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DESIGNING THE NATIONAL ARCHITECTURE OF INTELLIGENT TRANSPORT SYSTEMS

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Abstract

The development and introduction of intelligent transport systems (ITS) services are the main steps that will stimulate the application of new information and communication technologies in the transport system. The conditions of openness, interoperability, and flexibility of the system strengthen the active role of the industry in the development, construction, introduction, and impact of ITS. The implementation of these systems with it brings numerous benefits: reduction of traffic congestion and travel time, reduced fuel consumption and environmental pollution, and increased safety of pedestrians and cyclists.

This paper aims to present the methodology for designing the ITS architecture in the Republic of North Macedonia. The projected national ITS architecture and action plan set the framework for planning, analyzing, defining, deploying, and integrating ITS, while providing an understanding of their business, organizational and technical implications, integrating the three main elements: required functions, system participation in logical or functional entities such as subsystems and the flow of information and data that link these functions.

Keywords: Intelligent transport systems (ITS), architecture, ITS services, and subsystems

1 Introduction

Intelligent transport systems (ITS) are a global phenomenon, attracting worldwide interest from transport professionals, the automotive industry, and policy decision-makers [8]. ITS presents a new approach to solving old traffic problems. By changing approaches and trends in transport and traffic research, it can help reduce congestion, and pollution and improve transport efficiency and safety. Every country and every city has its transport system so different, ITS technologies are used to develop effective local, appropriate traffic and transport solutions in the context.

The Republic of North Macedonia as well as all Western Balkan countries suffer from similar problems such as the noncoherent introduction of ITS even on a national level (for different transport modes), lack of interconnection between modes and between different systems nationally and internationally, insufficient standardization of information exchanges, market actors' disparate capabilities in using information and communication technology (ICT), legal requirements hampering the use of ICT, and data security and privacy issues, etc. [6,9].

The implementation of ITS is a challenging process. The experiences from the application of ITS in the Republic of North Macedonia are modest and they are mainly in the field of; i) passenger information systems and services; ii) traffic management and control, and iii) operations and services in the field of public transport [9]. Fragmented and uncoordinated implementation, without the existence of national architecture and standards, cannot enable the benefits of the application of ITS for the users of their services.

The paper presents the theoretical and technological foundation of intelligent transport systems in road traffic, their functions, services, and areas of application. The main idea of the research is to design a

national architecture of ITS according to the directive of the European Parliament and the Council of the European Union. The paper is structured as follows. Section 2 presents the theoretical foundation of ITS. Section 3 describes the ITS application in the Republic of North Macedonia. Section 4 describes the national architecture of ITS and priority areas for ITS deployment. Section 5 provides a paper summary.

2 Theoretical foundation of Intelligent Transport Systems

The traffic system should provide rules of operation in which customer services will be integrated to provide users with confidential, accurate, and timely travel information. To ensure these operating rules, the system must meet the following requirements:

- Availability and quality of services;
- Interoperability of services;
- Continuity of services;
- Management of service information and their distribution;
- Growth, flexibility, and expansion of services;
- The objectivity of services and support;
- Evolution of services and
- Variations in the service configuration.

Fulfillment of the stated requirements does not lead to telematics systems (electronics, telecommunications, and computer technology) and their application in traffic systems. It is one of the greatest innovations since the advent of the car a century ago, and the advent of the highway seventy years ago. This innovation marks the beginning of the introduction of the so-called intelligent transport systems (ITS), which generally (though not exclusively) apply to road traffic.

ITS rely on the application of advanced information and communication technologies for transport and covers all modes and elements of the transport system, including vehicles, infrastructure, users, all in dynamic interaction [1]. For a complete review of ITS it is important to identify the basic interactions between transport, traffic and the system of activities (social, economic, etc.) Fig.1.

