STRATEGIC RESEARCH AGENDA

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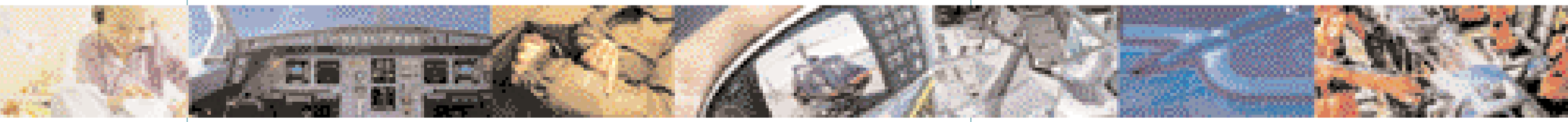

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Executive Summary

ARTEMIS

The ARTEMIS technology platform brings together actors from industry, small and medium-sized enterprises, universities, research centres and European public authorities in the field of Embedded Systems. One of its core objectives is to define a common strategic research agenda that will become a reference in its own domain and attract commitment of all stakeholders in the sector. ARTEMIS will help to create the necessary critical mass and co-ordinate research efforts and initiatives across Europe in order to establish and implement a coherent and integrated European research and development strategy for Embedded Systems.

Embedded Systems are Everywhere

Embedded Systems are specialised computers used in larger systems or machines to control equipment such as automobiles, home appliances, communication, control and office machines. With the constant evolution of electronics and software technologies, and pulled even more by demand from consumers, they are increasingly becoming an integral and often invisible component of the world around us. Today, embedded systems are just about everywhere; in cars, medical devices, aeroplanes, factories, electrical networks, in our living rooms and at work. Every day, we carry them around in mobile phones, keys, smart cards, electronic games or PDA’s. Embedded Systems are so universal because they add computing and communication capability to everyday products, equipping them with new, exciting functions. In this way, they also add new value to traditional goods. Already, 90% of computing devices are in Embedded Systems, and with current growth rates the number of embedded programmable components will reach 16 billion by 2010 (nearly 3 embedded devices per person on earth) and over 40 billion worldwide by 2020. But as the pervasiveness of embedded devices increases, so do the challenges in technology, interoperability, standardization, methodology, safety, and security.

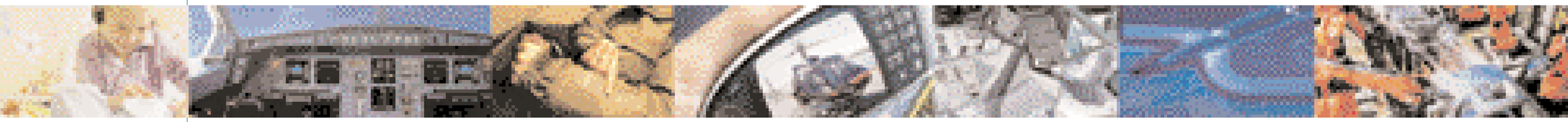
Embedded Systems Matter in Europe

Embedded Systems (ES) are an important enabler of product differentiation and user friendliness. They allow easy customisation of products to the many different languages and preferences that exist in Europe. Thus, ES take on the challenges of diversity and decentralization in Europe and turn it into a strength.

While other economies in the world are leading in the primary IT sector and the domains of consumer electronics or desktop computers, Europe has to exploit its strength in the secondary IT sectors. Europe’s competence in Embedded Systems underpins the competitiveness of key European industries, where leadership and market dominance are achieved by innovative and high-quality functionality in domains such as automobile and airplane electronics, industrial automation, telecommunications, medical systems and energy control. In these sectors, safety and reliability are critical and as such are a crucial part of the strategic research agenda for this domain.

Moreover, the capabilities and ubiquity of Embedded Systems will make possible the emergence of completely new society-scale applications, affecting cities, regions or entire continents in areas such as energy, environment, or social well-being. Mastery of

Executive Summary



Embedded Systems is a key enabling technology for turning these visions into reality. Europe needs to keep a leadership position, as the development of these sectors not only improves our economic strength but also directly affects the quality of life of our society.

Embedded Systems are Drivers of the European Economy

Intelligent functions embedded in components and devices will be a key factor in revolutionising industrial production processes, from design to manufacturing and distribution, particularly in the traditional sectors. These technologies add intelligence to the control processes in manufacturing shop floors and improve the logistic and distribution chains, resulting in an increasing productivity in a wide range of industrial processes. The possibility to deliver systems with new functionality or improved quality within a competitive time frame has ensured substantial market shares for the European economy in domains like automotive (37% in 2002), industry and energy (30% in 2002), or defence and space (30% in 2002). In this way, Embedded Systems directly impact on European competitiveness.

Another key factor is the increase of the share of the value of embedded electronics components in the value of the final product. In the next five years, this share is expected to reach significant percentages in areas such as Industrial Automation (22%), Telecommunications (37%), Consumer Electronics and Intelligent Homes (41%) and Health/Medical Equipment (33%). Moreover, the value added to the final product by embedded software is often orders of magnitude higher than the cost of the embedded devices themselves.

The impact of this increase can be best illustrated by the automotive sector. This sector alone has a turnover of € 500 bn p.a. and employs 2.7 million people in the EU. Given that 20% of the value of each car today is due to embedded electronics and that this is expected to increase to an average of 35-40% by 2015, more than 600.000 new jobs will be created in Europe in automotive ES alone. Similar developments are predicted for the avionics sector where the software production costs for embedded devices today are a significant cost factor of aeroplane development. Consequently, car safety, reduced fuel consumption and efficient air transport are but a few key drivers for research.

Technology for Small and Large Industry

The design and production of Embedded Systems has become a major driver for the European IT industry. It has also generated eco-systems of small and medium-sized enterprises, large industry actors, and research organisations. The ARTEMIS strategic research agenda for Embedded Systems will look to these production chains and take the whole innovation environment into consideration. The ARTEMIS agenda will support methods, tools and devices for timely development of reliable and safe products. SMEs are a natural and important constituency in this environment that will exploit increased co-operation in research for Embedded Systems architectures, design, or standards and create new market opportunities for European suppliers. These novel opportunities will in turn bring new challenges, e.g. for improved interoperability of embedded systems, for systems tools, design methodology, IPR protection, and certification.

Technology Challenges and Economic Opportunities

Cost, security, interoperability, reliability, and productivity are only a few of the challenges threatening European competitiveness in Embedded Systems today. Europe needs to address these challenges in a co-ordinated and focused way. ARTEMIS will establish an environment supportive of innovation in which both co-operation and competition in technological development are enhanced. It will stimulate the emergence of a new supply industry for components, tools and design methodologies. It will focus research and development efforts, thus avoiding fragmentation and making more effective use of resources, and it will facilitate the take-up of results.

Improvements in ES development time and reliability through the use of tools will create a significant competitive advantage for European industry. European ES tool makers today are often small and medium sized enterprises that are closely linked with both academic research centres and with large industry players. Improved interoperability, reliability, and security at lower costs and higher productivity will strengthen SME's in European value chains and at the same time help to secure and create jobs at industry level in the EU.

ARTEMIS Application Domains

The ARTEMIS approach consists of removing barriers between application sectors, stimulating creativity and yielding multi-domain reusable results. The application contexts include Industrial Systems, i.e. large, complex and safety critical systems in areas such as automotive, aerospace, manufacturing, and specific growth areas such as biomedical systems. Nomadic Environments refers to enabling devices such as PDA's and on-body systems to communicate in changing and mobile environments that offer users access to information and services while on the move. Private Spaces includes homes, cars and offices for improved enjoyment, comfort, well-being and safety. Finally, Public Infrastructure refers to major infrastructure such as airports, cities, and highways that embrace large scale deployment of systems and services.

Objectives and Priorities

Primary research objectives of the ARTEMIS SRA are novel technical solutions to address the extreme complexity of new systems. Research focused on industrial priorities will cover reference designs and architectures, seamless connectivity, middleware, design methods, implementation processes and tools. This will be complemented by foundational science and technology research that will offer new solutions with a scientifically rigorous basis to the technical barriers that hinder progress towards the goals in the applications context.

The results will be embodied in the methods and tools of ARTEMIS so that the artefacts produced with them will be guaranteed to have the required properties. Foundational science and technology research in ARTEMIS will generate new solutions to recognized problems and will explore the "unknown" so that a steady flow of innovative ideas in the field of novel Embedded Systems is maintained.

ARTEMIS not only targets research projects, but also optimizing the innovation environment for Embedded Technologies. Overcoming fragmentation - in markets and RTD policies - will help in the acceleration of product development, but also in developing standards and regulations, e.g. in certification and safety.

Executive Summary

Making it Happen

The common pan-European strategic research agenda is a tool for realizing the industry-driven and long-term vision of the ARTEMIS technology platform. It will support a joint financing policy and impact assessment and assist in optimally allocating programmes and resources to different technology and policy challenges. It will also help monitor alignment and co-ordination of research policies in Europe such as the EU Framework programme, national and regional research programmes and a Joint Technology Initiative in the field of Embedded Systems.

ARTEMIS supports the creation of a Joint Technology Initiative (JTI) as a Public-Private Partnership to create the necessary critical mass required for implementing selected parts of the strategic research agenda. Its core should be an industry-driven programme for collaborative RTD that focuses on the downstream part of the SRA. The European Commission, Member States and Industry will create a joint strategy for trans-national funding of Embedded Systems research and development.

ARTEMIS has established a governance and integration framework where industry, research organisations and public authorities across the EU join forces. The strategic research agenda is an important tool in co-ordinating joint efforts and optimally implementing the JTI. Rules of procedures are designed to ensure openness, fairness, and transparency to all the stakeholders in the field.

Now is the time to pull European forces together in order to maintain leadership in one of the most dynamic, pervasive, fascinating and promising areas of information technology: Embedded Systems.

