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Analysis of the effects of a Joint Technology Initiative (JTI)

in the area of Nanoelectronics

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1. EXECUTIVE SUMMARY

Introduction

A Joint Technology Initiative (JTI), a public-private partnership between industry, Member States and the Commission, is planned for nanoelectronics, with as major objectives:

- to increase and coordinate in a single programme the resources needed for industrially-driven cooperative R&D in Europe and to transfer results in major application sectors;

- to increase the level of strategic partnerships and initiatives among European partners and to provide European industry with the critical mass in terms of resources and competencies to play a significant role at global level;

- to experiment a new way of executing industrial R&D in order to efficiently anticipate the changing business and research models, more adapted to industrial needs in particular for SMEs, combining for the first time national, EU and private funding.

This document focuses on the impact analysis of such a JTI, based on the results of extensive consultations of the Commission with stakeholders in the nanoelectronics domain.

Problems and challenges

Nanoelectronics is pervasive and the motor for innovation in many areas today including mobile communications, transport, computing, consumer products, and manufacturing automation. This gives it a large economic impact or a high socio-economic relevance as for security, healthcare, aging, energy saving, and environmental monitoring. Europe must safeguard its capability to design and produce its products following its own standards of high quality, sustainability and environmental friendliness.

Nanoelectronics is a global market ($265bn in 2005) directly stimulating a larger electronics industry ($1340bn) but Europe is not gaining market share. Europe is a net importer of nanoelectronics: 12% of the worldwide semiconductor production capacity is located in Europe, while 20% of the worldwide semiconductor products are consumed in Europe. The global competition is fierce, especially by countries like Taiwan, Korea, China and the USA.

Business models are changing. Nanoelectronics becomes a global activity. Integrated Design and Manufacturing (IDM) companies are increasingly relying on foundries (third-party fabs) and go fab-lite for their added-value operations or even fab-less, cooperating in ecosystems of knowledge for their R&D and in strategic alliances for their access to the most advanced technologies. This is the result of the growing capital investments (e.g. 5.5 B€ for a typical mega fab) required to research and manufacture the new generations of components. This goes above what individual companies can afford (except Intel) in terms of return on investment and rate (18%) of research. Consequently, generic nanoelectronics technology research is executed in a few major alliances, while manufacturing of advanced commodity products is done in a few mega fabs. Europe must assure that its companies can play a strategic role in these global alliances and can keep added-value operations including advanced manufacturing in Europe, accessible to European partners (including SME's active in equipment, support, systems integration and design). One of the main competitive risks is a 'technological lockout'. European suppliers might fall so far behind their competitors that they are unable to catch up.

Research models are changing. Europe must further assure that the research can be executed on European soil in order to maintain high added-value jobs in Europe. This requires a shift from the linear model where research results are transferred from universities to institutes and industry, into a model where research is done in cooperation, deeply embedded in the industrial web supporting the knowledge ecosystems. Moreover the research must produce sufficient critical mass and allow for sharing access to expensive state-of-the-art infrastructures, supporting the European industry and its researchers in acting globally.

Delocalisation of nanoelectronics manufacturing holds a real risk of migrating also added-value activities toother parts of the world. Some countries have developed special incentives to attract and retain foreign semiconductor investment, whereas the EU lacks a dedicated sectoral approach to support this key industry. Europe must react with comparable measures.

Product performance and functionality is growing. Advances in miniaturisation allow ICT to be embedded everywhere, providing enhanced functionality, more intelligence and more personalised products and services. These added-value operations are key elements for product diversification and a strong European competence. They form the basis for a European Strategic Research Agenda combining miniaturisation with other system integration elements aimed at key European lead markets. This holds a huge economic potential in the knowledge-based society. Europe can just not afford to miss this future and become dependent for its social progress and well-being on other regions of the world. The semiconductor industry will also have to face the challenge of combining the shortening of the product life cycles with the increasing complexity of those products. In fact, only a significant investment in advanced R&D allows keeping up the pace of innovation in this sector.

Technological challenges are manifold. As technologies shrink in the nano domain, research is becoming increasingly multi-disciplinary. Bringing European competencies together is essential for future progress. The rising complexity to overcome the technological roadblocks requires increased human effort and an expensive infrastructure. Mobilisation of all resources and worldwide cooperation is required to realise the milestones. It is also expected that traditional miniaturisation will reach its limits in 10-15 years. Activities have to be started to prepare for beyond the traditional scaling of devices. Part of the R&D will have to focus on improving the efficiency of production. The capabilities to design new products are lagging behind the technological progress. The European research fabric will need to redirect itself to take better account of the technological opportunities and will need to invest more in applied research. This requires a fundamental shift from single science, technology thinking into multi-disciplinary system thinking.

Europe's public research investments in nanoelectronics are fragmented: Eureka, the Framework Programme (FP), national/regional initiatives (including various 'pôles de compétitivité'). Consequently, Europe's research landscape is in the need of a convincing, efficient coordinated approach in the area of nanoelectronics.

Market failures justify a public intervention in the nanoelectronics domain. Basic knowledge, developments of new equipment, materials and design tools are cross-cutting many applications, are difficult to protect, create many knowledge spillovers and are to be considered as "public good". Research is speculative and exploitation of the results uncertain with fierce global competition which creates imperfect and asymmetric information. SMEs engaged in high-tech innovative projects may find it difficult to reach critical mass to compete at worldwide level. The pervasiveness of nanoelectronics across a wide range of industries, public sector tasks and societal applications makes it impossible for R&D actors to reap the full return of their efforts. This creates major R&D spillovers and positive externalities. Coordination and networking problems among market actors, public sector, and cross-sectoral application domains also justify public intervention in pre-competitive R&D.

Policy

Stakeholders have recognised the critical nature of the problems and have gathered in the ENIAC European Technology Platform (ETP), in which all players work together to reinforce the EU's leading position in the design, integration and supply of nanoelectronics. The platform has published a Strategic Research Agenda (SRA) outlining the evolution of the field from a medium- to long-term perspective and identifying a number of important technological and regulatory challenges for Europe.

The proposed ENIAC JTI will be one of the pillars for implementing the **technological and economic objectives** of the ENIAC ETP. The JTI is to contribute to sharing the escalating costs of the R&D activities and infrastructures; take or maintain leadership in diversifying applications of semiconductor technologies; manage breakthroughs in technology and in design in order to fill the ever-widening gap between technologically achievable and economically feasible; provide SMEs with effective tools to support them in their innovation process and to act at global level.

Several options to implement the JTI were evaluated and discarded. These vary from doing nothing (business as usual) to participation in joint actions by Member States (with various legal models). Only a new action at Community level can develop an approach that combines the benefits of European integration with fast alignment of goals and industrial policies and with flexibility in participation and national commitment by Member States.

The analysis of the potential implementation options for the ENIAC JTI concluded that **a 'Joint Undertaking' model** on basis of Article 171 of the Treaty **is the only option that satisfies the constraints and requirements to achieve the objectives.** It's a structure durable over time with legal personality that (a) provides a legal framework for the collaboration of all public and private stakeholders, (b) is capable of receiving funding from different sources, and (c) is capable of launching major initiatives of longer duration.

It is further expected that the JTI will create **additionality** in terms of extra R&D expenditure thanks to the foreseen EC investment of €450m leveraging a €3bn programme with additional national support and greater industry funding (1 euro of the EC contribution to leverage an expected 6 to 7 euros of R&D effort). More importantly the JTI will create **'behaviour additionality'** in terms of European collaborative projects launched, acceleration of R&D results, expanded scale, scope and complexity of the projects.

Structure and governance

The founding members of the ENIAC Joint Undertaking (JU) would be Member States, the European Community and R&D performers. Other members can join the JU at a later stage. The R&D performers, i.e. industry and research organisations, are represented in the JU via an association called AENEAS. The statutes of this association have to follow the general principles of fairness, transparency and openness for accession.

The Governance Structure of the Joint Undertaking is made of a Governing Board, an Industry and Research Committee, a Public Authorities Board (PAB) and an Executive Director with a Secretariat.

The JU will elaborate a multi-annual work programme based on the SRA, under which R&D activities will be implemented through open calls for proposals. Participation to these calls will be open to all organisations and not only to the members of the association. State members of the JU will annually commit resources that will be mainly spent to fund their respective national participants. The EC will also commit a budget (contributed by the FP). Industry will cover more than 50% of its R&D cost for the JU through in-kind contributions. In addition, industry will cover approximately two thirds of the operational and non-R&D costs of the JU through cash contributions.

Economic Impact

European public funds act as a magnet for further private and national investments. Many national policies are being aligned with the European ones. Several new strategic initiatives are launched by Member States to support these technologies.

The total nanoelectronics value chain is concerned by this initiative. It is therefore of vital importance to build anchors for European top companies to stay here. Such anchors will be made of pools of competence and will be created through the fostering of networking between companies and research institutes. Furthermore, strategic alliances between nanoelectronics component suppliers and system designers will provide more incentives to keep knowledge in Europe and to create diversified products with a European flavour.

The impact of achieving the JTI technical objectives will bring Europe at par with other players worldwide for being considered a strategically important partner in global alliances in view of the diversification and integration of complex systems.

The JTI will remove uncertainty by creating the stability for investing in a long lasting initiative. Especially for SMEs, the new arrangements will offer a more attractive regime. A further benefit of the JTI compared to the current co-existence of various schemes is the increased efficiency of EU-level disbursements, the savings expected from avoiding preparation of proposals in different languages, the streamlined project reporting procedures and an increased success rate due to guaranteed harmonised funding procedures.

Social and environmental impact

The JTI will contribute to maintain and create more and better quality jobs, in line with the re-launched Lisbon strategy. Mainly the greater use of nanoelectronics-based products and services will lead to the creation of several thousands of jobs in Europe.

The JTI is oriented towards the vision of 'ambient intelligence': environments that are aware of our presence and responsive to our needs. The JTI targets such environments with six application domains: healthcare, energy, mobility & transport, security & safety, communication and education & environment. All have a high social relevance and contribute to improving the quality of life and well being in our society. Unless the public sector intervenes with adequate support, it is clear that individual firms cannot expect sufficient returns to justify the level of R&D investments that would be socially optimal. For instance, this applies to environmental monitoring and management which is a key application area for the JTI.

All electronic systems use electricity and are part of a general trend towards the 'electrification' of society. However, use of electronic systems also allows better management and control of energy efficiency. For example, nanoelectronics will be essential in the intelligent portable systems needed to reduce energy consumptions in the house, in the plants and in the transport systems that will be a key factor for the protection of the environment. In many applications this is their primary purpose. Moreover, reduced power consumption for electronic devices is an important and ongoing technical objective.

Nanoelectronics must be developed in a safe and responsible manner, in line with the European Commission's safe, integrated and responsible strategy for nanosciences and nanotechnologies for Europe in its Communications "Towards a European Strategy for Nanotechnology" COM(2004) 338 and "Nanosciences and nanotechnologies: An action plan for Europe 2005-2009" (COM(2005) 243). The strategy confirms that nanotechnology and nanoparticle developments should address any potential public health, safety, environmental and consumer risks upfront by generating the data needed for risk assessment, integrating risk assessment into every step of the life cycle of nanotechnology-based products, and adapting existing methodologies and, as necessary, developing novel ones. The establishment of the Nanoelectronics Joint Undertaking will bring all stakeholders together to discuss these important issues, to agree on common ways to address any potential risks and more specifically to call on common measures to support environmentally sound management of nanoelectronics life-cycle.

Benefits and Risks

The overall financial support from the EC in the area of nanoelectronics will increase during FP7.

The risks for the FP are very low. The EC contribution is conditional on the contributions of the Member States and will be made in annual commitments/disbursements depending on the progress of the JTI.

It is expected that part of the activities in the area of nanoelectronics currently supported within the Eureka clusters will be progressively integrated in the ENIAC JTI.

What if no action? Europe may run the risk that the competence to integrate new functionalities into smart systems will follow the off-shoring trend of commodity manufacturing, weakening in the long run the capability to produce in Europe added-value in electronic systems. This would result in a dramatic decrease in competitiveness in general, particularly as nanoelectronics is at the bottom of a wide food-chain forming the basis of the knowledge society and a motor for the future economy at large. This would also have major consequences for the number of high quality jobs, not only in the hardware sector but for all other activities dependent on hardware innovation. In order to avoid such a doom scenario, there is a political will to safeguard more European competence on European soil while encouraging strategic alliances to form knowledge-based ecosystems as well as to strengthen European presence in global alliances.

Monitoring

The JTI will be concurrent with FP7 and will be subject to similar procedures of monitoring and evaluation. The ENIAC SRA provides the baseline for assessments, of which the criteria could include increase in investment, efficiency in procedures, technological progress, non-technological activities and involvement of SMEs and new players. Two monitoring assessments are foreseen: one at the mid-term and one at the end of the life of the Joint Undertaking.

Conclusion

A JTI on nanoelectronics is proposed to help safeguard European competitiveness in nanoelectronics. An integrated European initiative of longer duration designed to link the different required competences together will deepen the strategic alliances between European partners providing for sufficient critical mass in terms of resources, access to infrastructure and competences to compete or cooperate at worldwide level.

2. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

This document focuses on the impact analysis and ex-ante evaluation of a Joint Technology Initiative (JTI) in the area of nanoelectronics and on a review of the potential governance arrangements. The procedures followed reflect the Commission's guidelines for ex-ante impact assessments[1]. Parts of the impact assessment were subject to contracts with external consultants awarded after tendering procedures.

The impact assessment drew on the results of extensive consultations of the Commission with stakeholders in the nanoelectronics domain following the development of the ENIAC Technology Platform[2] established in June 2003. More than 30 meetings were held with the industrial Forum of Stakeholders, the Steering Committee[3] and several Working Groups (in particular the Strategic Research Agenda (SRA) and Governance groups), and the national public authorities represented in the "Mirror Group[4]" gathering representatives from 21 Member States and Associated Countries. The relevant topics for this impact assessment such as the Strategic Research Agenda and the Joint Technology Initiative have been publicly presented and discussed in major events such as the ENIAC annual meetings (Brussels 2004, Leuven 2005, Monaco 2006), the Information Society Technologies Conference IST-2006 (Helsinki) and the public presentations of the ENIAC SRA in November 2005 and November 2006.

In the final step of this consultation process, representatives of the ENIAC Steering Committee and the Mirror Group met with an external consultant on three occasions over the period July-September 2006. These meetings focused specifically on the contents of this report and involved wide-ranging discussions to compile previous results, provide further inputs and to review the 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 market data, but also on studies that provide a detailed picture of R&D and market trends in nanoelectronics-related areas: *Effectiveness of R&D to increase the competitiveness of European industry in the sector of micro/nanoelectronics* by Inno Group (resulting from an open tendering procedure by the INFSO Nanoelectronics Unit) and *The European semiconductor industry 2005 competitiveness report* by ESIA, both published in end 2005. The Inno study presents an assessment of the current R&D activities in nanoelectronics as a whole that takes into account technological, sectoral, market-related and funding aspects. The ESIA study presents the status of the semiconductor sector in a global market, analyzes the main challenges ahead for Europe and makes a number of recommendations for maintaining and enhancing the competitiveness of the European semiconductor industry.

Finally, the interim drafts of the present paper were reviewed by the ENIAC Support Group, the Mirror Group and an ad-hoc inter-service group[5]. The recommendations from the

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[1] *Impact Assessment Guidelines*, SEC(2005) 791, European Commission, 2005 with March 2006 update.
[2] ENIAC Technology Platform, http://www.eniac.eu
[3] Summarized in a written contribution by Pasquale Pistorio, Honorary Chairman STMicroelectronics, 12 September 2006
[4] Members of the Mirror Group are AT, BE, BG, CH, DE, DK, ES, FI, FR, GR, IE, IL, IT, LT, LV, MT, NL, NO, PT, SE, UK
[5] Representatives of DG BUDG, ECFIN, ENTR, LS, RTD, SG were invited

Commission's Impact Assessment Board[6] have also been adopted, leading to more focus in the main text and the addition of annexes for further background information.

The methodologies used in the present report, including rechecking original data sources, are satisfactory and represent a sound basis for assessing the economic impacts of the JTI.

[6] Opinion delivered on 30th May 2007

3. PROBLEM DEFINITION

3.1. What is the Issue or Problem that may require Action?

Europe's future success as a dynamic and competitive knowledge-based economy depends crucially on our ability to master developments in nanoelectronics and to foster a strong and competitive nanoelectronics-based industry. The importance of nanoelectronics as an enabler for innovation, its technological challenges and the worldwide competition are described in Annex I.

In a context of fierce competition and high innovation rate, Europe will be a strong actor if it is able to address the following problems:

- The **exploding R&D and manufacturing costs** for the next generations of components;
- The need to mobilize **more and different competences** in a multi-disciplinary and more coordinated manner to address the growing variety of the technology;
- The **high risks** associated with the technical challenges and the financial perspectives;
- The necessity to **react in a flexible and timely manner**, given the cyclical and rapidly changing nature of the industry involved;
- The need for a **holistic approach** to research, through strategic partnerships and large initiatives between the manufacturers and their customers, linking technology, manufacturing, design and application development;
- The capacity to efficiently exploit the opportunity offered by a vibrant **network of European SMEs** and the emerging "regions of knowledge".

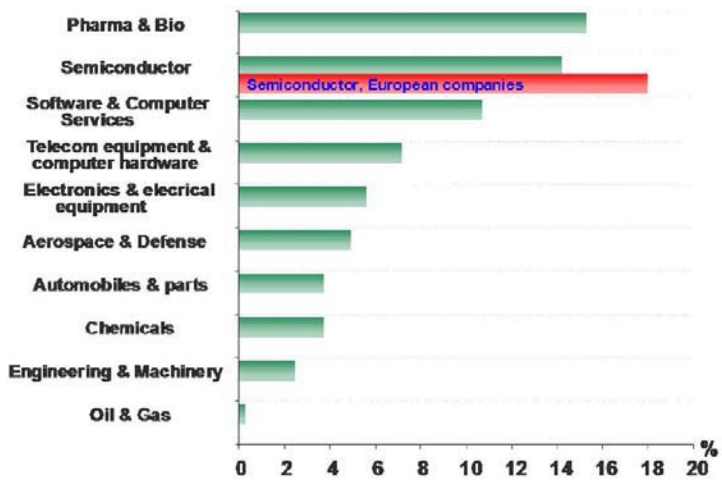
To reap the benefits of the upcoming technological progress, Europe needs to be able to turn multi-disciplinary scientific knowledge into industrial advances. Therefore, it is essential that a strong collaboration takes place at all levels: research organisations with industry, application drivers with technology pushes, public sector with private initiatives. This would allow the combination of technology-driven development with market-led research in one integrated effort.

Large Research Efforts for Nanoelectronics

The complexity of developing nanoelectronics components, both in designing and manufacturing the chips, requires a very high investment in R&D. In fact, the semiconductor industry is one of the most dependant sectors on its R&D intensity. In Europe, the semiconductor manufacturers have invested more than 18% of their annual sales in R&D over the last years (Figure 3-1).

While such an effort was necessary in order to take part and keep up in the global race, it is unlikely that the semiconductor manufacturers will keep increasing their total R&D expenditures in the next years. Their R&D investments have reached a ratio that would no longer be bearable if the up-going trend would continue. It is even predicted that, in order to stay competitive, the European R&D efforts will decrease in the next years and come closer to the worldwide average value of 14-15%.

Figure 3-1 : Research intensity (source: EC and MEDEA+)



However, the need for intense R&D is more than ever recognized as a key to success in making the next generations of components and integrated systems. In fact, only a visionary and significant project investing in advanced R&D and transfer into innovation will allow Europe to keep up with the pace of innovation in this sector. Hence, the future research landscape in nanoelectronics will most likely show a shift of some of the private R&D investments towards collaborative research inside strategic alliances allowing them to address the above problems. This should happen in a pre-competitive environment in which public intervention can help coordinate and leverage the required investments from all parties involved: industry, research organisations, universities and public bodies.

