Intelligent Transport Systems (ITS) Interoperability Assurance Drivers

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ABSTRACT

Interoperability is one of crucial problems in transport systems and it is touching especially the systems, when their complexity is growing with application of information and communications techniques. Directive of 2010/40/EU on frameworks of the implementation of intelligent transport systems in the area of the road transport and interfaces with other types of transport has established measures to ensure ITS conformance, interoperability and continuity. Here there is review of the drivers to ITS interoperability achievement, as well as processes of their practical application. Special focus is on testing of the implementation of standards and the specifications.

KEYWORDS: intelligent transport system, ITS, C-ITS, interoperability, testing

1. Systems Interoperability vs Transport Systems - Where is Problem?

Interoperability problem appears everywhere when different systems or even only their fragments, treated as the certain integral units from functional, structural or implementation point of view are supposed to cooperate with each other. It is caused by the fact that as a rule these objects treat their environment and other systems as the outside world, with properties not entirely known and controlled.

Attempts to establish the cooperation of such items often create problems. It takes place particularly in all complex systems, including telecommunications and computers (generally information and communication technologies – ICT), in which interoperability assurance is a required condition.

In the context of European public service delivery, according to definition from the European Interoperability Framework, interoperability means "the ability of disparate and diverse organisations to interact towards mutually beneficial and agreed common goals, involving the sharing of information and knowledge between the organisations, through the business processes they support, by means of the exchange of data between their respective ICT systems" [3].

Most of transport systems provide or use general public services. Considering network and infrastructural character of transport systems and their significant reach, they should cooperate with other systems, as well as they often should be divided into cooperating parts. From these considerations, interoperability is one of crucial problems of transport systems, and it touches especially systems which complexity grows with information and communications technologies application.

These statements lead to conclusions that there is need to find, in the intelligent transport systems area, solutions removing barriers in the interoperability assurance and facilitating or sometimes even enforcing cooperation mechanisms.

Telecommunication branch has long experience and worked out methods of network systems creation and maintenance, where interoperability assurance is one of key problems [14]. These methods could be applied in ITS.

2. System intelligence - interoperability facilitation or not?

According to European Telecommunication Standard Institute (ETSI) presentation *ACHIEVING INTEROPERABLE STANDARDS - THE ETSI APPROACH* [6] "we live in an interconnected world and interoperability is key to drive it forward". It is visible especially in the cases as:

- advanced ITC applications, for example: digital home, smart house, machine to machine communications (M2M), Internet of Things, intelligent transport systems etc.;
- possible selection, by users, of growing offers of producers and suppliers with variety of products addressed to different client segments (business, public, private) and being response for different needs;
- expectations of easy and not expensive deployment and operation by not experienced users;
- the use of market mechanisms by producers, taking into account the economy scale and the fact the most of products have world range.

Many (if not the most) from above problems is connected with solutions in which the basic roles play ITC systems. Particularly these are systems introducing "an intelligence" to processes of the production, the distribution and the utilization. The basement of this intelligence is widely understand cooperation.

The systems or even their components bad cooperation or lack of it is usually expensive, because:

- levers the confidence to the producer technology or his brand ("they do not know how to resolve the problems");
- dissatisfies consumers, and by these causes changes of the products interest or makes difficult the deployment of new solutions ("it not useful or not mature for our application");
- obstructs or even makes impossible the realization of composite and complicated projects, integrating different products (physical ones, services, the information), integrating different technical and technological solutions, covering large areas or different organizations.

Interoperability assurance demands certain costs, however usually interoperability is profitable and often this is obligatory. The intelligence of products often enlarges their complexity, but also enlarges the flexibility of their adaptation to conditions of their production and the use, and consequently also to the coexistence and the cooperation with other objects. Thus intelligence is a chance not only for new products but also for their interoperability. These general statements refer to ITS area as well.

3. Models of intelligent systems interoperability assurance

Sometimes it could be noticed the impression that the interoperability problem appeared not long ago. A fact is that it gained on the meaning in the relationship with the development of network applications in different spheres. It touches properly all: from mass market users of internet applications up to highly specialized centres workings on new technical solutions which have to work in networks. So there is problem: what should be made to assure interoperability and what really happens with it. Especially it refers to the systems with the complex network logic, like for instance intelligent transport systems.

In this context European activities in favour of the interoperability and Polish national interoperability frameworks, which refer also to ITS problems, should be mentioned.

The *European Interoperability Strategy - EIS* and *European Interoperability Framework - EIF* [3] have to help the assurance of the seamless cooperation of public administrations both in each country and between countries of the European Union.

