Analysis of Effectiveness of European Nanoelectronics R&D programmes in developing value chains

C Pickering and N Adams – Innovation Bridge Consulting, 24th July 2011

1. SCOPE

The scope of projects to be included in the analysis was defined as follows:

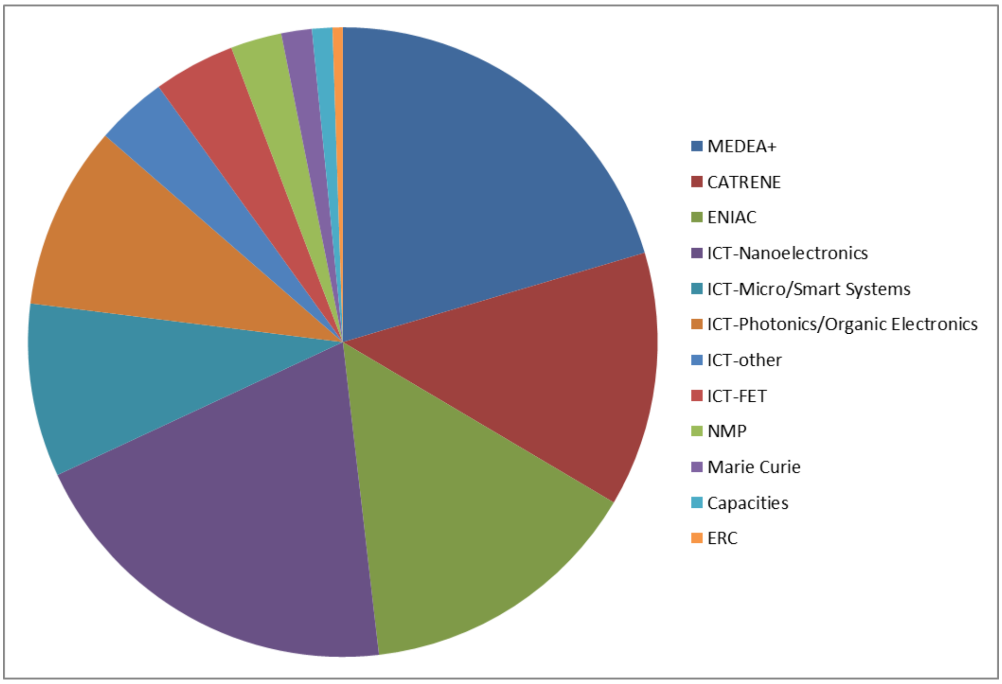
- All projects funded by the Nanoelectronics Unit of DG/INFSO
- Projects funded by the Microsystems Unit of DG/INFSO which included integration with micro-electronics (excluding stand-alone MEMS projects for example)
- Projects funded by other DG/INFSO Units in the ICT programme which included integration with micro-electronics, e.g. in application-related Challenges and Future Emerging Technologies (FET), but excluding embedded systems architecture-related projects
  - Photonics projects were included when the photonic system was integrated on CMOS, for example, but excluded when they were focused on discrete photonic components such as lasers.
  - Organic electronics and Organic Large Area Electronics (OLAE) were mostly excluded as the technology is relatively immature and dimensions/integration densities, etc are not at the nanoelectronics scale
- Projects funded by DG/RES in the Nanosciences, Nanotechnologies, Materials and new Production technologies programme which included integration with micro-electronics
- All projects funded by ENIAC (European Nanoelectronics Initiative Advisory Council)
- All projects funded by EUREKA clusters CATRENE and MEDEA+ (Phase 2 projects only)
- Projects related to nanoelectronics and integration in other EU programmes including Capacities (Research for SMEs and Research Potential of Converging Regions), People (Marie-Curie Industry-Academia Partnerships and Pathways (IAPP)) and Ideas (European Research Council).

The study captured and analysed publicly available data on all relevant FP7, CATRENE, MEDEA+ and ENIAC projects contracted since 2007, a total of 191 projects. These are broken down as shown in Table 1 and Figure 1 below.

Table 1 – Breakdown of projects analysed

Programme	Sub-programme	No
COOPERATION	ICT-Nanoelectronics (including Design)	38
	ICT-Micro/Smart Systems	17
	ICT-Photonics/Organic Electronics	18
	ICT-other	7
	ICT-FET	8
	NMP	5
JTI/JU	ENIAC	28
EUREKA	MEDEA+	39
	CATRENE	25
CAPACITIES	Research for SMEs	1
	Research Potential of Coverging Regions	1
PEOPLE	Marie-Curie Industrial-Academic Partnerships	3
IDEAS	ERC Advanced Investigator Grants	1

Figure 1 – Breakdown of projects analysed



It can be seen from the above that the number of projects funded directly by the Nanoelectronics Unit of DG/INFSO only amounts to about one-fifth of relevant projects, with about half of all projects funded by the ENIAC/ CATRENE/ MEDEA+ Programmes (called Joint E/C/M in the following). The differing nature of the Member States' (MS) support for the latter means that there will be a geographical bias towards some MS compared to FP7 which is open to all MS on an equal footing. The data have been analysed as a whole but the FP7 data has been split out separately, since the effectiveness of the FP7 funding of Nanoelectronics was the primary objective of this study.