The Fragmentation of Research Funding in the EU

Europe's research investments in nanoelectronics are split across several initiatives: the EU's research Framework Programme, EUREKA, and national/regional initiatives, as well as industry's own proprietary R&D (Table 3-1). Total 'pre-competitive R&D' – that is carried out under public programmes - is estimated at around €1300m, which is roughly covering the sum of fundamental and applied research today. However, the required investments in fundamental and applied research are likely to increase in the future while the costs of product development will need to be strictly kept under control considering the shortening life cycles and the competition from other regions of the world. This shows that more public/private sources of financing the R&D activities may shift towards more advanced cooperative research efforts in Europe, targeting towards a ratio of public/private investments closer to 1/3-2/3 as in the Barcelona objectives.

Table 3-1 : European Expenditures on Nanoelectronics Research

Type of R&D	€M/yr	R&D Financing	€M/yr
Fundamental Research	300	EC Framework Programme	140
Applied Research	1100	EUREKA	260
Product Development	2200	National Programmes	500
Prototyping	1000	Regional Support	400
		Total Public Funding	1300
		Industry (proprietary)	3300
Total	**4600**		**4600**
Source: Inno Group, 2005			

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, 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 areas where EU25 can arrive to agreement for spending **a relatively small percentage of the EU's total public budget**. For example, FP6 amounted to only 5-6% of all public support for civilian research expenditure in the EU[7].

Moreover, the Framework Programme concentrates on pre-competitive innovation with a time horizon of 7+ years which is less suited for the time frame of industrially oriented nanoelectronics research. Despite putting emphasis on SMEs, the Framework Programme only reaches 20% participation when the nature of market-led research in nanoelectronics would benefit from 50 % participation.

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 that this is a necessity but the FP budget would not be sufficient to sustain. The EUREKA framework has notched up some notable achievements over the years, most notably the longstanding collaborations in the form of "cluster projects" in the areas of microelectronics (the JESSI, MEDEA and MEDEA+, Eurimus, Pidea, Euripides clusters) and software-intensive systems (ITEA and ITEA2). These have been valuable cooperation mechanisms through which up to €260m of public funding are provided to R&D industrial projects every year. It is not a coincidence that all four current

[7] Cordis (Community Research and Development Information Service) database on Innovation articles

cluster projects of EUREKA concern the ICT domain; overall, around two-thirds of EUREKA project funds are estimated to be in the area of ICT.

However, EUREKA and its cluster projects also have well-recognised **shortcomings**. Its nature of an 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 levels and predictability of public funding available have constantly weakened the effectiveness of the scheme. Up to date, EUREKA has not been able to correct or resolve these underlying problems[8]. Despite being capable to address industry-led research, the EUREKA set-up contributes to the fragmentation of the R&D landscape in nanoelectronics.

At **national level**[9], 14 out of 122 funding programmes in 23 EU Member States and Associated Countries are dedicated or have significant relevance for Nanoelectronics research. Similarly, 12 out of 30 Member and Associated States have identified Nanoelectronics as "a most important official ICT policy priority".

In front of the major challenges facing the European industry and economy, Europe's research landscape is fragmented and lacks in a convincing efficient approach in the area of nanoelectronics: 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 nanoelectronics research in the face of fierce international competition. In such a fast-moving global market, Europe needs the ability of coherently focusing on common objectives, but also the ability to adapt the objectives to changing industrial and market circumstances. It must develop a European approach combining technology-driven and market-led research, building critical mass but also allowing flexibility at both strategic and operational levels without suffering all the drawbacks of inter-governmental schemes.

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

[8] Annual Impact Report of EUREKA 2005 (May 2006)
[9] Cistrana survey. http://www.cistrana.org/, Cistrana is a project initiated by a European Research Area (ERA) working group of Member and Associated States.

3.2. What are the Underlying Drivers of the Problem?

Technological Complexity is Escalating R&D Expenses and Changing the R&D Landscape

In the last 30 years, the almost perpetual improvements in semiconductor performance coupled with cost reductions were achieved by miniaturisation technologies. These were following an empirical law, Moore's law dictating a doubling in density and performance every 2.5 to 3 years while it takes an average time of 6 years to develop one generation of technology. However the rising complexity, the required human capital and the investments in R&D and manufacturing are so huge now, that one can expect progress to slow down and that a more global cooperative effort will be required to take the next hurdles.

Research in manufacturing and technology that was so far undertaken at universities and institutes will need to be done in close collaboration with industrial entities. The linear model of transferring research from basic science to the manufacturing unit, involving different actors is no longer valid. Research will shift to a model where cooperation between all research actors in so-called competence clusters will become dominant. The European industry and research community has to follow these trends, and where possible to take the lead, in order to remain competitive.

Changing Business Models

Nanoelectronics becomes increasingly, because of its nature, a global activity. Offshore manufacturing in foundries is already practiced. Most new huge mega-fabs are being built in the Asian Pacific region (Taiwan, Japan, China, South Korea). Most of these plants are run by Alliances to share the risks and costs. Global cooperation becomes a must and is not any longer an option.

With costs of such plants approaching €5bn, Integrated Design and Manufacturing companies (so called IDMs) increasingly take the decision to work more closely with these foundries in order to keep up with the miniaturisation progress (Moore's Law). Progressively more IDMs allow the foundries to handle not only the traditional Integrated Circuit production but also R&D. Over time, the advantage from internal process technology for IDMs will become less a differentiator for many products.

Moreover the cost for research is growing at a faster pace compared to growth of the revenue. For instance European semiconductor companies spend between 16 and 18 % on research, which is higher than any other industry and above the worldwide level. Such a situation obviously calls for a further consolidation in bigger entities and for setting up more strategic alliances to deal with research as well as production and share the increasing risks.

Most of European semiconductor manufacturers are of the IDM type and plan to go into a "fab lighter" position covering system on chip design and, with respect to manufacturing, concentrate on more added value additional processes. In some cases the semiconductor part of their business is taken over by private equity. This change of business model calls for a deeper collaboration among the different actors. Moreover, the traditional value chain from manufacturer to systems designer becomes a value ecosystem, a cluster alliance, where research and developments are done in cooperation, and where all functions are individually optimised towards the total system level. In this changing landscape, many European companies offer excellence at system level in different application fields. They should maintain this position. Moreover, companies must also safeguard the possibility to design in their products societal, environmental and sustainability concerns specific to Europe.

Nanoelectronics have an immense potential for future applications but their research and industrialization need high levels of human, time, capital and competence resources. To make the required resources available in the short product cycles of the nanoelectronics industry will need strategic partnerships between all shareholders of the value-chain.

Impact and Limitations of Public Funding Policies

An important question in an industry as fast-moving as nanoelectronics is whether public R&D financing has a deep impact on the market. Some analysts consider support for near-market R&D projects not to be very efficient as they are subject to changes in company strategies[10]. On the other hand, other analysts have shown that large initiatives, such as the Japanese VLSI programme, the US Sematech programme, and the European JESSI, have played a critical role in allowing companies from those countries to stay at the forefront of competition. An appropriate conclusion would appear to be that a winning scenario is the convergence of public objectives with industry's strategic interests.

3.3. What are the Risks in the Current Situation?

The current situation in nanoelectronics development, which is characterised by increasing competitive pressures from globalisation, escalating investment costs, changing business and research models, and a fragmentation of research efforts, brings substantial threats and risks for Europe. ICT are not only crucial to the competitiveness of all industries, they also present opportunities to transform our economy and society in the face of major challenges such as population changes, climate change and sustainability. Nanoelectronics underpin the next generations of ICT systems that will facilitate this.

The current fragmented situation will lead to a **loss of competitiveness for Europe.** Electronics feed the whole economic food chain: the **opportunity to create jobs and innovate** new products and services **is at risk**. Nanoelectronics are so central to value creation in the modern world that an economy that fails to master nanoelectronics loses a significant part of its innovation capability. Europe must retain the high degree of flexibility and innovation necessary to adjust to the rapid pace of market change.

One of the main competitive risks is a '**technological lockout'**. Rising costs of capital investment and research as well as the increasing pace of technological change could lead to a situation where European suppliers fall so far behind their international competitors that they are unable to catch up. This situation would be made all the more risky by the industry's cyclical nature and above-average market volatility. If **loss of competitiveness** was to occur, it **would not be gradual but step-wise**, therefore creating huge knock-on effects for end-user industries and the EU's balance of trade.

From a technological point of view the risks are two-fold. In the short term, the development trajectory is well known – as set out in the ITRS roadmap; but without sustained and focused effort, Europe will be **unable to keep up with international competitors in realising the ITRS milestones** and ensure a distinctively European flavour in their interpretation. At the

[10]For further discussion on these issues see *Effectiveness of R&D to Increase the Competitiveness of European Industry in the Sector of Micro/Nanoelectronics,* Inno Group, 2005

same time, we have to **intensify efforts to seek major breakthroughs in diversifying the technology for the long-term**, which will form the basis for future generations of electronic systems.

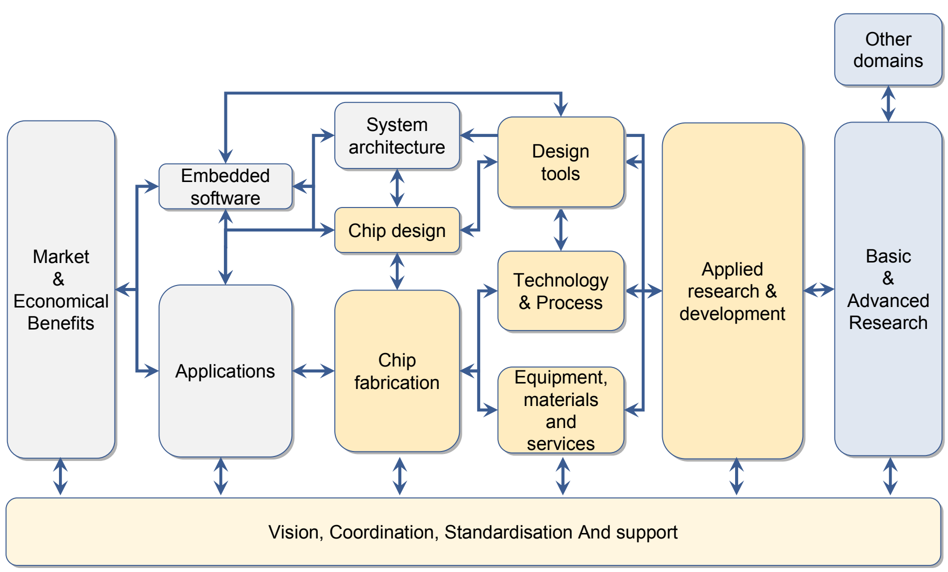
The European economy has benefited considerably from the success of its microelectronics industry. Over the last fifteen years, the sector has invested around $35bn in fabs, laboratories and R&D, thereby creating more than 50,000 highly qualified jobs and with a threefold 'trickledown effect' of locally created jobs[11]. So far, Europe has largely resisted the delocalisation trend that has affected other regions. **Delocalisation remains a threat, however, with a very real risk of first manufacturing and then higher added-value activities migrating to Asia**. Already we have seen the number of European designs stagnating.

Whereas China, Japan, Korea, Malaysia, Singapore, Taiwan and the US have developed special incentive schemes to attract and retain foreign semiconductor investment, **the EU lacks a dedicated sectoral approach to supporting this key industry**. Indeed, revisions to EU industrial policy over recent years have actually reduced the financial support for the large investments necessary for leading-edge semiconductor manufacturing facilities, leaving a void in large-scale future investment. Europe needs incentives to support the build-up of a competitive and distinctly European nanoelectronics industry.

3.4. Who is Affected, in What Ways, and to What Extent?

The nanoelectronics industry comprises of a complex value chain, running from basic research, technology and materials, through to design, manufacturing and applications (Figure 3-2).

Figure 3-2 : The Nanoelectronics Value Chain



Source: INNO Group. 2005

[11] *The Future of the European Microelectronics Industry,* MEDEA, 2003

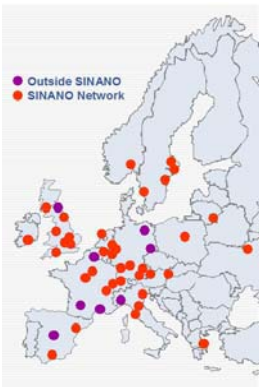
The European industry enjoys a good position, with three **integrated device manufacturers (IDMs)** among the world's top-ten nanoelectronics companies[12]. Europe also has more than ten much smaller IDMs, typically one or two generations behind in terms of technology and focusing on specific segments, like automotive, aerospace or telecommunications. In 2004, the total revenues of European IDMs were almost $28bn, of which $25bn was accounted for by 'the big three'.

The last 20 years have seen a process of 'deverticalization', whereby it has become more and more difficult for a single company to master efficiently the whole value chain. The most recent manifestations of this have been the creation of **'fab-lite'** companies, who develop strategic niches in-house and partner with pure manufacturing fabs for 'standard' products, and **'fab-less' companies**, who choose to invest in design and marketing and to subcontract manufacturing to 'foundries'. Those companies require reduced capital investment, are in close contact with the market through application developers, and are not limited by the internal manufacturing technologies. To succeed, however, they need clear product differentiation, design expertise, strong controls over intellectual property and subcontracting. Europe has an array of fab-lite and fab-less companies as well as **innovative SMEs** specialising in areas such as Intellectual Property (IP-blocks) and application design.

Europe has been less strong in **semiconductor equipment**. Although it acquired a leading position in lithography, today's majority of equipment vendors are American or Japanese. Europe has no main player in the design automation tool market, although there are some promising start-ups. Indeed, the increased complexity, the number of materials used, the growing number of different processes and equipments open new opportunities for new entrants in this field.

There is a large array of **academic laboratories** throughout Europe involved in the nanoelectronics sector. Many of the laboratories are also focused on several other sectors, such as nanotechnology, microsystems, or solid-state physics. SINANO, a Network of Excellence in Silicon-based Nanoelectronics devices launched under FP6, groups 43 laboratories from 16 European countries. In addition, Europe has a strong base of **non-academic laboratories** including three major state-of-the-art laboratories mostly focused on applied R&D[13] (Figure 3-3).

Figure 3-3 : Research Laboratories involved in Nanoelectronics (source: SINANO, 2005)

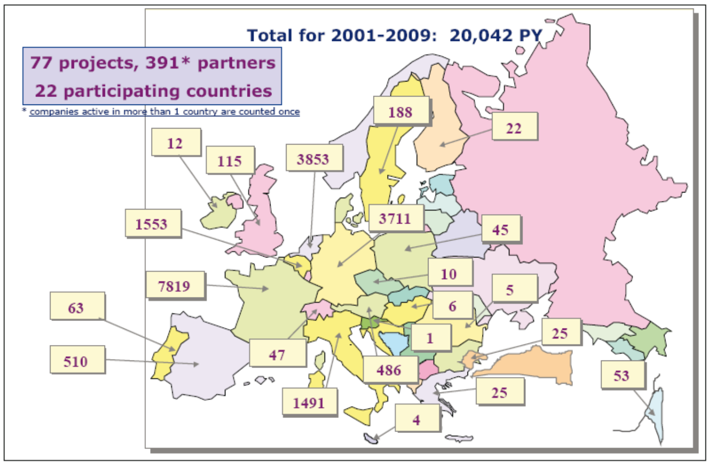


[12]The 'big three' are: Infineon-Qimonda, STMicroelectronics and NXP Semiconductors (ex- Philips Semiconductors)

[13]These laboratories are: Fraunhofer MicroElec Alliance, Germany (1600 staff, budget €170m per year); IMEC, Belgium (1300 staff, €160m/yr); and CEA-LETI (1430 staff, €157m/yr). Ref: *Inno Group, 2005*

To illustrate the wide geographical spread of the industrial nanoelectronics sector in Europe, the following figure shows the location of the research partners involved in MEDEA+ (Figure 3-4). All those organisations are directly affected by any initiative touching upon the R&D investments in nanoelectronics, not just the 3 main semiconductor manufacturers. Their future is at stake, while the innovation capability in Europe would be seriously hindered by the lack of a strong, leading-edge nanoelectronics sector. This would impact many thousands of companies throughout Europe, who rely heavily on advanced IT components for developing their own innovative products and services.

Figure 3-4 : Participants in MEDEA+ (source MEDEA+, 2006)



Public authorities are interested in the nanoelectronics 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. 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 nanoelectronics 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.

3.5. How would the Problem Evolve, All Things Being Equal? Is an intervention at Community level justified?

Hence, the nanoelectronics field in Europe has reached a turning point. It has the potential to drive innovation and growth and contribute significantly to European competitiveness and economic and social change. But it also faces a fragmented research landscape, escalating technological complexity and research costs, and increasing international competition. All of these factors are set to be exacerbated over the coming years, making the current approach unsustainable. **Europe must increase and make better use of its investments in this strategic area**.

Two major factors, underlined by ENIAC, highlight the necessity for the European Union to act:

- ∉ Welfare of the European nanoelectronics sector is strongly related to the establishment of a strong network of various competencies. No European state can claim to possess all of these top competencies.

- ∉ Huge R&D infrastructure investments are required in order to stay in the race driven by the ITRS roadmap. Today no European manufacturer has the ability to invest alone in such infrastructures. The sharing of infrastructures together with cooperative research on processes between industries and academia is therefore of prime importance. Moreover, it is widely recognised that local incentive schemes are the main contributors to the net cumulative income of the fab, even more so than the huge wages differences between developed and developing countries.

> Setting up a limited number of megaprojects relevant to the semiconductor community is essential for its future presence in Europe. Such partnerships are a unique source for enhancing Europe's competitive edge across all sectors of the economy and for creating high-tech industry clusters as global poles of competitiveness of which Europe takes advantage. In addition to pre-competitive partnerships at a horizontal level, i.e. among semiconductor companies, increasing emphasis needs to be placed on encouraging vertical partnerships that integrate capabilities along the supply chain. The strategic objective here is to ensure competitiveness throughout the development and production chain and establish the links between semiconductor suppliers, manufacturers and end-user enterprises that are as synergistic as possible.
>
> *Source: The European Semiconductor Industry: 2005 Competitiveness Report*

The above demonstrates the **necessity** to set up Europe-wide initiatives to support European competitiveness in the field of nanoelectronics. Moreover, synchronising the efforts to manage the portfolio of European competencies and infrastructures would enable Member States to achieve greater efficiency than would be made individually.

Market Failure and European Value Added of Community Intervention

A recent report on innovation market failures and state aid[14] has identified four major market failures that may have a significant impact on the innovation process and its exploitation:

- ∉ **R&D spillovers**: the process of undertaking innovation, or the end result of the innovation process (e.g., a product), often generates wider benefits (positive externalities). Left to the market, projects that, from a private perspective, are not directly profitable, but would generate large social benefits for instance, may not be taken forward.

- ∉ **Appropriability** : knowledge and ideas are often *non-excludable*: it can be difficult to exclude others from using the innovation and to make them pay individually for the benefit they receive. Again, firms may give up projects as a result.

- ∉ **Coordination**: firms rarely innovate alone. However, problems may exist that have an adverse impact on the ability of companies to coordinate or at least interact, and so deliver innovation. A wide range of problems may arise, including difficulties in coordinating R&D and inadequate access by smaller firms to the innovation system.

[14] Innovation market failures and state aid: developing criteria – November 2005

- ∉ **Imperfect and asymmetric information**: this affects, in particular, financial markets. Due to information problems, SMEs engaged in high-tech innovative projects with good prospects may find it difficult to obtain financial investments.