ARTEMIS
the European Technology Platform for Embedded Intelligence and Systems

Technology platforms were conceived to "... bring together public and private stakeholders to set up and implement common research agendas in fields of industrial relevance..." to address the target of R&D investment that is 3% of GDP, as defined at the Lisbon European Council in 2000.

ARTEMIS - "Advanced Research & Technology for Embedded Intelligence and Systems" - is the Technology Platform for Embedded Systems. The term "Embedded Systems" describes electronic products, equipment or more complex systems, where the embedded computing devices are not visible from the outside and are generally inaccessible by the user. ARTEMIS is an Industry-led initiative to reinforce the position of the EU as a leading worldwide player in the design, integration and supply of Embedded Systems. It brings together leading industrial and academic groups with national and European bodies to establish and implement a coherent and integrated European research and development strategy for Embedded Systems.

The Strategic Research Agenda outlines the evolution of the field from a medium to long-term perspective and identifies a number of important technological challenges that have to be met in order to allow Europe to implement the vision of the 'Building ARTEMIS' document as set by the High level Group on Embedded Systems. It sets financial objectives for R&D in Embedded Systems with a cumulative annual increase of more than 18% in pre-competitive cooperative R&D from 2005 to 2010 supported by 700 M€ of public funding (national and European) in 2010.

Embedded Systems
are everywhere

Courtesy of DaimlerChrysler

Embedded Systems are everywhere, built into cars, roads, bridges and tunnels, into medical instruments and surgical robots, into homes, offices and factories, into aeroplanes and airports, into mobile phones and communication and virtual reality glasses, and even into our clothes. They are interconnected into networks of many devices- the car to the fixed road infrastructure, the smart card to the banking systems.

Embedded Systems technologies are deployed in all market sectors - automotive, aerospace, medical, environment, communications, entertainment, textiles, transport, logistics, printing and chemicals, food & drink, timber and materials.

Embedded Systems have a major impact on the way these sectors work and collaborate, how they will develop, how they are perceived by both professionals and the public, and how successful their products will be on the world market.

While the USA has led the world in the domain of desk-top PCs and the associated networks, Europe has quietly led the revolution in Embedded Systems. While we may not be aware of their presence, we are familiar with the advanced capabilities and services they give us in mobile phones, cars, smart-cards, aircraft, and digital set-top boxes for TV.

Embedded Systems know-how underpins the competitiveness of key European industries such as automobile, consumer electronics, medical systems, and energy control. The situation is similar in other sectors as more and more embedded electronic systems are used to make products and processes more intelligent.

The European automotive sector has a turnover of around €500Bn p.a. and employs 2.7 million people in the EU. 20% of the value of each car today is due to embedded electronics and this will increase to an average of 35-40% by 2015.
This increase in car electronics will create more than 600.000 new jobs in Europe in automotive Embedded Systems alone.
Similarly in the avionics sector, embedded software now accounts for a significant proportion of the development costs of an aeroplane.

With the constant evolution of electronic devices and software technologies, there will be more and more Embedded Systems integrated into equipment. Already today 90% of computing devices are in Embedded Systems and not in PC's, the growth rate is more than 10% per annum and forecast to be over 40 billion devices worldwide by 2020. Moreover, the value added to the final product by embedded software is often orders of magnitude higher than the cost of the embedded devices themselves.

Deployment of vast numbers of systems poses extraordinary challenges. Being integrated into objects or systems that are important to everyday life and are likely to last for long periods of time, the large number of heterogeneous, interacting Embedded Systems elements makes interoperability a key concern, as these elements simply have to work together once connected.

As they pervade all artefacts of life, from children's toys to space probes, so more of the value of those artefacts will be derived from their embedded intelligence. By the same token, more of the complexity of those artefacts will derive from Embedded Systems, and their dependable and safe operation will increasingly be contingent on the proper design and operation of Embedded Systems. Increased public awareness about their dependence on Embedded Systems will raise expectations, but will also raise concerns about potential failures, and about safety, privacy and security. This places a high value on the dependability of Embedded Systems, on their quality, and on privacy issues related to their use.

Embedded Systems
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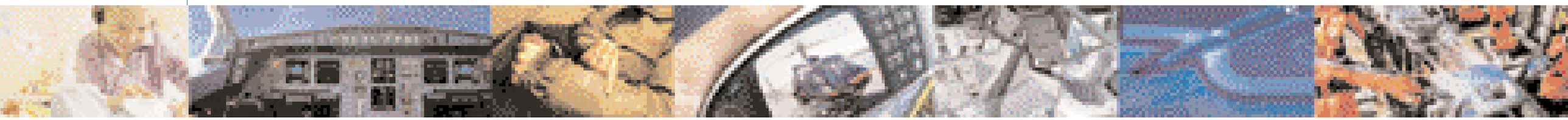
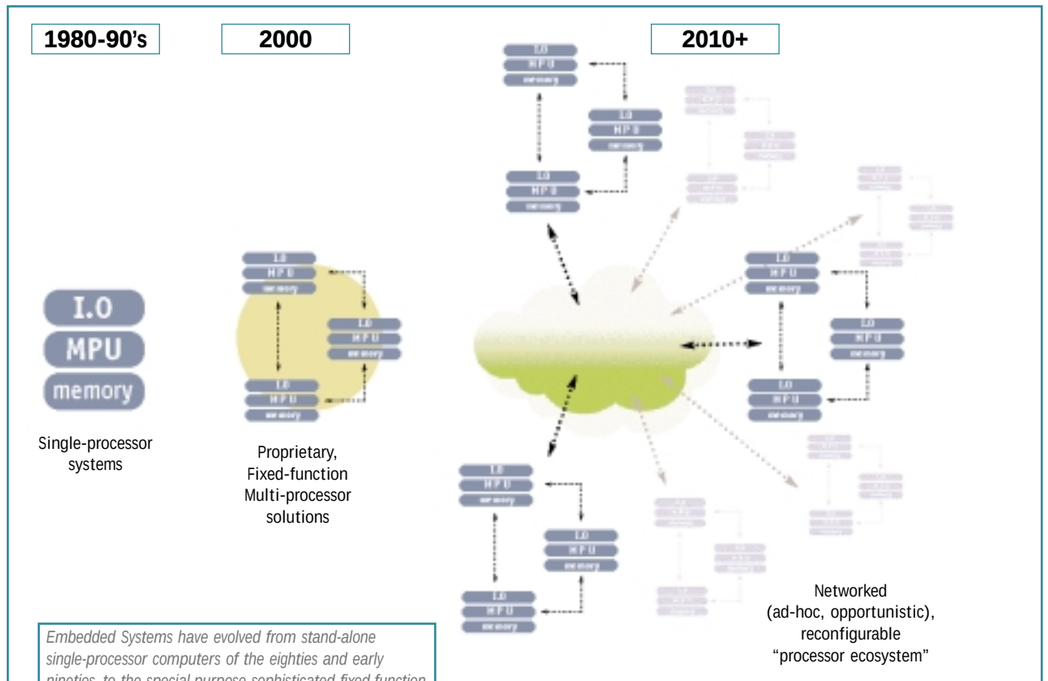


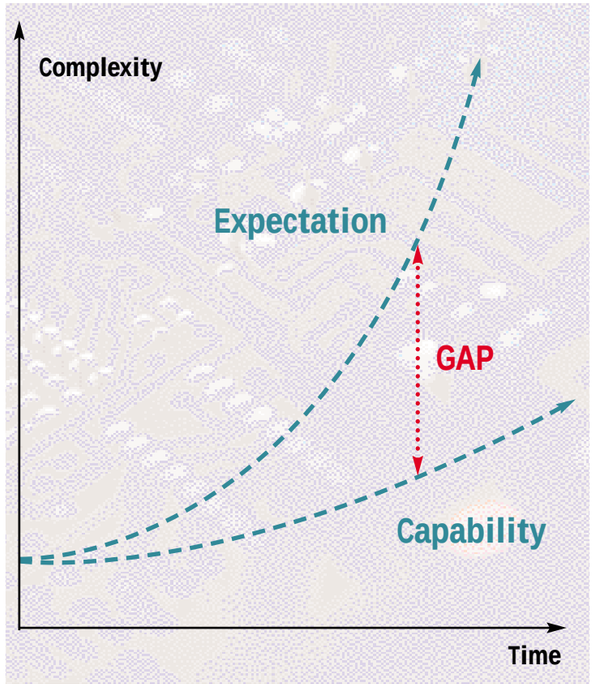


Embedded Systems have evolved from stand-alone single-processor computers of the eighties and early nineties, to the special-purpose sophisticated fixed-function multi-processor systems of the present day associated with increasing communication capacities

Embedded Systems have evolved from stand-alone single-processor computers of the eighties and early nineties, to the special-purpose sophisticated fixed-function multi-processor systems of the present day associated with increasing communication capability. They are anticipated to evolve to the standard-based multiprocessor platforms and to ad hoc, opportunistic, adaptive, self-organising 'processor ecosystems' of 2010+.

Nano-scale electronics and the increasing system complexity will necessitate the modularisation of device construction (a device being, for example, a mobile terminal) simply to keep the design effort manageable and successful. To retain their usability, this increasing system complexity will necessitate and will make possible the development of cognitive capabilities, to bring useful intelligence to the computing devices. Cybernetic systems that contextualise, learn and act autonomously present fascinating challenges and open new perspectives at the borders between ICT and other disciplines such as cognitive science and biotechnology.

The market for electronic equipment is characterised by a constant need to bring to the users innovative products and services with increasing functionality at ever diminishing price. The increase of the technologies capabilities of the hardware as described by Moore's Law[1], is out-pacing the productivity improvement of the designers. This leads to an ever widening design productivity gap that must be addressed by ARTEMIS. In future, this "productivity gap" is projected to increase even more unless this phenomenon is addressed. So, in addition to supporting the evolution of the state-of-the-art to keep in step with Moore's Law, research programmes need to be defined to stimulate disruptive technological solutions to close this widening gap, and to make radical advances in design capabilities. The ARTEMIS initiative must stimulate this essential technology growth in Europe, leveraging on a proven track record of capabilities in this field.