The strategy (EIS) has a character of the political support declaration for interoperability which has to be transformed „into the pack of specific projects and results".

Framework (EIF) is therefore "an agreed approach to interoperability for organisations that want to collaborate to provide joint delivery of public services" It specifies such common elements as "vocabulary, concepts, principles, policies, guidelines, recommendations, standards, specifications and practices". On the base of EIT rules, 25 recommendations addressed to public administrations and public services managers were developed. The recommendations indicate specific activities recommended for services interoperability assurance on all levels – from political up to technical.

In Poland is in force *Regulation of the Council of Ministers of 12 April 2012 on National Interoperability Framework, minimum requirements for public registers and information exchange form, as well as minimum requirements for ICT systems* [4]. It introduced National Interoperability Framework, in terms of „courses of action (...) in the range of the selection of resources, methods and standards used to the set-up, deployment, operation, monitoring, review, maintenance and improvement of the ICT systems" [4]. Purpose is the assurance of „semantic, organizational and technological interoperability with the assurance of the technological neutrality" [4]. These are very general descriptions which should be treated as general guidelines.

In the Regulation the most important is the expression of requirements for publishing in the Public Information Bulletin and in the interoperability repository information on interoperability, which has essential influence on the cooperation in the realization of public services.

Rules of interoperability achievement on the technology level were strongly expressed. It means obligation to apply of minimum requirements for ICT systems, defined in the Regulation [4].

4. Standardization role in interoperability assurance

Transport telematics standardisation is an activity oriented on ICT systems and devices, on processes inside and in their environment as well as on services provided by these systems to users. Essentially the standardization refers to functionalities of solutions and telematics applications, their usefulness in compliance with user's needs and conformance with requirements, standards and recommendations. The standardisation in telematics has a relationship also with eliminating of the overflow functionality and the variety of solutions and applications. Services quality and safety required is also important factor should be considered in compliance with users needs and requirements.

The assurance of conformance of telematics solutions and applications has an immediate relationship with the assurance of their electromagnetic compatibility and interoperability in terms of electromagnetic waves usage as the physical medium. The electromagnetic compatibility consists of the assurance of functionalities of devices and telematic systems in collision free work in the specific environment, including infrastructure of the transportation. It is connected with not emission of harmful electromagnetic interferences in this environment and also with noise immunity.

Standardization is a tool for the realization of all these user needs and requirements. It makes possible the unification of the requirements and after that solutions and applications are unified. Then worked out models and examples are presented in the form of standards, recommendations and guidelines. Telematics compatibility and interoperability is one of the key purposes of these documents.

Essentially standardization make possible the assurance of efficient, collision free cooperation, with improved and controlled quality and safety of transport systems, including ITS. Standardization has positive influence on best practices dissemination in systems and devices design. It restricts solutions variety, creation of many isolated islands and cost of production and operation. Basically standardization should be technology independent, however the borders between standards and technologies and their product recipes could be not sharp.

Standardization is one of activity domains of state agencies, groups of interested producers and independent international organizations.

In the global scale the leading role in the standardization plays *International Organization for Standardization (ISO)*. Another organizations supplement these activities. *International Electrotechnical Commission – IEC)* develops standards concerning electric, electronic and related domains, also telecommunication. In the telecommunication domain acts the specialized organization *International Telecommunication Union (ITU)* which develops and distribute its recommendations mostly in the area of telecommunication. All international standards are the base for regional and national standards, however some regional or national standards become global standards (like for instance Internet or GSM).

In Europe there are three regional standard organisations recognized by European Union: *European Committee for Standardization (CEN), (European Committee for Electrotechnical Standardization (CENELEC), European Telecommunications Standards Institute (ETSI)*. Their mission is to prepare from scratch or admission of standards worked out by ISO, IEC and ITU and sometimes extension of the standards. In some cases these organisations carry ordered work on the base of European Commission mandate. One of the purposes of these organisations is development support of the harmonised European market. The market should be well ordered in the interoperability aspects.

In Poland there is state founded *Polish Committee for Standardization (Polski Komitet Normalizacji – PKN)* which is a member or, in some cases, a founder of mentioned above international standard organizations. This committee is main national body aimed on creation of Polish set of standards. It transposes international standards without any changes in their contents. PKN can also create specific Polish standards. Application of all Polish standards (including harmonized EU standards) is not mandatory. PKN activity area covers all domains including transport, telematics and telecommunications from the service and technology views.