If an innovative sector is likely to be affected by one of these market failures, there is an indication that innovation is sub-optimal and that a public intervention has the possibility to increase the level of innovation and associated exploitation. Nanoelectronics is affected by all these factors.

Market failure in nanoelectronics would lead to a situation where the market is dominated by a few non-European players, which brings along the risk of tying European high-tech companies to the "good will" of a few market leaders in nanoelectronics technology.

Unless ambitious and concerted action is urgently taken, there is a risk that Asia and the US become the sole bastions of industrial excellence in this field, leveraging their strong investments and skills in nanoelectronics. This would have serious consequences for the competitiveness of the high-tech European companies. In addition, it could lead to organisations outside the EU creating an anti-competitive scenario in Europe. Indeed, considering that several non-European semiconductor manufacturers are vertically integrated with final products (e.g. Samsung), the European system companies would be forced to rely on competitors for the supply of critical components with the risk of losing ground in the race for innovation. The intervention of Public Authorities at European level is needed to create the necessary innovation environment for high-tech industry to thrive, as well as providing a state of the art research infrastructure.

It is clear that **only an action coordinated at Community level** can **develop an approach which combines the benefits of European integration with fast alignment of goals and industrial policies and with flexibility in participation and national commitment by Member States**.

3.6. What are the Overall Policy Objectives and What are the Expected Effects?

3.6.1. Policy Objectives

The overarching objective is to help **realise Europe's potential in the future markets for intelligent products, processes and services by strengthening and coordinating innovation and investment in nanoelectronics R&D**. This is fully in line with the Commission initiative[15] "i2010" (European Information society in 2010) in the context of the Lisbon strategy and the Barcelona objectives. The aim is to achieve world excellence in nanoelectronics, allowing the development of future generations of electronic components and their use in virtually any high-tech product and service offered to the citizens.

This is also in line with the vision of the European Technology Platform on Nanoelectronics (ENIAC ETP - see Annex II for further details), as set out in their Strategic Research Agenda[16] (SRA): to contribute to European competitiveness through pre-competitive, collaborative R&D on nanoelectronics. The SRA aims at securing global leadership, creating

[15] Communication from the Commission COM(2005) 229 - The "i2010" initiative provides an integrated approach to information society and audio-visual policies in the EU

[16] ENIAC Strategic Research Agenda, First update, November 2006

competitive products, sustaining high levels of innovation, and maintaining world-class skills within the EU.

That objective implies ambitious technological and economic objectives in response to the problems identified in the preceding sections:

(1) Share the escalating costs of the R&D activities and infrastructures in order to maintain Europe in line with the international industrial roadmap (30% cost reduction of elementary logical functions achieved by semiconductor components per year), and thus increase (or at least maintain) for the next 10 years the European market share for semiconductors from the current 18%.

(2) Take or maintain leadership in diversifying applications of semiconductor technologies and applying them to innovative markets, holding at least 30% of the worldwide nanoelectronics market share in at least 3 application domains.

(3) Manage breakthroughs in nanoelectronics design, in order to fill the ever-widening gap between what is achievable by the technology and what can economically be designed and tested. A step increase of the design productivity should be targeted within 5 years.

(4) Provide European SMEs with effective and efficient tools to support them in their innovation process by linking them to industrial technology leaders and state-of-the-art research organisations. Research projects should involve at least 40% of SMEs beside large industry and research organisations.

3.6.2. Expected Effects

By strengthening and coordinating innovation and investment in nanoelectronics R&D, Europe will contribute to the intense R&D effort that is required for the industrial and research organisations to take part in the global race, while overcoming the current fragmented R&D landscape. This will lead to more efficient and focused research efforts concentrating on key technologies and knowledge of importance to European players throughout the ICT value chain.

The technological and economic objectives address market failures for which public intervention is justified (Table 3-2).

Table 3-2 : Addressing Market Failures in R&D Domains

	R&D Spillover	Appropriability	Coordination	Information
1. Sharing costs	✓ New processes and technologies ✓ Exploitation of materials and technologies in other domains	✓ Agreed IPR arrangements	✓ Access to fabs for SMEs and R&D institutes ✓ Linking academic research with industrial priorities ✓ Close cooperation among fabs	✓ State-of-the-Art infrastructures ✓ Access to investors and advanced technological and critical market knowledge
2. Diversifying applications	✓ Further exploit core technology in different application fields	✓ Agreed IPR arrangements	✓ Access to fabs for SMEs and R&D institutes (R&D on alternative uses) ✓ Close relationships with "alternative" markets ✓ Wide variety of required competencies	✓ Access to investors and advanced system knowledge
3. Design breakthroughs	✓ IP libraries for wide uptake	✓ Get access to design rules for a particular technology	✓ Access to tools for SMEs and R&D institutes	✓ Access to investors
4. Involving SMEs	✓ Develop niche application markets	✓ Privileged relationship with large companies	✓ Access to fabs and close cooperation with large manufacturers	✓ Access to investors

∉ **R&D Spillovers** are more likely to happen in the technology domains where results such as new processes and new equipments may be further used and applied to other domains through components not being part of the international roadmap.

∉ The **coordination failures** are primarily in getting access to state-of-the-art process facilities and equipment (both R&D and production) to R&D institutes and SMEs, and in adequately forecasting the future research and development needs on the basis of critical activities going on elsewhere. These are not able to invest in such developments or equipment but need access to them in order to innovate and demonstrate proofs of concept. Initiatives such as Multi-project Circuits (CMP[17]) or Europractice[18] are good examples of coordination activities that can be set up in this domain. Moreover, the European nanoelectronics industry is currently sponsoring research in universities and research centres with more than €70m per year[19]. If those large companies would leave Europe, the financial support for the corresponding scientific research would be lost as well.

∉ Similar considerations can be made with the *design breakthroughs*. A particular set of players within this domain is composed of IP and fab-less companies. Despite many success stories and opportunities, these companies are facing increasing design costs and coordination is required in order to have access to shared, standardised and interoperable libraries (Table 3-3), thus reducing **appropriability failures**.

Table 3-3 : Failure Reasons for Fab-less Companies

✓ The lack of reusable and genuinely pre-qualified design IP: a major reason for purchasing a pre-designed function block is to reduce both cost and risk. If there is a large effort required to integrate the block into a larger design, the purpose/benefit of IP is reduced;
✓ The lack of interconnect standards between functional blocks;
✓ The lack of growth in some of the target markets over the last three years;
✓ The challenges IP companies have in achieving revenue scale purely on royalties;
✓ The reluctance of semiconductor companies to share upside potential through royalties;
✓ The desire of in-house development teams to defend and develop skills. Additional to this is the likelihood that semiconductor companies will only outsource the lower value-add parts of the design leaving the higher value parts for themselves;
✓ Modules and packaging technologies allow many of the cost advantages thought possible by large scale system-on-chip designs; and
✓ Long term, open source design libraries may emerge for standard components.

∉ **Information failures** mainly correspond to the huge investments to be made for building and maintaining state of the art production facilities but also to highly risky investments to be made to support prospective research beyond the current technologies. Also the information flow between the actors in the total value chain is not always optimal although essential to adequately forecast the future technology ad market needs. Finally, small companies and start-ups in the nanoelectronics sector are facing difficulties to access Venture Capital funding.

Market failure has also a geographical component. The increasing costs and resources for R&D and investment in production, the growing complexity of the processes, the multi-disciplinary nature of the developments all require **coordination at worldwide level**. As a consequence, deverticalization is a global phenomenon. Companies such as AMD, TI,

[17] The key idea of the multiproject chip system is that sharing a chip or a wafer among several projects makes it possible to greatly reduce manufacturing costs, which allows users at universities to fabricate chips at an extremely low cost – http://cmp.imag.fr

[18] EUROPRACTICE is a European Commission initiative, funded by the Information Society Technologies (IST) Programme. The aim is to improve the competitiveness of European industry by the adoption of advanced electronics technologies - http://www.te.rl.ac.uk/europractice_com/

[19] estimation derived from discussions with major European semiconductor companies

Freescale, etc… follow a similar trend as most European companies (NXP, ST, Infineon, Qimonda,…), with the notable exception of Intel who can still afford to progress on its own scale and paste thanks to its unique strength on the market. Deverticalization at worldwide level is a key tool for major private companies for correcting market failures by building alliances. However, this mainly holds for companies already operating globally. Many market failures still exist for smaller companies and between research institutes and industry that justify public intervention.

Looking closer at **coordination in the nanoelectronics value chain** (Figure 2-2), advanced chip fabrication is located in a few regions in Europe (France, Germany, Ireland, Italy), and technology & process R&D in a few innovation ecosystems (Dresden, Grenoble, Leuven-Eindhoven). Basic and advanced R&D is spread widely over Europe (Figure 2-3). However, their efforts need to be linked with the industrial poles or innovation ecosystems to valorise their results in Europe.

In **equipment, materials and services**, Europe has some competencies in specific parts. Some are spread over various SMEs throughout Europe. In a few cases, Europe holds a key strategic position. For instance, Europe lags behind in several materials aspects - except for SOI where SOITEC, France is leading - because these materials are R&D spillovers of global supplier companies who have their main business in other industrial sectors. On the other hand, Europe is leading in photolithographic production equipment, due to a close cooperation between ASML located in the Netherlands, Zeiss in Germany some hundreds of SME suppliers mainly located in the Netherlands and a major research institute (IMEC, Belgium). The close relationship with some semiconductor companies (ST-Philips) in the context of a cooperation in MEDEA+ was considered an asset to guide the research. Europe has this unique position because the US failed to build up such a total competence chain to produce this complex equipment. This example underlines the need for coordination across borders even if sometimes the integration of the results is very focused in one specific region. The European position in equipment, materials and services is based on individual success stories of some SMEs or larger companies. These need access to the main innovation ecosystems and fabrication areas to acquire the critical mass in competence required to act at global level and to valorise their results.

In **chip technology and fabrication of components**, Europe is considered weak in production of memories and microprocessors and related advanced technology, despite the presence of some non European companies (Intel, AMD). Europe has a leading position in logic devices for several application-specific markets and power electronic components. In order to progress in these fields, Europe will need to maintain access to the most advanced miniaturisation technology developments going on at worldwide level. Many spillovers of developments in memories and processor technology are expected in the field of logic devices. European companies must ensure access and occupy a strategic position in global alliances addressing these generic developments in order to take the benefits of those spillovers. It is also expected that developments and knowledge for advanced logic components addressing one application field will create spillovers in other application fields. The need to act as a global ecosystem for generic developments and generic innovation at worldwide level and for specific applications at European or even at regional level justifies public funding at European level.

Design, system integration and application competencies are available to some extent in all regions in Europe and for many application sectors, with a notable exception for computing. The ability to coordinate and combine the system developments with the design and system architecture activities is considered to be a European asset enhanced by the close collaboration between system companies (Nokia, Siemens, Alcatel, …) and semiconductor companies (ST, Infineon, NXP), still capitalising on the past IDM nature of most European semiconductor suppliers. Generic design platforms are only weakly covered and Europe has very little presence in CAD. However, it needs access to such tools in order to cope with the increasing design complexity and costs. The cooperation between system and semiconductor companies creates an advantage for Europe in the **application and system architecture** domain with many spillovers between different application domains including societal applications of public interest.

Regional coordination and cooperation is very important between the major regions involved in the most advanced developments to increase critical mass and efficiency. However, cooperation is also required with less involved regions in order to provide their local companies and institutes with an access to state-of-the-art competencies to valorise their developments and to transfer nanoelectronics progress into innovative applications.

These geographical considerations demonstrate the need for access, coordination, cooperation and information sharing between different regions to overcome a 'regional' market failure and contribute to the globalisation of the field.

Europe as well as all other regions in the world must have a presence in, or access to all activities in the nanoelectronics value chain if it is to maintain competence in this strategic field and if it wants to maintain or enlarge its market position and reap the economic and social benefits related to the nanoelectronics based applications.

4. POLICY OPTIONS

4.1. Approach to reach the objectives

New Instrument in FP7

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. The FP7 co-decided by the European Parliament and Council has recognised the problems described in the previous section, 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 Agenda. JTIs have been identified by the Commission[20] as part of FP7 to support a limited number of European Technology Platforms in reaching their objectives[21]. 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 type of instrument 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. The Community offers a legal and organisational framework that allows the effective pooling of resources from R&D undertakers, the Commission and also from national governments. In this way JTIs "transcends" the Framework Programme and national programmes, integrating both in an area where urgent action and industrial strategic focus is necessary**. Setting up the JTI as an integral instrument to run alongside the Framework Programme is an essential step in achieving the Framework Programme's overall objectives.**

As indicated by the FP7 impact assessment[22], the implementation of **Joint Technology Initiatives** will contribute to the achievement of the Lisbon competitiveness objective and the Barcelona targets for research spending, identifying areas critical for European competitiveness and supporting ambitious, research agendas which will be strategic and long-

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[20] "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

[21] *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.

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

term in nature, while involving the commitment of massive financial, organisational and human resources through public-private partnerships.

Implementation of Joint Technology Initiatives

FP7 establishes[23] that a **"Joint Undertaking" model on the basis of Article 171 of the Treaty[24]** will be the specific legal instrument to implement the JTIs. Article 171 of the Treaty offers a wide range of possible implementation structures for Community research and development programmes, of which the most prominent is a Joint Undertaking. 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 the Joint Technology Initiative 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 remainder of the document will refer to "**ENIAC JTI**" (or **JTI** in short) for the Joint Technology Initiative option, and in some cases as "**ENIAC Joint Undertaking**" (or **Joint Undertaking** in short) when dealing with the implementation details of the legal structure (legal, governance, funding schemes, etc.).

Why a JTI in the nanoelectronics field?

Nanoelectronics has been identified by the Commission as one of the potential areas for the establishment of a JTI (resulting from the work of the ENIAC Technology Platform) during the implementation of FP7[25], confirmed by the Competitiveness Council meeting on 4-5 December 2006[26].

The JTI in Nanoelectronics (**ENIAC JTI**) is a means of setting up and running a European Industrial R&D Programme in this area that runs alongside and is tightly coupled to the more foundational nanoelectronics research that is typically funded under the FP and to the MEDEA+ (EUREKA) programme aimed at some lead markets covering specific national priorities (Figure 4-1).

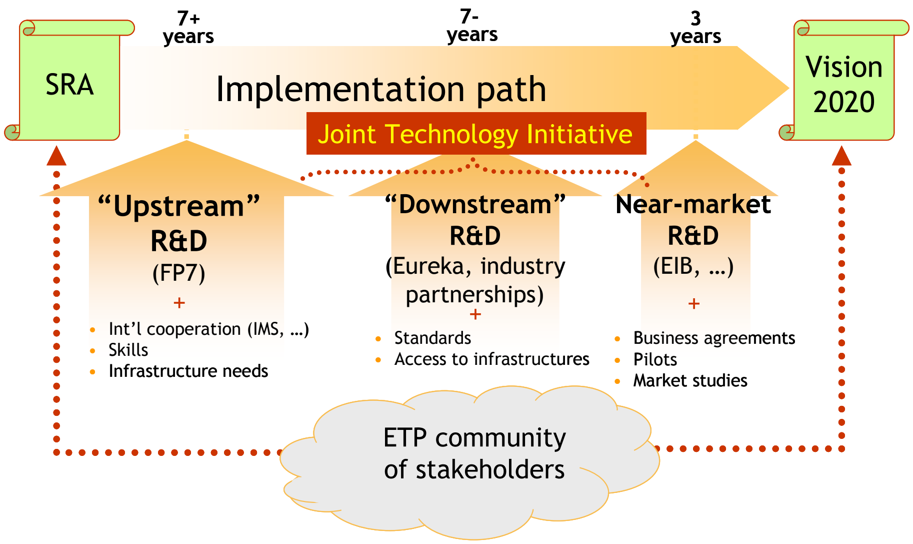
[23] FP7 text "Each Joint Technology Initiative will be decided upon individually, either on the basis of Article 171 of the Treaty (this may include the creation of a joint undertaking) or on the basis of Specific Programme Decisions in accordance with Article 166(3) of the Treaty.".

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

[25] 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

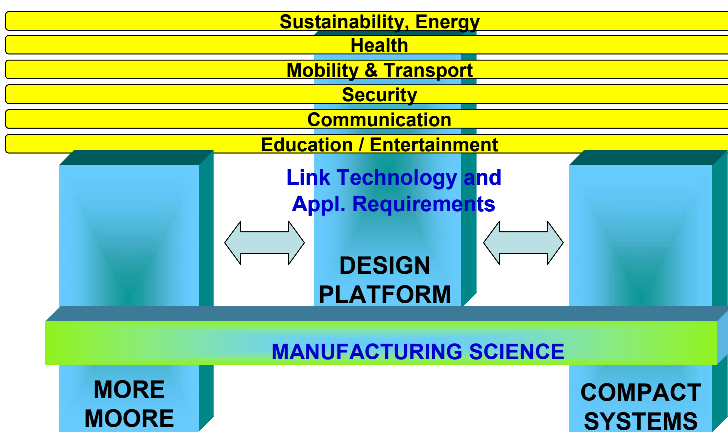
[26] 15717/06

Figure 4-1 : JTI scope



The technologies that would be addressed under the JTI R&D activities are a significant portion (~50%) of the ENIAC SRA objectives: parts of the domains More Moore, More than Moore and Heterogeneous Integration (called Compact Systems), Equipment and Materials (as manufacturing science), Design (Figure 4-2).

Figure 4-2 : JTI Contents



Those topics have a strong industrial drive for exploitation in key application sectors where Europe has a leading position. Research in these domains will contribute to achieving the technological and economic objectives highlighted in section 3.6.1.

The critical mass and greater flexibility and focus brought by the JTI instrument is especially relevant in the nanoelectronics field. The nanoelectronics sector has a strong industrial orientation and addresses the core of the Lisbon agenda by supporting innovation and competitiveness for key sectors in the EU. It has a broad constituency, much of it outside of the core ICT sector. The systemic nature of the technology, requiring close links between research, innovation and deployment; the high level of investments and risks involved; and the in-depth strategic alliances: all make the nanoelectronics field an excellent candidate for a Joint Technology Initiative.

4.2. Options discarded

Some options have been considered but discarded for the following reasons:

∉ Do-Nothing

The Do-Nothing option relates to a policy of no financial intervention at EU level in the field of nanoelectronics research and technological development (discontinuation of funding this area in FP7). As pointed out by the FP7 impact assessment[27], the Do-Nothing can be clearly ruled out as an option as it would go against the **need to invest more and better in research and innovation** and the **building of an integrated European Research Area** in a critical area for European competitiveness.

∉ Implementation of the JTI by alternative legal models

During the preparation of FP7, several 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[28] and the following is a summary of its conclusions with the most relevant alternatives considered for the legal entity form and a brief analysis of their implications for the Commission participation[29]:

- ∉ **The "European Economic Interest Grouping" (EEIG) model** (e.g. European and Developing countries Clinical Trial Partnership, EDCTP). Potentially light procedures as the legal form is already recognised and accepted in all Member States. The joint and several liability of the members is a major obstacle, especially in view of the participation of private organisations. The participation of the Community in such a legal structure has been discarded in general.

- ∉ **The "Non-Profit Organisation" model -** it could be an **Association** (e.g. asbl INTAS) or **Foundation** (e.g. European Energy Foundation), established under national law (non harmonised). The legal structure is subject to changes by national legislation. The principle of "one member, one vote" and majority voting would pose significant problems of control over the Community contribution. The participation of the Community in the legal structure is allowed only if the other members are Member States or third countries, and is strongly discouraged.

- ∉ **The "Commercial Private Company" model -** involves the formation of a profit-making enterprise, generally limited by guarantee. It is subject to changes by national legislation. There are restricted means of control for the Community (each member has a voting right in relation to his number of shares). Community participation can be accepted only in exceptional cases.

