Strategic Research Agenda

Standardisation

ARTEMIS

Strategic Agenda for Standardisation

in support of the

Artemis Strategic Research Agenda

Preface

ARTEMIS *(**A**dvanced **R**esearch & **T**echnology for **EM**bedded **I**ntelligence and **S**ystems)* is a 'European Technology Platform'. This is a public-private partnership led by European industry with the goal to establish and implement a coherent and integrated European research and development strategy for Embedded Systems.

Embedded technologies are becoming dominant in many industries, such as communications, aerospace, defence, manufacturing and process control, medical equipment, automotive, and consumer electronics. This trend is likely to continue, given the ever-increasing possibilities for new applications offered by ever-advancing communications, embedded computing devices, and persistent storage.

Industries using and developing embedded systems differ significantly in business and technical requirements and constraints. Development cycles of complex industrial equipment, such as aeroplanes, industrial machines and medical imaging equipment, but also cars, are much longer then the development-cycles of other high-volume, cost-dominated devices for private customers, such as DVD players, mobile phones, ADSL modems and home gateways. Safety requirements are different for an aeroplane, for a car and for a mobile phone. Security, privacy and data-integrity all pose differing requirements in different environments.

Industry of a specific domain is increasingly confronted with the integration of requirements from other industries. In cars, for instance, there are not only the traditional safety requirements, but also for power-train control, for CO_2 production, and requirements from the consumer and mobile industry, with the increasing integration of entertainment and mobile communication into the total system. We see little cross-fertilization and reuse over the different industrial domains, as segmentation of markets with their differing requirements has resulted in a fragmented supply industry and research field.

One of the main ambitions of Artemis is to overcome this fragmentation, cutting barriers between application sectors so as to 'de-verticalize' the industry, sharing across sectors tools and technology that are today quite separate and establishing a new embedded system industry that supplies tools and technology that are applicable to a wide range of application sectors.

Embedded systems usually do not operate in isolation, but are often used in combination with other systems to realize an overarching function. Such larger systems are referred to as 'systems of systems'. Examples are a digital television that is integrated in the digital home, a medical diagnostic device that is embedded in the hospital workflow environment, and a car that interchanges information with other cars in its vicinity in order to improve safety. Also the large infrastructural systems, such as the air traffic control system, the electric power grid and of course the telecommunications infrastructure may be viewed as complex systems-of-systems. These systems are characterized by large-scale networked integration of heterogeneous and often intelligent components.

In the extreme, we see the formation of 'sensor networks', even aggregations of 'smart dust', where completely new challenges have to be addressed, related to such different research areas as low power

communication, energy scavenging, micro devices, sensor and data fusion, and controlled emergence of system properties.

Given that the environment of open systems of systems cannot be controlled and specified, and thus cannot be completely modelled, it follows that the reliability and performance of a system may be compromised by unforeseen environmental behaviour. Consequently, we will also require new and so far unexplored approaches to safeguard the safety, security, reliability and robustness of the embedded systems of the future. The use and integration of off-the-shelf components is also a challenge, as such components were not designed from the perspective of the decomposition of the system at hand.

The changeover from design by decomposition to design by composition raises some of the most challenging research and development questions in the embedded systems domain today.

This change, and the ambition for cross-sectoral commonality, inspires much of the specific research proposed in the Artemis Strategic Research Agenda.

The ARTEMIS Strategic Research Agenda (SRA), published in June 2005, outlines the objectives and the research topics that need to be investigated in the field of embedded systems. This present document is one of a trio of documents that amplify that original SRA with more specific research priorities. These three parts of the 'full SRA' are concerned with:

- Reference Design and Architecture,
- Seamless Connectivity & Middleware, and
- System Design Methods & Tools.

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.

Each part of the SRA was produced by a group of experts that devised their own method of working. While the three Expert Groups liaised so as to achieve coverage and avoid inconsistencies, each of the three documents has its own structure and style, with this preface being the only common element.

