ARTEMIS JOINT UNDERTAKING

PORTFOLIO ANALYSIS

Revision: 4.0 (publication release)

Date: 20/02/2013

Document: ARTEMIS-ED-2012.51

Authors: Alun Foster and Eric Schutz, with valuable support from Patrick Vandenberghe, Berta Ferrer-Llosa, Antonio Vecchio and Georgi Kuzmanov.

Editor: Alun Foster

Table of Contents

1. EXECUTIVE SUMMARY

This report forms an analysis of the execution of the ARTEMIS programme after four Calls, both in respect to the coverage of the technical work programme and with regard to the implementation of the main ARTEMIS strategic element, being to build "Self-sustaining Innovation Ecosystems" for the advancement of embedded-systems technologies in Europe, as a mechanism to both address the present fragmentation of R&D and to assure better take-up of results that can improve industrial efficiency and competitiveness.

The ARTEMIS-JU programme is radically different than existing instruments, both in the manner in which the R, D and I activities are funded (a tri-partite model with funding from Industry, participating Member States and the EU through the Framework Programme 7 of the European Commission) and in its strategic positioning, which combines top-down strategic guidance with bottom-up definition of the technical issues to be addressed. Activities that could create the "Self-sustaining Innovation Ecosystems" called for in the Multi-Annual Strategic Plan are not fundable in this model. For this, the ARTEMIS-JU relies heavily, and with success, on the community of actors supported by the private partner (ARTEMIS Industry Association) to organize themselves around "clusters" of projects encouraged by annual "ARTEMIS Technology Conferences". Successful clusters can apply for ARTEMIS-IA labeling as an ARTEMIS "Centre of Innovation Excellence" (a formalization of the "Self-sustaining Innovation Ecosystem" concept). To date, there are three such CoIEs, on safety-critical (electronic) engineering, on process automation and on energy-efficiency in intelligent buildings.

After four Calls, ARTEMIS-JU has 44 running projects representing a total R,D & I investment of 708M€, comprising 228M€ National contributions, 116M€ contribution by the EU and 363M€ from Industry. The ratio of National to EU funding – a figure of merit of the leverage effect of the EU contribution which must be at least 1.8 – is 1.96. The Average Countries per Project is about 7, compared to a historically typical 3 to 5, indicating that the ARTEMIS programme has achieved one of its high-level goals - reducing fragmentation – by enlarging the typical project 'footprint' at a European level.

Of the 586 unique entities participating in ARTEMIS projects (with many organization participating in multiple projects), 207 (35%) are Large Enterprises, 210 (36%) are SMEs and 169 (29%) are public research organisations. That more that 70% of the participants are industrial players indicates the true industrial focus of the programme. That 36% of the organisations are SMEs can be explained by the National contribution, favourable to SME participation, and the establishment of local ARTEMIS networks.

The distribution of investment over the 8 ARTEMIS Sub-Programmes shows a large distortion in favour of ASP1 (Safety-critical systems, with 32%) and ASP5 (Architectures, with 26%): ASP1 because of its high importance for the Transport and Medical industries, attracting larger projects with directly industrially relevant outcomes, and ASP5 through the high technical complexity of low-power multi-core platforms, attracting generally smaller-scale projects and higher academic content. The effort distribution over the three "Industrial Priorities" too shows a strong bias towards "Design Methods and Tools, driven partly by the preponderance of ASP1 projects and also due to the other priorities (Reference Designs and Architectures, and Seamless Connectivity and Middleware) necessarily requiring development tools to support them.

The report also contains a study of the clusters developing within the ARTEMIS programme, and details some highlights of projects that have completed at the time of writing.

1.1. Main Conclusions

A summary of the most important conclusions, described in Chapter 8:

- The “Think Big” philosophy produced large and successful projects, while the support of ARTEMIS-IA has encouraged ‘clusters’ of projects leading to the establishment of CoIEs.
- The tri-partite funding model has assured a broader Europeanization of its projects and has also contributed to a higher enrolment of SMEs
- The ARTEMIS programme, at present levels, is likely to finish at roughly one half of its originally anticipated size, limited mostly by the National investment. While ARTEMIS has a strong industrial lead, a future programme should engage the strategic considerations of the participating states much earlier in its definition process.

2. INTRODUCTION

This Portfolio Analysis gives a description and state-of-play of the ARTEMIS-JU programme's "ASP" projects up to Call 2011, i.e. all projects whose technical content and evaluation/selection criteria fell under the concepts, vision and strategy described in the AWP and MAP/RA documents 2008/2009/2010/2011 that were themselves inspired by the first ARTEMIS SRA published by ARTEMIS-IA in 2006.

The ARTEMIS Joint Undertaking's annual Calls each release an Annual Work Programme (AWP), which serves to describe the technical content of proposals submitted for each Call. This AWP is in turn derived from a Multi-Annual Strategic Plan and Research Agenda (MASP/RA), which lays out the general strategies for a series of subsequent calls. The MASP/RA itself is derived from the over-arching vision described in the ARTEMIS SRA by ARTEMIS-IA, and both MASP and the AWPs are elaborated by the members of the ARTEMIS-JU IRC, which are the same persons as the Steering Board of the ARTEMIS Industry Association – the private partner in the public-private partnership that the ARTEMIS-JU is.

Each AWP splits the programme into a set of eight "ARTEMIS Sub Programmes" (see further for details) which, while the fine-detail of the description or the title of each one has evolved over the four Calls, the basic thematic content of each has remained the same.

Due to the trans-national component of the funding mechanism (with 22 participating ARTEMIS Member States) it was deemed not to be useful to modulate the budget allocated to each sub-programme as a means of steering the programme. Instead, all sub-programmes have been open in each Call, with no 'earmarking' of parts of the budget for any specific one.

The ARTEMIS programme, with its four calls from 2008 to 2011, to date has amassed a total of 44 projects:

- Call 2008 – 12 projects
- Call 2009 – 13 projects
- Call 2010 – 10 projects
- Call 2011 – 9 projects

A key aspect of the ARTEMIS-JU MASP/RA is that it promotes "Self-Sustaining Innovation Ecosystems" to maximize R&D impact. From this, it is already seen that some powerful project clusters have emerged, which will be discussed in more detail later in this document. It is the strong belief of those involved in the ARTEMIS programme that such clustering is a vital aspect in facilitating the concrete valorisation of R&D project results, and therefore converting the R&D efforts into true Innovations in products, services and ways of working to produce these.

N.B. ARTEMIS as community for embedded systems comprises two legal entities: the ARTEMIS Industry Association (ARTEMIS-IA) and the ARTEMIS Joint Undertaking (ARTEMIS-JU). When "ARTEMIS" is used in the text of this document, it refers to the total community by default without differentiating the two legal entities. When talking about ARTEMIS programme and ARTEMIS projects, by default, the ARTEMIS-JU programme and projects are meant. However the "ARTEMIS SRA" is issued by ARTEMIS-IA as ARTEMIS-ETP ("European Technology Platform").

3. HISTORIC BACKGROUND – THE ARTEMIS SRA

Set up in response an initiative of European Commission Liikannen in 2004, a European Technology Platform (ETP) for Embedded Systems was established. In the document "Building ARTEMIS", a high-level group of industry leaders identified work towards the establishment of a Joint Technology Initiative, The ARTEMIS ETP was given an identifiable governance structure (so became more than an informal discussion group) which brought a large cross-section of the European ICT/systems industry together to define a VISION and detailed STRATEGIC RESEARCH AGENDA (SRA) for embedded systems in Europe. This was published in 2006, and has served as the basis from which the ARTEMIS-JU programme was developed.

The VISION centres on the ubiquity of Embedded Systems and the economic and societal importance of Innovation in this branch of ICT.

The AGENDA recognises a number of Research challenges and addresses new ways of stimulating INNOVATION (as the driver of economic well-being). It also puts forward ideas for new ways of funding RD&I, intended to empower European companies to achieve better valorisation of R&D results and using the model of a Public-Private Partnership as means of implementing the "Joint Technology Initiative" concept.

This in turn led to the establishment of the ARTEMIS Joint Undertaking (JU) in 2008, by decision of the European Council. Earlier in 2007, the ARTEMIS-ETP was transformed into the ARTEMIS Industry Association (ARTEMIS-IA) as legal entity to continue the work of the ARTEMIS-ETP and to become the private partner in the ARTEMIS Joint Undertaking.

4. ARTEMIS-JU – VISION, MISSION AND OBJECTIVES

4.1. Addressing the Goals of the ARTEMIS Programme

4.1.1. Vision and Mission

From its outset, the ARTEMIS-JU has adopted the vision and main goals (mission) described in the Council Regulation of 2008 and in the subsequent MASP/RA documents in the years 2008-2011. These are described in the Mission Statement as:

*"**Mission statement:** to define and implement the Research Agenda for the development of key technologies in the field of Embedded Computing Systems, by creating a sustainable public-private partnership and leveraging and increasing private and public investment in the sector of embedded systems in Europe.*

***Vision and Objectives:** The ARTEMIS JU aims to achieve effective coordination and synergy of resources and funding from the industry, the Framework Programme, national R & D programmes and intergovernmental R & D schemes, thus contributing to strengthening Europe's future growth, competitiveness and sustainable development.*

***Values:** ARTEMIS seeks to foster collaboration between all stakeholders such as industry, including small and medium-sized enterprises (SMEs), national or regional authorities, academic and research centres, pulling together and focusing the research effort. The ARTEMIS JU adopts a commonly agreed research agenda closely following the recommendations of the Strategic Research Agenda developed by the ARTEMIS Technology Platform. This Research Agenda identifies and regularly reviews research priorities for the development and adoption of key technologies for embedded computing systems across different application areas in order to strengthen European competitiveness and allow the emergence of new markets and applications important to society.*

***Strategy:** The ARTEMIS JU will support R & D Activities through open and competitive calls for proposals published on a yearly base, to attract the best European research ideas and capacities in the field of Embedded Computing systems. Proposals submitted to ARTEMIS JU calls undergo a technical evaluation and selections process carried out with the assistance of independent experts. This process ensures that allocation of the ARTEMIS Joint Undertaking's public funding follows the principles of equal treatment, excellence and competition. "*

The Council Regulation that established ARTEMIS clearly demarcates the responsibility for elaborating the technical work programme to the private partner in the JU (the ARTEMIS-JU IRC, consisting of the same persons as the Steering Board of the ARTEMIS Industry Association, ARTEMIS-IA) and for decisions on financial matters to the public sector partner (representatives of the participating Member States and the European Commission). The ARTEMIS-JU Office, under guidance of its Executive Director, fulfils the necessary management of all operational aspects of the execution of the programme.

In order to reinforce the larger perspective of ARTEMIS' goals, being primarily to boost valorisation of R&D results and to stimulate true Innovation (capital 'I') as opposed to scientific novelty, four guiding principles were adopted:

"Think BIG" i.e. consider that ARTEMIS projects should have appropriate critical mass and societal insight to assure significant impact of the public funds used ("taxpayer value-for-money"). This is moderated by observing that "Big" refers to the IMPACT of a project, not necessarily its size in term of partners or total budget; the idea being the ARTEMIS adage that the programme should comprise some "large projects supported by smaller, targeted initiatives".