The above models are less efficient (various legal barriers), provide less critical mass (more adequate for a sole public or private membership but not both) and are less suited (lack of possibility to establish a dedicated regulation fitted for purpose) for achieving the objectives of a public-private partnership.

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[27] "More Research and Innovation - Investing for Growth and Employment :A Common Approach" Impact Assessment {COM(2005) 488 final}
[28] Commission inter-service Working Group (TP WG 3) in the "Options for establishing Joint Technology Initiatives" (24-11-04)
[29] The Commission participation in other legal structures is regulated by its guidelines C(2004)2958 of 4-8-2004

∉ Participation in joint actions by Member States

This option for achieving the ENIAC JTI objectives is based on Article 169 of the Treaty[30], which enables the Community to participate in research programmes undertaken jointly by several Member States[31] as part of the FP implementation. This option was discarded as it would present a number of difficulties:

(1) This option would address to a certain extent the fragmentation of research in Europe by bringing the Community into national R&D programmes undertaken by several Member States. However, the policy objective of strengthening and coordinating investment in nanoelectronics R&D is above all motivated by industrial competitiveness objectives. This is not necessarily achieved by participating in national R&D programmes/activities that may be geared towards specific interests. The Community would have to verify the adequacy of the national programmes with respect to the technological and economic objectives highlighted in section 3.6.1, without disposing of a serious lever on the participating Member States.

(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 nanoelectronics are of such a magnitude that an industry-driven approach is required. As the action focuses on industrial objectives that are important for economic competitiveness, industrial participation is necessary to guide the elaboration of the Research Agenda, ensuring consistency between industrial strategies and priorities and public funding policies. In addition, industry's participation is necessary to ensure their long term commitment to the objectives.

(3) The joint implementation of research programmes by several Member States would need the establishment of a private-law legal structure. The Commission guidelines32 indicate that in principle the Commission cannot participate in such bodies. Therefore, the Commission would have to contribute financially through a grant and have a limited influence but not actively lead the developments.

However, the participation of the Commission in the legal structure is of paramount importance. The EC 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 involved parties (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 the full control on its own contribution.

4.3. Conclusions of the different approaches

From the analysis in the previous sections, the **ENIAC JTI** implemented through a “Joint Undertaking" model on the basis of Article 171 of the Treaty as described in section 4.1 is the

[30]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”

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

[32] C(2004)2958 of 4.8.2004

only option that satisfies the constraints and requirements to achieve the objectives of the action: the Joint Undertaking is a structure durable over time with legal personality that (a) provides a legal framework for the collaboration and direct participation of the public (Member/Associated States and the Commission) and private stakeholders, and (b) is capable of receiving funding from different sources (e.g. grant from the Community, loans from the EIB, others)

The options considered in section 4.2 cannot be considered appropriate for the proposed actions, as they do not satisfy the above constraints.

4.4. 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 ENIAC 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 Euripides). Commission support would be through the regular instruments in the four Specific Programmes of FP7, in particular for collaborative research under the Cooperation Programme. This option will be considered as the baseline option.

(2) ENIAC JTI - "**Joint Undertaking**" on the basis of Art. 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 ENIAC 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. It is created by a legislative procedure (Council Decision) that implies the definition of all the characteristics of the entity in a Council Regulation. A detailed description of proposed model for governance and operations of the Joint Undertaking can be found in the next section.

5. STRUCTURE AND GOVERNANCE OF THE ENIAC JOINT UNDERTAKING

5.1. Participation and Legal Form

The founding members of the Joint Undertaking (ENIAC Joint Undertaking) under Article 171 of the Treaty would be Member States, the European Commission and industry (grouped in an Industrial Association called AENEAS). Other members can join in at a later stage:

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

- **Private entities** will participate in the Joint Undertaking predominantly through membership of AENEAS. The statutes of AENEAS follow the general principles of fairness, openness and transparency for accession of new members, and include special provisions for participation and representation of SMEs and for ensuring overall that industrial involvement reflects a wide industrial constituency[33].

- **Third Countries** with active policies or programmes within the scope of the ENIAC JTI and **other entities** (e.g. European Investment Bank) capable of contributing substantially to the realisation of the objectives of the Joint Undertaking will be able to participate through special accession agreements that will be negotiated between the ENIAC Joint Undertaking and the candidate.

The participation of private entities (industry and academia) in the legal structure of the JTI could be done on an individual basis or through the vehicle of a non-profit association. However, the latter provides a 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 with a very simple process, whereas if individual organisations were members of the JTI directly it is likely that the Council would need to be involved for the addition or removal of members.

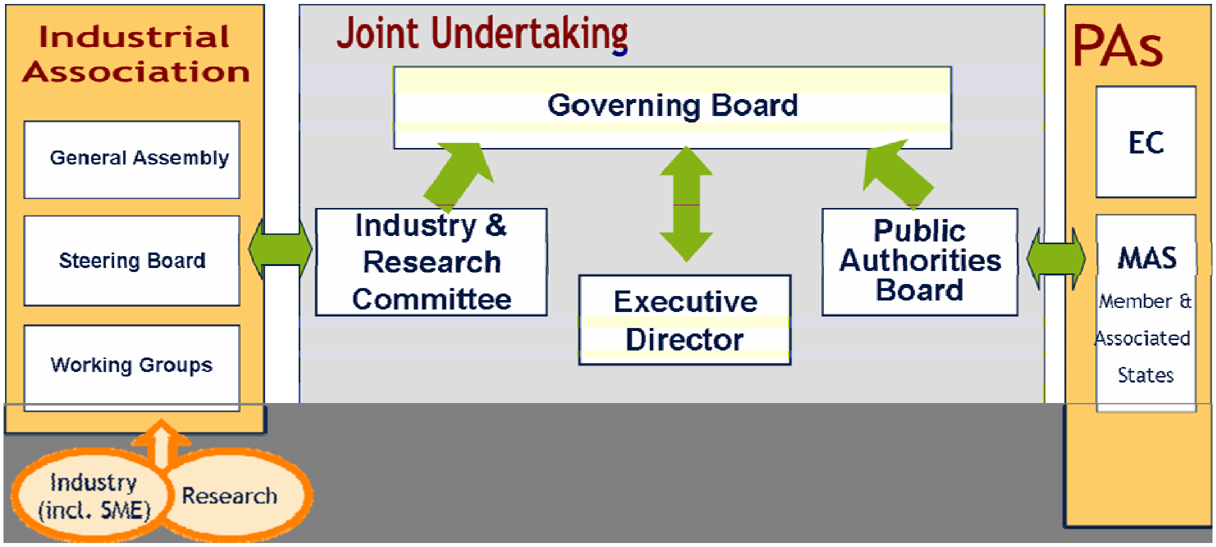
The participation of private entities through the association will ensure that industrial and academic involvement reflects a wide constituency rather than being a 'closed shop' of a few key players. The statutes of the association have to follow the general principles of fairness, openness and transparency for accession, and include special provisions for participation and representation of SMEs and academia. In addition, **the JTI's calls for proposals will be public and participation will be open to all organisations and not only to the members of the association**.

5.2. Governance Structure

The bodies of the Joint Undertaking will be the Governing Board, the Industry & Research Committee, the Public Authorities Board, and the Executive Director (Figure 5-1).

[33] AENEAS Statutes

Figure 5-1 – 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. The balance of the voting rights will be 50% for the Industrial Association and 50% for public authorities (Commission and participating States). The distribution of the votes for the public authorities will be established annually in proportion to the funds committed to the JTI's activities.

Industry & Research Committee: It will be responsible for the definition of the JTI industrial policy regarding the technological and research strategy, dissemination, public relations and other activities.

Public Authorities Board (PAB): Composed of national public authorities and the Commission. It will be responsible for decisions involving allocation of public funds following JTI calls for proposals.

Executive Director: Is the legal representative of the Joint Undertaking and ensures its day-to-day management. A **Secretariat** will be established to support the Executive Director in all his/her tasks. Non-financial tasks of the Secretariat may be subcontracted by the ENIAC Joint Undertaking to an external service provider with relevant experience, such as the ITEA or MEDEA offices.

5.3. Operations and Funding Model

The Joint Undertaking will focus mainly on the downstream part of the SRA. Its core will be an industry-driven programme, complementary to the MEDEA+ cluster of EUREKA for collaborative R&D. The JTI will elaborate a multi-annual work programme based on the SRA, under which R&D activities would be implemented through open calls for proposals. States members of the JTI will annually commit resources that will be spent mainly to fund their respective national participants in projects selected under these calls. The Commission will also commit a budget (contributed by the Framework Programme) for the JTI that supplements the funds committed by participating states. Industry will commit matching in-kind contributions and funds – more than 50% of the total costs of the projects - to execute the

R&D work. In addition, industry will contribute to operating and non-R&D costs of the JTI through cash contributions.

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 through a three-tier system:

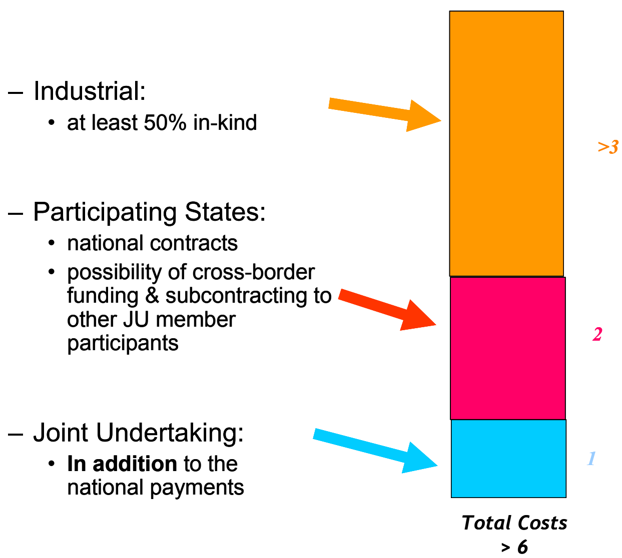
- The Joint Undertaking provides a flat rate funding percentage to all participants in selected projects of the calls launched by the ENIAC Joint Undertaking.

- Participating States provide an additional public funding to their national participants, which will complement the JU funding up to their national funding rate of projects or to a level specifically defined for this cooperative initiative by the State involved.

- Industry will commit matching in-kind contributions and funds – more than 50% of the total costs of the projects - to execute the R&D work.

As an example, a typical project could be financed 52% by industry, 32% by Member States contributions and 16% by the Commission's contribution to the ENIAC Joint Undertaking (Figure 5-2).

Figure 5-2: ENIAC Joint Undertaking Project Financing



Industry will contribute to the operating and non-R&D costs of the JTI through cash contributions. This is confirmed in a letter addressed to Commissioners Reding, Potocnik and Vice-President Verheugen[34], signed by 9 CEO's and senior executives of the main companies involved in the ENIAC Technology Platform. It is estimated that industry will provide funding of at least €24m during the initial 7 years of the JTI for the operating costs of running the Joint Undertaking.

The participants from countries that have not made commitments of funds for the Call will be eligible for the flat-rate funding percentage (anticipated at 16.7% of total participant costs) from the ENIAC Joint Undertaking.

[34] Letters of support from the main ENIAC industrial stakeholders on 31.01.06

These provisions ensure adequate flexibility of the ENIAC Joint Undertaking funding model. On the other hand, ENIAC Joint Undertaking funds that are *not* provided in combination with national funds will initially be capped at about 10% of the overall JTI budget spent on projects following a given call for proposals, so as to preserve the incentive for Member and Associated States to join the scheme and increase their annual commitments.

5.4. Appropriateness of Governance Model of the Joint Undertaking

An important question is whether in the proposed Joint Undertaking model the right members are involved and the governance model and legal structures foreseen are appropriate. The design of decision-making within the ENIAC 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 the ENIAC Joint Undertaking activities.

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

(3) The principle of **separation** of public-private bodies. The Joint Undertaking makes a clear and formal separation between the roles of public and private entities. The Industry & Research Committee leads on the definition of the Research Agenda and on industrial policy and related activities. The Public Authorities Board leads in decisions on allocation of public funds. For instance, the PAB 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 of industry participants.

(4) The principle of **independence** of the Executive Director. The Director has no decision or voting rights within either the PAB or the R&IC and acts totally independently of outside interests. The Executive Director has overall responsibility for the evaluation and selection process and, overseen by the Governing Board, will take all reasonable measures to respect its independence and efficiency.

(5) The principle of **effectiveness**. The ENIAC Joint Undertaking will utilise and build on existing mechanisms as far as possible rather than set up some 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 and common procedures for evaluation, review and monitoring: all will contribute to a more flexible approach compared to the current situation and make the JTI efficient to operate, both for participants and for the initiative itself.

6. ANALYSIS OF IMPACTS

6.1. Economic Impact

6.1.1. Impact of Strengthening and Coordinating R&D

6.1.1.1. Mobilisation of resources

For an EC contribution of **€450m** (for the duration of the Framework Programme), **the estimated mobilisation of funding for R&D activities in the ENIAC JTI is about €3bn** over seven years (Table 6-1), of which around 55% would come from industry, and the rest from public funding (European Commission and Member and Associated States involved).

Table 6-1: JTI Funding Scenario

	Total 2007 - 2013		
€, million	**Private**	**Public**	**Total**
FP	1050	1050	2100
E!	1500	810	2310
JTI - Industry	*1680*		*1680*
JTI - Community		*450*	*450*
JTI – Member States		*880*	*880*
JTI total	**1680**	**1330**	**3010**
National	5770	2880	8650
Total Co-funded	*10000*	*6070*	*16070*

In the baseline scenario (Table 6-2), for a similar additional EC contribution of €450m (for the duration of the Framework Programme), the total research efforts would be 13% lower.

Table 6-2: Baseline Scenario

	Total 2007 - 2013		
€, million	**Private**	**Public**	**Total**
FP	1500	1500	3000
E!	1500	810	2310
JTI	**0**	**0**	**0**
National	5770	2880	8650
Total Co-funded	*8770*	*5190*	*13960*

Leverage Effect

A main benefit of the ENIAC JTI for all stakeholders - industry, national public authorities and the Commission – is a better leverage effect than the "Business-as-usual" scenario (in the sense of a better mobilisation of resources by the Community contribution for nanoelectronics research in Europe).

Following the funding model detailed in section 5.3, the ENIAC JTI will allow to combine (add up) national and Community funding in such a way that 1 euro from the Community will leverage approx. 1.8 euros at national level. This funding will trigger private research efforts in a proportion depending on the funding rate (currently 50% in the FP and 35% on average in EUREKA). The incentive induced by the additional Community funding will increase the level of national funding which will in turn allow greater private research efforts. **Thus, the proposed mechanism enables one euro of the Commission's contribution to leverage an expected 7 to 8 euros of R&D effort.**

In the "Business-as-usual" Commission's contribution does not have any leverage effect at national level, and if invested through the current instruments of the Framework Programme one euro of the Commission's contribution would be matched by roughly one euro of private funds.

Additionality

There are several indications that the ENIAC JTI will be able to **attract additional funding** to R&D activities in nanoelectronics:

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 additionality mechanism foreseen in the ENIAC Joint Undertaking actually provides a strong incentive to increase national funds in the targeted areas, and **precludes substitution of national funding** as higher commitments of funds by a State result in higher amounts of Joint Undertaking funds made available to participants from that State.

At industrial level: as pointed out in the Commission communication on Economic reforms and competitiveness[35], additionality at industrial level remains extremely difficult to define and monitor at an operational level. As outlined in section 3.2, it is unlikely that the semiconductor manufacturers will continue increasing their total R&D expenditures, but the JTI should rather trigger a shift of the private R&D investments towards collaborative research at European level allowing for better cost sharing of exploding R&D costs and help keeping the R&D activities in Europe.

Indeed, industry has clearly shown its commitment to increase its collaborative funding level: As stated in their support letter for the ENIAC JTI[36] and in the ENIAC Strategic Research Agenda, industry expects – and hopes – that the national public funding available would more than double, provided that the ENIAC JTI is launched with sufficient Commission support; in this case they commit to double their pre-competitive R&D through the JTI (currently channelled mainly through the EUREKA clusters MEDEA+ and Euripides) 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 on this requires looking

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

[36] Letter sent to Vice-President Verheugen and Commissioners Reding and Potocnik , 31.01.2006

at the specific research objectives of the ENIAC JTI. All of the technical domains expected to be addressed in the JTI are essential for improving the long-term competitiveness of their products and services. However, 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 live rather than to more generic technologies (only those can be developed in a pre-competitive environment) that will not benefit just one company but the entire sector. The latter point is related to the **"behavioural additionality"** that is achieved by public grants; i.e. inciting 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 made **in Europe**. Industry R&D is increasingly global and companies locate it wherever 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 determinant for a company's decision on where to spend its R&D money. By stimulating strategic alliances between the actors in the value chain and forming knowledge clusters, the JTI will safeguard that research in nanoelectronics is executed in a European context.

Overall, for Europe to intensify its investment in R&D – as foreseen 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**: that the funding environment is sufficiently clear and stable over a longer duration to sustain industry investment; that public investments are being made in training and infrastructure; that there is no unnecessary red tape; and that regulatory issues are being anticipated and understood.

In the "Business-as-usual" scenario it is very unlikely that there will be additional money invested: the level of national funding through the EUREKA clusters tend to remain steady or even decline. On the other hand, the ENIAC JTI option provides a clear and stable framework that has received tangible national commitments and indications of likely budget increase for the areas covered by ENIAC in national programmes. The ENIAC 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 is not possible in the "Business-as-usual" scenario. As a result, competitors will be able to reduce costs by sharing enabling technologies.

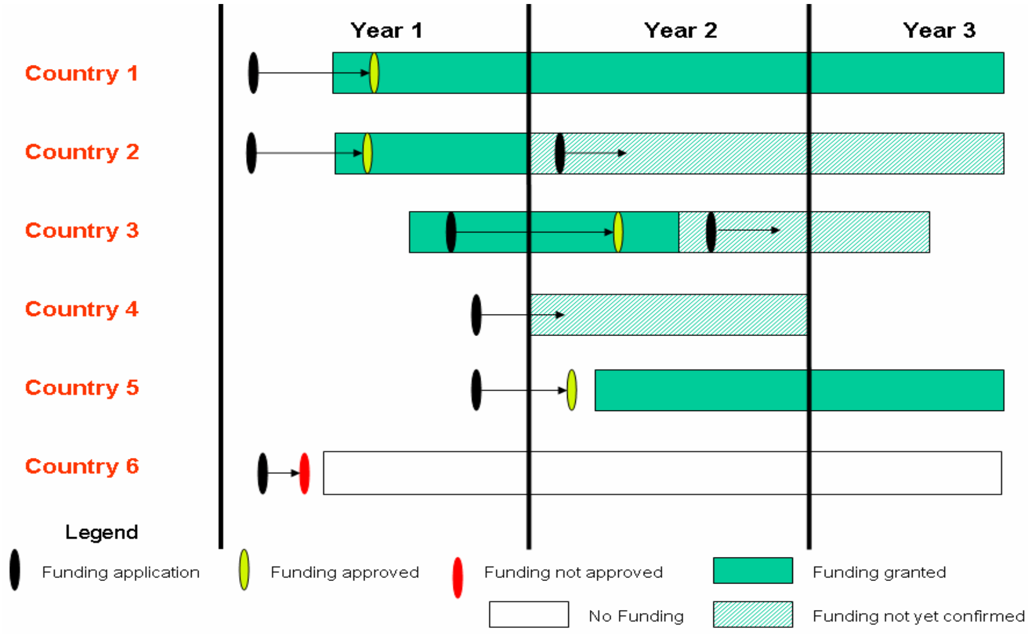
6.1.1.2. Impact of Removing Budget Uncertainty

Budget uncertainty is a key barrier in the current EUREKA approach. The funding schedule for potential participants in one (real) EUREKA project[37] is illustrated in Figure 6-1. As shown for this (typical) EUREKA project, two out of the six partners never obtained public funding; and for the other four there were just two or three whom funding periods coincided over time.

