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SELECTED ASPECTS OF IMPLEMENTATION OF WEATHER CONDITIONS MONITORING SERVICE IN CONTEXT OF THE NATIONAL TRAFFIC MANAGEMENT SYSTEM

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Summary: The article presents the functional, physical, and communication aspects of the service implementation of intelligent transport systems. The characteristics of weather conditions monitoring service was shown as well as, technologies which enables service provisioning and distribution of data flow. Ways of delivering services, and a description of their functioning was also underlined. The implementation of intelligent transport systems is in fact one of the methods to improve the transport system in the country. It enables to increase road capacity, as well as the level of safety of traveling without interfering with the existing infrastructure. The paper was prepared on the basis of existing standards and regulations and available literature. The publication has been prepared within the framework of the project Development of Road Innovations funded by the National Centre for Research and Development and the General Directorate for National Roads and Motorways (Contract No. DZP/RID-I-41/7/NCBR/2016).

Keywords: intelligent transport systems, FRAME, weather conditions monitoring service

1. INTRODUCTION

ITS (Intelligent Transport Systems) systems are made of individual transport telematics devices, which cooperation is possible thanks to support of solutions in field of computer science, telecommunications, electronics and automation [18]. One element of intelligent transport system can not be an individualized solutions, which has its distinct character [17]. This is due to the fact that it is required for these elements to be interoperable within the system. It is necessary in this case, to coordinate the assumptions related to these systems, mainly due to a huge variety of tasks executed by them and a wide area of application [14]. This ensures better exchange of information between the systems and is realized through the establishment of a compact ITS architecture, applicable throughout the country [3]. This procedure aims to organize norms and standards and leads to increase functionality and efficiency of intelligent transport, as well as expansion of the systems. Development of a specific architecture requires general knowledge on transport as well as knowledge of the realities and hazards present in this area [7]. Approved architecture should meet the needs
and expectations of all individuals interested in the ITS. As an example – a traffic management service, especially management of environmental information was chosen to show functionalities and relations between systems.

2. SERVICE IMPLEMENTATION METHOD - REQUIREMENTS

The weather conditions monitoring service, in the main service of environment information management, in the category of traffic management, is implemented, among others, through gathering data about road surface condition and weather data, for example slippery conditions on the carriageway, air temperature, wind direction and its strength, visibility. Weather data are gathered at certain points in a lane (e.g. air temperature, relative air humidity, wind direction and force, precipitation intensity and type, air transparency). The data about the road surface are gathered in the same way (substructure temperature, occurrence of slippery conditions on the road surface, occurrence of winter slipperiness removal agent, presence and height of the snow cover, column of water’s height (alarm water level). Transferring them is applied within other system functions, among others to detect threats to traffic safety, execute maintenance works, transfer information to users in the scope of current conditions on roads or to self diagnose the operation’s correctness of the devices. This service is often used in the National Traffic Management System, e.g. in Warsaw [4,5]. Its main task is to prevent dangerous situations caused by unfavourable weather conditions on national roads and to improve traffic safety. The service’s recipients are traffic management operators, I2V vehicle drivers and environment information management operators.

3. SERVICE’S FUNCTIONAL STRUCTURE

The system should be able to provide monitoring of weather and surface conditions on selected road sections. The function can transfer the data in order to use them within other system functions, among others to detect hazards to traffic safety, conduct maintenance works, transmit information to users in terms of current road conditions [16]. The function can self diagnose the correctness of the devices’ operation. The ISO international standard 14813-1 describes this domain as “Activities that monitor and notify weather and environmental conditions.” This involves the collection of information related to weather and other environmental conditions in order to support traveller information systems (e.g., VMS, radio alerts) [13]. This function includes both automated weather sensors and water level/tidal monitoring and prediction. This service group contains activities that result in monitoring of weather conditions, including fog, ice, snow, wind, rain, and heat; along with prediction of specific conditions as they impact the condition of the pavement and the overall
travelled way, including icing and visibility. Sample services include both road weather information monitoring and road weather prediction [6].