The level of funding for the different programmes (where information is available) is as shown in Table 2. The CATRENE and MEDEA+ national funding support is estimated by averaging levels of support by country and by type of participant. The eligible costs of the FP7 projects are only about 12% of the eligible costs of all relevant programmes.

Table 2 – EU Programme funding

Programme	No of projects	Eligible Costs (million €)	National Funding (million €)	EU Funding (million €)
CATRENE	17*	1044	355 (approx)	0
MEDEA+	39	1691	575 (approx)	0
ENIAC	28	656	181	109
FP7	99	493	0	346

**with cost data available*

2. APPROACH

Analysis has been performed of the number of projects and participation against the different types of EU projects, to ensure the nature of the Nanoelectronics projects being funded by Joint E/C/M and FP7 programmes as defined above was taken into account. In order to understand the participation of different players in the supply chain, the projects were divided into groups defined as Application, Integration, Design, and Equipment focused projects, based on an amalgamation of the types of projects defined in the various programmes as shown Table 3 below. This chosen definition also aligns well with the definition of projects used by the Nanoelectronics Unit, the sponsor of this study.

Table 3 – Project grouping

ENIAC Project Categories	CATRENE Project Categories	DG/INFSO Nanoelectronics Unit Project Categories	**EU Project Definition used in this study (main focus)**
Applications	Applications	-	**APPLICATION**
Semiconductor Process & Integration	Process Development and Systems Integration	TECHNOLOGY	**INTEGRATION**
Design Technologies	Design Automation	DESIGN	**DESIGN**
Equipment, Materials & Manufacturing	Manufacturing Science	MANUFACTURING	**EQUIPMENT**

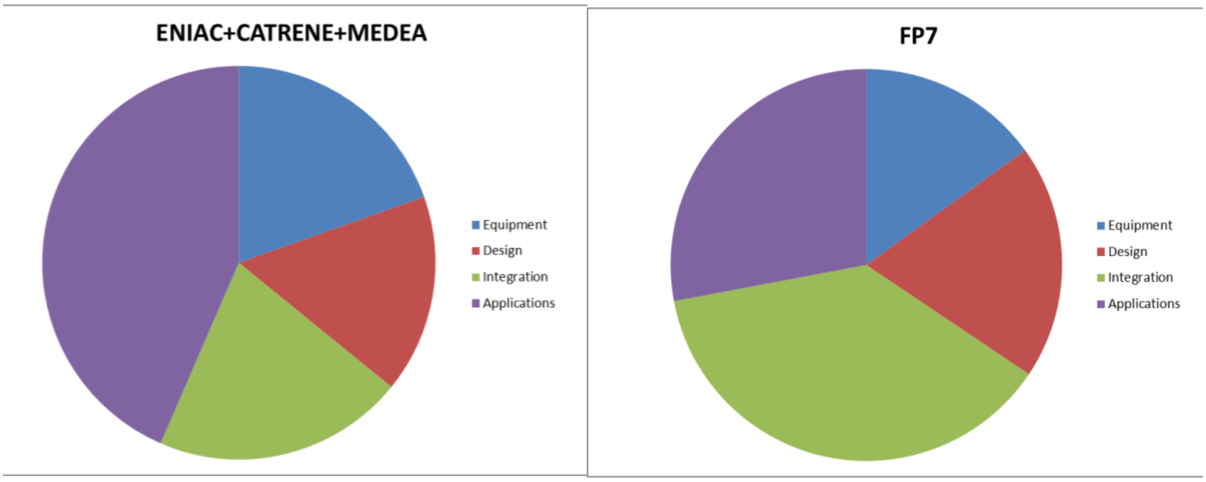
Table 4 below shows the results of this analysis for a total of 191 projects.

Table 4 – Breakdown of projects analysed by project type

Types of EU Projects / Instruments	Equipment	Design	Integration	Application	Miscellaneous Policy/ Strategy Projects	**TOTAL**
ENIAC	6	2	2	18	0	28
CATRENE	4	2	10	9	0	25
MEDEA	8	11	7	13	0	39
ENIAC+CATRENE +MEDEA	18	15	19	40	0	92
FP7	14	18	35	26	6	99
TOTAL	32	33	54	66	6	191

The breakdown in the table above is shown in the pie-charts below (Figure 2). It can be seen that there are more projects focusing on 'Integration' in FP7 and less on 'Application' than Joint E/C/M, reflecting the fact that ENIAC/ CATRENE/ MEDEA are intended to be more application driven. It should also be noted that the FP7 project SEAL - Semiconductor Equipment Assessment Leveraging Innovation - includes 17 Equipment sub-projects.

Figure 2 – Breakdown of project types



3. PARTICIPATION IN FP7 EMERGING SUPPLY CHAINS

Participation in projects has been analysed against type of participant using the following designations in Table 5.

Table 5 – Definition of types of participants used for project analysis

Supply Chain Position	Designation
1. Product/ system suppliers	OEMs (O)
2. Sub-system provider • including Electronic Contract Manufacturing 3. Integrated Device Manufacturer • including Fabless 4. Foundry	Integrators (I)
5. Design House 6. Design Tool Supplier	Designers (D)
7. Processing and Metrology Equipment Manufacturer 8. Materials Supplier	Equipment/Material Suppliers (E)
9.Research Institutes and Universities	Research Institutes (R)

It should be noted that the major players in the various supply chain categories participate in all types of project (e.g. IDMs participate in 'Application', 'Design' and 'Equipment' focused projects as well as those designated 'Integration', though 'Integration' projects are of special interest to them).