All three of these parts of the SRA are living documents that will be continuously refined and updated as research results arrive and as the technological and societal environment changes during the coming years.

Contents

1. Mission

The Working Group that prepared this section of the Artemis SRA has, as its mission, to:

- *provide the vision, priorities and guidelines for the standardisation policy of ARTEMIS to support the Artemis ambitions for cross-domain synergies, composability, reusability, reliability, interoperability, verification and certification*
- *propose to the ARTEMIS Board a standardisation policy, including scope, in line with the ARTEMIS vision and ambitions, and consistent with the ARTEMIS stakeholders' policies;*
- *promote the ARTEMIS vision to domain specific Standards Organisations (as for example: Aero, Automotive, Energy, Telecom, Consumer, Medical...);*
- *establish a method to identify and position standards in relation to ARTEMIS objectives in order to establish ARTEMIS recommendations for action aiming at improving consistency across different standards and standardisation organisations;*
- *establish links with European (ETSI, CEN/CENELEC, AUTOSAR, Eurorec, ...) and global standards organisations (ISO/IEC, ARINC, ITU, OMG, IEEE, IHE, HL7, Continua ...) and global standards organisations (ISO/IEC, ARINC, ITU, OMG...) and liaise with other Networks of Excellence, projects and groups working in the field (e.g. EWICS/TC7, ERCIM);*
- *establish links with communities, such as other European Technology Platforms, dependent upon embedded systems (but for whom embedded systems are not part of their core business) to ensure acceptability of standards;*
- *establish closer relationships between the research and standardisation communities; to engage researchers better in the standardisation process and to support research projects in development of a standardisation strategy;*
- *create awareness of the business value of standards, backed up IPR - especially among SMEs;*
- *deliver a Standardisation Strategic Agenda (this document) to complement the Artemis Strategic Research Agenda. This document will be used as input to the future FP7 work-programmes, JTI work-programmes, and National Programmes;*
- *initiate ideas for projects to support Standardisation from a holistic system perspective.*

2. Context & Scope

Artemis Standardisation activities are focused on the specific needs to realise the aims of Artemis and specifically to help implement the other parts of the Artemis SRA through standardisation-related activities. Artemis Standardisation activities do not address all standards pertinent to Artemis and its participating organisations, many of which will emerge and evolve naturally, through the operation of the market. The emphasis is on Artemis priorities such as cross-domain communication and inter-operation.

The scope encompasses:

- systems, including functional entities - not just software,
- 'process' (including management) - not just 'product', and
- 'standards' of all kinds
  - those produced by official standards organisations;
  - ad hoc standards (that might later be made official);
  - domain-specific standards (though paying attention to the cross-domain ambitions of Artemis), and
  - generic standards

3. Targets for Artemis Standardisation

2008: standardisation included as a work item in all Artemisia JTI/JU projects;
framework for prioritization of Artemis standardisation initiatives;
links with all European and International Standardisation Organizations established

2009: links to other ETPs and related research projects and institutions established

2010: a general process for cross-domain convergence

4. Method of Work

The Artemis Standardisation Working Group first established and agreed with the Artemisia Steering Board its mission and scope *(see above)*. From the mission and scope the specific standardisation needs for Artemis have been identified and will continue to be identified, and from them will flow the activities envisaged for the future.

Inputs to this process were taken from a wide range of members of Artemisia, representing all Artemis sectors and technical domains.

There is an extremely large number of relevant standards for embedded systems, wide diversity in their scope, wide diversity in their nature, and wide diversity in the standardisation processes by which they are created and maintained. In consequence, a critical aspect of this Strategic Agenda is the proposed formulation of an approach to prioritisation of standardisation activities and identification of the appropriate form of action (which is not necessarily the creation of standards).

5. The Embedded Systems Standardisation Landscape

The Artemis 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.

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).

