph of station and single sensor data

The System is highly user-configurable, with configuration of desired stations in-view, alarm values on all sensors, and with user-rights, which can be configured to sensor-level, it means the administrator of the system can configure user rights so users can view only some values supplied by station. This can be helpful, if you cannot or don't want users to view operation-relevant data (road freeze temperatures etc.). Maintenance of system is provided by web interface, as usual.

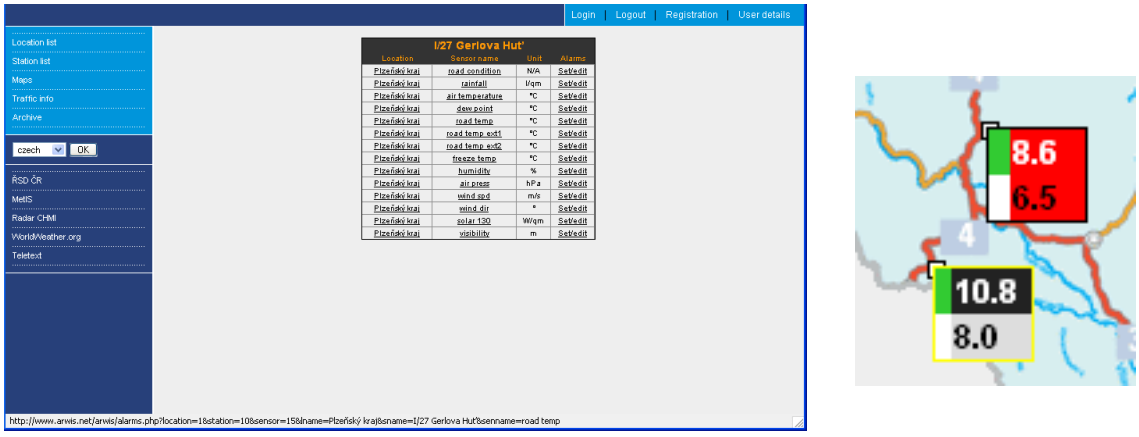


figure 11 Screenshot of ARWIS Webside: Alarm settings and in-map alarm detection

With ARWIS system you gain modern, flexible and reliable system, which can be used in heterogenous network environment.

5. ROAD WEATHER SERVICE PLATFORM FOR TRAVELER AND TRAFFIC INFORMATION

Weather incidents like thunderstorms and strong showers, fog, chilling humidity, and snowfall represent serious safety risks on roads. Local thunderstorms will inevitably lead to a prolongation of travel time. Appointments cannot be kept; individual stress and the risk of accidents are rising. Sleekness caused by rain, snow and ice is playing a vital role in about 30 % of all accidents within Germany and similar situations are discovered in other European countries. This risk can be reduced by accurate, road related warnings of unfavourable weather and road conditions.
Therefore a road weather information platform was developed by micKS MSR GmbH under support and cooperation by the BMW Group FIZ and also in cooperation with the T-Traffic company ddg GmbH (→ [5]).
This service operation platform is able to process different meteorological and road weather data sources, which also can have various time and geographical references and producing TMC coded warnings and messages referenced to short road sections based on digital map links or TMC locator. The fusion of various data sources is achieved by a knowledge base (see also figure 12).
The mobile Traffic information service provider T-Traffic and ddg now operates regularly a version of the platform under license provided by micKS company. Another application for the weather Server is the Bavarian Traffic Information Agency (VIB) established by the Bavarian Interior Ministry and by a consortium of private companies (Siemens AG, PTV AG, micKS MSR GmbH, mdv Gmbh). The system build up will be shortly finished . The contract duration is 10 Years (see also [7]).

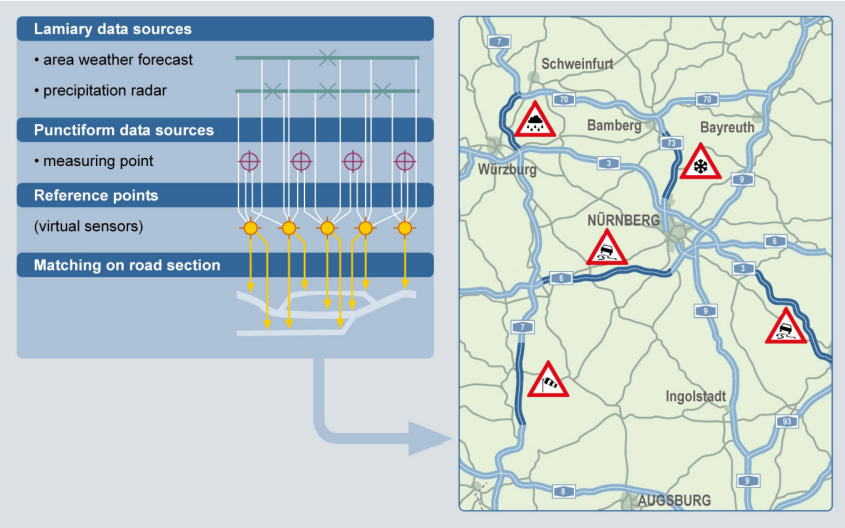


figure 12 different geographical referenced data sources are processed and mapped to road sections