Methods of the service implementation include module classes from A to H. Within them, there are:

• A – the devices in the class A are installed to collect and process the basic data on the road surfaces condition and weather data for traffic management, road maintenance, supervision of road maintenance. The elements in the class A are in places on the road network with a stable thermal characteristic, in places resulting from maintenance companies’ settlement.

• B – the devices in the class B are used to warn early of black ice in characteristic points: switchboards, road structures (without tunnels), others (e.g. forest boundary, acoustic screens’ occurrence boundary).

• C – the devices in the class C are used for automatic black ice prevention systems (range of parameters selected by the system designer). The elements in this class are in areas, where suddenly occurring slippery conditions cause special safety hazard.

• D – the class D is a class dedicated to bridges for: traffic management and maintenance.

• E – the devices in the class E are installed to warn of sudden reduction of visibility. Elements in this class are near the places, where fogs that significantly threaten the safety emerge regularly.

• F – the devices in the class F are installed for traffic management (information on traffic obstacles due to the flooding of the carriageway). Elements in this class are in areas, which are very likely to collect water causing safety threat.

• G – the devices of the class G are installed to enable actions in the field of road maintenance due to high water levels in reservoirs and watercourses. Elements in this class are within the reservoirs, in which the likelihood of overflow of waters on the carriageway is high.

• H – Mobile meteo stations in the class H are installed in order to verify the need to install stationary meteo stations – gathering supplementary data for traffic management and road maintenance. Data gathering can take place anywhere; the stations can be mounted on road maintenance vehicles.

4. TECHNOLOGIES ENABLING PROVISION OF SERVICES – PHYSICAL STRUCTURE

An indispensable tool for enabling correct operation of the service is a software of the environment information management subsystem. It is the system element responsible for the analysis of data about the road surface condition and weather data to warn vehicle drivers of the adverse conditions on the road. (e.g. slippery surface, fog). The module allows to:

• analyse environmental data in order to verify whether there is a need to undertake certain actions, e.g. to warn the traffic participants;
• transfer the analysis results and propositions of recommended actions to the operator for approval (not all actions must require prior approval);
• transfer the data about the approved (and proposed) action to the Database about Environment.

The module enables to use the gathered data to obtain forecasts of environmental conditions (including in accordance with criteria pre-defined by the interface operator) that will occur on the road network covered by the system and in its environment [8]. The module allows the interface operator to:
• manage the collection and transmission of the environmental data;
• present the environmental data;
• perform the forecasts according to the criteria pre-defined by the operator and their presentation;
• change the criteria/parameters of the function of analysing the environmental data;
• approve the actions obtained by analysing the action propositions (for actions not exercised automatically by the System).

Weather stations should be in areas characterised by the occurrence of weather anomalies, i.e.: the area of watercourses or specific atmospheric phenomena, and the places especially exposed to the emergence of road incidents i.e.: nodes and intersections area. The subsystem is to execute the following tasks:
• collecting the data from the weather stations;
• forecasting the weather situation;
• sending the data on the conditions on the road to the Traffic Management Centre (Centrum Zarządzania Ruchem, CZR);
• generating of warnings about weather conditions dangerous for traffic (e.g. slippery road surface, side wind, fog, etc.).

The subsystem is to automatically run the appropriate procedure on variable message signs by displaying an appropriate restriction. The data from the weather station should be transferred to the CZR for intervention of the maintenance services [11,12]. The pilot weather information module impacting the traffic consists of:
• weather stations,
• variable message signs,
• CCTV devices,
• test web site.

An essential element of a road weather station is a microprocessor data logger, whose task is to provide automatic acquisition, archiving and processing of measurement data, indicating change trends and prior alerting of the possibility of occurrence of dangerous road conditions in close time, local supervision of the functioning of all the weather station components, monitoring the power supply condition, technical diagnostics of sensors and other components of the meteorological station and analysing the data in order to control the quality of measurements and generate alerts [15]. Communication with weather stations takes place through the GSM network [10]. For this purpose, the stations are equipped with communication units with communication software enabling bundling of data and implementation of the TCP/IP protocol [5]. In the European Union countries, there are harmonised standards of communication protocols and formats of transferred information:
• DATEX – protocol for the exchange of information about the situation on the roads for communication between traffic management centres as well as to the media and
private information providers. DATEX was used in many applications in Europe. The newly created version of the standard (DATEX II) will cover all types of information, including times of road sections journeys and placing variable message signs.

