ProSE

Promoting Standardization for Embedded Systems

Survey and Classification of Existing Standardization Bodies

Task 1.1

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1 Introduction

1.1 Overview, Purpose and Scope

The objectives of WP1 are the following:

1. Classification of existing standardization bodies and areas of interest for embedded smart systems, providing a classification of them regarding their activity and acceptance level, functional scope and relatedness to concrete aspects of embedded systems, impact of areas (economic, society) they are handling for wide spread smart embedded systems application, work regulations and procedures, and interest in the ProSE initiative
2. A charter and work model for ProSE that concretizes the supporting activities and the corresponding procedures for the systematic promotion of standardization in diverse areas of embedded technologies
3. A set of concrete evaluation criteria for filtering the applicants (areas of interest) and choosing the standardization candidates.

Task 1.1 provides a survey on “landscape” of existing standardisation bodies and communities.
This includes a “landscape” of involvement of ARTEMISIA members in (embedded systems) standardization and an evaluation of contact points and interests.

The objective of Deliverable D 1.1 is to document the results of Task 1.1.

1.2 Partners

ARC task leader
Contributions from ARC, Thales, FhG, ESI, AVL, CEA, Acciona, Infineon.

2 Overview standardization areas and organisations

2.1 Motivation for and purpose of Standardization in Artemis

The Artemis Strategic research Agenda (SRA) identifies the following key emerging challenges in the field of embedded systems:

- *to overcome the fragmentation of the supply industry and research, cutting barriers between application sectors so as to 'de-verticalize' the industry, sharing across sectors tools and technology that are today quite separate;*
- *to make the change from design by decomposition to design by composition.*

To achieve the transition from a vertical domain-specific approach towards a layered approach requires deployment of widely accepted standards (either official or de facto) to provide the necessary openness, interoperation and intercommunication within and between embedded systems and within and between embedded systems design flows.

However, the fragmentation of embedded systems markets, technologies, and research communities has had the consequence that, until now, the standardisation activities for embedded systems have also been very fragmented over different committees, different contributing communities, and even different standardisation bodies. This fragmentation has the consequence that existing and emerging standard proposals and standardisation bodies that serve embedded systems communities are also very fragmented. A major role for Artemis is therefore to harmonise standardisation activities across the various domains of Artemis, in parallel with development of cross-sectoral technological solutions.

Purposes for standards

Artemis standardisation activities must recognise the wide range of different purposes for standards, including:

- aggregation of demand to support innovation;
- facilitation of interoperability and composability, including the seamless connectivity of Ambient Intelligence[1];
- enhancement of competition by differentiating products and services with measurement standards;
- both reassurance to the public, and enhancement of competition (by enabling new market entrants) through standards for safety, quality, environmental impact, etc.;
- enhancement of industrial efficiency by the application of management standards that embody best practice;
- rapid establishment of markets, accelerating take-up of technology;
- opening and enlarging of markets.

These differences in *purposes* for standards lead to widely varying *types* of standards.

[1] http://en.wikipedia.org/wiki/Ambient_intelligence

Responsiveness of the standardisation process

Artemis standardisation activities must take into consideration the persistent concerns of industry that the emergence and evolution of desired standards has not, in recent years, kept pace with increasingly rapid technology development. These concerns have been recognised by the European Commission which has accepted that there is a need to modernise the standardisation process for ICT[2]. Yet a recent study commissioned by DG-Enterprise reported that the present approach to standardisation is still ill-suited to the needs of ICT with its 'fast changing landscape'[3].

Participation in the standardisation process

The study referenced above also recognised the difficulty of engaging an appropriately broad cross-section of the interested community. Specifically, it recommended a *"high level strategy dialogue between Member States, technology providers, technology users, SDOs and specification providers"* and that this should be complemented by *"a platform permitting an operational dialogue between SDOs and specification providers, technology users and providers, and public interest organisations".* Artemis is such a platform, and we intend to do bring about that dialogue (for embedded systems, at least).

Another independent European Evaluation refers to the minor impact of European funded projects and the European Technology Platforms to standardization and the need to increase efforts in this area:

"Those platforms which are more advanced … should focus on the regulations and standards that affect the commercialisation of research … to encourage the use of research results to turn them into products and services."

(ref.: ftp://ftp.cordis.europa.eu/pub/technology-platforms/docs/evaluation-etps.pdf).

The Artemis Working group on Standardization and the ProSE Support Action meet this request.

[2] Council resolutions of 28 October 1999 and 1 March 2002; Commission Communication COM(2004) 674; and the subsequent 'action plan'

[3] The specific policy needs for ICT standardisation" (ENTR/05/59)

2.2 Standardization organizations and classification of standards

2.2.1 Classification of Standards and Organizations:

There are three major groups of standardization organizations (examples do not claim to be complete):

- **Independent Standardization Organizations** on international or national basis with official status:
  - **International,** based on co-operation of national expert groups or mirror committees: ISO, IEC
  - **European**, based on working groups and fora: CEN, CENELEC
  - **Large national ones**: USA (IEEE, ISA, ANSI), China and India arising

- **Industrial standardization groups/consortia/companies**:
  - **International:** OMG (UML, MDA, CORBA, DDS, SysML…), Open Group (e.g. RT- and ES Forum, Posix, RT-Linux, safety-critical RT-JAVA), OSGi, RTCA, ARINC, … (US-dominated)
  - **(Mainly) European:** ETSI (has achieved ESO (European Standards Organization) status bxy the EC), FlexRay, …, pre-standardization WG (e.g. EWICS TC7)

- **De facto standards (e.g. MicroSoft Windows, IBM, SAP, …)** based on widely used proprietary products, or developed by industrial or others (associations, non-profit organizations):
  - MicroSoft Windows Embedded Standard 2009, Windows Embedded Devices Standard (not recommended for safety-critical applications)
  - Proprietory: e.g. ABB Fieldbus Plug Serial Interface
  - The Open Software or Open Source movement has set de facto industry standards: Linux examples with widespread adoption of Tools and IDEs (Integrated Development environment): GCC (Gnu Compiler Collection), Eclipse as basis for many IDEs.
  - Multi-domain modelling: e.g. Modelica, Simulink
  - Middleware: AUTOSAR (automotive only, but to become automotive de-facto standard)
  - SoC standards (at the moment de-facto-standards or proprietory standards):
    - AXI,AHB, OCP, etc. to standardise the hardware interface
    - all parts of the software stack will have (de facto) standards, e.g. for operating system, streaming frameworks, media standards, etc.
  - Web technologies: W3C (in Europe hosted by ERCIM)
  - Operating systems: Tiny OS, OSEK, Nota, …

Relevant de-facto standards which would need promotion are referenced in detail in D1.2.