Guiding principles of the standardisation system

Artemis supports the following objectives for a standardisation system (4):

- *It promotes the rapid convergence of both creation and use of standards that may not materialise spontaneously because of lack of scale effects and/or coordination between stakeholders;*

1) http://en.wikipedia.org/wiki/Ambient_intelligence
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)
4) The European Commission is seeking to establish objectives for a standardisation system that is 'at the service of innovators'. During Autumn 2007 the Commission sought comment on a Discussion Paper in preparation of the future Commission Communication "Towards an increased contribution from standardisation to innovation in Europe" (ENTR/I3/JA D(2007) The objectives presented here are a compilation of objectives suggested in that discussion paper and others suggested in an Artemis response to that paper. They may be revised following publication of the Communication, expected early in 2008.

- *It distributes influence on processes and outcomes in fair and realistic balance with contributions to the work and the magnitude of economic and social impact represented by stakeholders;*
- *It makes available to the public a sufficient stock of standards supporting needs for interoperability, comparable measurements, quality ranges and process improvement in all economic sectors, including services;*
- *It is responsive to the needs for standardisation in innovative fields, accompanying the wishes of innovators to standardise new technologies at the right pace;*
- *It supports the development of standards for global markets, with a strong brand within Europe and the world;*
- *It includes all the relevant actors of innovation in the standards-making process: industry, private and public R&D, SMEs, communities of users, etc, allowing their effective contribution to standards-setting;*
- *It respects and preserves the legitimacy of regulation, by working along the principle of full consensus for all standards and deliverables that will be referred to by regulation;*
- *It is effective at transferring knowledge to industry, R&D, SME, users, etc;*
- *It is effective at facilitating the application of standards by all those who may benefit from it;*
- *It preserves a fair and effective balance between incentives for R&D and other innovation efforts and the disclosure of valuable novelties to society on one hand versus the possibilities for economic actors and society at large to benefit from such advancements on reasonable terms on the other hand.*
- *It is efficient, and is sufficiently cohesive, whilst adapted to the specificities of different sectors;*
- *Its governance schemes include all those who have a stake in standardisation and aim for the implementation of the preceding criteria.*

For each sector that is represented in Artemis, an outline of the present standardisation baseline is presented in the 'landscapes' section in the Annex.

6. Artemis Standardisation Approach

Given the wide scope, the multiplicity of standards, and the multiplicity of standardisation organisations pertinent to embedded systems, it is unrealistic to suppose that the problem of fragmentation for embedded systems can be resolved by Artemis bringing all embedded systems standardisation activities under one management umbrella.

Instead, Artemis must identify and then stimulate and facilitate the highest priority actions necessary to facilitate harmonisation and alignment, so as to achieve the cross-domain compatibility required.

Forum

To this end, the WG will establish a forum that will bring together stakeholders of all kinds - industry (manufacturers, suppliers and users); standardisation bodies, professional, trade, industrial and consumer associations; regulators and certification or licensing agencies; public authorities; EU and national officials; and other ETPs and related platforms and organisations - not necessarily European-only.

Framework for prioritisation

The WG will establish a framework for analysis of the present standardisation position and a method to determine standardisation priorities for Artemis based upon the present state of standardisation; the European position vis-à-vis the rest of the world; and the relative capabilities of the various players in the market. Based on this analysis, the WG will recommend the most appropriate form of action. This *could* be development of a new standard, or harmonisation of existing standards, but it could also, for instance, be a market action or a research action to understand better the need for a standard.

Artemis has identified three types of motivation for cross-sector technology and standards:

1) where common technology is necessary for the concept to be viable. For instance, the Private Space domain *requires* a common infrastructure for markets such as energy, health, multimedia, security, etc. (Note that "Private space" can also be passenger cell in a car, so it is NOT limited to the home.)

