COMMISSION OF THE EUROPEAN COMMUNITIES

Brussels, 15.5.2007
SEC(2007) 582

COMMISSION STAFF WORKING DOCUMENT

Annex to the Proposal for the Council Regulation on the setting up of the ARTEMIS Joint Undertaking

Analysis of the effects of a Joint Technology Initiative (JTI) on Embedded Computing Systems

[COM(2007)243 final]
[SEC(2007) 583]

TABLE OF CONTENTS

EXECUTIVE SUMMARY

BACKGROUND

This impact assessment examines options for stimulating innovation and investment at European level in the field of embedded computing systems research, in particular through the establishment of a Joint Technology Initiative (JTI).

The Seventh Framework Programme (2007-2013)[1] introduces the concept of Joint Technology Initiatives (JTIs) as a response to the real research needs of industry and other stakeholders. Through the commitment of massive financial, organisational and human resources, JTIs are expected to implement ambitious research agendas in genuine public-private partnerships at European level. JTIs should pursue activities that are of common European interest[2] and they should contribute to the achievement of the Lisbon competitiveness objective and the Barcelona targets for research spending[3] in areas that are critical for European competitiveness. With JTIs, the Community offers for the first time a legal and organisational scheme for effective pooling of resources from both the public and the private sector in specific areas and across Europe.

Information and communication technologies (ICT) are of increasing economic and social importance and will play a key role in realising the renewed Lisbon strategy for European growth and employment[4]. The Commission's "i2010" initiative[5] (European Information Society in 2010) has also identified the strengthening of innovation and investment in ICT research as a priority in the effort to address the increasing productivity gap between Europe and competing zones. Embedded computing systems — the invisible electronics and software that impart intelligence to products and processes — are an especially important part of the ICT landscape as they underpin competitiveness, innovation and growth in key sectors of European industry (e.g. the automotive and aerospace branches, consumer electronics, telecommunications, and automation). Embedded systems add value to products by providing them with new intelligent functions, they increase productivity in manufacturing, logistics and the distribution of goods and services, and open the way to entirely new markets and societal applications — from personal health systems to environmental monitoring.

"Embeddedness" is one of the major technological drivers of digital convergence, and embedded computing has been identified as one of the EU's main industrial and technological

---

1 Decision of the European Parliament and of the Council on FP7 N° 1982/2006/EC of 18 Dec. 2006.

2 SEC (88)1882

3 {COM(2005) 488 final} "More Research and Innovation - Investing for Growth and Employment :A Common Approach" Impact Assessment

4 Communications from the Commission: COM(2004) 757 "Challenges for the European Information Society beyond 2005", COM(2005) 24 — "Working together for growth and jobs. A new start for the Lisbon Strategy", COM(2006) 502 — "Putting knowledge into practice: A broad-based innovation strategy for the EU".

5 The "i2010" initiative provides an integrated approach to information society and audio-visual policies in the EU.

strengths in global markets[6]. Already by 2000, 98% of computing devices sold worldwide were embedded in products[7]. Forecasts predict more than 16 billion embedded devices by 2010 (nearly three devices per person on earth) and over 40 billion of such devices by 2020[8]. The central role of embedded electronics in innovation and value creation is reflected in their increasing share in the value of the final product. Within the next five years, the share of such systems is expected to reach significant levels[9] in the automotive sector (36%), industrial automation (22%), telecommunications (37%), consumer electronics and intelligent home equipment (41%), and applications related to health and medical equipment (33%). Furthermore, the value added to the final product by embedded software is much higher than the cost of the embedded device itself.

Worldwide, R&D in the field of embedded systems is expected to double over the next 10 years, supporting the growth of this expanding market. Whereas total R&D should increase by around 170% over the next ten years, expenditure on embedded software R&D is predicted to increase by 225%, from €58bn in 2002 to €132bn by 2015[10].

The ARTEMIS Technology Platform[11] brings together all the relevant sectors of industry, research centres, universities and European public authorities in the field of embedded systems. It is motivated by the belief that everyday life in our society and the competitiveness of industry in almost all sectors will increasingly depend on embedded computing. Its driving vision is "a major evolution of our society in which all systems, machines and objects will become digital, communicating, self-managed resources". Its aim is to create the necessary critical mass and to coordinate the research efforts and initiatives needed across Europe in order to implement a coherent strategy for EU leadership in the field. One of its core tasks is the definition of a common "strategic research agenda" (SRA) that will become a reference in the field and attract investment from all stakeholders. The first version of the SRA was published in March 2006.

CONSULTATION

The impact assessment drew on the results of extensive consultations held by the Commission with stakeholders in the embedded systems domain following the creation of the ARTEMIS Technology Platform in January 2004. Consultations were held with national public

---

6 Commission Communication COM(2006) 697, SEC(2006) 1467 — "Economic reforms and competitiveness: key messages from the European Competitiveness Report 2006".

7 G. Borriello and R. Want. "Embedded Computation meets the World Wide Web." Commun. ACM, 43(5):59--66, May 2000.

8 Embedded Computing, Joseph A. Fisher, Paolo Faraboschi & Cliff Young. Fisher (2005) and AUTOSAR — Automotive Open System Architecture. http://www.autosar.org.

9 Worldwide Trends and R&D Programmes in Embedded Systems by FAST GmbH (resulting from an open call for tenders issued by INFSO's Embedded Systems Unit) and Software Intensive Systems in the Future by IDATE and TNO,

10 *Software Intensive Systems in the Future,* IDATE/TNO, 2005.

11 ARTEMIS Technology Platform, http://www.artemis-office.org/dotnetnuke/.

authorities in the Platform's "Mirror Group[12]", gathering representatives from 24 Member States and Associated Countries. The relevant topics for this impact assessment, such as the Strategic Research Agenda and plans for the Joint Technology Initiative, were publicly presented and discussed at major events such as the ARTEMIS annual conferences (Rome 2004, Paris 2005, Graz 2006), the Information Society Technologies Conference IST 2006 (Helsinki), and the public presentation of the ARTEMIS SRA in March 2006 (Brussels).

As the final step in this process, three consultation meetings focused on the contents of this impact assessment. They gave rise to wide-ranging discussions to collate and review previous results and provided further inputs for an in-depth assessment of the proposed governance structure for the Joint Technology Initiative.

The assessment of the economic impacts has drawn primarily on public domain data, in particular two recent studies published in 2005 providing a detailed picture of the funding landscape (public and private) and technological and market trends in embedded systems-related areas[13].

THE NATURE OF THE PROBLEM

Insufficient R&D investment

Europe lags behind its international competitors in investment in ICT research and innovation and needs to address its productivity gap with competing zones. Overall in the EU, ICT accounts for around 18% of total R&D expenditure compared to 34% in the United States and 35% in Japan[14]. The difference is even more marked on a per capita basis, where the EU spends around €80 per head compared to €350 per head in the US and €400 in Japan. This situation is reflected in, and partly explains, Europe's poor performance in productivity and economic growth.

For embedded systems research in particular, total public funding in Europe[15] is only 11% of the total for ICT, despite the economic importance of the area and the fact that embedded systems-related R&D accounts for more than 50% of total business expenditure on ICT R&D in all sectors.

The fragmentation of research funding in the EU

There are several funding programmes relevant to embedded systems in Europe. Firstly, the Framework Programmes have made major investments in ICT research over a number of

---

12 Members of the Mirror Group are AT, BE, BG, CH, CZ, DE, DK, ES, FI, FR, GR, HU, IE, IL, IT, MT, NL, NO, PT, RO, SE, SI, SK, UK.

13 Worldwide Trends and R&D Programmes in Embedded Systems by FAST GmbH (resulting from an open call for tenders issued by INFSO's Embedded Systems Unit) and Software Intensive Systems in the Future by IDATE and TNO,

14 Commission Communication "*i2010: A European Information Society for Growth and Employment", European Commission, 2005.*

15 Around €380m annually

years. However, they represent a relatively small percentage of the EU's total public budget[16]. Another funding mechanism is the inter-governmental Eureka scheme. This is a valuable cooperation framework through which up to €200 million of public funding is provided to industrial R&D projects every year in the areas of embedded systems and software-intensive systems. However, Eureka has well-recognised shortcomings: duplication of evaluation and project monitoring procedures at inter-governmental and national level, variable levels and poor predictability of the public funding available, and long delays before starting projects have consistently weakened the effectiveness of the scheme.

At national level, 17 out of 122 funding programmes in 23 EU Member States and Associated Countries have significant relevance for embedded systems research. In some countries, embedded systems activities are spread over several (sometimes disconnected) programmes, while in others it is not possible to identify whether there are relevant activities at all in the area.

In the face of the major challenges confronting Europe's industry and economy, Europe's research landscape is fragmented and unable to come up with a coherent response in the area of embedded systems: the Framework Programme budget is limited compared to the overall public research budget in Europe; Eureka lacks efficiency and focus; and national efforts are scattered and not focused on common objectives. **Current instruments do not provide an appropriate framework for mobilising European resources on a large scale and around common objectives, while remaining effective and efficient**.

Technological complexity is a major challenge

Over the last 20 years, embedded systems have evolved from simple stand-alone single-processor computers to advanced multiprocessor systems with increasing communication capabilities coupled to the "real world" through sensing and actuating functions. In future, interconnected embedded devices will populate large, heterogeneous and reconfigurable 'processor ecosystems' in a wide variety of applications where safety, security, robustness and efficient operation need to be guaranteed. The resulting complexity is a huge technological challenge that currently cannot be met due to the **lack of a systematic approach and associated engineering methods and tools** to support the design and inter-operation of hardware and software systems of such sophistication and complexity.

Innovation in the field is also hindered due to a **lack of common standards and tools**. Acceptance of design tools in development organisations will be poor if there is a danger of being "locked in" to a specific vendor and no open standards exist. In the long run, the productivity impact of improved design practice will only be unleashed if adequate, open standards for establishing tool chains exist. Similarly, new standards will be needed to allow diverse embedded devices and electronic systems to talk to and "understand" each other.

Skills and the scarcity of human resources

In order to manage increasing system complexity and the gap in design productivity, European companies are using ever-increasing numbers of software programmers and outsourcing programming tasks to third countries. It is clear that this is not a sustainable

---

16 FP6 accounted for 5-6% of all public support for civilian research expenditure in the EU.

solution in the longer term; on the contrary, the likelihood of system faults and software bugs increases with the size of teams working on a system development project. Europe also has to reverse the brain-drain of highly skilled engineers and doctoral graduates (mainly to the USA) and address the slowdown in imports of foreign third-country graduates.

What is at stake

Europe's capability to provide **domain-specific integration know-how** has given the EU a large share of the market in secondary market domains such as the automotive, industrial and energy sectors, or defence and space. This leadership position needs to be maintained and strengthened by harnessing the new embedded technologies. But embedded systems are not only crucial to the competitiveness of existing European industry sectors: they are also at the heart of the next generation of ICT systems that will transform our economy and society in the face of the major challenges of globalisation, ageing, climate change and sustainability. Much in the same way that the first two "waves" of the IT revolution (desktop computing in the 80s and the internet in the 90s) led to the creation of new markets, the third wave made possible by the "embedding of intelligence" in our everyday environment is coming unannounced and will see the creation of **even larger markets** for applications we cannot yet fully grasp.

At risk is not just the opportunity to create jobs and to innovate in products and services in the short term, but **the very ability to innovate**. Embedded systems are so central to value creation in the modern world that an economy that fails to master embedded systems and meet their technological challenges will lose a significant part of its innovation capability. An even more important risk is that Europe will be unable to reap the benefits from the new markets created by the "embedding of intelligence", and will become dependent on non-European technology, as has already happened with the desktop and internet waves of IT. In addition, unless it is able to nurture and retain talent, Europe will be unable to attract or retain the best researchers in relevant fields.

Finally, there is a 'cultural' risk. These intelligent systems will touch upon the lives of European citizens in very intimate ways. European industry needs to be able to **respond to home-grown demand in a way that recognises Europe's unique preferences and values**. A strong European industry and research community are essential for this.

Unless ambitious and concerted action is urgently taken, there is a risk that leadership in systems engineering, the flagship of EU industrial excellence, will be lost to Europe's international competitors.

THE CASE FOR EU ACTION (subsidiarity test)

The embedded systems field has reached a threshold. It has the potential to drive innovation and growth and contribute significantly to European competitiveness and economic and social change. But Europe's current leading position in key sectors is under threat from global competition, a fragmented research landscape and escalating technological challenges. All of these factors are set to be exacerbated over the coming years, making the current approach unsustainable. Europe cannot continue to rely entirely on a cumbersome research structure that lacks focus and leads to duplication of effort. And European industry cannot hold back from developing the interoperable solutions necessary for success in new fast-growing markets. **Europe must increase and make better use of its investment in this strategic area**.

The current structure of European industry does not provide the necessary framework in which to develop the enabling technologies and standards that are necessary to cope with the huge challenges posed by the increasing complexity of embedded systems and their applications. There are several reasons for this: first, many of the technologies involved transcend the traditional industrial sectors, whereas most industrial developments are still sectoral; second, the European design tools and software industry is very fragmented with hardly any major players that can lead developments; and third, many of the technologies that need researching are generic and enabling in nature, or are technological "commons" meant to be shared by a diverse set of stakeholders. Furthermore, many of the technology components and tools — such as future middleware "glue" and design and software tools — are for markets that do not yet exist, and their development therefore entails high risks.

Without a focused and coherent industrial R&D programme able to draw on all sources of R&D investment (public or private), European efforts in embedded systems research will continue to be scattered and unstructured. Progress will be held back by the **lack of coordination of industrial R&D objectives, duplication of effort, unnecessary bureaucracy, and suboptimal use of limited research funding.**

Only Community legislation can establish an operational R&D framework that combines the benefits of European integration with rapid adaptability of industrial goals and policies and with flexibility in participation and national commitment on the part of Member States.

OBJECTIVES

The overarching objective is twofold. On the economic and technological side, the aim is to launch an initiative to **realise Europe's potential in the future markets for intelligent products, processes and services** and achieve world leadership in embedded technologies, allowing the cost-effective deployment of seamlessly connected systems and the spearheading of applications that enhance the safety, security and well-being of citizens. On the policy side, the realisation of these ambitious technological and economic objectives depends on the **creation of a true European Research Area and on fostering investment in this area**.

In particular, the policy aims are the following

(1) To create a single, Europe-wide R&D programme that is industrially driven and focuses on selected, specific joint technological and economic objectives.

(2) To put in place a new mechanism able to combine, for the first time, national, EU and private funding within one coherent funding instrument that allows a number of countries to move forward within a flexible legal framework ("variable geometry") while remaining effective and efficient.

(3) **To ramp up R&D investment in Europe** by providing incentives to industry and Member States to increase their R&D expenditure.

POLICY OPTIONS AND ANALYSIS

The following two policy options have been considered for analysis:

(1) **'Business-as-usual' option**. This is a continuation of the current working arrangements. Parts of the ARTEMIS Strategic Research Agenda would be implemented through the existing EU instruments and, separately, through national programmes including some intergovernmental cooperation under Eureka (MEDEA+ and ITEA2). Commission support would be through the regular instruments in FP7. This option will be considered as the baseline option.

(2) **"ARTEMIS JTI" - *Joint Undertaking*** on the basis of Article 171 of the Treaty **to implement a "Joint Technology Initiative"** with the participation of industry, the European Commission and Member States, building on the existing ARTEMIS Technology Platform. In this model, the Community (represented by the Commission) would be a full member alongside other entities willing to commit funding or contributions in kind. The Joint Undertaking would be created by a legislative procedure requiring the definition of all the characteristics of the entity in a Council Regulation.

ECONOMIC IMPACT

Economic benefits from the achievement of the technological objectives

The economic benefits of achieving the technological objectives of the ARTEMIS JTI can be partly quantified, in particular in terms of reductions in system design costs and development lifecycles. The analysis shows that the **ARTEMIS JTI will achieve gains of at least €14.7bn per year** in reduced development costs by 2015, equivalent to at least 55k person-years of effort compared with the "business-as-usual" scenario. The net present value (NPV) of these gains in 2006 is estimated at €109bn.

The economic impact of achieving several other goals set forth in the Strategic Research Agenda (e.g. achieving seamless cross-domain interoperability) is much harder to quantify, although it may be extremely significant as it would lead to the creation of entirely new markets for applications.

Financial leverage effect

The proposed ARTEMIS JTI option will enable every euro contributed by the Commission to leverage about 2 euros at national level plus additional private research efforts, to yield an expected overall **leverage effect of 1 to 7 euros of R&D effort**. In the "business-as-usual" option, the Commission's contribution will not have any leverage effect at national level and would be matched by roughly 0.5 euros in private funding (under the new rules for Framework Programme 7).

A more efficient R&D and innovation framework for industry

The ARTEMIS JTI provides R&D actors with a reliable and efficient framework that **removes the budget uncertainty** that exists in the present EUREKA system, allowing industry stakeholders to better plan their investments.

Due to the streamlining of procedures through the ARTEMIS JTI, each R&D project will gain six months compared to the EUREKA system in the "business-as-usual" scenario. Furthermore, a 50% reduction will be achieved in the effort required for proposal preparation and submission. The ARTEMIS JTI will thus yield net savings of €73m over the "business-as-usual" scenario (equivalent to ~4% of industry's total commitment to the JTI). Further savings will accrue from reductions in project management costs as a result of removing unnecessary duplication in reporting and monitoring, estimated at about €52m over the lifetime of the JTI. Overall, **the ARTEMIS JTI would thus save €125m in "procedural costs" compared with the business-as-usual scenario.**

Streamlined and quicker procedures will have a knock-on effect in terms of the productivity of the research process, allowing research results to be brought to market more rapidly. This reduced time-to-market is, potentially, one of the most significant of all the benefits of the ARTEMIS JTI. Cutting even a few months off the development cycle can allow a company to get to market ahead of its competitors (and so gain higher market share) and/or have a longer period through which to recoup its R&D investment.