Another classification is depending on the preferred use either generic or in a specific application domain or context (this classification is used in **chapter 3**):

- **Generic (cross-domain) standards**
    - Non-functional properties (dependability, performance, usability, Q…)
    - Processes (life cycle dep./indep., supply chain dep., certification)
    - Generic methods, tools, middleware, interfaces
- **(Application) Domain specific standards (areas).** Examples are:
    - Automotive
    - Aerospace, Air Traffic management
    - Railways
    - Medical equipment (devices), healthcare
    - Process control, Manufacturing, Enterprise Management (diff. levels)
    - Telecommunications
    - Ambient Intelligence, AAL (private Space, Home)
    - Infrastructure, Logistics

This can be mapped into a **"Matrix"** structure:

- Dimension 1: International/industrial/de facto
- Dimension 2: generic/application domain specific

This mapping is performed in chapter 3 along the generic/domain standards line as primary and the international/industrial/de-fact axis as secondary priority.

2.2.2 Stakeholders with respect to standardization

Stakeholders include:

- Industry (Manufacturers, Suppliers and "Users")
- standardization bodies,
- EU (and national) officials
- Other ETPs and related platforms/organizations
- public authorities,
- professional, trade or industrial associations
- regulators,
- certification/licensing agencies and assessors,
- various interest or user groups (e.g. consumer associations)

The appropriate mix of stakeholders will be invited to contribute their needs and views.

2.2.3 Co-operation of research projects with respect to standardization

As already mentioned above, several studies resulted in requesting more co-operation between research projects and standardization, i.e. results of research projects should target more to influence or become standards in the end. Unfortunately, the limited duration of funded research projects (3 – 4 years in general) is prohibitive, since standardization cycles are much longer (5 years and more, and standardized can only be results which normally are delivered at the end of the project after which there are no resources left for a standardization cycle. There have been already support actions draw standardization action plans for groups of related projects, and some projects have targeted at some standardization impact afterwards by support actions or industrial or research groups involved in standardization. Examples are:

- COPRAS: Draft document on Standards Action Plan for Embedded Systems Cluster (RTCA SC 205, ARINC, IEC 61508 MT, AUTOSAR, FlexRay analysed, action steps for revisions proposed), for other areas as well.
- COPRAS/HIJA (RT-Java for safety critical systems)
- DECOS results (by partner Audi into AUTOSAR safety, ARC in IEC 61508 MT)
- SECOQC (ETSI: Quantum Key Distribution Standard ISG)(ARC)

A potential candidate from Artemis projects of the first round could be:

- CESAR: RTP (cross-sectoral Reference Technology Platform)(co-ordinator AVL);
- ADAMS (promotion of UML MARTE)

2.3 Standardization and the ARTEMIS research and application context

The ARTEMIS Strategic Research Agenda (SRA) is proposing a set of research topics to enable a changeover from design by decomposition to design by composition to overcome today's fragmentation of the embedded industry and separation of markets. The research domains addressed by ARTEMIS are:

- Reference Design and Architectures
- Seamless Connectivity and Middleware
- System design Methods and Tools

For each of the research domains, a specific SRA was created:

- **The Reference Design and Architecture SRA** establishes common requirements and constraints that should be taken into account for future embedded systems, and will establish generic reference designs and architectures for embedded systems that can be tailored optimally to their specific application context.

- **The Seamless Connectivity & Middleware SRA** addresses the needs for communication at the physical level - networks; at the logical level - data; and at the semantic level - information and knowledge. Middleware must enable the safe, secure and reliable organization - even self-organization - of embedded systems under a wide range of constraints.

- **The Systems Design Methods and Tools SRA** sets out the priorities for research into the ways that these systems will be designed in future so as to accommodate - and optimise the balance in achievement of - a number of conflicting goals: system adequacy to requirements, customer satisfaction, design productivity, absolute cost, and time to market.

For the Application Contexts, ARTEMIS defines:

- **Industrial systems** - large, complex and safety critical systems, that embraces Automotive, Aerospace, Manufacturing, and specific growth areas such as biomedical
- **Nomadic Environments** – enabling devices such as PDAs and on-body systems to communicate in changing and mobile environments, that offer users access to information and services while on the move
- **Private Spaces** - such as homes, cars and offices, that offers systems and solutions for improved enjoyment, comfort, well-being and safety.
- **Public Infrastructure** – major infrastructure such as airports, cities and highways that embrace large scale deployment of systems and services that benefit the citizen at large (communications networks, improved mobility, energy distribution, intelligent buildings ...).

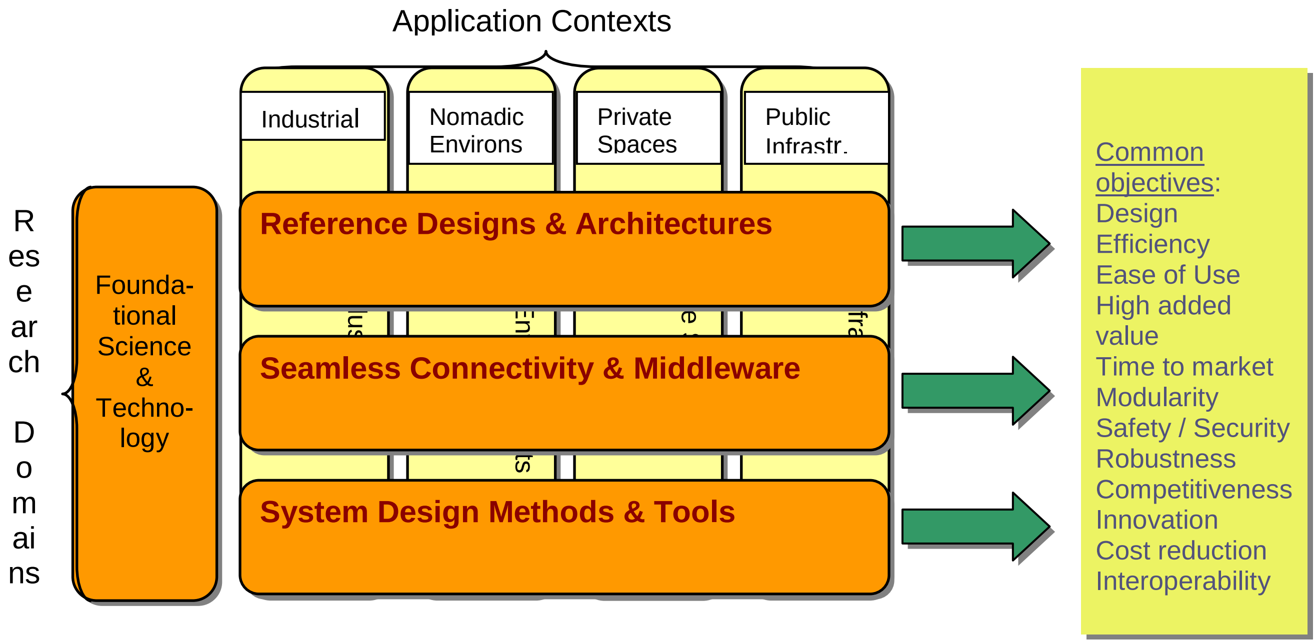

Fig. 2-1 ARTEMIS Scheme Application Contexts vs. Research Domains (ARTEMIS SRA)