Figure 3 and Table 6 below show the top participants, as defined by the total number of projects in which they are partners, in **FP7-only Nanoelectronics Projects (excluding Joint E/C/M projects).** Research Institutes are the dominant players in FP7 Nanoelectronics Programmes, with only 3 of the top 19 participants (involved in 6 or more projects) being industrial companies. However, as can be seen from Figure 3 and is discussed further later, most of the significant Research Institute participants (with the exception of EPFL and University College, Cork) also participate in the Joint E/C/M Programmes where Industry is more heavily involved, which improves the opportunities for technology transfer.

Figure 3 – Top participants in FP7-only Nanoelectronics projects

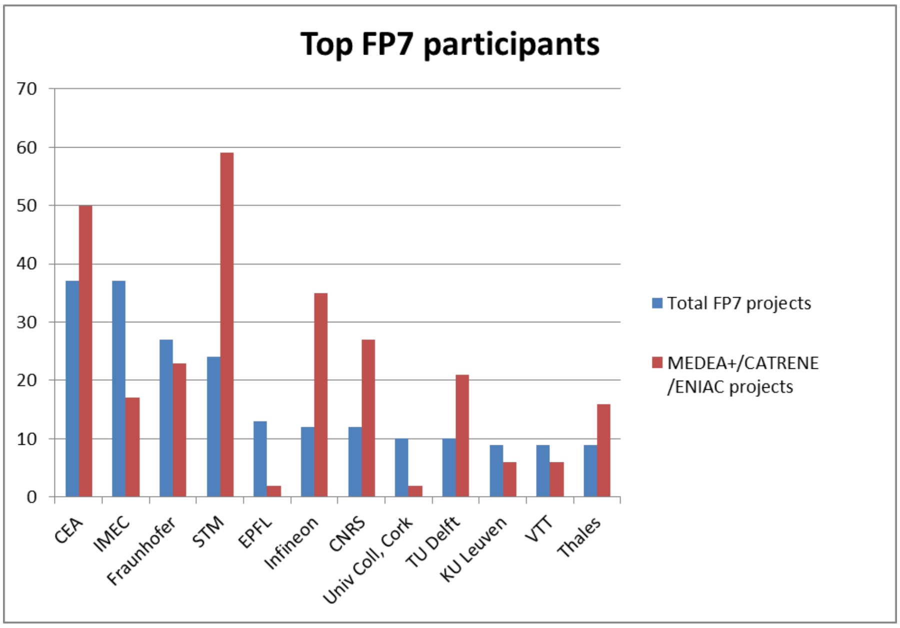


Table 6 – Top FP7-only Nanoelectronics participants

No	Participants List	Category	No of FP7 Projects
1	CEA - All Labs	R	37
2	IMEC	R	37
3	Fraunhofer	R	27
4	STMicroelectronics	I	24
5	EPFL	R	13
6	Infineon	I	12
7	CNRS - All Labs	R	12
8	TU Delft	R	10
9	University College Cork	R	10
10	Thales	O	9
11	Katholieke Universiteit Leuven	R	9
12	VTT	R	9
13	Consiglio Nazionale delle Richerche	R	9
14	Chalmers Institute	R	7
15	Consorzio Nazionale Interuniversitario per la Nanoelettronica, Bologna	R	6
16	National Centre for Scientific Research Demokritos	R	6
17	Catalan Institute of Nanotechnology, Barcelona	R	6
18	TU Berlin	R	6
19	KTH Stockholm	R	6
20	Philips	O	5
21	Robert Bosch	I	5
22	Siemens	O	5
23	Centro Ricerche Fiat	O	5

The picture is different if **all project types - Joint E/C/M and FP7 -** are included in the analysis, as shown in Figure 4 and Table 7 below. There is still a major involvement of Research Institutes, with 5 out of the top 10 participants, but now 5 out of the top 10 players are Industry. Individual major Industry players in Manufacturing Supply Chains are generally not heavily involved in FP7: they have more involvement in the Joint E/C/M Programmes, e.g. Philips, NXP and Atmel (now Lfoundry).