The quantitative and qualitative advantages of the ARTEMIS JTI over "business-as-usual" in removing budget uncertainty, streamlining procedures and shortening time to contract is specially important in terms of 'behavioural additionality', as the more attractive regime (especially for SMEs) will broaden participation and increase the number of new partners in the R&D activities.

More efficient R&D spending by public authorities

A further benefit of the ARTEMIS JTI is that the expected ~€750m of national money spent through the ARTEMIS JTI will be allocated through common European procedures and work plans as in the Framework Programme. It is reasonable to expect that the impact of this spending on GDP will be similar to that of EU-level expenditure, and much higher[17] than in the "business-as-usual" scenario, where this funding would be disbursed according to the different priorities of national programmes.

Broader economic and social impacts

With respect to competition in the internal market**,** the **common technologies** developed by the ARTEMIS JTI will provide a level playing field for embedded systems-based industry and for European regions, leading to increased cost-effectiveness for ICT and end-user industries and increased competition for products and services based on standardised platforms.

The ARTEMIS JTI will draw on the ARTEMIS Technology Platform's policy for mobilising resources, promoting ARTEMIS standards, fostering collaboration with international partners, with the aim of opening new markets for EU industry, and helping Europe become a 'brain magnet' for the best researchers worldwide.

The ARTEMIS JTI will have an impact on society in a number of ways, contributing to more and better quality jobs — in line with the relaunched Lisbon strategy — and enabling smarter working and more agile production. Greater use of embedded systems-based products and services will lead to the creation of jobs in Europe, in the ICT sector as well as the overall

---

[17] In the long run, FP-level disbursements have 89% more impact on GDP per euro invested than the same funding allocated at national level: Commission Staff Working Paper annexed to the proposal for the 7th Framework Programme {COM(2005) 119 final}, Annex 1, p. 59.

economy, through both direct and indirect effects. Many ARTEMIS applications will support human operators and/or enhance automation and control, thus increasing the added value of jobs across a wide range of application domains.

The application scenarios under the ARTEMIS Strategic Research Agenda that motivate the future development and integration of embedded systems technologies have a strong societal orientation. Environmental monitoring and management itself is an important application area for ARTEMIS. For instance, mesh networks based on large numbers of sensors and actuators will be able to monitor their surroundings and respond accordingly, in order to improve the abatement of industrial pollution or to monitor sensitive ecosystems.

MEETING THE CRITERIA FOR A JOINT TECHNOLOGY INITIATIVE

The proposal satisfies all of the criteria set out for a Joint Technology Initiative under the Seventh Framework Programme:

- *Scale of the Impact on Industrial Competitiveness and Growth*: **Embedded systems are a strategic technology for Europe.** This is because embedded systems technologies underpin the future development of major high-tech sectors that are key to the EU's economic strength and are significant drivers of innovation and growth.

- *Degree and Clarity of the Definition of the Objective and Deliverables to be Pursued:* The Strategic Research Agenda (SRA) of ARTEMIS sets out **tangible industrial objectives** to keep Europe at the forefront of the embedded systems field, aiming at realising Europe's potential in the future markets for intelligent products, processes and services. The SRA addresses the development of common technology for high value-added embedded systems across different application areas in order to deliver common embedded computing platforms, middleware for seamless connectivity of devices, and better methods and tools for system design.

- *Inability of Existing Instruments to Achieve the Objective*: While the EU will continue to invest in embedded systems research under the Framework Programme, the regular FP instruments alone cannot bring together resources and expertise on the scale needed to meet the investment challenge. **None of the existing instruments can combine, under one umbrella, industry, Member States and the Community**. The proposed public-private partnership provides a platform to pool resources from the Framework Programme, Member States and industry, and can build sufficient critical mass to pursue the ambitious objectives set. The involvement of Member States is crucial to achieving the objectives, since they account for a very substantial proportion of public R&D in relevant fields. The involvement of the Commission is also crucial as an integration driver, guarantor of the common JTI processes, and provider of funds.

- *Added Value of European-Level Intervention*: The proposed public-private partnership to implement the ARTEMIS JTI will provide the necessary legal and organisational framework to stimulate long-term commitments from all stakeholders and to allow the Strategic Research Agenda to be implemented in a seamless manner across Europe. Such a new framework can be established only by **action at Community level,** which will combine the benefits of European integration with **rapid adaptability of technology goals and industrial policies and with flexibility in participation and commitment on the part of Member States**.

- *Strength of the Financial and Resource Commitment from Industry*: Industry has already invested a lot of effort in preparatory activities and **will financially contribute to the operating costs of the JTI at 1% of the overall costs of the R&D** (estimated at around €2.7 billion). The initiative is recognised at the highest level of the management of the main industrial partners involved, who have expressed their long-term commitment to it on numerous occasions, including in a signed letter[18] to Vice-President Verheugen and Commissioners Reding and Potočnik. In terms of in-kind contributions of resources to R&D projects, **industry is expected to contribute around 60% of costs**.

- *Importance of the Contribution to Broader Policy Objectives Including Benefit To Society*: Achieving the ARTEMIS JTI technological objectives will have direct benefits for European industry of **at least €14.7bn per year** by 2015 through savings in development costs**.** Further indirect benefits can be expected from this improved profitability in terms of increasing market share and revenues, moving to higher added-value product segments, and improving longer-term technological competitiveness. In addition, the JTI will bring benefits for stakeholders through improvements in the efficiency and organisation of the research funding regime: the new structure will remove budgetary uncertainty and unnecessary bureaucracy, avoid duplication in evaluation and monitoring, and enable shorter times to market. The JTI will also create new jobs in the wider economy and open the way to new applications to improve the safety, security and well-being of citizens.

- *Capacity to Attract Additional National Support and Leverage Current and Future Industry Funding*: The ARTEMIS Joint Undertaking uses Community funding as a lever to increase and align national funding towards common goals and objectives and to provide incentives for greater investment by industry. Industry is prepared to double its resources in this field over the next years. The Joint Undertaking also provides a mechanism for broadening participation in R&D and for industry to act together towards common goals and objectives so as to achieve greater market leverage in how results are exploited and applied. For a total Community funding of €410m for R&D activities, the ARTEMIS Joint Undertaking should **leverage seven times that amount, 60%** of which should come from **the contributions of industry and other R&D actors**.

CONCLUSION

The proposed Joint Technology Initiative on Embedded Computing Systems (ARTEMIS JTI) is **an appropriate means to implement an initiative to realise Europe's potential** in the future markets for intelligent products, processes and services. The ARTEMIS JTI addresses the **core of the Lisbon agenda:** it will pursue objectives of high strategic value for EU competitiveness; will foster greater investment in the area by industry; will allow Community funding to be used as a lever to align national funding in a flexible way towards common goals and objectives, creating a true European Research Area in the field; and will provide a mechanism for broadening participation in R&D and for industry to act together towards common goals and objectives, so as to achieve greater market leverage in how results are exploited and applied. The JTI governance and operation model also provides an appropriate framework to combine the strengths of inter-governmental schemes (Eureka) and European programmes while overcoming their weaknesses.

---

18 Letters of support from the main ARTEMIS industrial stakeholders on 06.02.06.

1. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

Consultation

This document focuses on the impact analysis of the ARTEMIS Joint Technology Initiative and the review of the potential governance arrangements. The procedures followed reflect the Commission's guidelines for ex-ante impact assessments[19]. Parts of the impact assessment were subject to a contract with an external consultant awarded after a tendering competition.

The impact assessment drew on the results of extensive consultations held by the Commission with stakeholders in the embedded systems domain following the creation of the ARTEMIS Technology Platform[20] in January 2004: more than 40 meetings were held with the industrial Steering Board, the Executive Committee and several Working Groups (in particular the Strategic Research Agenda (SRA) and Governance and Financial Strategy groups), as well as the national public authorities represented in the "Mirror Group[21]" with representatives from 24 Member States and Associated Countries. The relevant topics for this impact assessment, such as the Strategic Research Agenda and the Joint Technology Initiative, were publicly presented and discussed at major events such as the ARTEMIS annual conferences (Rome 2004, Paris 2005, Graz 2006), the Information Society Technologies Conference IST-2006 (Helsinki) and the public presentation of the ARTEMIS SRA in March 2006 in the presence of Commissioner Reding.

In the final step of this consultation process, representatives of the ARTEMIS Steering Board and the Mirror Group met with the external consultant carrying out the study on three occasions over the period July-September 2006 (a dedicated meeting on 13 September and two meetings in the margins of important ARTEMIS events — ARTEMIS Summer Camp 5-7 July 2006 and the Joint Steering Board/Mirror Group meeting on 21 September). These meetings focused specifically on the contents of this study and involved wide-ranging discussions to collate previous results, provide further inputs and review the final results. The study also undertook an in-depth assessment of the proposed governance structure of the Joint Undertaking implementing the Joint Technology Initiative.

For economic analyses, the assessment has drawn primarily on public domain data, in particular two recent studies that provide a detailed picture of technological and market trends in embedded systems-related areas: *Worldwide Trends and R&D Programmes in Embedded Systems* by FAST GmbH (resulting from an open call for tenders by DG INFSO's Embedded Systems Unit) and *Software Intensive Systems in the Future* by IDATE and TNO, both published in 2005. The FAST study presents an assessment of the current state of the embedded systems domain as a whole, taking into account technological, sectoral, market-related and funding aspects. The IDATE/TNO study presents a quantitative evaluation of the impact of software activities on the world economy, focusing on the internal development of software in both the ICT and non-ICT sectors. The methodologies used in both studies,

---

19 *Impact Assessment Guidelines*, SEC(2005) 791, European Commission, 2005.

20 ARTEMIS Technology Platform, http://www.artemis-office.org/dotnetnuke/.

21 Members of the Mirror Group are AT, BE, BG, CH, CZ, DE, DK, ES, FI, FR, GR, HU, IE, IL, IT, MT, NL, NO, PT, RO, SE, SI, SK, UK.

including rechecking original data sources, are satisfactory and represent a sound basis for assessing the economic impacts of the ARTEMIS JTI.

2. PROBLEM DEFINITION

2.1. The importance of embedded systems

The economic dimension of ICT research

Information and communication technologies (ICT) are of increasing economic and social importance, underpinning productivity, innovation and growth. They are key to the EU's ambitions under the Lisbon strategy for improving competitiveness, employment and sustainability and making the EU the world's most dynamic knowledge-based economy and society[22,23].

Member States have recognised the contribution of research and development to this agenda and have set targets — known as the Barcelona Objectives — to increase their spending on research to at least 3% of GDP by 2010, two-thirds of which should come from the private sector[24]. Progress towards this objective has been slow, however, especially in increasing the industrial component. Meanwhile, the debate has moved on, with the focus now shifting downstream to the way research results are used within the market (innovation), the importance of knowledge and skills in exploiting innovation, and the role of 'lead markets' and procurement of research and development in pulling through radical innovations[25].

In the context of the Lisbon strategy and the Barcelona Objectives, the Commission initiative[26] "i2010" (European Information society in 2010) has identified the **strengthening of innovation and investment in ICT research** as a priority in the effort to address the increasing productivity gap between Europe and competing zones.

The importance of embedded systems research

Embedded computing systems — the invisible electronics and software that impart intelligence to products and processes — are an especially important part of the ICT landscape. They **underpin the competitiveness of key areas of European industry**, including the automotive and aerospace branches, consumer electronics, telecommunications devices and equipment, and manufacturing automation. "Embeddedness" has been identified

---

[22] Communications from the Commission COM(2004) 757, "Challenges for the European Information Society beyond 2005", COM(2005) 24 — "Working together for growth and jobs. A new start for the Lisbon Strategy", COM(2006) 502 — "Putting knowledge into practice: A broad-based innovation strategy for the EU".

[23] EU ICT Task Force report "Fostering the Competitiveness of Europe's ICT industry" (November 2006).

[24] *Communication More Research and Innovation — Investing for Growth and Employment: A Common Approach, COM(2005) 488 final.*

[25] *Creating an Innovative Europe: Report of the Independent Expert Group on R&D and Innovation*, "The Aho Report", European Commission, 2006. http:europa.eu.int/invest-in-research/.

[26] The "i2010" initiative provides an integrated approach to information society and audio-visual policies in the EU.

as one of the major technological drivers of digital convergence, and **embedded computing** is seen as one of the **EU's main industrial and technological strengths in global markets**[27].

Intelligent functions embedded in components and systems are in demand across a wide range of application areas. They will be a key factor in revolutionising industrial production processes, adding intelligence to process control and to the manufacturing shopfloor, helping improve logistics and distribution — and so **increasing productivity**.

The central role of embedded electronics in innovation and value creation is reflected in their **increasing share in the value of the final product**. As reflected in Table 2.2 below, within the next five years, such systems are expected to reach significant levels: in the automotive sector (36%), industrial automation (22%), telecommunications (37%), consumer electronics and intelligent home equipment (41%) and applications related to health/medical equipment (33%). **The value added to the final product by embedded software is much higher than the cost of the embedded device itself**.

Embedded systems are drivers of innovation

Embedded systems are an important enabler of innovation. They allow products and services to be differentiated and made smarter and more user-friendly. They allow us to design systems and applications that are cheaper, safer, more reliable, and more secure. Europe's competence in embedded systems underpins the competitiveness of key European industries, such as the automotive and aerospace branches, industrial automation, telecommunications, consumer electronics, medical systems and energy, where leadership and market dominance are achieved by innovative and high-quality functionality. These are largely sectors concerned with the engineering of large complex systems, whether cars, airplanes, power plants or telecom networks: these are precisely the domains where the widespread use of embedded computers has become the main source of innovation and market advantage.

Take for example the case of the car: today 20% of its value comes from the embedded electronic components (new models can contain more than 50 controllers and more than 1 million lines of code) and over **90% of innovations brought to the market rely on advances in embedded software and hardware technologies**. Take the example of a physically much smaller system — the mobile phone. Mobile phones today combine the capabilities of a small laptop of just a few years ago with those of a camera, a music player and a phone, with much more to come in the near future! A television set today contains hundreds of thousands of code lines on which its entire functionality is based; in the 1980s, embedded software content was essentially nil… . As for the aeronautics sector, the number of lines of code per functionality in aircraft systems has increased from 10 to 10^5 between 1970 and 2007… All this vertiginous functionality relies on enormously complex software embedded in the mobile device and running on the chips it contains.

Furthermore, the capabilities and ubiquity of embedded systems will make possible the emergence of completely new societal-scale applications, affecting citizens, cities, regions or entire continents in areas such as energy, environment, or social well-being. The safety of our lives already relies on the embedded electronics and controls that make our home appliances less prone to human error, our cars safer, our manufacturing and power plants less likely to

---

27 Commission Communication "Economic reforms and competitiveness: key messages from the European Competitiveness Report 2006", COM(2006) 697, SEC(2006) 1467.

cause accidents. The monitoring of our environment increasingly relies on embedded sensing, computing and control to warn us of hazardous situations and reduce pollution from plants, cars and buildings. We increasingly use electronic devices for our entertainment and social life, from the GPS device that guides us through the maze of the streets of an unknown city to our portable multimedia devices. And there is much more to come. The ability to design and interconnect powerful and cheap embedded computing systems will allow us to construct intelligent homes that care for their elderly inhabitants and actively optimise their energy consumption; accurate fire detection systems that would put an end to the fires that devastate south European countries; or electricity distribution systems that are fully reliable.

Mastery of embedded systems is essential for Europe to maintain a leadership position that contributes both to its economic strength and the quality of life of its citizens. But as the pervasiveness of embedded systems increases, so do the challenges in technology, interoperability, standardisation, methodology, safety, and security.

Globalisation of markets and R&D; embedded systems markets and trends

Already by 2000, 98% of computing devices sold worldwide were embedded in products28, and current forecasts predict more than 16 billion embedded devices by 2010 (nearly three devices per person on earth) and over 40 billion of such devices by 202029. This means that today the volume of the embedded systems market is about 50 times as large as the desktop market — an economic factor that cannot be underestimated.

Assessing market size and value is however problematic for embedded systems, since the technology penetrates many different areas of the value chain. Trade data tend to underestimate the position since they exclude all the value added by in-house development, which is significant and growing. **The real value of embedded systems as part of the final product value is much higher than the market size**. Wherever market figures are quoted, 'value' figures are the most relevant.

While it is clear that embedded systems are a strategic technology, the diversity of embedded systems and their applications makes it difficult to quantify the market size and growth. One indicator is the market for electronics, which covers many of the hardware components associated with embedded system products (including semiconductors, microcontrollers, microprocessors and memory products, and passive, electromechanical, power and discrete components).

Current estimates suggest the world market for electronics is worth around €850 billion, of which Europe has a market share of around 26% (Table 2.1). Growth rates in embedded systems are significantly higher than for general electronics in all application sectors.

[28] G. Borriello, R. Want. "Embedded Computation meets the World Wide Web." Comm. ACM, 43(5):59--66, May 2000.

[29] Embedded Computing, Joseph A. Fisher, Paolo Faraboschi & Cliff Young. Fisher (2005) and AUTOSAR — Automotive Open System Architecture. http://www.autosar.org.

.

Table 2.1: Electronics and Embedded Systems Markets and Growth Rates, 2002 – 2004 *(Source: FAST Study, based on various sources)***)**

Industry domains	Size of world market for electronics (€, bn)	European market share in electronics	Average annual growth rate of electronics market	Average annual growth rate of ES market
Automotive branch	30.1	37%	10%	10%
Avionics/ Aerospace	29.6	30%	5%	14%
Industrial automation	88.9	30%	5%	7%
Telecommunications	83.2	28%	9%	15%
Consumer electronics & intelligent homes	182.9	10%	8%	15%
Health & medical equipment	193.0	24%		18%

The economic importance of embedded systems is underlined by their share in the value of the final product (Table 2.2). Although estimates vary, the general picture is of a significant and increasing contribution to added-value in all application sectors.