Courtesy of Airbus

[1] *Moore's Law:*
Based on empirical observation, Gordon Moore projected in 1965 that the complexity of electronic circuits will double every 18 months.
Up to now, this has proven to be true, and it is expected to still continue for some decades.

Embedded Systems
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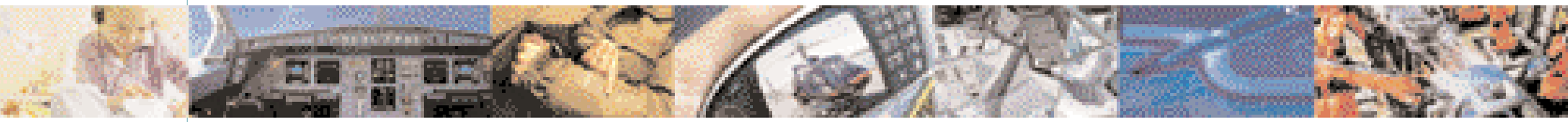


Applications drivers

ARTEMIS will develop ambitious application scenarios that motivate the future development and integration of Embedded Systems technologies. In addition to facilitating the focusing and prioritisation of research, the common goals will encourage coherence, compatibility and synergy of technological developments.

The driving applications have a visionary, medium to long-term perspective; they raise a number of important technological challenges. As markets are increasingly becoming bottom-up driven, implying that the availability of components determine the products, these driving applications will correspond to future product and service markets that are expected to exhibit fast growth rates due to socio-economic trends.

Visionary applications will drive ARTEMIS research and stimulate the development of technologies which may be useful in unpredictable ways: it is not intended, within the ARTEMIS initiative, to realise the visionary applications *per se*.

Industrial systems

Automotive: "Frugal, safe car"

To reduce fuel consumption and pollution, the target is set on the "near-zero emission" car. The Western European automotive industry has already reduced the average fleet fuel consumption drastically (a 35% reduction from 1976 to 2002, and has committed to additional reduction of 25% compared to the 1995 level by 2008)[2]. Similarly, to reduce road fatalities, the "100% safe" car is envisioned, where neither the driver nor the vehicle is the cause of any incident. This very ambitious goal can only be reached by using more intelligent systems, so called 'active safety' systems, where context awareness in the Human Machine Interface (HMI) is needed to reduce the workload of the driver, with sensors, actuators and smart software embedded throughout the vehicle. (Note that this is not limited to the car only, but it embraces road transport in general). Ad-hoc networking is a prerequisite for car-to-car communication in the background of active safety systems. To render individual transport safe (c.f. the European eSafety initiative), affordable and attractive to everyone, techniques based on proven, reusable components are envisaged, allowing more features to be offered at lower cost. Embedded Systems are also key technologies for smart production in the field of car manufacturing in general, the integration of the supplier chain and related logistics. In addition, the vision of the customisable car offers higher added-value to the user and powerful possibilities of product differentiation to the manufacturer, in turn yielding improved competitive advantage.

Aerospace: "Customisable, time efficient safe air transport"

Embedded Systems will be key enablers and differentiators for the European civil air transport industry. They will support the vision of extremely customisable, affordable and life cycle sustainable products and services, for environmentally friendly, safe, secure and time efficient transfer of people and goods within Europe and across continents. By 2011, Embedded Systems will improve their airborne energy consumption by 30%, for fuel efficiency, performance and environmental friendliness. They will have high precision, full predictability and advanced robustness for 100% operational availability and reliability. They will offer full situational awareness and human-centred intuitive paperless operation to ensure total safety in any circumstance. They will enable the high bandwidth, secured, seamless connectivity of the aircraft with its in-flight and on-ground environment for passenger convenience and overall fleet management. They will support advanced diagnosis and predictive maintenance, assuring a 20-30 years life cycle supportable product. The Embedded Systems design environment and tools will provide a significant reduction in the development cycles as well as in customisation and upgrade, and will finally enable life cycle optimised product design, through advanced management of complexity, fast prototyping, composability and advanced verification and validation strategies.

Manufacturing & Process Industries: "Efficient, flexible manufacturing"

The "100% available factory" reduces the environmental strain of manufacturing industries while maximising manufacturing efficiency. Embedded Systems will precisely control process parameters, including the active reduction of pollutants, which reduces the total cost of manufacture. Further competitive advantage in manufacturing industries is assured by efficiency, meaning 100% plant availability and low maintenance that reduces cost. This will not only augment manufacturing employment in Europe, but also assure jobs in the design and manufacture of the manufacturing equipment itself. Manufacturing flexibility is mandatory, to assure agile adaptation to market demands, particularly for individual customisation, thus reinforcing the competitive position. This will be achieved through reduced commissioning and production ramp up times, allowing fast changes in product type or grade to be made. Concrete targets are to reduce commissioning time from 3-6 months to less than 1 month, and assuring quick turn-around times, where model change-over time is reduced from 8-12 weeks to 1-2 weeks. Improvement in end product quality can also be achieved through active control of the manufacturing process, supporting the move from "off line" to "in process" quality control through advanced automation. Improved man/machine interaction through advanced Embedded Systems and "human-in-the-loop" control systems improves quality and productivity by assuring zero operator errors, as well as reducing accidents.

Nomadic Environments: "Walk, Talk, Hear, See"

A key element in the success of the mobile telephony system is that it addresses a basic human need - to communicate and to be informed. This is an early example of mobile life that is less tied to specific locations and enables users to enjoy a fuller experience of life and better productivity. Yet despite the technical progress, the dream of being able to talk to people and access information/entertainment anywhere at anytime is still being frustrated by technical limitations that prevent easy deployment of new, creative services. Issues to be resolved include the demand for ubiquitous, secure, instant, wireless connectivity (end-to-end) to the service. At the same time these must allow unhindered convergence of functions as well as

[2] VDA/ACEA

Embedded Systems
are everywhere

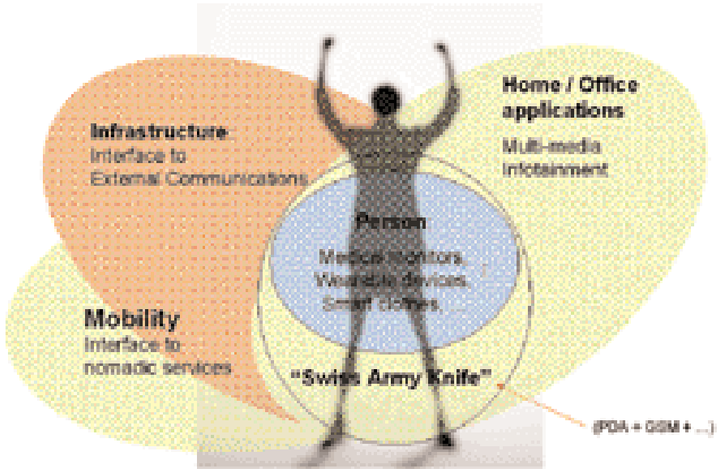
global & narrow-range (sensor) networks. Light, handy, high-functionality terminals are demanded, in which sophisticated energy management techniques “beat the heat” and ensure that “the battery never goes flat”. This is becoming the dominant concern in low-power designs. Embedded Systems will also improve the ultra-low-power connections and increasing processing, storage, and display capabilities. Advances in these areas itself will open a huge secondary market offering mobile services. In order to encourage use by a broad crosssection of the population, friendly human-device interfaces will be developed, with the active participation of future users from an early stage.

Private spaces: “Efficiency, safety and pleasure in the home”

The establishment of business cases around New (digital) Media is already launched, though the goal of ubiquitous yet secure, safe and easy to use access to information and entertainment with appropriate content anywhere has yet to be realised. Reuse and certification of Embedded Systems will allow consumer electronics to better adapt to a very fast market with cycle times of as short as 3 months. In addition, in the near future almost every device will be connected to some network.
Collections of such devices will form systems, such as the Audio/Video system in one’s home. Managing the complexity of the desired and ensuing system behaviour in the context of a large number of connected heterogeneous devices will be a considerable challenge. Embedded Systems will enable further improvement in the comfort and economic efficiency of the home - through intelligent and rational energy use, for example. At the same time they offer a safe and secure home, in a multi-vendor environment, encompassing both user-centred reliability and security, in view of the demographic changes that are apparent in society, for families as well as solo’s, elderly and disabled people. In addition, the significant cost reduction possible in portable medical care equipment through the use of Embedded Systems facilitates the introduction of eHealth services, by means of intelligent, portable systems that form the basis of improved health monitoring. Investment in this field also enables the augmentation of education (eLearning), that helps to bridge the “Digital Divide”, as well as participation in socially beneficial eGovernment schemes. To realise all this potential, there is a need for multidisciplinary, multi-objective, systems design techniques that will yield appropriate price/performance for acceptable power and with manageable temporal behaviour.

Public Infrastructure: “Secure and dependable environment”

Embedded Systems open real opportunities for improved operation and security of public infrastructures and many challenges must be met for modern public infrastructures to become a competitive economy. The improved mobility, both of people and of goods, through fast, efficient, safe and accessible public transport (trains, metro, roads, maritime transport,...), the supply of utilities and energy, a better connected communication infrastructure, are all examples of Public Infrastructures that can take benefit from the huge potential offered by Embedded Systems. Embedded Systems are providing solutions to increase the simplicity of use, connectivity,



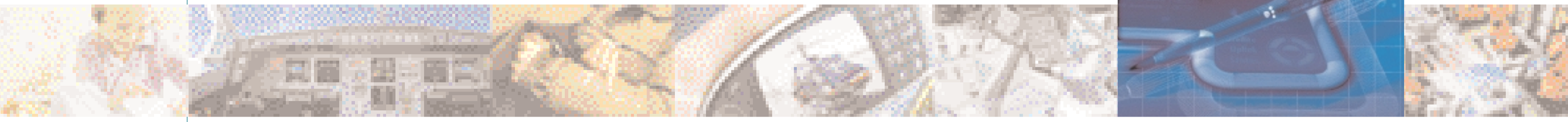
Managing the complexity of the desired and ensuing system behaviour in the context of a large number of connected heterogeneous devices will be a considerable challenge

interoperability, flexibility and security. Safer and secure, better controlled road infrastructure (active road safety support, traffic management systems with more cooperative vehicles, active bridges, secure tunnels, ...) are achievable through greater integration of Embedded Systems.