Figure 4 – Top participants in all EU Nanoelectronics projects

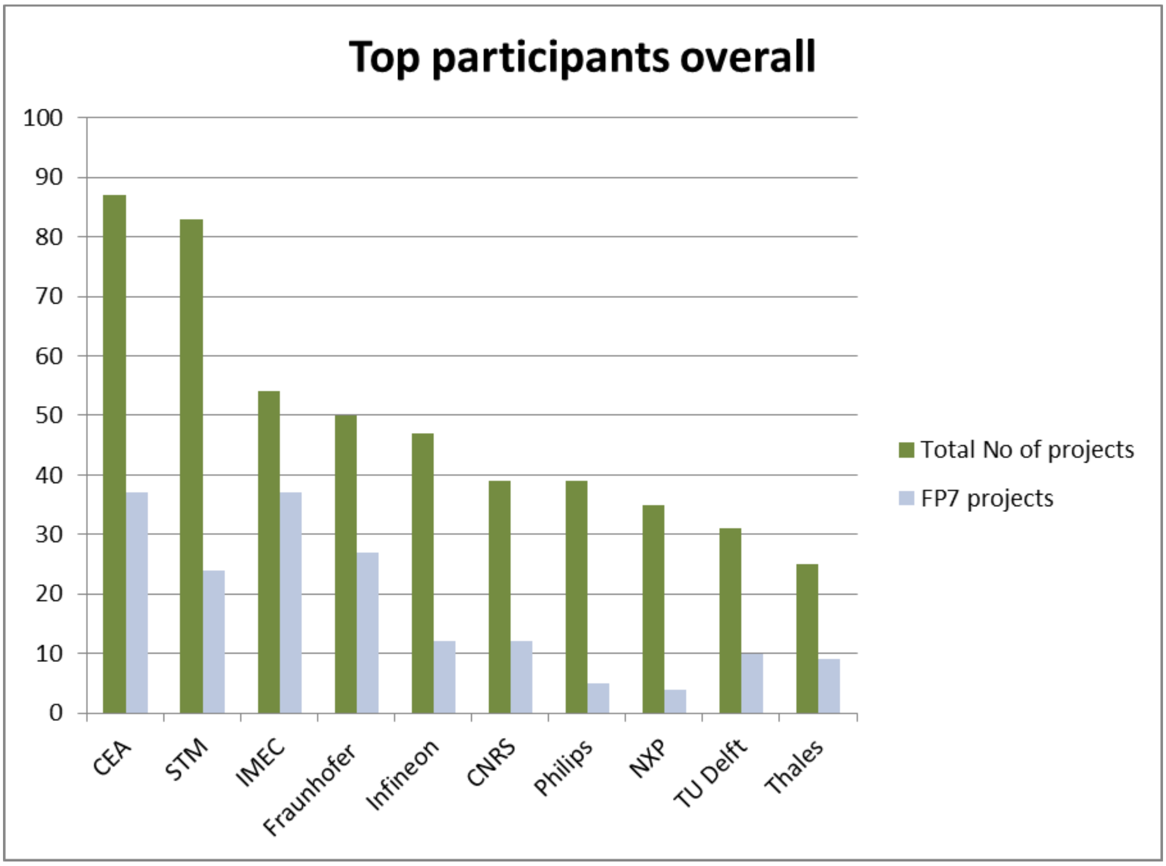


Table 7 – Top participants in all EU Nanoelectronics projects

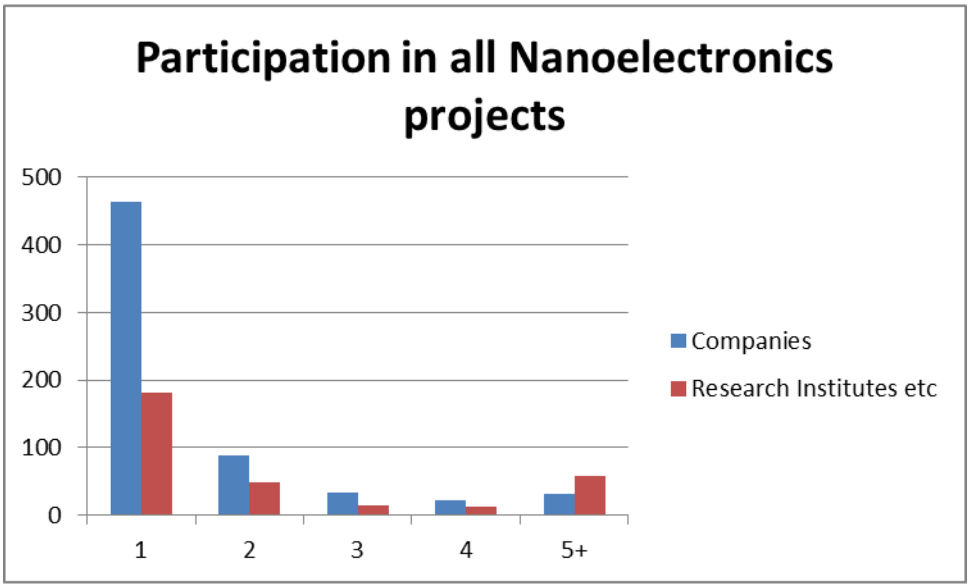
No	Participants List	Category	Total No of Projects - Joint E/C/M and FP7	No of FP7 Projects
1	CEA - All Labs	R	87	37
2	STMicroelectronics	I	83	24
3	IMEC	R	54	37
4	Fraunhofer	R	50	27
5	Infineon	I	47	12
6	CNRS - All Labs	R	39	12
7	Philips	O	39	5
8	NXP	I	35	4
9	TU Delft	R	31	10
10	Thales	O	25	9
11	Katholieke Universiteit Leuven	R	15	9
12	VTT	R	15	9
13	EPFL	R	15	13
14	Atmel Rousset (now Lfoundry)	I	14	0
15	TU Eindhoven	R	14	2
16	Robert Bosch	I	13	5
17	Consiglio Nazionale delle Richerche	R	13	9
18	Numonyx	I	12	4
19	University College Cork	R	12	10
20	EADS	O	11	2
21	Siemens	O	10	5

The distribution of participants in all Nanoelectronics projects (Joint E/C/M as well as FP7) is shown in Figure 5 below: approximately 647 companies and 324 research institutes (including universities, agencies, associations, etc) are involved in one or more projects. A relatively small number of participants (33 companies and 60 institutes) are involved in 5 or more projects, indicating the dominance of major institutes and large companies. A significant finding of this analysis is that there are a large number of organisations involved in only a few projects (a 'long tail'), with approximately 466 companies and 186 research institutes involved in only one project.