Table 2.2: Share of Embedded Systems or Electronic Components in the Value of the Final Product or Service, 2004-2009 *(Source: FAST Study, based on various sources)*

Industry domains	2004	2009
Automotive branch	20%	36%
Avionics/ Aerospace	n.a.	n.a.
Industrial automation	>13%	22%
Telecommunications	>23%	37%
Consumer electronics & intelligent homes	>14%	41%
Health & medical equipment	25%	33%

The high relevance of embedded systems for industry drives R&D in this area. Research in embedded systems constitutes a very significant proportion of total business expenditure on ICT R&D for all sectors (Table 2.3). In several cases (e.g. the automotive branch, aerospace, ICT hardware, and consumer electronics), it is already well over 50% and will intensify further over the next five years, with R&D in embedded systems expected to grow at a faster rate than ICT R&D overall.

Table 2.3: Business R&D Expenditure on ICT and Embedded Systems, 2003 and 2009 *(Source: FAST Study, based on various sources))*

Industry sector	BERD on ES, 2003 (€ bn)	Share of ES in R&D for ICT	BERD on ES, 2009 (€, bn)	Share of ES in ICT R&D
Automotive branch	9.0	75%	14.4	80% (+ 5)
Avionics/ Aerospace	1.7	58%	3.2	69% (+ 11)
Industrial automation	1.0	43%	1.4	46% (+ 4)
ICT equipment	37.5	74%	75.4	82% (+ 8)
Consumer electronics	11.3	67%	22.8	77% (+ 10)
Medical equipment	0.3	22%	0.8	35% (+ 13)
ICT services	2.6	10%	4.2	13% (+ 3)

NB: ICT equipment here relates to R&D within the ICT industry itself on both hardware and software (i.e. for functionality/added value built into hardware when it is delivered)

Worldwide, R&D in the field of embedded systems is expected to double over the next 10 years, to support the growth of this expanding market. Whereas total R&D will increase by around 170% over the next ten years, expenditure on industrial software R&D is predicted to increase by 225%, from €58bn in 2002 to €132bn by 2015[30]

Around 50% of all proprietary industrial ICT R&D in Europe is related to embedded systems in some form. Estimates vary: FAST estimates the figure at ~€12bn, IDATE at ~€18bn, while the ARTEMIS Technology Platform puts it at around €20bn. All sources are agreed, however, that such research is concentrated overwhelmingly (>95%) in the six high-tech sectors identified above.

30 *Software Intensive Systems in the Future,* IDATE/TNO, 2005.

2.2. What is the issue or problem that may require action?

Insufficient investment in R&D

Despite the **increasing economic and social importance** of ICT, Europe lags behind its international competitors in investment in ICT research and innovation. Overall, ICT in the EU accounts for around 18% of total R&D expenditure, compared to 34% in the United States and 35% in Japan[31]. The difference is even more marked on a per capita basis, where the EU spends around €80 per head compared to €350 per head in the US and €400 per head in Japan. The situation is reflected in, and partly explains, **Europe's poor performance in productivity and economic growth**.

For embedded systems research in particular, total public funding in Europe (around €380m annually[32]) is **only 11% of the total budget for ICT** in public funding programmes, which is not at the level of its economic importance: areas related to embedded systems account for **more than 50% of total business expenditure** on ICT R&D in all sectors.

Europe's competitors have been quick to recognise this situation and have made major investments in ICT. Asian countries such as Taiwan, Korea and, particularly, China are investing large amounts of public funds in new production facilities and design capabilities. Similarly, Japan is supporting its microelectronics industry through its Semiconductor Leading Edge Technologies (SELETE) organisation. The USA is also investing massively in electronics, especially through defence projects — both directly with support for R&D and through government purchase of the resulting products. Emerging economies, such as China, India and Brazil, are fast becoming world-class centres for research and innovation, where they compete on cost and, increasingly, also on know-how. It is indicative that the Tsing Hua University (China) has risen from 62 to 28th place in the global ranking produced annually by the Times[33].

The fragmentation of research funding in the EU

Europe has made **major investments in ICT research over a number of years under the Research Framework Programmes**. Concentrating on high quality, the EU's ICT research programmes both focus and integrate Europe's ICT-based science and research, and were the first to include the new Member States in collaborative projects. This effort is being renewed and expanded under the forthcoming Seventh Framework Programme (FP7). It includes a number of innovations to ensure research meets the needs of the European economy and society, including a seven-year timeframe for programme planning, an increased budget and simpler procedures. Greater emphasis than in the past is given to the needs of European industry, to help the ICT sector compete internationally and develop its role as a world leader in key sectors. Nevertheless, the Framework Programme still has significant limitations: its contents reflect those areas where the EU25 can agree to spend **a relatively small percentage**

---

31 Commission Communication "*i2010: A European Information Society for Growth and Employment", European Commission, 2005.*

32 Study of Worldwide Trends and R&D Programmes in Embedded Systems (FAST GmbH).

33 *WORLD UNIVERSITY RANKINGS, The Times Higher Education Supplement, 6 October 2006.*

of the EU's total public budget. For example, FP6 accounted for only 5-6% of all public support for civilian research expenditure in the EU[34].

Another funding mechanism is the **inter-governmental Eureka scheme**. Eureka has proved to be a valuable cooperation mechanism that complements the FP in important ways. In particular, it allows cross-national R&D cooperation in areas where it is needed but which the FP budget would not be able to support. The Eureka framework has notched up some notable achievements over the years, most notably the longstanding collaborations in the form of "cluster projects" in microelectronics (the JESSI, MEDEA and MEDEA+ clusters) and software-intensive systems (ITEA and ITEA2). These have been valuable cooperation mechanisms, channelling up to €200 million of public funding to R&D industrial projects every year. It is no coincidence that all four current Eureka cluster projects concern the ICT domain; overall, around two-thirds of Eureka project funds are estimated to be devoted to ICT.

However, Eureka and its cluster projects also have well-recognised **shortcomings**. Its inter-governmental mechanism means that once a project has been accepted by Eureka it often then needs to go through the national procedures of each partner for individual national grants just as any other national R&D project. On top of the duplication of evaluation and project monitoring procedures, the variable level and predictability of the public funding available has consistently weakened the effectiveness of the scheme. To date, Eureka has not been able to correct or resolve these underlying problems[35].

At **national level**[36], 17 out of 122 funding programmes in 23 EU Member States and associated countries are dedicated to or have significant relevance for embedded systems research. In some countries, embedded systems activities are spread over several (sometimes disconnected) programmes, while for others it is not possible to identify whether there are relevant activities at all in the area.

In face of the major challenges confronting the European industry and economy, Europe's research landscape is fragmented and unable to come up with a convincing response in the area of embedded systems: the Framework Programme can define top-down priorities but requires broad agreement on priorities for budget allocation, and its overall budget is severely limited compared to the overall public research budget in Europe; Eureka is bottom-up but lacks efficiency and focus, and national efforts are scattered and not focused on common objectives.

Current funding instruments are inadequate: the need for public and EU intervention

Substantial added value can be realised by a European-level approach that draws together and intensifies some of the current research efforts (national, European or private) in order to address the needs of Europe in terms of industrial competitiveness. Europe has to step up its game, in quantity as well as quality, in embedded systems research in the face of fierce international competition. In such a fast-moving global market, Europe needs to be able to

---

34 Cordis (Community Research and Development Information Service) database of innovation articles.

35 Annual Impact Report of EUREKA 2005 (May 2006).

36 Cistrana survey. http://www.cistrana.org/. Cistrana is a project initiated by a European Research Area (ERA) working group representing Member and Associated States.

focus coherently on common objectives and to adapt these objectives to changing industrial and market circumstances. It must develop a European approach that builds critical mass but also allows flexibility at both strategic and operational levels without suffering all the drawbacks of inter-governmental schemes.

Current instruments do not provide an appropriate framework for mobilising European resources on a large scale around common objectives. They also lack the flexibility to enable Europe to go forward in a structured and organised way that allows for "variable geometry" in mobilising private, European and national funds while remaining effective and efficient.

Industrial R&D structure and key generic solutions for future markets

Finally, the increasing complexity of embedded systems and their applications poses huge technological challenges (as detailed in the next section). However, the current structure of European industry does not provide the necessary framework to allow the **market-driven development of the key enabling technology components, methods, tools and standards**. The middleware "glue" and the design and software tools necessary for future applications have not been developed, as the markets for them do not yet exist. Moreover, in the medium term, the "traditional" approach of increasing the labour force (designers, developers and testers) to cope with increasing complexity and functionality is not a sustainable solution. Disruptive technologies applicable to a wide range of sectors have to be developed. As a result, **the research costs are too high and the associated risks too great** for industry.

2.3. What are the underlying drivers of the problem?

Technological complexity is a major limitation

Embedded systems face huge technological challenges. These arise mainly from the lack of a systematic approach and associated engineering methods to support the design of hardware and software systems of **increasing sophistication and complexity**. Over the last 20 years, embedded systems have evolved from stand-alone single-processor computers to special-purpose, advanced multiprocessor systems with increasing communication capabilities (Figure 2.1). As systems become linked together and more interdependent, they are expected to evolve into a networked, reconfigurable 'processor ecosystem'.

Miniaturisation (towards the nano-scale) and the increasing number and functionality of components are bringing about a step-change in system complexity. Designers are looking to use modular approaches to keep the design effort manageable and successful. Even so, the increase in technological capabilities is outpacing improvements in the productivity of designers, leading to an ever-widening design productivity gap[37] (Figure 2.2). Figure 2.2 illustrates the rapid exponential growth of design complexity (following Moore's Law[38]) compared with the linear increases in design productivity (expressed as the average number of transistors designed per staff/month). In other words, current approaches to systems design

[37] This problem, first introduced as *design productivity crisis* in 1999 by Sematech (www.sematech.org), is nowadays well known under the name the productivity gap or *design gap*.

[38] According to Moore's law, complexity (expressed in number of transistors per integrated circuits or in computing power per unit cost) doubles every 16 to 18 months.

(and in particular for networked embedded systems) are proving inadequate in the struggle to keep up with system complexity.

Figure 2.1: Evolution of Embedded Systems

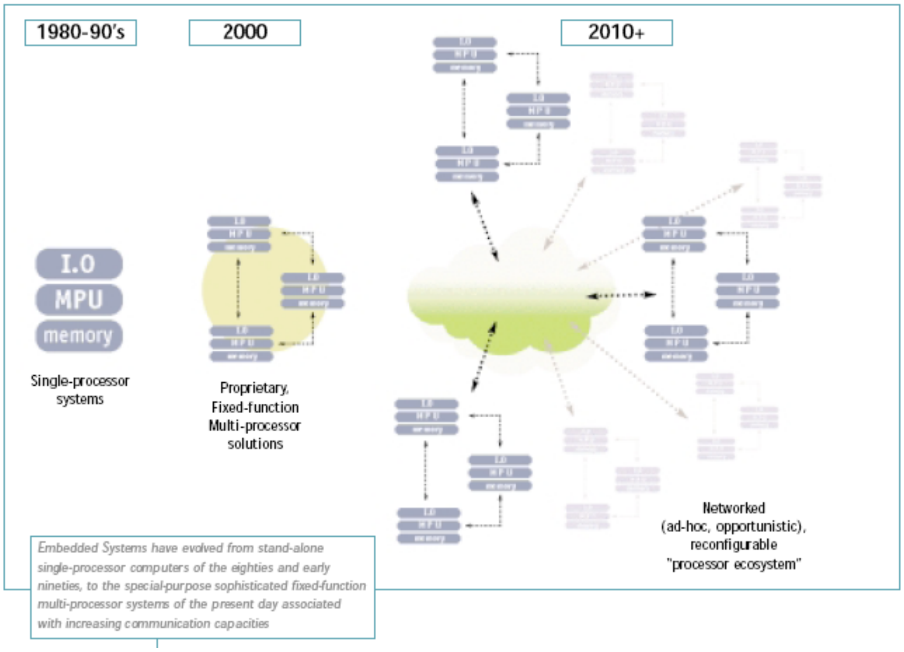
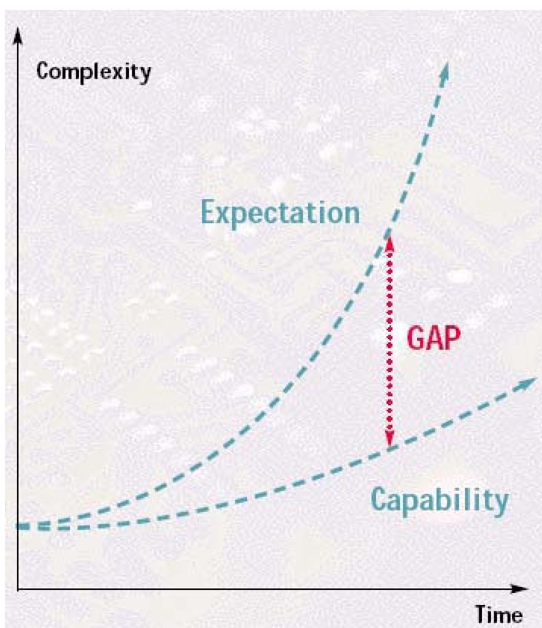


Figure 2.2: The Design Productivity Gap



Interoperability between embedded systems is a major challenge

In the medium term, this design complexity will make progress unsustainable. So, as well as supporting the evolution of the state-of-the-art, research programmes must stimulate disruptive technological solutions to close this widening gap and achieve major breakthroughs in design capabilities.

Interconnected embedded devices populate large and heterogeneous reconfigurable 'processor ecosystems' in a wide variety of application fields. There is an **increasing need** for a kind of **"lingua franca"** that would allow all these diverse electronic devices and systems to talk to and "understand" each other. Market innovations and increases in productivity will be possible only if open, reusable cross-sectoral solutions are available, such as open and **common standards and middleware** that ensure **interoperability and seamless connectivity** amongst heterogeneous devices for a wide range of applications. There is also an increasing need for **generic architectures** built for a set of similar products that share a common technology platform as well as having a common functionality. The use of generic solutions in industrial software development has been shown to have significant advantages in terms of the reuse levels of the developed software and a reduction in the development time of follow-up products.

The embedded tool industry in Europe

The market for embedded platforms and their components in Europe is based on a small number of major enterprises served by a high number of suppliers (mainly SMEs) that occupy smaller and more specific niches in the software markets by developing domain- and enterprise-specific solutions. These characteristics indicate the high fragmentation of the market for embedded systems. Often, the combination of a big player and many SMEs leads to the emergence of clusters around the big enterprise, fostering the diffusion of knowledge.

Europe's capability to provide **domain-specific integration know-how** has given it a large share of the market in secondary market domains like the automotive, industrial and energy sectors, or defence and space.

At the same time, there are tool suppliers and consulting firms that mostly focus on specific domains or on single components. The **value of design tools** in industrial practice hinges to a large degree on **interoperability** with third-party tools, and the suitability of the tools environment in heterogeneous supply chains. Today, there are a surprisingly high number of tools employed in both research and industry to move from specification to design and implementation, but the degree of industrial adoption of new techniques is very low. Especially in large and heterogeneous value chains, such as the automotive and aeronautics industry (with thousands of suppliers/subcontractors involved in the process), innovation in the field is often hindered due to a **lack of common standards and tools**.

Acceptance of design tools and methods in development organisations will be poor if there is a danger of being "locked in" to a specific tool vendor and no open standards exist. In tightly integrated tool chains, the different tools have to offer extension mechanisms and better usability. In the long run, the **productivity** effects of improved design practice will only be unleashed if adequate, **open-standard and simple techniques for establishing tool chains** exist.

Skills and the scarcity of human resources

In the absence of disruptive technological solutions, the approach followed to tackle the widening design productivity gap is to add further human resources. As the new generations of embedded systems are increasingly complex and demand higher levels of functional safety and security, the number of R&D workers in the embedded systems field has to be increased accordingly. The worldwide population of embedded systems developers is estimated to have been between 460 000 and 488 000[39] in 2005, growing to 530 000 in 2007 at the start of Seventh Framework Programme (FP7). Assuming the current growth rate (10%/year), the **R&D population** in the embedded systems field is therefore expected to **double over the next 10 years**.

It is clear that just increasing the labour force is not a sustainable solution in the area of embedded systems. Europe cannot continue to hire more programmers indefinitely to tackle the design gap. In order to manage increasing system complexity and the gap in design productivity, European companies are using ever-increasing numbers of software programmers and outsourcing programming tasks to third countries. It is clear that this is not a sustainable solution in the longer term: firstly, developing countries providing outsourcing facilities are already suffering a severe shortfall of IT skilled staff to support their economic growth[40]. Moreover, the likelihood of system faults and software bugs increases with the size of teams working on a system development project. The ever-increasing complexity of interconnected embedded systems cannot be tackled by simply adding more programmers, but with novel approaches and associated engineering methods and tools. Europe also has to reverse the brain-drain of highly skilled engineers and doctoral graduates (mainly to the USA) and address the slowdown in imports of foreign third-country graduates. Although Europe has seen strong increases in engineering graduates (three times as many engineers as North America in 2002), it has to fight a **brain-drain** of highly skilled engineers and doctoral graduates (mainly to the USA) and a **slowdown in imports of foreign third-country graduates** (much of the world has now developed an infrastructure capable of retaining and using these highly educated people productively)[41].

2.4. What are the risks in the current situation?

ICTs are not only crucial to the **strength** and competitiveness of European industry, they also present **opportunities** to transform our economy and society in the face of major challenges such as ageing, climate change and sustainability. Embedded systems are at the heart of the next generation of ICT systems that will facilitate this. Much in the same way that the desktop computing (in the 80s) and internet (in the 90s) "waves" of the IT revolution led to the creation of new markets, the third wave made possible by the "embedding of intelligence" in our everyday environment is coming unannounced and will see the creation of **even larger markets** for applications we cannot yet fully grasp. The wave will of course come to Europe as well; the only question is: **will Europe be in a good competitive position to lead these developments in accordance with its economic interests and its cultural values?**

On the other hand, the current situation in embedded systems development — characterised by increasing technological complexity, lack of cross-sectoral interoperability, weak links in the embedded systems value chain, escalating competitive pressures arising from

---

[39] ARTEMIS Strategic Research Agenda, and Study of Worldwide Trends and R&D Programmes in Embedded Systems (FAST GmbH).