2) where, although not essential, there can be a common benefit from common technology and associated standards. The benefit might, for example, come from opening the market so as to provide users with more choice and suppliers with more market potential. Examples include:
   - critical systems - where, for instance, technology might be shared between aircrafts and cars;
   - ad hoc systems - such as systems involving car-to-car communication (though this is verging on the 'necessary' category);
   - "device and plant" groups such as manufacturing, assembling radars in a system, or assembling components of a cell phone around a common internal communicating infrastructure;
   - systems of systems - though this concept is rather new and it is too early yet to consider standardisation

3) where, for instance, devices and systems - nomadic devices being the driver - may communicate meaningfully with other devices or systems without any prior arrangement. This will require more than middleware standards as conventionally understood, but some way to directly use semantics. This concept is still

in the stage of early research, but if this kind of technology can be developed then it will pervade most other domains, as it will be so much more advanced.

Specifically, the Artemis Standardisation WG will decide on:

- a method for representation and analysis of:
  - the scope of existing, evolving or potential standards,
  - their contribution to the cross-sectoral aims of Artemis (see the preceding paragraphs),
  - the state of maturity of standardisation topics, that could be:
    - mature (perhaps in a 'maintenance' state, but also possibly evolving - like functional safety). RTD may well be required to inform the evolution of standards.
    - new (already in preparation, whether by industry bodies or stands organisations). Appropriate actions for such early developments may well include RTD, so as to inform the standardisation initiative.
    - in a pre-standardisation state (or before) - where standards are or will be needed (e.g. 'AmI seamless connectivity'). Appropriate actions for such exploratory developments will often be RTD, well in advance of standardisation per se.
  - the technological and market factors that motivate them and that influence their realisation, and
  - their (potential) technological and economic impact
- a method for analysis of standards to inform prioritisation for action, taking into account:
  - the aims of Artemis
  - market maturity;
  - technological maturity;
  - public awareness and risk perception;
  - European strengths and weaknesses vis-à-vis extra-European strengths and weaknesses; and in particular Intellectual Property ownership, business priorities and impact on business models.
- a method for:
  - prioritisation of areas for action, based upon these analyses;
  - identification of the most appropriate form of action, taking into account the analyses indicated above.

7. The way forward

Analysis

Starting in 2008, Artemis will begin to establish the framework for prioritisation described in the 'Approach' above.

Initial candidates for action

While that work proceeds, some initial candidate areas for prioritisation have been identified:

- In contrast to the many efforts towards low-level connectivity solutions, for the purpose of "design by composition" standardisation priorities should be in the definition of higher level protocols and ontologies that:
  (1) facilitate the consolidation of functionalities embedded in appliances, controllers, actuators and sensors and ..
  (2) enable the natural interaction of humans within such an ensemble of intelligent devices.

- These ambitions will be best served by standardisation in the areas of modeling languages and ontologies to support modelling; meta-modelling; model (and tool) inter-operation; and multi-domain modelling.

- The processes for V&V and the processes and regimes for certification should be modified, where necessary, so as to enable acceptance of model-based V&V and certification.

- Service-Oriented-Architecture is also a good basis for the ARTEMIS goal of design by composition since it includes the concepts of service composition and service orchestration. To achieve the ideals of SOA, the formulation of standard ontologies for describing services is a priority, so that composite services need exist only at a meta-level as an ontological description including a workflow based on other, available services.

- To support the realisation of such concepts, a context bus and a service bus have been defined (5) as well as an input and an output bus, to which sensors, actuators, controllers, appliances, and even software components may attach in order to enable the ensemble to achieve a certain level of self-organization. Artemis sees high potential for standardization regarding the languages, protocols, ontologies, and dispatch strategies to be used on such buses.

Projects within the Artemis Joint Undertaking

In the near future, Artemis will, through the about-to-be-launched 'Joint Undertaking' seek proposals in pursuance of its Strategic Research Agenda. All projects to be supported by the JU will be required to agree a strategy for standardisation, including a rationale for that strategy that takes into account the Artemis aims embodied in this document. This will be required even if a proposed project is not proposing any standardisation activity: the rationale for the decision not to contribute to standardisation must still be made clear.

Regulation

This document has already recognised the need for regulatory processes - and related certification

5) http://www.aal-persona.org/

requirements - to be modified to accommodate the new development processes envisaged by Artemis. It has also recognised the need to overcome the bias toward fragmentation arising from specialised standardisation communities.