2.4 GAP Analysis: Overview Applications/Technology/Standards

The following table is a reference table of ARTEMIS application contexts, technology domains and standards (committees, candidates), including typical examples for each application context and technology domain***. It represents in a compressed form the contents of the detailed elaboration of standardization areas, standards and standards organizations as outlined in chapter 3.***

The most important group of emerging embedded systems areas, Ambient Environments and AAL (Ambient Assisted Living), are elaborated in chapter 4.

Note: The Standards / Standardization Candidates / Committees is differencing between major standards (already established on the market; solid industrial standard), upcoming standards (proposed or early committed; state of the art, but not state of the practice) and potential or emerging standards (row 1 to 3).

Therefore, candidates are classified in three tiers:

1- Solid industrial standards that could be promoted in different sectors (potential cross-sectorial standards).

2- Upcoming standards (state of the art, but not state of the practice).

3- Potential or emerging standards.

Example from the analysis table 2-1:

Nomadic Environments	Mobile Telephony	(1 existing) GSM, UMTS
		(2 upcoming) WAP
		(3 potential/emerging) LTE – Long Term Evolution

Application Context	**Technology Domain**	**Standards / Candidates / Committees**
Industrial (e.g. Automotive / Aerospace / Manufacturing)	(HMI) Human-Machine Interface	ISO (e.g. ISO 13407:1999) (major)
		W3C (e.g. EMMA)
	Embedded Architectures	CAN-Bus (ISO), LINUX/ECLIPSE
		Flexray (Industrial)
		Autosar (Industrial)
	Functional Safety	IEC 61508, IEC 61511, IEC 61131, Do178B,…
		ISO 26262, Do 178C
Nomadic Environments	Mobile Telephony	GSM, UMTS (ETSI)
		WAP, Windows Embedded,
		LTE – Long Term Evolution
	Entertainment	ISO/IEC JTC1/SC29/WG11 (MPEG4, MPEG7), MP3
		MPEG A – E
		MP3Plus
	(Wireless) Sensor Networks	ZigBee, IPv4, TinyOS, IEEE 802.11, RS 232, *many others, too fragmented*
		FreeRTOS, MantisOS
		6lowpan, IPv6
	Security	WAP 2, PKI
Private Spaces	eHealth services	Medical Device Directive MDD (e.g. IEC 62304), Med. Functional Safety (IEC 60601)
	eLearning	SCORM (from ADL Initiative)
		Learning Object Metadata; Computer-Supported Cooperative Learning (CSCL)
		Blended Learning
	Connected heterogeneous devices	Universal Plug and Play (UPnP), OSGi, r-OSGi, SOA, HAVi, Jini, *…..too many, fragmented*
		Gap
		Gap: Self-organizing middleware infra-structures (results from R&D projects ?)
	Ambient Assisted Living	*Continua health alliance; VDE/VDI/IT*
		Gap in the overall area
		Gap in the overall area
Public Infrastructure	Wireless Sensor Networks	See above
	Services and service description	Service-oriented Architecture (SOA), W3C
		Service Descriptions: DAML+OIL
		Topic Maps
	Security	See above
	Billing / Ticketing	ISO 17799, ITIL
		BSI SINA (Secure Internet Architecture)

Table 2-1: Artemis – Application Context, Technology Domains and Standards

Although the list makes no claim to be complete at all, some interesting interpretations can be made:

- Still **established technology domains** like automotive or mobile telephony that are addressing a broad market have only a few but widely accepted standards that are also applied by competitors (some of them, like GSM, UMTS, which have strengthened the European position as market- and technology leader, by all of them).
- **Technologies** that researched for some years and that are **only a few steps away from the broad market have to face a variety of different standards**. Examples are: **Wireless sensor networks** or the field of connected heterogeneous devices. Here, it is not decided yet, which standard will become widely accepted by the manufacturers and / or the market. Consequently standards have to be promoted and to be established by both research and manufacturers.
- **Applications (or technologies)** that are addressing an **emerging market** of the future have a **tremendous lack in standards**, and / or even are missing relevant standardization committees. A prominent example is the **Ambient Assisted Living** domain that is one of the most important application fields of ICT technology in the future. Here, obviously a lot of effort has to be done. ***This was especially noted as result of the Standards Session at the AAL Conference in Vienna, Oct. 1st, 2009 (a detailed analysis of this issue is performed in chapter 4).***

As outlined in D1.2, in certain areas (e.g. modeling languages, RT-languages and OS), there exist several standards in parallel for similar application areas or development phases, which results in need for convergence. Therefore among the selected candidates there are convergence issues to be promoted:

- **SysML – Modelica – Scicos convergence**
- **HIJA, RTSJ Java, Ravenscar convergence**

3 Standardization landscape

3.1 Overview

If we look into the web for "Embedded Systems Standards" we will find only a few mentioned under these combination of terms:

- *OSEK operating system (automotive), MicroSoft Windows Embedded Standard 2009, Windows Embedded Devices Standard*
- *COPRAS/HIJA safety critical Java*
- *ProSE (ERCIM News 75 article)!*
- *Open Group RT & Embedded Systems Forum (last document 2004!)*
- *Debug standards (IEEE 1149.7, NEXUS)*

The provocative answer to the question "Are there Embedded Systems Standards" would be "almost none", although there are many standards existing which have impact for embedded systems although not specifically designed for them: functional safety, communications, APIs, ….

The conclusion is: Embedded Systems Standards landscape is at least as fragmented as the Embedded Systems industry and research as stated in the Artemis SRA!!

As a result: must also take existing or evolving standards and support revisions to adapt to networked embedded systems requirements.