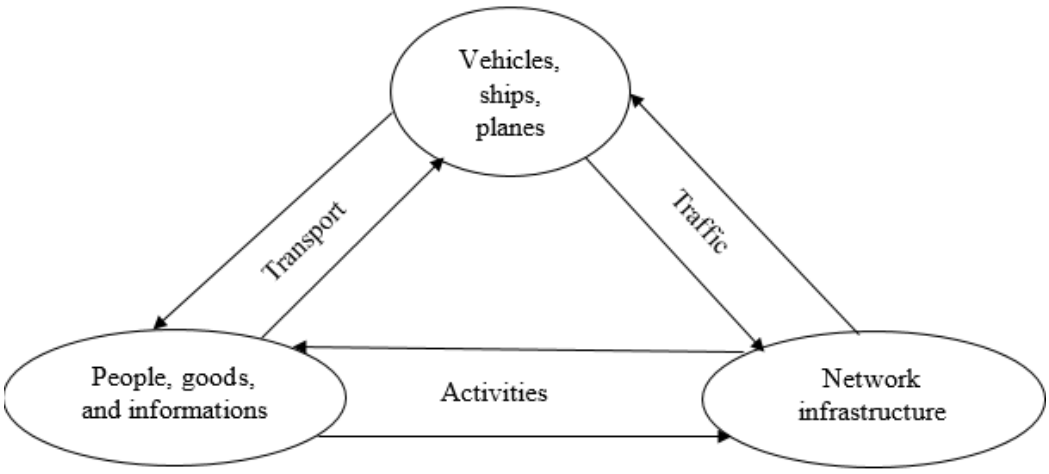

Figure 1: Basic interactions between transport, traffic, and activities [8]

ITS offers a wide range of component integration to achieve the full effect. The key ingredients are planning, good communication, and coordination between partners and stakeholders. ITS rely on a wide

range of technologies and features. Some of the most important ITS technologies and components are the following:

Communications:

- Microwave, radio, and infrared-based short-range communications used in electronic toll collection and electronic leakage of commercial vehicles
- Mobile communications - used to obtain real-time travel information, fleet management, incident response
- Internet - used to obtain real-time travel information, travel planning, payment, and traffic pictures.

Geographical location

- Global Navigation Technology (GNSSCN) - used for satellite-based positioning at automatic vehicle location (AVL), vehicle tracking, and electronic toll collection at a distance.

Geographic information systems

- Used for location-based databases for transport networks and location-based services.

Receiving and exchanging data

- Used for traffic management and real-time information

Camera systems

- Used for coercion and security (personal security)

Detection and classification

- Used in traffic management, incident management, safety, security

Vehicle systems

- Used for travel information, in-vehicle control systems, to avoid collisions

Digital mapping

- These are databases for road and transport networks that are stored on digital media (e.g., CD-ROM). Digital maps are key to ITS. They are used in traffic management, traffic information, route guidance, parking management, tracking the routes of trucks, and directing to recreational areas.

3 Analysis of ITS application in the Republic of North Macedonia

The Republic of North Macedonia is at the very beginning of the process of applying for ITS. Solutions from the area of *traveler service information, traffic management and operations, and public transport services* are implemented mainly in the capital city of Macedonia, Skopje [1].

Traveler Information Services is a key element of ITS deployment and an essential component for effective and efficient traffic management. They are designed to provide the traveler with comprehensive real-time traffic information allowing for well-informed travel decisions (pre-trip information) and during the journey (on-trip). In Skopje, five variable message signs have been implemented. They include real-time information concerning a road network and traffic conditions.

One way to promote greater use of public transport is by providing real-time passenger information. The automatic location of the vehicles allows one to obtain the time of departure/arrival and transfer from one to another vehicle that stands out at the stops, at home, etc. In Skopje, there are several signs on certain public transport lines on the bus stops, which show real-time bus arrival.

A special and crucial element for traffic management and ITS is the Traffic Management and Control Centre (TMCC). To cope with the increased traffic, demand a TMCC using the UTOPIA (Urban Traffic Optimization by Integrated Automation) adaptive system has been built in Skopje in 2014 because of the FP7 project CIVITAS RENAISSANCE and with extra funding from the EBRD grant. Currently, it monitors and manages 90 intersections in real time [1]. New parts of the road network are being constantly added. TMCC is organized based on the highest standards and its main functions are: obtaining traffic data in real-time, regulation the traffic signal system, traffic monitoring, giving priority to public transport, and providing real-time information for drivers. This Centre constitutes a solid base for the introduction of new incoming solutions such as Smart Parking or Smart Free Parking System in the Skopje center, as well as Share Transport solutions [1].

