ProSE

Promoting Standardization for Embedded Systems

Strategic Agenda for Standardisation
Final Version
Task 3.3

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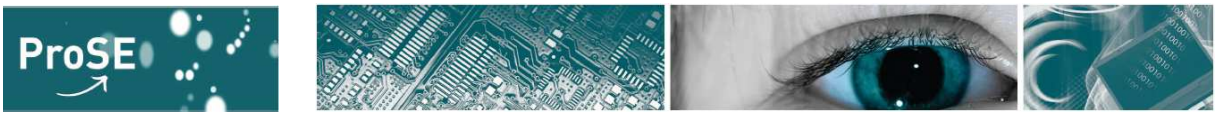

Distribution Table

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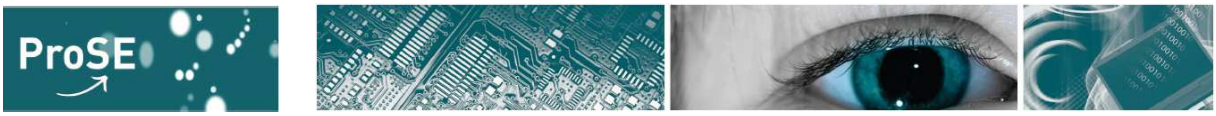
Change History

Version	Date	Reason for Change	Sections Affected
Delivery 0.1	Jan-25-2010	First working version – based on the ToC proposed by ESI and the current official strategic agenda for standardization	All
Delivery 0.2	Jan-25-2010	First Delivery for Sections on Targets for ARTEMIS Standardisation and ARTEMIS Standardisation Approach	All
Delivery 0.3	Feb-4-2010	Version with Sections 1, 2, 3, and 7 completed and the remaining sections edited	All
Delivery 0.4	Feb-04-2010	Review E. Schoitsch	All
Delivery 0.41	Feb-05-2010	Contribution from J.Laka to 2.8.6 Projects within the ARTEMIS Joint Undertaking	2.8.6
Delivery 0.5	Feb-19-2010	Refocused and restructured in accordance with outcome of Management Meeting, Feb-08-2010 (see notes of that mtng)	All
Delivery 0.6	Mar-12-2010	Contributions to Landscape section	3
Delivery 0.7	Apr-14-2010	Refinements previous to ProSE workshop on Apr 20	5
Delivery 0.8	May-5-2010	Refinements after ProSE workshop on May 4 (CEN, ETSI, TUB, Consortium)	3,5
Prov. Version 1	May-13-2010	Final version of the “Provisional delivery”	All
Final Delivery 1	September-2-2010	Includes several recommendations from the second ProSE review as well as inputs from Task 3.3	All
Final Delivery 2	September-8-2010	Updates after project internal peer-reviews	All
Final Delivery 3	September-10-2010	Improved section 3 of the SA	Sec 3
Final Delivery 4	September 16-2010	Updated with feedback from consortium	All
Final Delivery 5	November 26-2010	Updated with feedback from ProSE workshop	All
Final Delivery 6	December 13-2010	Circulated as final candidate to the ProSE consortium	All
Final Delivery 7	January 12-2011	Included feedback from the Consortium. Final Delivery (7)	All
Final Delivery 8	January 17-2011	Included feedback from the Consortium. Final Delivery (8)	Section 1



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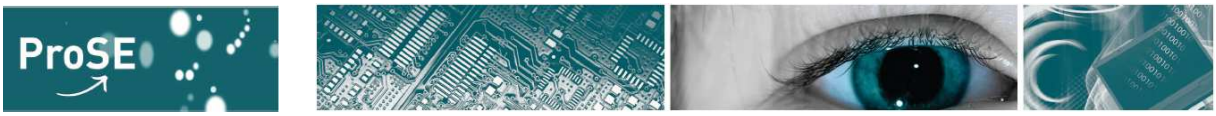


1 Introduction

This Strategic Agenda for Standardisation is proposed by *ProSE* Project (*Promoting Standardization for Embedded Systems*) to the Embedded Systems community, particularly the ARTEMIS Technology Platform (*Advanced Research & Technology for EMbedded Intelligence and Systems*), the ARTEMIS Joint Undertaking and the Industrial Association ARTEMIS-IA.

This Strategic Agenda for Standardisation establishes a framework of **strategic initiatives for standardisation** that could be used to meet different European, national or individual organisational interests in the embedded system domain. This Strategic Agenda builds on the 2008 version of the *ARTEMIS Strategic Agenda for Standardisation*[1] and updates it by recognizing the need to provide more specific mechanisms for promoting standardisation and the need to improve coordination among a large and diverse group of stakeholders in industry, standardisation and regulation bodies, consumers, and academia.

1.1 Release Notes

This is the final version of the Strategic Agenda for Standardisation following two previous deliveries:

1. Provisional version released on May 2010 to the Artemis community and identified experts.
2. Initial version of the final Strategic Agenda for Standardisation[1] produced for the ICT 2010 event “Digitally Driven”[2]. This version was produced with desktop publishing tools and delivered as physical document to interested parties. A low resolution version of the document can be delivered upon request.

This final release should be used in future phases of Standardisation promotion activities. All the proposed mechanisms, actions and promotion activities of this document are meant to be continued through the ARTEMIS-IA Standardisation Working Group and the ARTEMIS JU selected experts, facilitators and stakeholders, in order to evolve the strategy and derive a concrete annual implementation plans for the coming years[3].

Note that this is a live document that will require updates every two to three years.

[1] https://www.artemisia-association.org/sra
[2] http://ec.europa.eu/information_society/events/ict/2010/
[3] As part of the ARTEMIS JTI activities

1.2 ARTEMIS & Standardisation

ARTEMIS is a 'European Technology Platform' (ETP). It paved the way for the ARTEMIS Joint Undertaking, 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.

One of the main ambitions of ARTEMIS is to:

> ***"overcome fragmentation in the Embedded Systems industry by 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."***

To achieve these ambitions, standardisation is essential to enable communication and inter-operation within and across systems in different application sectors, to enable 'plug and play' of components and 'IP blocks' within and across sectors, and to ensure interoperation of tools in a 'tool chain'.

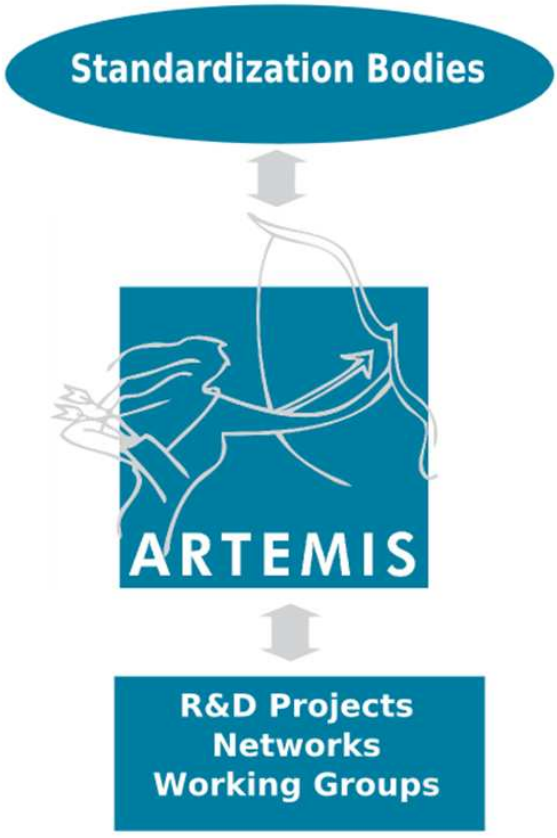


Figure 1 ARTEMIS and Standardisation Bodies

As the above figure suggests, this Strategic Agenda identifies the **ARTEMIS community** (industrial association, technology platform, joint technology initiative, joint undertaking, chambers and structures) as a key player to foster the standardisation activities of projects, networks and working groups (national or regional clusters, centres of innovation excellence etc). The ARTEMIS community would then create continuous support and guidance mechanisms for standardisation activities to discover and/or meet the appropriate standardisation development organisations, creating awareness, implementation mechanisms and processes to support the maturation of standards.

1.3 The role of ProSE

ProSE is a 32 month Support Action project within the 7th Framework Programme having the aim to support the Embedded Systems community in the implementation of their objectives with regard to standardisation.

Prior to the launch of ProSE, the ARTEMIS Standardisation Working Group developed a first version of the *ARTEMIS Strategic Agenda for Standardisation*. This document established a framework of strategic initiatives for standardisation that could be used to meet different European, national or individual organisational interests in the embedded system domain.

As indicated above, ProSE has taken forward the work of that Working Group, and updates the 2008 content by:

- providing more specific mechanisms of promoting standardisation,
- proposing ways to improve coordination between stakeholders in industry,
- recommending ways to foster cooperation between research actors on the field of embedded technologies,
- setting provisions of a methodology for identification, prioritisation and promotion of standardisation actions,
- Identifying immediate actions to handle a selected set of priorities.

1.4 Audience

This Strategic Agenda for Standardisation targets the main following audience:

1- **The ARTEMIS community in general**: As a 'European Technology Platform', ARTEMIS brings together the main stakeholders – research organizations, universities, networks and all significant industries from the technology and value chain – in the field of Embedded Systems and technologies. ARTEMIS devises and implements a common strategy for the development, the deployment and the use of these technologies in Europe. Moreover ARTEMIS as ETP has led to the creation of the ARTEMISIA Industrial Association and, together with the European Commission and member states, the creation of the ARTEMIS

Joint Undertaking. The ProSE Strategic Agenda for Standardisation should be seen as a means to reinforce the ARTEMIS aim to enhance the Embedded Systems innovation ecosystem in Europe, as described in the ARTEMIS SRA (2006 edition) and the ARTEMIS JU Multi Annual Strategic Plan (MASP), being used accordingly by this community.

2- **Technical managers and Product managers** that need to leverage standards for their development or integration endeavors, and require an approach agenda and guidelines to help them implement their own strategy. Although this Strategic Agenda for Standardisation has clear links with other elements of the ARTEMIS baseline documents, it can be used as example by other research initiatives where Embedded Systems play an enabling role.

3- **Researchers** that need to understand and get insights about the role of standardisation and the potential benefits that could arise from applying a consistent strategy for standardisation.

1.5 Agenda Stakeholders

This Strategic Research Agenda considers as **stakeholder** any **industry, research actor, organisation, standardisation body, policy maker** etc. who can be positively or negatively **impacted** by, or **cause an impact on**, **the mechanisms** and **complementary actions** derived from the agenda.

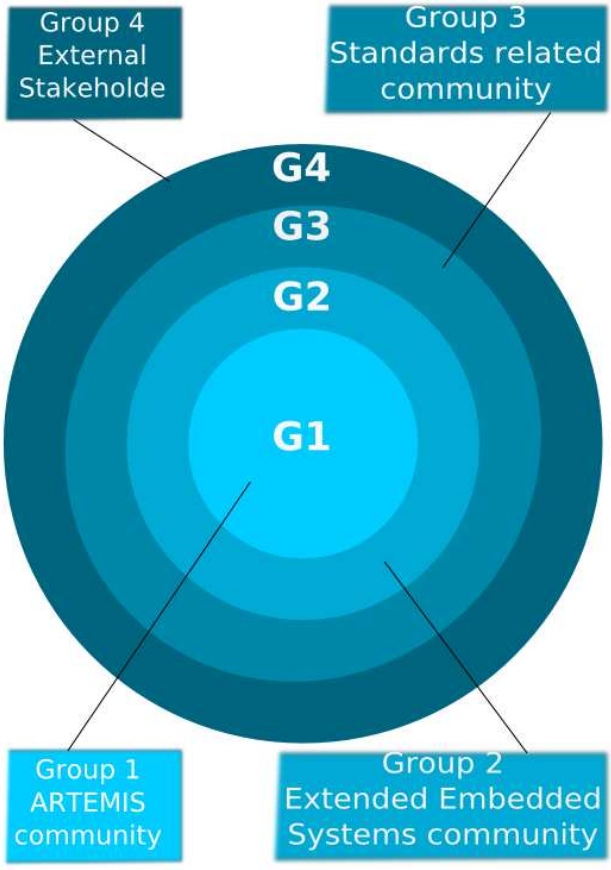


Figure 2 ProSE Stakeholders

Stakeholders include:

Group1: **ARTEMIS community**

Group2: **Extended Embedded Systems community**, including:
- Industry (Manufacturers, Suppliers and Integrators).
- Significant non-European Embedded Systems actors.
- Other ETPs and related platforms.

Group3: **Standards related community**, including technical committees and work groups[4], certification/licensing and regulators etc:
- EU (and national) officials.
- Public authorities.
- Professional, trade or industrial associations.
- Regulators.
- Certification/licensing agencies and assessors.

Group4: **External stakeholders**, including:
- Various interest or user groups (e.g. consumer associations).
- Communities (technical, commercial, etc).
- Society in general.

[4] Standardisation bodies (e.g. CEN, CENELEC, ETSI, OMG etc) are recognized as key facilitators and not as stakeholders. TCs, WGs and other entities participating in standardisation initiatives facilitated by standardisation bodies are the real stakeholders (industries, interest groups and research entities).

2 Scope

The scope of this Strategic Agenda is aligned with the scope of the *ARTEMIS Strategic Agenda for Standardisation 2008 Version*. It is focused on the specific needs to realise the aims of ARTEMIS, such as cross-domain interoperability and systematic re-use, and on supporting the implementation of the ARTEMIS SRA through standardisation-related activities. It does not address standards that may be expected to emerge and evolve naturally through the operation of the market.

The scope encompasses 'standards' of all kinds

- Those produced by official standards organisations.
- *Ad hoc* and *de facto* standards (that might later be made official and *de jure*).
- Domain-specific standards (though paying attention to the cross-domain ambitions of ARTEMIS).
- Generic standards.

This Strategic Agenda is itself a short-term agenda in the sense that it should be revised regularly, but it is intended to achieve impact over all of the short term, medium term and long term. It contains **recommendations for ARTEMIS to take significant responsibility for over-seeing standardisation in Embedded Systems and to institute long-lasting processes that should have both medium and long-term impact in a much more general way than promotion of specific standards**.