However, along with the standardisation regimes, the regulatory regimes also contribute to the fragmentation of the embedded systems markets, technologies, and research and development communities. Regulation can encourage procedural and cultural differences that create barriers to cross-sectoral co-operation and sharing. Artemis will seek to identify such barriers and find ways to avoid or surmount them.

8. ANNEX: Embedded Systems Sector/Domain Standardisation Landscapes

In this section the state of standardisation in the various sectors addressed by Artemis is set out, including trends and directions for the foreseeable future. This provides a baseline and context for the Artemis standardisation strategy. First some general trends are indicated, and then the specific status of particular sectors.

Motivation for evolution of standards

In all sectors, stakeholders - whether corporate customers or end-users - are becoming more and more sophisticated and having higher and more explicit expectations of enriched, converging, interoperable services with higher availability, integrity, safety and security.

In particular, most sectors are affected by increasing concerns over safety and security. These concerns are addressed differently in different sectors. In aerospace the focus might be on the software for the flight control system, to ensure that the aircraft 'behaves'. In manufacturing, the focus is on avoiding accidents and avoiding environmental pollution.

In all sectors, interoperability is becoming more and more important, for a variety of reasons. Devices of different manufacturers must be integrated. Moreover, the extent of integration is increasing, such as the integration of safety critical and entertainment functionalities in cars. Increasing integration requires more, better and more flexible communication between devices and subsystems - especially with the introduction of RFID and sensor networks.

The reduction in variants of products and interfaces enabled by better interoperability leads to cost reduction and enhanced asset efficiency. Greater interoperability opens up markets, allowing greater freedom of choice for both system integrators and consumers. Product Lifecycle Management standards, for instance, are used to enable ecosystems of collaborative partners sharing the same models. However, the need for interoperation of legacy systems with ones developed against novel standards - in aerospace, for instance - poses some difficulties.

In parallel, there is the motivation to exploit the potential for new and better products and services allowed by technological progress and encouraged by market demand and evolving user behaviour. In telecommunications, there are also the continually evolving requirements for use of the spectrum; necessitating more data bandwidth at the same time as greater mobility.

Internationalisation of standardisation

Generic standards, e.g. on non-functional system properties or on processes, which are often of public concern, are therefore international or European, e.g. ISO/IEC standards of functional safety, security, quality, usability, and certification.

In the majority of application sectors, there is a mix of international, de facto and proprietary standards. In aerospace, and to a lesser extent in rail, it is inevitable that the need for operational interoperability, coupled with an open market for aircraft and avionic systems, leads to an emphasis on international standards. In the automotive sector, although there is not (as yet) such a pressing need for international interoperability, there is nevertheless a need for international certification and a need for interoperability of both safety critical and entertainment systems. In the rail sector, standards are typically international, and in Europe generally linked to EU Directives.

In the manufacturing and logistics sector there is also a mix of open, international, proprietary and *de facto* standards:

- Open (= like open source): e.g. UML, XML
- International: IECxxx (most customers request this standard)
- De facto: (not formally standardized) e.g. MS-Office, MS-Operating Systems for Control Systems
- Proprietary: e.g. ABB Fieldbus-Plug Serial Interface

In telecommunications specifically, the aim is to have open, international (at least at European Level) standards. Standards are typically developed within ad hoc groups and endorsed by international standards bodies. Standards are typically open to other users, on an international base, such as IEEE de facto international standards. However, they can sometimes be specific to particular markets (e.g. Europe, USA, Japan, China).

Ultimately, interoperability supported by international standards enables a global vision in which different parts of the industry and consumers can interact regardless of things like location, language, and country of origin.

Public concerns

Unsurprisingly, public concerns reflect the concerns of the industrial actors in the various sectors (or vice versa). Safety and security are prominent in most sectors, and increasingly privacy and environmental impact.

An ever more demanding public has ever-increasing expectations for quality and efficiency of service - more comfortable travel, for instance, with avoidance of delays, and easier to use consumer products.