It is recommended to view clause 4.3 and especially figure 4 in *ETSI EG 202 798 V1.1.1 (2011-01) ETSI Guide Intelligent Transport Systems (ITS); Testing; Framework for conformance and interoperability testing* [8]. This is snap-shot of ITS base standards which may be used as a base for ITS interoperability assurance works.

5. ITS deployment according to 2010/40/EU Directive

In the European Union dominates the conviction about the need of the existence of coordinated transportation covering all countries and all transport modes. This is regulated with Directives of Parliament and Council. The breakthrough meaning for ITS has the *DIRECTIVE 2010/40/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport* [1] and connected with it COMMISSION DECISION of 15 February 2011 concerning the adoption of the Working Programme on the implementation of Directive 2010/40/EU [2]. From these documents emerged plans of the specifications and related standards elaboration for conformance, interoperability and continuity assurance of preferred activities.

These specifications are developed under the aegis of the European Commission and accepted as delegated acts in compliance with an article 290 of Treaty on the Functioning of the European Union.

It was planned the adoption of specifications for six preferred activities, namely:
- EU-wide multimodal travel information services;
- EU-wide real-time traffic information services;
- definition of minimum requirements for road safety related universal traffic information;
- harmonized provision for an interoperable EU-wide e Call;
- ITS based information services for safe and secure parking places for trucks and commercial vehicles;
- ITS based reservation services for safe and secure parking places for trucks and commercial vehicles.

The European Commission invited standard organizations: CEN/CENELEC and ETSI to the elaboration of the coherent set of standards, specifications and guides which have to help in implementation and deployment of co-operative intelligent transport systems in the European Union. For these reasons standardization mandate M/453 [11] was issued. It was assumed use of other projects results and the cooperation with other normalization bodies (see fig. 1).
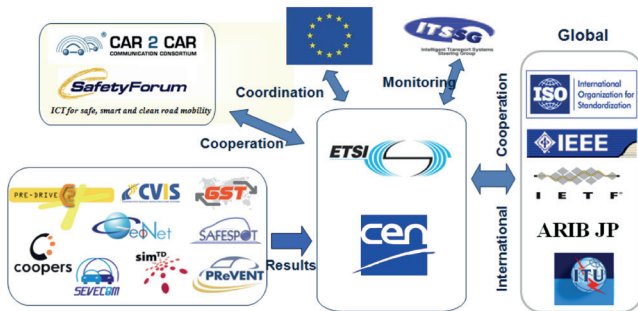
Fig. 1. Mandate M/453 cooperation context

Results of works within the mandate M/453 framework can be reviewed on internet portals of CEN TC278 and ETSI. The state of the works is periodically, reported to the European Commission [12], [13].

6. Question of interoperability obligation and means for interoperability enforcement

Existing European regulations and also national ones, in the ICT area, avoid the obligations of the usage of specific regulations. Liabilities are limited mainly to problems of the safety and the electromagnetic compatibility. Remaining norms, specifications, guides have a character of recommendations. It means de facto resignation from the implementation of all of these regulations which are not mandatory.

However if interoperability is desirable, this it is worth to start mechanisms promoting solutions and products which comply interoperability conditions and will cooperate with each other. For that is necessary to evaluate which solution or product is interoperable and which one do not comply interoperability requirements.

Solutions and products complying specified conditions, it means that they are conformed with specific standards and specifications, but also in fact are able (confirmed with suitable test) to the cooperation in practical applications, should receive the interoperability certificate. Such certificate should show the normative and verified range of the solution, the product or the application use.

This is not the final method for elimination of solutions or products not having interoperability features at all, or having it out range of test. Nevertheless this is efficient method and could be practically applied.

7. How to test the interoperability and how to use the test results?

Interoperability testing should be executed to prove practically that the threat exists due bad cooperation or to show that there is real lack of the cooperation. Interoperability test have to determine the places where problems with cooperation exist and it has an essential influence on results of the activity of systems. Elimination of the threat or the lack of local interoperability is not a guarantee of the existence of entire interoperability.