Thus, we have three groups of standards to look at for potential promotion activities:

- Existing standards to be adapted/maintained (a potential group of candidates could be functional safety standards)
- Evolving standards to be influenced (potential examples could be ISO 26262 or AUTOSAR, a successful example already promoted is the ISG (Industrial Specification Group) of ERCIM/ETSI on Quantum Key distribution)
- New standards to cover new areas (potentially rich fields would be: ambient intelligence, AAL (Ambient assisted Living))

From among the existing and evolving R&D results, ProSE will via a negotiation process with public involvement (stakeholders and extended group) identify those that could claim to be good standardisation candidates in either one of the addressed types of standards.

Reference table on standardization organizations and standards:

Generic cross-domain standards suited for dependable embedded systems			
Standards type	Area	Standard	Reference in D1.2
Non-functional properties	Safety	IEC 61508 Functional Safety	
	Security	ISO/IEC 62443 Security of Industrial Process measurement and Control	evolving
		ISO/IEC 61487-4 Profiles for secure communication in industrial networks	evolving
		ISO 15408 Common Criteria	Established, mature
Processes	Maturity models	CMMI (SEI)	Established, mature
		ISO 15504 SPICE	Established, mature
	Product Management	PLM	
		STEP	
Software	Modelling		
Middleware	Middleware platform	OSGi (JAVATM)	
		OMG: CORBA, DDS	
	OS	IEEE 1003 POSIX	
Modelling			

3.2 Standards and standardization organizations

3.2.1 Generic/Cross-domain Standards suited for Dependable Embedded Systems

Given that one of the missions of Artemis is to overcome the fragmentation among application sectors so as to 'de-verticalize' the industry, in the first place an overview is provided on standards that are not specific to any domain, covering:

- Non-functional system properties such as
  - (Functional) Safety
  - Security
  - Performance
  - Quality
  - Usability
- Processes
  - Life-cycle dependant Processes
  - Life-cycle independent Processes
  - Supply-chain dependent issues
  - Certification
- Generic methods/tools/tool chains. Fundamental underpinning for such interoperation and integration is supported by model-based development and validation
- Generic middleware and communication infrastructures (e.g. operating systems, gateways, interfaces, …)
- Electronics
- Interfaces and domain-specific adaptation of generic standards (this will be discussed in a separate chapter)

Specific comment on Software:

- In the past, many standardisation activities were driven by bodies such as IEEE, often initiated by government agencies, most notably the US DoD. A lesser, but still influential role was filled by academia (think of the CMM model from Carnegie-Mellon's SRI). When PC's became widespread, official standardisation was more or less taken over by companies such as Microsoft and Sun, mostly in the fields of programming languages and, more importantly in programming, or application development environments.

- The Open Software or Open Source movement also has set a number of de facto industry standards: Linux is probably the best known example. Judging from recent developments, this trend is strengthening. Examples can be seen in the widespread adoption of GCC (Gnu Compiler Collection), and of Eclipse for the development of IDE's. This trend is fuelled by the still growing semiconductor market, on the one hand, and the increasing cost of software development. Many of the above mentioned tools are seen as 'Silicon Enabling': ensuring increased number of sold chips, not as IP of any company. On the other hand, increasing application programmer activity is key in managing system development cost: providing standardised application tool platforms is one factor in this.

- Integration of development processes and interoperation of developed software and systems requires multi-domain modelling capabilities such as those promised by Modelica.

Specific comment on middleware:

- OSGi (Open Services Gateway initiative) Alliance: the OSGi Alliance is an independent non-profit corporation comprised of technology innovators and developers and focused on the interoperability of applications and services based on its open component integration platform at middleware level.

- OMG: The Object Management Group (OMG) is a consortium that produces and maintains computer industry standard open specifications for interoperable enterprise applications. Its members include virtually every large company in the computer industry, and hundreds of smaller ones.

Specific comment on process standards:

- During the early years of software engineering, the realisation of the infeasibility of testing all possible interactions of software-based systems with their environment led the industry to focus on process standards such as ISO9000 and its variants, CMMI, Spice etc.

- In recent years process standardisation has become less prominent as the industry (and its customers) have re-emphasised the need to focus on the actual performance of software-based systems, rather than on how they were produced. Even more recently, the concept of ‘software as service’ is leading to the application of ‘service level agreements’ to the functioning of software-based systems.

- While process standards have become less important for the specific process of software generation, there has been a parallel increase in interest in the overall product development process that is encapsulated in the notion of ‘Product Lifecycle Management’ (PLM). This is - or can be (different players have different perspectives) - extremely broad and can encompass not only design, development and test, but also product portfolio management and strategy development.

- PLMIG (Product Lifecycle Management Research Interest Group) is an industry-led grouping whose goal is to promote PLM research within Europe.

- The (main) standards in use or under maintenance include
    - STEP (the Standard for the Exchange of Product Model Data) which describes how to represent and exchange digital product information. It forms a key component in PLM and is encapsulated in an ISO standard (ISO 10303).
    - AP233
    - Doors, Simulink (Proprietary/de facto)
    - UML/SYSML
    - VHDL, RosettaNet
    - U3D, 3DXML

- The priority standard in development is the System Architecture Modeling Language Modelica. This is an open, declarative rather than procedural standard that is intended to facilitate the collaborative design of innovative products.

Standardisation and pre-standardisation/expert organizations for generic standards:

Official International/European/US/national standardization groups:

- ISO (International Standards Organisation) (157 members, national standards organizations of most industrial and developing countries) e.g. TC22 (functional safety)
- IEC (International Electrotechnical Commission) (68 members, national electrotechnical/electronic committees/associations), e.g. TC65 (SC65A for functional safety, SC65B&C for buses, etc.), TC56 (dependability).
- CEN (European Committee for Standardisation) (members are the national standardisation bodies of most European countries).
- CENELEC Comité Européen de Normalisation Electrotechnique (members are the national electrotechnical standardisation bodies of most European countries).
- IEEE (Institute of electrical and electronics engineers)
- Other national standardisation organizations (preparing for WG and proposing new work items)
- ETSI (European Telecommunications Standards Institute) (has official ESO status)

Industrial standardization organizations:

- OMG (Open Management Group) OMG is a consortium that produces and maintains computer industry open specifications for interoperable enterprise applications. Membership: virtually every large company in the computer industry and hundreds of smaller ones. NOTE: Most OMG work is taken over by ISO standards.
- The Open Group (Open Source Movement) (300 industrial members)
- ISA (Instrument Society of America)
- OSGi Alliance
- PICMG PCI Industrial Computer Manufacturers Group: consortium of over 450 companies that collaboratively develop open based computer architectures for telecommunications, industrial, and military use
- SPIRIT Industrial consortium which tries to establish IP and tool integration standards to enable improved IP reuse through design automation enabled by IP meta data description
- OSCI Open SystemC Initiative. OSCI members represent a range of worldwide electronics organizations, ranging from SoC companies, tool vendors, intellectual property suppliers, and embedded software developers. Specifications are open.
- VITA VME Industrial Trade Association Industry