More generally the public wants better information about what it is happening around them, and more options for better-informed choice.

Qualification and certification

All Artemis sectors have requirements for qualification and/or certification. In the various transport sectors and in manufacturing and process engineering, safety is a key concern, with comprehensive and stringent requirements, particularly in aerospace.

In addition, there are increasing pressures for qualification on interoperability - such as fieldbus certification in manufacturing. Indeed, in the telecommunications sector, interoperability is tested - typically by an independent test laboratory or in a rotating manner within the facilities of the main market players, inviting other player to test products.

Concerns about the standardisation process

All sectors experience difficulty reaching consensus due to the different interests of the participating parties in the standardisation work. In aerospace and rail, for instance, there is concern over the dominance of the major stakeholders through their lobbying actions on regulations within a rather closed market. In manufacturing, what appears at first sight to be a technological issue of RFID standardisation is actually a political issue, deriving from different national standards. Even in telecommunications, where standards are seen as market enablers rather than market barriers, the economic terms for using standards for which industry retains IPR's (eg: CDMA) is a major problem in achieving consensus.

Traditionally the dominance of the US has been a concern to European industry, but now China intentionally deviates from some important international standards, for instance to reduce the licences that are attached to some of the consortium standards. For industry this has the disadvantage of market fragmentation, thus reducing the chance to earn back the costs invested in innovation.

Sometimes, there are too many standards *("When is a standard not a standard?").* For instance, in manufacturing there are 8 fieldbus standards and 11 Industrial Ethernet standards ... many of which are never used.

Finally, the main standardisation concern in most sectors - especially in telecommunications - is the cycle time necessary to get new standards approved. This cycle is slower than the technical and technological capabilities of the market players.

8.1 Generic/Cross-domain Standards 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
  8.2 Life-cycle dependant Processes
  8.3 Life-cycle independent Processes
  8.4 Supply-chain dependent issues
  8.5 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.

- Standard: OSGi (Open Services Gateway initiative)

- 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.

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.

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

- 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).
- Other national standardisation organizations (preparing for WG and proposing new work items)
- ETSI (European Telecommunications Standards Institute)
- 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.
- The Open Group (Open Source Movement) (300 industrial members)
- IEEE (Institute of electrical and electronics engineers)
- ISA (Instrument Societsy of America)
- EWICS TC7 (European Workshop on Industrial Computer systems, TC7, Reliability, Safety and Security)

- ERCIM - European Research Consortium for Informatics and Mathematics
- HSE (Health and safety Executive (UK)
- OSHA (Occupational Safety and Health Administration)
- SEI (Software Engeineering Institute, Carnegie Mellon University, Software Processes and Maturity Models)
- 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

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

- ISO/IEC 61508 (Functional Safety of E/EE/PE Systems)
- ISO/IEC 62443/ISA SP99 ("Security of Industrial Process Measure-ment 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
- CMM (Capability Maturity Model, for systems), CMMI (Capability Maturity Model Integration, software)
- 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,

8.6 Aeronautics and aerospace

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.

8.7 Automotive

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:

- CIA, CAN (Controller Area Network) in automation
- LIN (Local Interconnect Network)
- FlexRay
- Autosar. Automotive Open System Architecture. Industry.
- 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, ...)
- Environmental standards (exhaust pollution EU3, EU4, EU5,.....)
- Communication standards e.g. car-to-x communication, IVN (ETSI, ISO, MOST, AUTOSAR, Flexray.....)
- Safety standards (Brakes, lights, reflectors, airbags.....car immobilizer, tire pressure monitors,.....)
- Mechanical standards (DIN, ISO, VDA,.....)

Priority standards in development:

- Inter vehicle/road structures communications

8.8 Rail

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:

- CENELEC TC9X and TC256
- RAMS (EN-50126, EN-50128 y EN-50129),
- IEC-61508. SILs
- 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, ...

8.9 Telecommunication

N/B. Cellular aspects are excluded, being within the remit of the e-mobility platform.