The publicly available data do not allow SMEs to be identified explicitly so it has not been possible to analyse the role played by SME participants. Access to EC information on company size would allow the benefits to SMEs of participation in FP7 to be studied.

The UK situation is particularly noteworthy. The UK is a significant player in FP7 overall and UK universities, in particular, receive large amounts of EU funding. However, no UK universities or companies appear in the top ranking: the highest participating University is Cambridge with 6 projects and the highest participating company is Oxford Instruments with 3 projects. Therefore the thinly spread nature of participation in the UK may be detrimental to the effective use of the EU funding in developing supply chains.

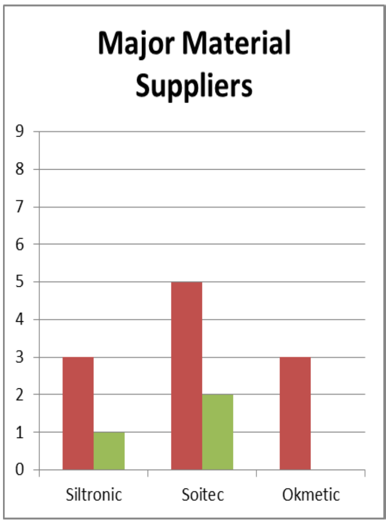
Figure 5 – Distribution of participation in (all) EU Nanoelectronics projects

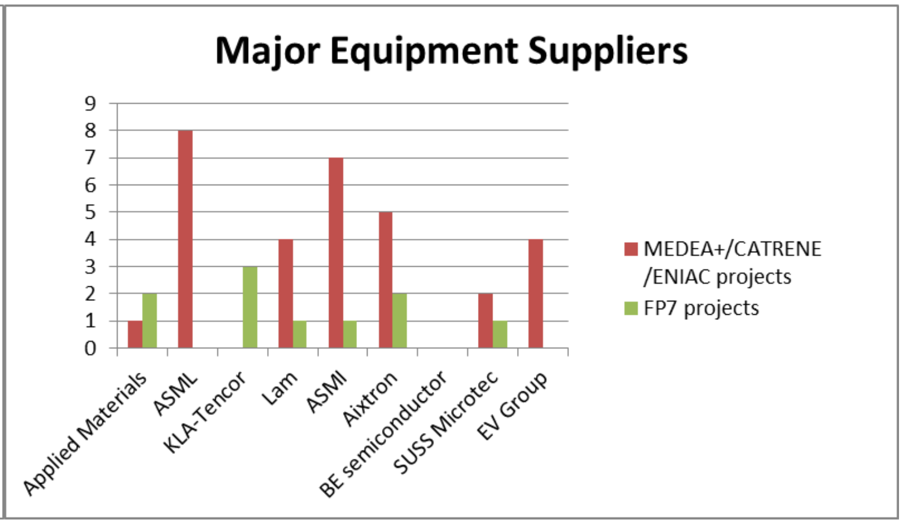


4. SUPPLY CHAIN COVERAGE

The project data has been analysed for participation by the major supply chain players in the EU. Included in this analysis are US-based companies that have a European presence. The major companies have been taken from recent market data and the ICT Man Study[1] performed for DG/INFSO by VDI/VDE and CEA-LETI. In the following charts the companies are shown in order of market ranking (based on 2009 revenues) decreasing from left to right, starting with the market leaders on the left. The companies cited are mainly European companies, with foreign companies (mainly US-owned) included if they participate in EU R&D projects. (NB Major market leaders who do not participate in EU R&D projects, e.g. from Japan, China, Taiwan, etc are not included.)

<u>Material and Equipment Suppliers</u>

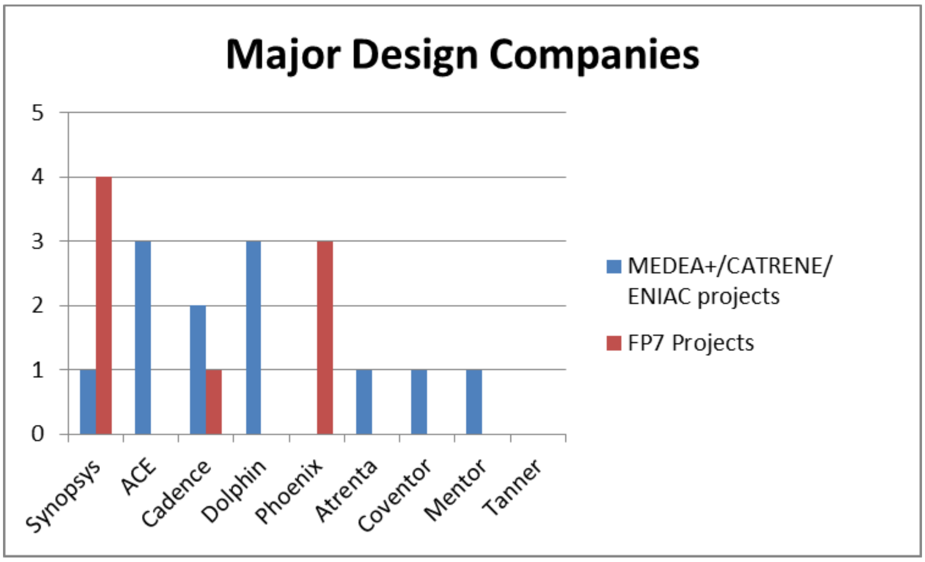




[1] ICT Man: Exploring the Potential of ICT Components and Systems Manufacturing in Europe, 1 April 2011