[40] India will need a 2.3 million-strong IT workforce by 2010 but has a yearly shortfall of 100.000 qualified employees in the IT sector. This shortage will amount to nearly 0.5 million by 2010 (source Nasscom-McKinsey report 2005)

[41] NSF Science and Engineering indicators 2006.

globalisation, and a fragmentation of research efforts — bears substantial **threats and risks** for Europe.

The current fragmented situation in Europe is ineffective and inefficient. Without a focused and coherent industrial R&D programme able to draw on all sources of R&D investment (public or private), European efforts in embedded systems research will continue to be scattered and unstructured. Progress will be held back by the **lack of coordination of industrial R&D objectives, duplication of effort, unnecessary bureaucracy,** and **suboptimal use of limited research funding**.

This, in turn, will lead to a **loss of competitiveness for Europe**. At risk is not just the opportunity to create jobs and to innovate in products and services in the short term, but also **the** very **ability to innovate**. As explained in the previous section, embedded systems are so central to value creation in the modern world that an economy that fails to master embedded systems loses a significant part of its innovation capability. Without a coherent effort to develop an infrastructure for embedded systems research, Europe will be **unable to meet the technological challenges** and will fall further behind its international competitors. Unless it is able to nurture and retain talent, Europe will be **unable to attract or retain the best researchers** in relevant fields.

An even more important risk is that Europe will be **unable to reap the benefits from the new markets** created by the "embedding of intelligence", and become entirely dependent on non-European technology, as has already happened for the desktop and internet waves, adopting applications ultimately developed elsewhere and entirely relying on non-EU technology for their supply and operation.

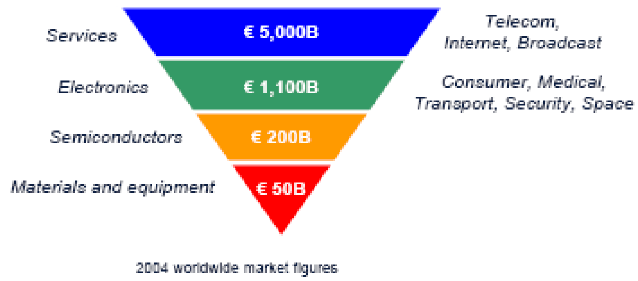
The current situation also represents a risk from a **standards** point of view. Standards are essential in global markets, but with the current proliferation of standards organisations, their impact depends on speed of action and the ability to bring players together through alliances. This is essential in encouraging market pull and establishing lead markets for innovative ICT-based applications. Europe's **contribution to standardisation is currently fragmented** and many of the key bodies are dominated by major US companies. Europe needs to improve its effectiveness in establishing and influencing internationally agreed standards. As well as promoting standardisation within Europe, concerted action is needed to promote European standards on the world stage.

Finally, there is a **'cultural' risk**. The intelligent systems enabled by embedded systems will touch upon the lives of European citizens in very intimate ways. Secure access to public services; tracking of goods, vehicles and people; monitoring of our viewing and browsing habits; robots and software agents that know our personal details: all will be enabled by embedded systems technologies. European industry needs to be able to **respond to home-grown demand in a way that recognises Europe's unique preferences and values**. And European citizens need to be able to exercise democratic scrutiny over products and systems that may impact on privacy or ethics. A strong European industry and research community are essential for this.

2.5. Who is affected, in what ways, and to what extent?

Embedded systems sit in the middle of the 'inverted pyramid' of electronics markets, a key link between chips and low-level hardware components on the one hand and end-user products and services on the other (Figure 2.1).

Figure 2.1: The Inverted Pyramid of Value



The value chains in embedded systems are highly complex. The **supply industry** comprises not just large enterprises, for which the markets are effectively global, but also many small and medium-sized enterprises (SMEs). These small companies are essential to innovation, and larger enterprises subcontract some of their R&D work to them or use them as sources of ideas and technology. Increasingly, individual SMEs have to work together — with other SMEs or with larger firms — as part of wider production chains, clusters or industrial 'eco-systems'. A new supply industry is expected to emerge which is able to use standardised results and technologies (components, middleware and design tools) as building blocks for these new ecosystems.

System integrators take research results and use them within innovative products and services. This is not a linear model and often the system integrators are in end-user industries such as the automotive and aerospace sectors, telecommunications and consumer electronics. These industries have complex supply chains that provide huge amounts of added value to systems and components, and ultimately to the final product. To compete, European players need to move faster in world markets and to be at the forefront of innovation. Access to standardised methods and tools will enable them to innovate more quickly across the product and service lifecycle while significantly reducing development costs. Common European platforms will also provide a basis for competition in world markets. In the automotive branch, for example, many new cars already have more than 50 embedded controllers, more than 1 million lines of code and several different bus (communication) systems carrying thousands of signals. This will increase further in future as systems such as parking assistance, adaptive cruise control and brake-by-wire become commonplace. In-car entertainment and navigation systems are also in increasing demand, requiring the industry to become more flexible in building in compatibility with consumer electronic devices such as mobile phones, PDAs and MP3 players.

Embedded systems research is inherently multidisciplinary, spanning both a range of technological disciplines (computer science, electronic and mechanical engineering, cognitive sciences, control, etc.) and a broad range of application fields. To meet the medium- to long-term research needs of European industry, **close cooperation is necessary between the best academic and industrial research** groups. Academic efforts need to be more directed and focused so as to improve their outputs and keep brain power in Europe. Within such a diverse field, there is scope for pooling European knowledge within centres of excellence. Industry-academic collaboration should also extend to education and training, so as to close the gap between academic theory and industrial practice.

National public authorities are interested in the embedded systems arena as policy-makers, regulators and funding bodies. They are looking to leverage their own research efforts, avoid duplication and develop synergies between national and European programmes and policies. They are severely limited in their actions due to the conflict between their mandate, which is national, and the nature of the problems they tackle, which is European or even global (although Eureka is a partial answer to this problem). This is especially true for public authorities in smaller Member States that lack the critical mass at national level to launch meaningful and effective action. At present, therefore, few Member States have national programmes focused exclusively on embedded systems, although relevant research is addressed under general ICT research. Public authorities also have to be alert to the regulatory and policy issues arising from new applications, concerning aspects such as safety, security, digital trust and the environment.

Finally, European **citizens** are affected by embedded systems in a variety of ways: through lower cost products and services; through improved safety, security and quality of life arising from innovative applications; and through improved access and choice.

2.6. How would the problem evolve, all things being equal? Is intervention at Community level justified?

The embedded systems field in Europe has thus reached a threshold. It has the potential to drive innovation and growth and contribute significantly to European competitiveness and economic and social change. But Europe's current leading position in key areas also faces global competition, a fragmented research landscape, escalating technological challenges and increasing international competition. All of these factors are set to be exacerbated over the coming years, making the current approach unsustainable. Europe cannot continue to hire more programmers indefinitely to tackle the design gap. It cannot continue to rely only on a cumbersome research structure that lacks focus and leads to duplication of effort. And European industry cannot hold back from developing the interoperable solutions necessary for success in new fast-growing markets. **Europe must increase and make better use of its investments in this strategic area**.

Market failure and the European added value of Community intervention

The current structure of European industry does not provide the necessary framework in which to develop the key enabling technological components, methods, tools and standards necessary to cope with the huge technological challenges posed by the increasing complexity of embedded systems and their applications. As a result, **the research costs are too high and the associated risks too great**. Given the limited resources available, market failures will prevent the market from reaching optimal output for the following reasons:

Positive externalities/knowledge spill-overs: R&D in embedded computing systems, as in many other areas of research, generates benefits for the economy and society in the form of knowledge spill-overs. Where only the market decides, a number of projects may have an unattractive rate of return from the perspective of a single private company, even though they would be beneficial for society or economy as a whole. This is because profit-seeking businesses neglect these external effects of their actions when deciding how much R&D they should undertake. Consequently, projects that could be in the common public interest may not be pursued unless the government intervenes.

Public goods/knowledge spill-overs: The creation of general knowledge through foundational and applied research on the development of cross-cutting technology for high value-added embedded systems is costly and labour-intensive, whereas it is ultimately impossible to prevent others from using this knowledge. Many businesses tend to free-ride on the general knowledge created by others, which makes companies unwilling to create this general knowledge themselves. On the other hand, European companies will become inefficient or disappear altogether if they do not acquire their own portfolio of 'general' knowledge. To ensure that they do, governments may have to pay partially or fully for more long-term, foundational, and/or generic research.

Imperfect and asymmetric information: R&D in embedded computing systems is characterised by a high degree of risk and uncertainty. Due to imperfect and asymmetric information, private investors may be reluctant to finance valuable projects and highly qualified personnel may be unaware of recruitment possibilities in innovative businesses. As a result, the allocation of human and financial resources may not be adequate in these markets and projects valuable for the economy may not be carried out.

Coordination and network failures. The ability of businesses and Member States to spontaneously coordinate or at least interact to deliver R&D may be limited for various reasons, including difficulties in coordinating R&D and finding adequate partners. Difficulties arising from fragmentation of the research landscape in Europe on the one hand, and the extremely high costs of developing new technologies and the need to mix competences from different scientific fields on the other, can only be overcome through a strongly coordinated initiative combining all the means available.

Europe "lost" the desktop computing (in the 80s) and internet (in the 90s) waves of the IT revolution to Asia and the US; a third wave is now coming: information processing and communication capabilities embedded in the real world that surrounds us — within our furniture, our clothes, our buildings and our cars.

Market failure in embedded computing systems would lead to the same situation as in the personal computing market, where both hardware and software are dominated by a few non-European players. Unless ambitious and concerted action is urgently taken, there is a risk that Asia and the US will take over the last bastion of EU industrial excellence (i.e. systems engineering), leveraging their strong investment and skills in IT. This would have serious consequences for the competitiveness of high-tech European companies. In addition, it could lead to organisations outside the EU monopolising European markets. The intervention of public authorities at European level is needed to provide a state-of-the-art research infrastructure and to create the necessary innovation environment for high-tech industry to thrive.

It is clear that **only action at Community level** can **develop an approach that combines the benefits of European integration with rapid adaptability of goals and industrial policies and with flexibility in participation and national commitment on the part of Member States**.

The European Technology Platform in embedded computing systems

Stakeholders have recognised the critical nature of this problem and have come together in the ARTEMIS European Technology Platform (ETP). The Platform comprises players from industry, SMEs, universities, research centres and public authorities who are working together to reinforce the EU's leading position in the design, integration and supply of embedded systems.

The Platform has published a Strategic Research Agenda (SRA) outlining the evolution of the field over a medium- to long-term perspective and identifying a number of important technological and regulatory challenges for Europe. To help meet these challenges, the SRA sets out a comprehensive programme of action to focus and coordinate research, encourage innovation and streamline policies. To implement its SRA, the ARTEMIS ETP envisages a synergistic approach based on a combination of European, industry and national funding. However, the Framework Programme (FP) can reflect only some of the SRA goals in its work programme. Conversely, Eureka and the related scattered national programmes are bottom-up and cannot drive the SRA vision to realisation in a coordinated way. Maintaining this status quo will not achieve the ambitious goals necessary to put Europe at the forefront of embedded systems markets.

2.7. What are the overall policy objectives and what are the expected effects?

The overarching objective is twofold. On the economic and technological side, the aim is to launch an initiative to **realise Europe's potential in the future markets for intelligent products, processes and services** and achieve world leadership in embedded technologies, allowing the deployment of seamlessly connected systems and the spearheading of applications that enhance the safety, security and well-being of citizens. In addition, these ambitious technological and economic objectives have to be combined with the **political will to create a true European Research Area and foster investment in this area**.

2.7.1. Policy objectives

In particular, the policy objectives are the following:

(1) To create a single, Europe-wide R&D programme that is industrially driven and focuses on selected, specific joint technological and economic objectives.

(2) To put in place a new mechanism able to combine, for the first time, national, EU and private funding within one coherent funding instrument that allows specific sets of countries to move forward within a flexible legal framework ("variable geometry") while remaining effective and efficient.

(3) **To ramp up R&D investment in Europe** by providing incentives to industry and Member States to increase their R&D expenditure.

2.7.2. Technological and economic objectives

The Strategic Research Agenda addresses the development of common technology for high value-added embedded systems across different application areas. This common technology includes:

- Reference designs offering standard architectural approaches for a range of applications;

- Middleware solutions for seamless connectivity and wide-scale interoperability;

- Integrated design methods and software tools for rapid development and prototyping; and

- Piloting new applications in the specific contexts of home, nomadic, industrial and public-infrastructure environments.

To focus its research and innovation activities, the SRA has set a series of high-level targets to be attained by 2016. These include:

- 50% of embedded systems deployed worldwide to be based on ARTEMIS results and developed under the engineering discipline established by ARTEMIS.

- Twice as many European SMEs engaged within ARTEMIS in the embedded systems supply chain, from concept through design to manufacture, delivery and support.

- ARTEMIS to have generated at least 5 'radical innovations' of a similar paradigm-breaking nature to the microprocessor, digital signal processing or software radio. As a general indication of innovation, the number of relevant patents granted per annum to European companies engaged in ARTEMIS should have doubled.

Particular emphasis is given to closing the design productivity gap between potential and capability. Specifically, the SRA targets are to:

- Reduce the cost of system design by 50%, through approaches enabling a much higher degree of strategic reuse and easier assembly.

- Achieve a 50% reduction in development cycles, through a focus on design excellence, including validation, verification and certification.

- Manage a complexity increase of 100% with a 20% reduction in effort, through techniques to better manage uncertainty in the design process and upgradeability across the lifecycle.

- Reduce by 50% the effort and time required for revalidation and recertification, so that this is linearly related to the changes in functionality.

Other targets that are not expressed in quantitative terms but are equally important include: achieving the cross-domain seamless connectivity and inter-operability necessary for 'ambient intelligence'; developing fully integrated tool chains to support the development of embedded systems across the lifecycle; making embedded systems and devices more reusable between sectors and developing related standards; and improving the European research infrastructure and education system to better meet the needs of industry.

2.7.3. Expected effects

Achieving the above objectives is expected to have the following effects:

- **Focusing effect:** to focus R&D agendas more effectively than the current dispersed national programmes and bottom-up Eureka clusters. This will provide a coherent structure for Europe's fragmented research efforts in embedded systems and help build a European Research Area (ERA) in the field.

- **Greater flexibility:** To provide a mechanism to mobilise Member States that are ready to work towards common goals in a flexible way according to their available resources and enable them to adapt promptly to the rapidly evolving needs of the area, so helping to build critical mass for embedded systems research in Europe.

- **Integration of national efforts**: To pursue objectives defined at European level within the SRA of the relevant Technology Platform, and to carry out project selection according to a common, single European process and according to criteria published in advance.

- **Leveraging effect:** To provide incentives to industry and Member States, attracting additional national support and leveraging greater industry funding. This will directly contribute to the Barcelona Objectives of increasing Europe's R&D spending to 3% of GDP, with two thirds coming from industry.

- **Programme efficiency:** To combine the strengths of transnational (Eureka) and European programmes while overcoming their weaknesses. In particular, to avoid uncertainty in national budgets (compared to Eureka) and the duplication of evaluation and monitoring procedures. The adoption of common procedures should allow shorter times-to-contract while avoiding additional red tape for participants.

- **Economic efficiency:** To reduce the time-to-project, allowing industry to execute projects more quickly and hence accelerate the time-to-market for research results. Faster product development, fewer lost market opportunities and higher productivity can bring huge benefits for companies in a situation where windows for action are shrinking.

- **Economic impact:** Economic impacts are expected through: achieving the technological objectives (improved productivity of the research process); simpler and more efficient procedures (lower overheads for participants and greater concentration of research resources); and from shorter times to contract (improved competitiveness and growth in jobs). These aspects are analysed in detail in section 5.

3. POLICY OPTIONS

3.1. Approach to reaching the objectives

New Mechanisms in FP7

Recently adopted by the European Parliament and Council, the Seventh Framework Programme (FP7) (2007-2013) is an important point of departure for Europe. It reflects a consensus that to equip itself as a competitive and dynamic knowledge-based economy

Europe must redouble its efforts to increase and get better returns from its R&D investments. FP7 has recognised the problems described in the previous sections, and introduces the concept of **Joint Technology Initiatives (JTI)** as a major innovation to **give concrete answers** to the need for **greater strategic focus, for assembling a critical mass of research in key areas, for better coordination in research, and for tighter coupling between research and innovation**.

A JTI is **a public-private partnership**, mainly resulting from the work of European Technology Platforms (ETP) to implement (parts of) their Strategic Research Agendas. JTIs have been identified by the Commission[42] as an FP7 instrument that can support a limited number of European Technology Platforms in reaching their objectives[43]. As reflected in the FP7 text:

"In a very limited number of cases, the scope of an RTD objective and the scale of the resources involved could justify setting up long-term public private partnerships in the form of Joint Technology Initiatives. These initiatives, mainly resulting from the work of European Technology Platforms and covering one or a small number of selected aspects of research in their field, will combine private sector investment and national and European public funding, including grant funding from the Seventh Framework Programme and loan and guarantee finance from the European Investment Bank. "

JTIs are a new means to respond to the real needs of industry and other stakeholders, able to accommodate variable configurations of public authorities (Commission and Member and Associated States) in a way that is not possible under the 'traditional' FP7 instruments. For the first time, the Community will offer a legal and organisational framework that allows the effective pooling of resources from R&D performers, the Commission and national governments. In this way, JTIs "transcend" the Framework Programme and national programmes, integrating both in an area where urgent action and industrial strategic focus is necessary**. Setting up JTIs alongside the funding schemes of the Framework Programme is an essential step in achieving the Framework Programme's overall objectives.**

As indicated by the FP7 impact assessment[44], the implementation of **Joint Technology Initiatives** will help achieve the Lisbon competitiveness objective and the Barcelona targets for research spending, identifying areas critical for European competitiveness and supporting ambitious research agendas that are strategic and long-term in nature, involving the commitment of massive financial, organisational and human resources through public-private partnerships,

Why a JTI in the embedded systems field?