Buildings - public and private - integrating a variety of sensors and actuators, and intuitive interfaces to naturally responds to user’s needs, will be more comfortable yet economical and provide secure access and exploitation. Examples of such infrastructures include integrated end-to-end capabilities, vending machines, toll collecting, access control, traffic regulation, more cooperative vehicles, more secure bridges and tunnels, active sensing and decision making surveillance in undergrounds, railways and communication networks.

The future of an intelligent infrastructure in the utilities and energy sectors will require global integrity of large numbers of independent and autonomous systems from different organisations. This will pose new challenges for the integration of these intelligent sub-systems so they can be used collectively. For all types of infrastructure, Embedded Systems will be triggered or activated at any time, anywhere, anyhow, through the use of networking. To support this capability, Embedded Systems will have to be “network enabled”, and incorporate capabilities of self-management and self-supervision as well as mechanisms to auto-recover from failures. Embedded Systems will also support all aspects of the lifecycle of such infrastructures including ownership, long-term storage, logging of system data, maintenance, alarms, actions by the emergency services, authorisation of access and usage, and charging and billing under a range of different conditions of use.

Embedded Systems R&D in Europe



Investment in R&D has a direct impact on economic growth. The table below compares R&D related parameters for Europe with those of the USA and of Japan.

	EU-25	US	Japan
R&D Intensity (% of GDP)	**1,97**	2,59	3,12
Researchers per thousand labour force (FTE)	**5,5**	9,0	9,7
Share of world scientific publications (%)	38,3	31,1	9,6
Scientific publications per million population	639	809	569
High-tech exports as share of total manufacturing exports	19,7	28,5	26,5
Share of world high-tech exports (%. 2002 figures)	16,7	20,0	10,6

Figures from 2003 (source: European Commission)

Despite having the largest share of scientific publications, and despite the present level of investment in R&D, Europe lags behind in key areas, most significantly in the intensity of R&D investment and in the ability to retain leading researchers. These two parameters are critical to the ability to convert scientific knowledge, into economically beneficial developments.

Any high technology product such as those incorporating Embedded Systems activities is typically more "R&D intensive" than products of mature markets. Both the Member States, through national programmes and EUREKA, and the European Commission, via the Framework Programmes, recognise this and provide significant support for collaborative R&D in relevant fields. (The EUREKA initiative supports Embedded Systems mainly through two clusters: ITEA and the MEDEA+ applications steering group).

Courtesy of Nokia

Scenario for European R&D in Embedded Systems

The worldwide R&D in the field of Embedded Systems is expected to double over the next 10 years, in order to support the growth of this expanding market. Europe is today a major player in this field, and has to continue to invest heavily to further enhance this position.

Pre-competitive, collaborative R&D is a key enabler of Europe competitiveness. The funding support of public authorities plays a catalytic role in stimulating synergetic efforts between all organizations involved (large companies, SMEs, Research Institutes and Universities).

ARTEMIS proposes the following scenario for European R&D in Embedded Systems. It assumes that industry doubles its R&D effort in the field of pre-competitive, collaborative R&D over the next 5 years. At the same time, public authorities contribute funding at the same level, while industry allocates the corresponding resources, together with research institutes and universities.

As European public spending on ICT R&D is already significantly below levels in the USA and Asia, this minimal investment is mandatory for achieving ARTEMIS Vision.

	2005			2010			2015		
(€ million)	Private	Public	Total	Private	Public	Total	Private	Public	Total
FP	70	70	140	150	150	300	225	225	450
JTI/E!	225	130	355	450	450	900	700	700	1 400
National	100	50	150	200	100	300	300	150	450
Funded	**395**	**250**	**645**	**800**	**700**	**1 500**	**1 225**	**1 075**	**2 300**
Ind. Prop.*	20 000	–	20 000	31 000	–	31 000	48 000	–	48 000
Total	**20 395**	**250**	**20 645**	**31 800**	**700**	**32 500**	**49 225**	**1 075**	**50 300**

*Industrial Proprietary

These total European R&D expenditure estimations are derived, guided by industry's own insights, as an extrapolation of data from the following studies : "Embedded Systems Market Analysis 2002/3". VDC, 2004. "Software Intensive Systems in the Future", IDATE (in collaboration with TNO), September 2005. "Study of Worldwide Trends and R&D Programmes in Embedded Systems in View of Maximising the Impact of a Technology Platform in the Area", FAST GmbH (in collaboration with Technische Universität München), November 2005.

The ARTEMIS vision & targets
for Embedded Systems

Courtesy of Infineon Technologies

The vision driving ARTEMIS is a major evolution of our society in which all systems, machines, and objects will become digital, communicating, self-managed resources. These transformations will be possible through advances in Embedded Systems technologies and their large-scale deployment, not only in industries and services but in all areas of human activity.

This evolution will have a range of consequences for society and for the economy:

- Life in our society, and its security and safety, will increasingly depend on Embedded Systems technologies;
- The competitiveness of European industry from almost all sectors will rely on their innovation capability in the area of Embedded Systems;
- Given the dramatically increasing importance of Embedded Systems to productivity growth, Embedded Systems technologies will be critically important in redressing the present imbalance in productivity growth between Europe and the US and Asia.

Taking a leading position in Embedded Systems requires significant investment in research and development. ARTEMIS will therefore facilitate and stimulate European success in Embedded Systems by:

- **establishing an environment supportive of innovation** in which both co-operation and competition in technological development are enhanced;
- proactively stimulating the **emergence of a new supply industry** for new components, tools and design methodologies supporting Embedded Systems;
- focussing research and development to make more effective use of resources, to **avoid fragmentation,** and to facilitate deployment.

As they form the enabling technology for many areas of enterprise, the importance of Embedded Systems to the world economy and makes it imperative for Europe to intensify its efforts in this area. European efforts must at least match, if not exceed, comparable investments being made in the USA and Asia:

the aim is for Europe to achieve leadership in intelligent, interconnected Embedded Systems. Therefore, ARTEMIS recognises the need to focus this investment.

To establish the required focus, **ARTEMIS has set the following high level targets to be attained by 2016:**

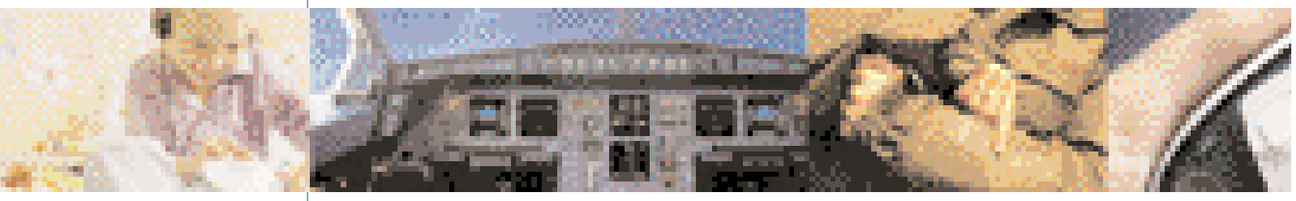
- *50% of Embedded Systems deployed throughout the world will be based on ARTEMIS results and will have been developed within the engineering discipline established by ARTEMIS, encompassing hardware, software and systems design for Embedded Systems.*
- *ARTEMIS will have achieved the cross-domain connectivity and communication capabilities necessary to realise the seamless interoperability between the 'Ambient Intelligent Environments' envisaged for the European citizen (at home, travelling - in various modes, at work, in public spaces, ...).*
- *There will be twice as many European SMEs within the aegis of ARTEMIS engaged in the Embedded Systems supply chain, from concept through design and manufacture, delivery and support, as there are today.*
- *There will be an integrated chain of European-sourced tools, based on ARTEMIS results, to support development of Embedded Systems from user requirements, through system design, to system-on-chip production.*
- *ARTEMIS will have generated at least 5 'radical innovations' of a similar paradigm-breaking nature to the microprocessor, digital signal processing and software radio. As a general indicator of innovation, the number of relevant patents granted per annum to European companies engaged in ARTEMIS will have doubled.*
- *By 2016, the European research infrastructure and education system will have developed the capability to support the fast dynamic evolution of the embedded systems industry needs in terms of design skills, based on the ARTEMIS recommendations. Major educational programmes and technology acquisition programmes will be able to deliver new skills in less than 2 years.*
- *To close the design productivity gap between potential and capability, ARTEMIS will:*
  - reduce the cost of the system design by 50%. Matured product family technologies will enable a much higher degree of strategic reuse of all artefacts, while component technology will permit predictable assembly of Embedded Systems.
  - achieve 50% reduction in development cycles. Design excellence will aim to reach a goal of "right first time, every time" by 2016, including Validation, Verification and certification (to the same and higher standards as today)
  - manage a complexity increase of 100% with 20% effort reduction. The capability to manage uncertainty in the design process and to maintain independent hardware and software upgradability all along the life cycle will be crucial.
  - reduce by 50% the effort and time required for re-validation and re-certification after change, so that they are linearly related to the changes in functionality.
  - achieve cross-sectoral reusability of Embedded Systems devices for example, interoperable components (hardware and software) for automotive, aerospace and manufacturing) that will be developed using the ARTEMIS results.