[37] Source: EUREKA Cluster presentation in CISTRANA workshop "Best practice in Multinational Programme Collaboration", Köln 18.01.06

Figure 6-1: Example of EUREKA Funding Schedule

(The horizontal bars show the time span of the activities in the project)



Firms are less reluctant to invest in preparing R&D projects if they know that funding will follow or can be assured for a longer period. The JTI will remove the funding uncertainty, providing a reliable framework with calls for proposals that have secured a budget allowing industrial stakeholders to plan their investments. Provided the Member States fulfil their financial commitments, and the JTI procedures are as efficient as planned especially regarding the one-step budget allocation/approval procedure, these new arrangements will offer a more attractive regime and should broaden the participation.

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**. Previous analysis made for the impact assessment of FP7[38] 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 allocated at national level (Table 6-3). 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 between the ENIAC JTI and the "Business-as-usual" Scenario. Indeed, the expected €840m of national money spent through the ENIAC JTI can be assimilated to EU disbursements since they will be allocated though common European procedures and focused work plans as in the Framework Programme, whereas in the "Business-as-usual" this money is disbursed according to the different priorities of national programs.

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

Table 6-3: 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 export		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

6.1.1.3. Impact of Streamlined Procedures

EUREKA is a cooperation mechanism which 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", the ENIAC JTI will:

∉ Remove the budgetary uncertainty, through binding Member States commitments under the Regulation.

∉ Remove duplication in proposal submission and evaluation, where currently different procedures are applied at national level in addition to the EUREKA level.

∉ Enable shorter time-to-contract.

∉ Remove unnecessary red-tape for participants.

These innovations will impact on stakeholders in the following ways:

∉ Applicants' time and costs in preparing proposals will be reduced significantly compared to the current application arrangements under EUREKA.

∉ In addition, a proportion of 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 adhere to a single procedure rather than the different national procedures which apply under EUREKA.

Overall, the ENIAC 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 has been possible to develop a first-level estimation based on published data and conservative assumptions.

At present, MEDEA+ funds around 10 projects per year, with an average of 13 partners per project[39]. Assuming an over-subscription[40] of around 3:1 and an average of 2 person-months per partner for proposal preparation and submission, this suggests a total effort on nanoelectronics proposals of around 780 person-months per year. At an annual R&D staff cost of €200k, this equates to €13m of effort per year, or €91m over the seven-year life of the JTI. Assuming common and streamlined procedures achieve a 50% reduction in the effort required under proposal submission, **the ENIAC JTI would thus contribute a net saving of €45.5m over the Business-as-usual Scenario. This is equivalent to ~2.7% 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. Total EUREKA investments in nanoelectronics are around €500m[41] per year and project management is assumed to account for around 5% of projects' annual costs. A reduction to 3% per annum (a 40% improvement) would reduce operating costs by €10m, equivalent to **€70m over the lifetime of the JTI** compared to the **Business-as-usual** Scenario.

Overall, **the ENIAC JTI would thus contribute a net saving of some €115.5m over the Business-as-usual Scenario.**

6.1.1.4. Impact of Shorter Time 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 schedule is less than 12 months for 51% of OEM products and less than 2 years for 85% of products[42]. 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. 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 ENIAC industrialists, **one company estimated that a reduced time-to-market of 3 months would be worth €3bn per year for its**

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[39] MEDEA+ Programme Review Report 11 1S-2006

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

[41] MEDEA+ Programme Review Report 11 1S-2006

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

business alone. Another noted that pre-competitive industrial R&D offered a powerful means 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 improvement of the ENIAC JTI over the "Business-as-usual" in removing budget uncertainty, streamlined procedures and shorter time to contract is specially important in the light of **behavioural additionality**, as the more attractive regime (**especially to SMEs)** will broaden the participation and increase the number of new partners to the R&D activities.

6.1.2. Impact of Achieving the Technological and Economic Objectives

Evaluating the impact of implementing a new instrument aimed at supporting the financing of the nanoelectronics sector R&D is not as straightforward as it would appear, due to the pervasive character of this sector.

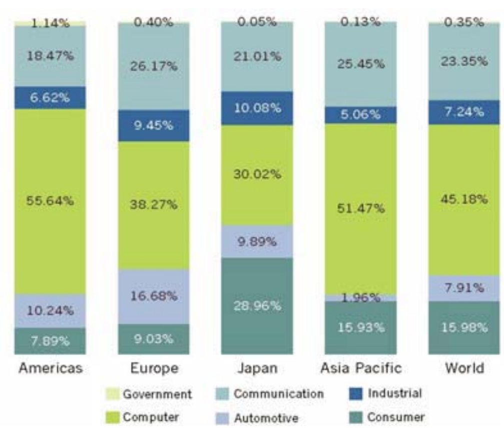
Nevertheless, some undoubtedly qualitative elements may form the basis for further discussions on economic impacts:

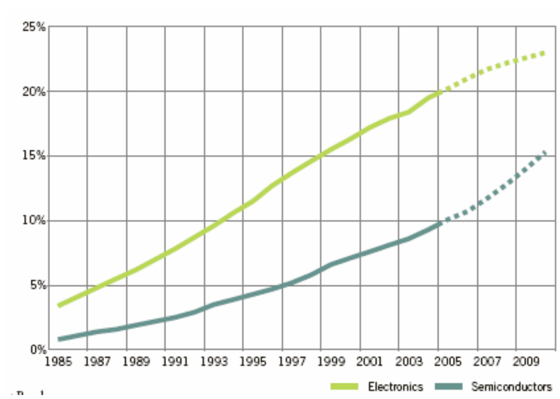
∉ Nanoelectronics components are considered to be the "intelligence" of the final products proposed by vertical markets (automotive/transportation, health, ICT, government see Figure 6-2-a). For these industries, European nanoelectronics often represent the single major differentiating success factor and value added contribution in their respective markets.

∉ Nanoelectronics components represent an increasing proportion of production costs of these goods (see Figure 6-2-b , the case of the automotive sector).

Figure 6-2: (a) Semiconductor market splits by industry segments (2004) – in % on total (source WSTS)

(b) Development of electronics and semiconductor content of the production costs of an average light vehicle (source Bosch)





∉ Due to the complexity of systems design, a close relationship, more often concretised by a close geographical positioning between electronic components suppliers and applications developers, is sought. It is the complete semiconductor value chain, ranging from innovative chip design to electronic systems integration and electronic value added in the end-user product, which enables the industry to achieve global competitiveness.

- This is also extended to the R&D lifecycle of nanoelectronics where electronics designers (both front-end and back-end) need access to state of the art EDA[43] tools and libraries. The development of such tools requires privileged access to process development, due to increased complexity derived from new physical effects impacting electronic components.

- According to the European Semiconductor Industry Association (ESIA) Europe imports more chips than it produces. ESIA's concern is that Europe will host fewer wafer fabs than other parts of the world, therefore resulting in lower potential for semiconductor innovation: R&D is increasingly linked to the leading-edge process technologies in the fab.

Any efforts made to support the European nanoelectronics industry will then not only support the more than 120 000 jobs within the European nanoelectronics industry and research but will also allow increased innovation and productivity in the vertical markets, thus supporting the employment of the 3 million people within the transportation sector[44], of the 7 million people employed in communications, and in information services and media. The same justification can be extended to other sectors.

From this high-level analysis, the expected JTI impacts can be derived in relation to the objectives identified in section 3.7.2.

6.1.2.1. Impact of achieving objective 1: Share the increasing costs of the R&D activities and infrastructures in order to maintain Europe in line with the ITRS roadmap.

The ITRS roadmap identifies short to medium technical targets to be achieved with use of the CMOS technology. Keeping Europe connected with this roadmap allows large players to stay in the race compared to their worldwide competitors (Table 6-4) and small players to benefit from spillovers to address alternative and innovative markets.

European partners will be able to achieve the critical mass in resource and competence in the JTI which will allow them to play an important role in the decision-making process in global alliances. In addition, the innovative SMEs may use their participation in the alliance networks in the JTI to broaden their market view and establish a presence at world wide level.

European public funds are far below the level needed to set up state of the art infrastructures or the critical mass of R&D. Nevertheless they are the magnet of further private and national investments. Many national policies in terms of technical and scientific priorities are aligned with the European ones. Moreover, several new strategic initiatives are launched by Member States to support these technologies. The French initiative called 'Pôles de Compétitivité' aims at building regional networks of universities and industries to enhance the national competitiveness of the industry, in line with the Lisbon agenda. In 2006 for example, €82m of public investment will translate into €1bn projects in the Grenoble based Minalogic Pôle de Compétitivité.

[43] Electronic Design Automation
[44] Source Eurostat

Table 6-4 : Top 15 Ranking of Semiconductor Companies

2006 Top 15 Worldwide Semiconductor Supplier Ranking (Fcst, $M)

2006 Rank (Fcst)	2005 Rank	Company	Headquarters	1Q06 Sales ($M)	2Q06 Sales ($M)	1H06 Sales ($M)	3Q06 Sales ($M)	4Q06 Fcst ($M)	2H06 Sales ($M)	2006 Fcst ($M)	2005 Sales ($M)	06/05 % Change
1	1	Intel	U.S.	[illegible]	5,215	15,255	[illegible]	[illegible]	16,325	31,580	[illegible]	[illegible]
2	2	Samsung	South Korea	[illegible]	4,581	8,986	5,062	5,465	10,529	19,475	[illegible]	9%
3	3	TI	U.S.	[illegible]	[illegible]	6,765	[illegible]	[illegible]	7,105	13,870	[illegible]	23%
4	4	Toshiba	Japan	[illegible]	2,154	4,471	2,809	2,790	5,559	10,030	9,045	11%
5	5	ST	Europe	[illegible]	2,481	4,854	2,517	2,562	5,076	9,930	[illegible]	12%
6	7	TSMC*	Taiwan	[illegible]	[illegible]	4,911	[illegible]	[illegible]	4,804	9,715	[illegible]	18%
7	6	Renesas	Japan	[illegible]	2,083	4,046	[illegible]	[illegible]	4,124	8,170	[illegible]	-1%
8	8	Hynix	South Korea	1,522	1,635	3,157	2,027	2,191	4,218	7,375	5,596	32%
9	9	NXP	Europe	[illegible]	1,504	2,999	[illegible]	1,573	3,966	6,965	[illegible]	14%
10	9	Freescale	U.S.	[illegible]	1,503	3,000	[illegible]	1,526	3,080	6,080	5,598	9%
-	-	Total Top 10	-	29,149	29,255	58,404	31,527	32,659	64,186	122,590	115,726	6%
11	11	NEC	Japan	[illegible]	1,481	2,767	1,462	1,496	2,958	5,725	5,593	2%
12	12	Micron	U.S.	[illegible]	1,332	2,574	1,416	1,576	2,936	5,510	4,954	11%
13	16	AMD	U.S.	[illegible]	1,216	2,548	1,328	1,444	2,772	5,320	3,936	35%
14	13	Infineon**	Europe	1,227	1,250	2,477	1,288	1,292	2,578	5,055	4,808	5%
15	18	Qimonda***	Europe	[illegible]	1,227	2,345	1,310	1,350	2,660	5,005	3,490	43%
-	-	Total Top 15	-	35,454	35,661	71,115	38,322	39,766	78,088	149,205	138,506	8%

*Pure-Play Foundry **Not including Qimonda ***Spin-off from Infineon

Source: IC Insights, Company reports

The whole nanoelectronics value-chain is concerned by this objective as, even if most of the fabs might be in Asia, they will need state of the art equipment and materials to process the components. Europe has a strong expertise in the field. The backlog per region of a European equipment manufacturer such as ASML shows exports to Asia of 67% (compared to 6% for Europe and 27% to the USA). Moreover, ASML is not an isolated case. Looking at the VLSI Inc best awards for equipment manufacturers (Table 6-5) shows that for wafer processing, material handling and assembly equipment, among the 40 awards, 14 are for European based companies, 16 for Asian (mainly Japan) based companies and 10 for American based companies. Moreover, several non-European companies have research labs in Europe.

Table 6-5: VLSI Research Inc BEST Awards for equipments manufacturers

2006 10 BEST WAFER PROCESSING EQUIPMENT

(Small Suppliers Based on Revenue)

1	Nissin Ion Equipment Co., Ltd	Asia
2	Oxford Instruments	Europe
3	Unaxis Wafer Processing	USA
4	EV Group	Europe
5	AIXTRON AG	Europe
6	SEZ Group	Europe

2006 10 BEST WAFER PROCESSING EQUIPMENT

(Large Suppliers Based on Revenue)

1	Varian Semiconductor	USA
2	ASML	Europe
3	Hitachi Kokusai Electric Inc.	Asia
4	Tokyo Electron Limited	Asia
5	Dainippon Screen Mfg. Co., Ltd.	Asia
6	Hitachi High-Technologies	Asia

				Corporation	
7	SUSS MicroTec	Europe	7	ASM International N.V.	Europe
8	SEN Corporation	Asia	8	Applied Materials, Inc.	USA
9	Axcelis Technologies	USA	9	Novellus Systems, Inc.	USA
10	S.E.S. Co., Ltd.	Asia	10	ULVAC, Inc.	USA

2006 10 BEST MATERIAL HANDLING EQUIPMENT			***2006 10 BEST ASSEMBLY EQUIPMENT***		
1	SUSS MicroTec	Europe	1	ACCRETECH-Tokyo Seimitsu	Asia
2	Seiko Epson Corporation	Asia	2	HANMI Semiconductor	Asia
3	ACCRETECH-Tokyo Seimitsu	Asia	3	Orthodyne Electronics	USA
4	Rasco GmbH	Europe	4	DISCO Corporation	Asia
5	Electroglas, Inc.	USA	5	Towa Corporation	Asia
6	Multitest	Europe	6	ICOS Vision Systems Corporation NV	Europe
7	Advantest	Asia	7	ASM International N.V.	Europe
8	Tokyo Electron Limited	Asia	8	Alphasem	Europe
9	Shinano Electronics Co.,Ltd.	Asia	9	Kulicke & Soffa	USA
10	Cascade Microtech, Inc.	USA	10	F & K Delvotec Bondtechnik GmbH	Europe

It is therefore of vital importance to build anchors for these companies to stay in Europe. Such anchors will be made up of competence pools and innovation potential and will be created through the encouragement of networking between these companies, research institutes (IMEC, LETI, and Fraunhofer) and by giving them access to state-of-the art prototype fabs, which will be a primary focus of the JTI.

6.1.2.2. Impact of achieving objective 2: Take the leadership in diversifying applications of semiconductor technologies and applying them to alternative innovative markets.

Due to the fact that nanoelectronics are expected to have a substantial impact on the world's economy, market volumes are appropriate indicators for its economic significance. Nanoelectronics contribute substantially to many product improvements and enable the production of completely new products.

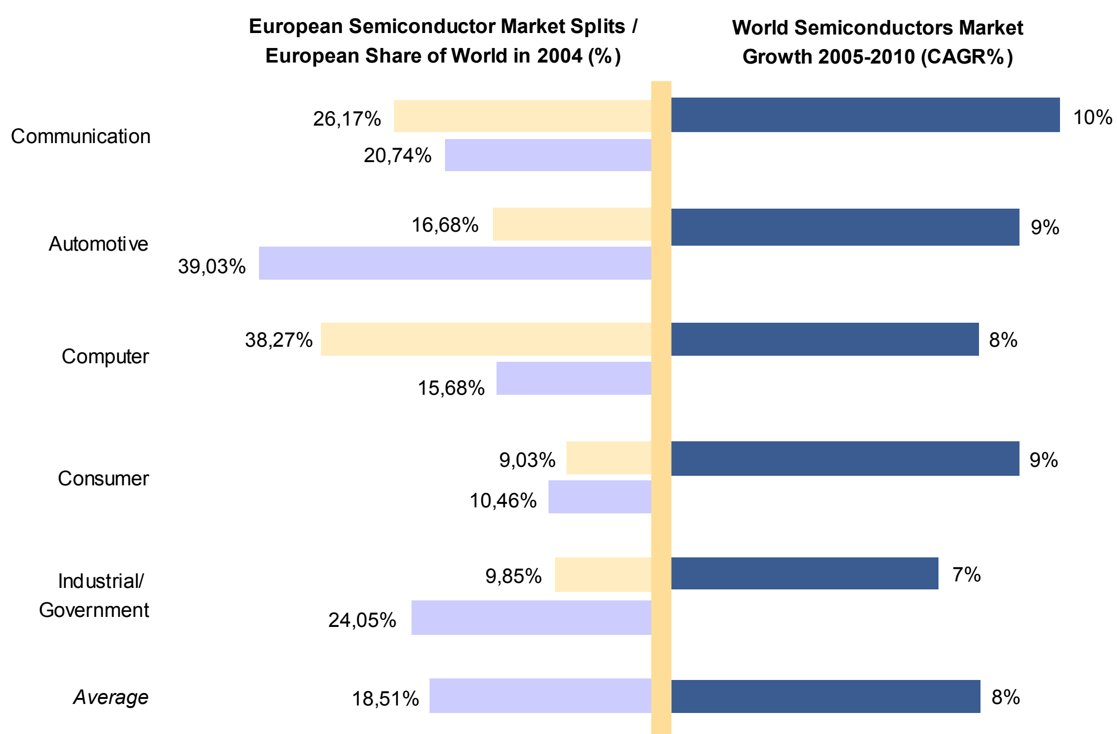
Most market forecasts for nanoelectronics originate from the start of the 21st century, with a time horizon of up to 2011-2015. According to data from the World Semiconductor Trade Statistics (WSTS) semiconductor sales are expected to surge to \$400bn in 2011. Chip sales have hit a new $100bn plateau approximately every 4-5 years, starting in 1994, but the time to reach those benchmarks has been widening -- the industry achieved $204bn in the boom year of 2006, and won't hit $318bn until 2008. Compound annual growth rate from 1990-2006 was about 10.4%, while CAGR for 2006-2011 is expected to be 10.6%.

Meanwhile, expenditure on new equipment from semiconductor firms has also increased (fabrication, assembly, test, etc). Capital spending has an expected growth of 14% to $53bn this year -- still below the record $60bn set in 2000 -- but will surge to $84bn by 2011. However at this level, the ratio of capex as a % of semiconductor sales should still be the same as it is now, around 21%.

From a market growth perspective, Europe has come up short. In 2005, the European semiconductor market was worth $40bn, up 1.7 percent, however the world market grew 8.2 percent, according to WSTS. In 2006, Europe is expected to grow 17.9 percent, whereas the U.S. market is forecast to grow 21 percent and Asia 28 percent.

European semiconductor market drivers will include automotive electronics and communications (Figure 6-3), but also many other segments such as health/medical, environment, entertainment and security. Concentrating on European strengths by offering innovative technologies to the most promising sectors will allow to increase the market shares of not only the nanoelectronics industry itself (go above 20%) but also the application or user industries for which market volumes are even larger.

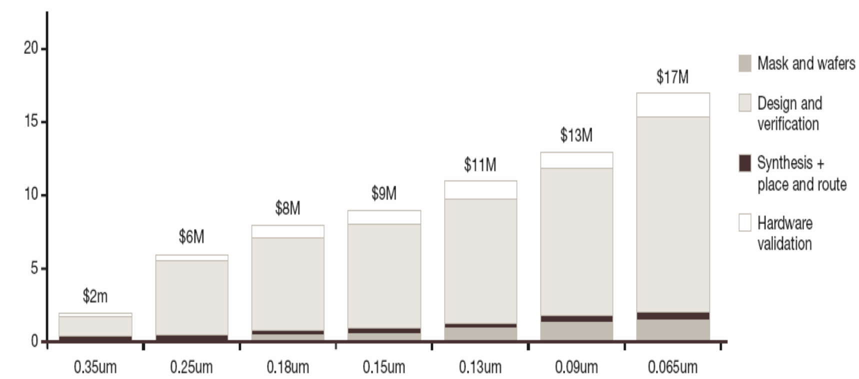
Figure 6-3: Sectoral positioning of European nanoelectronics (source WSTS)



<u>Impact of achieving objective 3</u>: Manage breakthroughs in electronic design, in order to fill the ever-widening gap between what is achievable in technologies and what can economically be designed and tested.