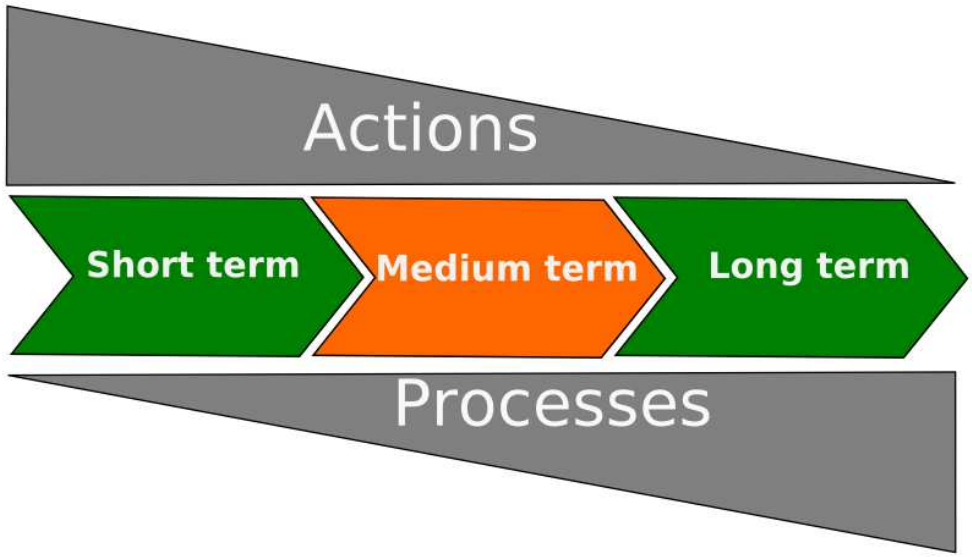


Figure 3 Impact of actions/processes vs. time

While the generic recommendation to implement the long term processes has a strategic value, the agenda contains specific recommendations to ARTEMIS for support of a selection of specific

standardisation actions in both the short term (tactical) and the medium (transition to strategic) term.

While much discussion exists on the classification of private specifications as de-facto standards for some industries, ProSE adopts the categorisation provided by the COPRAS Guidelines[5] and included in the ProSE Charter.

Categories & types of standards	Formal standards	Informal standards	Private specifications
Normative standards (describing with which something should comply)	developed by a national (AENOR, ANSI, DIN, etc.), regional (CEN, CENELEC, etc.) or international (ITU, ISO, IEC, etc.) standards body, and passes through this organization's formal approval process	Technical specifications developed by a formal standards body, or a Standards developing Organization (e.g. IEEE, IETF, W3C, etc.) and based on consensus among organizations' members, or the participants in the process, and approved according to the relevant procedures of the organization concerned	Specifications developed by a single company, a trade association or an (industry) forum with closed membership
Informal standards (providing helpful information and guidance)		Recommendations or reports developed by a formal standards body, or a Standards Developing Organization, and based on consensus among organizations' members	Reports, recommendations, codes of conduct, etc., developed by a single company, a trade association or an (industry) forum with closed membership

Figure 4 Standards and Categories, COPRAS

The scope of the standards that are the subject of specific action is unlimited (within the constraints of the ARTEMIS interests set out above). It includes:

- Systems, sub-systems and software, including functional entities (e.g. models for sub-systems).
- Products and product lines.
- Components, including 'IP blocks'.
- Processes, including both technical processes and management processes.

[5] Based on principles for the categorization of standards provided by Dr. Peter Hatto, Chairman UK NTI/1and ISO TC 229 Nanotechnologies Standardization committees

3 The Embedded Systems Standardisation Landscape

The *ARTEMIS Strategic Agenda for Standardisation 2008 version* described some aspects of the landscape of standardisation for Embedded Systems. In particular, it established the need for standardisation to fulfil the specific aims of ARTEMIS. ProSE has now expanded that initial description of the landscape.

3.1 Needs for Standards in the Embedded System Industry

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, etc. Moreover the conclusion of the landscape setting activities of ProSE is quite negative: The Embedded Systems standards landscape is at least as fragmented as the Embedded Systems industry.

A recent study commissioned by DG-Enterprise[6] on ICT standardisation policy needs 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".

The ARTEMIS SRA identifies the following key emerging challenges in the field of Embedded Systems:

a) 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.

b) To make the change from design by decomposition to design by composition.

Standards are a core concern in both challenges:

a) 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.

Issues: 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 standardisation

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

committees, different contributing communities, and even different standardisation bodies. This fragmentation has the consequence that existing and emerging standard proposals are also very fragmented across both application sectors and design flows and their associated tool-sets. In fact it is not uncommon to find several “flavours” of apparently standardised technologies, producing undesired technical dialects that obstruct the technical and semantic interoperability of tool-sets and methods. Moreover we need to consider the fact that most of future embedded systems are likely to be heterogeneous, dynamic coalitions of systems of systems. As such they will have to build upon multi-domain applications and platforms and then assessed to common, or at least well-integrated, standards and guidelines.

b) In a typical development process, an embedded system is developed by composing pieces which, all or in part, have already been designed or implemented independently by different teams or different companies. This allows flexible integration of designs and implementation artefacts and the easy inclusion of novel and ever-increasing complex functionalities. Thus, the ability to integrate components and subsystems gives competitive advantage in the embedded system market.

Issues: The lack of an overall understanding of the interplay of the subsystems and of the difficulties encountered in integrating very complex parts cause system integration to become a nightmare in the embedded system industry. The reason for these issues is clearly the difficulty in managing the integration phases with components/subsystems that come from different suppliers who use different design methods, different domain models, different software architectures, different hardware platforms, and often proprietary real-time operating systems and development frameworks.

3.2 Relationship between Embedded Systems RTD and Standardisation

There have been many attempts over the years to encourage research and technology development projects to address standardization, in order to facilitate take-up of project results - and for take-up not to be precluded by standardisation on alternative technology. However, this does not usually happen. An independent European Evaluation[7] 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. “

There is a variety of reasons why this is so:

[7] ref.: ftp://ftp.cordis.europa.eu/pub/technology-platforms/docs/evaluation-etps.pdf

- During the limited lifetime of research projects, results do not become sufficiently mature for standardization;
- Even when researchers are employed by companies that are actively engaged in standardisation, the researchers often do not have direct responsibility to deal with standardisation issues and are not familiar with the market drivers that motivate standardisation, and there is poor communication between researchers and the people in their companies who are aware of standardisation issues and competent to handle them;
- Industrial partners do not define a standardisation roadmap to provide a framework for researchers to contribute to standardisation;
- Standards are (generally) documents that require ongoing engagement extending beyond the lifetime of specific research projects;
- Even when standardisation is addressed by research projects, it is often addressed too late to create significant impact.

Nevertheless, some projects have addressed standardisation after the end of their projects either by targeting industrial or research groups involved in standardization or through follow-on support actions. And as an alternative approach, there have also been some support actions to draw up standardisation action plans for groups of related projects. Examples of more successful RTD-led standardisation actions include:

- HIJA (RT-Java for safety critical systems)
- DECOS results (by partner Audi into AUTOSAR safety, AIT in IEC 61508 MT)
- SECOQC (ETSI: Quantum Key Distribution Standard ISG)(AIT)
- GENESYS (GENeric Embedded SYStem Platform - TUV)

Annex A contains also extended information about specific standardisation projects that form useful and significant baselines for ProSE:

Project	Programme	Description
MAXI-QUEST	FP5	The project aim was to improve mutual awareness and initiate sustainable measures that would improve integration between the suppliers and users of normative research. The consortium included CEN, 3 National Standardization Bodies and a leading NMI with extensive experience of both research and standardization
INTEREST	FP6	INTEREST: Integrating Research And Standardisation. The overall objective of INTEREST was to develop taxonomies of standards, of research outputs and of research-standards relationships and to contribute to the improvement of the interface between research and standardisation, and thus contribute to the effective diffusion and utilisation of research which is being performed in Europe.

COPRAS	FP6	The 'COoperation Platform for Research And Standards' aimed to establish a supporting action to enable the FP6 IST projects (in all the three envisaged calls) to interface with the standardization activities in Europe and elsewhere in a consistent and effective manner while increasing standards awareness within the research and technical development area.
NO-REST	FP6	The Networked Organisations - REsearch into STandards and Standardisation Project (NO-REST) was created to investigate the applicability and dynamics of standards in the e-business, e-government and ICT sectors in order to develop tools for the assessment of their performance and of the impact they have on networked organisations.
ARCADIA	FP7	ARCADIA's major objective of advancing the European Research Area in the Embedded Systems field is based on the appropriate involvement of National and Regional Authorities across Europe.
COSINE	FP7	COSINE 2 (Co-ordinating Strategies for Embedded Systems in the European Research Area) is a Specific Support Action (SSA) whose goal is to enhance the impact of European RTD strategies in the area of Embedded Systems.

Notwithstanding the efforts of some projects, such as these, there is a clear need to address the structural obstacles to more efficient and effective interplay between research and standardisation.

3.3 Role of standardization bodies

Understanding the role of **Standards Development Organisations** (SDOs) for the production of what we call "good standards" is key to implement promotion activities. Good standards say "what" needs to be developed, not "how", and allow different technological implementations to achieve more or less the same effects while remaining interoperable among different implementations. SDOs do not write standards - a typical misconception. SDOs facilitate the standardisation process and provide rules, regulations, support and intelligence for industries, interest groups and research actors to produce good standards.

While standardisation bodies typically offer services that facilitate the preparation of standards they are not, in general, pro-active in scanning the development of technology and seeking to identify the most appropriate topics for standardisation. Instead, it is necessary for interested parties to propose topics to the standardisation bodies. SDOs are key enablers and facilitators rather than active players. Moreover, the project INTEREST [INT-I 2005] show that 50% of organisations and their representatives in Technical Committees (TC) are industrial, and 28% are members of industry supported interest groups. Only 14% of participants are research actors, demonstrating the predominant role of market drivers on standardisation activities.

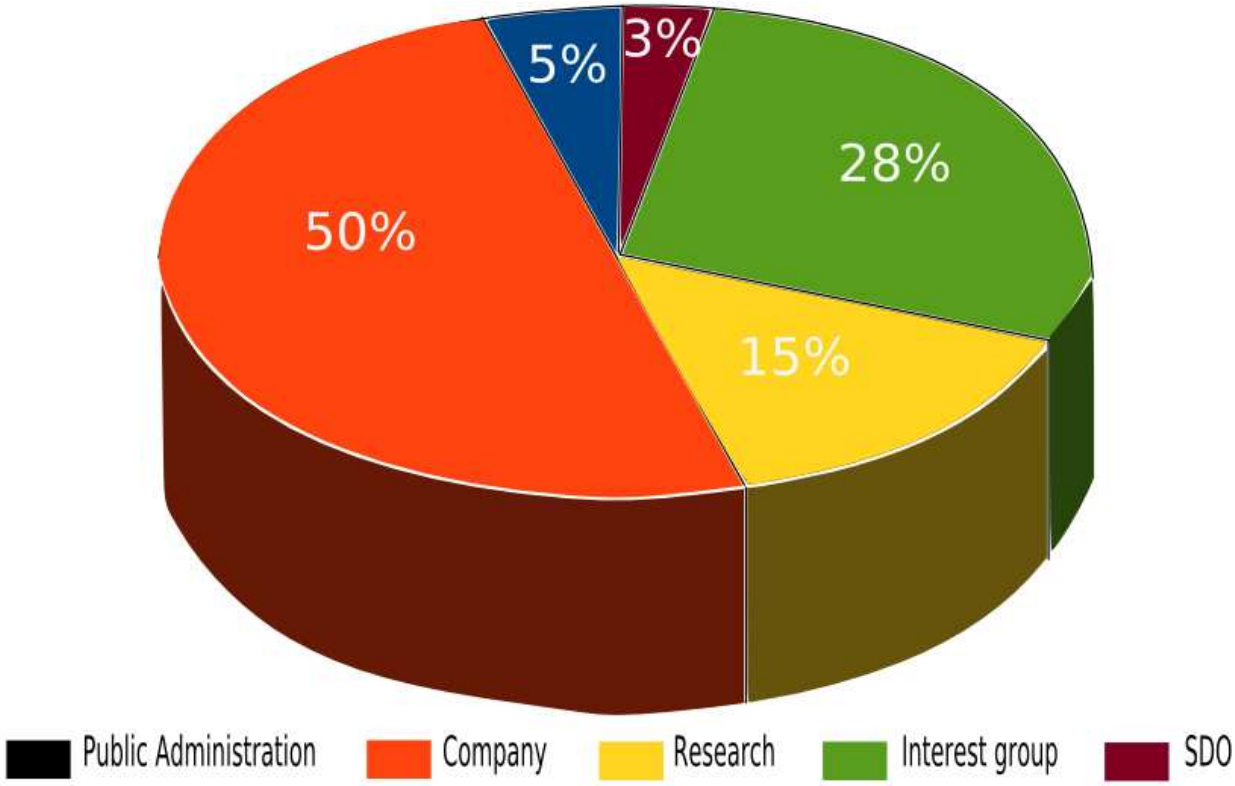


Figure 5 Distribution by organisation type at CEN, CENELEC and ETSI. INTEREST.

Structural problems in industry and in the nature of research programmes inhibit the ideal flow of ideas from research to standardisation. If the standardisation bodies are not to take a proactive lead then, at least in the field of Embedded Systems, this must be the role of ARTEMIS – as indeed was originally envisaged in its Strategic Research Agenda .

3.4 Role of standards in the market

The incubation, maturation and adoption of standards can powerfully accelerate the market adoption of new embedded technologies. Standards compliance is a powerful market delivery mechanism, as technology developers, suppliers, integrators and vendors avoid the risk of costly modifications and unmanageable product portfolios that may result from customized or proprietary implementations, or non-compliance with regulations (e.g. safety related). Standards give intermediate embedded system integrators and final consumers the confidence that products will work together, that they will have alternative market choices, and that they won't be subject to always non-desirable vendor lock-in situations.

Standards perform a range of key functions in a modern and technology based product and services economy:

1. They may foster compatibility and **interoperability** between services, products or systems; they may serve to enhance quality.

2. They provide market **stability**, when standards provide a consolidation around a framework of meaningful, widely accepted standards. The greatest value of standards is felt when an industry gathers consensus through an open, fair and equitable process [IEE-SA,2009].

3. They may efficiently increase **reuse,** enabling economies of scale and trade.

4. There is clear connection between the development of standards, the associated process of standardisation, and the long run growth of **productivity**.

Several international initiatives are in place to provide standards-related platforms to foster trade and market adoption of products that comply with standards. We can identify several, some horizontal and focused in general on standards and bilateral trade (e.g. the ANSI initiative "Standards Portal" fostering trade between the US, India, China and Korea[8]) others vertical in terms of industry (e.g. the Industry association for printed circuit board and electronics manufacturing service companies –IPC- standards focus [9]) and finally some fostering "single markets" (e.g. the *New Approach Standardisation in the Internal Market* initiative of CEN, CENELEC and ETSI together with the Commission and EFTA[10]).

However standardisation, while accepted as a trade fostering mechanism, is not a cheap process itself as it involves costs that in many cases are not clearly identified as investment (CAPEX) or expenditure (OPEX). Moreover, what is the return on investment (ROI) of the standardisation activity? Is there a clear profitability index (PI) associated to each standard? What is the net present value (NPV) of investment in standardisation? All these questions remain under discussion, and are not in the scope of ProSE.

There is little doubt that standards, apart from providing interoperability and variability management, are fundamental for productivity in the medium-long term as they contribute in improving the time-to market, while creating levels of confidence on procurement processes. If we focus our considerations on productivity in the ICT industry, we will find that there is clear connection between standards, productivity gains and technical change. As stated by "*Most studies of growth based upon the idea of a production function have concluded that technological change – in the form of changes in the underlying relationship between inputs and output, as opposed to the accumulation of inputs – has been responsible for a major share of improvements in productivity*" [DTI,2005].