The project, which amounts to18.6 million EUR, the highway between Tabanovce and Gevgelija will have installed devices for measuring the weight of the vehicles in movement, weather stations – systems for providing information about weather conditions on the road and for measuring greenhouse gasses, surveillance cameras will be installed, as well as SOS road telephones and electronic traffic signalization for informing the drivers about the road conditions. At the same time, all these parameters about the road conditions will be monitored by the Public Enterprise for State Roads' Control Center [2].

The experiences of ITS application in the Republic of Macedonia are modest and there is a disharmony between the ITS and the physical characteristics, the number of services and capabilities, and ITS service locations in the view of application efficiency. Before ITS application detailed analysis with a focus on planning, designing, and implementing integrated systems in each period and geographical area, with a systematic mechanism for achieving the goals and requirements of all participants need to be established.

4 The national architecture of ITS and priority areas

The system architecture of ITS provides a logical framework, based on the needs of the user in planning, defining, and integrating transport systems.

The European architecture of ITS has been created within the project KAREN (1998-2000) [9]. The main goal of this initiative was to promote the deployment of ITS mainly in road traffic in Europe by designing a framework that would provide a systematic basis for planning ITS implementations, facilitating their integration when multiple systems were to be deployed, and helping to ensure interaction, including across European borders [10].

The FRAME architecture was established to support the development of ITS and to encourage their introduction in the EU Member States, by facilitating the integration process and interoperability, promoting the standardization of functionalities, interfaces, and data models [3].

The national ITS architecture will show clearly, and unambiguously which processes need to be standardized, especially in communications and data exchange. Based on relevant interfaces and operational needs, user needs, and hardware and software specifications, the architecture helps identify the nature of the standards - local, regional, or international. The system architecture aims to assist in the deployment of ITS in the following areas: intelligent transport systems to be integrated with other systems and easy to manage, easy to maintain, upgrade and expand, meet customer expectations, etc.

Applying the European architecture of ITS not only will applications work together, but they can also become interoperable at the European level, which is a feature of greater importance. National ITS architecture will: *provides an open market for services and equipment; allows economies of scale in production and distribution; ensure consistency of information; encourage investment and provides interaction among all.* It, therefore, facilitates clear communication between them and provides valuable support to decision-makers.

Risks that exist in the absence of ITS architecture are:

- It will not be able to provide the expected services because the components, both publicly and privately owned, are not fully compatible;
- It is difficult to expand or change according to the service requirements;
- Will not be able to adapt when new technologies appear.

The lack of non-existent ITS architecture can result in the creation of so-called "Technological islands", which over time will lead to incompatibilities. That's why it's good for each country to design its own ITS architecture because it helps *to get the best value for the investment and effort you put in in the long run.*

The ITS architecture consists of:

- **Overview (or conceptual model)** - a diagram that shows the whole system and explains its operation;

- **Functional (or logical) architecture** (or point of view) - a set of diagrams and specifications that show the functions or processes needed to meet the needs of the user;

- **Physical architecture** (or point of view) - through diagrams and specifications for physical components and their locations for a particular application;

- **Communication architecture** (or point of view) - analysis of the communication requirements of the connections required between the locations shown in the physical architecture.

The services in the proposed Macedonian ITS a multi-layered architecture are grouped in 6 areas. Figure 2 depicted the priority areas and activities for deployment of ITS in the Republic of North Macedonia according to the Directive 2010/40/EU. Defining and classifying stakeholders that will use the architecture is a crucial element that allows the defining the responsibilities and thus preventing organizational problems [7].

