Intelligent Transportation Infrastructure For Traffic Incident Management System Support

m-r Kostandina Veljanovska, MASc[i]

Abstract - **Actual trends in the computer science, neural networks and artificial intelligence at all have become inseparable part of our daily life. Transportation systems are also under that influence. A broader view of the research in the field of implementation of the new technologies in freeway traffic management and freeway traffic incident management is given in the paper. The research was done at the Faculty of Technical Sciences - Bitola and the University of Toronto, Canada.**

Keywords - **intelligent transportation systems (telematics), intelligent transportation infrastructure, ITS architecture, incident detection.**

I. Introduction

Traffic congestion are very often caused by incidents - accidents, vehicle malfunctioning, road maintenance, or other unpredictable or predictable events… Video surveillance and sensors on the road can help for rapid incident detection. Computerized emergency vehicles scheduling enables fast reaction on site. Changeable Message Signs (CMS) can re-route drivers on the alternative routes.

These technologies can shorten travel time for 10 to 45 % in the congested case.

Republic of Macedonia, trying to provide safer roads is among the countries - beginners in designing its own traffic incident management system (TIMS) applying intelligent transportation systems (ITS). This state of the art is motivation factor for engaging scientists in the filed of traffic engineering and information sciences. In that direction is the effort of this paper - to give a complete picture of intelligent transportation infrastructure (ITI) for TIMS, i.e. picture of the information organization, processing, transfer and management in a complete system in Europe and in the world. Our efforts to approach EU would have the meaning of following the standards in traffic and integration in the European transportation infrastructure.

II. ITS

The answer of the many of our traffic and transportation problems lies in a broad range of various technologies known as ITS - intelligent transportation systems. ITS - a multidimensional approach towards satisfying our transportation needs consists of a substantial number of technologies, information processing, communications, control and electronics. Connecting these technologies to transportation systems can save lives, energy and money. Implementation of these technologies means real revolution the way traffic has been understood. In this paper implementation of intelligent transportation systems (ITS) in traffic incident management research done at University of Toronto and Sv Kliment Ohridski - Bitola is presented.

A. Definition

ITS is a system that gives services for the customers using the information system, adapted to the customer. ITS are open and adaptable, offering implementation of different technologies for interactive and multimedia work and on the other side complete coverage starting from micro-location, street, city, region, nation and the world as a whole.

B. Aim

The aim of ITS creation is to improve traffic and transportation quality by avoiding traffic congestion, travel time savings, drivers and passengers safety and commodity improvements, goods and services exchange, improvement of the total information transparency. As a result we get higher level of customer satisfaction and overall environment prosperity. Among the key aims in ITS creation are today's science imperatives lower pollution and lowering energy dissipation.

III. ITI

ITS domain comprises systems starting with control systems till automatic freeways. But, the starting point in implementation is the core of the systems. The implementation could be done step by step. **Intelligent transportation infrastructure (ITI**) is the core of ITS.

Intelligent transportation infrastructure (ITI) is the key element necessary for a complete implementation of ITS. It is an integrated system from nine synergetic connected systems of traffic components.

Basically, ITI is the ITS infrastructure and these component have to be developed first. ITI consists of these integrated components:

- Traffic signal control
- Freeway management
- Public transportation management
- Incident management
- Electronic fare collection
- Electronic tool collection
- Railway crossings
- Emergency management services
- Regional multi-modal traveler information

ITI refers to the part of ITS which deals with hardware, software, services etc., which now and especially in the future will complete and support all traffic related activities.

Usually, ITI is implemented in the urban areas, and afterwards it includes commercial vehicles and rural needs.

IV. ITS ARCHITECTURE

Every system initially has its own architecture. Architecture means common starting point and common language. In USA and Canada there is National ITS architecture. It is the frame that refers to 29 ITS user services. Architecture defines subsystems and data flow (information that has to be exchanged among subsystems) needed for proper ITS operation. ITS architecture does not define the actual design or what to purchase. It is a subject of a local choice.

Terminology is important, as well as the basic structure of the architecture. On the basic level, architecture defines series of functions. Those are different activities that system has to perform. For example, traffic surveillance or public transport vehicles surveillance. There is a substantial number of complex functions or high level functions and they are divided in sub-functions. For example, low - level functions are HOV lane usage surveillance (HOV = High Occupancy Vehicles). On a higher level, functions are defined graphically as Data Flow Diagrams DFD. Every low-level function is precisely defined with Process Specification (P-spec).

Architecture is indeed software, which enables simple and easy designing of ITS services, needed to be implemented on site, depending on the local circumstances, user requirements and constraints. Both logical and physical architecture contain implementation constraints depending on the local circumstances in the real world. For example, in the Canadian ITS architecture there are constraints from the point of view of the environment (environment, road, potential obstacles etc.), human factor (driver, traveler, maintenance personal, pedestrians, etc), systems (company user, financial institution, governmental administration, media, etc.) and other systems (other vehicles, other TMC etc.).