5.1 Road weather service operation platform in europa-wide multimodal on-trip traffic information

Under the framework of the EU project eMOTION (= Europa-wide multimodal On-trip Traffic InformatiON – see also [8]) also for the weather platform europe-wide interface standards and data models were specified.
Road weather information can play its role in a Europe-wide traffic information network. As an example see figure 13.

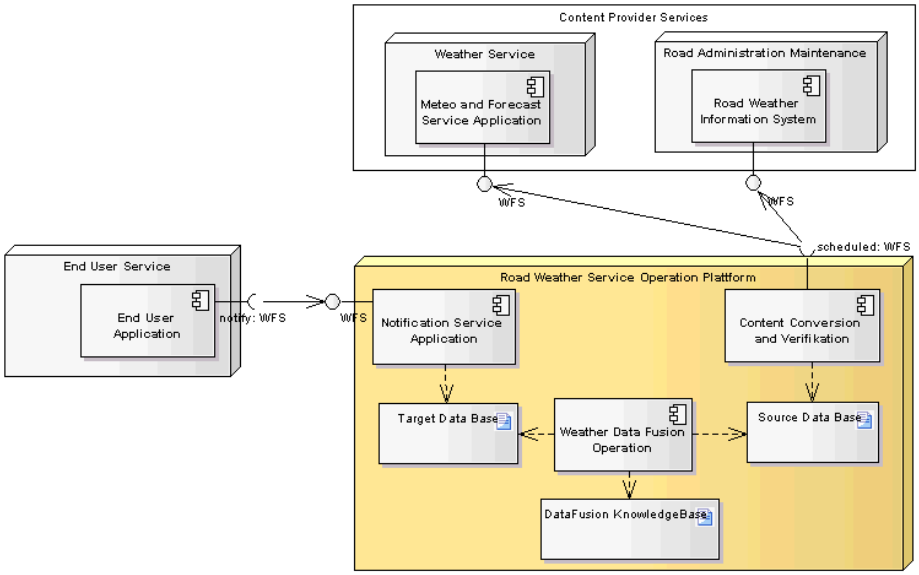


figure 13 UML Diagramm: Road weather service operation platform in a emotion service network

Data sources of different content providers are acquired from the weather server by means of standard emotion interfaces (like WFS = Web Feature Service) and data models following the ISO 191xx and DATEX II standards. The service operation platform delivers service data ready to use for service providers, who run end user applications. The service providers are in charge of distributing the service information to mobile end user devices and handle the business related affairs.
The emotion framework also include registry services, where interested service providers or other potential customers can ask for available content or service operation platforms. On the registry a customer can obtain all necessary meta data (see also [6]) information about the available sources as well as information about the licence conditions under which the provider is willing to sell their content. Digital rights management services are also provided by the emotion group.

5.2 Extended floating car data gain coverage of road condition content

Data from the floating traffic can gain the coverage of data sources evidently. The BMW Group FIZ has started the development of extended floating car devices (XFCD) with the capability of collection all data from various sensors and systems in a vehicle in order to report critical situations during the drive. For example heavy rain from the built in wiper rain sensor, aquaplaning and slippery conditions from the behaviour of the ABS and so

