3. CALCULATION RESULTS AND GRAPHIC DEPENDENCIES

The numerical results in Table 1 have been found on the base of analytical dependency (7) for two typical values of y: y=1,8m – curve 1 and y=6,24m – curve 2 and the graphic dependencies of E=2!\(x^2\) have been built in Fig. 2.

The problems of increasing the stability of radio and electronic equipment used in railway transport against the effect of electric and magnetic fields are part of the general theory of providing electromagnetic compatibility. In certain important aspects, which determine the operation of radio equipment under the conditions of railway transport [3], the distribution of contact network electric field strength has a specific character. In that sense, the obtained graphic dependencies and analytical expressions of assessment give a possibility to determine the distribution of the electric field as an essential component of electromagnetic compatibility. This distribution determines the quality and reliability of radio electronic equipment.

REFERENCES


4. CONCLUSIONS

The analytical dependencies worked out for contact network electric field potential and strength as well as the numerical results obtained give a possibility to look for providing the admissible effect of these interference. This effect should be in compliance with the existing standards in this field [4].

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REFERENCES


**Fig. 2.**
to provide a platform for the other groups within the transport telematics part of ISO, rather than to act as a "World-wide Standard" [9].

Table 1. TICS fundamental services from ISO [10].

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Traffic Management: Public Transport

| 6. Transportation Planning | 23. Public Transport Management |
| 7. Traffic Control | 24. Demand-Responsive Transport Management |
| 8. Incident Management | 25. Shared Transport Management |
| 10. Parking/Enforcing Traffic Regulations |       |
| 11. Infrastructure Maintenance Management |       |

Vehicle

| 13. Automated Vehicle Operations |       |
| 14. Longitudinal Collision Avoidance |       |
| 15. Lateral Collision Avoidance |       |
| 16. Safety Readiness |       |
| 17. Pre-crash Restart Deployment |       |

ISO TICS Reference Architecture

| 5. Provide Advanced Driver Assistance |       |
| 6. Provide Traveler Journey Assistance |       |

There are several identifiable stages in the architecture development process; these include development of Reference Architecture; Logical Architecture; and Physical Architecture. The Reference Architecture is a concise, logical framework, which guides the development of more concrete system architectures. It will be used in the future by particular industry groups to develop specific, logical and physical architectures in a cohesive manner. The Reference Architecture elaborates the conceptual behaviour, and in so doing it provides more detail about the modularity. A physical architecture is reached when the actual distribution of the system modules is defined, thus leading to important implications for communications.

The Reference Architecture, created using the UML, can be broken down into three generalised key concepts that describe the extent of the system and how it is intended to work. These key concepts include "Applications", "Actors" and "Interactions", i.e. the way the applications and actors interact with each other to perform certain tasks (Fig. 2). Applications are referred to as use cases and actors represent any person or organisation that interacts with the ITS system. In rough terms Use cases will correspond to the eighth level functional Areas in both the European ITS Framework and US National ITS Architectures. The interactions required between applications (use cases) and actors to perform certain typical types of task are referred to as packages - the major packages are: Transport, Roadside, Vehicular Events, Operation Interfaces, Roadside Peripherals, Payment, Vehicle Interfaces and Travel terminals. Nine actors represent the outside world - they interact with the architecture and all of them have a hierarchy of other actors underneath them. With the hierarchies included, the total number of actors becomes 33. For illustration, Fig. 4 shows the hierarchy of the actor "User".

Regardless of what kind of methodology is to be used, the first step comprises definition of user requirements. For the ISO Architecture, the user requirements are defined as the TICS Fundamental Services [10]. They are divided into 32 Service Groups (Tab. 1).

Fig. 1. European ITS Framework Architecture Documents.

The ISO TICS Fundamental Services were used as one of the main starting points for the definition of the European ITS User Needs. However, all other subsequent activities looking towards the European ITS Framework Architecture were based on the process-oriented methodology and resulted in a set of document as shown in Fig. 1 [11]. Since the choice made by ISO has been to use OOD methodology and to describe its architecture using the UML, actual comparison with the current European ITS Framework Architecture is difficult (Tab. 2). Some of documents can hardly be created since certain kinds of diagrams (e.g. a context diagram) are not supported by the OOD methodology.