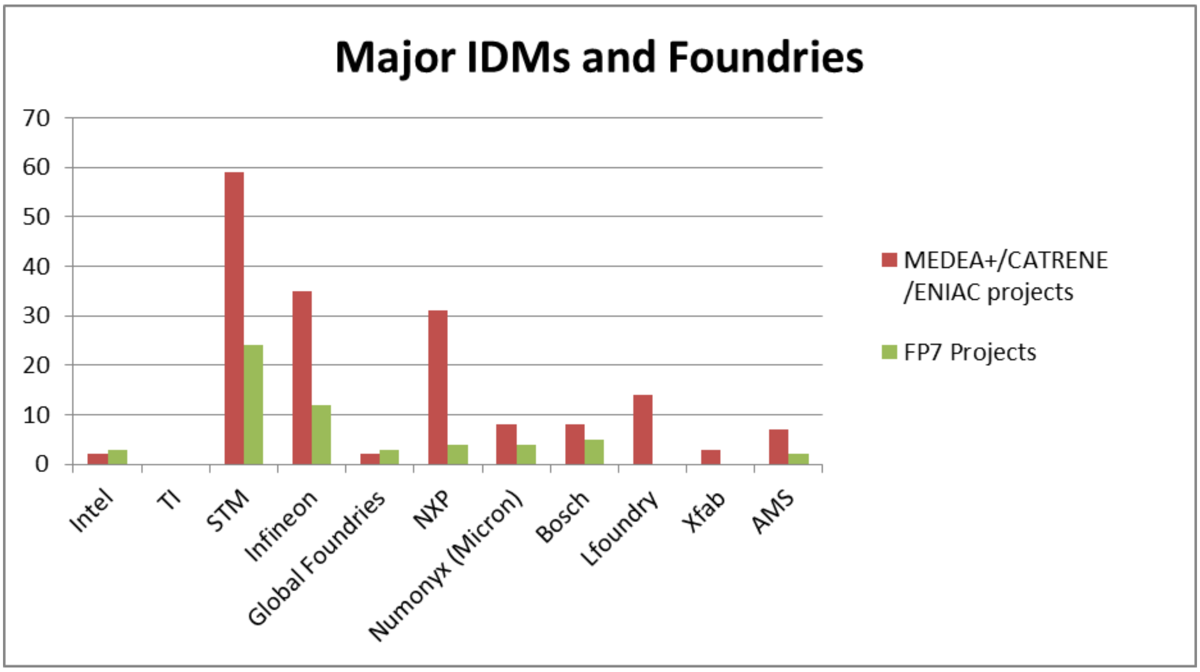
- Major Equipment providers are much more involved in Joint E/C/M Programmes than FP7. The EU is strong in Equipment but due to low internal consumption within the EU exports a lot to large markets in US and Asia.
- Note the absence of BE Semiconductor Industries N.V. in all EU-funded projects and the absence of ASML in FP7, which is significant since the NL equipment industry accounts for 70% of the EU total. ASML has received significant funding from previous Framework Programmes and now is more involved in the application oriented Joint E/C/M programmes.

Design houses and tool suppliers



- Major design companies have limited involvement in both Joint E/C/M and FP7 Programmes (each participant is involved in a relatively small number of projects), reflecting fragmented activity/ capability and the high involvement of SMEs in this domain.