---

42 "Science and technology, the key to Europe's future — Guidelines for future European Union policy to support research", COM(2004) 353 of 16.06.2004.

43 *Report on European Technology Platforms and Joint Technology Initiatives: Fostering Public-Private R&D Partnerships to Boost Europe's Industrial competitiveness,* SEC(2005) 800, European Commission, 2005.

44 "More Research and Innovation - Investing for Growth and Employment :A Common Approach" Impact Assessment {COM(2005) 488 final}.

FP7[45] identifies Embedded Computing Systems as one of the areas where the establishment of a JTI could be of particular relevance (resulting from the work of the ARTEMIS Technology Platform). This was confirmed by the Competitiveness Council meeting on 4-5 December 2006[46]..

The critical mass and greater flexibility and focus brought by a JTI is especially relevant in the embedded systems field: it will have a strong industrial orientation and address the **core of the Lisbon agenda** by supporting innovation and competitiveness for key sectors in the EU; there are already a variety of important national efforts and trans-national initiatives (Eureka clusters); it has a broad constituency, much of it outside of the core ICT sector; and the systemic nature of the technology requires close links between research, innovation and deployment. All these factors make the embedded systems field an excellent candidate for a Joint Technology Initiative.

The JTI on Embedded Computing Systems (**ARTEMIS JTI**) is a means of setting up and running a European Industrial R&D Programme in this area to run alongside and tightly coupled with the more foundational embedded systems research typically funded under the FP.

Implementation of Joint Technology Initiatives

FP7 specifies[47] that a **Article 171 of the Treaty[48]** may provide the specific legal basis for implementing the JTIs. Article 171 of the Treaty offers a wide range of possible implementation structures for Community research and development programmes, including a Joint Undertaking. In the context of JTIs, the main advantage of a Joint Undertaking is that it creates a strong and efficient coordination mechanism, able to structure and handle contributions coming from different fields and sectors. Although the application of Article 171 to the concept of Joint Technology Initiatives is novel, there are a number of examples where Article 171 has been used to set up Joint Undertakings in the research field, including, notably, Galileo under EC rules and JET in the framework of EURATOM.

The rest of this document will refer to "**ARTEMIS JTI**" as the Joint Technology Initiative option, and in some cases as "**ARTEMIS Joint Undertaking**" when dealing with the implementation details of the legal structure (legal issues, governance, funding schemes, etc.).

3.2. Options discarded

Some other options have been considered but were discarded at an early stage:

∉ *Do nothing*

---

45 Proposal for a Council Decision concerning the Specific Programme "Cooperation" implementing the Seventh Framework Programme (2007-2013) of the European Community for research,-technological development and demonstration activities; COM(2005) 440, 21 September 2005

46 15717/06

47 FP7 text: "Each Joint Technology Initiative will be decided upon individually, either on the basis of Article 171 of the Treaty (this may include the creation of a joint undertaking) or on the basis of Specific Programme Decisions in accordance with Article 166(3) of the Treaty."

48 Article 171: "The Community may set up joint undertakings or any other structure necessary for the efficient execution of Community RTD programmes."

The ‘do nothing’ option refers to no financial support at EU level for embedded systems research and technological development (discontinuing the funding of this area in FP7). As pointed out by the FP7 impact assessment[49], this option can be clearly ruled out as it would go against the **need to invest more and better in research and innovation** and **for building an integrated European Research Area** in a critical area for European competitiveness.

∉ ***Implementation of the JTI using alternative legal models***

During the preparation of FP7, several other options were considered by the Commission for setting up public-private partnerships to implement JTIs that could accommodate the participation of industry, the European Commission and Member States. An **extensive analysis** was carried out by a Commission Inter-Service Working Group[50] and the following is a summary of its conclusions regarding the main alternatives considered for the form of legal entity, together with a brief analysis of the implications for Commission participation[51]:

- ∉ **The "European Economic Interest Grouping" (EEIG) model** (e.g. European and Developing Countries Clinical Trial Partnership, EDCTP). Potentially light procedure, as the legal form is already recognised and accepted in all Member States. In the existing (EDCTP) and potential future initiatives (e.g. Ambient Assisted Living in FP7), the participation of the Commission in the legal structure has been discarded as an option.

- ∉ **The "Non-Profit Organisation" model** — an **Association** (e.g. INTAS asbl) or **Foundation** (e.g. European Energy Foundation), established under national law (non-harmonised). As in the previous case, the participation of the Commission in the legal structure is strongly discouraged. The principle of "one member, one vote" and majority voting would anyway pose significant problems of control over the Community contribution.

- ∉ **The "Commercial Private Company" model** — involves the formation of an enterprise, generally limited by guarantee. Community participation is not permitted under Commission guidelines.

∉ ***Participation in joint actions by Member States***

This option for achieving the ARTEMIS JTI objectives is based on Article 169 of the Treaty[52], which enables the Community to participate in research programmes undertaken

---

49 "More Research and Innovation - Investing for Growth and Employment :A Common Approach", Impact Assessment {COM(2005) 488 final}.

50 Commission Inter-Service Working Group (TP WG 3) in the "Options for establishing Joint Technology Initiatives" (24-11-04).

51 Commission participation in other legal structures is regulated by its guidelines (C(2004) 2958 of 4-8-2004).

52 Article 169: "In implementing the Framework Programme, the Community may participate in RTD programmes undertaken by several Member States, including participation in the structures created for the execution of those programmes."

jointly by several Member States[53] in implementing the FP. This option was discarded as it would present a number of difficulties:

(1) The JTI is above all motivated by **industrial competitiveness objectives** and not by the need for the Community to participate in national RTD programmes/activities. Moreover, at present few Member States have national programmes dedicated to embedded systems research; instead, **funding is scattered across a range of programmes** of varying relevance or where this relevance is unquantifiable.

(2) Article 169 of the Treaty only covers the public sector and does not allow for private-sector participation, which is essential to ensure industrial relevance and focus in such a fast-moving field. **The markets and opportunities in embedded systems are of such a magnitude that an industry-driven approach is required**. As the JTI focuses on industrial objectives that are important for economic competitiveness, industrial participation is necessary to guide the preparation of the Research Agenda, ensuring consistency between industrial strategies and priorities and public funding policies. In addition, industry's participation is necessary to ensure its long-term commitment to the objectives.

(3) The joint implementation of research programmes by several Member States would need a private-law legal structure to be established. The Commission guidelines[54] indicate that in principle the Commission cannot participate in such bodies. Therefore, the Commission would be able to contribute financially through a grant and have a limited influence **but not be able to actively lead developments**.

However, the participation of the Commission in the legal structure is of paramount importance. It must have a decisive strategic role in (a) the adoption and implementation of the Strategic Research Agenda and (b) the integration process, driving and balancing the different interests of the parties involved (Community, Member States and industry). The Commission is the only actor that can defend the Community's interests in this process. The direct participation of the Commission will also ensure full control over its own contribution.

3.3. Conclusions on the different approaches

From the above analysis, implementing the **ARTEMIS JTI** through a "Joint Undertaking" model on the basis of Article 171 of the Treaty as described in 3.1 above is the only option that satisfies the constraints and requirements for achieving the objectives of the action: the legal entity has to be a structure durable over time, with legal personality, which (a) provides a legal framework for the collaboration and direct participation of public (Member/Associated

---

[53] In FP7, this approach will be tried amongst others in the proposed initiative on Ambient Assisted Living: www.aal169.org.

[54] C(2004) 2958 of 4.8.2004.

States and the Commission) and private stakeholders, and (b) is capable of receiving funding from different sources (e.g. grants from the Community, loans from the EIB, etc.).

The options considered in 3.2 above cannot be considered appropriate for the proposed action, as they do not satisfy the above constraints.

3.4. Option scenarios

Following the conclusions above, only the following two policy options have been considered for further analysis:

(1) **'Business-as-usual'** option. This is basically a continuation of the current working arrangements. Parts of the ARTEMIS Strategic Research Agenda would then be implemented through the existing EU instruments and, separately, through national programmes, including some intergovernmental cooperation under Eureka (MEDEA+ and ITEA2). Commission support would be through the regular instruments in the FP7's four Specific Programmes, in particular for collaborative research under the Cooperation Programme. This option will be considered as the baseline option.

(2) **ARTEMIS JTI – 'Joint Undertaking'** on the basis of Article 171 of the Treaty **to implement a "Joint Technology Initiative"** with the participation of industry, the European Commission and Member States and FP7 Associated Countries, building on the existing ARTEMIS Technology Platform. In this model, the Community (represented by the Commission) would be a full member alongside other entities and national authorities willing to commit funding or contributions in kind. A JTI is created through a legislative procedure (Council Regulation established by means of the consultation procedure) that implies the definition of all the characteristics of the entity in a Council Regulation. **A detailed description of the proposed model for governance and operations of the Joint Undertaking can be found in the next section.**

4. STRUCTURE AND GOVERNANCE OF THE ARTEMIS JOINT UNDERTAKING

4.1.1. Participation and legal form

The founding members of the Joint Undertaking (ARTEMIS Joint Undertaking) under Article 171 of the Treaty would be Member States (to be determined at the time of discussion in the Council), the European Commission and a non-profit industrial association called ARTEMISIA. Other members can join at a later stage:

- **Member States or Associated Countries** that are not part of the initial founding group can become members through a simple request to join, in which they commit to the obligations and rights of the members as described in the ARTEMIS Joint Undertaking Statutes annexed to the Council Regulation.

- **Private entities** will participate in the Joint Undertaking predominantly through membership of **ARTEMISIA**[55]. ARTEMISIA is open for membership to research and development actors in the area of embedded computing systems and promotes the broad involvement of industry, including in particular SMEs and other research and development stakeholders. **Third Countries** with active policies or programmes in the field of the ARTEMIS JTI and **other legal entities** capable of contributing substantially to the realisation of its objectives will be able to participate in the Joint Undertaking through special agreements to be negotiated between them and the ARTEMIS Joint Undertaking.

The participation of research and development actors (industry and academia) in the legal structure of the JTI could have been either on an individual basis or through a non-profit association. However, the latter provides a more flexible and elegant solution, in particular when the number of stakeholders is large: new companies and research organisations may join the association at any time through a very simple process, which might not be the case if individual organisations were to be members of the JTI directly.

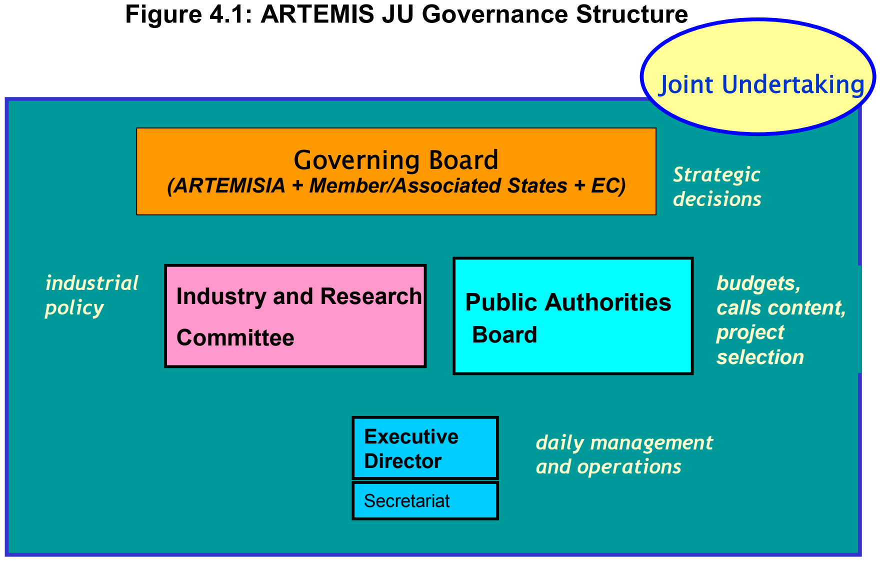
The participation of research and development actors through ARTEMISIA will ensure that industrial and academic involvement reflects a wide constituency rather than a 'closed shop' of a few key players. The statutes of the association have to follow the general principles of openness and transparency for joining, and include special provisions for the participation and representation of SMEs and other research and development stakeholders, including academia. In addition, **the JTI's Calls for Proposals will be public and participation will be open to all organisations (whether members of ARTEMISIA or not) from any Member State or Associated Country**.

4.1.2. Governance structure

The bodies of the Joint Undertaking will be the Governing Board, the Industry and Research Committee, the Public Authorities Board and the Executive Director (Figure 4.1).

[55] www.artemis-office.org.

Figure 4.1: ARTEMIS JU Governance Structure



Governing Board: The Governing Board has overall responsibility for implementing and supervising the execution of the JTI programme and takes all decisions of a strategic nature. Voting rights will be split equally: 50% for ARTEMISIA and 50% for public authorities (Commission and participating Member States and Associated Countries). The distribution of the public authority votes will be established annually in proportion to the funds committed to the JTI's activities.

Industry and Research Committee: This will be responsible for the definition of the JTI's industrial policy regarding the technological and research strategy, in particular the definition and updating of the JTI's Research Agenda.

Public Authorities Board (PAB): This is composed of national public authorities and the Commission. It will be responsible for decisions on the scope and budget of Calls for Proposals launched by the JTI and the selection of proposals and allocation of public funds following such calls.

Executive Director: the legal representative of the Joint Undertaking, ensuring its day-to-day management. A **Secretariat** will be established to support the Executive Director. The non-financial tasks of the Secretariat may be subcontracted to an external service provider with relevant experience, such as the ITEA or MEDEA offices.

4.1.3. Operations and funding model

The Joint Undertaking will focus mainly on the downstream part of the strategic research agenda (SRA). At its core will be an industry-driven programme, similar to the ITEA2 and MEDEA+ Eureka clusters for collaborative R&D. The JTI will produce a Research Agenda based on the SRA, under which R&D activities would be implemented through open Calls for Proposals. For the funding of these R&D activities, the **Commission** will make a financial contribution to the Joint Undertaking (a maximum of **€410 million** under the Framework Programme), which will be supplemented by the funds committed annually by **participating States** (estimated to be more than 1.8 times the Commission contribution, i.e. around **€750 million** in total) to fund their respective national participants in projects selected under the

Calls for Proposals. Industry and other R&D actors will provide matching in-kind contributions — estimated at around 60% of the total costs of the projects — to carry out the R&D work. The financial contribution of the ARTEMIS Joint Undertaking to the budget of each call will be equivalent to 55% of the total amount committed by the ARTEMIS Member States (achieving thus the 1.8 ratio between Community and national contributions). Although the commitments of the Joint Undertaking to the calls are proportional to the sum of national commitments, **the funding from the Joint Undertaking is not pre-allocated per country**.

One of the key benefits of the Joint Undertaking will be **the leverage effect of Community funds**. Projects selected following Calls for Proposals will be financed under a three-tier system:

- The Joint Undertaking will fund part of the total costs of the projects selected in Calls launched by the ARTEMIS Joint Undertaking. This financial contribution to participants in projects shall be provided at a percentage of the total costs[56] incurred for implementing the project. This percentage shall be determined on a yearly basis by the ARTEMIS Joint Undertaking and be up to 16.7%. This percentage shall be equal for all participants in Projects arising from any given Call for proposals.

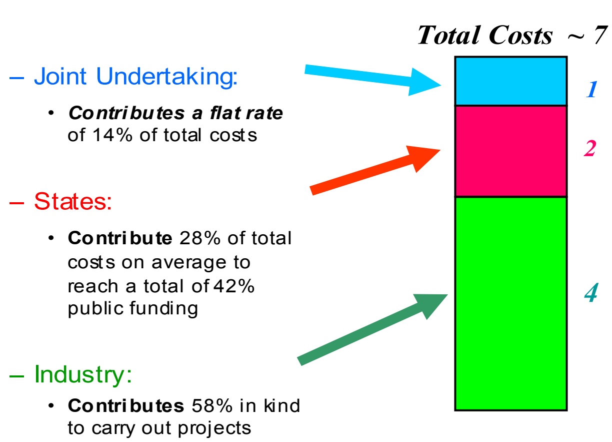
- Participating States will provide additional funding for their national participants in the selected projects according to the applicable national rates and rules for public funding.

- Research and development actors will provide matching in-kind contributions and funds — more than 50% of the total costs of the projects — to carry out the R&D work.

As an example, assuming a funding percentage of 14% from the Joint Undertaking and an average additional public funding of 28% through Member State contributions, a typical project could be financed by public funding covering 42% of its costs with the remaining 58% in the form of in-kind contributions from industry (Figure 4.2).

Figure 4.2: ARTEMIS Joint Undertaking Project Financing

.



56 "total costs" as defined when appropriate by the funding authorities Issuing the grant agreements

Overall, for a Community financial contribution of €410 million, and assuming an average percentage of the financial contribution of the Joint Undertaking to project costs of 14-15%, the estimated overall costs of the R&D projects launched by the ARTEMIS Joint Undertaking would thus be about €2.7 to 2.8 billion.

As for the operating costs of the Joint Undertaking, ARTEMISIA will financially contribute to the operating costs of the JTI at 1% of the overall R&D costs (i.e. at least €27 million during the initial period of the Joint Undertaking (2007-2017)). The Commission will also make a financial contribution to the operating costs of the ARTEMIS Joint Undertaking (up to €10 million). These two financial contributions amount to **less than 1.5% of the estimated overall costs** of the R&D activities of the Joint Undertaking. Member States and Associated Countries will also make in-kind contributions to the operating costs, as they will facilitate the implementation of projects by carrying out financial viability checks, cost claims processing and administrative and financial audits of national participants in projects on behalf of the Joint Undertaking. This method of implementation allows for a lean administrative structure for the Joint Undertaking, is not disruptive for national administrations, uses contractual models that are familiar to the R&D actors, and should be particularly cost-effective.