Table 2. Comparison of the functionality in the ISO and European Architectures according to [9].

ISO TICS Reference Architecture

| 1. Provide Electronic Payment Facilities | 2. Provide Safety and Emergency Facilities |
| 5. Provide Advanced Driver Assistance |       |
| 6. Provide Traveler Journey Assistance |       |

4. USAGE OF METHODOLOGY

One of the key ITS application areas determined for early implementation in Slovakia concerns the service "Electronic Payment". It covers fee collection systems concerning vehicle related transport services such as toll, parking and route guidance as well as fare collection and advanced payments for a wide range of services (Fig. 4).

Fig. 2. Top Level Use Case Diagram.

Fig. 3. Hierarchy of Actors of the Type "User".

All these diagrams help to answer the questions: "What applications are included in the system?"; "Who are the actors (users and application providers) included in the system?"; and "How do they interact to perform and provide certain services within the system?".

In addition to these key concepts, other UML diagrams are used, mostly Class diagrams (define the abstract elements that comprise the Reference Archetypes) and Sequence (Interaction) diagrams (describe how the implied objects of the system cooperate to provide the services defined in the use case).

Fig. 4. Electronic Payment Use Case Diagram.

Payment Means: This transaction captures the expression of a contract between the Traveller and the external Issuer via a Collection Agent that allows the Traveller to access the services available in the payment system, e.g. an account in a credit card system or an electronic purse. The Collection Agent transacts the credit to an electronic purse used by a Traveller. A Clearing Operator receives registration of a credit payment means for a Traveller from the Issuer to be used. Fare Collection: These transactions collect fares from urban public transport users for the use of current public transport services, and advanced payments for public transport services and for other (Yellow Pages) services. The point of collection may be pre-embarkation, or on-board. These transactions use the Payment Transaction use case. The Traveller must provide the payment instrument. Vehicle Charges: These transactions provide facilities for the electronic fee collection from vehicles as they pass through roadside collection points. They use the Payment Transaction use case. The Vehicle is sensed by a Roadway Peripheral and must carry a payment instrument. Payment Transaction: These transactions maintain a centralised store of data on the prices (tariff) being charged for tolls, spaces at parking lots and fares. They enable Vehicle Operators and Travellers to pay for tolls, fares and parking lot charges, plus other (Yellow Pages) services in advance and in the case of Travellers, as part of their journey planning facilities.

The logic of the Electronic Payment transactions is on principle described in the sequence diagram in Fig. 5.
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<td>29. Electronic Payment</td>
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<td>15. Lateral Collision</td>
<td>30. Electronic Financial Transactions</td>
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<tr>
<td>16. Safety Readiness</td>
<td>31. Safety Enhancement for Vulnerable Road Users</td>
</tr>
<tr>
<td>17. Pre-crash Restraint</td>
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Traffic Management Public Transport

7. Traffic Control 24. Demand-Responsive Transport Management
8. Incident Management 25. Shared Transport Management
11. Infrastructure Maintenance Management
12. Vehicle Enhancements
13. Automated Vehicle Enhancements
14. Longitudinal Collision Avoidance
15. Lateral Collision Avoidance
16. Safety Readiness
17. Pre-crash Restraint Deployment
18. Emergency Notification and Personal Security

Regardless of what kind of methodology is to be used, the first step comprises definition of user requirements. For the ISO Architecture, the user requirements are defined as the TICS Fundamental Services [10]. They are divided into 32 Service Groups (Tab. 1).

ISO TICS Reference Architecture European ITS Functional Architecture
1. Traveler Information 1. Provide Electronic Payment Facilities
2. Traffic Management 2. Provide Safety and Emergency Facilities
5. Public Transport 5. Provide Advanced Driver Assistance
7. Electronic Payment 7. Provide Support for Lane Enforcement
8. Safety 8. Manage Fleet Operations

There are several identifiable stages in the architecture development process; these include development of Reference Architecture, Logical Architecture, and Physical Architecture. The Reference Architecture is a concept or meta-model, which guides the development of more concrete system architectures. It will be used in the future by particular industry groups to develop specific, logical and physical architectures in a cohesive manner. The architecture elaborates the conceptual behaviour, and in so doing it provides more detail about the modularity. A physical architecture is reached when the actual distribution of the system modules is defined, thus leading to important implications for communications.

