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Intelligent transport systems — System architecture, taxonomy, terminology and data modelling — Training requirements for ITS architecture

Systèmes intelligents de transport — Architecture, taxinomie, terminologie et modélisation de données, relatives aux systèmes — Exigences de formation pour une architecture ITS

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 25104 was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

Introduction

The objective of this Technical Report is to propose generic training requirements for the skills required to understand and develop architectural models for Intelligent Transport Systems (ITS).

This Technical Report has been prepared to assist organizations in developing the knowledge and skills of their own staff and those of allied organizations such a suppliers and customers, and to assist academic institutions to develop curriculum and syllabus.

The approach taken is the proposal of a taxonomy of the knowledge elements of ITS architectural theory and practice. This approach has been widely used in other fields where it is often entitled as the “Body of Knowledge” (BOK), for example the software engineering BOK or SWEBOK.

Intelligent transport systems — System architecture, taxonomy, terminology and data modelling — Training requirements for ITS architecture

1 Scope

This Technical Report discusses the development for generic education and training requirements for the teaching of ITS architecture, and the acquisition of skills to interpret and develop ITS architectures.

This Technical Report provides suggestions to those planning education and/or training courses associated with ITS system architecture as to the subjects that should be studied.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14813-1, *Intelligent transport systems — Reference model architecture(s) for the ITS sector — Part 1: ITS service domains, service groups and services*

ISO/TR 14813-2, *Transport information and control systems — Reference model architecture(s) for the TICS sector — Part 2: Core TICS reference architecture*

ISO/IEC 19501, *Information technology — Open Distributed Processing — Unified Modeling Language (UML) Version 1.4.2*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
architecture
set of concepts and rules describing the interrelationship between entities in the entire system, independent of the hardware and software environment, reference [1] and described through a series of views that may be at varying levels of generality/specificity, abstraction/concretion, totality/component and so on

3.2
system architecture (Intelligent transport)
framework for ITS deployments

NOTE It is a single, high-level description of the major elements or objects and the interconnections amongst them. It provides the framework around which the interfaces, specifications and detailed system designs can be defined. An architecture is not a product design, nor a detailed specification for physical deployment, reference [1].

3.3
business case
structured proposal for business improvement that functions as a decision package for decision-makers

The business case should explain why a project is required for the business and what the product or service is going to be. It should include an outline of the “Return on Investment” (ROI), or a cost/benefit analysis for the project, the project's product and performance characteristics, major project risks and the opportunities.

The business case addresses, at a high level, the business needs that the project seeks to meet. It includes the reasons for the project, the expected business benefits, the options considered (with reasons for rejecting or carrying forward each option), the expected costs of the project, a GAP analysis and the expected risks.

4 Symbols and abbreviated terms

AASHTO	American Association of State Highway and Transportation Officials
ANSI	American National Standards Institute
APTA	American Public Transportation Association
APEC	Asia Pacific Economic Cooperation
ARIB	Association of Radio Industries and Businesses (Japan)
ARINC	Air Radio Incorporated
ASTM	American Society for Testing and Materials
BCA	Benefit cost analysis
CEN	Comité européen de normalisation
CEPT	Conférence européenne des administrations des postes et des télécommunications
ETSI	European Telecommunications Standards Institute
EU	European Union
FCC	Federal Communications Commission (USA)
GAP	good/average/poor
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
ITE	Institute of Transportation Engineers
ITS	Intelligent Transport Systems
ITU	International Telecommunications Union
ITU-T	International Telecommunications Union — Telecommunications
ITU-R	International telecommunications Union — Radio
NEMA	National Electrical Manufacturers Association
OASIS	Organization for the Advancement of Structured Information Standards

OMG	Object Management Group
ROI	Return on Investment
SAE	Society of Automotive Engineers
TE&A	Test, Evaluation & Acceptance
TIA	Telecommunications Industries Association
TICS	Transport Information & Control Systems (old name for Intelligent Transport Systems)
UN/CEFACT	United Nations Centre for Trade Facilitation and Electronic Business
USDoT	United States Department of Transport
W3C	World Wide Web Consortium
WG1	Working group 1 (of TC 204)

5 Subjects for education and training

5.1 Background information

This Technical Report arose from work by WG1 on the elaboration of ITS Architecture standards and their application. It appeared that the successful uptake of relevant standards and practices would be dependent partly on the effectiveness of the education, training and organizational development related to ITS architecture.

The education and training requirements identified are those which have occurred within the development activities of the ISO TC204 WG1. A list of references is provided in the Bibliography. See References [6] to [17].