Regulatory organizations:

- HSE (Health and safety Executive (UK)
- OSHA (Occupational Safety and Health Administration)

Other (pre-) standardization groups/organizations (non industrial, non-official):

- EWICS TC7 (European Workshop on Industrial Computer systems, TC7, Reliability, Safety and Security)
- ERCIM – European Research Consortium for Informatics and Mathematics

- SEI (Software Engeineering Institute, Carnegie Mellon University, Software Processes and Maturity Models)

Main standards of the above mentioned groups in the non-domain-specific standardisation areas:

From official standardization institutions:

- ISO/IEC 61508 (Functional Safety of E/EE/PE Systems)
- ISO/IEC 62443/ISA SP99 ("Security of Industrial Process Measurement and Control – network and system security")
- ISO/IEC 61784-4 Profiles for secure communications in industrial networks" (IEC 61784-4)
- ISO/IEC TC56 – Dependability (e.g. IEC 60300, Dependability Management)
- ISO 9126 (ISO 25000) (SW Engineering – Product Quality)
- ISO 15504 – SPICE (Software Process Improvement and Capability Determination)
- ISO 15408 – Common Criteria (Security)
- ISO 17799 (ISO 27001, ISO 27002) (Information Technology -- Code of practice for information security management)
- ISO 9000 (Quality Management)
- IEEE 1003 – POSIX

From industrial consortia and academic institutions:

- CMM (Capability Maturity Model, for systems), CMMI (Capability Maturity Model Integration, software) (SEI, Carnegie Mellon University/DoD)
- OMG Standards:
  - The OMG's flagship specification is the Unified Modelling Language (UML) and the multi-platform Model Driven Architecture (MDA).
  - The OMG's own middleware platforms are CORBA and DDS.
  - SysML provides architectural specification methods.
- OSGi standards on universal middleware: JAVATM
- Open Software (Open Group)
- VITA Open Standards Organization for e.g. unmodified VME32/64 backplanes
- PCI specifications: include AdvancedTCA, AdvancedMC, MicroTCA, COM Express, and CompactPCI
- IP-XACT. Defines specifications for electronic elements APIs and will extend in the direction of including also non-functional aspects (SPIRIT consortium).
- OSCI standards: TLM - Transaction Level Modeling
- SoC standards:
  - AXI, AHB, OCP, etc. to standardise the hardware interface
  - all parts of the software stack will have (de facto) standards, e.g. for operating system, streaming frameworks, media standards, etc.
- Open Software de-facto Standards: Linux, GNU compilers, Eclipse system,

3.2.2 Aeronautics and aerospace standards

Aeronautics and aerospace industry standards are dominated by industrial consortia and regulatory groups.

Main actors are Industry (manufacturers of aircraft, airborne equipment, ATM systems, airlines), the aviation safety agencies [EASA in Europe, FAA in the USA], Advisory Committees [RTCA, SEI], Standardisation Organisations [Eurocontrol, EUROCAE, ISO], Conformity Assessment Authorities [ACAA]. Fora include:

- ARINC. Aeronautical Radio Inc.
- EUROCAE. European Organisation for Civil Aviation Equipment
- SAE. European Organisation for Civil Aviation Equipment

Main standards in use and under maintenance include:

- AADL-- Avionics Architecture Description Language)
- IMA (Integrated Modular Avionics)
- RTCA [DO160, DO178B, DO254, DO255, DO297]
- ARINC [ARINC653, 664]
- EUROCAE standards
- Eurocontrol Standards
- AFDX

Priority standards in development:

- standards related to safety, security, interoperability, environmental impact.

Changes in the standardisation process for the sector will come from adoption by the aeronautic domain of Single European Sky and Clean Sky principles that will lead to a new generation of avionic systems and a new ATM model. In parallel, standards and rules coming out from those EC initiatives will significantly impact avionic systems, ATM structures and the way people will approach the air transport system.
To achieve cross-domain re-use and become more cost-efficient, avionics industry is observing standardization in other mass-product, safety-related areas, e.g. automotive (FlexRay bus, co-operation in projects like CESAR).

3.2.3 Automotive standards

We include here communication within the vehicle, with the infrastructure (2025) and from vehicle to vehicle (2030); control of the powertrain, suspension and chassis, and standardisation concerned with development and testing.

Main actors: Industry (safety aspects) and regulators (national, local)

- SAE. Society of Automotive Engineers International (SAE).
- Autosar consortium
- ERTICO/Telematicsforum (Europe's Intelligent Transportation System Organization)

The main standards in use or under maintenance:
International:

- Road vehicle standards are ISO (DIN, …) domain. This includes e.g.
    - CIA, CAN (Controller Area Network) in automation
    - LIN (Local Interconnect Network)
    - Safety standards (Brakes, lights, reflectors, airbags.....car immobilizer, tire pressure monitors,...)

- Functional Safety standard (upcoming ISO 26262)
- Mechanical standards (DIN, ISO, VDA,......)
- Certain communication standards

Industrial consortia standards are:

- FlexRay
- Autosar: Automotive Open System Architecture.
- GIFT/ICT (CAN tranceiver specification & testing)
- MOST (Media Oriented System Transport)
- Safe By Wire Plus
- AEC, Automotive Electr. Council - Q100
- ESDA - Human Metal Model
- Supply standards (TS16949, ...)

Certain standards are defined by directives and international agreements:

- Vienna Agreement
- Environmental standards (exhaust pollution EU3, EU4, EU5,.....)

Priority standards in development:

- Inter vehicle/road structures communications

3.2.4 Rail standards relevant for electronics and software

Main actors:

- International organisations, e.g. CER, EIM, ERA, UNIFE, UIC, ETSI, ATOCs, CENELEC, CEN
- other normative bodies
- railway equipment manufacturers
- railway operators

Main standards in use or under maintenance are International or European official standards:

- CENELEC TC9X and TC256
- RAMS (EN-50126, EN-50128, EN-50129),
- IEC-61508 (SILs, basis for EN 50126/28/29 series)
- IEC 61375-1, Train Communication Network
- ERTMS/ETCS (European Railway Traffic Management System/European Train Control System

Priority standards in development include standards related to:

- safety & security
- interoperability
- EMC

Changes under way in the standardisation process for the sector include accommodation of all the EU directives concerning:

- safety
- EMC
- interoperability

- operation
- passengers with reduced mobility, ...