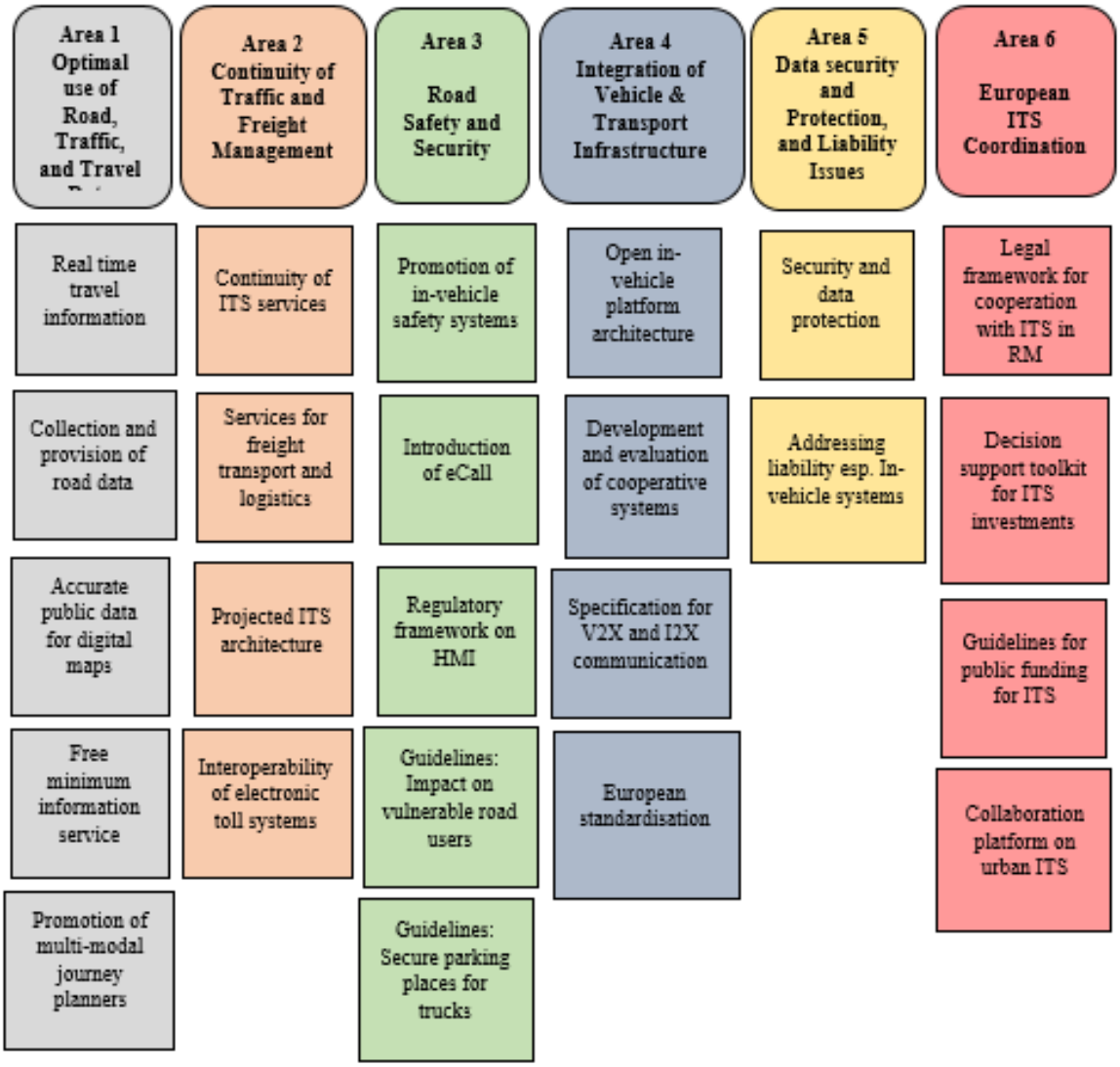

Figure 2. Priority areas and activities for deployment of ITS in the Republic of North Macedonia [7]

Conclusions

ITS are a basic condition for achieving a successful, modern economy as well as the existence of smooth and efficient transport of people and goods. Failure in this area threatens competitiveness and indicates unsustainable use of transport infrastructure.

The projected national architecture of ITS for the Republic of Macedonia sets the framework for planning, analysis, definition, deployment, and integration of ITS, providing simultaneous understanding of their business, organizational and technical implications, integrating three main elements: required functions, system participation in logical or functional entities such as subsystems and the flow of information and data that link these functions.

The development and introduction of intelligent transport systems (ITS) services are the main steps that will stimulate the application of new information and communication technologies in traffic and transport.

The implementation of these systems will provide numerous benefits for our country, such as: a reduction of traffic congestion and travel time, reduced fuel consumption and environmental pollution, increased safety of pedestrians and cyclists, etc.

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