There is also provision for the ARTEMIS Joint Undertaking to reimburse the costs of participants in selected projects from Member States or Associated Countries that are not members of the ARTEMIS Joint Undertaking and do not commit funds for the Calls. However, it is not expected that there will be many such cases as the Member States and Associated Countries that seem willing to participate in the Joint Undertaking already account for most of the R&D players in this research area.

4.1.4. Appropriateness of the governance model for the Joint Undertaking

An important question is whether the proposed Joint Undertaking model includes the right members and the governance model and legal structures envisaged are appropriate. Decision-making within the ARTEMIS Joint Undertaking is based on **five core governance principles**:

(1) The principle of **representation** according to the mobilisation of resources. Voting rights are split equally between the public and private parties, and for the public authorities votes are distributed according to the proportion of funds they commit to Joint Undertaking activities.

(2) The principle of **cooperation** between public and private partners. The decision-making process relies on the participation of both sides, with neither party able to make decisions on its own since each has 50% of the voting rights.

(3) The principle of the **separation** of public and private bodies. The Joint Undertaking makes a clear and formal separation between the roles of public and private entities. The Industry and Research Committee takes the lead in defining the Research Agenda and in industrial policy and related activities. The Public Authorities Board leads in decisions on the allocation of public funds. For instance, the latter has sole responsibility for the final selection of projects following Calls for Proposals involving public funds, and also approves the content of these Calls, thus avoiding any conflicts of interest among industry participants.

(4) The principle of **independence** of the Executive Director. The Executive Director has no decision or voting rights within either the Public Authorities Board or the Industry and Research Committee and acts totally independently of outside interests. The Executive Director has overall responsibility for the evaluation and selection process and will take all reasonable measures to ensure its independence and efficiency.

(5) The principle of **effectiveness**. The ARTEMIS Joint Undertaking will utilise and build on existing mechanisms as far as possible rather than set up new mechanisms from scratch. It will make use of the valuable experience accumulated over the years under Eureka in areas such as contract establishment and handling. Rolling work plans, regular calls, faster turnaround times and common procedures for evaluation, review and monitoring will all contribute to a more flexible approach compared to the current situation and ensure efficient operation of the JTI, both for participants and for the initiative itself.

5. ANALYSIS OF IMPACTS

5.1. Economic impact

5.1.1. Impact on mobilisation of resources

Leverage effect

One of the main benefits of the ARTEMIS JTI for all stakeholders — industry, national public authorities and the Commission — is a better leverage effect than with the "Business-as-usual" scenario (in terms of better mobilisation of resources through the Community contribution for embedded systems research in Europe).

Under the funding model detailed in section 4.1.3 above, the ARTEMIS JTI will combine national and Community funding in such a way that every euro contributed by the Community will leverage about two euros at national level, and 4 more euros from the private sector. The Community financial contribution of **€410 million** will cover 14-15% of the overall costs of all R&D projects launched (so the estimated **overall costs of the initiative would be about €2.7 to 2.8 billion.)**. The remaining ~€2.3 billion is obtained as follows: the Community contribution will mobilise around **€750 million** of national funding (i.e. 1.8 times the Community contribution as indicated in 4.1.3). The ~€1160 million of public funding will be complemented by private research efforts in proportion in the form of in-kind contributions to execute the projects (to a total of around €1.6 billion). The amount of these private efforts at project level will depend on a case-by-case on the percentage funding applied by the ARTEMIS JTI and the additional funding rate of the different countries, but it will be between the current 50% in the FP and the estimated 65% on average in Eureka.

The incentive of additional Community funding will increase the level of national funding, which will in turn boost private research efforts. **Thus, the proposed mechanism will enable each euro contributed by the Commission to leverage an expected 7 euros of R&D effort.** For a Commission contribution of €410m, the **total funding mobilised for R&D activities in the ARTEMIS JTI is estimated at about €2.7 or €2.8 billion** over the period 2008-2017, of which around 60% would come from industry and the rest from public funding (European

Commission and the Member States and Associated Countries that are members of the Joint Undertaking).

In the "Business-as-usual" scenario, the Commission's contribution does not have any leverage effect at national level, and, if invested through the current instruments under the Framework Programme, each euro contributed by the Commission would be matched by roughly 0.5 euros of private funds (following the new rules for FP7).

Additionality

There are several indications that the ARTEMIS JTI will be able to **attract additional funding** for R&D activities in embedded systems:

At national level: there is certainly no way to guarantee that any JTI would result in "fresh" money transferred to research from other national budgets. However, the mechanism envisaged in the ARTEMIS Joint Undertaking actually provides a strong incentive to increase national funds in the targeted areas, and **precludes the substitution of national funding** as higher commitments of national funds by State members result in higher amounts of Joint Undertaking funds made available. As an example, even though the ARTEMIS Joint Undertaking does not yet exist, Finland has already committed €70m in the form of a verbal undertaking by their Prime Minister[57], and the discussions among Member States have already prompted other countries to increase the budget allocated to embedded computing systems in their national programmes. Moreover, some countries that have so far not invested in this area through Eureka have informally informed the Commission that they will be willing to join in and commit funds for Calls issued by the Joint Undertaking.

At industrial level: As pointed out in the Commission communication on economic reforms and competitiveness[58], additionality at industrial level remains extremely difficult to define and monitor at an operational level. This is because it is practically impossible to know which publicly subsidised investments would have been undertaken by industry anyway — and therefore to establish whether "crowding-out" has occurred.

In the case of embedded systems, however, industry has clearly shown its commitment to increasing its funding. As stated in its support letter for the ARTEMIS JTI[59] and in the ARTEMIS Strategic Research Agenda, industry expects — and hopes — that the national public funding available would more than double, provided that the ARTEMIS JTI is launched with sufficient Commission support. Should this be the case, it has undertaken to double its pre-competitive R&D (currently channelled mainly through the EUREKA clusters ITEA and MEDEA+) under the JTI within 5 years from the JTI's launch.

The question then is how much of this doubling of pre-competitive R&D promised by industry would have taken place anyway. To make an educated guess requires looking at the specific research objectives of the ARTEMIS JTI. All of them (platforms, middleware,

---

57 Prime Minister Matti Vanhanen at the plenary session of the European Parliament on 25 October 2006, outcome of the Lahti summit meeting

58 Commission communication "Economic reforms and competitiveness: key messages from the European Competitiveness Report 2006", COM(2006) 697, SEC(2006) 1467.

59 Letter sent to Vice-President Verheugen and Commissioners Reding and Potočnik.

methods and tools) are "commons" for the six industry sectors in Tables 2.1 and 2.2, i.e. they are essential for improving the competitiveness of their products and services, but are not perceived in these sectors as attractive products in their own right (they are products for the tool industry, which is however orders of magnitude smaller than the user industry). Therefore, without public intervention, industry has the tendency to focus on R&D projects that are short-term and have a clear link to the business model of a particular product rather than to "commons" technologies that will not benefit just one company but an entire sector, and which need to be co-developed in cooperation with other companies and academia. The latter point concerns the **"behavioural additionality"** achieved by public grants: i.e. inducing companies to participate in joint developments that have a social or economic overall return that may be much larger than the return to any single organisation.

Another relevant consideration is that input additionality is of interest only when the industrial investment is in Europe. Industry R&D is increasingly global and companies locate their operations where they get the best conditions. Public financial aid, in the form of an efficient R&D programme with important networking effects, can be an important factor in determining a company's decision on where to spend its R&D money.

Overall, for Europe to intensify its investment in R&D — as envisaged under the Barcelona objectives — industry needs to be assured that its investment in Europe is well spent. **This assurance derives in large part from the policy context for research**: the funding environment must be sufficiently clear and stable to sustain industry investment; there must be public investment in training and infrastructure; there must be no unnecessary red tape; and regulatory issues must be anticipated and understood.

In the "Business-as-usual" scenario, it is very unlikely that additional money will be invested: the level of national funding through the EUREKA clusters will tend to remain steady or even decline. On the other hand, the ARTEMIS JTI option provides a clear and stable framework that has received tangible national commitments and indications of likely budget increases for the areas covered by ARTEMIS in national programmes. The ARTEMIS Joint Undertaking also provides a mechanism for broadening industrial participation in R&D (achieving "behavioural additionality") and for industry to act together towards common goals and objectives that are not achievable under the "Business-as-usual" scenario.

5.1.2. Impact of achieving the JTI's technological objectives

The technological objectives of the ARTEMIS JTI, as defined under the Strategic Research Agenda, were set out in section 2.6.2 above. In economic terms, some of these objectives involve **reductions in both the cost of system design and in development lifecycles of 50% by 2016**, essentially through improvements in the efficiency of the system design, development and testing process, while at the same time achieving the goal of designing systems that are "right first time, every time". These two quantitative goals, reductions in cost and in time, are roughly equivalent and will therefore be considered together. Based on data on sector R&D expenditure, it is possible to estimate the impact of such an outcome on industry.

There are several other goals set forth in the Strategic Research Agenda, such as achieving seamless cross-domain interoperability, producing at least five radical innovations, doubling the number of European SMEs engaged in the embedded systems supply chain, having 50% of embedded systems deployed world-wide based on ARTEMIS results, etc. The economic impact of achieving these objectives is much harder to quantify even though it may be extremely significant. For example, if seamless cross-domain inter-operability between embedded systems is realised through middleware platforms, **it will lead to the creation of entirely new markets for applications** that would be next to impossible to quantify with any degree of confidence. For example, standardisation of the PC platform led in the mid-eighties to the emergence of the market for desktop computing applications, from word processing to gaming, and the introduction of the web-based internet platform in the early nineties led to e-commerce and other internet applications. In both cases, the breadth and pervasiveness of the economic impacts were not anticipated beforehand.

Therefore, the present assessment limits itself to just the two objectives mentioned in the first paragraph, but the **result should be considered as a lower bound for the expected benefits**.

In economic terms, an embedded system is an intermediate good, i.e. it produces value indirectly rather than in and of itself. Moreover, such systems are comprised of and depend upon other intermediate goods, namely embedded hardware and software. Of the two, the software is the most significant, since it gives the system its functionality and intelligence.

Much of embedded software development is undertaken in-house within end-user industries or their supply chains. This makes any estimation of the economic value of customised or embedded software much more complicated than for software developed as a 'producer good', i.e. packaged software developed and marketed as a discrete product. An important point is that once software has been developed, its production value is almost nil. So even if software represents a key part of the product, its cost per product unit sold may be very small and will vary widely depending on the number of product units sold. Hence, it is more useful to rely on data on R&D expenditure than on production expenditure in estimating economic impacts. It should be noted that the vast majority of the R&D expenditure referred to below is on proprietary product development and not pre-competitive research of the type financed under national or European programmes[60].

Embedded software also has other characteristics that influence the analysis. It is not necessarily visible in a product, as numerous tools (simulators, CAD) are now required to get the finished product. Hence, it is necessary to consider both the product level (software costs per unit) and the process level (costs of development and testing tools) in estimating the direct cost of software development.

As noted in section 1 above, for economic analyses this document has drawn on two recent studies by FAST GmbH and IDATE/TNO. These provide a detailed picture of technological and market trends in embedded systems-related areas and are considered to provide the best available data for estimating the JTI's economic impact. Based on these, this analysis assumes that:

i) the ARTEMIS objective of a 50% reduction in the cost of system design or development effort is achieved through the ARTEMIS JTI[61] (compared with the "Business-as-usual" scenario);

[60] Although it is very difficult to quantify these two types separately.

[61] This objective was set by the ARTEMIS Technology Platform during the process of the elaboration of the SRA as referred to in sections 2.6 and 2.7. The achievement of this objective obviously depend on

ii) if the JTI is not launched ("Business-as-usual" scenario) there will be no reduction in the cost and development effort foreseen in the projections up to 2016 (in fact, this is a very conservative assumption[62]).

iii) the resulting higher efficiency may be expressed in economic terms, either as the value of the development effort saved or as an equivalent number of new R&D jobs created.

Based on figures from the 2005 FAST study, European industry's expenditure on embedded systems research (hardware and software) will more than double over the period of the JTI, from €12.1bn in 2003 to €26.8bn in 2015[63] (Table 5.1). Achieving the ARTEMIS 50% objective will thus bring about a total saving in R&D effort of €13.4bn per annum by 2015. This is equivalent to around 50k R&D man-years by 2015.

Table 5.1: Industry expenditure on embedded systems research

Sector	Share of ES R&D in total R&D, 2003, %	ES R&D spending 2003, €bn	Share of ES R&D in total R&D, 2015, %	ES R&D spending, 2015, €bn
Automotive branch	8	2.4	9.3	4.3
Aerospace	15	1.3	22.6	2.9
Industrial Automation	6	0.3	4.6	0.5
IT Hardware & Telecom Equipment	43	6.3	64.0	15.0
Consumer Electronics	10	1.4	14.9	3.3
Medical Equipment	4	0.08	9.4	0.3
ICT Services	10	0.3	10.3	0.5
Total	**10.8**	**12.1**	**15.1**	**26.8**

the execution of the R&D during the following years; the assumption took the expert's view that this R&D is reasonably able to produce the necessary results.

62 The average code size of embedded software has increased nearly 10 times over 5 years (see www.techonline.com/community/related_content/21543), which is roughly consistent with the doubling every 18 months predicted by Moore's law. Thus, the baseline scenario assumes that sufficient technological progress will have been achieved — even without the JTI — to be able to develop 100-times more complex systems in 10 years while at the same time keeping pace with a market growth, as illustrated in Table 2.1, of more than 10% per annum..

63 These figures were derived by taking FAST's estimates for global sectoral R&D and factoring out Europe's share of ES expenditure. General R&D is projected to grow at 4% p.a. and ES R&D at around 8% p.a. FAST assumes ES growth of ~12% to 2009, but for the whole period of the JTI we adopt a more conservative figure.

An alternative estimation based on the IDATE/TNO study, which considers embedded software only, values the JTI component of the ARTEMIS 50% objective at €9bn in 2002, rising to €20bn by 2015. This is equivalent to around 80k R&D person-years by 2015. To put this into context, ITEA2 currently has an annual effort of around 1500 person-years per year, and aims to increase this to 2500 person-years by 2010.

The above estimates are based on the six industry sectors listed. Extrapolating to the entire economy is relatively easy today, since the FAST study estimates that about 95% of embedded systems are used in these six sectors. However, the situation in 2015 could be significantly different since electronics are being used in more and more goods and services[64]. Here, we make another very conservative assumption that the entire economy will use just 10% more embedded systems in 2015 than the six sectors alone.

Conclusion

In summary, the best estimates based on sectoral data are that the ARTEMIS JTI will achieve gains of at least €14.7bn per year in reduced development costs by 2015, equivalent to at least 55k person-years of effort.

This improved profitability of European industry will result in increased competitiveness and in increased market share worldwide. It will allow industry to devote more resources to research, rather than product development, so that it can move to higher added-value product segments and avoid commoditisation. This is particularly important given that know-how in embedded computing systems is a strategic asset of EU companies in the leading sectors (see section 2.2) [65] [66]. In addition, a more efficient development process should make it affordable for a larger number of companies, especially SMEs, allowing them to integrate high-end embedded systems in their products and processes and thereby gain a competitive advantage.

In order to calculate the net present value (NPV) of these gains we assume a geometric progression from nil to 14.7 billion between 2009 and 2015, constant gains for 10 years to 2025 and zero after that (we assume that the technologies developed will become obsolete after 2025), an equal spread of the 3bn JTI costs between 2008 and 2014 and a discount rate of 4%. **The NPV in 2006 is then €109bn**. This figure is only indicative, since a more precise NPV calculation would require cash flows to be discounted at a rate according to their different risks, which would need a more accurate assessment of the future value of the gains.

Taking a macro view, achieving the ARTEMIS technological objectives (under both the JTI and the ETP) would **contribute around 3.4% to added value in European high-tech manufacturing** (defined in terms of six key sectors in 2002), **increasing to 4.9% by 2015 (Table 5.2)**. This assumes that Europe is able to retain its share in these manufacturing sectors (~28% of world added value) over this period.

Table 5.2: Contribution of software R&D gains to manufacturing added value

---

64 For example, it is anticipated that embedded systems will be extensively used in the future in buildings, agriculture and environmental monitoring, whereas these sectors are almost non-existent today.

65 Commission communication "Economic reforms and competitiveness: key messages from the European Competitiveness Report 2006", COM(2006) 697, SEC(2006) 1467.

66 IPTS(2005) "The 2005 EU industrial R&D investment SCOREBOARD".

	2002	2015
World added value in key sectors	€957 bn	€1460 bn
European manufacturing added value in key sectors(1)	€268 bn	€409 bn
ARTEMIS software development savings as proportion of European manufacturing added value	3.37%	4.9%

(1): Key sectors are: aerospace, the automotive branch, consumer electronics, medical equipment, telecom equipment and automation. World and sector added-value figures based on IDATE/TNO, 2005.