One of the basic tasks of the architecture is to assign functions to the different components or ITS subsystems, which operate together. Examples of subsystems are information services providers, traffic management etc. Traffic incident information, as well as all other relevant information have to be exchanged among specific subsystems if we want coordinate and integrated ITS operation. So, ITS architecture defines links, i.e. the way of connection among subsystems. This is done at the logical level as a **data flow**.

Logical architecture defines data flow diagrams and process specifications. According to the Canadian National ITS architecture, logical architecture defines functions, for example, incident detection, or incident verification; while physical architecture defines where those functions could be found, for example, in traffic management center (TMC).

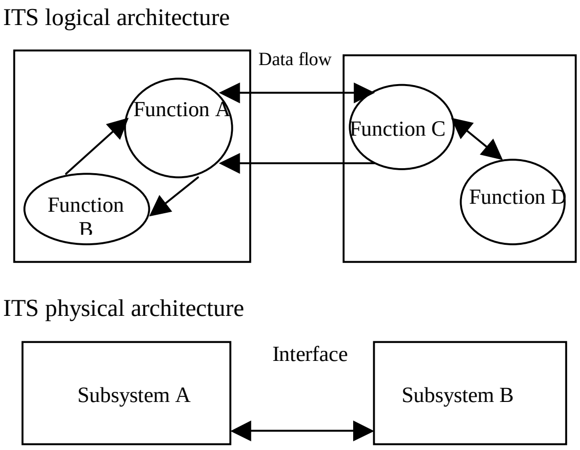

Fig.1 Logical and physical ITS architecture

Figure 1 shows scheme of ITS logical and physical architecture. Logical architecture defines functions which have to be performed in the subsystems i.e. data exchange. Physical architecture defines the way the functions defined in the logical architecture are realized, i.e. the way the subsystems are connected (interface).

Physical architecture defines subsystems, assigns functions to the process specifications (p-spec) and documents the interface (the way of connection) for the data flow among subsystems. In the Canadian ITS architecture physical architecture contains three levels: communication (how the information is transferred among transportation subsystems), transportation (which are the transportation systems that transfer specific information) and institutional (institutional structure, politics and supporting strategies).

A. National ITS architecture - ITI connection

Architecture documentation gathers highly detailed technical documentation. How the architecture operates can be seen in the ITI component connections diagram. Figure 2 shows simplified diagram of ITI components and their basic connections, the way they are defined in the National ITS Architecture.

Figure 2 shows type of the data that have to be exchanged among different ITI components (shown with arrows). Arrow peak shows in which direction data have to be transferred. These data definition and exchange direction are defining the interface (the way the components communicate). Technically speaking, almost all interfaces are bi-directional because computer systems have to communicate that way so the data transfer can be performed.

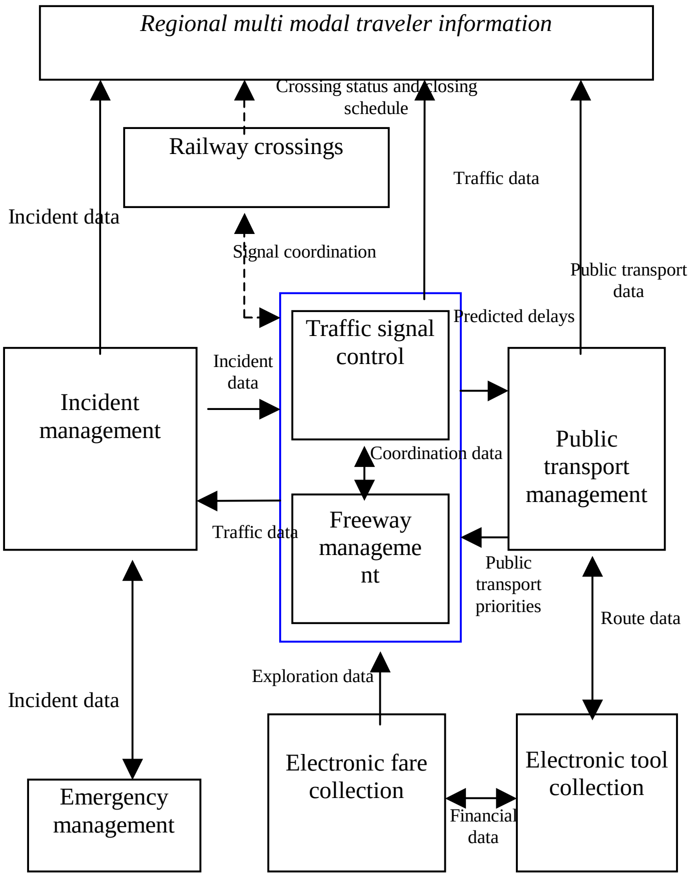

Figure 2. ITI components and connections among them

V. Freeway Traffic Management System (FTMS)

Traffic management means congestion management which results of

- Geometry design inconsistency of a freeway and
- Traffic regulation (including insufficient capacity),

that appeared as recurrent reasons and non-recurrent or random reasons:

- Incidents,
- Maintenance and reconstruction, and
- Weather conditions,

According to FHWA non-recurrent reasons can cause about 60% of congestion.