[8] http://www.standardsportal.org/
[9] http://www.ipc.org/ContentPage.aspx?Pageid=Standards
[10] http://www.newapproach.org/

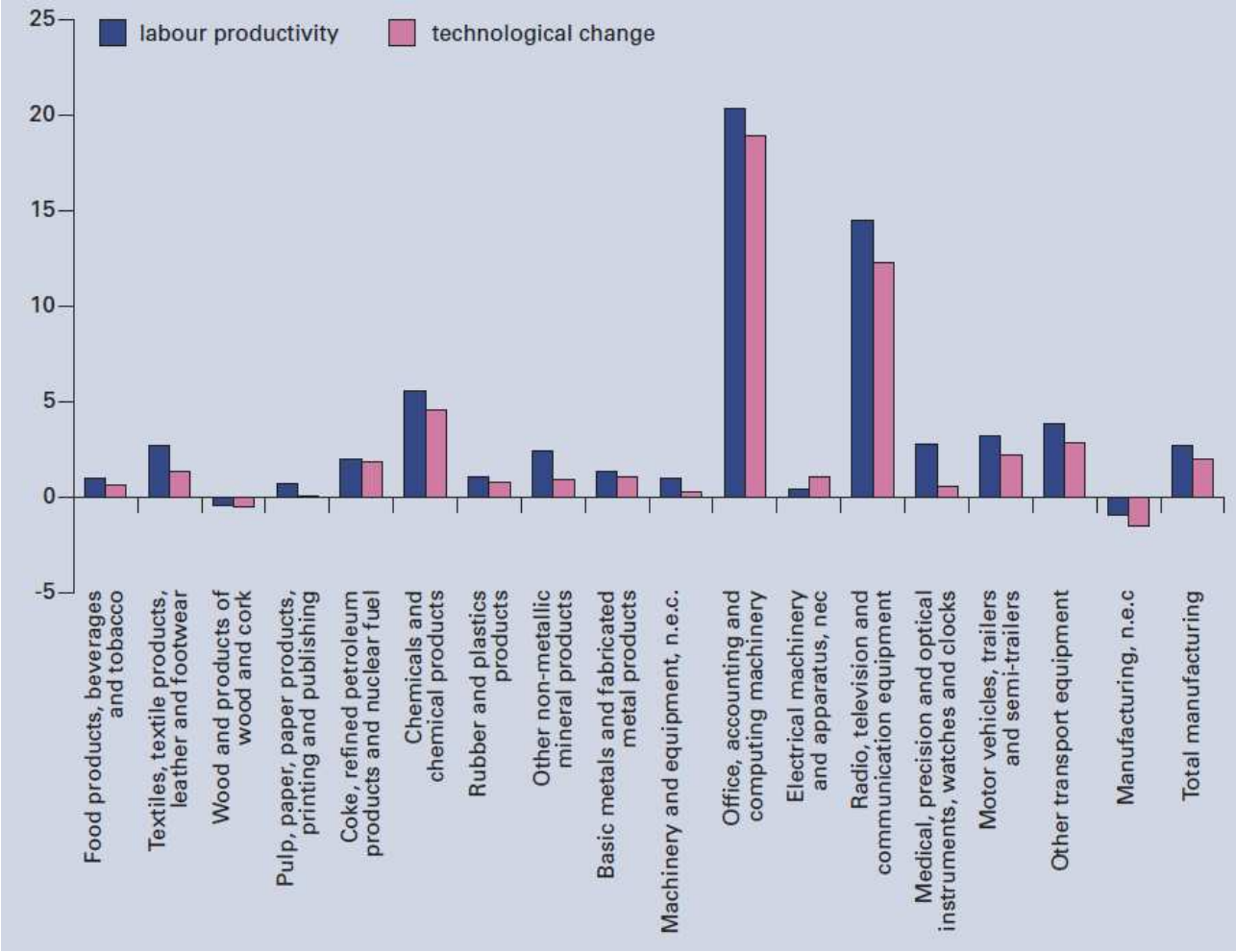


Figure 6 Contribution of Technological Change to the Growth of Labour Productivity
By Manufacturing Sector 1990-2000 (% per annum) – OECD (STAN) database as at April 2004 [DTI,2005]

Note that while all sectors are dependent one way or another on Embedded Systems and communication technologies, the great winners are those related directly with the “broad ICT” sectors. While the connection between productivity and technology change is variable across different industries, as stated in the above figure, there is an industry independent relationship between technology change and standards, as the widespread adoption of computing or communication technologies requires certain levels of technical and even semantic interoperability that cannot be realised without common places and vocabularies provided by standards.

There is also evidence [DTI,2005] that shows how the market is demanding more standardisation efforts, as shown by the significant growth of standards released in Europe. The following figure shows this increase for Europe and four key countries (UK, Germany, France and Italy):

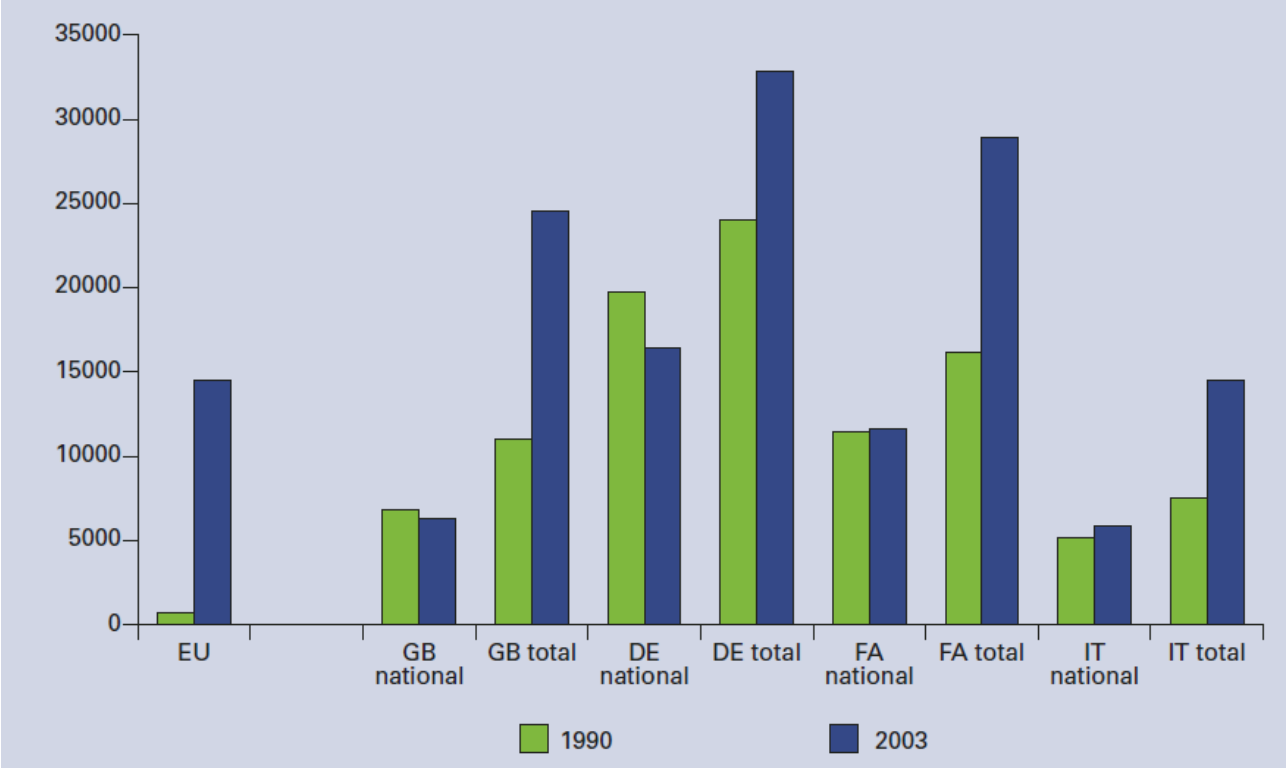


Figure 7 The Growth of the Standards Catalogue in Four Economies (1990-2003). PERINORM[11]

The connection between the availability of standards, the associated process of standardisation, and the long run growth of productivity is clear, and ProSE aims to set and maintain strategies for R&D initiatives on Embedded Systems to tackle the standardisation efforts from the very beginning, providing support for those researchers and initiatives (projects, networks, platforms etc) looking after the establishment of future market standards or the cross-domain application of established standards, and fostering market synergies.

3.5 Specific standardisation needs in Embedded Systems

An annex to the 2008 *ARTEMIS Strategic Agenda for Standardisation* provided a snapshot of the standardisation issues concerning ARTEMIS application sectors – both within sectors and across them. This revealed a great number of topics of concern for standardisation, initially addressed among other teams and communities through the ARTEMIS WG on Standardisation.

Given this vast space of possibility for action, ProSE filtered and prioritised topics for special attention. The way in which ProSE did this is outlined in the next section (*Section 4: 'Approach'*). The results are summarised in section 6 of the present document *('The Way Forward')*. In addition, the ProSE Deliverable D2.2 *'Intermediate Report on Standards Promotion Process'*, which details the process of prioritisation, provides considerably more detail on a prioritised set of key candidates than was possible in the 2008 strategic agenda.

[11] PERINORM is a database edited by AFNOR, BSI and DIN covering national and international standards.

4 Approach

The approach taken by ProSE in the derivation of this Strategic Agenda followed the ARTEMIS approach, as set out the 2008 version of the *ARTEMIS Strategic Agenda for Standardisation*. A guiding principle of that strategic agenda is that given the wide scope of ARTEMIS, the multiplicity of standards, and the multiplicity of standardisation organisations pertinent to Embedded Systems, it would be unrealistic to address the problem of fragmentation for Embedded Systems by bringing all Embedded Systems standardisation activities under one management umbrella. Instead, the approach taken by ProSE has been to **identify the highest priority needs** for standardisation actions to support the aims of ARTEMIS, and **to facilitate** those actions.

To achieve this, ProSE established a methodology for prioritisation of standardisation needs and for building links with the standardisation bodies in order to foster the emergence of standards in line with the high level objectives of ARTEMIS. ProSE undertook:

- Study of the state-of-the-practice, and identification of the gaps in terms of standardisation.
- Identification of expert groups that contribute to formulation and prioritisation of standards.
- Provision of operational support to gather structured knowledge from experts (e.g., assessments, workshops).
- Communication of the global findings and results to get further feedback.
- Systematic selection of candidates for standardisation.
- Definition of appropriate (according to the standards' maturity level) strategies to foster standards.
- Definition of a revised Strategic Agenda for Standardisation (*this present document*).

ProSE first explored the current situation regarding standardization organizations and other bodies, groups and other key players with a significant interest in standardisation. The *'Embedded Systems Standardisation Landscape'* set out in the 2008 strategic agenda provided a basis for this work. The work and the results are described in Deliverable D1.1 *'Survey and Classification of existing Standardization Bodies'*.

ProSE also explored the current situation regarding needs, achievements and expected future areas of interest in the field of Smart Embedded Systems, with a focus on the emerging results of R&D activities. This work and the results, including more than 50 promising candidates for standardisation promotion, are described in Deliverable D1.2 *'Survey and Classification of relevant R&D Results in Embedded Systems'*.

In parallel, ProSE devised a process for identifying, prioritising and promoting candidate topics for standardisation actions involving more than 275 experts familiar with ARTEMIS technologies. This process is described in Deliverable D1.3 *'ProSE Charter: Work Model and Procedures'.* One of the key aspects of the charter is that the work model describes a transparent and non-biased mechanism to transform qualitative information into quantitative data that can describe the attractiveness of a particular candidate, under 27 criteria items. The criteria items are:

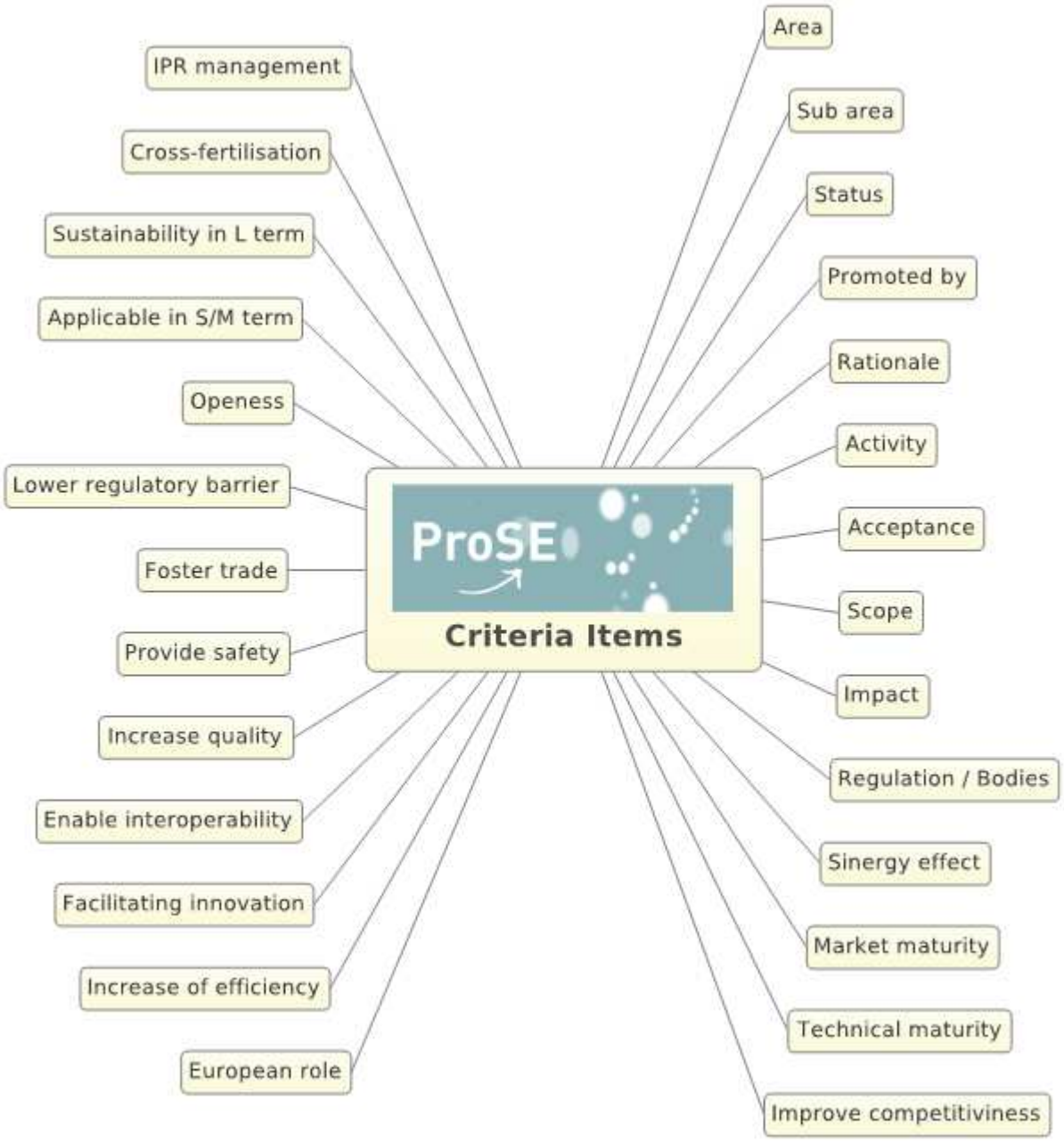


Figure 8 ProSE Criteria Items

Each criteria item has a clear rationale or set of key questions in order to assess each of the different aspects with objectivity:

ID	CRITERIA	RATIONALE
1	Area	Does the candidate fall clearly into one or more of the ARTEMIS Application Domains ? (two required)

ID	CRITERIA	RATIONALE
2	Sub area	Does the candidate fall clearly into one or more of application sud-domains such as 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, etc ?
3	Status	Does the candidate fall clearly into one of the three categories of existing, evolving or potential standards?
4	Promoted by	Does the candidate have clear promoters, significant to the field of embedded systems ?
5	Rationale	Does the candidate have solid technical standardisation objectives, significant to the field of embedded systems ?
6	Activity	Does the candidate present evidences of sustained and substantial activity ?
7	Acceptance	Does the candidate standardisation activity have significance acceptance? Acceptance is key in several aspects, such as in training and technical staff availability. Finding staff, trained and experienced in standardized technologies is many times easier – and hence cheaper– than finding the same staff trained to work with proprietary technology.
8	Scope	Does the candidate scope represent major benefits for the industry of embedded systems ?
9	Impact	Does the candidate standardisation activity provide improved sales efficiency?
10	Regulation / Bodies	Does the candidate present links or □oger□an□tions with key regulatory or standardisation bodies ?
11	Sinergy effect	Does the candidate provide evidences of possible cross-domain synergies across technical areas or application domains ?
12	Market maturity	Does the candidate target mature markets, ready to embrace and accept standards ?
13	Technical maturity	Does the candidate show technical maturity ?
14	Improve competitiviness	Does the candidate standardisation potential / impact provide increased market access and product or service acceptance ?
15	European role	Does the candidate support the advancement of European Technologies ?
16	Increase of efficiency	Does the candidate standardisation activity support economies of scale, providing the means for systematic reusability of modules and artifacts?
17	Facilitating innovation	Does the candidate facilitate innovation by providing technical layers for actors that can benefit of the candidate technology by developing innovative products and services on top of them ?
18	Enable interoperability	Facilitating interoperability and composability of standardised Technologies and domains.
19	Increase quality	Does the candidate standardisation activity provide the means for quality products/services, through prototyping, testing, certification etc?
20	Provide safety	Does the candidate serve the public by safe and dependable products.
21	Foster trade	Does the candidate standardisation activity provide simplification of contractual agreements, or lowering of trade barriers?
22	Lower regulatory barrier	Does the candidate lower regulatory barrier in national or regional markets by providing norms or recommendations required to deliver technologies in those geographical markets ?

ID	CRITERIA	RATIONALE
23	Openess	Does the candidate provide openness in the for of “open standards” ?
24	Applicable in S/M term	Does the candidate standardisation activity provide short-term market applicability? Products that use standards are less likely to require short-medium term replacement in order to integrate with other, newer products and standards organizations many times provide migration paths to newer versions of standards supporting next generations of product.
25	Sustainability in L term	Does the candidate standardisation activity provide long-term market applicability? Investments are better protected since the market generally provides replacement for standards based products in case technologies have to retire.
26	Cross-fertilisation	Does the candidate show potential for cross-domain applicability even if not considered from the beginning ?
27	IPR management	Does the candidate standardisation IPR policy deliver appropriate practices?

Table 1 The ProSE criteria for candidate assessment

The collection of 27 criteria items is the key to understand the ProSE processes, as depicted in the following figure.

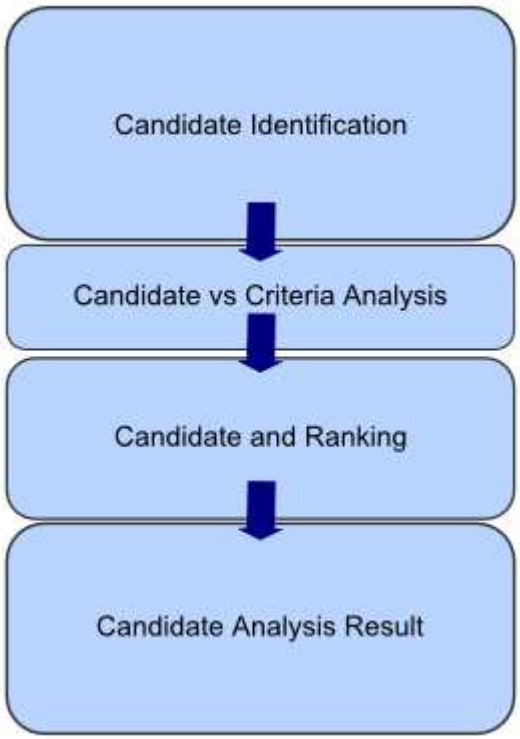
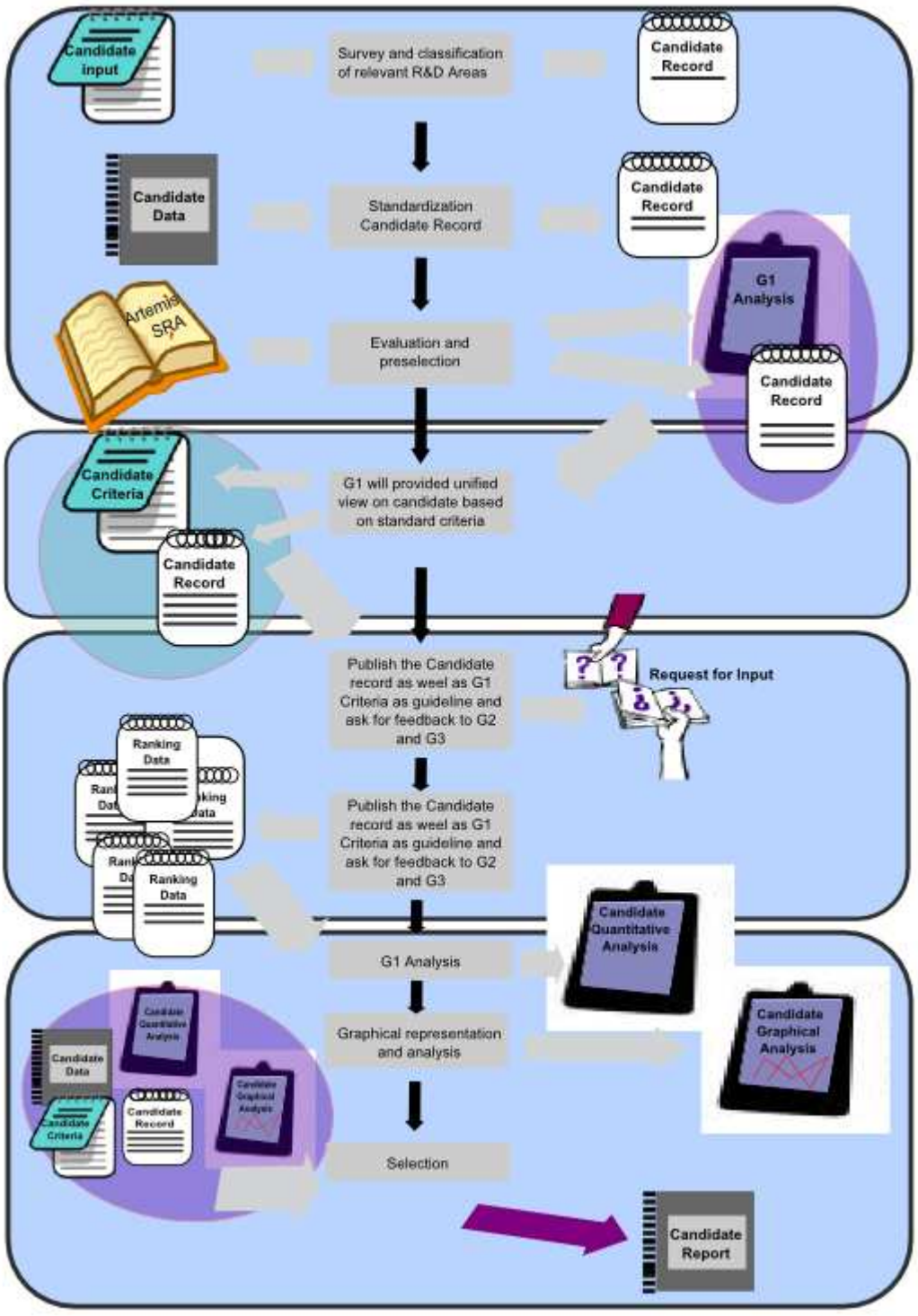


Figure 9 ProSE High Level Process

Based on the results of these activities, ProSE then defined a set of cooperation actions between the providers of the candidates, standardization bodies, and stakeholder communities to reach a certain quality and consensus.

This process was performed in parallel with promotion activities. As an example, workshops were organized to discuss individual initiatives and to establish the further coordinated actions required for acceptance at level of national and international standardisation bodies.



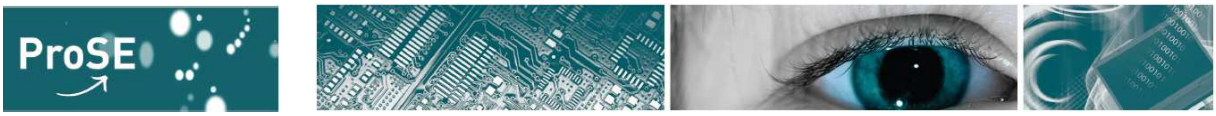


Figure 10 ProSE general activities and processes

Major goal of the expert participation in ProSE was candidate enrichment and candidate brokering.

☑ Enrichment of standardization candidates in a way that proposed candidates reach a mature status to be successfully promoted, a standardization body is found and first contacts between body and candidates are established. Obviously this requires intense interaction between the promoting team (ProSE) and the stakeholders and experts (including standardisation organizations). As most efficient form of interaction personal addressing (number one choice) and indirect addressing via workshops or booths on conferences was chosen.

☑ Brokering of standardization candidates to appropriate Standardisation Bodies either means initiating a new work item, or influencing evolving standards respectively initiating or influencing maintenance of existing standards. Here, the promotion function of ProSE is not aiming at writing standards, but feels responsible for establishing contacts between responsible experts from the Standardization Bodies as well as from other stakeholders appropriately, including ProSE partners' existing involvement in standardization groups and national committees.

Obviously both processes – enrichment and brokering – have to run in parallel, in order to identify most promising standardization candidates, in order to help defining a mature status (that is approved by involved experts), in order to identify standardization needs (regarding existing (maintenance phase, updating), evolving (influencing) and potential new ones in areas not yet covered), and in order to establish contacts between promising standardization candidates and appropriate standardization bodies.

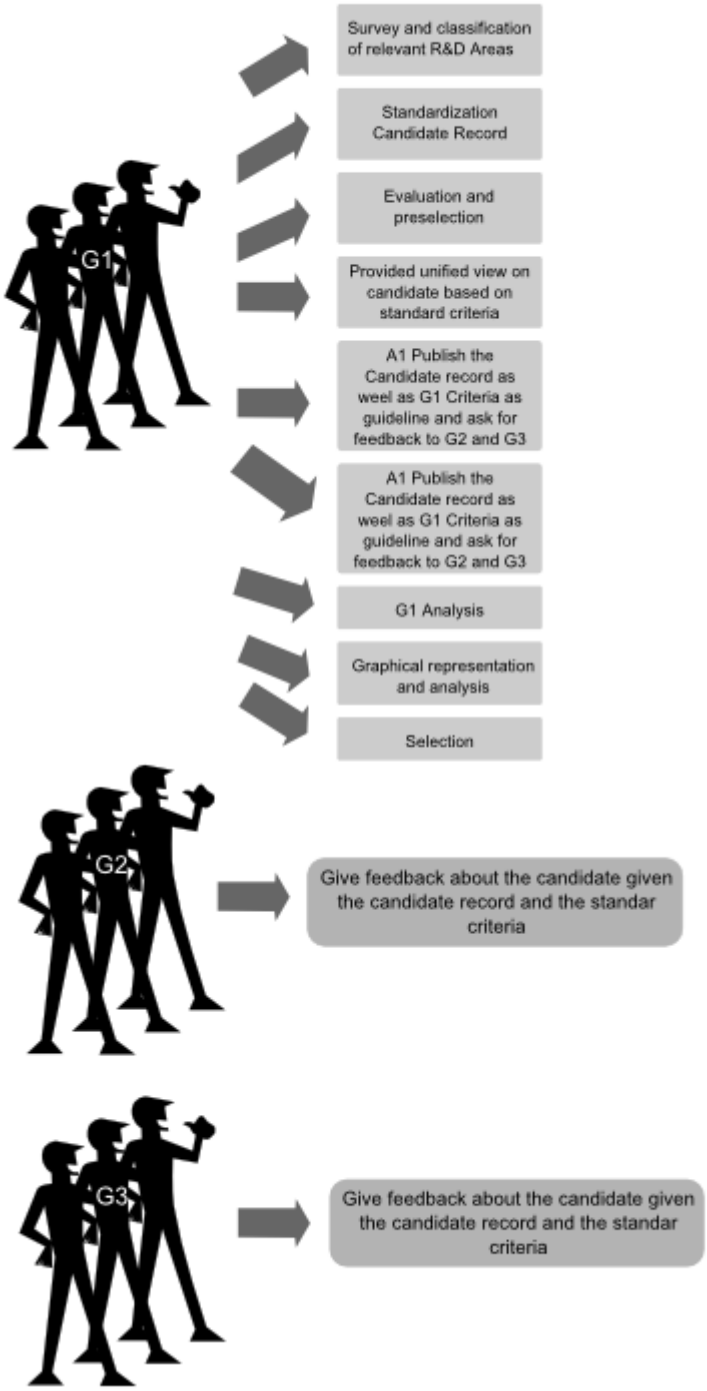


Figure 11 ProSE Roles (G1-G2-G3)

During this phase, an additional activity was an examination of the role and effect of IPRs for standards promoted by ARTEMIS.

These activities led to the selection of a limited set of high priority standardisation topics. ProSE Deliverable D2.2 *'Intermediate Report on Standards Promotion Process'* describes in detail the process by which these were selected. *(See Section 5 of the present document – 'The Way*

Forward'). An unanimous conclusion of all workshop participants was that a constant promotion activity is needed and a continuous process is required.

However, as the project evolved it became apparent that to achieve a rich engagement of the community in the project, and to achieve the ProSE timescales, it was necessary to deviate occasionally from the processes that were defined in the earlier phases of the project. ProSE Deliverables on the ongoing evaluation of ProSE Practices provide a critique of the approach taken by ProSE, describes the mitigating actions to address the difficulties that were experienced, and offers some 'lessons learned'.