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Payment Means covers any transaction that takes payment or establishes credit with a TICS service provider. Cash transactions may prime an electronic purse or debit from the purse. These transactions occur at will and any time a Traveller actor makes an up front payment. Each resource use (or fare) met by credit payment involves transactions of two use cases. Vehicle Charges (or Fare Collection) set up the accounting at the start. Payment Transaction is invoked at the end of service. There is dependency on the Event Class for processing payment violations. The Roadway Class is dependent on the Payment Class for all transactions, which involve payment for use of resources. Operations of the Vehicle Interfaces class provide the payment means for vehicles. Operations of the Travel Terminals class support other Traveler Payment. Operations of the Operating Interfaces class provide interface to the Financial actors.

5. CONCLUSIONS
Use of the UML ensures that one comprehensive model and general methodology can be used for the development of architecture and standards through to the actual implementation of ITS software and systems in the transport network. Thus:
- Every complex system is best approached through a small set of nearly independent views of a model - no single view is sufficient;
- Every model can be expressed at different levels of fidelity; and
- The best models are connected to reality.

Therefore it is proposed to adopt a methodology based on UML for documenting the Slovak Reference Architecture being created. A commercially available CASE tool is to be used to implement this approach. The work has partially been supported by the Grant Agency of the Slovak Republic VEGA, grant No. 1/044/04 “Theoretical Foundations for Implementing e-Safety Principles into Intelligent Transportation Systems”.

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[9] European ITS Framework Architecture Overview (D 3.6) Issue 1, August 2000

I. GENERAL DESCRIPTION OF ERTMS SYSTEM
European Railway Traffic Management System (ERTMS) consists of the subsystems: European Train Control System (ETCS), Radio transmission system GSM-R (and European Train Management Layer ETML).

1.1. ETCS (European train control system)
The basis for development of an ETCS system is a complex of specifications resulting mainly from social conditions. These specifications ensure interoperability of ETCS equipment manufactured by various suppliers. They define functions, procedures, performance ratios as well as ETCS system architecture and relations between various subsystems that are important for assurance of interoperability. Individual suppliers are free to select optimum technical equipment. The ETCS system is characterized by modular structure, which enables engineering, modernization and construction of various modules at any time using the available techniques.

Such definition of the structure makes possible the expansion of ETCS concept. In the future, the management of strict control of revisions to the ETCS specifications shall ensure firstly maintenance of primary interoperation objective and secondly: the possibility of directional development of ETCS system.

1.1.1. Architecture of etcs
The specification of ETCS system requirements is described by a so-called core of European ETCS with its interfaces to: radio system GSM-R, line traffic protection systems, onboard train equipment.

Overall functional structure with links between system core and interfaces is shown on Fig. 1.

Onboard equipment – Eurocab ETCS contains transmission equipment and antenna for data exchange with the trackside: Eurobalise, Eurolog, digital GSM-R device and equipment linking with Eurovector.

The trackside ETCS equipment contains data transmission equipment using balises, loops or GSM-R, as well as additionally various types of interfaces linking with the fixed installations of railway traffic equipment.

Fig. 1. Functional structure of ETCS.

1.1.2. Available application levels
The ETCS project shows advantages of 3 application levels for ETCS that may be determined using the following features:
- a way to raise the standard, especially in relation to the onboard equipment (it is possible to start the system up using level 1, and subsequently introduce level 2 or even level 3 within the same system specification),
- backwards compatibility (such as train level 2 may also travel on the line level 1, etc.),
- consistent system behavior,
- minimum expenditures.

1.2. GSM-R
GSM-R is a railway version of GSM (R – Railway) operating in the band of 900 MHz. GSM-R functionality corresponds to GSM 2+ making available to the users, besides talk channel, also the following features:
- a digital radio channel for data transmission,
- group calls, determination of call priorities, functional data exchange (using for example train numbers), and
- other specialized functions designed for such services as railways or police. GSM-R constitutes then a transmission carrier whereby drive clearances are sent.