General rules of interoperability testing are specified in ETSI documents, developed by the *Technical Committee (TC) Methods for Testing and Specification (MTS)* [7] based on the ISO/IEC 9646 standard [10] (see Fig. 2).
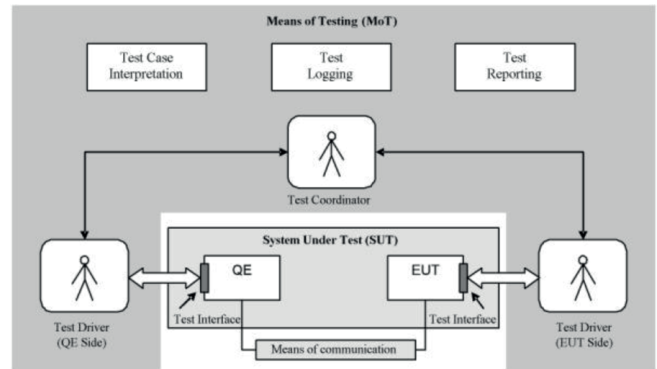

Fig. 2. Illustration of main concepts of interoperability testing (QE-Qualified Equipment, EUT - Equipment Under Test)

Interoperability testing is extension of conformance testing which determines how specific real implementation complains standards and specifications. It allows using already developed methods of conformance testing. Conformance testing and interoperability testing are practically complementary to each other.

The long duration, the complexity and the cost of interoperability test could be limited by test formalization and automatisation [9]. The formalization essence is use the standard test processes and connected tools such as conformance and interoperability statement forms. TTCN (Testing and the Test Control Notation) language also could be applied. Test prepared in this way can be executed (at least partly) and documented automatically.

Introduction to ITS conformance and interoperability testing is *ETSI EG 202 798 V1.1.1 (2011-01) ETSI Guide Intelligent Transport Systems (ITS); Testing; Framework for conformance and interoperability testing* [8]. The essence of this guide is:
- the introduction to the identification of tested implementations (IUT - Implementation Under Test) in the case of conformance test and the identification of tested devices (EUT - Equipment Under the Test) in the case of interoperability test, that is the indication „what has to be tested";
- the introduction to test procedures defining, that is to specification „how this has to be tested";
- the indication how to prepare test specifications of products, eg.: test purposes and structures of procedure sets (TSS&TP - Test Suite Structure & Test Purposes), forms of the specific implementation conformance statement (ICS - Implementation Conformance Statement) and/or the declaration of the function cooperation (IFS - Interoperable Functions Statement), descriptions of tests (TD - Test Description, recording of

abstract test methods (ATM - Abstract Test Method) and sets of test procedures (ATS - Abstract the Test Suite) in TTCN–3 language.

Fig. 3 presents relationships among components of testing processes. Please note that the base for the testing is set of ITS standards, mentioned in clause 4.
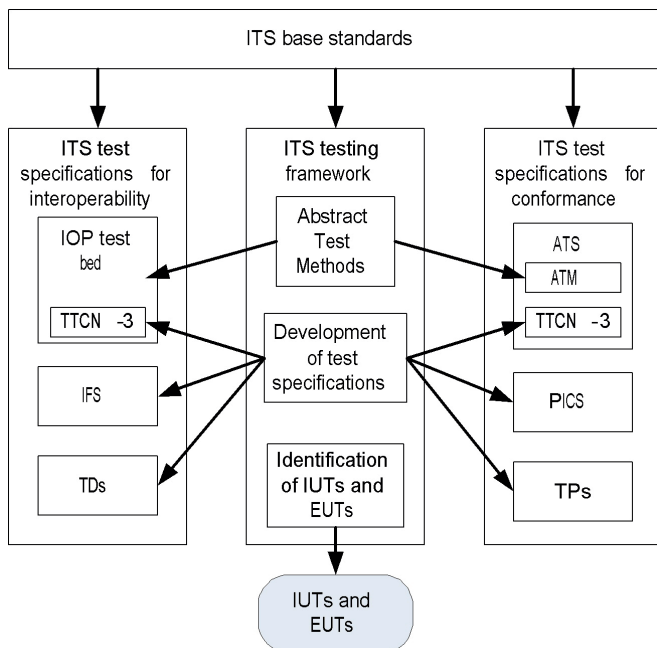

Fig. 3. ITS testing framework interactions

Preparation of some specific ITS standard implementation testing is supported by technical specifications (mainly developed by ETSI) related to base standards. Proper figure in present structure of these documents and their relationships.

General approach to testing assumes that standard or specially prepared forms (proformas) exist and they are filled with information on implementation conformance (ICS) or function cooperation (IFS). The fulfilment of these documents is an obligation of the designer and/or the producer and/or supplier of tested applications based on specific standards. Sometimes execution of these obligation is not easy. There are explanations that is disclosure of the internal propriety.

Standards or technical specifications should be annexed with test purposes specification (what specific features are to be tested and what is expected test result) and the structure of the test cases (test procedures) set and procedures themselves. Test cases and their sets can be developed on the standard and specification base within the framework of test preparations.

