

TECHNOLOGICAL ADVANCEMENTS IN ACQUISITION OF WEATHER DATA AND DETECTION OF ROAD SURFACE CONDITION

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ABSTRACT

Reliable, easy to operate and cost effective monitoring stations on the roadside are the most important data source for road and weather condition information. In hazardous Weather situations this data sources enable information systems to gain reliable information and warnings for maintenance operators and car drivers.

Modular fieldbus based and extremely compact technologies are new tendencies who leads to more dense monitoring networks on the road.

Intelligent “all-in-one” sensor devices which standard data interfaces are now the most advanced technology. One device in the pavement reporting all relevant parameters for the surface condition and one device in the atmosphere monitoring all necessary weather parameters. A new development of an non invasive surface sensor is also in progress. A prototype is currently under field test. The paper introduces the basics of this advanced monitoring technologie using the example of the Universal Measuring Bus (=UMB) technology.

KEYWORDS

Road Weather Information, Safety in Mobility, Winter maintenance, TMC Services, telematics, TTI (=Traveller and Traffic Information), ITS Infrastructure, Maintenance decision support system (=MDSS), Road Weather Monitoring.

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 helps improving the safety on roads for winter maintenance decision support as well as enhancing the information for the car drivers.

MODULAR REMOTE STATIONS WITH UNIVERSAL BUS TECHNOLOGY

Road Weather and environmental remote stations should be well arranged and arbitrarily extendable. Up to date remote stations should also be designed for low power consumption – which allows – under certain conditions - solar or/and fuel cell power supply assembly. Each top hat rail plugged Module should be able to 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 an embedded PC Module (resp. a small top hat rail mounted IPC). More about UMB Technology can be obtained from [1].

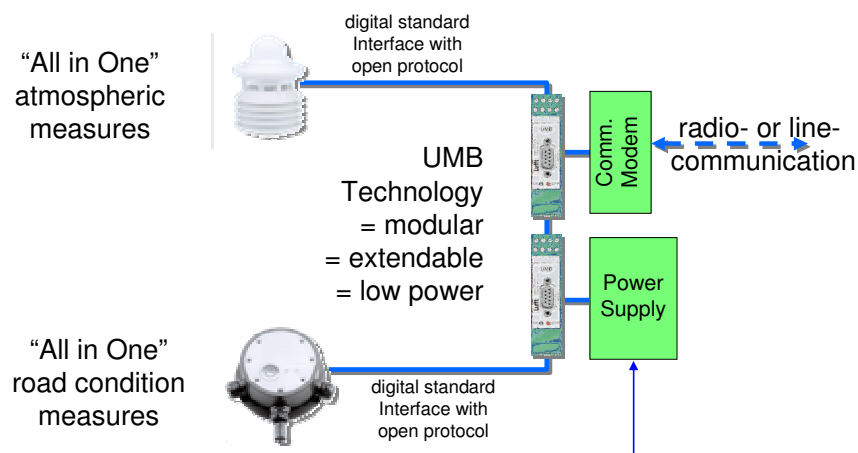


Figure 1 - A complete road weather station built up with a few elements

There was been developed intelligent devices, both for road pavement condition detection and for atmospheric road side weather situation. Complete road weather remote station can now be composed of two sensor devices only – the minimum amount possible.

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 increasing the density the acquisition network on the road, easy to install, compact, intelligent and maintenance friendly devices are necessary.

COMBINED SENSOR DEVICE FOR ATMOSPHERIC WEATHER

A complete intelligent atmospheric weather detector [9] device comprises “all in one” the following measures:

- Type and Intensity of Precipitation with an innovative Doppler radar sensor
- Direction and Speed of wind, with a non-mechanical ultrasonic transducer
- 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 – combined and compact weather sensor
without and with wind sonic sensor**

INNOVATIVE MICROWAVE DOPPLER RADAR PRINCIPLE FOR PRECIPITATION MEASUREMENT

Since about 4 Years when LUFFT introduces at first the R2S radar precipitation detector [2], 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%.