"Act Socio-Economic": the main goals being improved industrial efficiency "... to strengthen European competitiveness and allow the emergence of new markets and societal applications," i.e. a focus on key technical issues, solving high-visibility problems with commercially valorisable results

"Act Multi-national" (= "Act Pan-European"), consider national and/or regional strategic priorities and specific specialisations and expertise available within the diversity of the European Union.

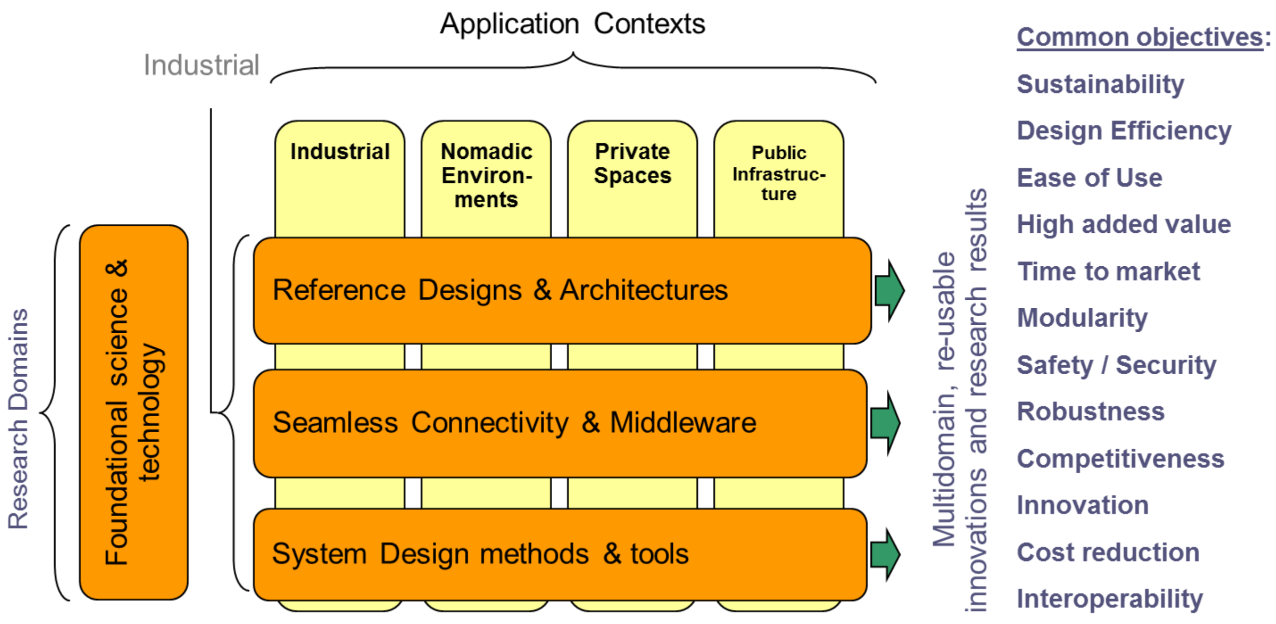
"Think Different": strive for significant and complementary added-value to existing programmes and projects.

4.1.1. Technical objectives – the Multi-Annual Strategic Plan / Research Agenda and Annual Work Programmes

As described above, the ARTEMIS JU was set up to implement relevant parts of the ARTEMIS SRA, using a new financing model combining National and EU funds, following the 2006 ARTEMIS SRA Vision and with a work programme derived from that SRA.

In order to describe its own work programme, the ARTEMIS-JU publishes a Multi-Annual Strategic Plan ("MASP") and a Research Agenda ("RA", being the work programme for each Call), with a yearly update. Important in this is that the ARTEMIS-JU has an industry-led, DESCRIPTIVE work programme, i.e. using "Top-down" strategic guidance to define and structure the work, specific details of the programme being provided by the industrial participants in a "bottom-up" mode with "Market Innovation" as its central theme. In this way, the ARTEMIS-JU programme seeks the complementary middle-ground between the prescriptive Framework Programme (EC) and the very open Eureka (trans-national) programmes.

The ARTEMIS-JU MASP/RA classifies the work to be done into "Application Contexts". Each application will of course have its own specificities, but the underlying technologies can and should, wherever practical, be re-used. These underlying technologies are called the "Industrial Priorities" to distinguish them from the far-from-market foundational science and technology work. To encourage re-use across the different context, they are diagrammatically arranged has horizontal actions supporting the (vertical) application contexts.



This basic concept has been adopted in the ARTEMIS-JU technical work programme, implemented as a set of eight "ARTEMIS Sub-Programmes" (ASPs). The ASPs (listed below) have evolved during the execution of the programme, in their names and detailed content, though the generic outline has remained constant. As the ARTEMIS-JU programme is an industry led initiative with a strong, market-facing character, the Foundational Science and Technology aspects are de-emphasised though not eliminated completely.

The 8 ARTEMIS Sub Programmes (ASPs)

- **ASP1:** Methods and processes for safety-relevant ES
- **ASP2:** Embedded Systems for Healthcare systems
- **ASP3:** Embedded Systems in Smart Environments
- **ASP4:** Manufacturing and Production Automation
- **ASP5:** Computing Platforms for Embedded Systems
- **ASP6:** ES for Security and Critical Infrastructures Protection
- **ASP7:** Embedded Technology for Sustainable Urban Life
- **ASP8:** Human-centred design of Embedded Systems

4.1.2. Innovation objectives

An important aspect of the ARTEMIS-JU MASP/RA, and consequently of the ARTEMIS-JU work programme, is the will to strengthen Europe's ability to convert its excellent scientific, research and development capability into commercially viable products and services or improved production methods for existing products.

In the Multi-Annual Strategic Plan of the ARTEMIS-JU, this is approached through the vision of establishing "Self-sustaining Innovation Eco-Systems", which past experience shows can be brought about by the attainment of sufficient "critical mass" with enough industrial "buy-in" of (non-differentiating) technological solutions. (See the ARTEMIS SRA document on Innovation Environment). While respecting the Pan-European vision of the programme, it is the expectation that such Innovation Eco-Systems can condense to form structured "Centres of Innovation Excellence" ("CoIE", modelled on the existing "Competitiveness Centres" or simply "Centres of Excellence" for scientific work). The ARTEMIS Industry Association has initiated a labelling scheme such that allows CoIEs to be recognised as such.

On this point, the ARTEMIS-JU faces a limitation in that the funding it provides can be used only for R&D activities – supporting activities that can financially support such non-R&D activity are not fundable under the present scheme.

To address this, and under the stimulus of the ARTEMIS-JU Office, the ARTEMIS community has adopted the approach that project clustering is a valuable first step towards establishing CoIEs and has actively implemented this through a series of annual inter-project workshops called the "ARTEMIS Technology Conferences", which complement the many other activities organised by the Industry Association.

To date, three such 'clusters' have successfully obtained an ARTEMIS CoIE label: **EICOSE** (European Institute for Complex Safety Critical Systems Engineering), **ProcessIT.EU** (Process Automation in industry) and **ES4IB** (Embedded Systems for Intelligent Buildings). See www.artemis-ia.eu/coielabel for more information.

4.1.3. Intangibles and longer-term impacts

The ARTEMIS Industry Association maintains a number of working groups in support of the programme. In addition to defining the technical work programme, these groups, voluntarily supported “in kind” by the industrial and academic employers of the people involved, address topics that are peripheral to the ARTEMIS-JU programme today yet have an important role for the future. These include Standardisation (which has resulted in the adoption of the PROSE* strategic document on standardisation), Open Source, Education, SME involvement, etc…, and in particular the WG Success Criteria and Metrics, the work and output of which is described below. The ARTEMIS Industry Association has opened their WGs for project officers of the ARTEMIS-JU to become members of the WGs to assure optimum cooperation between the Industry Association and the ARTEMIS-JU office.

*(*PROSE is a project funded under the FP7, set up by members of the ARTEMIS community specifically for the benefit of the ARTEMIS programme).*

4.1.3.1. The WG Success Criteria and Metrics

In order to monitor the progress of the ARTEMIS-JU programme, a specific working group “Success Criteria and Metrics” was set up. Its goal is to address the difficulty of converting the generic targets described in the ARTEMIS SRA, which had inspired the Council Regulation establishing ARTEMIS-JU, into measurable quantities and baselines. This it approached by means of a bottom-up study using a targeted questionnaire to the participants in ARTEMIS-JU projects, and the results of the first such questionnaire were published in 2011. A second questionnaire was launched during 2012 of which the detailed results are expected before the end of 2012. However, preliminary analysis of these results shows that ARTEMIS is gaining momentum on several important “intangibles” for the programme:

- Networks have been established and are fully operational. New partnerships and the involvement of SME’s has grown
- The Industry-driven approach and the combination of scientific & industrial views are considered to be key strengths and motivators within the ARTEMIS community
- There is growth of awareness of and interaction with “CoIEs”
- Business impact has been mostly observed in reduced development costs, reduced TTM and higher re-usability
- The ARTEMIS AWP targets, being revised for each Call, are a living instrument
- The Societal Challenges are addressed properly, with ‘’security and safety’’ being number 1
- The building of Prototypes and Demonstrators has seen growing attention, including public trials and/or field tests
- There has been increasing attention to press releases and press coverage, bringing ARTEMIS more into the public domain.

5. STATE-OF-PLAY OF THE PROGRAMME AFTER 4 CALLS

5.1. List of projects included in this analysis

This analysis includes data from all 44 projects resulting from the first four Calls of ARTEMIS. Most of the Call 2008 projects and one Call 2009 project have completed at the time of writing, while others are still in full swing. This analysis is therefore a snapshot of the programme. The projects are:

CALL	Project
2008	SOFIA
	EMMON
	CESAR
	iLAND
	INDEXYS
	SCALOPES
	CHARTER
	eDIANA
	SYSMODEL
	CAMMI
	SMART
	CHESS
2009	iFEST
	RECOMP
	SIMPLE
	SMARCOS
	ACROSS
	POLLUX
	R3-COP
	ME3GAS
	CHIRON
	ASAM
	eSONIA
	SMECY
	pSHIELD

CALL	Project
2010	D3CoS
	WSN DPCM
	IoE
	MBAT
	nSHIELD
	PRESTO
	ASTUTE
	HIGH PROFILE
	pSAFECER
	ENCOURAGE
2011	e-GOTHAM
	VeTeSS
	CRAFTERS
	DEMANES
	nSafeCer
	DESERVE
	SESAMO
	VARIES
	PaPP

5.2. Programme execution – the investment so far

Using statistics drawn from the awarded projects' data, the following table summarises the key investments made in ARTEMIS projects for the first four Calls.

Call	Total Costs (investment) M€	Total National Funding M€	Total EU funding M€	Total Public Funding M€	Own means M€	RATIO National vs. EU funding
2008	193,53	60,68	31,77	92,45	101,08	1,91
2009	206,00	67,64	33,64	101,29	104,71	2,01
2010	166,39	54,64	27,09	81,73	84,66	2,02
2011	142,14	45,21	23,67	68,88	73,26	1,91
Total	**708,06**	**228,17**	**116,17**	**344,35**	**363,71**	**1,96**

In addition to this, the following key figures are of interest:

The Average Countries per Project is nearly 7 (6,68). This indicates that the ARTEMIS programme has achieved one of its high-level goals of reducing fragmentation, by enlarging the typical ‘footprint’ at a European level. In other programmes, averages of 3 to 5 countries per project are more typical.