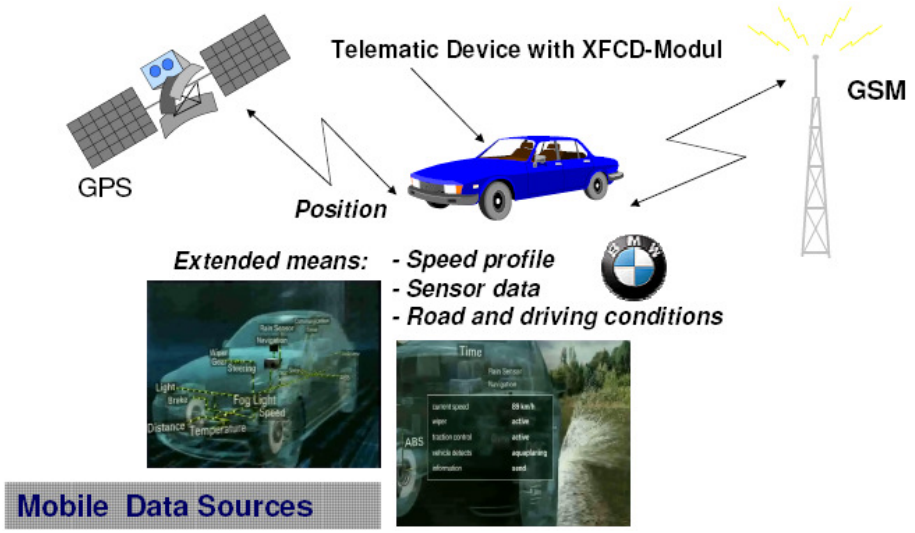


figure 14 XFCD Extended floating car data principle

on. These reports are transferred by mobile communication network. The data processed by a central content Server can be also valuable for winter maintenance decision support services.

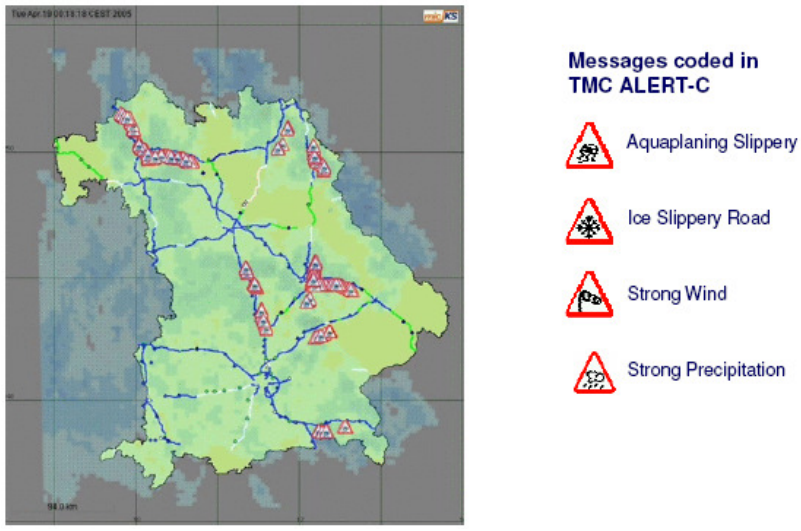


figure 15 Example of active TMC messages on highways in Bavaria

The platform did not provide user interfaces like websides etc.. The service provider is responsible for it. The figure 15 shows a possible visualisation of a certain weather situation. TMC Messages are displayed as icons, the condition of the road is shown as coloured sections. Overlay information can be provided for example the precipitation radar picture.

5.3 Quality management of information service

The only way to get an "over all" quality check is to collect reliably observations from experienced people and experts and compare them with the output of the information platform. On example of an observation from a driving car shows figure 16: heavy rain was detected only in a short section (ca. 2 km) on the highway near Oberpfaffenhofen, Bavaria, which was really encountered. There was also a rainy situation in whole southern Bavaria but the intensity was under the warning limits – except in this mentioned section.