5.2 What are “Intelligent Transport Systems”?

Intelligent Transport Systems have been described in a variety of ways including this from the ITS Handbook:

“ITS embraces a broad range of information technologies (IT), satellite and communications-based information, control and digital technologies. Collectively, these offer new possibilities for solving what seem to be intractable problems of congestion, traffic accidents, inefficient logistics, and the environmental impact of surface transportation” (see Reference [1]).

5.3 “User Needs” and “Fundamental Services” requiring ITS

ISO 14813-1 characterizes the ITS sector as comprising 12 “ITS service domains”. These are:

— Traveller information — Provision of both static and dynamic information about the transport network to users, including modal options and transfers.

— Traffic management and operations — Management of the movement of vehicles, travellers and pedestrians throughout the road transport network.

— Vehicle Services — Enhancement of safety, security and efficiency in vehicle operations, by warnings and assistance to users or control vehicle operations.

— Freight transport — Management of commercial vehicle operations; freight and fleet management; activities that expedite the authorization process for cargo at national and jurisdictional boundaries and expedite cross-modal transfers for authorized cargo.

— Public transport — Operation of public transport services and the provision of operational information to the operator and user, including multimodal aspects.

— Emergency — Services delivered in response to incidents that are categorized as emergencies.

— Transport-related electronic payment — Transactions and reservations for transport-related services.

— Road transport related personal safety — Protection of transport users including pedestrians and vulnerable users.

— Weather and environmental conditions monitoring — Activities that monitor and notify weather and environmental conditions.

— Disaster response management and coordination — Road transport-based activities in response to natural disasters, civil disturbances or terror attacks.

— National security — Activities that directly protect or mitigate physical or operational harm to persons and facilities due to natural disasters, civil disturbances or terror attacks.

— ITS data management — Collation, management and supply of ITS data to legitimate interested parties.

Within these domains, ISO/TR 14813-1 identifies some 123 specific service types, or “fundamental services”. (This list of services is dynamic and will change over time).

Each of the ITS services has associated with it, one or more use cases and actors as shown in ISO/TR 14813-2.

5.4 Systems architectures for ITS

In common with all other forms of complex ICT, there is a need for an overall view of the extent and purposes of the systems and networks employed in ITS. This is accomplished by means of so-called systems architecture, comprising the top-level functional and physical system frameworks. These systems architectures can be most easily developed from a generic form, commonly called a reference or framework architecture.

A system architecture comprises one or more technology-independent viewpoints that each concentrate on a specific aspect of the future deployment, e.g. logical (functional) viewpoints, physical viewpoints, communications viewpoints, organizational viewpoints.

NOTE Early system architectures used to give the title “architecture” to these viewpoints, which caused a certain amount of confusion.

From the geographical point of view, architectures may be defined at regional, national and international levels.

The benefit of using an architectural approach is long-term, with potential problems and issues being able to be identified early in the ITS deployment lifecycle, and hence being much cheaper to resolve than they would be if not identified until later, *c.f.* the 10:100:1 000 rule for the cost of fixing software faults throughout the software lifecycle. Being technology-independent, an ITS architecture can have a long life-time, though it will need to be maintained at regular intervals to ensure that it still covers the services that are required.

5.5 Standardization for ITS

Standardization is a natural consequence of using ITS architectures, with the (need for) standards being identified easily from the various viewpoints, in particular the “communications” viewpoints.

5.6 Interoperability is important and achievable

Interoperability has been defined by the ITS standards technical committee (TC204) as follows:

> *The ability of systems to provide services to and accept services from other systems and to use the services so exchanged to enable them to operate effectively together.*

Interoperability is increasingly being recognised as more than attending only to interfaces, embracing:

— user interfaces, documentation and training of users, i.e., operators and maintainers;

— protocol and message compatibility;

— compatible information models such that related meanings of data structures are consistent;

— semantic interoperability that ensures that the interpretation of the information that has been defined for compatibility and interoperability is also consistent and predictable to all involved parties.

5.7 Systems engineering for ITS

The key to the effective definition of requirements, analysis, design and specification of ITS is a systems engineering process that goes further than the traditional building or project services subcontract. Systems engineering is critical to success and cost-effectiveness of complex systems projects and ITS is no exception to that principle. This is increasingly recognised in such publications as the recently published guidebook from the USDoT[3].

Advice can also be obtained from the “International Council of Systems Engineering” (http://www.incose.org/).