The Average National Funding Rate (for ARTEMIS Member States only) is 33,22%. The Average EU Funding Rate over all participants is 16,41% (this small reduction from the theoretically fixed value of 16.7% is due to a specific arrangement required in Greece). The Average Total Funding Rate over all projects is 48,63 %, with the remaining 51,37% being provided by the participants’ own means.

The total R&D&I investment made in the programme to date is 708 M€, with 228 M€ National Contributions and 116 M€ EU Contributions, with the remaining 363 M€ being provided by the ‘private’ partners (Industries, large and small, as well as in some cases Public Research Organisations, PROs).

A key reference figure, stipulated in the Council regulation that establishes the ARTEMIS-JU, is the ratio between the National and EU contributions, which must be not less than a factor 1,8. The programme to date has established this ratio at 1,96, which is largely within requirements and allows margin for any reduction in EU funds leverage in the last Calls of the programme.

5.2.1. Programme participation: the attractiveness to Industrial and Research organisations.

To date, the ARTEMIS programme counts a total of 941 participations by organisations of various types.

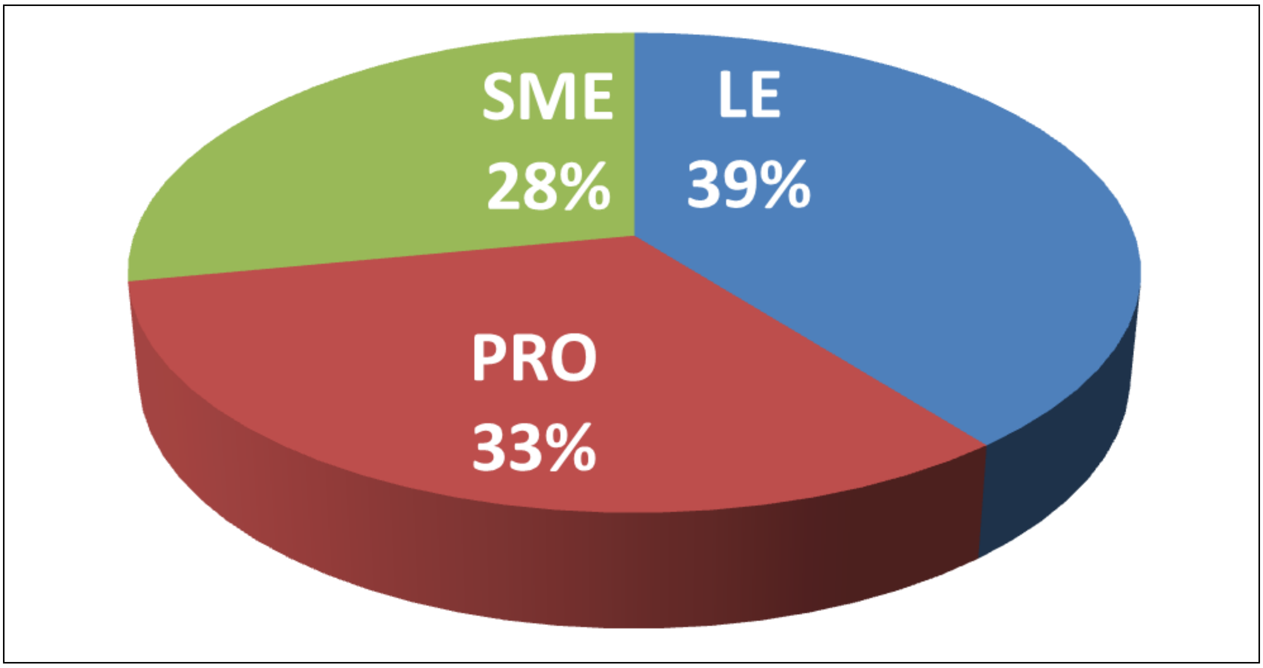
Call	Participations
2008	223
2009	286
2010	224
2011	208
Total	**941**

ARTEMIS classifies participants into “Public Research Organisations” (PRO), which embraces universities and other publicly funded institutions, “Large Enterprises” (LE) and “Small and Medium-sized Enterprises” (SME). The last two together represent the Industrial participation in the programme.

The split of participations by partner type is given here.

Call	LE	PRO	SME	Total
2008	88	79	56	223
2009	106	99	81	286
2010	101	58	65	224
2011	75	72	61	208
Total	**370**	**308**	**263**	**941**

Calculating the relative participations of each partner type gives this picture:



From this, two interesting observations may be drawn.

Firstly, that the programme has succeeded in attaining a strongly industrial focus, with 67% of the total participations being industrial players, large or small.

Secondly, though ARTEMIS has an ambition to increase the enrolment of SMEs, the only mechanism available for this is at the Programme level is the Selection Criteria on which project proposals are ranked. SME enrolment is mentioned only in one sub-criterion, where the evaluators are asked to rank the balance of the consortium regarding the useful participation of SMEs. There is no quota or other method applied, though the participation rules in certain member states do require or encourage SME participation (for example with favourable funding rates). Still, 28% of the total number of participations is from SMEs, indicating that the vision, goals and work programme of ARTEMIS are indeed attractive to them, possibly and in addition, because of the participation of Member States who understand more fully the needs of their SME communities.

A side-effect of the ARTEMIS funding model and proposal selection mechanism is that, when budgets are allocated, national funding in certain countries may “run out”, leaving some participants without National funding support. In many cases, the technical aspects of the project can be fulfilled by identifying equivalent partners in different countries, where funding is still available. Alternatively, a partner with no national funding may still participate with EU funding support only. It is interesting to note that, out of the 941 participations, 38 cases (4%) have chosen to participate without National funding support, receiving only the 16.7% EU funding. Of these, 12 are SMEs, 12 are large enterprises and (surprisingly) 14 are PROs. That these partners are willing to participate with only minimal public support indicates that the technical programme is highly compelling for them.

Unique Participations

The total number of participations counts the possible multiple projects a single organisation may be participating in. Counting unique participations (i.e. counting a participating organisation only once) yields the following table:

Total Unique Participations	LE	SME	PRO
586	207	210	169
	35%	36%	29%

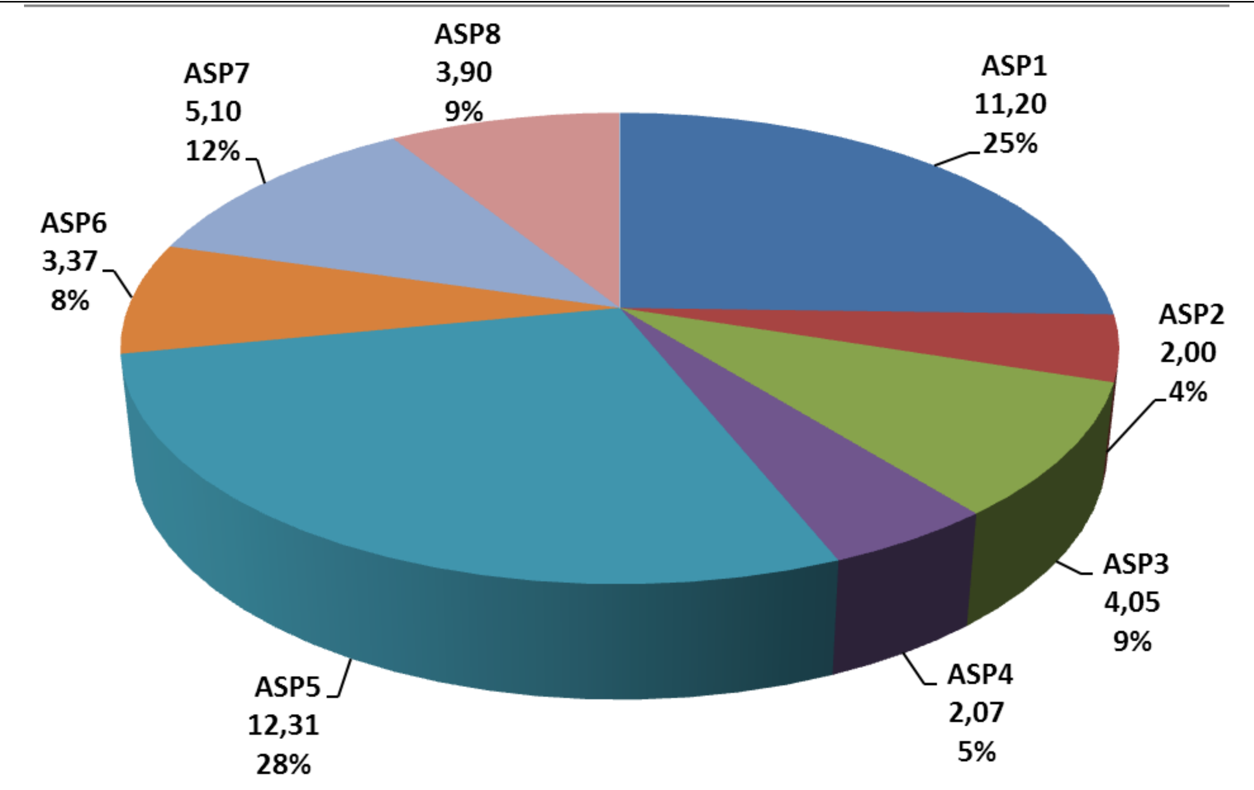
Counting this way removes the advantage that large enterprises and public research groups have in participating in multiple projects, and thus gives a better picture of the global ARTEMIS community participating in projects. In this way, we can see that roughly 70% of all participants are from industry, with a balanced mix of 35% each for large industrial companies and SMEs. (Note that, for the purposes of this analysis, the different divisions of the several multinational companies in different countries are counted as separate entities).

Of the 586 unique participations, 415 are single participations by an organisation. 109 organisations participate in 2 or 3 projects, while 50 participate in 5 or more. Among these “top scorers” we of course find the large industrial groups (ST, Infineon, NXP, AVL, Fiat Research, Barco, Siemens, Thales Acciona, Philips, etc…) and the large research organisations (VTT, CEA, Fraunhofer, Tecnalia, …), we also find a few SMEs (Integrasys, TTTech, …). That SMEs, with their traditionally limited resources, wish to participate to such an extent indicates that, for them, the ARTEMIS programme and the eco-system of companies involved in the projects is indeed very attractive. The establishment of local ARTEMIS “mirrors” at National level has also been observed (“Prometeo” in Spain, and ARTEMIS groups in Austria, Hungary and Denmark), which too facilitates SME participation.