The ARTEMIS strategy

For the Embedded Systems market, while custom designed systems add high value for their customers and individual projects and products may be highly profitable, the markets that they serve are necessarily highly fragmented. Traditionally, this has led to fragmentation of the supply industry and fragmentation of RTD investment.

The ARTEMIS strategy is conceived to overcome this fragmentation so as to increase the efficiency of technological development and, at the same time, facilitate the establishment of a competitive market in the supply of Embedded Systems technologies.

Many of the devices considered as "Embedded Systems" are becoming commodity products, manufactured in regions with a low cost base outside the EU. Many have already become so - many wireless devices, for instance, are built in Asia, under license from design companies in Europe. However, complacency about retaining a leading position in design is misplaced, as original Asian designs are already becoming available. There is nevertheless an opportunity to reinforce European industry through high value product differentiation.



It is in the conception, design and deployment of customised systems that high value will be added to nearly all products and services in the future Information Society. It is also in this area that Europe has traditionally been strong, with successes ranging from mobile phones, through bespoke systems for transport, to enterprise engineering in industry. ARTEMIS must derive maximum benefit from Europe's strengths while taking due cognisance of the strengths of its global competitors.

The ARTEMIS approach is to cut barriers between application sectors, stimulating creativity and yielding multi-domain reusable results. This will be achieved by specifying an ARTEMIS reference architecture that can support product development in a diversity of application domains, for example in automotive, aerospace and nomadic.

This reference architecture will be developed in close cooperation between the system architect from the participating industries and academia, and will supports interoperability of architecture-compatible components. The components, their selection and their configuration can be tailored to the needs of a particular application domain. We envision a system design process where the relevant components, with standardized interfaces, are combined to generate the desired emergent system properties for particular applications.

While ARTEMIS will seek maximum commonality across application sectors, it is recognised that different application domains impose differing demands on the technology to be developed. ARTEMIS has therefore identified a number of representative'Application Contexts' in which:

- sets of applications can share common domain expertise, design characteristics and requirements so that they can, in turn, share methods, tools, technologies and skills;
- the domains have a large market value and are of sufficient strategic importance to Europe to justify the investment in a shared research agenda.

These Application Contexts are:

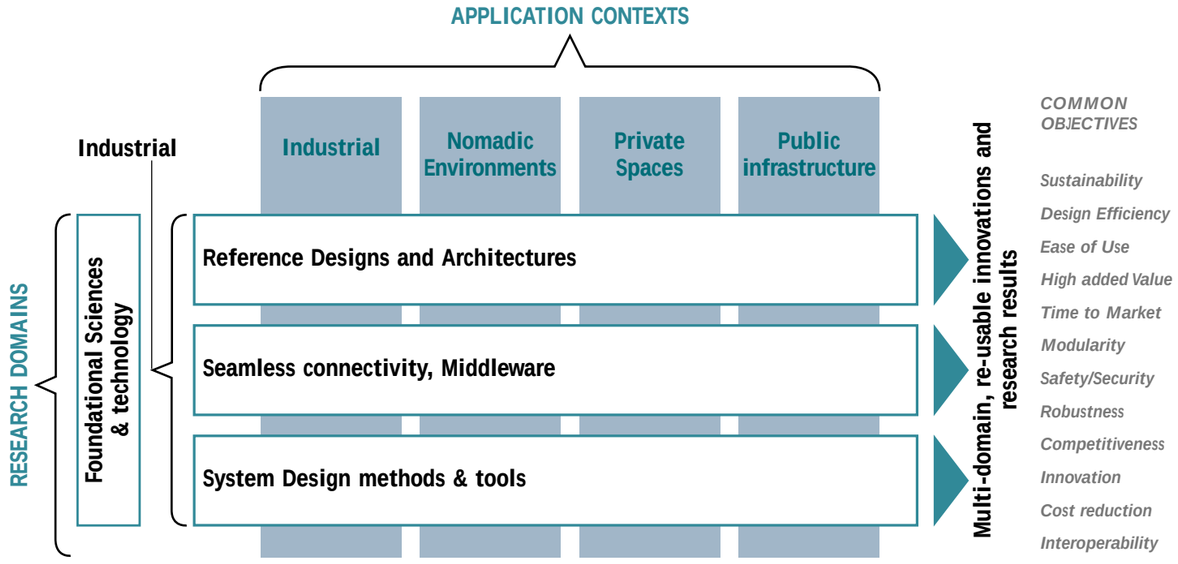
- "Industrial systems" - large, complex and safety critical systems, that embraces Automotive, Aerospace, Manufacturing, and specific growth areas such as biomedical
- "Nomadic Environments" - enabling devices such as PDAs and on-body systems to communicate in changing and mobile environments, that offer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

- perform co-research of pre-competitive visionary applications and of Embedded Systems methods, tools and technologies;
- identify both generic and specific technologies by 'doing' and 'demonstrating' on real-life systems.

Recognising that the fragmentation issue will not be resolved if the scientific and technological needs are addressed piecemeal within the existing structures of markets and of scientific and technological communities, the ARTEMIS strategy is to establish common technology to support the development of high value-added Embedded Systems across a wide range of application sectors.

This common technology will include:

- reference designs, that offer standard architectural approaches for a given range of applications to address the complexity challenge and build synergies between market sectors,



By analysing the technical requirements in each of these contexts in order to achieve the high-level targets, specific barriers to progress have been identified that have common characteristics across the different application contexts. Research into solutions for breaking through these barriers can therefore be focussed and shared by development engineers active in the different industries, resulting in significant re-use of research results and thus high returns on the invested research effort.
Having identified key application contexts, the ARTEMIS strategy is then to:

- middleware that enables seamless connectivity and wide-scale interoperability to support novel functionality, new services and build the ambient intelligent environment,
- systems design methodologies and associated tools for rapid design and development,
- generic enabling technologies derived from foundational science.

The ARTEMIS programme

ARTEMIS research priorities

The previous sections have highlighted two main targets: making basic scientific and technological advances to enable more complex and more capable Embedded Systems that address these visionary applications and gaining efficiency through common technology for high value-added custom design. This leads to two parallel sets of research objectives:

- Technical solutions that form the basis of developing the pre-competitive **industrial** goals, by attacking the extreme complexity of new systems through improved design and implementation processes and tools, and
- Research into **scientific foundations and technology** that will offer completely new solutions to the technical barriers that hinder progress towards the application context's goals.

Industrial research priorities

The main goal is to improve the business and competitiveness of participating industrial players, consistent with achieving the high-level targets described above, especially reducing the cost of system design and reducing time to market - in other words to provide practical answers to the problems caused by the growing "productivity gap".

As indicated in 'The ARTEMIS Strategy' above, the research required to achieve these objectives falls into three main areas:

Reference designs and architectures. The objective is the creation of a generic platform and a suite of abstract components with which new developments in different application domains can be engineered with minimal effort. A well-conceived platform will also allow the addition of application-specific modules, thereby increasing the reach of the reference design into more advanced and diverse application domains. They will challenge the functional and physical complexity issues and embrace all areas of the target application, also addressing functional and non-functional items such as:

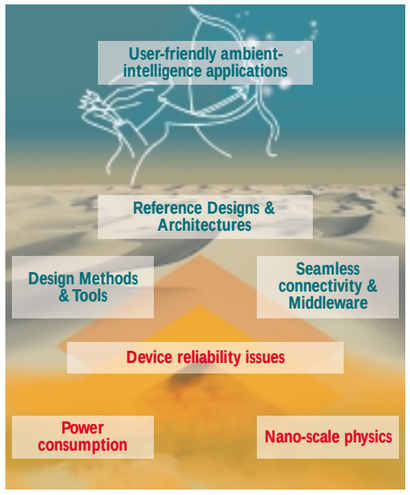
- Composability: a framework that supports the smooth integration and reuse of independently developed components is needed in order to increase the level of abstraction in the design process.
- Dependability and security: The provision of a generic framework that supports safe, secure, maintainable, reliable and timely system services despite the accidental failure of system components and the activity of malicious intruders is essential.
- High-performance embedded computing: for scalable multiprocessor computing architectures and systems incorporating heterogeneous, networked and reconfigurable components. The increase by several orders of magnitude of computing densities (FLOPS per litre and FLOPS per Watt) will be key for achieving embedded intelligence in area such as perception, multi-media content analysis, autonomy, etc
- Low-power: the advent of Giga-scale SoC will require system level techniques for handling the power dissipation of silicon.
- Interfacing to the environment: new ways of interfacing with the natural and the man-made environment, and in particular more intuitive ways for humans to interact with both technical systems and each other.

Seamless connectivity and middleware. This seamless connectivity is a vital element in the model of future Embedded Systems. It includes the middleware, operating systems, and other functions required to link the physical world, as seen by the networked nodes, to the higher layer applications. The following topics should be addressed in this area:

- middleware architectures that include certifiable operating systems (micro-kernels) that can be distributed and composed, and are able to support dynamic reconfiguration.
- developing ubiquitous connectivity schemes and networks of Embedded Systems, under the constraints of minimum power consumption and limited bandwidth.
- Self-configuration and self-organisation of the computational components in order to establish connectivity and services in a particular application context.
- Perception techniques for object and event recognition in order to increase intelligence in embedded systems and make distributed monitoring and control tasks in large-scale systems possible.

