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Evolution and selected implementation examples of ITS in the European Union

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ABSTRACT
Intelligent transportation systems (ITS) are evolving in response to a range of factors, which are discussed in this paper in conjunction with major directions of future ITS development. The technology of cooperation between the various elements of infrastructure and vehicles will determine further evolution of telematic solutions, leading to synergies arising from both existing and new applications, as well as from the advent of the Internet of things in transportation. The next step in the development of such systems is Cooperative ITS. It already has a solid foundation in the European Union's strategic documents on transportation, and the first implementations are under way.

KEYWORDS: Telecommunication, ITS, C-ITS, Intelligent Transportation Systems

1. Introduction

Isaac Asimov, who coined the term "robotics" and formulated the famous "three laws of robotics," [1] envisioned the advent of autonomous automobiles already in his 1952 story entitled "Sally." In science-fiction movies driverless cars have long been carrying passengers, while fleets of autonomous trucks operated by a remote control center have been delivering goods to pre-programmed destinations. Until recently, such technologies could only be envisaged in the distant future, being little more than conjectures of automotive engineers. However, rapid technological advances, ever increasing computer performance, and enhanced sensitivity of sensors have led to a point where objects can be rendered in real time with accuracy exceeding the ability of human perception. In particular, the safe movement of autonomous vehicles on the streets may be enabled by the evolution of Intelligent Transportation Systems (ITS) towards Cooperative ITS (C-ITS).

This paper aims to characterize the factors stimulating ITS evolution, identify the most likely lines of development, and present selected examples of existing implementations of these systems in the EU.

2. The causes and implications of ITS evolution

Of fundamental importance to road traffic is safety, which lies at the heart of ITS, being indirectly linked to its other objectives, such as:

- improvement of traffic management efficiency,
- maximization of benefits both for public transport and private vehicles,
- optimum utilization of the transport infrastructure,
- reduction of environmental hazards.

Road safety is understood both as a set of traffic rules and as a discipline aimed at creating appropriate conditions for road traffic. Road safety encompasses traffic management and organization, driver training and certification, transport psychology, certain aspects of emergency services, technical conditions and requirements concerning vehicles, roads, and traffic control devices, as well as the promotion of desirable behaviors in road users. [2] This broad definition shows the multitude of interconnected factors affecting road safety, which could be likened to a complicated equation whose results depend on many variables. The most unpredictable and, by the same token, the least controllable element of that equation is undoubtedly the human factor due to the individuality of human behaviors while driving. Indeed, road accidents are most frequently caused by inappropriate human behaviors [3], such as:

- failure to adapt speed to traffic conditions,
- failure to yield to right-of-way,
- improper overtaking,
- improper passing of stationary vehicles,
- improper passing of oncoming vehicles,
- improper driving through pedestrian crossings,
- improper left or right turns,
- improper reversing,
- improper lane changes,
- improper U-turns.

Therefore, in order to ensure broadly defined road safety given the existing elements of road infrastructure, one should strive to eliminate this most unpredictable variable, or at least limit it to a range of predictable behaviors. This can be achieved by the extension and modernization of transport infrastructure [16] or by the application of ITC technologies.

Particularly useful in this field are ITS and C-ITS solutions, whose increasing capacity to analyze the reality surrounding road users makes it possible to introduce a surveillance element to the above-mentioned equation. This can be done in two ways: directly, through onboard systems and sensors reacting to the driver's behaviors, and indirectly, through the same systems reacting to external factors and behaviors of other road users, including pedestrians.

The aforementioned possibilities are but the tip of an iceberg. The rapidly developing ITS technology has exceeded the expectations of its creators as the emergent opportunities cannot be precisely defined or delimited due to the dramatic advances in data processing and sensor development indicated above. Innovations include early warning solutions coupled to the steering system of the vehicle, which may correct the driver's mistake; autonomous means of public transportation, which may drop passengers off at their desired destinations; technologies supporting emergency and law enforcement services; and many others.