5.3. Technical coverage

5.3.1. Coverage of the ASPs

The allocation of projects to the APSs of the ARTEMIS Research Agenda gives the following distribution

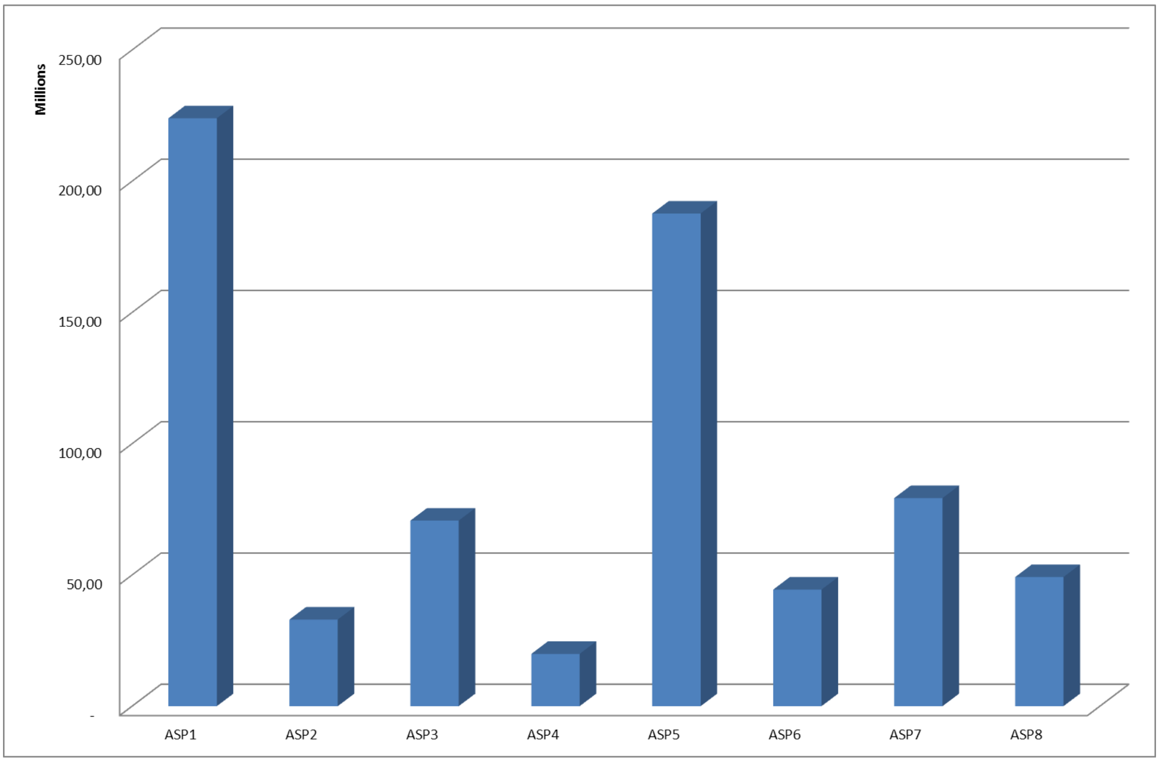


Note that fractional projects are possible here, as many ARTEMIS project proposals address key technological issues relevant for more than one of the ASPs. The independent experts who assist the ARTEMIS-JU in the evaluation and selection process are asked to estimate the allocation of project content to ASPs. The above numbers are the sum of all (partial) projects allocated to the ASPs – the total is thus 44.

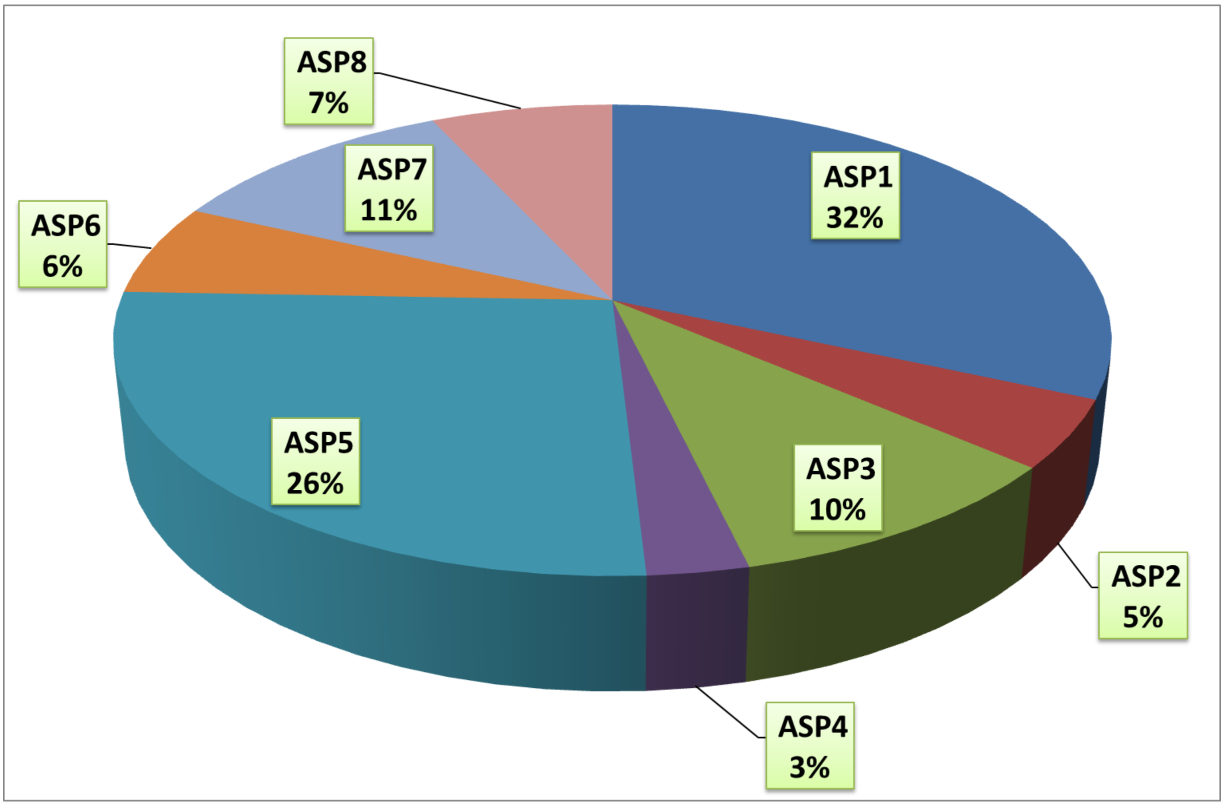
The preponderance of projects in ASPs 1 and 5 is immediately aparent. This is explained for ASP5 (architectures for embedded) by observing that this ASP, which is more upstream, technology focused, presents a much lower threshold to the more academic participants and will generally seed smaller projects due to the need for technology focus. ASP1, which focuses on safety-critical issues for embedded systems, on the one hand has a high impact on many application domains (automotive, aerospace, health, …) and one the other has a high focus on design processes and tools which are required across the whole of the electronics industry, due to the high impact they have on design efficiency and product certification (hence cost). The other ASPs typically have more specific application orientations.

However, simply counting projects, even with the additional refinement of partial project allocation to ASPs, is not really a fair comparison, as the size of projects in terms of partners, budgets etc… varies greatly. A better measure is to combine the ASP allocation matrix with the Total Cost of the projects, as a direct measure of the amount of effort being expended on these topics. Note that the ARTEMIS projects each contain a sufficiently diverse mix of countries, such that local variations in cost-per-manhour may be ignored for the purpose of this analysis.

The chart below shows the investment, as measured by Total Cost, made in all projects, and how this is distributed over the ASPs, using the same allocation data provided by the independent experts when the proposals were evaluated prior to selection (note that this was done *a posteriori* for the Call 2008 proposals, as this analysis was not foreseen at that time).



Proportionally, this is:



5.3.2. Analysis of project contributions to the Industrial Priorities

The contribution in projects towards the Industrial Priorities has been extracted by noting manpower expended, using the classification of the three Industrial Priorities identified in the ARTEMIS SRA of 2006 – Reference Designs and Architectures (RD&A), Seamless Connectivity and Middleware (SC&M) and Design Methods and Tools (DM&T), augmented by a category for Management, for Dissemination and for Application (which captures the contribution toward demonstrators).

Due to the large volume of disparate data, information has been extracted from a representative set of projects with significant levels of manpower. While not completely rigorous, it is felt that this approach gives a statistically meaningful outcome. The results of this analysis are shown in the table below.

Management	Dissemination	Application / Demonstration	RD&A	SC&M	DM&T
5%	4%	47%	9%	9%	26%

In this analysis, the percentage of manpower expended on project management is low compared to other programmes (typically, up to 10%), though this may be due to the economies of scale seen with the larger ARTEMIS projects included in this analysis. The percentage explicitly spent on dissemination may be felt to be disappointingly low, though this does not do justice to the enthusiastic participation to the various ARTEMIS events (especially the ARTEMIS Technology Conferences), which are generally not fully foreseen when the Technical Annex (the basis for claimable costs) for each project is constructed.

That roughly half of the effort is expended on "Application" is healthy for a programme that is market-facing and driving innovation. However, the heavy imbalance seen between the Industrial Priorities in favour of DM&T may require attention in future such programmes. While the presence of the very large CESAR project explains this distortion partially, the contributions to this figure from projects involved in multi-core architectures and from middleware also necessarily contain much work on tools dedicated to the architectural structures they define.

6. PROJECT CLUSTERS, AN ANALYSIS

After the first two calls – 2008 and 2009 – it was already becoming apparent that the community was putting forward excellent project proposals that did not align perfectly with the segregations described by the ARTEMIS Sub Programmes. This is to some extent to be expected: the ASPs have, by design, some technological overlaps and are not completely orthogonal – some are indeed more application specific while others are more technology oriented.

For that reason, already in Call 2009, the experts evaluating the proposals were asked to express their opinion about the contribution of each proposals, proportionally, to the various ASPs, so that the effort expended in each could later be estimated and analysed: this fractional allocation is the basis of the figures reported above.

Therefore, to better analyse the impact of the ARTEMIS programme on the Innovation community, an alternative classification based on Project Clusters has been adopted for the purposes of this analysis. Projects are put into clusters based on their general application field, and the inter-project exchanges noted, either within the cluster or between projects in different clusters (consistent with the “re-use” aspect of the ARTEMIS programme).

This chapter studies the interactions between projects that have already been achieved at the time of writing. Each cluster in the analysis of Chapter 5 is briefly described. It is interesting to note that interactions and transfer of know-how happens not only within each cluster, but also between projects that ostensibly belong to different clusters. For example, the results of the SOFIA project, on Smart Spaces, are taken up by other projects in the domains of manufacturing and on health-care, demonstrating the cross-domain re-usability of the results as called for in the original ARTEMIS SRA.

6.1. Hi-REL

(Projects: CESAR, CHARTER, CHESS, SYSMODEL, iFEST, RECOMP, MBAT, pSAFECER, nSafeCer, DESERVE, VARIES, VeTeSS)

Secure, industrial strength SW design tools and environments in which to operate them are of paramount important to many sectors of European industry, and in particular to the automotive, aerospace, industrial processes and medical/healthcare sectors. These industries form the backbone of virtually all European industrial output and the future welfare of these industries depends upon being able to deliver very high quality, hyper-reliable products that earn the respect of markets world-wide. As such, the domain we have classified as the ARTEMIS Hi-Rel cluster is of particular importance and interest to industry. We can see this by the very large participation in ASP1 projects, and in particular the enthusiasm with which a large and representative cross-section of European industry is cooperating in these projects. The list is long (see above) but most, if not all, orbit around CESAR.

CESAR is a very large project – the largest in the ARTEMIS portfolio. Its importance, both in size and of its topic, has generated such gravitational pull that many projects, after starting out as essentially free-standing entities, have quickly “moved into orbit” and provide inputs to CESAR or make use of its output.