Miniaturisation and the increasing functionality of components are leading to a step-change in system complexity (Figure 6-4). Designers are looking to use modular approaches to keep the design effort manageable and successful. Even so, the increase in technological capabilities is out-pacing the productivity improvement of the designers, leading to an ever-widening design productivity gap. In the medium term, this design complexity, together with Moore's Law, will make progress unsustainable. Research programmes must therefore not only support the evolution of the state-of-the-art innovations, but also stimulate disruptive solutions to fill this widening gap and achieve major breakthroughs in design capabilities.

Figure 6-4: Cost per design by technology (conservative estimate – realistic costs as much as 2.5x number shown). Source: Fab-less Semiconductor Association



There are tool suppliers and consulting firms that have a 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 is a surprisingly high number of tools employed both in research and in industry to get from specification to design and implementation, while the degree of industrial adoption for new techniques is very low. If semiconductor chip design is somewhat separated today from embedded software development, then industry is evolving towards a complete chain that goes from the semiconductor material toward the final chip functionalities, in particular within SoC (System on Chip) and SiP (System in Package) components. Innovation in the field may then be hindered due to a lack of common standards and tools.

The pressure to reduce design cost exists everywhere. Yet it is more pronounced in the chips that include analog circuits. In recent years, the demand for mixed-signal (analog and digital) IC products has accelerated. According to a recent Fab-less Semiconductor Association survey, about 40% of the wafers ordered by its members were for mixed-signal design. This increase in demand is growing rapidly, thanks to high-growth markets like wireless networks and digital-audio devices. According to the International Data Corporation (IDC), for example, the cumulative semiconductor revenue from wireless networks from 2003 to 2008 will hit more than $180bn. The market for audio ICs is set to exceed $6bn in three years. Despite such strong growth, increasing pressure is being placed on semiconductor companies to keep design costs down in order to remain competitive.

In the absence of disruptive technological solutions, the approach to tackle the widening design-productivity gap is the addition of further human resources. The new generations of integrated circuits are increasingly complex and demand higher levels of functional safety and security. Accordingly the number of R&D workforce in the design field has to be increased too.

Quantified targets have yet to be defined within the ENIAC SRA, and embedded software development shares the same problematic as that of integrated circuits development. One could therefore refer to the objectives of the ARTEMIS SRA, in order to define directions for the ENIAC JTI, which, within 10 years, are to:

- reduce the cost of integrated circuit design by 50%, through approaches that will enable a much higher degree of strategic reuse and easier assembly;
- achieve 50% reduction in development cycles, through a focus on design excellence, including test, validation and verification;
- manage a complexity increase of 100% with 20% effort reduction, through techniques to better manage uncertainty in the design process and upgradeability throughout the lifecycle.

To estimate the population of integrated circuit designers we assume that the development of a typical 90nm digital circuit involves 2.5 more embedded software developers than IC designers (source: NXP). Knowing that the worldwide population of system developers is estimated by FAST GmbH between 460.000 and 488,000[45] in 2005, it should be growing to 530.000 in 2007 at the start of FP7.

It is clear that just increasing the labour force is not a sustainable solution in the area of integrated circuit design. Europe cannot continue to hire more programmers indefinitely in order to tackle the design gap. Although Europe shows strong increases in engineering graduates in Europe (three times as many engineers as North America in 2002), it has to fight the brain-drain of highly skilled engineers and doctorates (mainly to the USA) and the slowing down of importing foreign third-country graduates (much of the world had developed an infrastructure capable of keeping home and using these highly educated people productively).

6.1.2.3. Impact of achieving objective 4: Provide European SMEs with effective and efficient tools to support them in their innovation process

Medium and long-term visions of market needs still appear to be a key element, both for the semiconductor industry and the application developers. In particular a clear advantage is given to semiconductor suppliers able to provide new functionalities to support application needs in a very short time to market. Moreover, SMEs are insufficiently involved in FP based European programmes due to the long and complex procedures. The ENIAC JTI is a way to get prepared for such needs and to guarantee such a short reaction time. This is in particular true for nanoelectronics, where a significant number of small innovative companies exists, with numerous Fab-less and IP SMEs, together with start-ups developing specific technology, design software, materials or equipment. Compared to equivalent companies in the US, those SMEs have difficulties in sustaining growth and surviving, often due to a lack of access to critical market data and vision, lack of venture capital funding and difficulties to access the fragmented European market.

On the other hand, high-tech SMEs are key contributors to innovation. Companies such as Intel or Cadence invest massively in SMEs to get a foot in the door to potential innovative

[45] ARTEMIS Strategic Research Agenda, and Study of Worldwide Trends and R&D Programmes in Nanoelectronics (FAST GmbH)

solutions that they could not develop internally. Those factors limit the growth of small companies and the innovation process in large companies. This holds particularly true in nanoelectronics where the sector faces fast technological changes both internal (Moore's law) and external to the sector (emergence of new applications).

A simple calculation can be made: according to the Fab-less Semiconductor Association (FSA), latest statistics indicate that 144 companies worldwide raised €1.4bn in 2004 versus 135 raising €1.2bn respectively in 2003. That growth represents the highest level funding since 2001. The average level of funding has also grown from €8.9m to €9.7m during the same period.

However, of this total of 144, only 18 companies were based in Europe, compared with 107 for the US as a whole in 2004. Based on the €9.7m average funding per company, we can then make the straightforward calculation that the €1330m of JTI public financing correspond to the financing of 137 start-ups over the 2007-2013 period (we take the assumption of a constant financing level of start-ups over the period).

This calculation does not correspond to the reality as the JTI financing will not be considered as "fund raising" but is a conservative estimation: These start-ups will benefit from those funds for their technological development. Moreover having public bodies investing in a particular technology will further attract VC funds, adding one more leveraging effect of the JTI fund.

The JTI is somewhat comparable to the US Advanced Technology Programme[46] which realises periodic impact assessment. Results of this public-private programme showed that more than 80% of firms having participated in an ATP project gain a 1 to 3 years acceleration of their R&D lifecycle. The JTI should target similar objectives in its technical domains *More than Moore* and *Design Automation*. This is realistic under the assumption that the projects supported by the JTI will be of a significant size which will allow the large industrial organisations to bring along several SME associates.

6.1.3. General Economic Impacts

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

Impacts on:	**ENIAC JTI scenario relative to the baseline case:**
Competitiveness, trade and investment flows	Positive competitive advantage of EU ICT industry and end-user industries More efficient EU nanoelectronics sector Potential to protect and increase the EU's market share Potential to reduce the EU's trade deficit on imported devices
Competition in the internal market	Level playing field for nanoelectronics-based industry and European regions Increased cost-effectiveness of nanoelectronics industry

[46] The Advanced Technology Programme (ATP) is a public-private partnership managed by NIST. Its mission is to accelerate the development of innovative technologies for broad national benefit - http://www.atp.nist.gov/

	and end-user industries Opportunities for new applications and markets
Operating costs and conduct of business	New paradigm for investment in nanoelectronics research and innovation within a public-private partnership Major cost-savings to industry through sharing costs and risks of research investment
Administrative costs on businesses	Cost of running the JTI small compared to the benefit Model foreseen is for a small and lean entity Options identified to outsource routine administration
Property rights	Property rights in ENIAC results will be identified on a case-by-case basis, according to rules that will serve as an industry model
Innovation and research	Extremely positive impact on innovation and research, pooling together resources into a coordinated and integrated programme ENIAC will dramatically increase the introduction of new technologies ENIAC will increase the level of industrial research ENIAC will promote a greater efficiency of resource allocation
Consumers and households	ENIAC results are expected to lead to a wide range of new products and services for consumers, leading to increased efficiency, safety and choice. ENIAC research will be strongly application-driven, focusing on five domains: health, mobility & transport, security & safety, communication, and education & entertainment.
Specific regions or sectors	Nanoelectronics systems are deployed in all market sectors – automotive, aerospace, medical, environment, communications, entertainment, textiles, transport, logistics, printing & paper, chemicals, food & drink, business services, etc.
Third countries and international relations	ENIAC will foster collaboration with international partners so as to: open new markets; mobilise resources; promote European standards; and help Europe become a ‘brain magnet’ for the best researchers worldwide. The JTI will provide competence and critical mass to participate in global alliances.
Public authorities	ENIAC funding will partly come from public money (EU, national and even regional) which will have a key role in leveraging private sector resources
The macroeconomic environment	The impact on the macroeconomic environment will be felt through a combination of all the above

6.2. Social and Environmental Impact

6.2.1. Social Impact

The ENIAC SRA – and by implication the JTI – impacts at the societal scale in a number of ways[47].

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

The ENIAC SRA is oriented towards the vision of 'ambient intelligence', living environments that are aware of our presence and responsive to our needs. Devices will know about their situational state, be able to recognise individual users, tailor themselves to each user's needs, and anticipate each user's desires without conscious mediation.

ENIAC targets such environments within six application domains: health, mobility & transport, security & safety, communication, energy & environment and education & entertainment. In health, for example, nanotechnology will bring a revolution in medicine: new bio-sensors that enable diseases to be diagnosed and treated earlier; intelligent medical implants that provide continuous monitoring of a patient's state of health; and advanced prosthetics to restore impaired sensory functions are just some of the likely developments. Innovations in other domains will include: new safety, security and environmental systems for cars and buildings; handheld portable communications devices that allow anytime, anywhere connectivity; and new means of capturing, storing, protecting and packing content.

ENIAC 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); e-learning services to help bridge the digital divide; and participation in socially beneficial eGovernment services.

Impacts on:	**ENIAC JTI scenario relative to the base case:**
Employment and labour markets	ENIAC will significantly increase productivity by enabling smarter working and more agile production ENIAC will lead to the creation of several thousands of jobs in Europe, in the ICT sector as well as in the overall economy through indirect or induced effect
Standards and rights related to job quality	ENIAC will lead to better quality jobs by supporting human operators and providing enhanced automation and control

[47] Complexity and Uncertainty – a prudential approach to nanotechnology, paper by Jean-Pierre Dupuy, Ecole polytechnique de Paris & Stanford University: there should be a co-evolution of technology and society. The dynamics of technological development is embedded in society. Technology and society shape one another. Therefore, it is important to do an ongoing normative assessment in order to link the future with the past and then with the future again.

	ENIAC results will increase the added-value of jobs across a wide range of application domains
Social inclusion and protection of particular groups	ENIAC 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); e-learning services to help bridge the Digital Divide; and participation in socially beneficial eGovernment services.
Equality of treatment and opportunities, non-discrimination	Not relevant
Private and family life, personal data	ENIAC will improve the choices available to European citizens in terms of work-life balance, while also improving safety and security.
Governance, participation, good administration, access to justice, media and ethics	ENIAC brings new working methods across industry and civil society. ENIAC's own governance structure involves participation from the full range of stakeholders: large industry, SMEs, academia, national public authorities and the Commission. Each of these groups will participate to the decision-making process.
Public health and safety	Both eHealth and environment are key ENIAC applications.
Crime, Terrorism and Security	Safety & security systems is a key ENIAC application, covering both personal/home protection systems and high performance systems for business and safety-critical applications
Access to and effects on social protection, health and educational systems	As above – eHealth, eLearning and eGovernment are key ENIAC applications.

6.2.2. Environmental Impact

6.2.2.1. Environment, Safety and Health (ESH) in nanoelectronics life-cycle

The European Commission promotes a safe, integrated and responsible strategy for nanosciences and nanotechnologies for Europe in its Communications "Towards a European Strategy for Nanotechnology" COM(2004) 338 and "Nanosciences and nanotechnologies: An action plan for Europe 2005-2009" (COM(2005) 243). The strategy confirms that nanotechnology must be developed in a safe and responsible manner and that nanotechnology and nanoparticle developments should address any potential public health, safety, environmental and consumer risks upfront by generating the data needed for risk assessment, integrating risk assessment into every step of the life cycle of nanotechnology-based products, and adapting existing methodologies and, as necessary, developing novel ones.

The risks for operators inside the production facilities are well under control. Particle density in production areas is carefully monitored, since dust particles are one of the main threats to the yield of semiconductor manufacturing, and the use of dangerous materials in the production flow has been reduced to minimum, due to the very high quality standards required.

Due to its knowledge-intensive nature, nanoelectronics is probably the manufacturing activity that has the best ratio between value produced and amount of waste products. The volumes of materials handled in a fab are extremely small, while the nature of the products requires an extreme degree of cleanness under strict control standards. The efficiency of the manufacturing processes is such that very minimal waste of materials takes place.

Differently from other nanotechnologies, end-products based on nanoelectronics are not as far as it is currently known affected by the problems related to the poorly known potential negative effects on environment or on people of materials dispersed in the form of nanosize particles. Even if the single elements of an integrated circuit are patterned with a resolution of a few tens of nanometres, the resulting device is a compact object which interacts with the environment on the macroscopic scale.

However, the nanoelectronics industry needs to face in a responsible manner the potential challenge of behaviour and transformation in the end-of-life stage of nanoelectronics components in line with the Commission integrated and responsible strategy for nanotechnologies. Potentially released nanomaterials may cause adverse effects on the environment or human health in the end-of-life stage. Therefore the necessary measures for the environmentally sound management have to be foreseen. The classification of waste in particular will be determining for the regime to be followed; when applied into electrical and electronic equipment, the end-of life stage is now subject to a comprehensive legislative framework under the Community's Waste Electrical and Electronic Equipment (WEEE) directive (Directive 2002/96/EC). 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 electronic tools, and consumer appliances, all of which are likely to contain nanoelectronics components in some form.

In addition, legal provisions are constituted by the chemicals regulation and in particular by REACH, the Regulation (EC) No 1907/2006[48]. REACH provides an overarching legislation applying to the manufacture, placing on the market and use of substances on their own, in preparations or contained in articles. REACH has no provisions referring explicitly to nanomaterials. However, as REACH applies to "substances"[49] individually, in preparations or contained in articles, manufactured nanoparticles such as carbon nanotubes, metallic nanoparticles, particles of oxides such as titanium dioxide and quantum dots, are all considered to be 'substances', and therefore covered by REACH.

[48] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC,OJ L 396 of 30.12.2006

[49] i.e. chemical elements and their compounds in the natural state or obtained by any manufacturing process including any additive necessary to preserve the stability of the products and any impurity deriving from the process used, but excluding any solvent which may be separated without affecting the stability of the substance or changing its composition.

Notwithstanding these considerations, the semiconductor industry has taken a proactive role towards its environmental responsibilities, pursuing voluntary initiatives to contribute to a comprehensive emission reduction program for PFCs, which goes beyond the Kyoto requirements. This worldwide initiative was started in 1997 and aims to reduce absolute emissions by 10% by 2010, using 1995 as a baseline. It is currently well on track. Similar ambitious programs have been undertaken by European semiconductor industry for the elimination of environmental unfriendly materials, like lead, and for the reduction of primary resources (water, energy) consumption per worked wafers.

6.2.2.2. Nanoelectronics applications for environment

The nanoelectronics manufacturing sector has changed significantly over recent years and generally has a good environmental record. Within Europe, the production process is regulated under Community environmental legislation, although much of the manufacturing is migrating to developing countries where environmental standards are not so high. Nevertheless, global companies are increasingly aware of their environmental reputations wherever in the world they operate.

All electronic systems use electricity and are part of a general trend towards the 'electrification' of society as a result of greater use of ICT. However, use of electronic systems also allows better management and control of system energy efficiency and in many applications this is their primary purpose. Moreover, reduced power consumption for electronic devices is an important and ongoing technical objective for designers, including under the ENIAC SRA.

Environmental monitoring and management itself is a key application area for ENIAC results. Mesh networks based on huge numbers of micro-scale sensors and actuators are envisaged, for situations such as industrial pollution monitoring and ecological assessment, which will be able to monitor their surroundings and respond accordingly. In addition, energy efficiency and environmental benefits are a key focus in the use of electronic devices in applications such as automotive control systems, industrial automation, and home automation.

Impacts on:	**ENIAC JTI scenario relative to the base case:**
Air quality	Environmental monitoring and management is a key application for ENIAC results. 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 – e.g. environmental technology will allow improved water filtration devices
Soil quality or resources	As above
The climate	Contribution through improvements in the energy and resource efficiency of manufacturing and business processes, consumer products and services, and public infrastructures.
Renewable or non-renewable	Electronic systems will facilitate the better integration of small-scale and renewable generation into energy

resources	networks. They will provide better means for a sustainable power supply, a reduction in air pollution and a sustainable environmental protection. They will provide solutions for improving renewable energy systems and help fostering their future implementation.
Biodiversity, flora, fauna and landscapes	Not relevant
Land use	Not relevant
Waste production / generation / recycling	Adverse effects on the environment and human health should be assessed for each individual application in their end-of-life phase
The likelihood or scale of environmental risks	No specific risks arise from JTI activities. All potential risks are covered by existing regulation and generic risks related to nanotechnology in general are covered by the action plan "A responsible approach towards Nanotechnology development". Improved monitoring and control through the use of electronic 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	ENIAC 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[50].
The environmental consequences of firms' activities	see Air Quality above
Animal and plant health, food and feed safety	Not relevant

[50] The 4th Nanoforum Report, Part 2, October 2005 mentions advantages towards the automotive transport (ecology, security, comfort, passenger safety)

7. BENEFITS AND RISKS

7.1. What if no action?

Competence in manufacturing is increasingly shifting to the Far East, and most European companies are concentrating to keep the more added value operations at home. It is vital for Europe to maintain a level of manufacturing competence in Europe capitalising on the existing ecosystems in some of its regions, and European companies must be able to participate in global alliances to safeguard their capability to innovate in their products. If not, Europe may run the risk that also the competence to integrate new functionalities into smart systems will follow the off-shoring trend, weakening in the long run the capability to produce in Europe added-value in electronic systems. Europe would loose its capability to design its own products following its own high standards of quality, sustainability and environmental friendliness, having to fully rely on other parts of the world. This would result in a dramatic decrease in competitiveness in general, particularly as nanoelectronics is at the bottom of a food-chain to build intelligence in all products, in all activities forming the basis of the knowledge society and for the ambient intelligence environment. Both are generally expected to be the next wave of ICT innovation to come and a motor for the future economy at large.

Europe would also loose its capability to control its socio-relevant / policy-relevant developments in sectors as healthcare, security, safety, mobility, environment, food control, and many more. This would have major consequences on the "well-being" and "well-living" standard of all European citizens and would have major consequences for the number of high quality jobs, not only in the hardware sector but for all other activities dependent on hardware innovation. In order to avoid such a doom scenario, there is a political will to safeguard more European competence on European soil while encouraging strategic alliances to form knowledge-based ecosystems as well as to strengthen European presence in global alliances.

Will a JTI help to safeguard European competitiveness in nanoelectronics? Will €450m for 6 years be of any help? First, €450m will trigger an R&D programme of €3bn. More important than money is that an integrated European initiative designed to link the different required competences together (manufacturing, design, technology; further miniaturisation as well as integrating more functionality and system capabilities; linking multi-disciplinary research with innovation stimulation) with a holistic approach, will deepen the strategic alliances between European partners and between manufacturers and the system innovators (the users of nanoelectronics based products). This will provide for the European participants sufficient critical mass in terms of resources, access to infrastructure and competences to compete or cooperate at worldwide level. It may anchor the research on nanoelectronics for a longer period (the coming 20 year) on European soil. It is essential to assure such a long term investment as it is generally expected that fast progress in nanoelectronics towards further miniaturisation and "integrated functionalisation' will be maintained for another 20+ years before other disruptive technologies may take over some of this progress. The strategic alliances and the formed knowledge ecosystems will further provide opportunities for many SMEs to cooperate within a larger vision and a larger context in order to grow and to be able to compete internationally.