Rapid technological progress will certainly also affect the automotive industry and the related field of road infrastructure. Geographic areas in which the road infrastructure fails to keep up with these advances will suffer from faltering attractiveness, which may translate into less commercial, public, and private investment (e.g., fewer houses built). Therefore, ITS projects should be regarded as long-term investments critical to the development of the regions in which they are implemented.

3. Characteristics of C-ITS

The transportation sector has been increasingly benefitting from the ongoing worldwide digital revolution. Similarly to almost all other areas of life, also here data digitization makes information the driving force for change. This fact has long been acknowledged by all major manufacturers of road, rail, water, and air vehicles. The main element of the modern car is an onboard computer, which collects, processes, and analyzes data about the vehicle. Various ITS solutions have become standard features in an increasing range of motor vehicles.

At the same time, road congestion is gradually becoming worse. According to data from the European Automobile Manufacturers Association (ACEA), in 2014 there was approximately one car per two inhabitants of the European Union, which corresponds to 291 million cars [4]. What is more, almost 40 million commercial vehicles should be added to that figure [4].

The development of telematic solutions for transportation has led to the emergence of a variety of telecommunications, IT, and information systems used both in vehicles and for the infrastructure. Indeed, the latter needs to take advantage of state-of-the-art technologies to adequately respond to the rapid changes in transportation patterns. This means that two parallel pathways, namely, onboard ITS and infrastructural ITS, ultimately pursue the same objective, which is the deployment of Cooperative ITS.

Cooperation between ITS solutions is the natural consequence of their existing capacities. This means that individual elements of road traffic, such as vehicles and infrastructure, and possibly also pedestrians and cyclists, will be able to communicate with one another to enhance road safety, improve the quality and efficiency of the transport system, and increase travel comfort. [5]

The development of cooperative systems will be of particular importance to autonomous vehicle technology, with prototypes being tested by most automotive manufacturers, as well as some other technological companies, such as Google. However, self-driving vehicles cannot realize their full potential without advanced cooperation with other road users. Autonomous vehicles cannot replace conventional ones overnight and communication networks need to gradually develop ways to ensure the safe coexistence of both types. The average age of vehicles on European roads is increasing; in 2015 was almost 10 years [4], and in some countries, such as Poland, as many as 75% of vehicles exceed the EU average. This is a serious problem which needs to be addressed in the context of C-ITS development.

In the field of road infrastructure, C-ITS may offer the greatest benefits to traffic control systems, which are widely implemented in cities with a view to improving the efficiency of urban transport networks. A good case in point is the largest and most modern system in Poland launched in the city of Łódź at the end of 2015. The system encompasses 234 intersections throughout the city and incorporates more than 200 ANPR and CCTV cameras. [6] Traffic control systems have enormous potential which can be used to manage the operation of C-ITS in urban areas and enable vehicle-infrastructure communication.

3. ITS in European Union policies

The European Union has long acknowledged the need to promote state-of-the-art, smart technologies in transportation. Congestion has been identified as a factor adversely affecting a transportation-based economy, the natural environment, and the safety of road users (especially the unprotected ones, such as pedestrians, cyclists, and the disabled, but also vehicle drivers and passengers).

In 1991, the public-private platform ERTICO-ITS Europe [7] was created to bring together ministries of transport, road operators, and enterprises in the transport industry; currently it has a membership of over 100. The organization's vision is "bringing intelligence into mobility" in order to pursue the goals of: [7]

- zero accidents,
- zero delays and fully informed people,
- reduced impact on the environment.

On December 16, 2008, the European Commission published a communication entitled the "Action plan for the deployment of Intelligent Transport Systems in Europe". The main policy objectives defined in that document are for transport and travel to become: [8]

- cleaner,
- more efficient, including energy efficient,
- safer and more secure.

The Action Plan is designed "to accelerate and coordinate the deployment of Intelligent Transport Systems (ITS) in road transport, including interfaces with other transport modes" [8]. It also stipulates the need to adopt a European approach to ITS development rather than focus on isolated regions. The six priority areas for action outlined in the document with a view to implementing ITS are: [8]

1. Optimal use of road, traffic and travel data;
2. Continuity of traffic and freight management ITS services in European transport corridors and in conurbations;
3. Road safety and security;
4. Integration of the vehicle into the transport infrastructure;
5. Data security and protection, and liability issues;
6. European ITS cooperation and coordination.