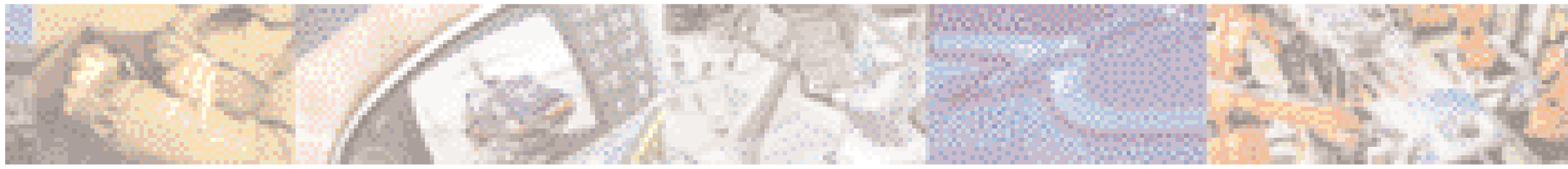
Design methods and tools. These are essential for rapid design and prototyping, without which it is unrealistic to attempt development of such complex systems. The objectives are : design efficiency, systematic design, productivity and quality. For example, radical design and verification methodologies, including specific approaches for systems modelling and simulation, enabling both software and hardware instantiation from high-level descriptions with automatic co-verification, are required in order to achieve an order of magnitude advance in productivity. The collection of novel tools and design flows to be developed we can call the "ARTEMIS Method". This will embrace research supporting:

- the development of specific tools, integrable into the core flow, that address key design problems of Embedded Systems. These design tools will address heterogeneous structures, particularly power efficient mapping on heterogeneous multiprocessing devices and complex memory hierarchies.
- The development of the management of the design process that address the complexity issue, product hierarchy, supply chain, and information flow management.
- interoperability between tools and procedures that are included in the "ARTEMIS method".



A research programme that tackles the extreme complexity of nano-scale technologies

Courtesy of Nokia



- the Artemis Method will ensure large acceptance by offering open interface standards, at the same time securing the intellectual property rights of the specific tools developed to support it.
- methods and tools for systematic traceability of component properties and their attributes, including safety and dependability, during development and integration.
- methods and tools for simulation, automatic validation and proving, and virtual Verification and Validation (V&V).
- Methods and tools for developing product lines of embedded systems.

Foundational science and technology research priorities

The basic premise of ARTEMIS is to provide multi-sector, re-usable results including generic and up-stream technologies. Scientific research within ARTEMIS will nevertheless be directed to address the particular demands of Embedded Systems as established within ARTEMIS and the challenges of the Application Contexts.
The scientific research that will be undertaken in ARTEMIS will address the particular demands of Embedded Systems within the ARTEMIS Application Context challenges and will enhance the intelligence of Embedded Systems in a way that enables achievement of the business and industrial objectives. It will provide a scientifically rigorous basis for the ARTEMIS reference designs, architectures, middleware and communication techniques. The results will be embodied in the methods and tools of ARTEMIS so that the artefacts produced with them will be guaranteed to have the required properties.
The ARTEMIS foundational science and technology research will generate new solutions to recognized problems and will explore the “unknown” so that a steady flow of innovative ideas in the field of novel Embedded Systems is maintained. In addition, participation in the ARTEMIS research programme will make a significant contribution to the education of a highly skilled multi-disciplinary workforce.

Concrete objectives in this field can be measured through:

- The increase of the number of refereed Scientific Publications at leading international conferences and journals in fields relevant to the Embedded Systems.
- Increase of the number of patents that are deployed in the European economy and ensure the leadership of European industry in the field of Embedded Systems.
- The increase of the number of college graduates and universities PhD in fields relevant to Embedded Systems area by 50% by the year 2016.

These foundational science and technology will be established by ARTEMIS for:

- ways to bridge between physics and computing: so that Embedded Systems will be context-aware and able to make optimum use of available resources - not just computational resources, but time, space, energy and material properties.
- hard real-time control: the automatic synthesis of control systems from abstract algorithms, taking into account distribution, heterogeneity, deferred implementation commitment, and autonomous management of all types of resource.
- novel computing architectures that do not (necessarily) respect the conventions of data and instruction similarity, linear memory access, control flow priority, and separation of data from semantics.
- modular, heterogeneous, composable systems and self organising, adaptive systems: to achieve predictable system properties from the complex composition of a heterogeneous set of (possibly unreliable) components.
- dependability and security: radical design and verification methodologies that will enable correct-by-construction design with automatic co-verification, so as to achieve an order of magnitude advance in productivity and allow privacy and content protection in dynamic and distributed environments.

A distinction is made between *inquiry-driven foundational research* and *targeted foundational research. Inquiry-driven foundational research* tries to achieve a better understanding of the fundamental principles and processes that are at the core of a domain of science. Deep-seated innovations, accompanied by a strategic paradigm shift of the prevailing opinions, often have their origin in spontaneous insights gained from *inquiry-driven foundational research.*
There are abundant examples in the history of science that major scientific breakthroughs are the unexpected result of an *inquiry-driven research* effort. It is impossible to plan for concrete results in the field of *inquiry-driven foundational research.* It is planned to set aside a limited amount of resources for building up a stimulating environment where the most creative European researchers from the field of embedded systems can work together and communicate freely in order to achieve a deeper understanding of the basic issues. Care must be taken that this free research climate is not undermined by unreasonable demands for short-range results or the pressure to support the prevailing current opinions.

In contrast to the *inquiry-driven foundational research, targeted- foundational research* is goal oriented. We distinguish between proactive and reactive targeted foundational research. *Proactive targeted foundational research* is focused on a specific set of targets that must be reached in order to bridge the gap between new insights gained from *inquiry-driven foundational research* and the starting point of a *pre-competitive research* effort. *Reactive targeted-foundational* research tries to find a science-based solution to problems that have been encountered in industry.
Both, *proactive* and *reactive targeted-foundational research* will be organized collaboratively between academia and industry, where the lead will be with the scientific party that has a proven strong research record in the field of *inquiry-driven foundational research.* The planning for the field of targeted- foundational research must be flexible in order to be able to adapt quickly to emerging results from the *inquiry-driven foundational research* and to problems encountered in industry.

Technology domains and challenges

In order to find an appropriate structure for the research efforts that are needed to reach the goals outlined in the previous sections, the dependence of the system properties established as described above are investigated and the progress in the selected technology fields listed in the following table. The dependency of the system property in column one on progress in a particular technology field is marked as follows:

• *low dependency;* •• *strong dependency ;* ••• *critical dependency*

System property depends on advances in the following technology fields	IP Reuse	Validation	Fault Tolerance	Security	Communication	Silicon Scaling	Sensor Actuators	Standardization
Utmost Functionality	•••	•	•	•	••	•••	••	•
Dependability	••	•••	•••	•••	•	••	•	••
Connectivity	••	•	•	••	•••	••	--	•••
Low Power	••	•	•	--	••	•••	•	••
Ease of Use	••	••	••	•	••	•••	••	••
Low Design Cost	•••	•••	••	••	•	••	•	••
Low Production Cost	•••	••	••	--	--	•••	••	•••
Time- To Market	•••	•••	•	••	••	••	•	••

The following enumerates the Grand Challenges for the technology domains that are to be addressed:

Embedded system architecture
The Grand Challenge in the field of embedded system architecture relates to development of a generic framework that supports the interoperability of a set of pre-validated components while making minimal assumptions

about the internal structure and implementation of the components.

Embedded System Architecture will address the following research topics

Architecture: composability, architectural services, legacy integration (hardware obsolescence) , Architecture Description Language(ADL).

Interface specification : operational specification, temporal specification, interface state, pre and post Conditions, Interface Models (ways/means model), Interface Description Languages (IDL), Rich interface specification.

Timeliness and power: WCET analysis, Power-aware scheduling, Dynamic Voltage Scaling (DVS), Power estimation, Clock Synchronization.

Networking: on-chip networks, communication primitives, determinism, testability, diagnosis.

Systems design

The Grand Challenge in the area of system design is to develop a design methodology and the associated tools for the rigorous design of dynamic embedded applications out of pre-validated heterogeneous components.
System design will address the following research topics:

Methodologies and Tools : Automated Software Synthesis; Platform Based Design; Middleware; Operating Systems; Architecture-aware Compilation; Integrated Design Environments; Virtual Design Analysis.

Modeling: Interdisciplinary Modeling Physical System, Computer system, Control Algorithms; Parametric optimisation; System Architecture Modeling and languages; Electronic Platform Modeling; Concurrent Modeling; Performance and resource Models; Multi-domain Models; Engine Transmission Modelling at the Critical Path for New Model Development.

Validation

The Grand Challenge in the area of validation is the reduction of the overall effort required to demonstrate convincingly that a given quality level of a system service has been achieved. At present, the effort for validation and certification amounts to a substantial fraction of the development cost of large embedded applications.
Validation will address the following research topics : Formal Analysis; Modular certification; Test bench for component validation, diagnotisc; Safety case analysis; FMEA.

Dependability

The Grand Challenge in the area of dependability is the provision of a generic framework that supports secure, reliable and timely system services despite the accidental failure of system components and the activity of malicious intruders. This requires technologies for the dynamic reconfiguration of nearly autonomous sub-systems.
Detecting tolerant architectures will be essential for building economical giga-scale computing systems (IEEE134850).
Dependability will address the following research topics:

Security: Intrusion tolerance; low-cost security; denial of service.

Fault tolerance: fault-hypothesis for different application domains; transparent fault tolerance; formally verified error masking mechanisms; determinism at all system levels; consistent global state in distributed systems; fault tolerant clock synchronisation; state aware system design, reliability Modeling ; Fast rebooting after failure.

Communication

The Grand Challenge in the area of Communication is the provision of ubiquitous wireless connectivity under the constraints of minimum power consumption and limited bandwidth. The vision of ambient intelligence depend critically on the availability of such an information infrastructure.
Communication will address the following research topics:
Low Power RF; discovery protocols; autonomous reconfiguration; peer to peer networks; communication support for standard protocols (WiFi, BluetoothTM, etc..); multi-hop sensor networks- MPEG 1-2-4 support.