3.2.5 Telecommunication

N/B. Cellular aspects are excluded, being within respective industry and well established.

Main actors: standards are promoted by industry fora and special interest groups - (Bluetooth SIG, Wifi Alliance, IETF, ...) and endorsed by standard bodies. The role of the telecommunications manufacturing industry and of the consumer electronic industry is fundamental. However, the evolution beyond classic telecommunication services (e.g. convergence of telephony, internet, media, consumer electronics) is strongly increasing the number of competitors and the level of competition.

The most important international/European/US standards bodies are:

- ETSI - European Telecommunications Standards Institute.
- ITU - International Telecommunication Union
- IEEE
- CEN/Cenelec
- ISO (protocols)
- IEC (safety, EMC)

Industrial consortia or alliances are:

- OMA - Open Mobile Alliance
- TISPAN
- IETF
- ISO/IEC
- HGI
- WIMAX forum
- WiMedia Alliance
- DSLForum
- VESA, Video Electronics Standards Association
- UCPS (China)
- BMCO (Broadcast Mobile Convergence Forum)
- EMBC (European Mobile Broadcast Council)
- CELF (CE linux Forum)
- UHAPI (Universal Home Application Programming Interface Forum)
- IGRS (Intelligent Grouping and Resource Sharing, Chinese DLNA counterpart)
- CEA (Consumer Electronics Association)
- MoCA, Multimedia over Coax Alliance
- Mobile DTV alliance
- W3C (World wide web consortium, in Europe hosted by ERCIM)

Standards enforcement is carried out by public regulators, competition rules are defined by the EC in Europe.

Main standards in use or under maintenance:

- MIPI - Mobile Industry Processor Interface/Slimbus. This establishes specifications for standard hardware and software interfaces in mobile terminals. The common objective of MIPI members (Intel, NXP, Nokia, STM, TI, HP, Samsung, Sony, etc.) is to simplify the design and implementation of hardware and software by driving consistency in application processor interfaces, promoting reuse and compatibility in mobile devices. No certification program is in place
- DVB, DVB-H
- Khronos
- 3GPP2
- LTE
- IEEE 802.11
- WiMax
- WiFi
- WiMediaMAC- an open standard for PC and consumer applications by WiMedia Alliance (Industrial - Intel, NXP, Nokia, STM, TI, HP, Samsung, Sony, etc.) Certification program in place.
- Zig-B
- Bluetooth
- GSM, GSM-R
- EDGE
- UMTS
- WCDMA
- TETRA
- LINK 16
- WNN
- CORBA
- SINCGARS
- PDH/SDH
- ATM
- all the IP network related standards including IPv6
- specialized standards for system management (like TR-069 of DSLForum for CPE management and configuration)
- MPEG standards family (ISO/IEC JTC1/SC29 WG11)
- UPnP
- ISMA (Internet Streaming Media Alliance)
- JVT (Joint Video Team)
- ITU-T, SG16 Q.6 (Video Coding Experts Group)
- OpenCable (US)
- SVP
- SATA-IO
- HDMI
- DPCP/ DisplayPort
- PCI / PCI-Express (point to point computer expansion card interface format) by Intel
- USB-IF (open industry standard for PC and consumer applications : Microsoft, Intel, NXP, NEC) Certification program in place

The priority standards in development are:

- WiMedia UWB
- NFC (near field connectivity)
- Bluetooth Wireless
- Software defined Radio (SDR) & Cognitive radio
- Home Network, Home Gateway
- network elements for meshed networks, MANET

Changes under way in the standardisation process for the sector include:

- increasing emphasis on formalisation of industry organisations so as to shorten the endorsement cycle at the official standard body (e.g. ETSI, ISO, IEC)
- a push to adopt international standards by co-opting same (or similar) standards by several bodies (ETSI, ITU, IEEE, IETF)
- growing concern about the IPR embedded in the standards. There is a need to regulate the conditions for use of standards and define the rules for IPR that might be part of the standards. The notions of royalty-free (RF) or fair, reasonable, and non-discriminatory (FRAND) standards are becoming important topics (ISO and IEC has already adopted a common strategy).
- New organizations and fora are appearing to address specific areas still not covered by already existing organizations; **this may imply convergence and interoperability issues across domain and device boundaries for co-operating objects, ubiquitous computing, ambient environments !!!**

3.2.6 Health (medical devices and systems)

There are many developments for standards in the health area and organisations promoting standards, some of them originate from the US but have now international structures. SDO's in the health area are:

Standards institutes:

- ISO (many separate standards for different types of (isolated) medical devices)
- IEC (with regards to safety, e.g. IEC 60601, IEC 62304)
- CEN with several technical committees (e.g. TC 251)
- IEEE with several committees (e.g. TC215 for data standards and 11073 for medical devices)
- ANSII (e.g. HITSP, HL7, CGL7)

Industrial groups and others:

- ASTM (e.g. CCR)
- NEMA (DICOM)
- Regenstrief Institute, Inc. (LOINC)
- US National Library of Medicine (UMLS)
- SNOMED
- IHE (mainly promotion)
- Continua (an industrial consortium related standards for tele monitoring

In other standardisation activities (e.g. USB, Bluetooth, Zigbee) medical profiles are being developed and also many informal standards arise e.g. in the area of bioinformatics and medical informatics in the form of mark-up languages.

3.2.7 Private Space / Home related standards

The home domain could be divided into
- building automation and
- home automation.

The main difference between building automation and home automation is, however, the human interface. In home automation, ergonomics is of particular importance.

Specific domotic standards include INSTEON, X10, EIB/KNX (standard promoted by "Konnex Association"), HomePlug, LonWorks, System Box, C-Bus, Universal powerline bus (UPB), UPnP, ZigBee and Z-Wave that will allow for control of most applications. In the area of “intelligent building”, there are additionally ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers: an international organization for heating, ventilation, air conditioning, or refrigeration -- HVAC&R), BACnet (a network communications protocol adopted worldwide as ISO 16484-5:2003), ARCNET, RS-232, RS-485, DALI, DSI, Dynet, Energy Star (a program created by the US government to promote energy efficient consumer products), LonTalk (a protocol created by Echelon Corporation for networking devices), Modbus, and oBIX.

Standardisation bodies, which are also affecting the home domain, are
- CENELEC, the European Committee for Electrotechnical Standardisation, has started work on “Smart Homes” standards
- ISO/IEC
- IEEE,
- CEN

Industrial standardization groups are amongst others:
OMA - Open Mobile Alliance, WiMedia Alliance, CELF (CE linux Forum), UHAPI (Universal Home Application Programming Interface Forum), IGRS (Intelligent Grouping and Resource Sharing), CEA (Consumer Electronics Association) and MoCA, Multimedia over Coax Alliance. Eu.bac is the European building automation and controls association.