While some standardisation actions have already been taken during the course of the ProSE project, the majority remain as recommendations for future initiatives, further detailed in section 6 – "Actions and Recommendations".

5 The way forward

This section comprises a set of **policies, actions, mechanisms and specific proposals** for support of standards in certain topic areas to promote standardisation. While these will require the engagement of many different actors in the Embedded Systems community, including industry, academia, standards organisations, and the European Commission, ARTEMIS, and specifically ARTEMISIA, must provide leadership.

From a general perspective, standardisation should be directed so as to bring advantages to the embedded system industry such as:

- Aggregation of demand to support innovation.
- Facilitation of interoperability and composability.
- 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.

More specifically, in view of the ambitions of ARTEMIS to ‘de-verticalize’ the industry, a major role for ARTEMIS is to harmonise standardisation activities across the various domains of ARTEMIS in parallel with development of cross-sector technological solutions with associated standard specifications.

This Strategic Agenda therefore continues to target cross-domain fertilisation as key challenge for the industry and the application of standards. Cross-domain synergy can be created in many different ways:

- Creating new standards.
- Extending existing standards.
- Filling gaps in the standards landscape.
- Improving the ‘fitness for purpose’ of relevant standards, and promoting them to be accepted by appropriate standardization body as official standards where this is not already the case.
- Replacing domain or application specific standards by more generic ones.
- Harmonising standards across different domains.

The most promising approach is to harmonise across different domains, identifying “standard lines” in the same way that product lines are managed: identifying families of standards by common

features (markets, technical issues, strategies), managing variability of market and research activities and if possible aligning standards so that they share common concepts that could be expressed in different ways but fundamentally share common semantics, and to achieve convergence of standards in related areas.

All key actions and recommendations of this section (5) are summarised and their interrelationships made clear in the next section (6).

5.1 Principles

ARTEMIS should adopt a set of principles to underpin the promotion of standardisation in the Embedded Systems domain. An initial set of principles are summarized below.

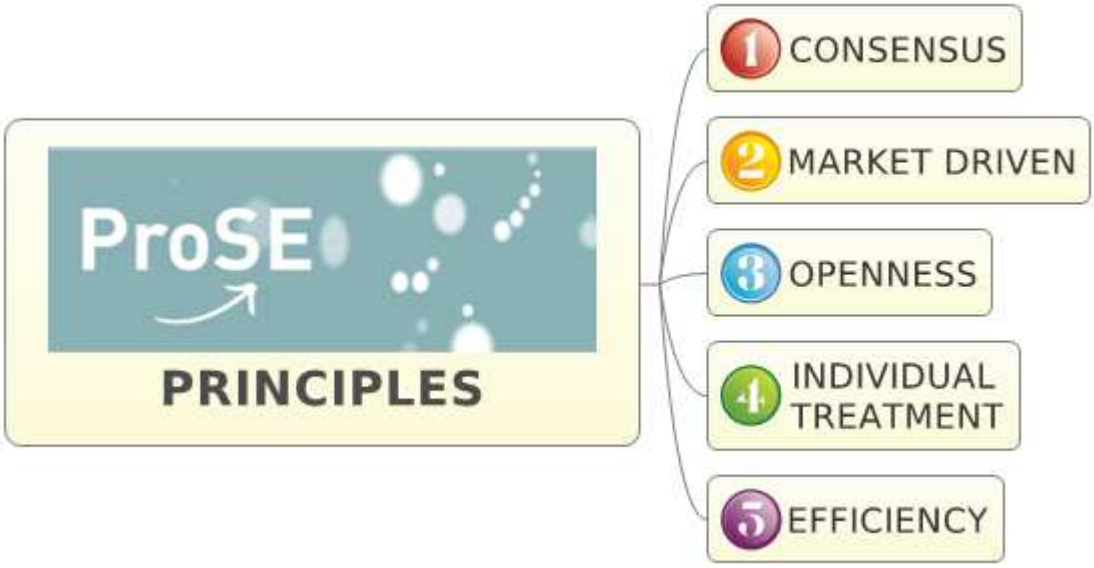


Figure 12 ProSE Principles

Consensus: decisions should be made through consensus among stakeholders. To help to achieve this ARTEMIS should maintain and evolve the structure of stakeholders for standardisation that has been established by ProSE.

Market-driven: the market and regulatory needs as well as the technological requirements and progress within the ARTEMIS application domains should determine the criteria for prioritisation. ARTEMIS should not favour candidate standards based upon whether they are formal, informal, or private standards, nor whether they are normative or informative standards. The ProSE Charter recognises this.

Openness: the processes of identification and evaluation of candidates that should be promoted for standardisation, and the process for evolution of the criteria used for identification and evaluation, should be open and transparent. In the processes followed by

ProSE, a variety of stakeholders played a role – the ARTEMIS community, the industrial community, the R&D community, and the standards community. These diverse interests have been and should continue to be impartially represented in the ARTEMIS standardisation activities. Reusing terms and principles applied by SDOs to the rules that they have adopted in the management of intellectual property rights related to their work, "fair, reasonable and non-discriminatory" terms must be applied, but this time to the processes of identification and evaluation of candidates.

Individual treatment: the promotion process must be driven by mechanisms that fit the problems at hand, since no unique standards mechanisms can satisfy all needs. ARTEMIS is not limited to existing or to emerging standards. Selected cases will receive support from ARTEMIS by getting started in the standards process where there are no pre-existing standards, or by extending existing standards where there are benefits to be gained by the ARTEMIS Embedded Systems community.

Efficiency: the process of standard formulation should be efficient and timely with regard to the evolution of the market. ARTEMIS aims to reduce the time to design and elaborate standards in order to better match the dynamic nature of our markets and economies. A standard should define essential characteristics instead of detailed designs, where possible. This is also consistent with the need to define standards that are suited for different contexts and to be implemented with different methodologies.

5.2 Standardisation and the Innovation Environment

ARTEMIS should seek better coupling between the standardisation process, the activities of research projects, and the evolution of markets and the marketing ambitions of industry. The ARTEMIS SRA highlights the fact that R&D efforts yield better results when an appropriate innovation environment exists to facilitate a more effective relationship between research and product development. It also recognises that this requires a structured approach to standardisation.

As indicated above in the section concerning the 'landscape' for Embedded Systems standardisation, this has not yet been achieved.

ProSE has begun this process by structuring and disseminating knowledge about existing standards within the various Embedded Systems domains, and by identifying good candidates for standardization activities. But this was only a start.

ARTEMIS must take this work forward, with the aim is to support the emergence or evolution of standards in a systematic and selective and systematic manner, as proposed by this strategic agenda. It must be done in a way that recognises and seeks to overcome the differences of aims, motivations, and expertise of the actors, and the different timescales of the various processes.

By doing this, ARTEMIS will contribute to realization of European standardization policy as defined by the council directive 98/34. The need to modernise the standardization process for ICT has

been highlighted by the European Commission[12]. ARTEMIS will also complement the action plan for ICT, defined by the Commission in March 2006, firstly by bringing a concrete solution to improve the adoption of standards in rapidly growing Embedded Systems of Systems, and secondly by enabling a better inclusion of more participants (e.g. SMEs) by providing a European point of contact to the SDOs.

5.3 Regulation

Along with differing sectoral standardisation regimes, different regulatory regimes also contribute to the fragmentation of the Embedded Systems markets, technologies, and research and development communities. Differing approaches to regulation can derive from quite different philosophies – such as the differences between process and product compliance, and between technical prescription and risk management. Differing regulation in different sectors can influence the nature of acceptable standards and the standardisation processes and lead to procedural and cultural differences that create barriers to cross-sector co-operation and sharing.

The 2008 *ARTEMIS Strategic Agenda for Standardisation* recognised the need for regulatory processes – and related certification requirements – to be modified to accommodate the new development processes envisaged by ARTEMIS. However, these matters are outside the scope of ProSE and this Strategic Agenda states that the efforts to lower regulatory barriers are to be left to National and European authorities, as unique responsible of regulations. However there is an influencing and interest triggering role for ARTEMIS on the Regulation aspect: As part of its ongoing support for standardisation, ARTEMIS must identify regulatory obstacles to achievement of the ARTEMIS goals and seek ways to remove or surmount them. ARTEMIS should identify and facilitate harmonisation processes to overcome regulatory barriers to innovation and to cross-domain interoperability and re-use.

5.4 IPR Management

Intellectual property plays an important role in standardization, especially in the telecommunications and electronic communications sector [ETSI-W-2010]. An acceptable IPR regime is key to attracting companies to standardisation activities (they must feel safe, they must see a business model). Intellectual Property Rights (IPRs) are very likely to be incorporated into standards and other deliverables and, in the preparation of those documents, IPR issues may arise. This tension between IPRs (destined for private, exclusive use) and standards (intended for free, collective use) is minimized by the IPR Policies of SDOs.

Importance must be given from any R&D standardisation activity to the basic understanding of (F)RAND principles (fair, reasonable and non-discriminatory). All (or most) SDOs follow these principles, but their actual rules differ in detail. It is therefore important that all parties involved in the standards-making process should be aware of the IPR principles pertaining to their particular situation and of their own responsibilities, and there should be good co-operation between all

12 Commission communication COM (2004) 674.

parties. As a general recommendation, R&D standardisation leads should check the public IPR policies and agreement documents published by the different SDOs[13].

As facilitators, SDOs like ETSI also own certain IPRs on behalf of its members. These IPRs include the copyright of its standards, technical specifications etc., as well as certain marks.

Finally, the nature of standardization bodies does not exempt them, nor their members or their activities, from the application of competition law. As a consequence, it is important for SDOs and their members to strictly comply with all laws on antitrust that relate to the conduct of their activities.

5.5 Continuity

To achieve a long-lasting impact, ARTEMIS should establish a self-sustaining process – an approach, a way of working, and a way of monitoring and steering the process – that will continue in a sustainable manner as long as it is effective in supporting realisation of the aims of ARTEMIS.

Standardization is a long term process, and the promotion of standardization must also be a long-term, dynamic process. Standards are not generally completed during the lifetime of a single project – whether it is a research project of a standards-oriented supporting action. In addition, standards must follow the fast evolution of the market and competition rules. One-off projects, such as ProSE, cannot maintain the required process.

ARTEMIS must therefore trigger a set of initiatives to keep pace with the changing needs.

5.6 Technical assistance

ARTEMIS must commit to provision of an adequate platform and set of mechanisms to assist stakeholders during the different processes of standardisation, and recognising the differing timescales of RTD and standardisation.

As indicated above (*Section3: 'The Embedded Systems Standardisation Landscape'*) some standardization bodies are offering services to help candidate topics for standardisation to come to a standard. However, they do not see it as their role to pro-actively seek potential standardization candidates: those wishing to promote possible candidates have to identify and address an appropriate standardization body. Yet pro-active technical assistance is of crucial importance for an efficient and effective standardisation process.

ARTEMIS along with European and national authorities must offer a good assistance platform for the different phases of the standardisation process, starting with the identification of

[13] ETSI: http://www.etsi.org/WebSite/document/Legal/ETSI_Guide_on_IPRs.pdf , CEN Agreement documents.

standardisation needs and ending with their application. However, one key stage is the adoption phase: in order to be effective in the delivery and adoption of new standards, there is a strong need to reduce the administrative overhead on the standardisation process.

One solution is implementation of collaborative platforms and virtual observatories that use as much as possible the new technologies. Concrete mechanisms to establish a solid assistance platform would be:

- creation and maintenance of databases containing different projects providing background for the standardisation efforts;
- creation of databases of experts organised by technical area and application domain to support the standardisation activities. These experts can be classified by stakeholder category, as defined in previous sections (standardisation bodies, consumers, academia, etc.);
- centralized activities around a proper Internet-based infrastructure providing team-specific collaborative tools (e.g., wikis, mailing lists), forums, and continuous dissemination actions;
- search for funding for cooperation actions such as collaborative meetings, administrative activities, consulting services, and whatever kind of activity that can add value to standardisation efforts;
- assistance to help find the most appropriate standardization body for standardisation candidates;
- facilities to enable projects (e.g. project coordinator) to establish contact with standardization bodies;
- support for mediation, including access to mediators, between industrial initiatives, collaborative projects, consumers, solution providers, researchers and standardization bodies.

ProSE has made a start on some of these mechanisms. It is now for ARTEMIS to build on the knowledge, relationships and expertise established during the course of ProSE.

5.7 Projects within the ARTEMIS Joint Undertaking

ARTEMIS takes a proactive approach to the support and management of standardisation issues within the portfolio of proposals that it supports through the 'Joint Undertaking'.

The ARTEMIS Annual Work Programme states, to those considering submitting proposals:

"proposals must make explicit their intended contribution to:

- *standard development and harmonisation, as the basis of any integration and inter-operation;*
- *open source reference implementations of standards, in order to facilitate their take-up in the market. "*

This Strategic Agenda finds room for enhancement to the ARTEMIS policies and recommends some actions to be taken in the next years. In fact current Call 1 ongoing projects do not yet have a coordinated standardisation activity, apart from *ad hoc* individual and per-project contacts[14].

ARTEMIS could:

- provide a more consistent standardisation focus through concertation actions directed to standardisation work packages active in each Application Sub-Programme (ASP);
- foster the creation of cross-project standardisation activities (horizontal actions).
- require all projects to be supported by the JU to show some sort of commitment to a cross-project and cross-ASP strategy for standardisation, including a rationale for that strategy that takes into account the ARTEMIS aims.
- provide even more concrete standardization criteria to be used in proposal evaluation;
- establish processes for monitoring and reporting on the contribution of both ASPs and specific projects to standardisation.

5.8 Initial topics for standardisation action

The processes followed by ProSE filtered an initial list of candidate topics for attention to standardisation from more than 50 to a 'long-short list' of 18 and thence to the following 'top 10' priority candidates:

(1) IEC 61508 Ed. 2.0: 2010 (solid mature industrial standard)
(2) Model Based Testing (MBT) (potential Standard / new area)
(3) CESAR (potential Standard / new area)
(4) ISO 26262 (upcoming / evolving standard)
(5) AUTOSAR Safety Model (upcoming / evolving standard)
(6) IEC 61511-MT(solid mature industrial standard)
(7) AUTOSAR Timing Model (upcoming / evolving standard)
(8) SysML (potential Standard / new area)
(9) GENESYS (potential Standard / new area)
(10) RTSJ (potential Standard / new area)

The initial ProSE approach sought specific candidate standards for either creation or evolution. However, discussion stimulated by ProSE revealed that while, ultimately, specific standards have to be modified or created, this should not be done in isolation. Instead, it is essential (for the purposes of ARTEMIS) that such considerations take account of the 'bigger picture'.

For instance:

- Functional Safety is a key issue. The ProSE standardization candidates IEC 61508 Ed. 2.0: 2010, CESAR, AUTOSAR Safety Model and ISO 26262 are all focusing on that important

[14] Currently ASP5 is organising a first "Subprogramme focused" workshop, and other ASPs could follow. This could be a good opportunity to adopt coordinated actions on standardisation actions per project.

point. Furthermore experts are proposing DO-178 and EN 50128 as additional candidates: these are also standards (in other domains) that have their focus on safety aspects.