COMBINED SENSOR DEVICE FOR ROAD PAVEMENT CONDITION

An intelligent sensor device to be installed into the pavement has proven its reliability in hundreds of installations. 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 [3] comprises “all in one” the following measures:

- Road surface Temperature
- Up to 2 Subsurface Temperature probes (e.g. for a depth of 30 cm)
- Water film depth measurement by means of a microwave radar transducer
- Freeze Point Temperature from the chemical concentration of the solution by their conductivity measured with gold electrodes and under consideration of the water film thickness and the temperature
- road surface condition (dry, ice, wet, slush) measured by the dielectric characteristics of the cover.

MICROWAVE RADAR TRANSDUCER FOR WATER FILM DEPTH

Accurate measurement of water film height is achieved by a microwave radar transducer built in the pavement sensor device. The characteristic and calibration curve of the radar transducer shows figure 3. The water film height is reported with a resolution of 0.01 mm. The maximum range is typically 3.00 mm. Due to the used method the measurement of the waterfilm is not be influenced from the concentration of deicing chemicals.

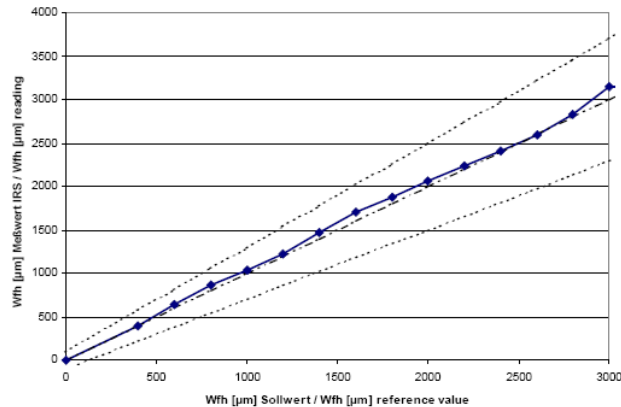


figure 3 – Measurement characteristic of the microwave radar transducer in the passive road sensor

ACTIVE MEASUREMENT METHOD FOR FREEZE TEMPERATURE DETECTION

The new developed Sensor device [8] measures the freeze point temperature by means of cooling and heating up a small sensitive area on top of the sensor surface. This active measurement method enables the sensor to measure the actual freeze temperature of the liquid solution on the pavement surface. This sensor can also be installed in combination with the passive sensor, described above, to enable a comprehensive knowledge about the condition on the surface. Other than the passive measurement of freeze temperature via conductivity, the active method is totally independent of the used de-icing chemical.



figure 4 – The new developed intelligent active freeze temperature road sensor

NON-INVASIVE ROAD SURFACE CONDITION DETECTION

In comparison with built in road surface sensor, a non invasive measurement provides accurate surface condition parameters with less installation and maintenance costs. For non invasive measurements an optical spectrometer method is used. Water, snow and ice have different spectrum adsorption characteristics. The development and field testing of a new and innovative Sensor is currently in progress. The sensor uses three different wavelength, which can be extended up to 8 spectrum lines.

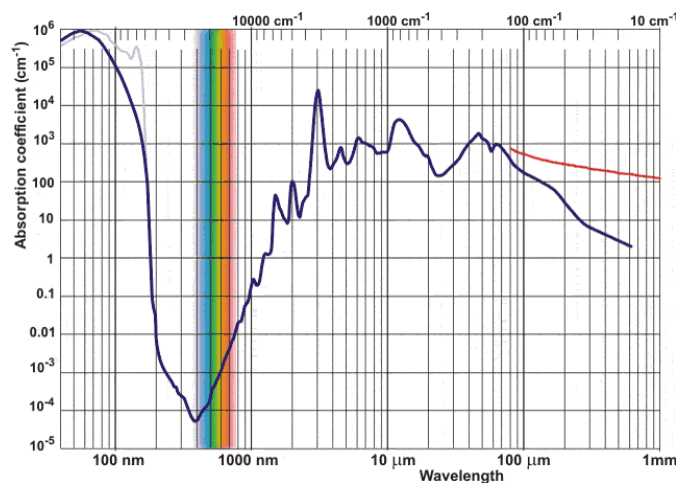


figure 5 – adsorption spectrum of waterfilm

As an example figure 5 shows the adsorption spectrum of a waterfilm layer on the road pavement. By means of the analysis of the reflected light emission in different spectrum lines the sensor provides layer depth up to 3 mm from waterfilm, snow and ice. Also the tire friction is reported, due to the measured surface condition. The area where the layer thickness is measured depends on the distance the sensor is mounted from the pavement surface. But typically is much larger than the measurement area of in pavement sensors. This leads to more reliable measures in terms of the actual pavement condition parameter. The non-invasive measurement can not detect the freeze temperature of the deicing chemical solution. For winter maintenance purposes, the non invasive sensor had to be combined with an in-pavement sensor with active freeze point detection.



figure 6 – prototype of LUFFT non-invasive surface sensor NIRS

The result of the actual status of the development shows figure 6. The Prototype NIRS-UMB is currently under field testing. The Sensor also includes measurement of road surface temperature by means of an Infrared measurement method.