What CESAR has created is a “Reference Technology Platform” (the CESAR RTP, or CRTP). In essence, this is a sophisticated toolkit to manage the plethora of tools needed when developing SW-intensive products for markets that demand absolutely highest standards of reliability, which must pass through complex certification processes, often by legislation. The CRTP allows relevant and interoperable tools to be selected for particular market/product requirements and generate a customised working environment in which these tools can be used to their best advantage. It is in essence a “Tool Platform”, as described in the ARTEMIS AWPs. For this, it feeds on its own technological developments, and a large and expanding data-base of tools and process descriptions (methods of working) from within itself or provided from outside sources (often, other projects' output).

All of the projects listed above address some specific aspect of SW design, relevant for this "Hi-Rel" cluster: SafeCer focuses on certification requirements; SYSMODEL on accessible model-based engineering tools, CHARTER offers Java-based tools capable of meeting stringent hi-rel requirements, and so on.

A key issue in this is the interoperability of the tools and data-formats they use, and CESAR and other projects organised the ARTEMIS Technology Conference 2012 specifically on this topic. An extract from the CESAR report on this event: *"In order to foster the exchange beyond project borders and research programmes on interoperability, CESAR has initiated the Interoperability Day 2012 under the umbrella of the ARTEMIS Technology Conference 2012. The event was hosted by CESAR and co-hosted by iFEST, MBAT and pSAFECER in conjunction with the Embedded World 2012 and the ARTEMIS Spring Event 2012. To increase the variety of interoperability approaches presented, a call for contributions had been launched within ARTEMIS, ITEA and national research communities. It resulted in an interesting group of contributing projects and initiatives, each highlighting a specific aspect of interoperability: CESAR (ARTEMIS), MBAT (ARTEMIS), iFEST (ARTEMIS), OSLC (Open Community), POLARSYS (Eclipse Industry Working Group), SAFECER (p- and n-, ARTEMIS), SAFE (ITEA), SMECY (ARTEMIS), SOFIA (ARTEMS), R3COP (ARTEMIS), SPES XT & SPES 2020 (National German).*

Although the approaches presented during this day are different with regard to scope and granularity, they are homogeneous in the big picture. A need for a generic basis to with specific applications has been recognized. An example is the large scope CESAR Interoperability Specification (IOS), where compatibilities with the iFEST approach have already been recognized. Events like this ARTEMIS Technology Conference are a first step in the right direction. It is now up to all stakeholders involved to push the harmonization of approaches forward and to foster and continuously improve an interoperability concept."

By opening up the AIPPs in Call 2012, ARTEMIS-JU is now offering the community of stakeholders the opportunity to take this initiative forward.

6.2. Energy Efficient Communities and Electric Car

(Projects in this cluster: eDIANA, ME3GAS, e-GOTHAM, ENCOURAGE, IoE, POLLUX)

eDIANA established a middleware platform designed to overcome the concerns of interoperability and longevity of the various sensors and actuators used to monitor and control heating in buildings. The architecture distinguishes "Cells" (living units, be they individual homes or apartments in a larger building) and "Macro-Cells" (being apartment blocks or industrial/office blocks). The middleware was shown to greatly improve the interoperability of devices from various manufacturers using diverse connection methods (different types of wireless or wired connections). From an embedded-systems viewpoint this proved to be ahead of the field, though the integration of mechanisms to actually improve the efficient use of energy still has to be improved. In a similar vein, ME3GAS is developing a new generation of smart gas meters with integrated communication devices and an electronic shut-off valve (which is non-trivial due to the safety risks implied by mixing electronics with potentially explosive gas). In the gas supply market, different communication methods presently prevail, so the meters are modular, allowing migration from GPRS connection to the utility supplier, to integration into the Home Area Network, initially using M-Bus and later Zigbee or other commodity protocols. In parallel, a demonstration residence using these commodity wireless protocols has been set up and is working, showing how the integration of such sensors into the home environment can indeed influence and aid more efficient use of energy, indeed exposing new business models based around equipment monitoring and maintenance. ME3GAS has studied the use of the eDIANA Middleware platform, but the work today is at too different a level: a future project could conceivably integrate the results from these two projects, however.

The projects ENCOURAGE and eGOTHAM address the energy efficiency topic mostly from outside the residence or user premises, with eGOTHAM studying the management of the external supply network (for both domestic and industrial use, with demonstrators in both) and ENCOURAGE looking specifically at the integration of locally generated energy and storage into the “Micro Grid” architecture. Both projects foresee developing quite large demonstrators, though these are indeed still quite small compared to the larger picture. This does not however limit the applicability of the output of these projects to future, larger scale field trials. ENCOURAGE specifically shares partners in the IoE and Green eMotion projects (see IoE below), and the project is being actively encouraged to follow up on these contacts.

The POLLUX project integrates closely with the IoE project: a part of the project deals with the provision of electrical energy for electric vehicles. Another major part of POLLUX is developing the new, distributed (embedded-systems) architectures for vehicle electronic controls that future generations will demand, and for this the project collaborates with other ENIAC, CATRENE, ARTEMIS, EPoSS, EUCAR, and other relevant EU platforms and as such is “*thought of as complementing, from the Embedded Systems point of view, the current efforts of Europe’s major stakeholders for enabling the forthcoming architecture of electric vehicles”.*

The IoE (“Internet of Energy”) is of a much larger scale, addressing the issues of energy supply management and associated business models at a higher level, modelled on the principles of the Internet (which it also uses as a communication backbone for the principles being developed). It provides for an integration platform for the types of energy management architectures developed in the other ARTEMIS projects listed above, as well as tackling the (non-trivial) integration of electrical mobility, and includes renewable generation and storage methods. The architecture design of course considers extensively the security and privacy issues connected with this domain. While cooperation with other ARTEMIS projects on energy efficiency has not been highlighted (except possibly ENCOURAGE), cooperation with CASTOR (FP7 STREP, focusing on the distributed power train and on battery management), ENIAC “E3Car” on component level (SiC, SOI, high and medium power modules) and ARTEMIS POLLUX (on architecture and module level) has been undertaken. In addition, cooperation between IoE and the FP7 ”Green eMotion” and “Finseny” (also part of the Future Internet initiative) has been started.

6.3. Low-Power Multi Core

(INDEXYS, SCALOPES, ACROSS, ASAM, SMECY, PRESTO, CRAFTERS, PaPP)

The projects running or finished in ARTEMIS on this broad topic show a similar dispersion of the topics they cover. It is therefore difficult to provide a complete picture of how they interact with each other, though many are referred to by projects in the other clusters, for the obvious reason that this is basic technology work.

The INDEXYS project decided to extend its duration in order to include some results of the ARTEMIS ACROSS project as both projects are based on the GENESYS architectural blueprint approach. (GENESYS is a project financed under the FP7, specifically aimed to provide such an architectural blueprint for the ARTEMIS programme to refer to). INDEXYS could in this way refer, not only to the INDEXYS demonstrators, but also to the much bigger ACROSS demonstrators providing more in insight on the advantages in using the GENESYS services in embedded design. Both INDEXYS and ACROSS target applications in the automotive/aerospace domain and thus also contribute to the large “Hi-Rel” cluster, as does SMECY.

ASAM (Automatic Architecture Synthesis and Application Mapping) addresses a uniform process of automatic architecture synthesis and application mapping for heterogeneous multiprocessor embedded systems based on Application Specific Instruction Set Processors (ASIPs) customizable to a particular application through instantiation and extension. From its input, being a high-level behavioural, structural and parametric specification of the embedded system required for a given application, this process will produce as output a corresponding optimised and application application-specific heterogeneous ASIP-based multi-processor system realising the required application's behaviour, satisfying the structural and parametric constraints, and optimising the objectives and trade-offs related to the physical and economic system characteristics.

In contrast, the objective of CRAFTERS is to guarantee secure, reliable, and timely system operation while conserving energy and introducing a very minimal run-time overhead. These are technological challenges of rapidly growing importance and vast market opportunities. The CRAFTERS project realizes a predictable and flexible many-core platform with a run-time scalable execution environment. Some versions of the platform as well as the execution environment will be based on open technologies and standards and made publicly available. The key R&D challenges include:

- scalable parallel programming
- application and middleware portability
- system-wide performance predictability
- power and technology awareness

Although Low-Power is really a major concern, it is not the only one addressed by the ARTEMIS projects (as it is evident from the descriptions of the above two). Some of the other projects address the equally severe concerns of programmability (e.g. SMECY), composability and predictability of multicore systems, where problems are getting even more severe with a shift from homogeneous to heterogeneous multi- and many-cores. On the top of that, design tools for multi-/many-core systems are generally missing, which is another hot topic relevant to all efforts for practically sound multicore developments (in and beyond low-power). Safety and security for multi-cores systems are yet largely unexplored domains and certification of such systems is still a challenge. All in all, multicores could be (and actually are) put in a much wider scope than low-power, i.e., also in the context of sections 6.7 and 6.8 below.

6.4. Things of the Internet

(Projects clustered around this topic: EMMON, iLAND, SMART, SOFIA, SIMPLE, WSN-DPCM, DEMANES)

Four ARTEMIS projects (SMARCOS/SOFIA/CHIRON/iLAND) presented their intermediate results at the 2011 ARTEMIS Technology Conference in Bologna (Italy) on September 12-13. The aim of the event was to provide public visibility over technical aspects raised and solved by ARTEMIS partners in the field of Smart Environments. Exchange of ideas resulted in an increase of R&D results' effectiveness empowering the impact on industry and on society at large.

As a direct result, the CHIRON project, on patient-centric healthcare, decided to adopt the platform developed within the SOFIA project as its communication backbone.

In addition, the projects iLAND, SOFIA and eSONIA together have materialized the creation of a special issue on a FIRST QUARTER JCR indexed journal (IEEE Transactions on Industrial Informatics) with the goal of producing a special issue with very high-impact publications, presenting a European view of the distributed systems middleware based on Service Oriented Architecture for industrial applications.

(Note here the influence of projects on each other, across the theoretic boundaries of a “cluster”: this is fully in line with the ARTEMIS goal of assuring broad take-up and re-use of R&D results).

Moreover, iLAND has organised together with eSONIA a special session in the IEEE INDIN 2012 conference (International Conference on Industrial Informatics) in Caparica, Portugal, raising further the visibility of their results.

The other projects listed above have not participated explicitly in such clustering activities, though the project SIMPLE (not completed at the time of writing, being from Call 2009) has already developed a (potentially patentable) highly re-usable technique for embedding security and trust information exchange within the ZIGBEE protocol. In addition, the eSONIA project released a low-power IPv6 stack implementation (6lowPAN), aimed at applications in industrial controls but applicable across many applications requiring extreme autonomy.

6.5. HMI

(Projects in this cluster: CAMMI, SMARCOS, ASTUTE, D3CoS)

Surprisingly, the ASP8 of the ARTEMIS work programmes, to which this cluster is mapped, on human-machine interfaces was initially undersubscribed and has to date attracted only these four projects. Other projects do refer to operator interfaces (for example eDIANA, where such a display/control panel is developed to work in the middleware platform for demonstration).