Interesting example of test events is ETSI initiative under the name of _Plugtests_™. ETSI organizes meetings witch a main objective is the possibility to test brought developed prototypes against standards and their cooperation with solutions of partners and competitors. This is also the opportunity to:
- standards and technical specifications improvement ,
- acceleration of the standardization process,
- reduction of the product time to market preparation ,
- support of new technical solutions deployment.

Plugtests™ meetings are accessible not only for ETSI members. They are supported by European Union entities. Examples are meetings, interesting for ITS world, which took place in the year 2013:
- eCall Interoperability event: Essen, Germany, 9-13 September 2013
- ITS Cooperative Mobility Services Event: Essen, Germany, 25-29 November 2013.

8. Proposal of ITS interoperability assurance plan for Poland

Remarks and statements formulated above lead to conclusions which can be treated as the outline of the plan of interoperability assurance of the ITS solutions and applications in Polish ITS environment.

1. For the beginning it should be agreed, that the ITS interoperability is a crucial factor and measures to assure it on all levels - from political through legal, organizational, semantic up to technical.
2. It should be determined the desired and required scope interoperability - what solutions and products in ITS systems and what ITS systems it will concern.
3. Considering the scope interoperability it should be selected adequate means for its assurance and it should be determined conditions of their deployment by regulation, organizational and procedural solutions, as well as by application the norms, standards and technical specifications.
4. The scheduled implementation of measures for interoperability assurance could begin, including means for the examination, the evaluation and the certification of specific ITS market solutions and especially the public transport systems.
5. Evaluation of interoperability, both functional and economic, should be one of routine activities and the conclusions should be treated as one of the causes for ITS solutions improvement.
6. ITS solutions interoperability should be tested and monitored by country organization supported by independent entities, including scientific and research ones, having at their disposal the specialized forces and the test equipment.

In the implementation process of the interoperability assurance minimal plan it is important to find the room for development and deployment of supporting tools valid for ITS. These tools should support interoperability implementation also by avoidance of island character of solutions and even greater systems. On the other side, these tools should facilitate producers, suppliers, operators and managers carrying up the interoperability assurance process.

Applications, mentioned here, should contain data concerning requirements, norms and standards of ITS solutions, procedures of their implementation, tools for the ITS solutions design complying interoperability. Applications of this type should be made available

to everyone in the ITS interested parties, including state services, so that they stimulate best practices and promote better solutions.

Authors of this paper think this a possible way of optimal taking care of ITS interoperability problems that exists in Poland.

Bibliography

[1] DIRECTIVE 2010/40/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport

[2] COMMISSION DECISION of 15 February 2011 concerning the adoption of the Working Programme on the implementation of Directive 2010/40/EU

[3] COM(2010) 744 final COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Towards interoperability for European public services *(anexed with EIS and EIF 2.0)*

[4] Rozporządzenie Rady Ministrów z dnia 12 kwietnia 2012 r. w sprawie Krajowych Ram Interoperability, minimalnych wymagań dla rejestrów publicznych i wymiany informacji w postaci elektronicznej oraz minimalnych wymagań dla systemów teleinformatycznych (Dz.U. 2012 nr 0 poz. 526) [in Polish].

[5] Intelligent Transport Systems, ETSI Portal

[6] WILES A., ZORIC M.: ACHIEVING INTEROPERABLE STANDARDS - THE ETSI APPROACH, ETSI, 2010

[7] ETSI EG 202 237: "Methods for Testing and Specification (MTS); Internet Protocol Testing (IPT); Generic approach to interoperability testing".

[8] ETSI EG 202 798 V1.1.1 (2011-01) ETSI Guide Intelligent Transport Systems (ITS); Testing; Framework for conformance and interoperability testing

[9] ETSI EG 202 810: "Methods for Testing and Specification (MTS); Automated Interoperability Testing; Methodology and Framework".

[10] ISO/IEC 9646 (all parts): "Information technology - Open Systems Interconnection - Conformance testing methodology and framework". (easier accessible is ITU-T Recommendation X.290 serie).

[11] Standardisation mandate addressed to CEN, CENELEC and ETSI in the field of information and communication technologies to support the interoperability of co-operative systems for intelligent transport in the European community, M/453, October 2009.

[12] Joint CEN and ETSI Response to Mandate M/453, CEN/ETSI Task Force on Standardisation Mandate M/453, 15 April 2010

[13] 2nd joint CEN/ETSI-Progress Report to the European Commission on Mandate M/453

[14] KOWALEWSKI M. et al: Interoperability of Intelligent Transport Systems, Archives of Transport Systems Telematics, Vol. 5, Issue 2, 2012