6 Example curricula for training related to ITS architecture and ITS standards

6.1 Prerequisite training

1.01 Introduction to architecture modelling

1.02 Unified modelling language (ISO/IEC 19501)

— 1.02.1 UML modelling tools

1.03 Process oriented modelling

— 1.03.1 Process oriented modelling tools

1.03 ISO TC204 tools for modelling

6.2 Introduction to ITS

2.01 Introduction to ITS

2.02 ITS terminology

2.03 ITS services

2.04 ITS business models

2.05 ITS requirements and use cases

2.06 Transport efficiency and ITS

2.07 Sustainability and ITS

2.08 ITS lifecycle

2.09 ITS and multimodality

2.10 ITS systems engineering

2.11 ITS and interoperability

2.12 System criticality, scalability

2.13 Certification

6.3 ITS technology

3.01 Information and communications technology (ICT) for ITS

3.02 Actor systems for ITS

3.03 ITS system interfaces

- 3.03.1 in-vehicle
- 3.03.2 infrastructure–vehicle
- 3.03.3 vehicle–vehicle
- 3.03.4 infrastructure–infrastructure

3.04 Sensor systems for ITS

3.05 User interfaces

3.06 Spatial systems and navigation

3.07 Standardization – relevant standards currently in development

3.08 ITS simulation tools

3.09 ITS technology in evolution

6.4 ITS theory

4.01 Use of abstraction

4.02 ITS systems architecture – description and business case

4.03 ITS information modelling (general)

4.04 ITS “fundamental” services (service domains, service groups and services)

4.05 Information modelling in ITS using object oriented techniques

4.06 Information modelling in ITS using process oriented techniques

4.07 Data fusion for ITS

4.08 Identification of people, vehicles and goods

4.09 The different types and uses of ITS Architectures

4.10 ITS systems analysis and design

6.5 Architecture aspects of ITS service provision

5.01 Traveller information systems

5.02 Traffic management and operations

5.03 Vehicle services

5.04 Freight services

5.05 Public transport

5.06 Emergency

5.07 Transport related electronic payment

5.08 Road transport related personal safety

5.09 Weather and environmental conditions monitoring

5.10 Disaster response management and coordination

5.11 National security

6.6 Technology aspects of ITS service provision (as they relate to system architecture)

6.01 Telecommunications for ITS – wireless networks, wired networks, optical systems

6.02 Information metadata standards

6.03 Location based services

6.04 Common Object Request Broker Architecture (CORBA)

6.05 Extensible Mark-up language (XML) in ITS standards, systems and services

6.06 Web services in ITS standards, systems and services

6.07 Internet Protocol (IP) for ITS

6.08 Abstract Syntax Notation No. 1 [ASN.1] in ITS standards, systems and services

6.09 Generic data registry standards

6.10 Generic IT user interfaces

6.11 Identification technology standards

- 6.11.01 Personal identification
- 6.11.02 Biometric identification
- 6.11.03 Vehicle identification

6.7 National and regional architecture development

7.01 The different roles and uses of national/regional architectures

7.02 Japan – National ITS architecture

7.03 USA – National ITS architecture

7.04 European Union (EU) – ITS architecture framework

7.05 Other national ITS architecture

6.8 Strategies to use standards in ITS

8.01 ITS requirements, analysis, design and delivery

8.02 Systems engineering for ITS

8.03 Business case and benefit-cost analysis (BCA) for ITS

8.04 Use case requirements specification for ITS

8.05 User test, evaluation and acceptance (TE&A) of ITS

8.06 ITS software development and integration

8.07 ITS data collection and analysis

8.08 Simulation and modelling for ITS

8.09 Device certification

8.10 Security and privacy (protection of ITS assets and personal data)

8.11 Verification and validation of functionality of ITS capabilities deployed against requirements

8.12 The role of industry consortia

6.9 The process of standards development for ITS

9.01 International Organisation for Standardization (ISO)

9.02 International Telecommunications Union (ITU)

- 9.02.1 International Telecommunications Union – Telecommunications (ITU-T)
- 9.02.2 International Telecommunications Union – Radio-communications (ITU-R)

9.03 International Electrotechnical Commission (IEC)

9.04 Internet Engineering Task Force (IETF)

9.05 World Wide Web Consortium (W3C)

9.06 United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT)

9.07 European Telecommunications Standards Institute (ETSI)

9.08 Comité européen de normalisation (CEN)

6.10 National standards development organizations (SDO) for ITS

10.01 US National Standards

- 10.01.1 American National Standards Institute (ANSI)
- 10.01.2 Society of Automotive Engineers (SAE]
- 10.01.3 Air Radio Incorporated (ARINC)
- 10.01.4 American Society for Testing and Materials (ASTM)
- 10.01.5 American Public Transportation Association (APTA)
- 10.01.6 Institute of Electrical and Electronics Engineers (IEEE)
- 10.01.7 National Electrical Manufacturers Association (NEMA)
- 10.01.8 American Association of State Highway and Transportation Officials (AASHTO)
- 10.01.9 Institute of Transportation Engineers (ITE)
- 10.01.10 Telecommunications Industries Association (TIA)