Integrated Design Manufacturers and Foundries

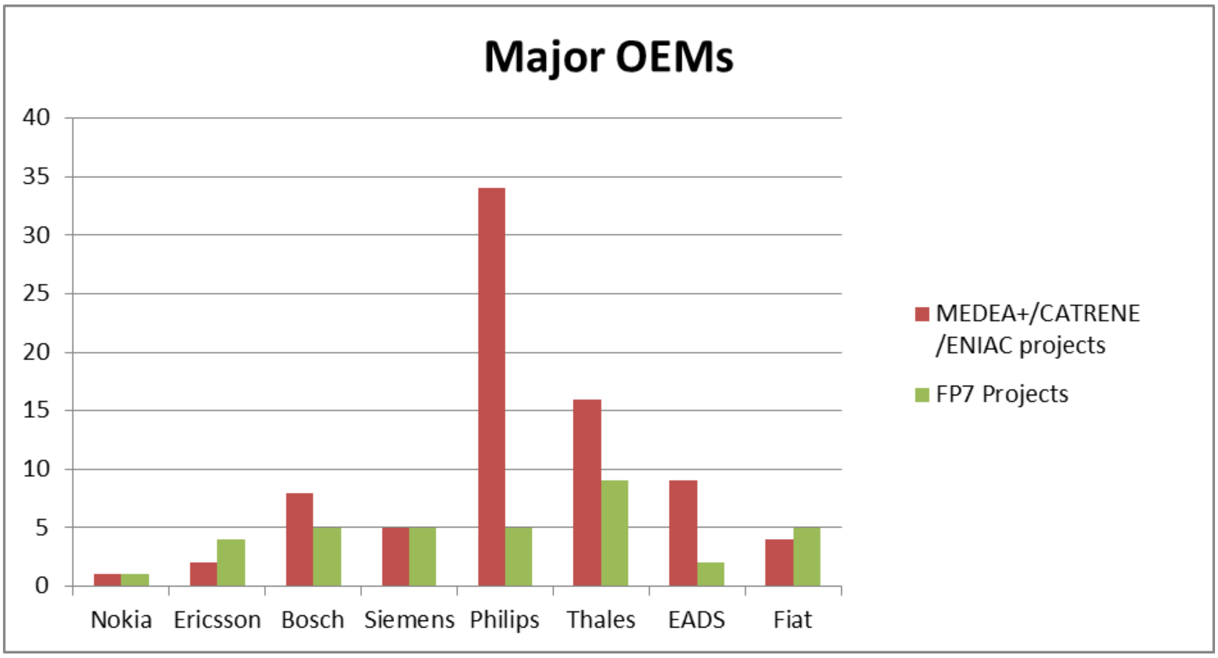


- Major IDMs are much more involved in Joint E/C/M Programmes than FP7 – even though there are twice as many ‘Integration’ projects in FP7, suggesting there are major inhibitors to Manufacturing IDMs (including Foundries) getting involved in FP7 compared to the Joint E/C/M Programmes. This is an important issue for More than Moore IDMs. Although major IDMs are collectively involved in 43% of FP7 projects this is dominated by STM and Infineon, who between them are involved in 33% of FP7 projects. NXP, Lfoundry, Xfab and AMS have little or no involvement in FP7.
- There are US owned companies in Europe that do not participate in FP7, e.g. TI. There are other US companies in Europe that participate to a limited degree, e.g. IDMs/Foundries: Global Foundries, Intel, Micron (which has acquired Numonyx), Equipment suppliers: Applied Materials, KLA Tencor and LAM.
- There is very limited UK Industry involvement in FP7 and the Joint E/C/M Programmes, with no significant players involved: e.g. ARM is in only one FP7 Nanoelectronics project. This is partially due to the lack of national funding for large companies in EUREKA and the low contribution to ENIAC. As the UK has a significant proportion of EU semiconductor fabrication production (e.g. including fabs such as National Semiconductor, International Rectifier) this is important. UK Universities are involved (though never in multiple numbers of projects as are the French and German Universities), so their know-how developed in EU-funded programmes is exported to companies in other countries, lost or transferred to UK companies through UK national activities.
- Fabless design companies are absent from the data, reflecting the lack of fabless EU companies who are major players in the global market.

<u>Electronic Contract Manufacturers</u>

- Electronic Contract Manufacturers, including Electronic Manufacturing Service (EMS) companies that provide Packaging, Assembly and Testing (PAT) for OEMs, and Original Design Manufacturing (ODM) companies that assemble electronics systems in high volume markets, are dominated by US and Taiwanese companies.
- Major EU EMS companies such as Elcoteq (FI) (ranked at no 7 in the global market with 2.9% market share), NOTE (SE) and new players like Nanium (PT) are not involved in these EU Programmes.
- There are no significant ODM companies in the EU.
- The US and Taiwanese EMS and ODM companies do not participate in EU R&D programmes, which may be a significant gap and disadvantage for the commercialisation of European R&D in global markets and supply chains.

Original Equipment Manufacturers



Major OEMs are much more involved in Joint E/C/M Programmes than FP7 – one factor may be that there are more (twice as many) 'Application' projects in the former. However this does not explain, for example, the extremely low involvement of Nokia and Philips in FP7. The data contain evidence on the extent of geographical clustering, with obvious examples being clear, e.g. CEA with STM, but due to the complexity and large volume of data it was not possible to analyse these geographical connections (e.g. how well Institutes like IMEC connect to nearby companies like Philips) in the time available.

5. QUALITY OF SUPPLY CHAINS AND EFFECTIVENESS OF TECHNOLOGY TRANSFER

The following analysis concentrates on the **FP7-only Nanoelectronics projects** to investigate how successful this programme is in developing supply chain participation, and its reliance on and linkage with the MS-funded programmes (EU and national) in pulling through technologies to the market.

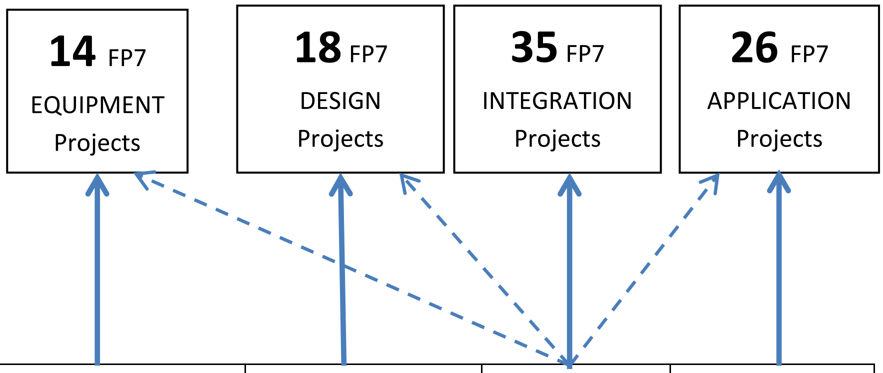
As Industry participates more in the Joint E/C/M Programmes than FP7 (e.g. Philips) the EU relies on technology transfer partnerships in non-FP7 instruments, e.g. through Research Institutes involved in both FP7 and Joint E/C/M Programmes and national programmes that bring teams together. Issues are:

- Can the Research Institutes involved in FP7 and not in Joint E/C/M Programmes, e.g. UK Universities, EPFL, etc effectively transfer this expertise to Industry players involved in Joint E/C/M Programmes and not FP7?
- How do IDMs, e.g. LFoundry and OEMs, e.g. Gemalto, involved in Joint E/C/M Programmes, and not FP7, access FP7 outputs?