In the area of **entertainment,** the most important alliances are the Digital Living Network Alliance (DLNA) and HDMI. DLNA is an international, cross-industry collaboration of consumer electronics, computing industry and mobile device companies with the objective to establish a wired and wireless interoperable network of personal computers, consumer electronics and mobile devices in the home and on the road, with design guidelines based on internationally recognized open industry standards together with a certification program to verify conformance.

Some standards use control wiring, some embed signals in the powerline, some use radio frequency (RF) signals, and some use a combination of several methods. Control wiring is hardest to retrofit into an existing house. Some appliances include USB that is used to control and connect to a domotics network. Wireless interconnection is mostly based on Wi-Fi 802.11b/g, Bluetooth, DECT, 802.15.4/ZigBee, Z-Wave, EnOcean (exploitation of slightest changes in the environmental energy using the principles of energy harvesting), and Consumer_IR (protocols for remote control). Bridges translate information from one standard to another (eg. from X10 to EIB). Other standards in use or under maintenance are WiMax, WiMediaMAC, COBRA, HDMI, PCI / PCI-Express and USB-IF. The large variety of standards and standards groups will raise the convergence issue “beyond bridges” as well.

4 Ambient Environments and AAL – the major standards gap

4.1 General Overview

The vision of Ambient Intelligence is based on the ubiquity of information technology, the presence of computation, communication, and sensorial capabilities in an unlimited abundance of everyday appliances and environments. Most prominent publications that had impact on wide fields of science and research within the last few years are:

(1) the ISTAG report on scenarios for Ambient Intelligence 2010 (Ducatel K, Bogdanowicz M, Scapolo F, Leijten J, Burgelman J-C.: Scenarios for ambient intelligence 2010, ISTAG report, European Commission, Institute for Prospective Technological Studies, Seville (November ARTICLE IN PRES2001). URL ftp://ftp.cordis.lu/pub/ist/docs/istagscenarios2010.pdf);

(2) the outline description of Ambient Intelligence given in Shadbolt N.: Ambient Intelligence. IEEE Intelligent Systems 2003; 2–3 and

(3) an article of one of the inventors of the notion Ambient Intelligence (Aarts E. Ambient Intelligence: a multimedia perspective, IEEE Multimedia 2004; 12–9).

(see references).

The notion of Ambient Intelligence was developed 1998 in a series of internal workshops that were commissioned by the board of the management of the Philips company.

It is obvious, that Ambient Intelligence will make substantial contributions to science (as well as to the economy), if its realization contributes noticeably to human well-being. But some paradigm shifts regarding technology development and technology usage have to be made. Up to now, it has been the user's responsibility to manage her personal environment, to operate and control the various appliances and devices that are available for her support. It is obvious that the more technology is available and the more options there are, the greater the challenge of mastering your everyday environment, of not getting lost in an abundance of possibilities. Failing to address this challenge adequately simply results in technology that becomes inoperable and thus effectively useless Through Ambient Intelligence, the environment gains the capability to take over mechanical and monotonous control tasks - as well as stressful feature selections and combinations - from the user and manage appliance activities on his behalf. To do this, the environment's full assistive potential must be mobilized for the user, tailored to his individual goals and needs. Realizing this, the user becomes an active part of her environment; she will be more than only a user that is trying to reach her goals by using the available environment technologies.
Consequently, AmI extends the technical foundation that was laid by former initiatives like Ubiquitous Computing resp. Pervasive Computing. These technologies triggered the diffusion of information technology into various appliances and objects of the everyday life. But now, Ambient Intelligence has to guarantee that those smart devices behave reasonably and that they unburden - instead of burden - the user (for more details, see [Aarts, Encarnação 2006].

Recent research initiatives follow elderly care (→ Ambient Assisted Living) or sensor-quipped environments (→ Wireless sensor networks, WSN) or special topics in Human-Computer Interaction.

PRoSE has chosen the topics

- Architecture / Middleware
- Semantic Services
- Service Interaction

as being most important for the realization of AmI Environments and applications. Thus is has been concentrated on a survey on these topics and on the selection of most promising candidates on that research fields.

4.2 Architecture/Middleware

In principle an architecture resp. a middleware for Ambient Intelligence should provide a technological platform that allows the seamless and natural access to AmI-services resp. Allows communication and cooperation of devices and application within an AmI environment. Furthermore It should provide some means for plug'n'play capabilities, so that device (resp. application) ensembles could be integrated in an ad-hoc fashion. In the past agent platforms or in which software components communicate and exchange messages were applied to realize this kind of distributed applications. A central property of this agent approach is a high autonomy of the included software components. The exchanged messages contain a high degree of semantics due to internal processing. Apart from that there are component systems, which have special parts that contain rules about the message flow or the organization of the components. The different approaches vary from common publish-subscribe mechanisms to the realization of distribution strategies between different agents. Representatives of this kind of technology are the

- FIPA initiative – Foundation for Intelligent Physical Agents (http://www.fipa.org)
- KQML initiative – Knowledge Query and Manipulation Language (http://www.cs.umbc.edu/kqml/)
- And projects like Ask-IT (http://www.ask-it.org/) or OASIS)for: Open architecture for Accessible Services Integration and Standardization) (http://www.oasis-project.eu/) that apply the FIPA standard for realizing the underlying component platforms.

Because FIPA and KQML are already established standards (with roots mainly in the U.S.), PRoSE concentrates on recent service-oriented platforms that distinguished components into service providers and service consumers and that makes available physical and logical architectures for networked nodes in order to provide the necessary communication and service discovery and service binding needs.
Prominent representatives are the AMIGO system (http://www.amigo-project.org) that had the goal of developing an open, standardized and interoperable middleware. The middleware here is a piece of software which has to be implemented on each device. Amigo views itself as a service-oriented architecture, which distinguishes between service providers and service clients. (but it is possible that one application can play both roles). The goal of the Amigo architecture is to make the composition of abstractly described services possible. (see figure 4); and the PERSONA system (http://www.aal-persona.org) that comprises a middleware and a set of specific functional components . The middleware realizes the communication buses and enables the orchestration of the ensemble based on a set of specified ontologies, protocols, and strategies. The functional components provided by the PERSONA platform are:

(1) Situation Reasoners for deducing higher level contextual info,
(2) Dialog Manager representing the system as a whole,
(3) Service Orchestrator providing facilities for defining and enacting composite services using existing services,

(4) Profiling Component,
(5) Privacy-Aware Identity and Security Manager,
(6) a context history entrepôt,
(7) AAL-Space Gateway, and
(8) a set of so-called I/O handlers responsible for (a) presenting the modality- and layout-independent system/application output to the user in a context-aware and personalized manner, and (b) collecting user input, in an environment with several I/O channels distributed overall in the AAL space. Other examples are DECOS (http://www.decos.at), ARLES, or LEICA.