There are two basic ways to analyze the adsorption spectrum at different spectrum lines: emission of different narrow-band lights and detecting broadband and the opposite way: emission of broadband light and detecting narrow-band.

In opposition to user sensor products on the market, the prototype of LUFFT follows the second method. The field test show really good results.

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 [4] or to the service platform.

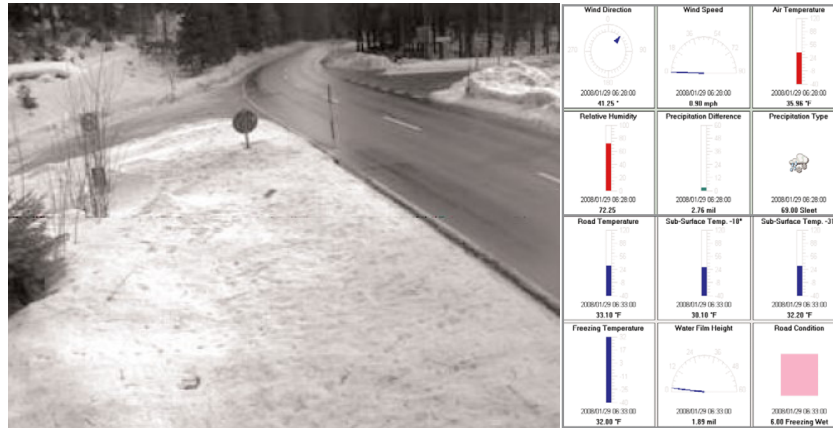


Figure 8 Example picture and indicator display of data from a road site in Bavaria

ROAD WEATHER INFORMATION SERVICE OPERATION PLATFORM

Weather monitoring from road sites are essential for support of winter maintenance. But also for information and warnings of car drivers, data directly from the road pavement are indispensable.

It is obvious that all types of accidents increase in winter condition. The accident rate under snow condition is principle two times bigger than on bare, dry roads. But the risk of accidents is even 10 ... 30 times higher if a critical road condition like snow or ice occurs unexpectedly [10].

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]. Europe wide harmonized interface specifications [6] were developed under the framework of eMOTION project funded by the EC, FP6 program. 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 9).

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 was finished end of 2008 and now running regularly. The front end is accessible for free by the public [7].

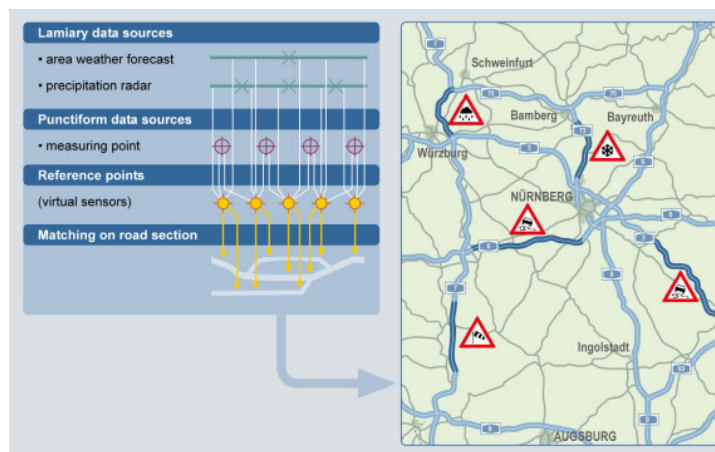


figure 9 – different geographical referenced data sources are processed and mapped to road sections

CONCLUSIONS

The immense progress in road environmental sensor devices and in forecasting of weather situations is not only useful for maintenance but also for information to vehicle drivers. The now available new technologies made it affordable to gain the density of the detection networks on the roads.

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.

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