- Tools for Modelling / Development (resp. Architecture Tools) are of increasing importance in domains where systems get more and more complex. Representatives of this kind of techniques are CESAR, MBT, GENESYS (from the ProSE candidates), but also MARTE, MEDEIA, EAST-ADL2 and JADE. RTSJ and SysML are addressing tools for immediate software development. There is a clear need for a standardized model-driven engineering approach applicable for different application domains.
- standards have to be implemented that are applicable between different domains to enhance cross-domain applications (e.g. GENESYS, CESAR) and to foster exchange of components between different application domains (e.g. automotive (AUTOSAR), aviation)
- some initial ProSE standardization candidates did not take sufficient account of the full context. E.g., instead of candidate R-OSGi the complete OSGi platform should have been chosen. The same holds for AUTOSAR – here instead of the considering the Timing Model and Safety Model as separate candidates, it would be better to address the complete AUTOSAR specification.

Moreover, it is not sufficient simply to identify standards with regard to which action is required. The ProSE methodology elicited more precisely detailed actions that will support the aims of ARTEMIS.

5.9 Prioritisation of standardisation actions

ARTEMIS should establish a methodology for identification, consideration, evaluation and prioritisation of candidate topics for standardisation actions. (Note that such actions may not be actually to seek standardisation, but might be simply to stimulate discussion in an appropriate forum about the potential for standardisation in that area.)

This Strategic Agenda recommends ARTEMIS to build on the methodology set out in the ProSE Charter (*ProSE Deliverable 1.3*), taking into account the lessons learned during the course of ProSE that are described in ProSE deliverable 3.1 *("First Evaluation of ProSE Practice"*).

5.10 Initial promotional actions proposed

Having prioritised topics for standardization action, ARTEMIS must then establish the ARTEMIS-oriented objective for any intervention in the standardisation process, and the way in which that objective is to be achieved.

ProSE has begun this process, as indicated in the table below, and for the future ARTEMIS must continue such a process. Note that this table includes not just the 'top ten' but the remainder of the 'long-short list' of 18 and an additonal 3 new candidates, MARTE, EAST-ADL2 and MEDEIA.

The final column holds some additional information (such as why some actions are proposed for PERSONA, even though its ranking value was rather low).

Ranking	Candidate	ProSE Objective	Action to be taken	Additional Info
1	**IEC 61508-MT**	Identify new areas for standardization activities and promising new standard candidates	Proposal of new application fields	Action already ongoing
2	**MBT**	become a European focus for embedded system standards for other non-European or trans-European actors (e.g. multinational industries)	Project Mogentes: MBT contacts established for IEC 61508 , and ISO 26262	Action already ongoing
3	**CESAR**	Provide support for their development, dissemination and acceptance, taking into account the need for international market impact of most standards	Will apply the ProSE Charter internally for identifying focus points of research	Outcome of ProSE Open Workshop
4	**ISO 26262**	become a European focus for embedded system standards for other non-European or trans-European actors (e.g. multinational industries)	Cooperation of IEC 61508-MT, CESAR, AUTOSAR Safety Model and ISO 26262 should be proposed	Promotions already initiated (MBT in ISO 26262 pro-posed similar as for IEC 61508)
5	**AUTOSAR** Safety Model	become a European focus for embedded system standards for other non-European or trans-European actors (e.g. multinational industries)	Cooperation with CESAR should be proposed	Outcome of ProSE Open Workshop
6	**IEC 61511-MT**	Related to IEC 61508	Look for adequate input related to enhancements already proposed for IEC 61508 (MBT, TTA)	Standardization activities started with completion of IEC 61508 in 2009/10
7	**AUTOSAR Timing Model**	become a European focus for embedded system standards for other non-European or trans-European actors (e.g. multinational industries)	Cooperation with CESAR should be proposed	Outcome of ProSE Open Workshop
8	**SysML**	provide support for their development, dissemination and acceptance, taking into account the need for international market impact of most standards	System@tic Lambda includes UML2, SysML, MARTE, AADL, (OMG, SAE accepted)	

Ranking	Candidate	ProSE Objective	Action to be taken	Additional Info
9	**GENESYS**	provide support for their development, dissemination and acceptance, taking into account the need for international market impact of most standards Additionally: establish links to European and international standardisation bodies and pre-standardisation organisation	Standardization topics (from GENESYS architecture) should be checked; cross-reference to CESAR should be established	Outcome of ProSE Open Workshop
13	**European Robotic Middleware**	provide support for their development, dissemination and acceptance, taking into account the need for international market impact of most standards	Propose co-operation between AIT, Gostai, and Artemis R3-COP project	Aiming for high level interoperability standards, measuring autonomous, co-operative and perceptive abilities (Outcome of ProSE Open Workshop)
16	**Bio inspired Sensors**	Evaluate impact and concrete focus to look at (field is very broad), talk to experts who commented on this topic	Discuss with ETSI who was interested in such a new topic	
18	**PERSONA**	provide support for their development, dissemination and acceptance, taking into account the need for international market impact of most standards. Additionally: establish links to European and international standardisation bodies and pre-standardisation organisation	successor project universal (started February 2010): get contact with ETSI	First contacts established on ProSE Open Workshop; Ambient Assisted Living important field of future research
NEW	**MARTE**	Contact ADAMS if support or co-operation needed	Contact ADAMS	Covered already by ADAMS project
NEW	**EAST-ADL2**	become a European focus for embedded system standards for other non-European or trans-European actors (e.g. multinational industries)	Cooperation with CESAR should be proposed	
NEW	**MEDEIA**	Provide support to the project team with respect to standardization, identify focus areas (see 4.3.,3) and standards bodies; would cover a gap not identified before!	Co-operation with MEDEIA project team should be proposed	Covers new area not taken into account before by ProSE team, meeting thus ProSE goal to address new areas

Table 2 Ranked Standardization Candidates and Actions to be taken after first period of candidate assessment and enrichment

ProSE has already initiated action along some of the lines proposed above. However, it should also be noted that some of these actions are not connected with specific standards but are more concerned with stimulating communication between the actors in a community – or a set of communities – so that the ambitions of ARTEMIS are more likely to be realised. Specific developments along theses lines so far include:

- Functional Safety: This is obviously still a key issue. The ProSE standardization candidates IEC 61508 Ed. 2.0: 2010, CESAR, AUTOSAR Safety Model and ISO 26262 are all focusing on that important point. Furthermore experts are proposing DO-178 and EN 50128 as additional candidates, also techniques that have their focus on safety aspects. The ProSE standardization candidates IEC 61508 Ed. 2.0: 2010 and IEC 61511 have been already approached proposing certain standardization candidates successfully in IEC 61508 (Model based Testing and Test case generation, Time-Triggered Architectures) via national and international committees. Since IEC 61508 Ed. 2.0 was already in its final stage during the project proposal (started as MT – Mantainance), we had to hurry to bring research results of DECOS and MOGENTES to standardization. This activity covered the MBT proposal as well ("Model-based Testing (MBT) and model-based Test case generation (TCG)"). IEC 61508 is a domain-independent generic functional safety standard, i.e. of cross-domain

applicability, and the methods and techniques promoted during this activity (time-triggered architecture, MBT and model-based TCG) are cross-domain as well, so this is fully in line with the ProSE and ARTEMIS objectives. IEC 61508 Ed. 2.0 is International Standard since April 2010, so both activities can be considered as first success stories. The next maintenance cycle may take as long as the first one, starting in 5 years, so now was the right time window for action.

- The same approach was tried by the Austrian National Committee with respect to MBT and TCG for ISO 26262, which is planned to become International Standard (IS) in 2011.
- Collaboration between techniques and standards should be encouraged. Here, for instance, CESAR could foster positive co-operation towards a more or less "open" standardization by considering interoperability standards, meta models, model interchange frameworks. Relations with TIMMO model, EAST-ADL2, ATTEST2, AUTOSAR, GENESYS should be checked here. This has been initiated by contacts to CESAR project management.
- Ambient Assisted Living research should aim for standardization towards high-level ("system-of-systems") standards, architecture, reference model, or interoperability.
- Standards promotion activity granularity and convergence: Several expert insights were helpful in looking at the standardization context rather than isolated proposals, thus supporting convergence issues. Some initial ProSE standardization candidates were chosen too isolated instead of being considered in its full context. E.g., instead of candidate R-OSGi the complete OSGi platform should have been chosen from the beginning. Same holds for AUTOSAR – here the complete AUTOSAR specification, instead of the Timing Model and Safety Model as separate candidates should have been proposed to the external experts and stakeholders. Thus, promotion activities need to take in account the level of granularity of the candidate, assessing the need to change the activity scope.

- Co-operation with ETSI in the e-Health committee/WG specialized task force is planned for PERSONA and/or the successor project UNIVERSAL. (This will be done by Fraunhofer in cooperation with ETSI.)
- Convergence of Standards for Embedded Systems Design: The need for a standardized model-driven engineering approach applicable for different application domains has been demanded in several workshops. Several standards or to-be standards have been in scope, including UML2, SysML, MARTE, AADL, System-C, IP-XACT, Ravenscar (consolidation, alignment, mapping), CVL and others. Close co-operation initiated at the ProSE Open Workshops.
- Robotic Middleware and Autonomous Systems: Co-operation between AIT, Gostai, and Artemis R3-COP project is proposed, aiming for high level interoperability standards addressing autonomous, co-operative and perceptive abilities drawing on the EUROP SRA and engaging the OMG Robotics Domain task Force, ETSI M2M WG (machine-to-machine communication), and the ETSI Wireless Group.

One important recommendation was an outcome of the ProSE Workshop in Darmstadt and the Panel discussion at the EAI Forum in Trento on "Standards and Regulations" on June 24, 2010:

> **"E&T (Education and Training) initiatives** (e.g. COSINE) and WGs (e.g. of ARTEMIS) have to include the standards awareness raising activities in their agendas"

The ARTEMISIA-E&T WG, in close co-operation with ProSE, started such activities to promote this in the ARTEMIS SRA&WP, first result was creating a new issue in the ARTEMIS Work Programme 2010: "**Section 4.8, Innovation Environment: includes new material on Education and Training", besides the standardization requirements**).

6 Recommendations & Mechanisms

This section contains a **summary of the general recommendations**, mechanisms and alternatives for the standardisation strategy[15].

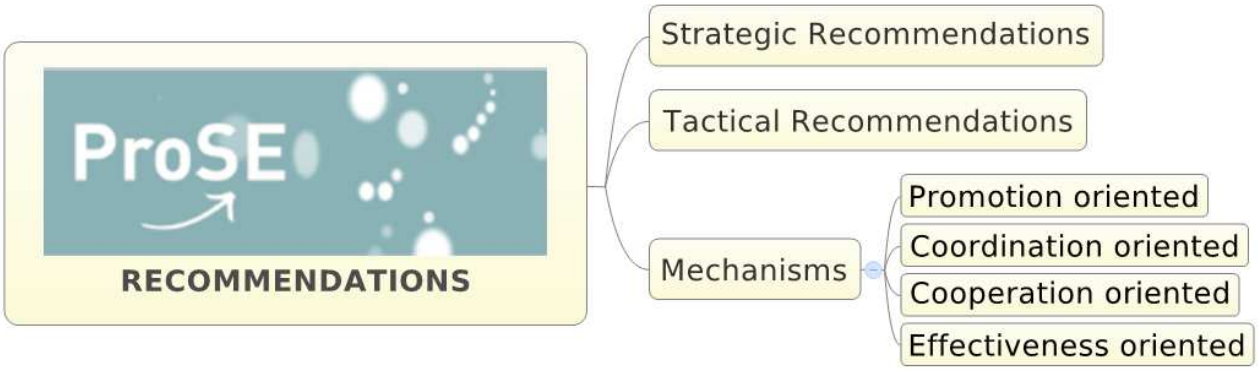


Figure 13 ProSE Recommendations Structure

Recommendations: Both Strategic and Tactical recommendations.

Mechanisms: Mechanisms or actions are organised by orientation.

- ☑ Promotion oriented. Actions that will create awareness, increase the role of standards in education etc.
- ☑ Coordination oriented. Actions that will help to increase the level of efficiency of all standardisation related actions.
- ☑ Cooperation oriented. Actions that will provide means for individuals or teams to work together on standardisation related topics.
- ☑ Effectiveness oriented. Actions that will enable standardisation related efforts to act in more effective and productive ways.

The following list contains the provisional framework of actions and recommendations.

6.1 Recommendations

6.1.1 Strategic Recommendations

ARTEMIS and its Standardisation Working Group should work at a high level to get the message to both politicians and the top-level leaders of European industry that the EU is losing momentum and losing opportunities due to the attitudes and policies of many companies today, and that both

[15] Recommendations and Mechanisms reviewed and enriched during the Open ProSE Workshop November 05 2010.

European governmental and administrative bodies (Parliament, Council and the Commission) and European companies must:

- ☑ Acknowledge that for Europe to succeed at innovation Europe must seek to be more effective in **bringing research results and new technology to the market**: It is not sufficient to support the 'upstream' research at which Europe excels.

- ☑ Recognise the need to **value standardisation** and to take leadership of standardisation (in appropriate domains).

- ☑ Recognise the need to **co-operate on standardisation across competitive boundaries** and to reconcile and manage the differences that presently inhibit such co-operation.

- ☑ **Invest in the efforts required to bring about standardisation**, allowing staff the time and support to bring about long-term benefits.

- ☑ **Invest in people and RTD** in order to feed the technology pipeline that provides the basis for standardisation.

- ☑ Facilitate a **recognition** of the role of standardisation in **Education & Training** courses.

- ☑ Consider establishing a **"European ICT Standardisation Grand Prize"** or **"European ICT Standardisation Hall of Fame"**, with a high profile in the public press and media.

ARTEMIS should seek to co-operate with European Standardisation Development Organisations at the highest level to identify priorities and **develop a strategy**, and for ARTEMIS to support implementation of this strategy. This should not just be 1-way 'co-operation' of industry gaining support of the SDOs, but **2-way**, with the SDOs informing ARTEMIS of their policies and developments so that ARTEMIS RTD can take account of them.

Such a European strategy for embedded systems standardisation should place special emphasis on **enabling technologies**, and especially integration, in which Europe has considerable capability, and which is important (even vital) to realisation of the aims of ARTEMIS.

ARTEMIS should facilitate the development of **European Standardisation Roadmaps** (recognising that it will perhaps not be appropriate to attempt a single roadmap to encompass all embedded systems topics).

ARTEMIS should explore with the Commission the possibility of a post-R&D 'downstream' programme for **deployment of RTD results** (similar to if not part of the CIP).

On some topics (e.g. Intelligent Transport Systems) the European Commission mandates action by the Standardisation Organisations. ARTEMIS should work with the European Commission to **consider whether any topics concerning Embedded Systems should be mandated in a similar way**.

6.1.2 Tactical Recommendations

☑ ARTEMIS to take significant responsibility for over-seeing standardisation in Embedded Systems - mechanism: **Standards Observatory**. This should be the mechanism to have a continuity of actions after ProSE, seeking better coupling between the standardisation process, the activities of research projects, and the evolution of markets and the marketing ambitions of industry.