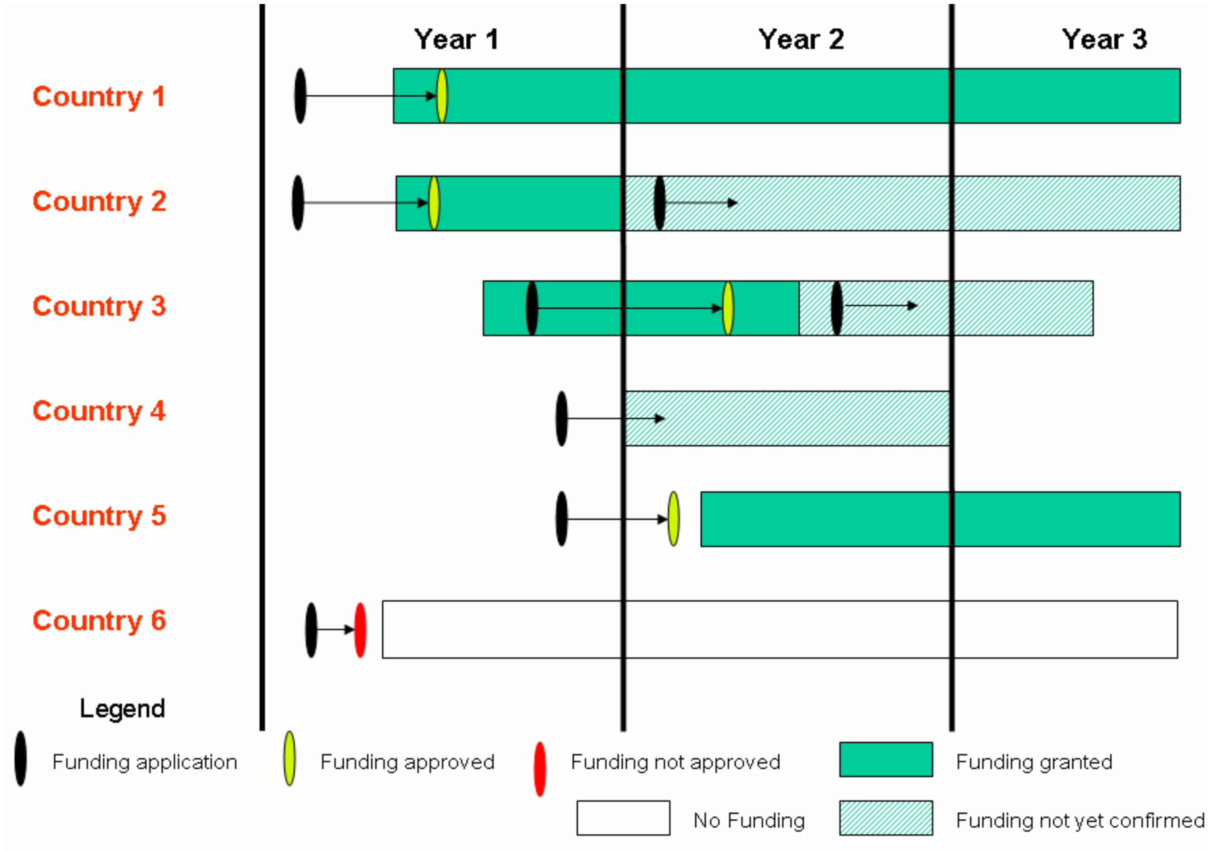
5.1.3. Impact of removing budget uncertainty

Budget uncertainty is a key barrier in the current Eureka approach. The funding schedule for potential participants in one (real) Eureka project[67] is illustrated in Figure 5.1. Firms are reluctant to invest in preparing R&D projects if they do not know that funding will follow. The JTI will remove this uncertainty, providing a reliable framework with calls for proposals that have already secured a budget and thus allowing industry stakeholders to plan their investments. Provided the JTI procedures are as efficient as planned, these new arrangements will offer a more attractive regime and should broaden participation, especially among SMEs.

Figure 5.1: Example of Eureka funding schedule

(The horizontal bars show the time span of the activities in a project. In one case, the funding was granted before the application was submitted)

[67] Source: Eureka Cluster presentation in CISTRANA workshop "Best practice in Multinational Programme Collaboration", Cologne 18.01.06.



As shown above for this (typical) Eureka project, two of the six partners never obtained public funding; and just two or three among the other four had funding periods that coincided over time.

EU-level versus national disbursements

A further benefit of the JTI is **the increased efficiency of EU-level disbursements compared to the same disbursements at national level**. A previous analysis to assess the impact of the Seventh Framework Programme[68] shows that, in the long run (by 2030), FP-level disbursements will have 89% more impact on GDP per euro invested and a 20% greater impact on jobs than the same funding at national level (Table 5.3). While it is not within the scope of this assessment to replicate such a detailed econometric analysis, it is reasonable to assume that similar benefits could apply when comparing the ARTEMIS JTI and the “Business-as-usual” scenarios. Indeed, the expected ~€750m of national money spent through the ARTEMIS JTI can be considered equivalent to EU disbursements since it will be allocated though common European procedures and focused work plans as in the Framework Programme, whereas in the “Business-as-usual” scenario this money would be spent according to the different priorities of national programmes.

[68] *Impact Assessment and Ex-Ante Evaluation of the 7th Framework Programme*, Commission Staff Working Paper, SEC(2005) 430, European Commission, 2005.

Table 5.3: Comparison of EU vs national Level Disbursements

		FP Disbursement	National Disbursement	Ratio FP:national
GDP		0.51	0.27	1.89
GDP corrected for quality		0.82	0.35	2.34
Extra-European exports		0.73	0.07	10.43
Extra-European imports		-0.35	0.21	-1.67
R&D intensity		0.061	0.058	1.05
Research employment		40400	33500	1.21
Total employment		492600	428400	1.15
Source: FP7 Impact Assessment				

5.1.4. Impact of streamlined procedures

Eureka is a cooperation mechanism that is neither able to receive and manage funds nor to impose agreed common processes on its participating countries. Compared to the current "Business-as-usual" scenario, the ARTEMIS JTI will:

∉ Remove the budgetary uncertainty by making Member State commitments binding under the Regulation.

∉ Remove duplication in evaluation/monitoring, where different procedures are currently applied at national level.

∉ Enable shorter times-to-contract.

∉ Remove unnecessary red tape for participants.

These innovations will impact on stakeholders in the following ways:

∉ The time and cost incurred by applicants in preparing proposals will be reduced significantly compared to the current application arrangements under Eureka.

∉ In addition, some proposals collapse through not getting national funding and are lost. This would be avoided under the JTI scheme.

∉ Further savings can be expected through the streamlined reporting procedures that will apply during project execution. Under the JTI, projects will follow a single procedure rather than the different national procedures that apply under Eureka.

Overall, the ARTEMIS JTI targets **a six-month improvement** in the processing of individual proposal applications compared to the current cooperation under Eureka. In addition, the application process will be more open and transparent (e.g. with clearer time frames and available budgets).

Estimating the value of these impacts is problematic due to the lack of concrete data on Eureka's operations. Eureka does not detail the financing per project, nor even the extent to which the overall funding target of a given cluster has been distributed. However, it is possible to develop a first-level estimation based on published data and conservative assumptions.

At present, MEDEA+ and ITEA2 each fund around 14 projects per year, with an average of 12 partners per project. Assuming an over-subscription[69] of around 3:1 and an average of 2 person-months per partner for proposal preparation and submission, this suggests a total effort on embedded systems proposals of around 1000 person-months per year. For an annual R&D staff cost of €120k, this equates to €20.9m of effort per year, or €146m over the seven-year life of the JTI. Assuming common and streamlined procedures achieve a 50% reduction in the effort required for proposal submission, **the ARTEMIS JTI would thus gain a net saving of €73m over the Business-as-usual scenario. This is equivalent to ~4% of industry's total commitment to the JTI during this period.**

Further savings will accrue from reductions in project management costs as a result of simpler reporting and monitoring requirements. Eureka investments are currently around €375m per year, and project management is assumed to account for around 5% of the annual costs of projects. A reduction to 3% per annum (a 40% improvement) would reduce operational costs by €7.5m, **equivalent to €52.5m over the lifetime of the JTI compared to the Business-as-usual scenario**.

Overall, **the ARTEMIS JTI would thus gain a net saving of €125m over the Business-as-usual scenario.**

5.1.5. Impact of shorter times to contract

Simpler and quicker procedures will have a knock-on effect in terms of the productivity of the research process, allowing research results to be brought to market more rapidly. This reduced time-to-market is, potentially, one of the most significant of all the JTI's benefits. Innovation cycles are shortening: the average product lifetime is generally around 2-3 years and in some sectors much less. OEM product development schedules are less than 12 months for 51% of OEM products and less than 2 years for 85% of products[70]. Cutting even a few months off the development cycle **can allow a company to get to market ahead of its competitors** (and so gain a higher market share) and/or have a longer period over which to recoup its R&D investment. Thus, timing can have a significant impact on the bottom line.

Such indirect benefits are difficult to calculate, however, since they will vary significantly depending on the sector concerned and the speed of commercial deployment of the resulting new technologies. But in consultations with ARTEMIS industrialists, **one company estimated that a reduced time-to-market of 3 months would be worth €3bn per year for its business alone**. Another noted that pre-competitive industrial R&D offered a powerful

---

69 Assuming higher over-subscription rates in Eureka (e.g. around ~5-6:1 as in the Framework Programme) would yield a significantly greater net impact.

70 "A new embedded software model to increase OEM productivity", IDC White Paper available through www.embeddedstar.com/technicalpapers/content/a/embedded2105.html.

way of tackling product factors (such as cost and performance) and development factors (such as cost and speed) in an integrated way.

The quantitative and qualitative benefits of the ARTEMIS JTI over the “Business-as-usual” scenario in removing budget uncertainty, streamlining procedures and shortening times to contract are especially important in terms of **behavioural additionality**, as the more attractive regime (**especially for SMEs)** will broaden participation and increase the number of new partners in R&D activities.

5.1.6. General economic impacts

Other aspects of the economic impact of the JTI are summarised in the table below.

Impacts on:	**ARTEMIS JTI scenario relative to the Business-as-usual option:**
Competitiveness, trade and investment flows	Positive competitive advantage for EU ICT industry and end-user industries More efficient EU ICT sector Increased economic exchanges within and outside the EU
Competition in the internal market	Level playing field for embedded systems-based industry and European regions Increased cost-effectiveness of ICT industry and end-user industries Increased competition for products and services based on standardised platforms
Operating costs and conduct of business	New paradigm for investment in embedded systems research and innovation within a public-private partnership Major cost-savings for industry through programme rationalisation
Administrative costs of businesses	Cost of running the JTI small compared to the benefits Envisaged model is for a small and lean entity Options identified to outsource routine administration
Property rights	Property rights to JTI results will be identified on a case-by-case basis, according to rules that will serve as an industry model Some key results, such as reference designs and architectures and middleware, will be available under non-proprietary/open-source terms
Innovation and research	Extremely positive impact on innovation and research, pooling together resources within a coordinated and integrated programme ARTEMIS JTI results will dramatically increase the introduction of new technologies

	ARTEMIS JTI results will improve the profitability of industrial research, increasing revenue by increasing market share, yielding higher added-value product segments, allowing for more investment in longer-term technological competitiveness ARTEMIS JTI results will promote more efficient resource allocation
Consumers and households	ARTEMIS JTI results are expected to lead to a wide range of new products and services for consumers, leading to increased efficiency, safety and choice 'Private spaces' (in particular the home) are identified as one of four key application drivers for ARTEMIS research
Specific regions or sectors	Embedded systems technologies are deployed in all market sectors — the automotive branch, aerospace, medicine, environment, communications, entertainment, textiles, transport, logistics, printing & paper, chemicals, food & drink, timber and materials
Third countries and international relations	The JTI can draw from the ARTEMIS Technology Platform's policy for fostering collaboration with international partners. This policy aims at: opening new markets; mobilising resources; promoting ARTEMIS standards; and helping Europe become a 'brain magnet' for the best researchers worldwide.
Public authorities	Funding of the JTI will partly come from public money, which will have a key role in leveraging private sector resources (**1: 7 leverage factor for Community contribution**)
The macroeconomic environment	The impact on the macroeconomic environment will be felt through a combination of all the above

5.2. Social and environmental impact

5.2.1. Social impact

The ARTEMIS strategic research agenda (SRA) — and by implication the JTI — impacts on society in a number of ways.

The ARTEMIS JTI will contribute to more and better quality jobs, in line with the relaunched Lisbon strategy. ARTEMIS results will significantly increase productivity by enabling smarter working and more agile production. Greater use of embedded systems-based products and services will lead to the creation of thousands of jobs in Europe, in the ICT sector as well as in the overall economy, through both direct and indirect effects. Many ARTEMIS applications will support human operators and/or enhance automation and control, increasing the added-value of jobs across a wide range of application domains.

The ARTEMIS SRA is based around four 'application drivers', ambitious application scenarios driving the future development and integration of embedded systems technologies over a medium- to long-term perspective. Three of these four application drivers have a strong societal orientation[71]. They are: *nomadic environments*, aiming to improve mobility and enable people to access information and entertainment anywhere at any time; improving the efficiency, safety and comfort of *private spaces*, primarily the home; and ensuring secure and dependable *public infrastructures* in areas such as energy, transport and communications. Their common challenge is to manage the complexity of new societal systems and applications in the context of a very large number of interconnected heterogeneous devices. In the utilities and energy sectors, for example, the future intelligent infrastructure will require the 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.

The fourth application driver is concerned with large industrial systems, such as cars, airplanes and manufacturing and process plants, where the *safety of people* is a key concern. Although significant research is already under way for designing foolproof embedded electronics for such safety-critical systems, their safe operation cannot be fully guaranteed, whether in vehicles or in a chemical factory. ARTEMIS results will directly contribute to system safety, and this is an explicit objective in the SRA.

ARTEMIS results are expected to make a significant contribution to social inclusion through applications such as: portable and remote medical and social care for people at home (especially the elderly and people with disabilities); and e-learning services to help bridge the digital divide.

Impacts on:	**ARTEMIS JTI scenario relative to the Business-as-usual option:**
Employment and labour markets	ARTEMIS JTI results will increase productivity by enabling smarter working and more agile production ARTEMIS JTI results will lead to the creation of thousands of jobs in Europe, in the ICT sector as well as in the overall economy, through indirect or induced effects
Standards and rights related to job quality	ARTEMIS JTI results will lead to better quality jobs by supporting human operators and providing enhanced automation and control ARTEMIS JTI results will increase the added-value of jobs across a wide range of application domains
Social inclusion and protection of particular groups	ARTEMIS JTI results are expected to make a significant contribution to social inclusion through applications such as: portable and remote medical and social care for people at home (especially the elderly and people with disabilities) or e-learning services to help bridge the digital divide
Equality of treatment and	Not relevant

71 The fourth application driver is concerned primarily with industrial systems.

opportunities, non-discrimination	
Private and family life, personal data	ARTEMIS JTI results will improve the choices available to European citizens in terms of work-life balance, while also improving safety and security Examples include the ARTEMIS work on 'nomadic environments' (e.g. for mobile working), 'private spaces' and secure and dependable public infrastructure
Governance, participation, good administration, access to justice, media and ethics	The ARTEMIS JTI will introduce new working methods across industry and civil society ARTEMIS JTI's own governance structure provides for participation by the full range of stakeholders: large industry, SMEs, academia, national public authorities and the Commission. Each of these groups will participate in the decision-making process.
Public health and safety	Both eHealth and the environment are key ARTEMIS applications
Crime, terrorism and security	Improved operation and security of public infrastructures (transport, communications, utilities, energy, buildings) is a key ARTEMIS application
Access to and impact on social protection, health and educational systems	As above — eHealth and eLearning are key ARTEMIS applications

5.2.2. *Environmental impact*

As electronic systems, embedded devices use electricity and are part of a general trend towards the 'electrification' of society resulting from greater use of ICT. However, the use of embedded systems allows better management and control of system energy efficiency, and in many applications this is their primary purpose: they will be needed to realise the energy savings potential in households (27%), commercial buildings (30%), transport (26%) and manufacturing (25%) as set out in the Action Plan for Energy Efficiency[72], which also states that "special attention should be paid to the opportunities offered by information and communication technologies". Moreover, reduced power consumption for embedded devices is an important and ongoing technical objective for designers, including under the ARTEMIS SRA.

The disposal of electrical and electronic equipment at the end of the product lifecycle is now subject to a comprehensive legislative framework under the Community's Waste Electrical and Electronic Equipment (WEEE) Directive[73]. WEEE introduces the principle of "extended producer responsibility", requiring producers to take responsibility for the environmental impact of their products, especially when they become waste. WEEE applies across ten categories, including IT and telecommunications equipment, medical devices, electrical and

---

72 Communication from the Commission, COM(2006) 545.

73 Directive 2002/96/EC of 27 January 2003 on Waste Electrical and Electronic Equipment (WEEE).

electronic tools, and consumer appliances, many of which are likely to contain embedded systems.

Environmental monitoring and management itself is a key application area for ARTEMIS. Mesh networks based on huge numbers of sensors and actuators are envisaged for applications such as industrial pollution monitoring and ecological assessment, which will be able to monitor their surroundings and respond accordingly. Embedded systems technology is already being used in several critical applications such as forest fire detection and fire-fighting actuation, the optimisation of water irrigation and fertiliser use, pollution measurement in urban environments, etc. In addition, energy efficiency and environmental benefits are a key focus in the use of embedded systems in applications such as automotive control systems, industrial automation, and home automation.

Impacts on:	**ARTEMIS JTI scenario relative to the Business-as-usual option:**
Air quality	Environmental monitoring and management is a key application for the ARTEMIS JTI Environmental applications will benefit from 'mesh networks' of huge numbers of sensors and actuators that are able to monitor their surroundings and respond accordingly
Water quality and resources	As above
Soil quality or resources	As above
Climate	Contribution through improvements in the energy and resource efficiency of manufacturing and business processes, consumer products and services, buildings and public infrastructures
Renewable and non-renewable resources	Embedded systems facilitate the integration of small-scale and renewable generation into energy networks
Biodiversity, flora, fauna and landscapes	Not relevant
Land use	Not relevant
Waste production / generation / recycling	See Air quality above
The likelihood or scale of environmental risks	No specific risks arise from ARTEMIS JTI activities. Improved monitoring and control based on embedded systems will cut the likelihood of environmental risks and help improve the response to industrial accidents and civil emergencies.
Mobility (transport modes) and the use of energy	ARTEMIS JTI results will contribute to improved mobility, both of people and of goods, through fast, efficient, safe and accessible public transport, the supply of utilities and energy, and a better connected

	communication infrastructure
Environmental consequences of business activities	See Air quality above
Animal and plant health, food and feed safety	Applications of sensor networks in agriculture and livestock farming

6. BENEFITS AND RISKS

6.1. Benefits and risks for stakeholders

Compared to the current situation, the ARTEMIS JTI brings a number of benefits for stakeholders, but also some risks.

For **industry** it offers:

∉ *Clear objectives and deliverables* driven by industry's own research priorities, as set down in the ARTEMIS SRA.