Freeway traffic management system (FTMS) consists of infrastructure elements chosen to satisfy the aims of the function, which they perform together. They include hardware (video, variable message signs - VMS, electronic vehicles identifiers, etc.), communication equipment, Traffic management center (TMC) (with appropriate hardware and software), people that work in the center. And the regulations and procedures established in order to provide continual operation of the all traffic related events on the freeway.

Freeway traffic management system (FTMS) consists of several subsystems (information system for the drivers, ramp metering system, etc.), which communicate among each other.

VI. Incident Management (IM)

Incident management is the most needed and from the safety point of view the most useful freeway traffic management system function.

Experienced drivers have learned to deal with recurrent congestion, planning their travel time lost in the congested traffic. However, non-recurrent congestion is unexpected and dangerous. In spite of the fact that it is unsafe, it can cause additional delay for the non-informed drivers.

Almost all non-recurrent or random congestion can be considered as traffic incidents, because they are potentially dangerous and can lead to conflicts.

Incident management needs coordinated operation and beforehand planned usage of human and technological resources, so the freeway can restore its complete capacity shortly after the incident occurred.

A. Incident Management Phases

As a first phase in incident management design characteristics of the incident have to be known. The incident influence on the freeway traffic in a certain region has to known also.

Rapid incident detection is a critical element in the incident management process. The faster the incident is detected, the faster the response and clearance would be. There is a substantial number of available technologies, starting with cheap manual methods, going to sophisticated automatic surveillance techniques which require high investments from the public agencies (probably governmental). The most significant factor is that ITS often promise dramatic improvement of the detection possibilities.

Rapid and on time response from the appropriate subjects can substantially reduce duration of the incident. So, in the second phase of the incident management usage of the computer technology is essential.

B. AID Algorithms

At the beginning of incident management system creation commonly used technique is telephone calls from the drivers or manual surveillance.

Automatic incident detection techniques surveillance use:

- Inductive loops
- Magnetometers
- Microwaves/radar
- Laser
- Infrared
- Ultrasound
- Sound
- Vehicles exploration (AVI, AVL).
- Closed - circuit television

Automatic incident detection technique efficacy depends partly on the type of the algorithm used for analysis of the detected data.

During the research, two types of algorithms for automatic incident detection were tested: conventional McMaster Algorithm (MMA) and non-conventional Neural Network Algorithm (NNA). The research was completely computerized with algorithms testing done on the database from QEW freeway in Toronto. Comparative results are shown in Table 1. Automatic incident detection algorithm testing has shown that neural network is far better for automatic incident detection than the McMaster algorithm. Both algorithms initially need parameters setting for the particular freeway or freeway section (MMA), i.e. initial training of the neural network and then testing and implementation.

Table 1. AID algorithms testing results

	Results	
	MMA	NNA
Correct classification (%)	70.47	66.84
Normal states detected (%)	94.83	62.48
Total detection rate (%)	20.90	57.98

VI. Conclusion

Existing FTMS research and analysis, as well as AID algorithms analysis has shown that implementing new computer technologies in traffic accident and /or incident management as potential accidents the number of accidents would decrease, damage would be less and the number of killed and wounded would decrease.

One of the key components in incident management subsystem as part of the FTMS are algorithms for automatic incident detection algorithms.

On the other hand, immediately establishing National ITS architecture is needed according to the developed countries examples.

Education and training as well as information for the users, i.e. potential users of the freeway traffic management system and freeway traffic incident management system are needed.

Literature

[1]. Вељановска, К., Функционални аспекти на интелигентната транспортна инфраструктура за поддршка на системот за управување со сообраќајни инциденти во РМ, Магистерски труд, Универзитет "Св. Климент Охридски" - Битола, 2002

[2]. Apogee/Hagler Bailly, Intelligent Transportation Systems: Real World Benefits. US DOT, Washington, DC, 1998

[3]. Carvel, J.D. and others, Freeway Management Concepts. Freeway Management Handbook, Texas Transportation, U.S.DOT, FHWA, 1997

[4]. Building the ITI: Putting the National Architecture into Action. US DOT, Washington, DC, 1996

[i] Kostandina Veljanovska, REK Bitola, 7000 Bitola, Makedonija, kostandina@rocketmail.com