☑ ARTEMIS to build on the **methodology** set out in the ProSE Charter (ProSE Deliverable 1.3), taking into account the lessons learned during the course of ProSE that are described in ProSE deliverable 3.1 (“First Evaluation of ProSE Practice”).

☑ ARTEMIS should use the proposed set of **European Standardisation Roadmaps** to provide a framework for coherent technology and standardisation development spanning multiple projects and time-periods greater than those of individual projects.

☑ Institute **long-lasting processes** that should have both medium and long-term impact in a much more general way than promotion of specific standards.

☑ ARTEMIS to identify and facilitate **harmonisation** processes to overcome regulatory barriers, to foster innovation and to enable cross-domain interoperability and re-use.

☑ Recommend for ARTEMIS **project proposals** to include a focused work package or task set on standardisation, following best practices available (CEN, ETSI, CENELEC, OMG etc), and ask participants to **demonstrate capabilities** by showing some significant background or participation on Technical Committees or Work Groups.

☑ ARTEMIS should **recognise and make the community aware** that standardisation via the ‘official’ standardisation route, involving the Standardisation Development Organisations, is not the only option. Collaborative ARTEMIS projects (and other RTD projects) often have the critical mass with which they could establish de facto standards. Formal recognition by the Standardisation Development Organisations could follow later. Standardisation Development Organisations generally welcome approaches to formalise de facto standards that have a significant following in the community.

☑ ARTEMIS should take **more account of market issues than the Framework Programme**, and should therefore place greater emphasis on standardisation.

☑ ARTEMIS **evaluation criteria for proposals** should place greater emphasis on standardisation and evaluators should be briefed more specifically on the expectations for standardisation. This should take into account any strategic standardisation roadmap for the domain.

☑ ARTEMIS projects should provide at the time of their reviews information on standardisation activities that are pertinent to their developments, and their **own positioning with respect to standardisation.** This information should also enable the ARTEMIS Standardisation Working Group to maintain the '**standardisation landscape'** established by ProSE. This in turn should enable the ARTEMIS community (not just RTD projects) to **identify opportunities** for exploitation.

☑ The **ARTEMIS exhibition should be exploited to raise the profile of standardisation**. The criteria for the award of prizes should not be changed, but the judging panel should be encouraged to consider and give recognition to standards-related work aimed at facilitating exploitation, giving greater emphasis to this issue for projects that have run longer.

☑ ARTEMIS to provide a more consistent standardisation focus through **concertation actions** directed to standardisation work packages active per ASP.

☑ ARTEMIS to include standardization awareness building and training in its agendas, and facilitate co-operation with **Education & Training** related initiatives, programmes and projects.

☑ Standards Observatory to take on ProSE designed processes, questionaires, charter and candidate selection method and **execute periodic selection/promotion/dissemination cycles.**

☑ This Strategic Agenda will require periodic monitoring and updates. The recommendation is to execute **monitoring and update cycles every two to three years**, aligned with ARTEMIS agenda cycles.

6.2 Mechanisms

6.2.1 Promotion oriented

☑ **Education:** Standardisation expertise requires years of non-formalised on-the-job activities. Excellence Networks such as ARTIST for Embedded Design and SDOs in cooperation to act as educational channel for future standard experts. E&T (Education and Training) initiatives (e.g. COSINE) and WGs (e.g. of ARTEMIS) have to include the standards awareness raising activities in their agendas.

☑ Create **awareness** about the importance of standardisation activities among **national R&D authorities,** in order to enable standardisation focused projects as spin-offs of R&D projects

☑ **Case Studies**: Create per-project basis Standardisation Case Studies where market and economic indicators should provide, in a consistent manner, quantitative measures about the impact of standards (ROI, NPV, PI, etc)

6.2.2 Coordination oriented

☑ Establish the **ARTEMIS community** (industrial association, joint undertaking and technology initiative, chambers and structures) as key player to foster the standardisation activities of projects, networks and working groups (national or regional clusters, centres of innovation excellence etc) and **channel them to the appropriate standardisation development organisations,** creating awareness, implementing mechanisms and maturating support processes.

☑ Establish a **catalog of "Standard Families"** to foster coordination among industrial and research actors in ARTEMIS active on the specific family. Examples: Standards for functional safety family, standards family for internet of things technologies, standards for AAL products, etc.

☑ Establish a permanent ARTEMIS driven **Standards Observatory** to proactively avoid fragmentation of standardisation activities. Fragmentation has the consequence that existing and emerging standard proposals and standardisation bodies that serve embedded systems communities are also very fragmented across both application sectors and design flows and their associated tool-sets.

6.2.3 Cooperation oriented

☑ Establish a periodic **ASP strategy review on standardisation** by the ARTEMIS Standards Observatory. This activity should foster cooperation among running projects (per ASP) as well as cooperation among ASP cluster projects and particular SDOs.

☑ Standards Observatory to identify current **market drivers for standardisation** and future drivers through prospective methods.

☑ Standards Observatory to define a **standardization roadmap together with industrial partners** to provide a framework for researchers to contribute to standardisation -organised per **ASP.**

☑ Creation of an open **catalogue of standards per ARTEMIS SRA application domains**, matched with managing SDOs and contact points.

6.2.4 Effectiveness oriented

☑ Standards Observatory to create a **public database of standardisation candidates after the ProSE model,** including a database of projects, best practices, guidelines and SDO contact points.

☑ Standards Observatory to provide a proper Internet-based **infrastructure** providing team-specific collaborative tools (e.g., wikis, mailing lists), forums, and continuous dissemination actions.

☑ Standards Observatory to create an **online help desk** to assist embedded technologies related projects and clusters on the specific topic of standardisation processes.

☑ Standards Observatory to search for funding for **cooperation actions** such as collaborative meetings, administrative activities, consulting services, and whatever kind of activity that can add value to standardisation efforts.

☑ Definition and application of a **measurement framework** for standardisation processes. Depending on the scope and capabilities of the Standards Observatory, create SLAs.

☑ R&D standardisation leads to be **informed about public IPR policies and agreement docs** published by the different SDOs as part of "project proposal guidelines". If possible, organise focused online webinars.

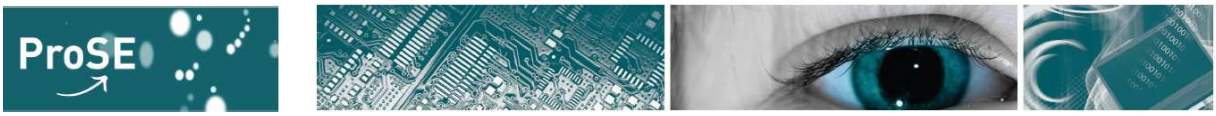
☑ Standards Observatory to provide **assistance** to help find the **most appropriate** standardization body for standardisation candidates

☑ Standards Observatory to establish **contacts** between projects (e.g. project coordinator) and standardization bodies

☑ Standards Observatory to establish **mediators** between industrial initiatives, collaborative projects, consumers, solution providers, researchers and standardization bodies

7 Abbreviations and Definitions

ARTEMIS	European Technology Platform represents the field of **A**dvanced **R**esearch & **T**echnology for **EM**bedded **I**ntelligence and **S**ystems
ARTEMIS-IA	ARTEMIS Industrial Association
CAPEX	Capital Expenditure
COPRAS	Cooperation Platform for Research and Standards
ETP	European Technology Platform'
FRAND	Fair, reasonable and non-discriminatory
GQM	Goal, Question, Metrics
IP	Intellectual Property
IPR	Intellectual Property Rights
JU	Joint Undertaking
MASP	Multi Annual Strategic Plan
NPV	Net Present Value
OPEX	Operational Expenditure
PI	Profitability Index
ProSE	Promoting Standardization for Embedded Systems
ROI	Return on Investment
SDO	Standards Development Organisations
SRA	Strategic Research Agenda



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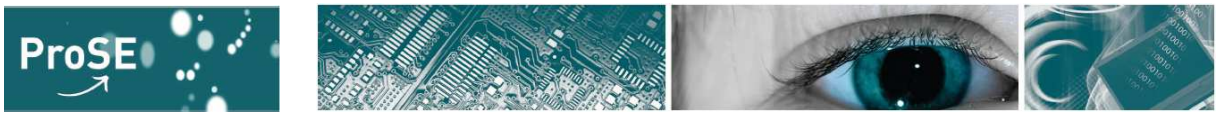
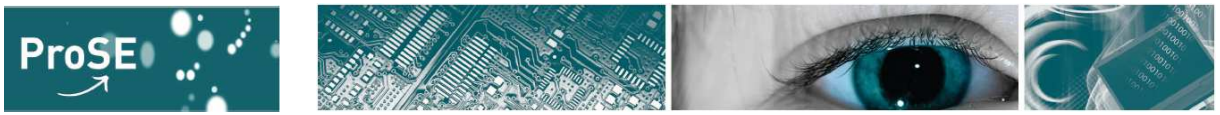


9 Annex A – Related projects

A number of background projects relevant to ProSE are included in this document to benefit researchers that wish to understand the context of standardisation research carried out in the past in Europe.

Project	Prog.	Description
MAXI-QUEST	**FP5**	The project aim was to improve mutual awareness and initiate sustainable measures that would improve integration between the suppliers and users of normative research. There are a number of barriers to integration and transfer of relevant research results into standards that have been highlighted. Better integration will contribute to wider policy objectives of the EU by maximizing the quality of European standards and efficiency of the standardization process. The project consisted of a user survey in 3 EU States, awareness workshops for suppliers & users of normative research, and a Congress to disseminate the results to influential stakeholders. The consortium included CEN, 3 National Standardization Bodies and a leading NMI with extensive experience of both research and standardization
INTEREST	**FP6**	INTEREST: Integrating Research And Standardisation. The overall objective of INTEREST was to develop taxonomies of standards, of research outputs and of research-standards relationships and to contribute to the improvement of the interface between research and standardisation, and thus contribute to the effective diffusion and utilisation of research which is being performed in Europe. In order to achieve this goal the following set of specific objectives were defined: • A thorough description of the state-of-the-art of the interface between research and standardisation. • The identification of rationales and incentives schemes within the research communities and contact with the standardisation bodies. • The identification of the barriers that hamper the transfer of research results to the standards setting process. • The development of a taxonomy of standardisation products, covering both formal and informal standardisation bodies, and of a taxonomy of research outputs. • The elaboration of a taxonomy of current research-standardisation-relationships. • The definition of policies for the optimisation of the interface between research and standardisation, possibly differentiated for relevant clusters of technologies including the development of an approach to enable the identification of the most appropriate types of standards products for different research sectors.
COPRAS	**FP6**	The 'COoperation Platform for Research And Standards' aimed to establish a supporting action to enable the FP6 IST projects (in all the three envisaged calls) to interface with the standardization activities in Europe and elsewhere in a consistent and effective manner while increasing standards awareness within the research and technical development area. We highlight the 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), as well as for other areas.



Project	Prog.	Description
NO-REST	FP6	The Networked Organisations - REsearch into STandards and Standardisation Project (NO-REST) was created to investigate the applicability and dynamics of standards in the e-business, e-government and ICT sectors in order to develop tools for the assessment of their performance and of the impact they have on networked organisations.
ARCADIA	FP7	ARCADIA's major objective of advancing the European Research Area in the Embedded Systems field is based on the appropriate involvement of National and Regional Authorities across Europe. ARCADIA will proceed through a roadmap-based-strategy plan which includes market trends & drivers, mapped technologies, application needs and application capabilities, research challenges, needed skills, and future research targets within the main industrial sectors Transport Air /Road, Nomadic Devices, Infrastructure and Health
COSINE	FP7	COSINE 2 (Co-ordinating Strategies for Embedded Systems in the European Research Area) is a Specific Support Action (SSA) whose goal is to enhance the impact of European RTD strategies in the area of Embedded Systems. It is designed to overcome the current fragmentation and overlapping of scattered strategic research initiatives in the area of Embedded Systems in Europe. COSINE 2 will focus on future strategies for Embedded Systems RTD programme activities in Europe based on integrating existing background studies, fill in gaps in the existing material, and compare it to extra-EU activities. It will interlink national policy makers, programme managers, and European Commission and industry groups to jointly exploit the potential for synergies of Embedded Systems RTD policies in Europe.

Table 3 Related standardisation and agenda development projects

10 ANNEX B: Details about Promotion Activities

10.1 Introduction

This Strategic Agenda refers to several promotion activities carried out during the lifespan of the ProSE project. In order to illustrate some of these activities, this annex contains details about the promotion of **TTA (Time Triggered Architecture) and MBT/TCG standardization issues in IEC 61508 Ed. 2.0 and ISO 26262**.

Note that several communities and projects have implemented the ProSE method during their standardisation candidate selection and promotion. As a significant example, the ARTEMIS CÉSAR project which is researching a cross-domain 'Reference Tools Platform' (RTP), particularly across automotive and aerospace domains, has applied the ProSE methods and processes. According to CESAR project leads the ProSE assessment criteria has proved to be appropriate and useful in identifying and analysing the options for standardisation. Other projects such as the ARTEMIS eDIANA project have identified that the ProSE process to identify candidates and promote their activities might have been useful at the beginning of the project, when the initial assessment for local-area communication standards (ZigBee, DECT, etc.) was underway.

The following sections will provide detail about one of the several activities taken under the umbrella of ProSE.

10.2 Time Triggered Architectures in IEC 61508/FDIS, Ed. 2.0 (2010)

During many years, the time-triggered protocols and TTA, the time triggered architecture, were developed by TU Vienna (Prof. Kopetz) ([6]-[9]). In the FP6 Integrated project DECOS [10], partially funded by the EC, a middleware was developed [10], with a model-based development tool chain, verification and validation means (DECOS Test Bench), including an approach to modular and incremental certification support [12]. In the dissemination and standardization work package, the need was identified to integrate TTA at the appropriate part of IEC 61508-3 (Software), which includes an architecture part.

In part 3, mandatory requirements, it was included in table A.2 (before that, this well accepted, very rigid architecture was not even mentioned in the basic functional safety standard!!) as highly recommended technique on higher SILs, whereas event driven architectures, even with guaranteed maximum response times, are not highly recommended at SIL4 (see entries 13a-c in table Table 10-1 below, which are a selected small part of table A.2 of the standard).

	Technique/Measure	SIL1	SIL2	SIL3	SIL4
13a	Cyclic behaviour, with guaranteed maximum cycle time	R	HR	HR	HR
13b	Time-triggered architecture	R	HR	HR	HR
13c	Event-driven, with guaranteed maximum response time	R	HR	HR	----

Table 10-1 Relevant part of Table A.2 – Software design and development – software architecture design

In table "Table C.2 – Properties for systematic integrity" of the FDIS it is classified as a very rigid method for transparent implementation of fault tolerance.

In Annex F it is referenced again as means to achieve temporal independence.

In Part 7, which is informative, it is described under “coding standards” and as method

“C.3.11 Safety and Performance in real time: Time-Triggered Architecture”.