- ALERT-C format – this is the coding system of traffic events description, which is designed to allow the transfer of information about events in the form of radio messages (TMC).
- The “Mare Nostrum” project aimed at the harmonisation of the format of the information transmitted to drivers on the variable message signs, so that the content would be independent from language and understandable across Europe.

5. DATA FLOW DIAGRAM

Like other highly complex systems, integrated ITS applications need a strategic framework as a basis for choices concerning their design and deployment. Such a framework is generally called a system architecture. An ITS architecture is a set of high level viewpoints that enable plans to be made for integrating ITS applications and services. It normally covers technical aspects, plus the related organisational, legal and business issues. For example, in Europe - European ITS Framework Architecture (FRAME) is used. The aim of this initiative is to promote the development of ITS in Europe by producing a framework which provides a systematic basis for planning ITS implementations. What is more, it is possible to facilitate systems integration and help to ensure interoperability, including across European borders. FRAME comprises a set of user needs which describe what ITS can provide and a logical, functional or physical viewpoint showing how it can be done [1,2]. Viewpoints may be shown especially by data flow diagrams or functional trees.

![Data flow diagram including functionality „Monitor weather conditions”](Source: Own elaboration on the basis of FRAME Architecture – Browsing Tool)
Fig. 2. Functional tree including functionality „Monitor weather conditions”
(Source: Own elaboration on the basis of FRAME Architecture – Browsing Tool)

As it can be seen in the FRAME architecture, in the weather conditions monitoring service, you can observe the complex set of relationships between the components. This is shown in Figs. 1 and 2.

The following is necessary for the implementation and functioning of the service: environmental data (about road surface condition and the weather), alphanumeric data. The following information from stakeholders influence the service operation: weather data from the environment. The data flow from the environment includes sensor indications to obtain data about the road surface condition and the weather. Traveller information can be submitted with, for example, the variable message signs (VMS), a website, as well as directly to the vehicle by the I2V interface [9]. The location of the system elements (weather stations) is shown on the map with black spots (fig. 3).

Fig. 3. Meteorological stations location in the country
(Source: Own elaboration on the basis of GDDKiA materials)
Thanks to the service, it is possible to inform the drivers about the current weather conditions and the road surface condition around the places, where these conditions are the most frequent causes of the collisions and traffic events. The drivers informed about the danger have a chance to adjust the speed and their driving style to the current conditions, which reduces the risk of situations threatening safety (e.g., a vehicle’s skidding because of the slippery road surface). The service allows the driver to predict the danger and avoid it.

6. SUMMARY

The ITS systems are built taking into account numerous legal and organisational conditions and individual needs of the users. For this reason, they are not finished products and their implementation requires clear definition of functional and technical requirements and, ultimately, the description of the procurement subject (OPZ) used in connection with public procurement procedures. The primary objective of using ITSs is to improve the efficiency of traffic (which can be understood as, for example, reduction of travel time) and traffic safety (i.e., reducing the number of traffic accidents, reducing the severity of the accidents in the form of the reduction of fatalities, seriously injured and injured number and the number of accidents involving unprotected traffic participants – motorcyclists, cyclists and pedestrians). The aim of the paper was to present the principles and selected requirements accompanying the implementation of the weather conditions monitoring service.

Literature

WYBRANE ASPEKTY WDRAŻANIA USŁUGI MONITOROWANIA WARUNKÓW POGODOWYCH W KONTEKŚCIE KRAJOWEGO SYSTEMU ZARZĄDZANIA RUCHEM


Słowa kluczowe: inteligentne systemy transportowe, FRAME, usługa monitorowania warunków pogodowych