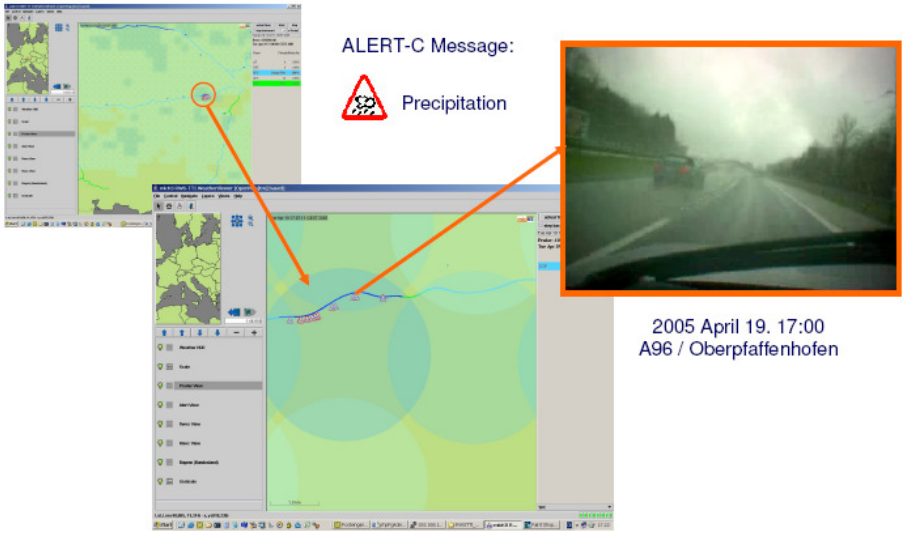
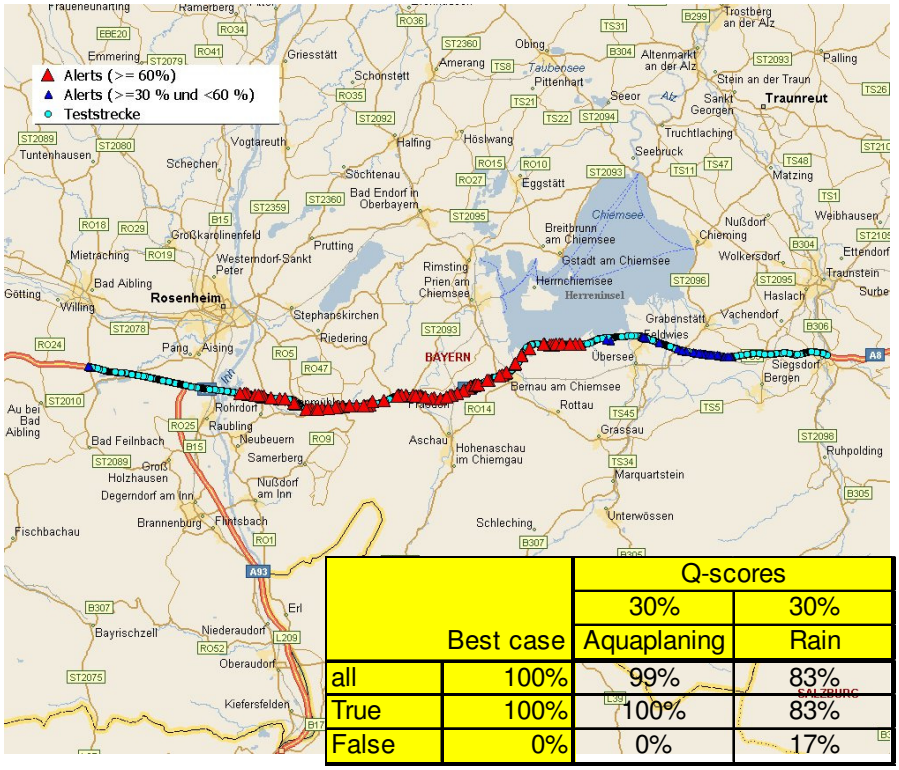


figure 16 Example for a observation from a driving car.

To meet the high requirements of a premium service, in the past BMW run several automatic quality measurement and evaluations, based on defined quality scores for message and service quality. For that purpose, data from surveying and probe collecting tours by XFCD vehicles from BMW are summoned.



		Q-scores	
	Best case	30% Aquaplaning	30% Rain
all	100%	99%	83%
True	100%	100%	83%
False	0%	0%	17%

figure 17 visualisation of a surveying tour and some results

6. CONCLUSIONS

Weather information, especially road weather become more and more important for traffic safety. Road weather information systems are a essential part for road maintenance decision support. The immense progress in road environmental sensor devices and in forecasting of weather situations not only useful for maintenance but also for information to vehicle drivers. Future technologies such as extending floating car data and the dissemination of board computers and navigation devices can also gain new data sources for maintenance.
Future research will have their focus on automatically consideration of weather and road surface condition in traffic situation forecast in order to control the traffic and also for logistic application in the transportation industry.

7. REFERENCES

[1] UMB Configuration Tool, Version 1.2, 2007, LUFFT GmbH, Fellbach Germany,
→ http://www.lufft.de/download/manual/UMB-Config-Tool_V12_d.pdf
[2] Manual R2S Sensor, V4, 2007, LUFFT GmbH, Fellbach, Germany,
→ http://www.lufft.de/download/manual/R2S_UMB_V4_d.pdf
[3] Manual IRS21, V1.30, 2007, LUFFT GmbH, Fellbach, Germany
→ http://www.lufft.de/download/manual/IRS_21V1.30_d.pdf
[4] Manual SmartView3, Version 1.2.8, 2007, Informatik Werkstatt, Ulm Germany,
→ http://www.lufft.de/download/manual/SmartView3%20V1.2.8_e.pdf
[5] Road Weather Information – A new approach to enrich driver information, Martina Neuherz, Georg Obert, BMW-Group FIZ, Munich Germany, ITS Congress London, 2006
[6] eMOTION System – Technical Specification, eMOTION Consortium, 2008, Deliverable D6 + Appendices,
→ http://www.emotion-project.eu → DOCUMENTS
[7] VIB Verkehrsinformationsagentur Bayern, OBB, Siemens, PTV, micKS, mdv, 2006
→ www.bayerninfo.de
[8] Europe-wide multi-Modal On-trip Traffic InformatION (eMOTION), eMOTION Consortium, Ing. Tomáš Stárek, Doc. Dr. Ing. Miroslav Svítek, Ing. Tomáš Tvrzský, ITS Praque, 2007, Postersession
→ http://www.emotion-project.eu