7.2. Benefits and Risks for Stakeholders

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

For **industry** it offers:

- *Clear objectives and deliverables* driven by industry's own research priorities, as set down in the ENIAC SRA.
- *A partnership* approach, with public authorities retaining decision power over public money (e.g. on content of calls, selection of projects, etc.), so avoiding conflicts of interest.
- *An attractive funding regime with larger public budgets* and a longer term commitment fostering a durable integration.
- *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 acceleration in the 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 nanoelectronics innovations.
- *Critical mass* to play a relevant role at global level, in global alliances.
- A *holistic approach* and an increased size of action.

The main risks for the private sector are that:

- *The JTI fails to secure buy-in* from a sufficiently wide range of industry stakeholders for the initiative to be representative and meaningful. The substantial groundwork done in successfully developing the SRA, and in setting up the Industrial Association (AENEAS), and the deep collaborations established suggest this risk is minimal.
- *Research fails to realise the set technological objectives*. This is an inherent risk in high-technology research; a collaborative approach helps minimise the impact allowing costs and risks to be shared by all stakeholders.
- *National funding fails to materialise*. Effective utilisation of industry funds depends on commitments of sufficient funds by Member States.

For **national public authorities**, the ENIAC 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,* through maintaining 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 here is the behaviour of Member States. Specifically, three scenarios can be envisaged in comparison with the scenario in Table 6-1:

- *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. Such a scenario, assuming a 50% mobilisation of funds, is shown in Table 7-1. In this case, the JTI mobilises only around €1500m, making it a similar size to the FP and current EUREKA clusters as a co-funding instrument for Europe's nanoelectronics research.

  The best way to counter this risk is to ensure that the JTI mechanisms are better than (or at least as good as) those of EUREKA. Assuming that individual national funding in the nanoelectronics field remains constant, countries would then have a major incentive to mobilise resources towards the JTI. Close attention is being paid to simplifying the evaluation and selection mechanisms to ensure this is the case.

Table 7-1: JTI Funding Scenario with 50% Under Mobilisation of National Funding

	Total 2007 - 2013		
€, million	**Private**	**Public**	**Total**
FP	1050	1050	2100
E!	1500	810	2310
JTI	**840**	**670**	**1510**
National	5770	2880	8650
Total Co-funded R&D	*9160*	*5410*	*14570*

- *Substitution of national funding by JTI funding*: Another possibility is that JTI 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).

  In practice, national funding is sufficiently high that only relatively small diversions are necessary to match the JTI top-up. For instance, starting from virtually zero in year 1, a progressive and cumulative diversion of national funding of only 3% per annum would be enough to cover all of the JTI top-up over the seven years. However, this would result in a funding profile that was highly skewed towards the later years rather than the relatively flat profile envisaged. Looking at it another way, a substitution rate of 32% of national funding would be necessary to match all of the EC top-up funds (€60m) from year 1 (Table 7-2). Such a scenario would result in around €3bn less in co-funding than the optimum of full take-up with no substitution.

Again, the additional mechanism provides an incentive, so the more Member States invest the more they get. If the JTI money did not depend on the national funding then there would be much bigger temptation to divert resources elsewhere.

Table 7-2: JTI Funding Scenario with 32% Substitution by National Funds

	Total 2007 - 2013		
€, million	**Private**	**Public**	**Total**
FP	1050	1050	2100
E!	1500	810	2310
JTI	**1680**	**1330**	**3010**
National	3870	1930	5800
Total Co-funded	*8100*	*5120*	*13220*

- *Over-subscription of JTI funds:* Alternatively, the JTI could be so popular that Member States commit 'too much' money to it and/or compete amongst themselves for the top-up, with the result that the EC commitment is used up over the early years. In these circumstances, most likely the JTI would apply for "fresh" money from the Framework Programme. This will also automatically have an effect on the industrial side, as they match the public funding even if it increases steeply. Moreover, the JTI can still continue to operate even if the EC contribution is exhausted: the overall driver is the integrated implementation of the common agreed agenda and the common procedures within the JTI framework.

  The situation for a 50% over-subscription is summarised in Table 7-3. In the event that no further funding is to become available and the JTI budget was capped at €2.9bn, then the top-up funding would be exhausted after 4.7 years (in 2010-11).

Table 7-3: JTI Funding Scenario with 50% Over-Subscription

	Total 2007 - 2013		
€, million	**Private**	**Public**	**Total**
FP	1050	1050	2100
E!	1500	810	2310
JTI	**2520**	**1890**	**4410**
National	5770	2880	8650
Total Co-funded	*10840*	*6630*	*17470*

More money is also expected to be generated because more Member States are participating, compared to current EUREKA Clusters. In addition, existing participants in MEDEA+ and Euripides are expected to use this mechanism and the image created by such a major initiative to generate more resources for these important fields. As in the normal EUREKA activity, 1 euro extra from public funding for nanoelectronics generates automatically one euro extra from industry.

Besides the cash resources, the JTI will mobilise substantial resources in the form of projects resulting from calls for proposals. ENIAC's industrial partners have stated their intention to double their investments in downstream pre-competitive collaborative R&D from 2005 to 2010, provided that the JTI develops successfully and in line with the financial projections in the ENIAC SRA. These investments are currently channelled mainly through EUREKA.

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 pole for external interactions.
- *Mobilising resources*, through significant leveraging of EU resources against national and industry funds (see Section 6.1.1 above).
- *Testing a novel instrument 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 instrument is expected to be put into use in other domains requiring a public-private partnership.
- *"Europeanisation" of part of nationally-funded research,* making thus 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.
- *Linking pre-competitive research with (lead) market-driven industrial research.*
- *Increased industrial and SME participation.*

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

The impact of setting up the JTI **with regard to competition** can be distinguished between having access to funding at various levels for research activities and having access to funding for the innovation resulting from the public funded research.

The research to be supported by the JTI addresses pre-competitive collaborative R&D, justified by the need to overcome market failures and create additionality. That is by nature meeting the conditions for state aid to industrial organisations. This should have no adverse consequences on the competitive landscape.

Regarding the competition for public R&D resources among industrial players, some governments provide funding for research in particular technology fields, some for specific application fields, some for more socio-economic activities while other countries do not. In the Eureka cluster MEDEA+, some countries participate with resources for nanoelectronics development (and their applications) and others do not. The same holds for the ERANET scheme under the Framework Programme. This may create unbalances for organisations in different Member States with respect to getting public support for their research activities. Within the JTI, organisations from all Member and Associated States can participate and will all get the same level of EU funding.

It is true that only States participating in the JTI will provide extra resources for the R&D of their national participants. These extra resources are provided according to national rules up to a varying percentage per State with a maximum defined by the state aid rules. Within the JTI, the nature of running collaborative research projects in a coordinated manner provides however a built-in incentive for the participants to request their States to participate in the JTI and at a similar funding level than others. We expect that along the duration of the JTI, the national differences will decrease. This extra benefit of the JTI can be monitored over time. The main risk is that the EU contribution may not be sufficient for some organisations to participate (in case of lacking national support), but we are confident that, in several cases, industry will consider that accessing the initiative is more important than the funding level. Their participation will prove this.

The JTI initiative targets only R&D and accompanying activities. No funding is planned to be directed to upgrading production capabilities or infrastructures, nor for direct product developments.

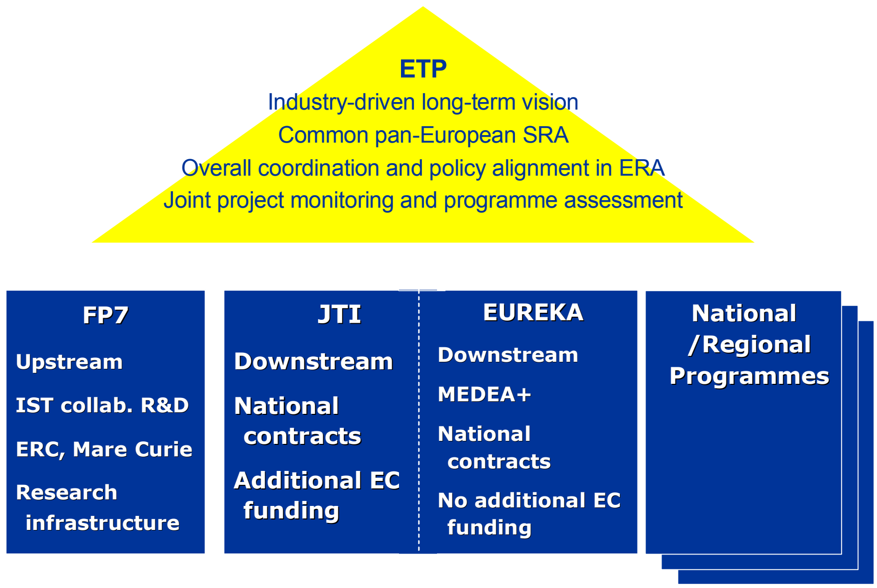
The economies of scale and the more stable and longer term commitment to the initiative are expected to offer all players involved an extra competitive advantage, however difficult to translate into real figures.

7.3. Relation of the JTI research with Community Programmes and EUREKA research

As set out in its SRA, the mission of the ENIAC Technology Platform's is to contribute to European competitiveness through pre-competitive, collaborative R&D on nanoelectronics that realises the vision of "Making the 2020 Information Society technologically feasible and economically affordable to serve the future demands of European society, increase high-skilled employment, and keep European industry competitive"[51]. The ENIAC JTI will be one of the three pillars – alongside the Framework Programme and national programmes – for implementing the technological and economic objectives of the ENIAC Technology Platform (Figure 7-1). The JTI will also implement supporting activities related to industrial policy, including the creation of open innovation environments, standardisation, international cooperation and the promotion of SMEs.

[51] ENIAC Strategic Research Agenda

Figure 7-1: Approach for Executing the ENIAC 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 nanoelectronics will increase during FP7. There will be two separate but coordinated budgets for nanoelectronics: one for the JTI and one for the other FP actions. A part of the new JTI budget will be contributed from the 'traditional' FP nanoelectronics budget which may remain at a similar level as in FP6, but another part of the JTI budget will come from new support in the FP.

The JTI could not however replace the type of research done in the ICT Programme and vice-versa – for several reasons:

The type of research is different: for nanoelectronics, the JTI would support more 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. On the other hand, the JTI will target ambitious, large-scale projects requiring R&D activities over a large spectrum of topics that would cover several objectives and themes with possibly different timeframes. So, the level of segmentation in the Framework Programme would not be suitable for such large scale programs.

(1) **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;

(2) **Participation of Member States**: not all Member States are expected to participate in the ENIAC Joint Undertaking. It will therefore be important to maintain the largest share of the Nanoelectronics activity within the ICT Programme.

(3) **Nanoelectronics research in FP7**: Finally, a significant Nanoelectronics 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 it would be the case in the JTI. Moreover, part of the most advanced pre-competitive nanoelectronics research is best done in relationship with nanotechnology and nano-manufacturing research in general or in the context of the concept of 'converging' technology.

Funding from the FP7 Cooperation Programme

The investment in this JTI in the first instance is 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 in total around €450m will trigger a coordinated multi-billion euros programme which would be a good return on invest 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 nanoelectronics research in the 2007-2008 timeframe, since the JTI will only start delivering project-wise in the second half of 2008, at the earliest. In case the ENIAC 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 €450m will be contributed by 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 the money not committed returns to the Cooperation Programme. In conclusion, the JTI proposes 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 (MEDEA+, Euripides) 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 that is based on long-term commitments from all stakeholders and to allow the industrial R&D objectives to be pursued in a focussed and effective manner across Europe.

It is expected that a part of the activities, if not all, in the area of nanoelectronics currently supported within the EUREKA clusters will be progressively integrated in the ENIAC JTI.

One alternative could be to integrate immediately these activities in the JTI. However, this is not a politically acceptable solution: integration by decree is often ineffective; what we rather need to create is a framework and the process through which progressive and partial integration can take place. 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. Moreover some focused activities driven by key lead markets of interest to a few regions may still be best executed under the EUREKA umbrella.

In conclusion, the ENIAC JTI will permit the alignment of hundreds of million of national funds to the commonly agreed SRA and to the Commission's own strategy. They 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, **JTIs will achieve a "communitarisation" of inter-governmental mechanisms**, such as EUREKA. The work that will be undertaken under the JTI should not be considered as a transfer of EUREKA activities under a new umbrella. It is rather a full partnership of all stakeholders (EC, Member States and industry/research) that is geared towards progressively achieving true European-level integration.

8. MEETING THE EVALUATION CRITERIA FOR JTIS

This report has considered a series of policy options in relation to the ENIAC JTI and has also looked at whether the JTI is the right instrument and has the appropriate governance model to achieve the policy and technological objectives. The assessment shows that the ENIAC proposal clearly satisfies all of the criteria set out for a Joint Technology Initiative under FP7:

∉ Scale of the Impact on Industrial Competitiveness and Growth:

Nanoelectronics are a strategic technology for Europe that will have a major impact on industrial competitiveness and growth (sections 3.1, 3.2)**.** Nanoelectronics technologies underpin the future development of major high-tech manufacturing sectors which 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 trigger this enabling nature and will foster innovation in many products and services of economic and relevance. The JTI will contribute to more and better quality jobs, and the application domains in health, mobility & transport, security & safety, communication, energy, environment & sustainability and education & entertainment are of high societal relevance.

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

The current fragmented situation holds significant risks for Europe (section 3.3). The EU faces a steady loss of competitiveness in nanoelectronics as a result of a fragmentation of its research efforts, increasing technological complexity, changing business and research models, and competitive pressures from other world regions. At risk are not just short term opportunities for new products and services but loss of the ability to innovate in those sectors with the greatest potential for value creation, for health and well being of citizens, and for 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 3.4, 3.5). The SRA is industrially guided and sets out **tangible and realistic objectives** to keep Europe at the forefront of the nanoelectronics field (section 3.6). A key element in delivering this strategy is the setting up of a European Industrial R&D Programme for Nanoelectronics in the form of the ENIAC 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 3.5, 3.6). **At present, however, there is no means to mobilise this funding in a focused and flexible way**. None of the existing instruments will allow 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 exercising a new way of governance promising less red tape. None of the existing programmes is capable to provide a critical mass, a long term commitment, an integrated approach of considerable size, a playing field for strategic industrial relationships and the flexibility and fast turn-around time required for an industrially oriented initiative in nanoelectronics to fulfil part of the objectives of the Strategic Research Agenda of ENIAC.

∉ Added Value of European-Level Intervention:

European-level intervention will bring significant added value (sections 3.5, 3.6). While the EU will continue to invest in nanoelectronics research under the Research Framework Programme, the regular FP instruments alone cannot bring together the necessary scale of resources and expertise to meet the investment challenge. **The proposed public-private partnership (Joint Undertaking) to implement the ENIAC JTI will offer 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 achieve coordination of funding from the Framework Programme, EUREKA and national funds, and can build sufficient critical mass to pursue the ambitious objectives set.

∉ Strength of the Financial and Resource Commitment from Industry:

European industry is committed to and is prepared to back the ENIAC JTI (sections 5, 6.1.1)**.** Industry is already today putting a lot of effort in setting up the Joint Undertaking. Industry 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 ENIAC JTI technological objectives will have **direct benefits** for European industry (section 6.1.2). Further **indirect benefits** can be expected from this improved profitability, as a result of increasing market share and revenues, investing 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 6.1.3, 6.1.4, 6.1.5). The new structure will remove budgetary uncertainty and unnecessary bureaucracy, avoid duplication in evaluation and monitoring, and enable shorter time to market. The JTI will also contribute to productivity and create new jobs in the wider economy (section 6.1.6, 6.2), 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 ENIAC 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 this has triggered several other countries to make provisions for increased budget allocations in the areas covered by ENIAC in their national programmes. Industry is prepared to double its resources in this field over the next 7 years (section 6.1.2). 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 total Community funding of around €450m, the ENIAC Joint Undertaking will leverage seven to eight times that amount in nanoelectronics 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.

The above demonstrate that the 4 main policy objectives are fully met by the JTI implemented through a Joint Undertaking: to create a single, Europe-wide, industrially driven R&D programme; to put in place a new instrument able to combine for the first time, national, EU and private funding; to ramp up R&D investment in nanoelectronics in Europe; and to strengthen strategic partnerships between different European actors in order to anchor research on European soil and strengthen their position at world-wide level.

9. MONITORING AND EVALUATION

JTIs will be concurrent with FP7 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 ENIAC SRA provides the baseline for the technical assessment of the resulting JTI projects.

The expected results stemming from the JTI and corresponding indicators are the following:

- *Leveraging resources and integrating national efforts*: by providing incentives to industry and Member States, additional national support will be attracted and greater industry funding will be leveraged.
  Indicators: (i)number of countries that commit funding to the Joint Undertaking; (ii)commitments and payments according to the plans; (iii)national funding committed and spent on projects selected by the Joint Undertaking; (iv)resources invested by industry in R&D work under projects selected by the Joint Undertaking.

- *Focusing on common R&D agendas more effectively than is currently possible*: the integrated holistic approach will enlarge the number of strategic partnerships between European players, creating new business ecosystems.
  Indicators: this result will be achieved *de facto* when the Joint Undertaking becomes fully operational - (v)number and level of partnerships.

- *High programme efficiency*: by removing uncertainty as to the availability of national budgets, getting rid of the duplication of evaluation and monitoring procedures, decentralised flexible management, linking pre-competitive research with closer to the market innovation. These benefits should lead to a programme that is popular and attractive to a broad variety of R&D actors, especially SMEs.

  Indicators: (vi)time interval between proposal submission and project selection decision by the Joint Undertaking; (vii)number of organisations, including SMEs participating in Calls for Proposals; (viii)overhead costs for operating the programme; (ix)results transferred in the market.

- *Significant economic and social benefits* will be gained to the extent that the R&D projects launched by the Joint Undertaking make progress in achieving its technological and economic objectives. This progress will be subject to periodic independent evaluation.
  Indicators: (x)patents filed resulting from projects; (xi)number of publications resulting from project.

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 will be set out in the Regulation and will probably rest with the Governing Board. In addition, the Commission may be obliged to 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 related to Commission funding were covered explicitly.

10. ANNEX I THE IMPORTANCE OF NANOELECTRONICS

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[52,53].

Member States have recognised the contribution of research and development to this agenda and have set targets – the so-called Barcelona Objective – to increase their spending on research to at least 3% of GDP by 2010, two-thirds of which should come from the private sector[54]. 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 pre-commercial procurement in pulling through radical innovations[55].

In the context of the Lisbon strategy and the Barcelona Objectives, the Commission initiative[56] "i2010" (European Information society in 2010) has identified the **strengthening of innovation and investment in ICT research** as one of Europe's information society and media policies to cope with the increasing productivity gap between Europe and competing zones.

Nanoelectronics as an Enabler for Economic Competitiveness

Globalisation is exposing the European economy to pressures both from high productivity, high added-value competitors such as the United States, and from emerging economies, especially China and South-East Asia, with their unbeatable cost structures and large numbers of technical graduates. The ever-faster pace of technological change is shortening innovation cycles and opening up more and more opportunities for new products, services and markets. At the same time, Europe faces major societal challenges such as an ageing population, climate change and preserving the European social model.