Its description is as follows to include the essential elements in a precise, short text:

Aim: Composability and transparent implementation of fault-tolerance into safety-critical realtime systems with predictable behaviour.

Description: In a Time-Triggered Architecture (TTA) system, all system activities are initiated and based on the progression of a globally synchronised time-base. Each application is assigned a fixed time slot on the time-triggered bus, which contains the messages exchanged between the jobs of each application which can therefore be exchanged only according to a defined schedule. In event-driven systems, system activities are triggered by arbitrary events at unpredictable points in time. The key advantages of a TTA are ([5]):

– **composability**, which greatly reduces the effort required for testing and certifying the system;

– transparent implementation of fault-tolerance, which makes the architecture highly recommendable for safety-critical applications;

– provision of a **globally synchronised time-base**, which facilitates the design of distributed real-time systems.

Communication between nodes is done using the *Time-Triggered Protocol TTP/C* ([6]) according to a static schedule, deciding when to transmit a message and whether a received message is relevant for the particular electronic module or not. Access to the bus is controlled by a cyclic *time-division multiple access (TDMA)* schema derived from the global notion of time. The TTP/C protocol guarantees ([8]) four basic services (core services) in a network of TTA nodes ([7]):

– **Deterministic and timely message transport**: Transport of messages from the output port of the sending element to the input ports of the receiving elements within an a priori known time bound. A fault-tolerant transport service is offered by a time-triggered communication service that is available via the temporal firewall interface which eliminates control error propagation by design and minimises coupling between elements. The timely transport of messages with minimal latency and jitter is crucial for the achievement of control stability in real-time applications.

– **Fault-tolerant Clock Synchronization**: The communi-cation controller generates a fault tolerant synchronised global time base (with a precision within a few clock tics) that is provided to the host subsystem.

– Consistent Diagnosis of Failing Nodes (Membership Service): The communication controller informs every SRU (“smallest replaceable unit”) about the state of every other SRU in a cluster with a latency of less than one TDMA round.

– **Strong Fault Isolation**: A maliciously faulty host subsystem (including its software) can produce erroneous data outputs, but can never interfere in any other way with the correct operation of the rest of a TTP/C cluster. Fail silence in the temporal domain is guaranteed by the time-triggered behaviour of the communication controller.

NOTE 2 Other time-triggered protocols are FlexRay and TT-Ethernet (time-triggered Ethernet).

10.3 Model-based Testing and Automated Test Case Generation

During the ProSE process of identifying most valuable standardization candidates, MBT (Model-Based Testing, with TCG, Test Case Generation)([13]), was identified as separate

standardization candidate. It turned out, that in a first approach, it would fit very well as highly recommended (HR) method in IEC 61508, and that many methods of testing with similar importance and relevance are discussed and assessed in the standard and its tables, but not MBT and TCG.

10.3.1 MBT and TCG as testing methods in IEC 61508/FDIS Ed. 2.0, Part 3

To include a method like MBT and TCG in a functional safety standard, all related tables and subchapters have to be addressed properly, and the methods respectively entries referenced throughout the document in Part 3 (mandatory part), and the method in a general manner be described in Part 7 (informative part). Part 3 has a table on software design and development, software module testing and integration (A.5), a table on Dynamic Analysis and Testing (B.2), a table on Functional and Black-Box Testing (B.3), and the related tables on detailed properties referring to B.2 and B.3 (which are C.12 and C.13 respectively). The latter ones define the rigidity and reliance which can be placed on the results with respect to safety when these methods are applied under certain conditions.

Note: HR means “Highly Recommended”, R means “Recommended”, NR “Not Recommended”, --- no specific recommendation for or against. The “Ref.” points at other tables in Part 3 and the descriptions in Part 7.

The proposed changes/additions with respect to MBT (TCG) are:

Table A.5 – Software design and development – software module testing and integration (See 7.4.7 and 7.4.8)

	Technique/Measure *	Ref.	SIL 1	SIL 2	SIL 3	SIL 4
1	Probabilistic testing	C.5.1	---	R	R	R
2	Dynamic analysis and testing	B.6.5 Table B.2	R	HR	HR	HR
3	Data recording and analysis	C.5.2	HR	HR	HR	HR
4	Functional and black box testing	B.5.1 B.5.2 Table B.3	HR	HR	HR	HR
5	Performance testing	Table B.6	R	R	HR	HR
6	***Model based testing***	***C.5.27***	***R***	***R***	***HR***	***HR***
7	Interface testing	C.5.3	R	R	HR	HR
8	Test management and automation tools	C.4.7	R	HR	HR	HR
9	Forward traceability between the software design specification and the module and integration test specifications	C.2.11	R	R	HR	HR
10	Formal verification	C.5.12	---	---	R	R

NOTE 1 Software module and integration testing are verification activities (see Table B.9).

NOTE 2 See Table C.5.

NOTE 3 Technique 9. Formal verification may reduce the amount and extent of module and integration testing required.

NOTE 4 The references (which are informative, not normative) “B.x.x.x”, “C.x.x.x” in column 3 (Ref.) indicate detailed descriptions of techniques/measures given in Annexes B and C of IEC 61508-7.

* Appropriate techniques/measures shall be selected according to the safety integrity level.

Table 10-2: IEC 61508-3 FDIS, Table A.5 – Software design and development – software module testing and integration

Table B.2 – Dynamic analysis and testing

(Referenced by Tables A.5 and A.9)

Technique/Measure *		Ref	SIL1	SIL2	SIL3	SIL4
1	Test case execution from boundary value analysis	C.5.4	R	HR	HR	HR
2	Test case execution from error guessing	C.5.5	R	R	R	R
3	Test case execution from error seeding	C.5.6	---	R	R	R
4	***Test case execution from model-based test case generation***	***C.5.27***	***R***	***R***	***HR***	***HR***
5	Performance modelling	C.5.20	R	R	R	HR
6	Equivalence classes and input partition testing	C.5.7	R	R	R	HR
7a	Structural test coverage (entry points) 100% **	C.5.8	HR	HR	HR	HR
7b	Structural test coverage (statements) 100% **	C.5.8	R	HR	HR	HR
7c	Structural test coverage (branches) 100% **	C.5.8	R	R	HR	HR
7d	Structural test coverage (conditions, MC/DC) 100% **	C.5.8	R	R	R	HR

NOTE 1 The analysis for the test cases is at the subsystem level and is based on the specification and/or the specification and the code.

NOTE 2 See Table C.12.

NOTE 3 The references (which are informative, not normative) "B.x.x.x", "C.x.x.x" in column 3 (Ref.) indicate detailed descriptions of techniques/measures given in Annexes B and C of IEC 61508-7.

* Appropriate techniques/measures shall be selected according to the safety integrity level.

** Where 100% coverage cannot be achieved (e.g. statement coverage of defensive code), an appropriate explanation should be given.

Table 10-3: IEC 61508-3 FDIS, Table B.2 – Dynamic analysis and testing

Table B.3 – Functional and black-box testing

(Referenced by Tables A.5, A.6 and A.7)

Technique/Measure *		Ref	SIL1	SIL2	SIL3	SIL4
1	Test case execution from cause consequence diagrams	B.6.6.2	---	---	R	R
2	***Test case execution from model-based test case generation***	***C.5.27***	***R***	***R***	***HR***	***HR***
3	Prototyping/animation	C.5.17	---	---	R	R
4	Equivalence classes and input partition testing, including boundary value analysis	C.5.7 C.5.4	R	HR	HR	HR
5	Process simulation	C.5.18	R	R	R	R

NOTE 1 The analysis for the test cases is at the software system level and is based on the specification only.

NOTE 2 The completeness of the simulation will depend upon the safety integrity level, complexity and application.

NOTE 3 See Table C.13.

NOTE 4 The references (which are informative, not normative) "B.x.x.x", "C.x.x.x" in column 3 (Ref.) indicate detailed descriptions of techniques/measures given in Annexes B and C of IEC 61508-7.

* Appropriate techniques/measures shall be selected according to the safety integrity level.

Table 10-4: IEC 61508-3 FDIS, Table B.3 – Functional and Black Box Testing

10.3.2 General short description of Model Based Testing (Test case Generation) in IEC 61508, Ed. 2.0, Part 7

The descriptions of software-related methods and techniques are collected in Part 7, Annex C, Overview of techniques and measures for achieving software safety integrity (see IEC 61508-3).

C.5.27 Model based testing (Test case generation)

NOTE This technique/measure is referenced in table A.5 (and C.5) of IEC 61508-3.

Aim: To facilitate efficient automatic test case generation from system models and to generate highly repeatable test suites.

Description: Model-based Testing (MBT) is a black-box approach in which common testing tasks such as test case generation (TCG) and test results evaluation are based on a model of the system (application) under test (SUT). Typically, but not only, the systems data and user behaviour are modelled using Finite state machines, Markov processes, decision tables or the like ([17]). Additionally, model-based testing can be combined with source code level test coverage measurement, and functional models can be based on existing source code.

Model-based Testing is the automatic generation of efficient test cases/procedures using models of system requirements and specified functionality ([13]).

Since testing is very expensive, there is a huge demand for automatic test case generation tools. Therefore, model-based testing is currently a very active field of research, resulting in a large number of available TCG (Test Case Generation) tools. These tools typically extract a test suite from the behavioural part of the model, guaranteeing to meet certain coverage requirements.

The model is an abstract, partial representation of the system under test's (SUT) desired behaviour. From this model, test models are derived, building an abstract test suite. Test cases are derived from this abstract test suite and executed against the system, and tests can be run against the system model as well. MBT with TCG is based on and strongly related to use of formal methods, so recommendations are similar with respect to safety integrity levels (SIL): HR (highly recommended) for higher SILs, and not required for lower SILs.

The specific activities in general are:

- build the model (from system requirements)
- generate expected inputs
- generate expected outputs
- run tests
- compare actual outputs with expected outputs
- decided on further action (modify model, generate more tests, estimate reliability/quality of the software)

Tests can be derived with different methods and techniques for expressing models of user/system behaviour, e.g.

- by using decision tables
- by using finite state machines
- by using grammars
- by using Markov Chain models
- by using state charts
- by theorem proving
- by constraint logic programming
- by model checking
- by symbolic execution
- by using an event-flow model
- reactive system tests: parallel hierarchical finite automaton
- ..etc.

Model-based Testing is specifically targeting recently the safety critical domain. It allows for early exposure of ambiguities in specification and design, provides the capability to automatically generate many non-repetitive efficient tests, to evaluate regression test suites and to assess software reliability and quality, and eases updating of test suites.

A thorough overview is provided by ElFar ([17]) and SoftwareTech 2009 ([13]), other details and domain specific issues are discussed in the other references ([14] – [24]).

10.4 ISO/DIS 26262

This demonstrates quite well the different approach of ISO/DIS 26262. Other issues different are, that ISO/DIS 26262 is more process oriented than IEC 61508, since it has to take into account the several tiers' supply chains, which is typical for the automotive sector. The processes are based on the V-model more explicitly as in IEC 61508, which is based on its own safety life cycle.

10.5 Introducing MBT in ISO/DIS 26262?

ISO 26262 takes much more model-based techniques and methods into account than IEC 61508 (see Part 10, Guideline, chapter 4, Key concepts, §4.1 relationship with IEC 61508). Nevertheless, model-based testing is not mentioned at all!

The appropriate place to put model-based testing/test case generation are part 6, chapter 9.4.3, Table 13 ("Methods for deriving test cases for software unit testing"), and chapter 10.4.4., Table 16 ("Methods for deriving test cases for software unit testing").

The tables in the example are copied from ISO/DIS 26262-6, which was the basis for the comments and voting by December 8, 2009 (so they do NOT contain the proposed changes of AT on MBT), and are for (national) committee members use only, since the standard is not a final IS at the moment.

The proposed additions concerning model-based test case generation forwarded by the Austrian Standardization Institute (FNA038 expert) as part of its comments are **(ISO/DIS 26262-6):**

Table 13 — Methods for deriving test cases for software unit testing

	Methods	ASIL			
		A	B	C	D
1a	Analysis of requirements	++	++	++	++
1b	Generation and analysis of equivalence classes	+	++	++	++
1c	Analysis of boundary values[a]	+	++	++	++
1d	Error guessing[b]	+	+	+	+

[a] This method applies to interfaces, values approaching and crossing the boundaries and out of range values.

[b] "Error guessing tests" can be based on data collected through a "lessons learned" process and expert judgment.

Table 16 — Methods for deriving test cases for software integration testing

	Methods	ASIL			
		A	B	C	D
1a	Analysis of requirements	++	++	++	++
1b	Generation and analysis of equivalence classes[a]	+	++	++	++
1c	Analysis of boundary values[b]	+	++	++	++
1d	Error guessing[c]	+	+	+	+

[a] This method may be used to partition possible input values of external interfaces.

[b] This method applies to parameters or variables, values approaching and crossing the boundaries and out of range values.

[c] This method considers situations usually leading to errors. Determining such test cases in an efficient way requires experience in testing as well as intuition combined with knowledge about the integrated software to be tested.

Table 10-5: ISO/DIS 26262-6 Software Unit and Integration testing

Note: ++ means “highly recommended”, + means “recommended”. ISO 26262 doesn’t use negative recommendations as does IEC 61508 with “NR – Not Recommended”.

MB 1	Clause No./ Subclause No./ Annex (e.g. 3.1)	Paragraph/ Figure/ Table/Note (e.g. Table 1)	Type of com-ment[2]	Comment (justification for change) by the MB	Proposed change by the MB
AT-3	9.4.3	Table 13	TE	As written in Part 10, §4.1, ISO 26262 takes into account requirements related to model-based development. But "Model based testing" ("Model-Based Testing is the automatic generation of efficient test procedures/vectors using models of system requirements and specified functionality") is not mentioned at all (see Model-based Testing, SoftwareTech July 2009, Vol. 12, No. 2, Software Testing: A Life Cycle Perspective, http://www.goldpractices.com/practices/mbt/)	Add row plus note c) 1e Model based testing[c] ++ ++ ++ ++ [c] Model-Based Testing is the automatic generation of efficient test procedures/vectors using models of system requirements and specified functionality, see (see Model-based Testing, SoftwareTech July 2009, Vol. 12, No. 2, Software Testing: A Life Cycle Perspective, http://www.goldpractices.com/practices/mbt/)
AT-4	10.4.4	Table 16	TE	As written in Part 10, §4.1, ISO 26262 takes into account requirements related to model-based development. But "Model based testing" ("Model-Based Testing is the automatic generation of efficient test procedures/vectors using models of system requirements and specified functionality") is not mentioned at all (see Model-based Testing, SoftwareTech July 2009, Vol. 12, No. 2, Software Testing: A Life Cycle Perspective, http://www.goldpractices.com/practices/mbt/)	Add row plus note d) 1e Model based testing[d] ++ ++ ++ ++ [d] Model-Based Testing is the automatic generation of efficient test procedures/vectors using models of system requirements and specified functionality,

Table 10-6: Austrian MBT/TCG (MOGENTES project) related comments on ISO/DIS 26262-6