As a result of the Action Plan, on July 7, 2011, the European Parliament and the Council issued Directive 2010/40/EU on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport. The directive defines ITS as "advanced applications which without embodying intelligence as such aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated and 'smarter' use of transport networks" adding that "ITS integrate telecommunications, electronics and information technologies with transport engineering in order to plan, design, operate, maintain and manage transport systems. The application of information and communication technologies to the road transport sector and its interfaces with other modes of transport will make a significant contribution to improving environmental performance, efficiency, including energy efficiency, safety and security of road transport, including the transport of dangerous goods, public security and passenger and freight mobility, whilst at the same time ensuring the functioning of the internal market as well as increased levels of competitiveness and employment." [9]

Article 2 of the Directive specifies four priority areas, whose scope is delineated in Annex I: [9]

1. Optimal use of road, traffic and travel data;
2. Continuity of traffic and freight management ITS services;
3. ITS road safety and security applications;
4. Linking the vehicle with the transport infrastructure.

The above areas give rise to six priority actions: [9]

1. the provision of EU-wide multimodal travel information services;
2. the provision of EU-wide real-time traffic information services;
3. data and procedures for the provision, where possible, of road safety related minimum universal traffic information free of charge to users;
4. the harmonized provision for an interoperable EU-wide eCall;
5. the provision of information services for safe and secure parking places for trucks and commercial vehicles;
6. the provision of reservation services for safe and secure parking places for trucks and commercial vehicles.

Also in 2011 the European Commission released a white paper entitled "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system". The white paper proposes four pillars of sustainable mobility: [10]

1. the application of state-of-the-art technologies,
2. legal regulations based on the "user pays" principle,
3. complete integration in the process of spatial planning,
4. precisely defined information aimed at raising social awareness and mobilizing social pressure on politicians to support sustainable development policies.

The objective of the Roadmap is to develop a fully functional, multimodal transport network as part of the Trans-European Transport Network, which will enable attainment of all goals of the EU's sustainable transport policy, including moving close to zero fatalities in road transport, by 2050. [10]

On April 14, 2016 the transport ministers of the 28 Member States of the European Union signed the Declaration of Amsterdam "on cooperation in the field of connected and automated driving: Navigating to connected and automated vehicles on European roads." The signatories recognized that connected and automated vehicles offer great potential for improvement of road safety, traffic flows, and the overall efficiency and environmental performance of the transport system. [11] They also acknowledged the importance of local and EU initiatives supporting innovation in the field of connected and automated driving, in particular through the C-ITS platform. [11] The Declaration of Amsterdam outlined five objectives, namely: [11]

1. to work towards a coherent European framework for the deployment of interoperable connected and automated driving, which should be available, if possible, by 2019;
2. to bring together developments of connected and automated driving in order to reach their full potential to improve road safety, human health, traffic flows, and to reduce the environmental impact of road transport;
3. to adopt a "learning by experience" approach, including, where possible, cross-border cooperation, sharing and expanding knowledge on connected and automated driving and to develop practical guidelines to ensure interoperability of systems and services;
4. to support further innovation in connected and automated vehicle technologies to strengthen the global market position of European industry;
5. to ensure data protection and privacy.

Upon the request of Poland, which was represented at the meeting by Deputy Minister Piotr Stomma, the declaration included a section on ensuring security and reliability of connected and automated vehicle communications and systems in light of the increase in cyber threats. [12]

The Member States and representatives of the automotive industry undertook to develop legal and regulatory foundations for the implementation of autonomous vehicles on EU roads.