The GENESYS platform (http://www.genesys-platform.eu/) is developing an cross domain reference architecture for embedded systems that can be instantiated for different application domains to meet the requirements and constraints documented in the ARTEMIS strategic research agenda. These requirements are composability, networking, security, robustness, diagnosis, integrated resource management and evolvability. The reference architecture will address common issues, such as complexity management, separation of communication and computation, support for different levels of quality of service, security, model-based design, heterogeneity of subsystems, legacy integration, optimal power usage, and diagnosis.

(De-facto-)standards for devices, communication protocols or even service description specification or service discovery protocols developed in the last few years and brought on the market by key players of the IT industry of often used as basic technology for realization of (more semantically meant) architectures. Here

- Universal Plug and Play (UPnP) (www.upnp-ic.org)
- HAVi (Home Audio Video Interoperability) (http://www.havi.org)
- JINI (new: RIVER) (http://www.jini.org, or new: http://incubator.apache.org/river)
- OSGi (or R-OSGi) Open Services Gateway initiative (http://www.osgi.org)
- Bluetooth

are most prominent examples that will have to be considered.

Also the field of tiny (or better: embedded) platforms have to be regarded by PRoSE. Operating systems and protocols for sensor nodes and embedded systems have to face different requirements than systems running on larger machines (obvious reasons: energy consumption, limited processing power). Here discovery protocols like ZigBee, Operating Systems like TinyOS and results of projects like RUNES (for Reconfigurable Ubiquitous Networked Embedded Systems, http://www.ist-runes.org) will be included into the PRoSE survery of possible standardization candidates.

4.3 Semantic Services:

Services are the main feature of components and applications that are part of any device ensembles. Services are representing functions that are offered by the variety of participating devices and applications. Different paradigms were developed in the past, from which the service-oriented architectures (SOA) and the agents are the most well-known. All comprise the specification of

- Language
- Protocols
- Ontologies
- Dispatch strategies

For allowing the description of services and the services capabilities, for defining non-functional aspects of proposed services and for allowing the realization of strategies for

- Service Discovery
- Service Binding
- Service Composition
- Service Decomposition.

Prominent specification for service descriptions are:

- Universal Plug and Play (UPnP) (www.upnp-ic.org)
- OWL (that builds on RDF and RDF Schema and stems from DAML+OIL.) (see www.w3.org)
- Web Services for interoperability between different software applications (SOA; see www.w3.org/2002/ws/)
- Or OWL-S (see http://www.daml.org/services/owl-s/) for allowing the description of the properties and capabilities of Web services in unambiguous, computer-interpretable form

4.4 Service Interaction:

Concerning service interaction quite mature standards for technical tools, specification models and design methodologies (also for accessibility and usability) or on the market (resp. are in the development phase). Examples are:

- ISO 13407 Human-centered design processes for interactive systems
- ETSI EG 201 472 HF: Usability evaluation for the design of telecommunications systems, services and terminals.
- ISO/DIS 9241-20 Ergonomics of human- system interaction – Part 20 Accessibility guidelines for information/communication technology (ICT) equipment and services (in development phase)
- DIN-Norm 33455 for barrier free products, policies and requirements
- Web accessibility initiative that refers to the practice of making websites usable by people of all abilities and disabilities (W3C's Web Accessibility Initiative (WAI), http://www.w3.org/WAI/, Guidelines: (http://www.w3.org/WAI/intro/wcag.php)
- "Design for all" that specifies some requirements for designing devices that are manageable by people of different age groups with special respect towards security, children, elderly and handicapped people
- DIN EN ISO 6385:2004-05 that describes policies for ergonomics

From the PRoSE view there is a big lack with regards to users' interaction in distributed environment facing a variety of different available services and functions. Objective must be to have specifications that covers technological platforms including authoring and simulation frameworks as well all necessary technical tools, specification models and design methodologies (also for Ambient Assisted Living accessibility and usability). Service interaction in a from that was intended by Ambient Intelligence means lot more that definitions and specifications of Menu-oriented, Dialog-oriented, goal-oriented vs. function-oriented approaches or even multimodal issues. We think that guaranteeing integrated service access could only be done by an integrated approach, means integrating interaction issues in service description standards. For that reason no explicit standardization candidate for service interaction could be found in the following sections (or also in D1.2 of the PRoSE project).

5 Abbreviations and Definitions

AREMA	American Railway Engineering and Maintenance-of-Way Association
ARINC	Aeronautical Radio, Incorporated
ARTEMIS	Advanced Research and Technology for Embedded Intelligence and Systems
ASAM	Association for Standardization for Automation and Measuring
AUTOSAR	Automotive Open System Architecture
CENELEC	Comité Européen de Normalisation Electrotechnique
DDS	Data Design System
EICOSE	European Institute for Complex Safety Critical Systems Engineering
ERA	European Railways Agency
ERCIM	European Research Consortium for Mathematics and Informatics
ETSI	European Telecommunications Standards Institute
EUROCAE	Airborne Equipment and Ground Systems for Civil Aviation
EUROCONTROL	European Organisation for the Safety of Air Navigation
EWICS TC7	European Workshop on Industrial Computer Systems, TC 7, Safety, reliability and Security
HIJA	High-Integrity Java Application
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
INESS	Integrated European Signalling System
ISO	International Standards Organization
ITEA	Information Technology for European Advancement
JINI	Java Intelligent Network Infrastructure
LTE	Long Term Evolution Standard (Global Mobile Suppliers Association)
MODELICA	Modelling Language for Component-oriented modelling of complex systems
NFC	Near Field Communication
NoTA	Network on terminal Architecture
OMG	Object Management Group
Open ADR	Open Automated Demand Response Communication Standards
OSGi	Open Services Gateway initiative
OWL	Ontology Web Language
OWL-S	OWL Semantic Mark-up Web Ontology Language
ProSE	Promoting Standardization for Embedded Systems
R-OSGi	Remote OSGi
RTSJ	Real-time Specification for JAVA
SAE	Society of Automotive Engineers
Scicos	Scilab Connected Object Simulator
SESAM	Single European Sky ATM Research Programme
SPICE	ISO 15504: Software Process Improvement and Capability dEtermination
SysML	OMG System Modelling Language
UML	Unified Modeling Language
uPnP	Universal Plug and Play

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