One important area is electronics, which today is the leader amongst manufacturing industries. Electronics generates more added value than any other manufacturing sector: at €1300bn (Figure 2-1), its market size is bigger than that of the automotive industry. All services and most industrial products rely on electronics to some extent. Without them Europe can neither maintain its current position in high value-added sectors, nor innovate in new products and services on which growth and jobs depend.

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[52]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"

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

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

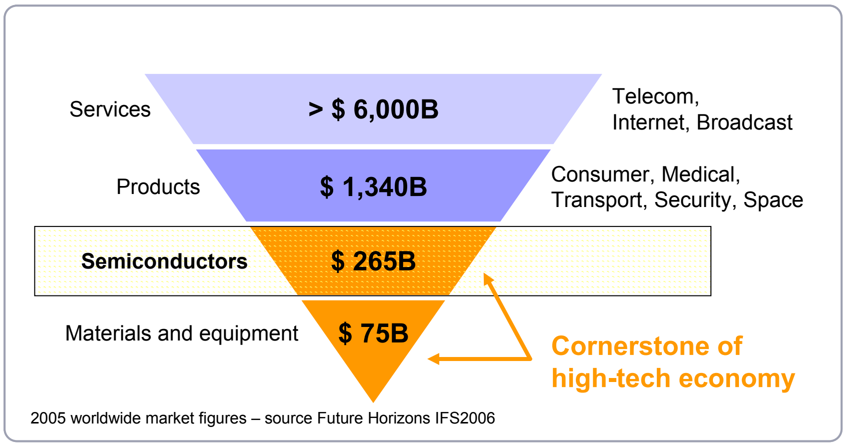
[55]*Creating an Innovative Europe: Report of the Independent Expert Group on R&D and Innovation*, "The Aho Report", European Commission, 2006. http:europa.eu.int/invest-in-research/

[56]Communication from the Commission COM(2005) 229 - The "i2010" initiative provides an integrated approach to information society and audio-visual policies in the EU

Electronics also play a vital role in the transformation of our society: access to the internet, mobility and e-commerce contribute to removing social and cultural barriers as well as bringing every citizen into the information age, with direct benefits to healthcare, welfare and environmental issues. ICT is transforming the way we live, learn, work and play.

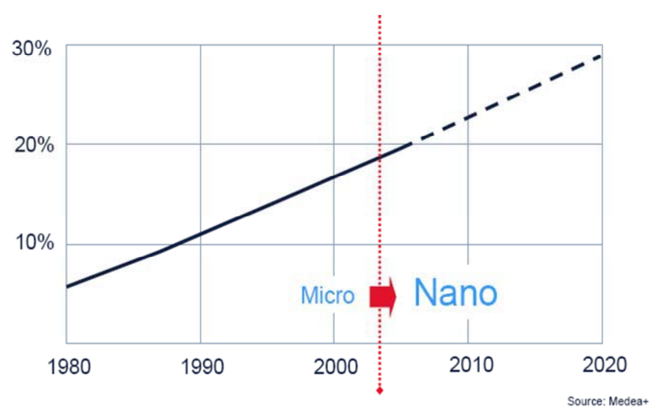
In the electronics sector, the semiconductor industry (designing and manufacturing "chips"), through its pervasive nature, underpins a pyramid of value, making it a key enabler of growth and jobs across the economy as a whole (Figure A-1). Overall, ICT now accounts for around 30% of all industrial investment, compared with 5% in 1960. In service sectors, expenditure on ICT hardware and software represents more than one-quarter of total expenses[57].

Figure A-1 : The Pyramid of Value



The shift from the past era of microelectronics, where semiconductor devices were measured in microns (1 millionth of a metre), to the new era of nanoelectronics, where they shrink to dimensions measured in nanometres (1 billionth of metre), will make electronics even more pervasive – and more strategic – than it is today. It will allow much more intelligence to be built into many more everyday items around us, with the result that chip technology will play a part in virtually every aspect of our lives, from personal health to traffic control and public security (Figure A-2).

Figure A-2 : Semiconductor Contents as % of end product value



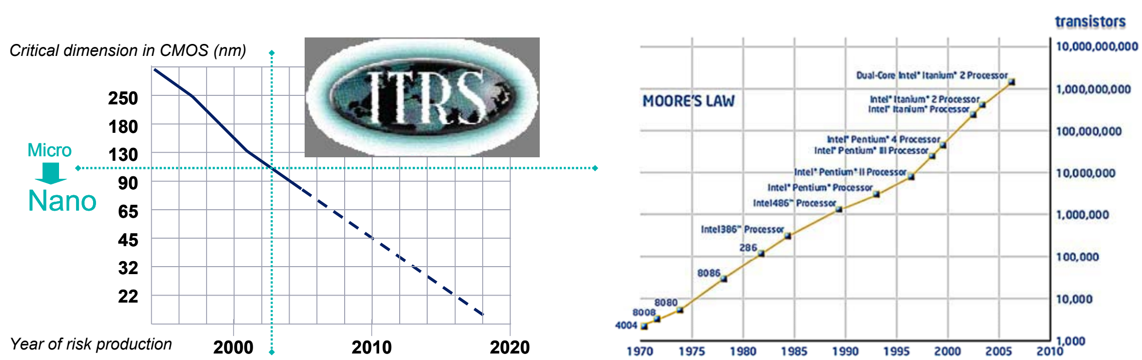
[57] OECD ICT scoreboard 2005

Technological development in nanoelectronics proceeds according to Moore's Law, which predicts that the performance of microprocessors will double roughly every two years. This exponential growth in circuit complexity using wafer-scale semiconductor technology has generated an incredible race to shrink the size of a device while increasing the performance of individual devices. It has also led to systems that are increasingly complex. The most advanced silicon chips available today carry as many transistors as there are people on Earth, making them increasingly difficult to design and test.

Moore's Law is fundamentally an economic argument, rather than a law of nature, resulting in an exponential reduction in the cost of delivering digital functions on silicon wafers. Over the last 40 years the cost of the basic digital component – the transistor – has decreased by 30% per year, a spectacular trend not seen in any other industry. It is this cost-down enabler that has allowed the microelectronics industry to continuously expand with double-digit growth over the past four decades.

The key parameters and technological challenges facing the industry are set out in the International Technology Roadmap for Semiconductors (ITRS). The ITRS is a global forum populated by semiconductor makers, equipment and material manufacturers and suppliers, institutes and universities. It identifies technology improvements and cost reductions up to 15 years into the future, as well as the associated challenges, and plays a leading role in determining the agenda for semiconductor technology worldwide (Figure A-3).

Figure A-3 : Moore's Law

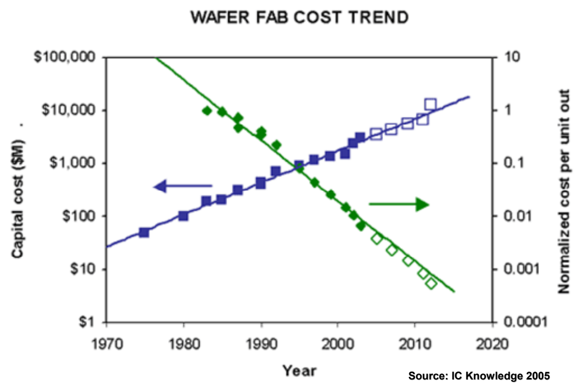


The two technological developments that have paved the way for Moore's Law are minimum pattern dimensioning (decreasing) and wafer size (increasing). In 1965, manufacturing relied on 25mm silicon wafers, compared to the 300mm used today. At the same time, dimensions of the smallest patterns on these wafers have reduced from the size of a lymphocyte (15 micrometre) to that of a medium-sized virus (100 nanometre). Today, this miniaturisation is the main mechanism behind the development of nanoelectronic systems, driving increased data storage capacity and computing power in complex high-volume semiconductor products such as stand-alone memories and microprocessors.

As dimensions become ever smaller, numerous issues arise as a result of physical laws and technical bottlenecks. Process complexity grows and design rules are becoming more and more complex. As a result, R&D expenses are increasing constantly (Figure A-4). The semiconductor industry typically spends around 15% of its revenue on R&D, making it one of the most R&D-intensive sectors – second only to biotechnology & pharmaceuticals.

Moreover, the constant increase in manufacturing capacity demands dramatic and sustained investment in capital expenditure: a state-of-the-art manufacturing facility, or fab, now costs over €5bn.

Figure A-4 : Increasing Complexity and Costs



Traditional miniaturisation approaches are expected to reach their limits 10 to15 years from now. It is likely that the transition to other types of technologies will rather happen gradually than abruptly. First novel types of nanostructures will be introduced in existing technologies. Then, traditional manufacturing techniques may be gradually replaced by other nanotechnology techniques. Later, it is expected that really disruptive technologies, fully exploring the changes in behaviour of materials that occur at atomic scale, might become necessary.

The behaviour of material at the nano-scale, the impact of quantum effects as size shrinks into the nano-range are nearly universal and scientists study them in many disciplines. Traditional industries have grown out of single disciplines: Physicists have natural connections to semiconductors; chemists support pharmaceutical industry; biologists are connected to life sciences. However, working in nanoelectronics requires an interdisciplinary approach involving physics, chemistry, material science, biology and engineering. Bringing these competences together is essential for future progress and will simultaneously lead to much creativity in new applications. Global and multi-disciplinary, that is how future research in nanoelectronics and miniaturisation technology will look alike.

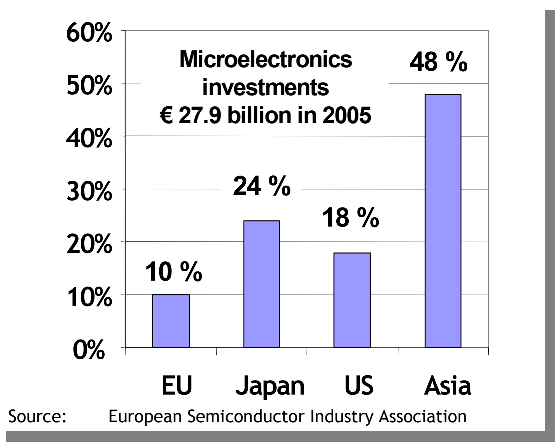
The upcoming applications will require continuous miniaturisation not only for the digital circuits but also integration for all other devices whose dimensions cannot be reduced as easily. This opens a whole area where innovation and new technologies are necessary. Even if the scaling of CMOS technology comes to an end in about 10 to15 years from now, CMOS will still remain for a long time the dominant technology in nanoelectronics. Progress will still happen by introducing additional functionality in the core CMOS technologies to make them more performing rather than relying on a next generation of miniaturisation techniques. It may also not be excluded that alternative techniques will be used to extend the traditional miniaturisation approach.

As a consequence, research is no longer executed in a linear fashion with transfer of results from universities into institutes and then industry, but through a more integrated approach with clusters or ecosystems of knowledge. The fast cycle times of innovation, the huge investments and large risks need to cope with different disciplines through better cooperation in integrated activities and strategic alliances.

Europe is a net importer of nanoelectronics[58]: 12% of the worldwide semiconductor production capacity is located in Europe while 20% of the worldwide semiconductor products are consumed in Europe. Moreover, the production of electronics systems is steadily growing worldwide, which creates a strong demand for semiconductors. In 2005, 24% of the worldwide semiconductor market was in China, which triggered a 35% growth of the Chinese semiconductor industry[59]. In this context, global competition is fierce to gain market shares in leading-edge technologies.

A key phenomenon over recent years has been the growth of the Asia-Pacific region, especially in the foundry business (Figure A-5). The main players are Taiwan, South Korea and now China: by 2003 their combined market share has increased to around 30%, compared to only 5% in 1990. According to one industry analysis, setting up a leading-edge fab in Asia is more than 220% more profitable than an equivalent plant in Europe[60]. As well as the cost structure, the Asian investment is made more attractive in these emerging markets by the existence of favourable incentives schemes. To date Asian fabs have mostly taken market share from the US and Japan, from large traditional actors who are not very active in the foundry business. European companies have managed to ride out this trend so far, maintaining production at a fairly constant share of ~10%. Asia will not limit itself to manufacturing, however, and as it moves up the value chain European companies will be more and more exposed.

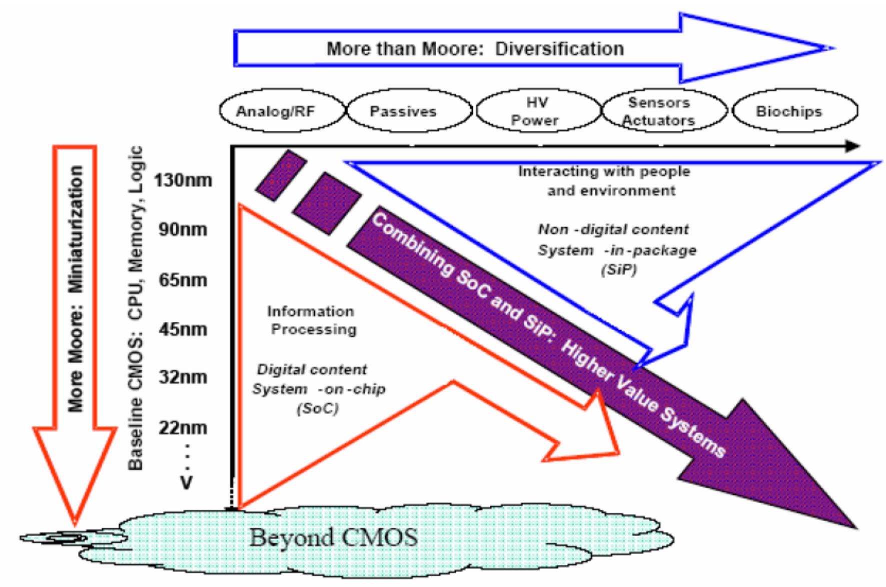
Figure A-5 : Capital Investments per Region



The nanoelectronics industry is facing a huge challenge in combining the shortening of the product life cycles with the increasing complexity of the products (Figure A-6). The opportunities for innovation are multiplying as the functionality per chip increases. This is a chance for Europe where some leading application markets are strong drivers for the ICT industry: e.g. telecoms, automotive, health, energy, all domains where ICT components will play an increasing role (and take a growing value share) in the future generations of products and services.

[58] *European Industrial Innovation Scoreboard 2005*, European Commission, 2005
[59] China's impact on the semiconductor industry, PicewaterhouseCoopers, 2007
[60] *The European Semiconductor Industry 2005 Competitiveness Report,* EECA-ESIA, 2005

Figure A-6 : Technological challenges (source: ITRS 2006)



The above changes in technology are prefiguring a potential change of the industrial landscape (Figure A-7). Since the 1950's, each decade has brought a new ranking of semiconductor companies reflecting the technological trend of the moment (moving gradually from simple logic functions to highly dense processor and memory chips). In the next decade, the effects of the move to nanoelectronics and its impact on functionality and system integration will be visible, likely bringing a new distribution among the top companies. Europe has to shape its future now.

Figure A-7 : Changing nature of industry (source: Future Horizons in IEF2007)

Entering The 7th Decade Of The Transistor Revolution

Decade	SC 1.0	SC 2.0	SC 3.0	SC 4.0	SC 5.0	SC 6.0	SC 7.0
Rank	1955	1965	1975	1985	1995	2005	2015
1	Hughes	TI	TI	NEC	Intel	Intel	?
2	Transitron	Motorola	Fairchild	TI	NEC	Samsung	?
3	Philco	Fairchild	Philips	Motorola	Toshiba	TI	?
4	Sylvania	GE	NSC	Hitachi	Hitachi	Toshiba	?
5	TI	RCA	Intel	Toshiba	Motorola	ST	?
6	GE	Sprague	Motorola	Fujitsu	Samsung	Infineon	?
7	RCA	Philco Ford	NEC	Philips	TI	Renesas	?
8	Westinghouse	Philips	Fairchild	Intel	IBM	TSMC	?
9	Motorola	Transitron	RCA	NSC	Mitsubishi	Sony	?
10	Clevite	Raytheon	GE	Matsushita	Philips	Philips	?
Total	$75	$1,528	$4,012	$21,479	$144,404	$227,484	?
Driver	Discretes	Std Logic	MOS	CMOS	MPU	SoC	?

Once Again The Industry Is Changing ... And The Outcome Again Different
Who Will Be The Winners In 2015 ?

A Cyclical Industry

Semiconductors represent around 20% of the market, with worldwide sales of $227bn in 2005 (Table A-1). Demand is being driven principally by new applications in communications, digital consumer products, automotive electronics, and energy & environmental management. Europe is well positioned in all of these markets with good worldwide growth potential. However, these are very demanding mass markets, both in terms of volume and prices. The only way to succeed is to increase faster than competitors the 'intellectual property on the chip', and therefore its R&D intensity.

Table A-1 : Worldwide Semiconductor Market Forecasts (in US$ and growth in %)

	2005		2006		2007		2008	
Future Horizons	230	8.2%	277	20.0%	337	22.0%	351	4.0%
WSTS	227	6.8%	245	7.7%	271	10.6%	306	13.2%
Databeans	226	6.8%	259	14.6%	293	13.1%	307	4.8%

The micro/nanoelectronics sector is subject to an approximate four yearly cycle, reflected by the revenue peaks in years 1995, 2000 and 2004. This pattern results from periodic divergence between the market demand and the capacities of manufacturing companies. When demand is high, most vendors invest in order to increase capacity. This then leads to overcapacity, excess inventory and market softening. In fact, observers report that the situation is more complex as the cycle is affected by other factors such as undercutting and market penetration by new entrants and trends in application sectors. This cycle is likely to continue, but with reduced amplitude as the improved understanding of the driving factors allows more rational capital spending and better monitoring of imbalances.

11. ANNEX II THE EUROPEAN TECHNOLOGY PLATFORM IN NANOELECTRONICS

Stakeholders have recognised the critical nature of the problems ahead and the necessity to act. They have gathered together in the ENIAC 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 nanoelectronics.

The Platform has published a Strategic Research Agenda (SRA) outlining the evolution of the field from a medium- to long-term perspective and identifying a number of important technological and regulatory challenges for Europe.

The Technology Platform addresses the development of application-driven technology across six key technical domains:

(1) Domain ‘More Moore’: focusing on advancing the internationally accepted ITRS roadmap towards the new technology nodes that will be introduced every 2 to 3 years and finding solutions to the technical challenges. This includes further advances in lithography, logic technologies, materials and low-power systems.

(2) Domain ‘More than Moore’: focusing on innovative means of integrating non-digital functions and devices onto silicon. These non-digital technologies will evolve along directions other than the straight path of Moore’s Law and present demanding technological challenges.

(3) Domain ‘Heterogeneous Integration’: aiming to accelerate the development of systems – containing both silicon and non-silicon technologies – on a single chip or in a single package. The challenge, essentially, is to interface nano-scale and micro-scale technologies in a way that is cost-effective for mass market production.

(4) Domain ‘Beyond CMOS’: focusing on highly disruptive materials science and device architectures for the point (currently predicted to be around 2020) when digital semiconductor technologies will have reached their physical limits.

(5) Domain ‘Equipment and Materials’: focusing on sound and innovative developments in manufacturing necessary to bring all the above technologies into production.

(6) Domain ‘Design': focusing on the definition and development of new generations of electronic hardware design tools that allow designers to handle the increasing complexity of nanoelectronics systems. In particular, it aims towards highly automated systems that offer a short time-to-market and fast ramp-up to volume manufacturing. There is a strong synergy here with the ARTEMIS Technology platform which targets design tools for embedded system software.

In addition to technological development, ENIAC brings forward proposals for enhancing the European research infrastructure for nanoelectronics, strengthening education and training, and fostering efficient innovation environments.

To help meet these challenges, the SRA sets out a comprehensive programme of actions to focus and coordinate research, encourage innovation and streamline policies. To implement its SRA, the ENIAC ETP foresees a synergistic approach based on a combination of European, private (industrial) and national funding.