In its Communication of November 30, 2016, the European Commission adopted "A European strategy on Cooperative Intelligent Transport Systems, a milestone towards cooperative, connected and automated mobility" with the aim of facilitation and coordination of projects, investments, and European structures to deploy the first commercial C-ITS vehicles by 2019. Related objectives include the improvement of road safety, traffic efficiency, and travel quality and comfort across the European Union. In particular, this technology is expected to reduce the main cause of accidents, namely, human error, by helping drivers make the right decisions. Vehicle-to vehicle connectivity is also a key factor enabling the implementation of autonomous vehicles in the near future. The basic elements of the strategy are presented in the Communication of November 30, 2016: [13]

1. Avoid a fragmented internal market – In light of the multitude of projects under way in the European Union, the primary goal is to prevent fragmentation and create synergies between the various initiatives.
2. Define and support common priorities – The strategy defines the basic services that should be launched as a first step by the national and local authorities as well as by automotive manufacturers and road operators.
3. Use a mix of communication technologies – Different communication strategies should be deployed to make C-ITS messages available in various transport situations and between different actors.
4. Address security and data protection issues – Citizens must have the assurance that their data are protected and used properly.
5. Develop the right legal framework – An appropriate legal framework should be established.
6. Cooperate at international level – International cooperation should be encouraged with leaders in C-ITS development, such as Australia, Japan, Singapore, and the United States.

5. ITS in European Union policies

Ongoing C-ITS projects in Europe include eCall, which is designed as a pan-European automatic accident notification system. During an accident or when prompted by the driver or a passenger, the system will send GPS coordinates of the vehicle involved in a collision and establish a connection with emergency services. The operator will then be able to communicate with the persons in the vehicle. According to estimates, eCall is supposed to reduce the response times of emergency services by 50% to 60% by dialing the European emergency telephone number. [5] In Poland, the 112 system operates on the basis of a document entitled "Design of the 112 System" issued by the Council of Ministers on October 16, 2007. In its final form, the system is to consist of:

- 16 regional public-safety answering points (PSAP), including 6 with extended IT functionalities,
- a technical surveillance and monitoring center,
- a training center.

Beginning as of April 2018, eCall will be mandatory in all new cars sold within EU. [5]

Through the platform C-Roads, authorities and road operators join together to combine existing C-ITS projects into an overarching action aimed at the development of one shared European C-ITS service. The core members of the platform are Austria, Belgium, the Czech Republic, France, Germany, the Netherlands, Great Britain, and Slovenia. [14] The main target of C-Roads is to launch a so-called basic package of "day-1-services" encompassing messages about traffic jams, hazardous locations, and road-works, as well as weather information sent directly to connected vehicles. [14] Subsequent stages will involve increasingly complex measures deployed as local pilot projects to be eventually rolled out across the European Union. [14]

One of the first applications of vehicle-to-vehicle and vehicle-to-infrastructure technology will be the Rotterdam – Frankfurt/M. – Vienna cooperative corridor. [15] The first two services to be deployed are a roadworks warning system and a vehicle data system for improved traffic management; the latter includes such elements as vehicle position and speed as well as information on fog and precipitation. [15] In both cases, communication capacity is to be ensured by a Wi-Fi or cellular network (3G, 4G). [15]

Several C-ITS projects are envisioned under the Connecting Europe Facility (CEF), which has replaced the trans-European network program, and which is aimed to foster the development of transportation, energy, and telecommunications.

One of these initiatives, known as NordicWay, is a day-1 C-ITS pilot project in the Scandinavian countries designed to improve road transport safety and comfort and connect it with other transport modes. [5]

The main goal of the I_HeERO program is to effectively deploy the eCall system in the European Union Member States. [5]

Ursa Major 2 targets the implementation of ITS in the core corridor linking the North Sea ports with the Rhine and Ruhr area and the urban areas of northern Italy and southern Germany. [5] The main beneficiaries of this project will be international truck drivers with one of the objectives being a system providing information on safe parking for trucks. [5]

Similarly, MedTIS II is designed to deploy ITS services in the corridor spanning the western Mediterranean coast: Portugal, Spain, France, and Italy – a total of almost 9000 km of motorways. [5]

Finally, the objective of Arc Atlantique is to enable ITS implementation along the Atlantic coastline from Portugal to Ireland via Spain, France, Belgium, the Netherlands, and Great Britain. [5]

6. Conclusion

The observations and considerations presented in this paper lead to the following conclusions:

1. Among the many determinants of ITS evolution, of particular importance are safety issues, which stimulate intensive development of new ITS functionalities and other driver-support systems.
2. ITS solutions are evolving towards C-ITS, leading to new standards in both passenger and freight transport, thus significantly affecting human life.