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 (eg: convergence of telephony, internet, media, consumer electronics) is strongly increasing the number of competitors and the level of competition.

The most important standards bodies are:

- ETSI - European Telecommunications Standards Institute.
- OMA - Open Mobile Alliance
- ITU - International Telecommunication Union
- IEEE
- CEN/Cenelec
- 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

Standards enforcement is carried out by public regulators

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
- 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
- COBRA
- 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)
- 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.
- New organizations and fora are appearing to address specific areas still not covered by already existing organizations.

8.10 Health

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:

- ISO
- 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)
- 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 markup languages.

8.11 Private Space / Home

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 OMA - Open Mobile Alliance, IEEE, CEN/Cenelec, ISO/IEC, 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. CENELEC is the European Committee for Electrotechnical Standardisation and 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 it and connect it 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.

8.12 Manufacturing, Construction, Infrastructure & Logistics

Main actors: Industry (including construction industry), operating through ...

- IEC (International Electrotechnical Commission) (http://www.iec.ch/)
  - International, often with strong European participation, sometimes renumbers standards developed by e.g. IEEE.
- IEEE - International but often US dominated
- ISO (International Organization for Standardisation)
- EN (issued by CENORM)
- ANSI
- OPC
- Fieldbus Foundation
- Profibus International
- Microsoft
- OMG
- VDI/GMA (http://www.vdi.de/vdi/organisation/schnellauswahl/fgkf/gma/index.php)
- ETSI (http://www.etsi.org)
- ISA (http://www.isa.org/)
- ARC (http://www.arcweb.com)
- Frost & Sullivan (http://www.frost.com)
- NAMUR (http://www.namur.de/)
- AIAG (Automotive Industry Action Group)(http://www.aiag.org/) Not-for-profit organization where retailers, automakers, suppliers and service providers work collaboratively to drive cost and complexity from the supply chain via global standards development and harmonized business practices.
- IAI (International Alliance for Interoperability) (http://www.iai-international.org/) IAI is an alliance of organizations dedicated to bring about a coordinated change for the improvement of productivity and efficiency in the construction and facilities management industry. Their members engage in national-industrial programmes that aim to change the organisation, process and technology of the industry.

Main standards in use or under maintenance:

- IEC 61131-3, IEC 61508, IEC 61850,
- ATEX
- ISA / S95
- Fieldbus Organizations (e.g., HART, ProfiBus, Fieldbus Foundation, MODBUS, OPC)
- UML (www.uml.org)
- XML
- some JEDEC committees
- BuildingSMART (http://www.buildingsmart.com/) The target of buildingSMART is improving the processes of the construction industry by using open standards. BuildingSMART views itself as a "Standard of Standards", containing many component standards. It hopes to increase the re-use of information between the separate business processes of the development of capital assets to improve accuracy, performance, and cost.
- IFC (Industry Foundation Classes) (http://www.ifcwiki.org/index.php/Main_Page) It is an object oriented file format with a data model developed by the International Alliance for Interoperability (IAI) to facilitate interoperability in the building industry
- BIM (Building Information Modeling) Building Information Modeling (BIM) is the process of generating

and managing a building information model, which is a set of information generated and maintained throughout the lifecycle of a building.

- oBIX (Open Building Information Exchange) (http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=obix) Standard for Web Services-based interfaces to building control systems. Building control systems include those electrical and mechanical systems that operate inside a building, including Heating and Cooling, Security, Power Management, and Life/Safety Alarms that are in nearly all buildings as well as the myriad of special purpose systems that may be tied to particular buildings such as A/V Event Management, Theatre Lighting, Medical Gas Distribution, Fume Hoods, and many others.

There are also governmental regulations, national legislation, and EU Directives, but these very often refer to IEC or similar standards.

Priority standards in development:

- FDI (Field Device Integration)

There are no foreseen changes anticipated for the standardisation process in this sector. The main challenge is to avoid fragmentation through cross-domain and global standardisation processes, by establishing links between standardisation bodies, application domain poles and coordinating R&D policies and targets.

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