The ARTEMIS project SMARCOS has had a successful project collaboration with the ARTEMIS project SOFIA, implementing the resulting project technologies in some of their use cases adding the possibility of multi-platform connection of events by broadcasting semantic information:

This collaboration was shown at the 2012 ARTEMIS Technology Conference: SOFIA provides principles, platform and design kit to enable interoperability among cross-domain environment-dependent applications and SMARCOS applies SOFIA technology on Attentive Personal Systems and Complex Systems Control (Collaborative Synergy-Navigation System). ASTUTE has collaborated with the Belgian national project “Tiii”, with who it shares some partners

6.6. eHealth

(Projects CHIRON, HIGH PROFILE)

Projects in this cluster, centred on ASP2, are few but welcome: this is an important area addressing a high-profile societal concern – the cost of healthcare for all and assuring a longer, active life of an aging population. The low success of subscription to this has been attributed to the difficulties that emerge when technologies from previously unrelated domains come together, in this case from the medical and the embedded-systems environments: a learning-curve exists during which mind-sets must converge to assure maturity of the programme and the proposals put to it.

The two projects presently show little interaction with each other: they address very different areas. While HIGH PROFILE develops advanced sensors and new techniques for enhanced medical imaging and merging of sensor data for improved diagnosis in the hospital environment, CHIRON looks at patient monitoring outside of the hospital, making use of Smart Spaces technologies.

CHIRON has already successfully collaborated with another ARTEMIS project. As mentioned above, and also shown at the 2012 ARTEMIS Technology Conference, the CHIRON reference architecture uses a middleware developed by the SOFIA project to support the Healthcare domain with Smart Spaces.

6.7. Safety and Security

(Projects: pSHIELD, nSHIELD, SESAMO)

pSHIELD, nSHIELD and SESAMO are 3 ARTEMIS projects contributing to the challenges listed in the ASP6 sub-programme of the ARTEMIS SRA (and its yearly implementation through AWP).

pSHIELD and nSHIELD descend from SHIELD, a proposal originally submitted to Call 2008 (CESIRA) than to Call 2009 (SHIELD) finally part funded in Call 2009 as pilot project (pSHIELD). In this respect, pSHIELD is a pilot project focusing on the full demonstration of only a subset of the technical objectives stated in the original SHIELD proposal, which unfortunately - after a positive evaluation - could not be fully financed because of lack of funding in some of the ARTEMIS Member State.

nSHIELD is the follow-up project of pSHIELD. The nSHIELD project is, at the same time, a complement and significant technology breakthrough of —pSHIELD as the first investigation towards the realization of the SHIELD Architectural Framework for Security, Privacy and Dependability (SPD). The roadmap, already started in the pilot project, aims at bringing to address SPD in the context of Embedded Systems (ESs) as —built in rather than as —add on functionalities, proposing and perceiving with this strategy the first step toward SPD certification for future ES. pSHIELD has covered the definition phase of this roadmap: nSHIELD will be in charge of the development and implementation phases. The SHIELD General Framework consists of four layered system architecture and Application Layer in which four scenarios are considered: 1) Railway, 2) Voice/Facial Recognition, 3) Dependable Avionic Systems and 4) Social Mobility and Networking.

The leading concept is to demonstrate composability of SPD technologies. Starting from current SPD solutions in ESs, the project will develop new technologies and consolidate the ones already explored in pSHIELD in a solid basement that will become the reference milestone for a new generation of —SPD-ready ESs. nSHIELD will approach SPD at 4 different levels: node, network, middleware and overlay.

The SESAMO project addresses convergence of safety and security in embedded systems at architectural level, where subtle and poorly understood interactions between functional safety and security mechanisms impede system definition, development, certification, and accreditation procedures and standards. The absence of a rigorous theoretical and practical understanding of safety and security feature interaction is currently a threat to market innovation. In this respect the potential impact of SESAMO is very relevant to ARTEMIS.

The project aims at developing a component-oriented design methodology based upon model-driven technology, jointly addressing safety and security aspects and their interrelation for networked embedded systems in multiple domains (e.g., avionics, transportation, industry control).

Key elements of the approach are:

- a methodology to reduce interdependencies between safety and security mechanisms and to jointly ensure their properties
- constructive elements for the implementation of safe and secure systems
- procedures for integrated analysis of safety and security
- An overall design methodology and tool-chain utilizing the constructive elements and integrated analysis procedures to ensure that safety and security are intrinsic characteristics of the system.

If successful, SESAMO may enable relevant improvements in design of ES (cost-efficient design, analysis, development, and assessment of distributed safety and security critical embedded systems).

6.8. Manufacturing

(Projects eSONIA, R3-COP)

eSONIA, which stands for “Embedded Service-Oriented Monitoring, Diagnostics and Control: Towards the Asset-Aware and Self-Recovery Factory.” is an ARTEMIS project aiming truly at the optimisation of factory automation. Its work centres on the intercommunication of devices and actuators in an aggressive, industrial factory environment especially making use of wireless technologies for easy deployment. Its key output to date is the release of an IPv6 “6lowPAN” protocol stack into the public domain, specifically designed to support autonomous (low-power) sensing devices. The project has not only been active technically, but also has been awarded for its clear public communications and dissemination activities. Though ostensibly an “industrial controls” project, eSONIA has networked well with others in the ARTEMIS “Things of the Internet domain (see above).

R3-COP is classified as “industrial”, though its focus is more on autonomous machines and the safety/reliability aspects that are critical to them. It is in fact a “robotics” project, though this special and important application of embedded systems is not clearly described as such in the ARTEMIS SRA or the AWPs derived from it (though the important characteristics required of it are). R3-COP studies both Technology and Methodology.

Technology:

- Fault-tolerant, high-performance processing platform based on a multi-core architecture
- Robust perception of the environment
- Reasoning, learning and reliable action control

Methodology:

- Development framework with an underlying knowledge base
- Tool platform for guarded development and standardised test
- Model-driven process for the compositional development of safety
- and security critical systems
- New validation and test methods for autonomous systems

Demonstrators from the ground-based (domestic), airborne (unmanned), and underwater domains will be shown.

7. Project Highlights, Call 2008

At the time of writing, all projects from the first ARTEMIS Call (in 2008) and one, 2-year project from Call 2009 have completed or are near completion. Here follows a brief summary of the achievements of these projects, with notes on what could not be accomplished during their execution.

7.1. CESAR

The CESAR project has delivered a great number of very valuable and innovative results in various areas. All of the results are documented to a very high standard and many of the results have been made public for the benefit of the embedded systems community (many of them are currently being accepted outside of the consortium). An impressive number of real breakthroughs have been achieved, with the project's main achievement being the CESAR Reference Technology Platform (CRTP) which has attracted interest well beyond the boundaries of the project.

Another project achievement which cannot be rated highly enough is the large number of PhD- and Master-theses which have been written within CESAR. Many young researchers thus had the valuable possibility to develop their skills in a mixed academic/industrial ecosystem. Also the academic results – many of them fundamental progresses over the state of the art – have been extensively published.

CESAR has shown the value of very large projects[*] – many previous projects also tried to produce consistent tool-chains but only achieved partial results because the consortia did not have the critical mass. CESAR for the first time managed to provide industrially acceptable solutions in (almost) all areas relevant for safety-critical embedded systems.

CESAR has also managed to provide a credible avenue for "life after the project", i.e. for the maintenance and continuation of the results achieved.

* Note: A very important prerequisite for the success of such large projects is a strong, consistent and knowledgeable management team – both technically and organizationally! This was true to a very high degree in CESAR.

7.2. CHARTER

Successes:

CHARTER defined a complete, Real-time Java*-based IDE (Integrated Development Environment) toolkit for high-reliability software development

The toolkit includes: Modelling, annotation-code generation, a certifiable Real-time Java compiler, a Real-time optimised Java Virtual Machine with deterministic Garbage Collection, resource analysis, formal verification, validation and test-generation tools. Demonstrators in Aeronautics, Automotive and Medical domains, referencing ISO 26262, DO-332/ED-217 standards, were used to prove its performance.

The results are made available for the ARTEMIS-CESAR "RTP" platform.

Regarding contributions to standards: RTCA SC-205 / EUROCAE WG-71, JCP, JSR(282 and 302), OMG, TOGAF, …

CHARTER also contributed certification guidance for dynamic memory management that went into Avionics standard DO-332

The valorisation of the project’s results will be through a hybrid COTS/OSS model, which benefits tool vendors involved in the project while making the key results also widely accessible

(*Java is a popular language for object-oriented programming, particularly in consumer electronics and web applications, and many engineering schools produce designers working with it. Until CHARTER, it has largely not been possible to make use of this language in any real-time critical application. The CHARTER tool-chain enables deterministic, real-time software to be developed using Java, opening up a vast resource of application code and engineering capability for high-reliability product development. It may also be seen as opening a pathway to rigorous, science-based engineering solutions for cost-effective implementations in mixed-criticality systems).

Work to be continued:

- Floating point equations are supported but still have the well-known caveats in handling “Not a Number” cases. The strong link with the CESAR project’s Reference Technology Platform (RTP) hopes to alleviate this in the near future.

- Full compliance with ISO 26262 (automotive safety standard) could not yet be demonstrated within the timeframe, even though the tools support this capability. Also, AUTOSAR (the automotive SW framework standard) is very “C”-centric in its description which complicated proof of compliance of efficient Java code. This can be addressed in the future.

-

7.3. CHESS

Successes:

CHESS created solutions to property-preserving (software) component assembly in real-time and dependable embedded systems, and to support the description, verification, and preservation of extra-functional properties of software components, at the abstract level of component design as well as at the execution level. Demonstrators cover a wide range of domains following a ‘separation of concerns’ concept. More specifically, the main project achievements could be summarized as follows:

- A Multi-concern Component Model embodying the ‘separation of concerns’ concept was proposed. A Multi-concern Component Methodology and Toolset for model-driven component-based architecture definition and transformations were developed
- The CHESS Modeling Language meta-model was defined. Transformations among models down to code as well as back-propagation capabilities were developed and tested. Extensions to the CHESS Modeling Language enhance the precision of extra-functional decorations and enable virtual multiprocessing.
- Dependable and secure component concerns were deeply investigated**.** A transformation engine for state-based analysis was defined and implemented, considering the whole transformation chain from CHESS to dependability analysis model and back-annotation
- Predictability, isolation and transparency component concerns were addressed by the CHESS methodology.

- Different execution platforms have been adapted to the CHESS concept – an Ada code generation engine makes it possible for functional source code generated in Ada, C and C++ for components with third-party utilities to be automatically and seamlessly integrated; An integration of Java in SystemC (see also the CHARTER project) provides the ability to exchange communication proto-cols/media between applications, and adds non-functional properties to communication latencies; C++ and Java/RTSJ code generators along with an extension of ObjectAda Raven allow execution time monitoring and deadline monitoring; An extension of JamaicaVM with an API for static thread creation was implemented along with a secure application manager.

Work to be continued:

- Security concerns using the CHESS methodology need to be investigated further.

7.4. eDIANA

Successes:

eDIANA has created a so-called "Middleware Platform" specification that allows various sensors and controls to communicate with each other, specifically aimed at energy management in houses and larger buildings (offices and/or residences). The middleware ensures that devices from different manufacturers can operate together*, using wireless or wired technologies. It also foresees connection to larger, district-level networks such as "smart grids". The platform's functionality and usefulness in the retrofit scenario were tested on three medium-scale application demonstrators.