3. In Poland, similarly as in other developed countries, ITS projects have been recently deployed in many cities. Importantly, those systems can be subsequently upgraded to C-ITS standards.
4. The ITS implemented in the city of Łódź is one of the most advanced solutions in Europe; however, it needs to be further extended to optimize it for future C-ITS deployment.
5. The European Union's development strategy stipulates the evolution of ITS towards C-ITS. At the same time, the EU devotes considerable funds to the implementation of projects generating the experience and knowledge necessary for further improvement of those systems.

Bibliography

[1] ASIMOV, I.: Świat Robotów, Tłumaczenie: Edward Szmigiel, Wydawnictwo: Varia-APD

[2] WICHER J.: Bezpieczeństwo samochodów i ruchu drogowego, Wydawca Wydawnictwa Komunikacji i Łączności WKŁ

[3] Wypadki drogowe w Polsce w 2014 roku, Komenda Główna Policji, Warszawa 2015. [On-Line]. Available: www.statystyka.policja.pl/download/20/167907/raportrocznyruchdrogowy2014r.pdf [date of access: 15.02.2017]

[4] European Automobile Manufacturers Association; www.acea.be [date of access: 15.02.2017]

[5] European Commission; www.ec.europa.eu [date of access: 15.02. 2017]

[6] KOZLOWSKI R., PALCZEWSKA A., JABLONSKI J.: The launching phase analysis of the implementation of polish largest intelligent transportation system. Archives of Transport System Telematics, vol 9, issue 2, May 2016

[7] ERTICO - ITS Europe; www.ertico.com [date of access: 15.02.2017]

[8] Komunikat Komisji: Plan działania na rzecz wdrażania inteligentnych systemów transportowych w Europie, 16.12.2008, Bruksela, str. 2-3; [On-Line]. Access: www.eur-lex.europa.eu [date of access: 26.01.2017]

[9] Dyrektywa Parlamentu Europejskiego i Rady 2010/40/UE z dnia 7 Lipca w sprawie ram wdrażania inteligentnych systemów transportowych w obszarze transportu drogowego oraz interfejsów z innymi rodzajami transportu. [On-Line]. Access: www.eur-lex.europa.eu [date of access: 26.01.2017]

[10] KRYSTEK, R.: Rola Inteligentnych Systemów Transportowych w realizacji celów Polityki Transportowej UE na dekadę 2010 – 20. [On-Line]. Access: www.przeglad-its.pl/2013/04/16/rola-inteligentnych-systemow-transportowych-w-realizacji-celow-polityki-transportowej-ue-na-dekade-2010-20 [date of access: 26.01.2017]

[11] Declaration of Amsterdam. [On-Line]. Access: www.english.eu2016.nl/documents/publications/2016/04/14/declaration-of-amsterdam [date of access: 20.02.2017]

[12] Ministerstwo Infrastruktury i Budownictwa; www.mib.gov.pl [date of access: 26.01.2017]

[13] European Commission Press Release Database; www.europa.eu [date of access: 26.01.2017]

[14] C-Roads Platform; www.c-roads.eu [date of access: 26.01.2017]

[15] C-ITS Corridor; www.c-its-korridor.de [date of access: 26.01.2017]

[16] KOZŁOWSKI, R.: Wpływ infrastruktury transportu na rozwój klastrów na przykładzie regionu łódzkiego w: Sosnowski J. [red.], Klastry logistyczne na tle procesów rozwoju regionu, Wydawnictwo Uniwersytetu Łódzkiego, Łódź 2011,