Silicon Scaling

The Grand Challenge in the area of Silicon Scaling from the system perspective is to elevate the design abstractions to such a high level that the effective reuse of large and proven Intellectual Property Blocks can be realised. The determinism of the chips must be maintained in order to support effective system level validation and certification.
The key to success in the embedded system market is how to connect system knowledge with IC knowledge. The following research topics will be addressed :
On chip networks; handling on-chip clock slew; Power optimised hardware-software design; Power control of an entire SoC, scaling out architectures versus scaling up frequencies; application specific micro-component architectures, architecture aware compilation.

Sensors and Actuators

The Grand Challenge in the area of Sensors and Actuators relates to the support of huge amounts of input and output data envisaged in the application contexts with minimal power requirements and fail-safe operation.
A great variety of sensors and actuators are necessary for diverse applications. The following research topics will be addressed: Sensors networks; MEMS technology integration, RFID (radio frequency identification).

Man-Machine Interfaces

The Grand Challenge in the area of Man-Machine Interfacing is to provision of intuitive interfaces that blend naturally into a given environment and that are easy to use. This requires research into cognitive models and users behaviour. Man-Machine Interface have to blend naturally into the user's current environment and have to be easy to use.
Transition from conventional unimodal, menu-based dialogue structures to polymodal , conversional dialogue structures is necessary.
The user has to be assisted to define his/her own goals rather than to use predefined function calls.

Research concerning cognitive models and user behaviour has to be done to determine the pool of goals that have to be expressed and to determine scenario dependent dialogue structure.

Distributed computing platform

The design situation becomes more complex when functions no longer necessarily exist in a given, self-contained and unique piece of hardware, but are distributed over several physical instantiations which themselves may not have a unique function. In the future, therefore, more and more use will be made of "soft prototypes", where advanced modelling and simulation tools take the place of the hardware prototype. Techniques of device self-organization are needed to guarantee the devices capabilities to cooperate. In addition conflict resolution methods have to be applied to solve conflicts between competing devices. Also middleware technologies must be developed that make the implementation possible in a distributed fashion. Only then the extensibility as well as the dependence of devices and device ensembles can be assured.

Self-organizing systems

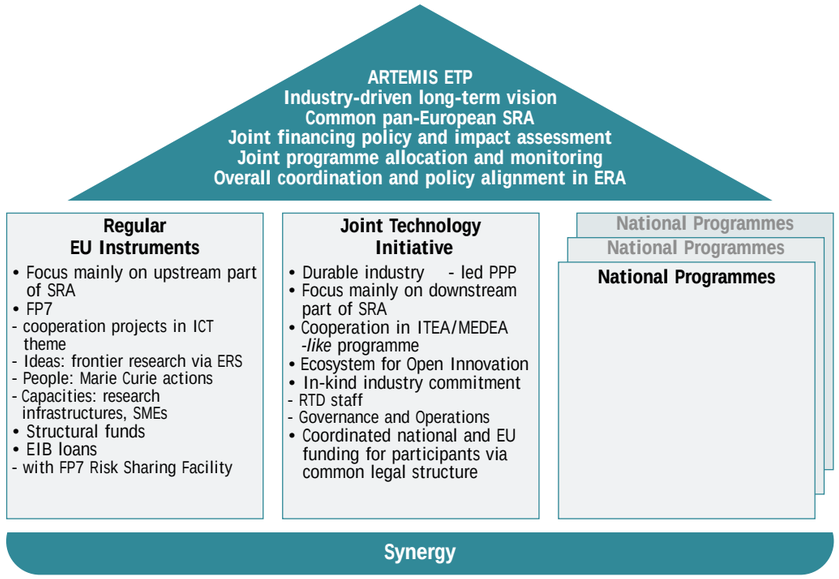
The Grand Challenge in the area of self-organizing systems relates to the reflection of a sovereign computational unit about its current situation and the devising of a plan of actions such that a high level goal can be decomposed into a set of goal-oriented steps that can be executed autonomously. These systems have to adapt themselves according to environment changes, the preferences of the user and the current user goals.
Technologies to be considered are : Position awareness, time awareness, discovery protocols, plan formulation, sensors fusion, "ways-and-means" modelling, neutral networks, expert systems or production systems.

Making it happen

In addition to proposing new technologies and designs for Embedded Systems, ARTEMIS brings forward proposals for improving the coordination of the European research instruments and for fostering efficient innovation environments. By doing so, ARTEMIS stakeholders ensure that the *right* research is conducted in the *right* way, using the *right* persons.

Co-ordinating european research resources

To implement its Strategic Research Agenda (SRA) and to achieve coordination and consistency of existing RTD European instruments, ARTEMIS puts forward a synergetic approach consisting of three pillars under a common roof, as depicted in the figure below.



For the left pillar, focussing mainly on the upstream part of the ARTEMIS SRA, use will be made primarily of the regular instruments in the four Specific Programmes envisaged for FP7, in particular:

- **Cooperation:** collaborative research projects, Networks of Excellence, coordination of national programmes (ERA-NET) and international cooperation under the thematic priority ICT;
- **Ideas:** foundational research on Embedded Systems funded via the European Research Council (ERC);
- **People:** Marie Curie Fellowships for training and public-private mobility of researchers;
- **Capacities:** research infrastructures for promoting the development of world-class Centres of Excellence for Embedded Systems in Europe; research at universities and institutes for (groupings of) SMEs.

To benefit from EU financial support through these instruments, ARTEMIS stakeholders will participate in the normal Calls for Proposals of FP7.

In addition, Centres of Excellence may envisage applying for EU Structural Funds, as well as loans from the European Investment Bank (EIB) in combination with the new Risk Sharing Facility foreseen in FP7. Furthermore, the new EU Competitiveness and Innovation Programme (CIP) may provide opportunities for SMEs.

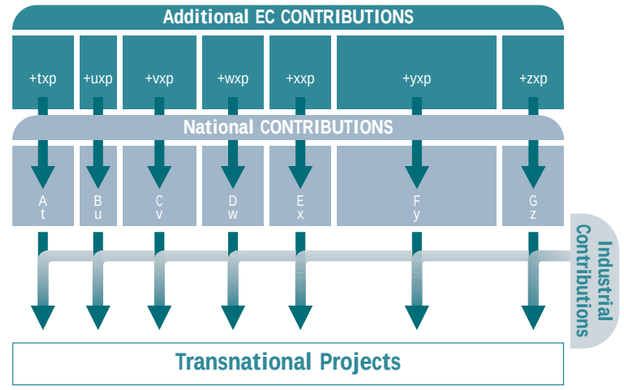
For the central pillar, focussing mainly on the downstream part of its SRA, ARTEMIS proposes setting up a Joint Technology Initiative (JTI). The only means to mobilise the critical mass required for implementing the selected parts of the SRA is a Public-Private Partnership combining private sector resources with national and European public funding.

The core of the JTI will be an ITEA/MEDEA+ -like industry-driven programme for collaborative RTD. In addition, the JTI will provide a flexible basis for common public-private actions to create a fertile ecosystem in Europe for Open Innovation in embedded systems, involving large firms, SMEs, institutes and universities.

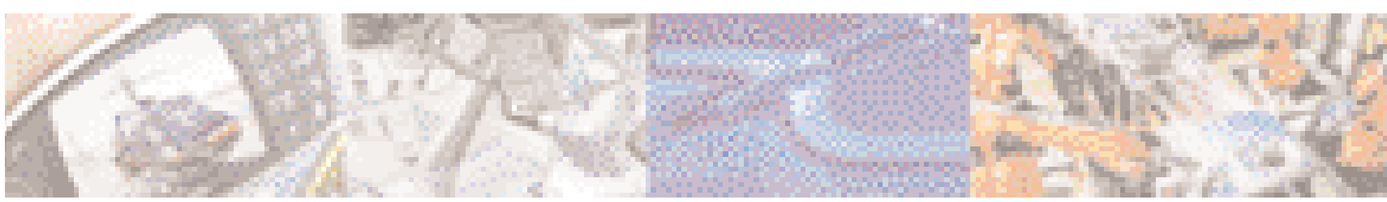
Regarding the JTI collaborative RTD programme, industry will commit to investing the RTD efforts necessary for accomplishing the selected SRA objectives. The private sector will contribute in-kind, mainly in the form of RTD staff executing the projects. With up to 50% of integral RTD costs publicly funded at national and European levels, industry will carry the remaining 50% of the integral RTD costs, as well as the costs and risks of all RTD and innovation on Embedded Systems beyond the phase of pre-competitive RTD that is publicly supported in the context of ARTEMIS. Furthermore, industry will cover the organisational costs of governing the JTI and its Operations structure.

On the public side, the EU will provide a financial incentive for Member States to focus national RTD activities in Embedded Systems on the ARTEMIS SRA; to join forces within the European Research Area (ERA); and to improve the efficiency of funding mechanisms for intergovernmental cooperation, in particular the ICT clusters in EUREKA. In essence, an EU contribution will complement the financial contributions from each Member State or Associated State engaged in the JTI to its national participants in transnational projects, as illustrated in the figure below.

Funding Strategy for transnational co-operation



The EU contribution will be pre-determined at a fixed percentage[3] of the national contributions. In this way, Member States and Associated States will be stimulated to participate in the JTI, increase their RTD expenditures on Embedded Systems, and cooperate transnationally. In addition, the scheme would optimally exploit the advantages and valuable experience of EUREKA ICT clusters such as ITEA and MEDEA+ in running industry-driven RTD programmes, while overcoming EUREKA's notorious problem of harmonising and synchronising funding.



[3] Different percentages may apply according to the type of actions supported: collaborative RTD, research infrastructures, lighthouse projects.