(* The ability of equipment to interoperate is a major consideration when building new installations, or when retrofitting for existing buildings. Worries about equipment compatibility, security of supply and "future-safe" issues effectively slows down the roll-out of technologies beneficial to saving energy and reducing our carbon footprint: a building has a very long lifetime, throughout which its monitoring and control equipment is expected to operate without requiring major re-investment should upgrades be required. A uniform "middleware" platform removes many of these concerns).

The eDIANA consortium is at the heart of the recently certified ARTEMIS-IA Centre of Innovation Excellence "ES4IB" (Embedded Systems for Intelligent Buildings), and one partner has set up a spinoff company (WSENSE, Rome) on wireless sensor networks based systems.

Work to be continued:

- eDIANA made some major advances in the Embedded Systems technologies used in monitoring and controlling the use of energy in buildings and how these can be easily interconnected and made interoperable. However, the studies on how this information and control capability should be used in practice to improve the energy efficiency of the building need further work. This is work for specialists in a different discipline that Embedded Systems design.

7.5. EMMON

Successes:

- Medium scale deployment of a fully-functional system prototype in a real world scenario (composed by hundreds of nodes);
- New WSN embedded middleware with better overall energy efficiency, security and fault-tolerance;

- New efficient and low power consumption WSN multilevel communication protocols and reliable middleware for large scale monitoring;

- Simulation models for WSN behaviour analysis;

- Centralized C&C Centre for easy and centralized monitoring;

- Mobile C&C station or device for local access, diagnosing, viewing and troubleshooting of the network;

- Comprehensive Toolset for assisting network planning and deployment of large scale WSN systems.

The project had the chance to setup the EMMON system in a real live environment. This deployment allowed the team to validate the EMMON architecture and system implementation. A number of lessons were also learnt from dealing with a large-scale deployment in a live site.

DEMMON1 is the first wireless network prototype developed by EMMON project. It was first demonstrated at the project review meeting at ISEP in Porto on 7th December 2010. DEMMON1 is, as far as we know, the largest implementation of a wireless sensor network in Europe. It consists of 303 nodes, measuring temperature, humidity and light level. The sensor nodes, placed on glass supports, were aligned with an axis that was 5° from the north-south axis and were given GPS co-ordinates. Tests, which involved changes of environmental parameters and progressive introduction of active nodes, were carried out in order to investigate the wireless network response. When a node selected at random was either covered by dark opaque material reducing the amount of available light, or when it was exposed to heat gradient from an electric heater, DEMMON1 responded promptly, giving the reading in the corresponding node. Scaling up tests were carried out by staged activation of nodes in groups of 100. DEMMON1 did not show any noticeable change of performance depending on the number of active nodes. From this basis, EMMON then developed “DEMMON2”, a real-life implementation of DEMMON1. At the “EMMON Open Day 2012” event in the SANJOTEC Business and Technology Park (São João da Madeira, Portugal) the “DEMMON2” demonstrator was presented, using more than 400 Wireless Sensor Nodes (WSN) for an environmental monitoring application.

DEMMON2 includes new integrated features, such as:

- instant queries
- temperature mapping
- OTAP (“Over-the-Air Provisioning”)
- remote restart
- portable device for maintenance and configuration
- automatic positioning

Work to be continued:

- The deployment is an error prone and time consuming process; this should be made more agile in future improvements to the system.

- Investigations should be made in direction of having a layout which is less rigid but that could maintain some of the structure imposed by the layout. It was noticed during the deployment that it was sometimes a hard task to deploy the defined layout. This was caused by minor mistakes like: programming the incorrect node or placing the node incorrectly; and were in some occasions hard to identify.

- Larger scale deployments in real world scenarios composed of tens and hundreds of thousands of nodes need to be investigated. It was not done within the project mainly due to cost-limiting factors.

7.6. iLAND

Successes:

iLAND set out to define a middleware architecture that could offer deterministic services with QoS-based resource management for networked systems with a high degree of dynamic composition. For this it would develop the necessary enabling technologies and demonstrate the concept on three applications. Aimed at devices that often operate in ad-hoc configurations, the middleware solution itself must be 'light-weight'.

iLAND architecture has been finalised, and the iLAND Reference Implementation (RI) has been implemented, including all the defined architectural elements. It is an open source component-based modular design (for function isolation and easy algorithm replacement) and platform independent (complete abstraction of specific resources, OS policies, and networking infrastructures).

The iLAND RI provides for:

- Deterministic middleware services. Bounded-time composition algorithms and dynamic reconfiguration algorithms have been developed for service-based networked applications. The iLAND approach is based on creating solutions that impose a number of limitations to the target systems that are realistic for the selected iLAND application domains.

- QoS-based resource management and support for adaptation. Combined resource management enables adaptation support to changing needs due to environmental or programmed changes. This allows for real-time execution support based on resource reservation.

- Built-in basic security hooks and policies. iLAND is not a security project but it has identified the precise slots that should be filled in to target security.

Modelling tools to support the iLAND RI have been developed. Demonstrators have been designed and implemented as a concept of proof for the iLAND middleware.

In total, 5 demonstrators have been implemented showing the advantages of the iLAND middleware:

- Laboratory prototype: experimental iLAND system for testing different reconfiguration scenarios.

- Remote Monitoring for Early Warning Using Public Transportation: iLAND technology is tested in a remote energy-constrained ad-hoc network.

- Distributed video surveillance with dynamic reconfiguration: the whole iLAND process is validated through a service oriented remote surveillance application.

- Daily activity monitoring application in home care domain: concept of proof for dynamic reconfiguration with soft real-time constrains.

- Healthcare monitoring application: validation of full iLAND process (from model to implementation) in the healthcare domain, using reconfiguration with hard real-time constraints.

Work to be continued:

- Publication of the open source code (Sourceforge) including a short description on the open source implementation is still pending.

- Although iLAND main focus is not security, it would still be beneficial to launch a systematic debate among developers and future users on how security features such as encryption could be included in the framework and associate potential trade-offs (security vs. performance) with targeted applications.

7.7. SOFIA

The objective of SOFIA is to create a semantic interoperability platform and a selected set of vertical applications to form an embedded system “Smart Environment”. The project addresses three vertical application areas – personal spaces, smart indoor spaces and smart cities. The main idea is to use semantic technologies to provide information-level interoperability between many different multi-vendor devices.

The project has been successful in demonstrating many different prototype applications of their technology, but more effort is required to achieve a robust and coherent development platform. Significant progress in disseminating the project results has been achieved. In particular, SOFIA organised an ARTEMIS Technology Conference, a key result of which was the adoption of its platform by the CHIRON project, on out-patient person-centric health monitoring. Fruitful collaboration with the ARTEMIS project SMARCOS was also undertaken.

In general the project has been successful, but has not fully succeeded producing a generic, reusable middleware solution (horizontal integration) that satisfies the requirements of all three vertical application areas. Instead, it has produced a set of middleware components that either function well at lower-level than is really required, or they have limited functionality and interoperability. That is, the produced middleware components do not cover fully the requirements of the vertical application area they are targeted towards.

7.8. INDEXYS

Successes:

INDEXYS has proven (with the development and evaluation of 3 demonstrators in the automotive[1], aerospace[2] and railway[3] industrial domains) that significant benefit can be derived from basing embedded design on the principles and services defined by the GENESYS[4] architectural blue print. The GENESYS architectural blue print provides a lot of support to embedded design activities and also offers, independently from the used technology, significant cost and development-time potential savings:

- Shorter time to market
- Lower development cost
- Cross domain benefit
- Improved reliability (long term)
- Benefits in re-use of design

The INDEXYS project has allowed to patent the approach for the CAN Router, a star architecture device for the CAN network. The CAN bus is initially designed as a bus architecture but INDEXYS has expanded the opportunities of the popular network technology towards a star architecture.

INDEXYS has significantly influenced and contributed to the release of the SAE Standard for the Time-Triggered Protocol TTP. TTP was filed for standardization at SAE shortly prior to the beginning of the INDEXYS project and was finally released during the INDEXYS project. The standard number assigned is AS6003. In addition TTEthernet, which was also filed for standardization prior to INDEXYS project, was strongly influenced by the project results. The standard for TTEthernet was released during the last work period of INDEXYS and obtained the SAE number SAE 6802.

(Notes:

1. The automotive demonstrator consisted of a CAN based star network and a FlexRay based star network. Since CAN and FlexRay initially is designed as a "bus architecture" the implementation as a star network is a novel design. The advantage in a star architecture is found in the significantly better safety features compared to the bus architecture. The star devices were developed within the INDEXYS project based on FPGA designs. The finally developed application was integrated into a real world Audi A7 to make the environment as real as possible.

2. The aerospace demonstrator developed several small components based on the Time-Triggered Protocol (TTP) and optical Ethernet based links. The applications ranged from developing a Remote Data Concentrator (RDU) based on TTP communication to a Network Access Controller (NAC) using gateways and optical links by Ethernet connections.

3. The railway demonstrator implemented a safe communication protocol implementation into real world railway signalling equipment investigating in depth diversity error mitigation concepts for the railway domain and evaluating the use of TTEthernet for the railway domain.

4. GENESYS is an architectural template defined and documented in a project supported by the EU's FP7 programme. The participants were largely organisations involved in the definition of the ARTEMIS SRA and subsequent work-programme, which had already indicated that such a template was a useful tool for secure embedded system design.)

Work to be continued:

- It may well be worthwhile to try to file the GENESYS architectural blue print as a standard. Since there is a very good cooperation with the ARTEMIS ACROSS project, INDEXYS has recommended the ACROSS project to further investigate this opportunity of filing the GENESYS blue print architecture and services for standardization.

7.9. SCALOPES

Successes:

- SCALOPES has developed cross-domain (horizontal) technologies and tools for next generation multi-core architectures. These technologies and tools are related to:

    i. application & programming models,
    ii. composability, predictability, and dependability
    iii. resource management
    iv. Power aware architecture and (v) reference platforms.

- These developments were driven by and proven for 4 different application domains:

    i. Communication infrastructure: the main result is the NAD tool. It is a networking application development tool designed to provide easy and fast application development for FPGA based networking devices. It consists of a graphical user interface, and provides module based system development (available as open source open source)

ii. Surveillance systems: the basis is the SPEar platform. The addition of HW coprocessors (massive computing structures) resulted in huge performance boosts for specific applications (like H.264 video encoding and motion estimation) with a power consumption of approx. 5W (compared to >80W for classical CPUs).

iii. Smart mobile terminals: the auto-parallelization of application on multi-core systems resulted in drastically reduced development time (compared to manual development). The performance speed-up and gain in power consumption were considerable (although lower than the manual version).

iv. Stationary video systems

- A key result is a simulation based performance analysis methodology (at chip level), based on a new solution for system level performance analysis called Application Task Mapping (ATM), which Synopsys has added to their Platform Architect product line. In essence ATM enables the rapid creation of an executable system model to collect information about performance metrics like throughput, latency, and resource utilization.

- An LCD television set with advanced 2D dimming backlight algorithms, resulting in approx. 50% power savings.