10.02 Japan National Standards

- 10.02.1 Association of Radio Industries and Businesses (ARIB)

10.03 National standards organization in country hosting training

6.11 Other organizations relevant to ITS standards

11.01 Conférence européenne des administrations des postes et des télécommunications (CEPT)

11.02 Federal Communications Commission (FCC)

11.03 Asia Pacific Economic Cooperation (APEC)

11.04 Object Management Group (OMG)

11.05 Organization for the Advancement of Structured Information Standards (OASIS)

11.06 ODG – OCIT Developer Group

6.12 Other architecture related issues

12.01 Evaluation of ITS proposals and risk assessment

12.02 ITS institutional issues

12.03 ITS systems integration – Complexity

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[2] PPK, *National Reference Architecture for Intelligent Transport Systems,* ITS Australia, 1999

[3] Department of Transportation, Office of Operations HOTM, Room 3404, 400, Seventh Street S.W., Washington, DC 20590;

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[4] WILLIAMS and SKINNER, *Intelligent Transport Systems — Standards*, Artech House, 2007

[5] IEEE 1471-2000, *Recommended Practice for Architectural Description of Software-Intensive Systems,* IEEE, 2000

[6] ISO/TR 14813-3, *Transport information and control systems — Reference model architecture(s) for the TICS sector — Part 3: Example elaboration*

[7] ISO/TR 14813-4, *Transport information and control systems — Reference model architecture(s) for the TICS sector — Part 4: Reference model tutorial*

[8] ISO/TR 14813-5, *Transport information and control systems — Reference model architecture(s) for the TICS sector — Part 5: Requirements for architecture description in TICS standards*

[9] ISO 14813-6, *Transport information and control systems — Reference model architecture(s) for the TICS sector — Part 6: Data presentation in ASN.1*

[10] ISO 14817, *Transport information and control systems — Requirements for an ITS/TICS central Data Registry and ITS/TICS Data Dictionaries*

[11] ISO/TR 17452, *Intelligent transport systems — Using UML for defining and documenting ITS/TICS interfaces*

[12] ISO/TR 24098, *Intelligent transport systems — System architecture, taxonomy and terminology — Procedures for developing ITS deployment plans utilizing ITS system architecture*

[13] ISO/TR 24529, *Intelligent transport systems — Systems architecture — Use of unified modelling language (UML) in ITS International Standards and deliverables*

[14] ISO 24531, *Intelligent transport systems — System architecture, taxonomy and terminology — Using XML in ITS standards, data registries and data dictionaries*

[15] ISO/TR 24532, *Intelligent transport systems — Systems architecture, taxonomy and terminology — Using CORBA (Common Object Request Broker Architecture) in ITS standards, data registries and data dictionaries*

[16] ISO/TR 25100, *Intelligent transport systems — Systems architecture — Harmonization of ITS data concepts*

[17] ISO/TR 28682, *A joint APEC-ISO study of progress to develop and deploy ITS Standards*

Other contacts

— United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) http://www.unece.org/cefact/about.htm

— American Public Transportation Association (APTA) http://www.apta.com

— Institute of Electrical and Electronics Engineers (IEEE) http://www.ieee.org

— National Electrical Manufacturers Association (NEMA) http://www.nema.org

— The U.S. DOT: ITS Professional Capacity Building (PCB) Program (provides comprehensive, accessible, and flexible ITS learning for the transportation industry. By using its resources, public agencies can build and sustain a capable and technically proficient ITS workforce and transportation professionals can develop their knowledge, skills and abilities while furthering their career paths) http://www.pcb.its.dot.gov/default.asp

— CITE: The purpose of the Consortium for ITS Training and Education (CITE) is to create an integrated advanced transportation training and education programme. The programme, based on a consortium of universities, is open to anyone pursuing a career in advanced transportation. Instruction offered through CITE may include graduate and undergraduate level courses, as well as skill-based training and technology transfer. In addition to its educational responsibilities, CITE will facilitate networking and communication among universities and other CITE members. http://www.citeconsortium.org

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