Making it happen

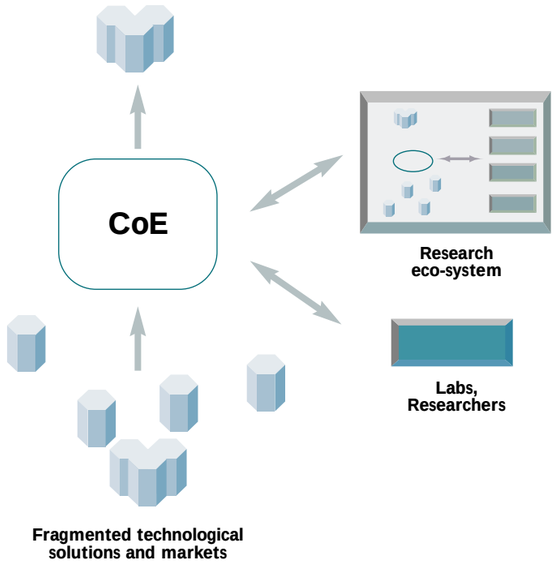
ARTEMIS innovation environment

ARTEMIS policies, procedures and processes will establish a new holistic approach to research, technology development, innovation and skill creation in a distributed industrial context of 'eco-alliances' and 'co-opetition'.

Creating new industrial eco-systems

By facilitating a more effective relationship between research and product development, ARTEMIS will accelerate the pace of innovation. In addition, one of the main purposes of ARTEMIS is to address the fragmentation in the existing market, and the concept of reference designs and middleware for specific application contexts is intended to refocus the structure of the market. ARTEMIS will therefore proactively stimulate the emergence of a new supply industry for the new components, the new middleware, and the new design tools to support the new ARTEMIS design methodologies and new protocols for intellectual property management. In order to achieve these objectives. ARTEMIS will launch a series of action plans to consolidate these eco-systems.

Optimised solutions



ARTEMIS' aim is to address the fragmentation in the existing market, and the concept of reference designs and middleware for specific application contexts is intended to refocus the structure of the market

Standards for Embedded Systems

Contributions to standardization are currently fragmented over many bodies and consortia, many of which are dominated by major US companies. The main objectives of ARTEMIS in the area of standards are:

- To favour open architectures in a context still dominated by proprietary solutions.
- To define and to promote a cross-sectorial approach.

ARTEMIS will undertake a strong action on standards relevant to Embedded Systems.

Standardisation and Regulation

Europe needs to improve it's effectiveness in establishing and influencing internationally agreed standards. In addition to promoting standardisation within Europe, ARTEMIS aims to strengthen European stakeholders' position in the international standardisation arena. Following the idea that many voices speaking as one is much stronger than one voice speaking for many, ARTEMIS will stimulate the creation of case-specific interest groups of parties (industry, institutes, …) sharing a common interest in upcoming standards initiatives. This approach is reflected in the following objectives, which will be handled by promoting the setting up of projects within the aegis of ARTEMIS, that provide specific support to such special interest groups. For practical and know-how reasons, such projects will tend to be sector-specific. These projects will be interlinked by a "cluster project" to encourage cross-sectorial relevance. Such a project will not replace the individual participation of it's constituents in standardisation initiatives, but rather complement it, assuring alignment and unity among the stakeholders.

- Establish a common vision among the ARTEMIS participants (e.g. on OpenSource, OpenStandards, CII, …)
- Elaborate a common position for specific standardisation initiatives (e.g. punctual, commercially significant and tactical issues)
- Identify upcoming topics for standardisation in a one to three year time horizon
- Encourage knowledge sharing by, for example, exploring possibilities for companies to share training programmes and come to a curricula for embedded system technology (courses on architecture, components, way of working, standardisation, etc.)
- Build and maintain an inventory of standardisation initiatives relevant for embedded systems

The coordination of the different projects is foreseen to be done by one cluster project, set up under the auspices of the permanent ARTEMIS Standards and Regulation Working Group. The cluster project will also elaborate on identifying areas where international collaboration is required (or not) and define the preferred working model (e.g. Joint Venture, Tender, EcoSystem, OpenSource, …), as well as establishing links with the various standardisation initiatives relevant for embedded systems.

Regulations, safety, security and digital trust certifications

In most application areas, the design, implementation and operation of Embedded Systems are constrained by European or international regulations concerning safety, security, digital trust, and the environment. These regulations have strong cost impacts on the design and engineering processes especially for software. Being able to produce certified Embedded Systems at acceptable cost is a major competitiveness stake for several European industries. ARTEMIS will:

- develop awareness regarding these regulations and their impact, and forge links with the regulation authorities to overcome regulatory barriers to the introduction of the new ARTEMIS technologies - particularly in safety critical contexts - and to accelerate harmonisation across Europe and internationally, so as to overcome market fragmentation.
- stimulate the creation of independent European certification bodies when necessary. Opportunities for European universities, Research Institutes and SMEs in this area will be investigated and promoted.
- stimulate development programmes that will enhance the capabilities of the European industries in the area of certified Embedded Systems.

Intellectual Property Management

The programmes envisaged by ARTEMIS will entail highly complex arrangements of sharing of Intellectual Property among a wide range of participants. ARTEMIS will establish a reference set of rules for inter-company collaboration and for industry-academic collaboration that will serve as an industry model.

Making it happen

Open Source policy

ARTEMIS will also promote and facilitate the creation of 'Open Source Eco-Systems' for the dissemination and commercialisation of the ARTEMIS technologies and services.
As stated in the ITEA Report on Open Source Software *"Open Source Software may well be one of the best tools to escape (at least partially) from the monopolistic position that certain giant non-European companies have established in areas that are key for European development and independence. ...In particular, it may also be one of the best tools for preserving and strengthening European access to and control of basic software for Embedded Systems in those application areas (e.g. automotive) where European software companies have a strong position, and where other global suppliers aim to extend their monopolistic positions elsewhere."*
ARTEMIS will exploit this potential by:

- setting-up a European infrastructure to host and support OSS initiatives relevant to ARTEMIS vision and priorities including the validation, certification and supply of OSS components.
- promoting whenever appropriate the creation of "Open Source Eco-Systems" for the dissemination and commercialisation of the software technologies and associated services produced by ARTEMIS projects.

Industry-Academia Collaboration

ARTEMIS will actively facilitate productive engagement and interdisciplinary working between industry and academia in several ways - not just through its collaborative research programme, but through innovative infrastructural mechanisms for coupling academia and industry in research and development, and through engagement of industry and academia in joint education and training initiatives.

Research Infrastructure

In order to meet the medium to long-term research needs of European industry, ARTEMIS will establish a new infrastructure of Centres of Excellence (CoE's). The ARTEMIS proposal is to focus on a small number of systems oriented CoE's, of a multi-disciplinary nature (e.g. Computer scientists, electronic and mechanical engineers, application specialists), well complemented with good academic groups and in-house R&D groups within the industrial companies, and specialized in specific sub-domains. Their mission will be to pursue the implementation of industrial research visions, as expressed in the ARTEMIS Strategic Research Agenda that are too long-term, too ambitious or too risky for industry itself to engage. ARTEMIS CoE's will focus European research efforts onto these industry-selected strategic domains and mobilize and integrate a significant critical mass for tackling the SRA challenges.

Education and Training

ARTEMIS will facilitate productive engagement of industry and academia to match the pace of evolution of educational systems and curricula to the rapid evolution in technologies. ARTEMIS will overcome the gap between the theory of academic education and the practise in industrial application. ARTEMIS will facilitate the development of new combinations of skills so that hardware designers will be able to appreciate the possibilities or limitations of software, and vice-versa. ARTEMIS will break down the present distinctions between system architects, hardware and software engineers, and promote a more holistic approach to system design. In addition, ARTEMIS will:

- develop courseware, establish graduate study programmes and industrial 'summer schools', and a Distinguished Lecturer Programme.
- support, recognize and promote the definition of curricula dedicated to Embedded Systems technologies and engineering.
- Establish ARTEMIS Chairs on Embedded Systems within leading European universities.

International Cooperation

The International Collaboration policy of ARTEMIS is based on ARTEMIS strengths and on 'win-win' concepts.
ARTEMIS will help Europe to develop 'brain magnet' capabilities to draw participation of the best brains in this area throughout the world. To this end, ARTEMIS will develop and communicates its Vision and Strategic Research Agenda globally. The creation of Centres of Excellence, and the increasing international visibility through communication, the web-site, Annual International conference, will be among the tools to foster this collaboration.
The added value of collaboration will become visible through:

- the opening of new markets, such as Asia, based on existing strengths; and fostering ARTEMIS standards as a worldwide basis;
- compensation for weaknesses in specific areas where there is no European equivalent;
- mutualisation of resources for the development of non-differentiating (business-wise) technologies;
- completion of the resources available to research ecosystems.

Each particular collaboration will pursue a specific aim of one of these kinds.

ARTEMIS governance and operation

ARTEMIS has established a governance and integration framework where industry, research organisations, public authorities, financial institutions and other stakeholders across the EU join forces and coordinate their actions for implementing the Strategic Agenda. Both the governance structure and the governance processes of ARTEMIS are designed to ensure the realisation of the ARTEMIS mission and objectives. They will also ensure openness, fairness and transparency to all the stakeholders in the field. The present structure of ARTEMIS Governance includes:

- a Steering Board, involving decision makers from leading stakeholders to define and update the Strategic Agenda and oversee its implementation,
- an Executive Board, as a smaller executive and operational representation of the Steering Board,
- a Mirror Group, ensuring the participation of Public Authorities at national, regional and European levels in their function as policy makers, regulators and funding bodies to develop synergies between ARTEMIS, European and national programmes and policies,
- Working Groups for specific predefined tasks, either permanent or on an ad-hoc temporary basis,
- an Office to facilitate and assist the ARTEMIS Platform in its activities and provide permanent secretarial, operational and public relations support for ARTEMIS,
- An annual conference to provide the means to interact with all stakeholders in the platform and beyond.

ARTEMIS Governance Structure and its operation modalities, detailing the membership, decision making process, eligibility, cost and funding of the structure, are described in the ARTEMIS Terms of Reference and Rules of Procedure document agreed and signed by the Steering Board members.