∉ *A partnership* approach, with public authorities retaining decision-making power over public money (e.g. on the content of calls, selection of projects, etc.), so avoiding conflicts of interest.

∉ *An attractive funding regime with larger public budgets*.

∉ *Lower overheads for project delivery*, through single gateway access to funding with streamlined processes for proposal evaluation and project selection and monitoring.

∉ *Reduced time to market* for new products and services due to the faster proposal evaluation and project selection process, bringing major benefits for competitiveness.

∉ *European-scale networks* between SMEs, large companies and academia that will speed the take-up and deployment of embedded systems.

The main risks for the private sector are that:

∉ *The JTI fails to ensure that a sufficiently wide range of industry stakeholders buy in to the initiative* for it to be representative and meaningful. The substantial groundwork done in successfully developing the SRA, and in setting up the Industrial Association (ARTEMISIA), and the far-reaching collaboration so far established suggest this risk is minimal.

∉ *Research fails to realise the set technological objectives*. This is an inherent risk in high-technology research, but a collaborative approach will help minimise the impact by allowing costs and risks to be shared by all stakeholders.

∉ *National funding fails to materialise*. The effective utilisation of industry funds depends on commitments of sufficient funds by Member States

For **national public authorities**, the ARTEMIS JTI offers:

- *Mobilisation of resources,* through the opportunity to *leverage own resources* against European and industry funding.

- *Critical mass*, through the opportunity to have *national budgets work in synergy* and *avoid duplication of effort.*

- *Strategic management,* by giving them a key role in the JTI's decision-making procedures.

- *Cost-effective implementation* in a way that is not excessively disruptive for national administrations, taking advantage of existing national-level procedures and staff for contracting and processing of cost claims under Eureka.

The main unknown in the mobilisation of resources is the future behaviour of Member States. Potential risk scenarios are profiled here:

- *No mobilisation of resources by Member States:* In this scenario, Member States fail to commit sufficient resources to Calls for the JTI to achieve its goals. The best way to counter this risk is to ensure that the Joint Undertaking operation mechanisms are better than (or at least as good as) those of Eureka. Close attention must be paid to simplifying the evaluation and selection mechanisms to ensure this is the case. Also, since the **additional JTI funding is not pre-allocated per country**, a "failing" national contribution can be replaced by other countries willing to benefit from the mechanism.

- *Substitution of national funding by JTI funding:* Another possibility is that ARTEMIS Joint Undertaking funding substitutes for national funding in specific projects, leading to a less than optimum increase in funding overall (and in the worst case to no net increase at all). Again, the ARTEMIS JTI mechanism provides an incentive **as the commitments of the Joint Undertaking to the Calls are proportional to the sum of the national commitments** (with a maximum Community contribution for R&D of €410 million over the duration of the initiative),, so the more countries commit the more money is available for the initiative and for national participants.

- *Over-subscription of JTI funds*: Alternatively, the ARTEMIS JTI could be so popular that Member States commit 'too much' money to it and/or compete amongst themselves for the additional money, with the result that the Community commitment is used up over the early years. In these circumstances, the Joint Undertaking would most likely apply for "fresh" money from the Framework Programme. Note also that the ARTEMIS Joint Undertaking could be expected to continue to operate even if the Community contribution were exhausted: the overall driver is the integrated implementation of the common agreed agenda and the common procedures within the ARTEMIS Joint Undertaking framework.

For the **European Commission**, key benefits are:

- *Building critical mass,* through involvement in an initiative with strong contributions from industry and the Member States. The JTI is expected to become a centre of gravity for Europe and a locus for external interactions.

- *Mobilising resources*, through significant leveraging of EU resources against national and industry funds (see section 5.1.1 above).

- *Testing a novel mechanism for industrial research* that is capable of making a concrete contribution to the Lisbon strategy and to the Barcelona objectives by having Community, national and private funds work in synergy. If successful, this novel mechanism could to be put into use in other domains requiring a public-private partnership.

- *"Europeanisation" of part of nationally funded research,* thus making a strong contribution to the development of the European Research Area.

- *Risk minimisation,* with the EU retaining control of its contribution in a way that ensures minimal financial risk.

- *Cost-effective implementation,* with the JTI having a light administrative infrastructure paid for by industry, retaining just the decision-making and financial capabilities.

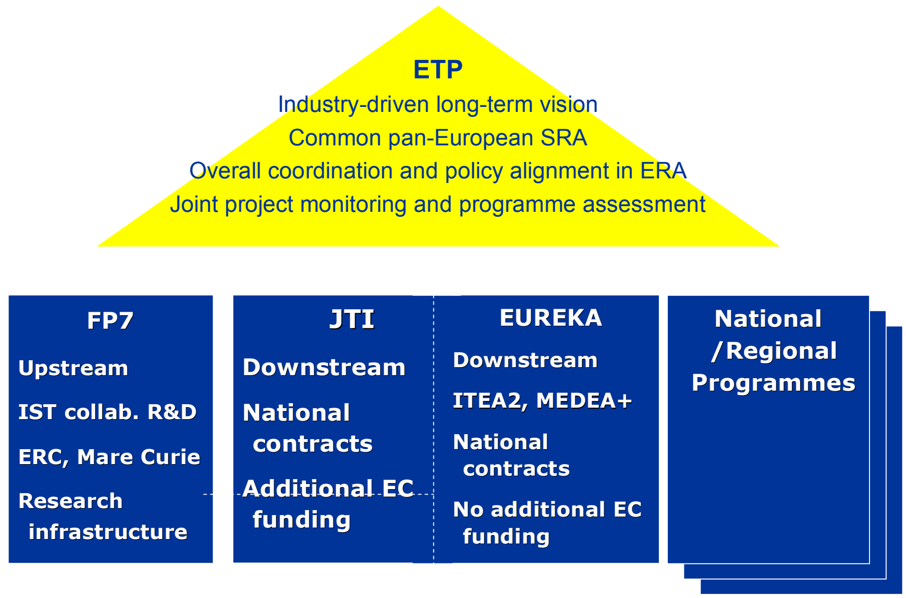
The risks relate primarily to the safeguarding of Community funds and to potential knock-on effects for existing research activities under the Framework Programme (see section 6.2. below).

6.2. Relationship of JTI research with Community Programmes and Eureka research

As set out in its SRA, the mission of the ARTEMIS Technology Platform is to contribute to European competitiveness through pre-competitive, collaborative R&D on embedded computing systems so as to realise the vision of "a major evolution in our society in which all systems, machines and objects become digital, communicating, self-managed resources"[74]. The ARTEMIS JTI will be one of the three pillars — alongside the Framework Programme and national programmes — for implementing the technological and economic objectives of the ARTEMIS Technology Platform (see Figure 6.1). The JTI will also implement activities that will support industrial policy, including the creation of open innovation environments, standardisation, international cooperation and the promotion of SMEs.

[74] ARTEMIS Strategic Research Agenda.

Figure 6.1: Approach for executing the ARTEMIS Strategic Research Agenda



JTI research vs FP7 research

The work of the Technology Platform and its SRA together with the industrial orientation of the JTI will allow complementary research actions to be addressed in the FP Work Programme. Thanks to this coordination, the overlap between instruments will be minimal, although some competition should be maintained.

The overall financial support from the Community in the area of embedded systems will increase during FP7. There will be two separate but coordinated budgets for embedded systems: one for the JTI and one for the other FP actions. Part of the new JTI budget will come from the 'traditional' FP embedded systems budget, which may remain at a similar level as in FP6, but another part of the JTI budget will come from new support under the FP.

The JTI could not however replace the type of research done in the ICT Programme — for several reasons:

The type of research is different: for embedded systems, the JTI would support downstream industrial research of the kind typically supported by Eureka, whereas research within the ICT Programme in this area is more upstream and foundational, objective- or inquiry-driven, with a more significant scientific component.

(3) **Different funding rates**: whereas the Commission FP covers 50% of the costs of industrial partners and the intention is to raise this to 75% for SMEs in FP7, the JTI is expected to cover only 30 to 50% of the costs, depending on the nature of the specific project and the country.

(4) **Participation of Member States**: not all Member States are expected to participate in the ARTEMIS Joint Undertaking. It will therefore be important to retain the major share of embedded systems activity within the ICT Programme.

(5) **Embedded systems research in FP7**: Finally, a significant embedded systems activity within the ICT Programme will be essential because it feeds into the political priorities of the FP7 Programme (the "grand challenges") and also because an "open space" for highly innovative bottom-up research is needed — i.e. research that is not prescribed top-down through roadmaps as would be the case in the JTI.

Funding from the FP7 Cooperation Programme

The investment in the JTI will initially be in the order of 2% of the funding allocated to ICT during the first two years of FP7, growing if the initiative proves to be successful to round 4% in the subsequent years of FP7. These commitments are, of course, dependent on the success of the JTI and the investment by individual Member States. As noted above, this investment of around €420m in total will trigger a coordinated multi-billion-euro programme, which would be a good return on investment for the public funding in FP7.

Obviously, these considerations will apply only when the Joint Undertaking has been launched. This means that the first FP work programme will need to accommodate all urgent needs in embedded systems research in the 2007-2008 timeframe, since the JTI will only start delivering projects in the second half of 2008 at the earliest. If the ARTEMIS Joint Undertaking is not launched by this time, some of that research would need to be addressed within the appropriate work programme of the Framework Programme.

The risks for the Framework Programme are very low. The Commission contribution is conditional on the contributions of the Member States and the proposed €420m figure (€410m for R&D activities and €10m for operating costs) is a maximum: it will be made in annual commitments/disbursements depending on the progress of the JTI. In the event that the initiative does not start or fails because resources from Member States are not committed, the FP7 money is safeguarded, as any money not committed returns to the Cooperation Programme. In conclusion, the JTI offers a **clear win-win situation** where more money is generated for the field, where this money is used for more collaborative research, and where the activities are clearly focused and more actively coordinated between the public and private sectors.

JTI research vs Eureka research

Currently much of the industrial R&D in EUREKA clusters (ITEA, MEDEA+ etc.) is not focused on concrete objectives and is loosely coordinated with Community-funded research. The Commission has an observer role in the clusters without much power to influence developments. It is thus currently difficult to enforce a truly European strategy based on long-term commitments from all stakeholders and allowing industrial R&D objectives to be pursued in a focussed and effective manner across Europe.

It is expected that the embedded systems activities currently supported within the Eureka clusters will be progressively integrated within the ARTEMIS JTI. One alternative could be to integrate these activities immediately (for instance, by requesting Member/Associated States not to support projects in these areas through the clusters).

However, this is not a politically acceptable solution: integration by decree is often ineffective; rather, what we need to create is a framework and a process through which progressive integration can take place. There is no doubt that if the JTIs prove to be efficient and effective during their initial years of operation, the EUREKA clusters would be progressively absorbed into them. Another practical reason for the transition phase is that currently running EUREKA projects would first need to close down. It would not be reasonable to expect industry and Member States to abandon an instrument in favour of another one that does not yet exist, no matter how attractive this new instrument may seem in theory.

In conclusion, the ARTEMIS JTI will enable hundreds of millions of national funds to be aligned with the commonly agreed SRA and the Commission's own strategy. It will also provide the Commission with a strong voice on how and where these national moneys are spent, a role that it does not currently have. In other words, **the ARTEMIS JTI will "communitise" inter-governmental mechanisms** such as EUREKA. At the same time, the work to be undertaken under the JTI should not be considered as simply bringing EUREKA activities under a new umbrella. It will rather involve a full partnership of all stakeholders (Community, Member States and industry/research) geared towards progressively achieving true European-level integration.

7. MEETING THE IDENTIFICATION CRITERIA FOR JTIS

This report has considered a series of policy options in relation to the ARTEMIS JTI and has also looked at whether the JTI is the right instrument and has the appropriate governance model to achieve the political and technological objectives. The assessment shows that the ARTEMIS proposal clearly meets the identification criteria set out for a Joint Technology Initiative under the Seventh Framework Programme:

∉ *Scale of the Impact on Industrial Competitiveness and Growth:*

Embedded systems are a strategic technology for Europe that will have a major impact on industrial competitiveness and growth (sections 2.1, 2.2). Embedded systems technologies underpin the future development of major high-tech manufacturing sectors that are key to the EU's industrial strength and which account for R&D investment of more than €12bn per year. They are significant drivers of innovation and growth and are crucial to the EU's future competitiveness and societal development. The mean value of electronic components in innovative products is growing, adding extra functionality and intelligence to products. Research and related activities under the JTI will further enhance this enabling nature and will foster innovation in many products and services of economic and social relevance.

∉ *Degree and Clarity of the Definition of the Objective and Deliverables to be Pursued:*

The current fragmented situation holds significant risks for Europe (section 2.3). The EU faces a steady loss of competitiveness in embedded systems as a result of the fragmentation of its research efforts, increasing technological complexity, and competitive pressures from other world regions. At risk are not just short-term opportunities for new products and services but also the very ability to innovate in those sectors with the greatest potential for value creation and growth in the long term. Investment in research is also necessary to meet the technological challenges and to nurture and retain the best researchers.

Stakeholders have recognised the need to act and have come together to define a Strategic Research Agenda for Europe to help meet the challenges (sections 2.4, 2.5). The SRA is industrially guided and sets out **tangible and realistic objectives** to keep Europe at the forefront of the embedded systems field (section 2.6.2). A key element in delivering this strategy is the setting up of a European Industrial R&D Programme for Embedded Systems in the form of the ARTEMIS JTI.

∉ *Inability of Existing Instruments to Achieve the Objective:*

The involvement of the Member States is crucial to achieving the SRA's objectives, since they account for a very substantial proportion of public R&D in relevant fields (sections 2.5, 2.6). **At present, however, there is no means to mobilise this funding in a focused and flexible way**. None of the existing instruments is able to coordinate, under one umbrella, both upstream and downstream activities — as covered by the Framework Programme, Eureka, national programmes and industry - while at the same time providing a new way of governance promising less red tape.

∉ *Added Value of European-Level Intervention:*

European-level intervention will bring significant added value (sections 2.5, 2.6). While the EU will continue to invest in embedded systems research under the Research Framework Programme, the regular FP instruments alone cannot bring together resources and expertise on the scale needed to meet the investment challenge. **The proposed public-private partnership (Joint Undertaking) for implementing the ARTEMIS JTI will provide the necessary legal and organisational framework to ensure long-term commitments from all stakeholders and allow the SRA to be implemented in a seamless manner across Europe**. In addition, such a public-private partnership provides a platform to coordinate funding from the Framework Programme, EUREKA and national funds, and can build sufficient critical mass to pursue the ambitious objectives set. A further benefit is that the expected ~€750m of national money spent through the ARTEMIS JTI will be allocated through common European procedures and work plans as in the Framework Programme.

∉ Strength of the Financial and Resource Commitment from Industry:

European industry is committed to and is prepared to back the ARTEMIS JTI (sections 4, 5.1.1)**.** Industry is now already putting a lot of effort into setting up the Joint Undertaking. It will also invest in setting up and financing the organisation of the JTI. The initiative is recognised at the highest level of the management of the main industrial partners involved, who have expressed their long-term commitment to it on numerous occasions.

∉ *Importance of the Contribution to Broader Policy Objectives Including Benefit To Society:*

Achieving the ARTEMIS JTI technological objectives will have direct benefits for European industry of gains of at least €14.7bn per year in reduced development costs by 2015, equivalent to at least 55k man-years (section 5.1.2). Further indirect benefits can be expected from this improved profitability, as a result of increasing market share and revenues, investment in higher-added value product segments, and strategic longer-term technological competitiveness. In addition, the JTI will bring benefits for stakeholders through improvements in the efficiency and organisation of the research funding regime (sections 5.1.3, 5.1.4, 5.1.5). The new structure will remove budgetary uncertainty and unnecessary bureaucracy, avoid duplication in evaluation and monitoring, and enable shorter times to market. The JTI will also contribute to productivity and create new jobs in the wider economy (sections 5.1.6, 5.2), while also enabling more sustainable management of economic infrastructures and natural resources.

- *Capacity to Attract Additional National Support and Leverage Current and Future Industry Funding:*

The ARTEMIS Joint Undertaking allows Community funding to be used as a lever to align national funding towards common goals and objectives and to provide incentives for greater investment by industry. There are already indications of tangible national commitments, which have prompted several other countries to make provision for increased budget allocations in the areas covered by ARTEMIS in their national programmes. Industry is **prepared to double its resources** in this field over the next 7 years (section 5.1.2). The Joint Undertaking also provides a mechanism for broadening participation in R&D and for industry to act together towards common goals and objectives so as to achieve greater market leverage in how results are exploited and applied. For Community funding of around €420m in total, the **ARTEMIS Joint Undertaking will leverage seven times that amount on embedded systems research**, more than half of which will come from industry. Moreover, the Community's contribution is safeguarded in the event of either under- or over-subscription of national funding.

8. MONITORING AND EVALUATION

The JTI will be concurrent with the funding schemes of the Seventh Framework Programme and will be subject to similar procedures for monitoring and evaluation. Such exercises will draw on the valuable experiences in monitoring and evaluation accumulated under both the Framework Programme and Eureka.

The ARTEMIS SRA provides the baseline for such assessments. Specific criteria could include:

- *Increased investment*: the distribution of funding per channel (ARTEMIS JTI, Eureka, national, private) and the success of the JTI in leveraging Member State and private sector investment.
- *Efficiency of procedures*: time to contract; success in working within common and simplified procedures; improvements in project monitoring and evaluation.
- *Technological progress*: in achieving the SRA objectives.
- *Non-technological activities*: such as impact on industrial policy and success of horizontal actions.
- *Involvement of SMEs and new players*: breadth of participation, clientele.

Two monitoring assessments are foreseen, one at mid-term and the other at the end of the life of the Joint Undertaking. Responsibility for these, as set out in the Regulation, is with the Commission, which shall undertake its own review of the JTI as a funding partner (or at least of its contribution). . Alternatively, this aspect could be covered through the Governing Board. This latter approach is preferable but would need to ensure that specific aspects relating to Commission funding were covered explicitly.