- At system level, power savings of 3x and a 5x cost improvement have been achieved by using the technical results on resource management. These results were achievable by a combination of latest SoC technology, optimization of resource assignment and the improved system architecture that was required to enable the creation of an embeddable display controller

Work to be continued:

- Further improve the methods and tools for automatic parallelisation, to bring the results closer to what is achievable with manual methods while keeping the improvements in development time and reduced power consumption.

7.10. SYSMODEL

Successes:

- The project has created a useful and accessible toolkit for System Level Modelling*, which can lower the threshold to improving productivity, especially for SMEs

- Based on the academic “ForSyDe” framework, the project has added key functionalities (“models of computation”, wrappers, domain-specific models …) integrating ForSyDe into popular “System C” language based development chains.

- Extensive training materials are now available, to facilitate further take-up of the ForSyDe framework and tools.

- Results are also made available to the ARTEMIS-CESAR “RTP” platform, as well as for the projects CRAFTERS, iFEST, ASAM, SMECY, other non-ARTEMIS projects and the ARTIST-DESIGN NoE.

- Six application demonstrators were executed by SMEs, using the tool kit and its extensions developed in the project, as proof of concept and evaluation of performance/risks.

(*System level modelling is a technique that promises major savings in product development time, by supporting design decisions early in the process thereby reducing errors and the re-works coming from them. However, it is a complex and sophisticated technique generally requiring access to expensive design tool chains. “ForSyDe” is an academic modelling framework, available basically free of charge, though it is not yet at the “industrial strength” required by industrial developers. SYSMODEL has however advanced its readiness for take-up considerably.)

Work to be continued:

- SYSMODEL showed that system-level modelling can potentially reduce total design time (including re-works) in five of the 6 applications studied, all of which had a strong real-time element. The VoIP router case, being essentially governed by pre-existing server architectures, did not show any advantage in using this technique.

- Further publication and dissemination: a book is planned, as is formal introduction of the training material into graduate courses.

7.11. CAMMI

Successes:

CAMMI has developed adaptive Man-Machine interfaces that respond to the workload of the operator (human-in-the-loop). The project focused on four industrial application domains: avionics (both EFIS - Electronic Flight Instrument Systems and GCS – Ground Control Systems), civil emergencies and automotive/agriculture.

- In the EFIS domain, three workload mitigation concepts have been developed: the Crew Workload Manager, Integrated data link, and Dual Operations. These concepts are designed as adaptive systems and aim to balance workload. Each of these mitigations were integrated into the EFIS demonstrator, and evaluated in experiments by external experts on the subject.

- The GCS has involved the prototyping of human machine interfaces in avionic and civil applications, characterized by a truly open architecture that can be easily integrated on any platform so offers inherent growth opportunities. The prototypes have been designed to improve MMI effectiveness, including the CAMMI methods and procedures and increasing the use of COTS solutions to ensure affordable capability and technology enhancement.

- In the Civil Emergencies Team (CEnT) demonstrator, the tactical handling of the emergency is done from a mobile Command and Control (C2) post. Here, the Commander manages the team and the Operation Analyst controls the sensors. The emergency team is equipped with PDAs and sensors. Depending on the workload, as measured by the Cognitive Monitor, the application then switches to the right ‘mitigation mode’. The mitigation strategies implemented are: “Highlighting of important information”, “Changing modality of the interaction”, “task offloading” and “task sharing”.

The CAMMI architecture has also been instantiated in the two sub-domains of road driving and agricultural machine operation, according to the following basic aspects:

- Workload estimation based on a metric related to context, being primary task behaviour and secondary task load

- Mitigation strategies consisting of:

i. adapting and prioritizing information based on workload estimation and information relevance

ii. Automated intervention on driver / operator assistance systems if the informative approach is not effective.

Work to be continued:

While the CAMMI concept is mainly reactive (mitigation measures to reduce the operator’s workload), it would also be worthwhile investigating pro-active concepts (so avoiding that the operator’s workload becomes too high in the first place).

7.12. SMART

SMART, though not completed at the time of writing due to a project extension, has developed a suite of tools and techniques for the design, deployment and commissioning of wireless sensor networks. Its main achievements are:

- A sophisticated WSN node, based on a low-power miniaturized Reconfigurable Device with a new, real-time reconfigurable processing unit and a very low power CPU for power efficient processing in WSN environments. It includes a mechanism for sensing the environment and re-configuring the Reconfigurable Devices in real-time

- secure WSN nodes providing high resistance to side-channel attacks, using innovative encryption and authentication schemes, data compression algorithms and video compression schemes meeting the very low power requirements of WSN nodes

- A middleware for the seamless programming, configuration and management of the SMART infrastructure

- A large real-world trial consisting of sensors and cameras, including face detection.

Work to be continued:

SMART, as a project, has not finished at the time of writing. The project is on track to deliver the above (making use of a 9-month extension), though does need to more widely publicise its work.

7.13. pSHIELD

pSHIELD is a pilot project focusing on the full demonstration of only a subset of the technical objectives stated in the original proposal SHIELD that unfortunately, despite a positive evaluation, could not be fully financed because of lack of funding in some of the ARTEMIS Member States.

SHIELD sets out to define a consistent architectural framework for Security, Privacy and Dependability (SPD), specifically for resource-limited embedded systems, designed to allow the SPD aspects to be considered very early in the design process (rather than being added as an afterthought, with consequent design inefficiencies and weaknesses, which is often the case today). In its final configuration, pSHIELD started off in a very difficult management situation. However, the innovative ideas expressed and revealed by the core technical contributors convinced us that the project consortium could rescue its difficult position. A short deadline was given to show recovery, and subsequent work was of excellent quality and justified proceeding with the project. Those changes paid dividends and, by the second year, the consortium had showed tremendous progress, further demonstrated at the final review meeting where again impressive results were shown.

Globally, the major goal of proving the feasibility and the innovation potential of the proposed approach to SPD integration has been fully achieved. The selected demonstrators are very effective and clearly show the added value of the pSHIELD technology.

The project has delivered some important breakthroughs and has documented them very well. Its main objective – to demonstrate the feasibility of the foundation concepts in SPD – has been achieved and a good foundation laid for nSHIELD (a follow-up project already funded by ARTEMIS).

Special mention is warranted for the fact that many deliverables are public and freely available on the project's website – which is a valuable service to the ES research community.

8. Conclusions and Recommendations

Some first conclusions that can be drawn from this analysis of the ARTEMIS programme and its implementation thought the ARTEMIS-JU:

- The hybrid top-down/bottom-up descriptive programme has provided the community of actors sufficient latitude for creative project proposals while visibly retaining the global strategic directions of the programme.

- The “Think Big” philosophy has indeed produced large and successful projects, as well as ‘clusters’ of projects leading to the establishment of CoIEs, encouraged and supported by ARTEMIS-IA. This can be seen particularly in the high-reliability electronics domain, which itself is of vital strategic importance to European industry. The AIPPs described for Call 2012 are a continuation of this strategy toward building self-sustaining innovation eco-systems: analysis of their performance in achieving this should be monitored, as well as - if not more closely than - the research and development work they contain.

- The present set of ASPs and Industrial Priorities currently do not fully match the partitioning seen and felt by industry at large. The dual-axis approach has, however, contributed to wide-spread circulation and discussion of project results. For the future, while keeping this dual-axis paradigm, the definition of the sub-programme topics could be refined, while the Industrial Priorities should better recognise the importance of development tools and processes across all technology classifications (architecture, middleware …). The Societal Challenges, added explicitly to the ARTEMIS SRA of 2011, should also be better highlighted.

- The ARTEMIS programme to date has managed to produce significant advances in the innovation capability of its participants and related enterprises, though this is not evenly distributed over all areas of the programme: a major concentration of effort and “success stories” exists around the hi-reliability topics. This is evidently of great strategic importance to Europe and to the participating organisations, so must not be de-emphasised any in the future. Other areas, particularly related to patient-centric eHealth, human interfaces to the systems (for ease-of-use and for safety reasons) and (to a lesser extent) to enable an energy-efficient society deserve higher attention.

- The tri-partite funding model has assured a broader Europeanization of the programme and its projects and has also contributed to a higher enrolment of SMEs into important technology and innovation eco-systems, especially through the larger initiatives in the programme.

- The ARTEMIS programme, at present levels, is likely to finish at roughly one half of its originally anticipated volume of investment, limited mostly by the National investment. While the programme has indeed suffered under the budget constraints coming out of the 2008 financial crisis and subsequent (quite dramatic) economic slow-down, the financial contribution of some of the participating member states has been significantly lower that the needs expressed by their industries. While ARTEMIS prides itself on the strong industrial lead in defining the technical work programme, a future programme may do well to engage the industrial strategic considerations of the participating states much earlier in the technical programme definition process.

9. ANNEX: SOURCES OF INFORMATION

9.1. Data used in this analysis

The financial data used in the compilation of this report is taken from a data-base of the projects' financial proposals, consolidated at the end of the negotiation phase (i.e. just prior to contact signatures). Evolutions during the course of the projects are not rigorously included. However, this is estimated to impact the finances at programme level to rather less than one per cent, so may be ignored. Information about the successes and technical progress made by the projects is compiled by summarising and "anonymising" information from various confidential reports, available only to the JU Staff.

9.2. Other useful sources of information

The web-site of the ARTEMIS Industry Association - www.artemis-ia.eu – also contains much information of a general nature under www.artemis-ia.eu/publications, and specifically about the ARTEMIS SRA under www.artemis-ia.eu/sra.

Another useful source of information is the public web-site made by each project. For Call 2008 to 2010 projects, these are listed here for convenience (few Call 2011 projects have their sites on line at the time of writing).

Call	Project	Website URL
2008	SOFIA	www.sofia-project.eu
2008	EMMON	www.artemis-emmon.eu
2008	CESAR	www.cesarproject.eu
2008	iLAND	www.iland-artemis.org
2008	INDEXYS	www.indexys.eu
2008	SCALOPES	www.scalopes.eu
2008	CHARTER	charterproject.ning.com
2008	eDIANA	www.artemis-ediana.eu
2008	SYSMODEL	www.sysmodel.eu
2008	CAMMI	www.cammi.eu
2008	SMART	www.artemis-smart.eu
2008	CHESS	chess-project.ning.com
2009	iFEST	www.artemis-ifest.eu
2009	RECOMP	www.recomp-project.eu
2009	SIMPLE	www.simple-artemis.eu
2009	SMARCOS	www.smarcos-project.eu
2009	ACROSS	www.across-project.eu
2009	POLLUX	www.artemis-pollux.eu
2009	R3-COP	www.r3-cop.eu
2009	ME3GAS	www.me3gas.eu
2009	CHIRON	www.chiron-project.eu
2009	ASAM	www.asam-project.org
2009	eSONIA	www.esonia.eu
2009	SMECY	www.smecy.eu
2009	pSHIELD	www.pshield.eu
2010	D3CoS	www.d3cos.eu
2010	WSN DPCM	www.wsn-dpcm.eu
2010	IoE	www.artemis-ioe.eu
2010	MBAT	www.mbat-artemis.eu
2010	nSHIELD	www.newshield.eu/
2010	PRESTO	www.presto-embedded.eu
2010	ASTUTE	www.astute-project.eu
2010	HIGH PROFILE	www.highprofile-project.eu
2010	pSAFECER	www.safecer.eu
2010	ENCOURAGE	www.encourage-project.eu