Networks of Excellence (NoE) can be helpful in transferring know-how from research institutes and universities to IDMs. For example, the NoE NANOFUNCTION involves a network of institutes developing processes, etc for More than Moore integration, working with STM.

Involvement of major market players in Manufacturing supply chains in the **FP7-only Nanoelectronics projects** is captured in Table 8 below, which shows how many of the 99 FP7 Nanoelectronics projects the major Equipment and Materials, Design, IDM/Foundry and OEM companies are involved in.

Table 8 – Involvement of major Equipment and Materials, Design, IDM/Foundry and OEM companies in FP7 Nanoelectronics projects



	EQUIPMENT AND MATERIALS SUPPLIERS	DESIGN COMPANIES	IDMs & FOUNDRIES	OEMs
No	9	8	43	25
% of Total (99)	9%	8%	43%	25%

The participation of the major players in the various parts of the supply chain is broadly in line with the types of projects being funded. For example, as shown in Table 8 above, the major OEMs are involved in 25 projects, in line with FP7 funding 26 'Application' projects. It should be noted that the major players in the various supply chain categories participate in all types of project: in particular IDMs participate in 'Application', 'Design' and 'Equipment' focused projects as well as those designated 'Integration', as shown above, though 'Integration' projects are of special interest to them. This indicates that FP7 is successfully involving major players across the supply chain.

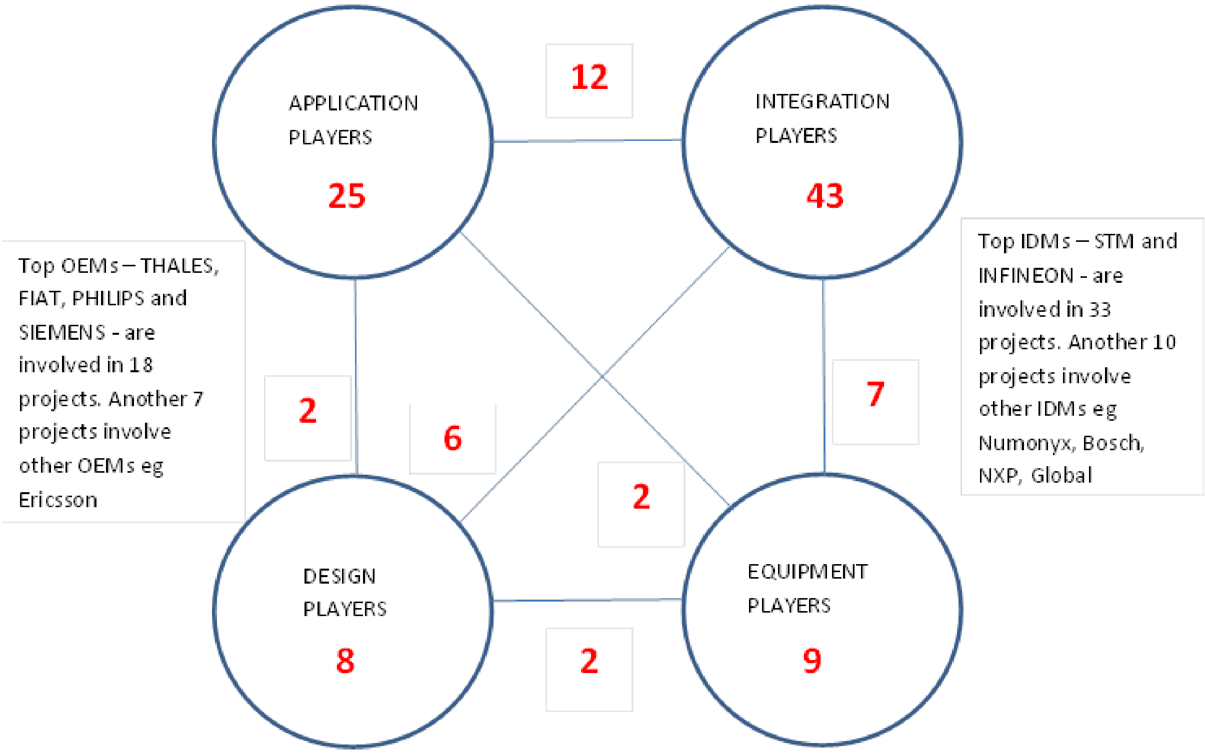
Major Design companies are involved in 8 FP7 projects, which is smaller than one would initially expect with 18 FP7 Design focused projects. This reflects the higher involvement of SMEs in design and the coverage of design activities by the IDMs and research institutes. Also, as shown below, the IDM involvement is dominated by the presence of STM and Infineon, and other major IDM players are either missing or have low involvement.

Figure 6 illustrates the linkages between the different types of supply chain partners.

- Looking at connectivity of major Equipment (E) companies with major IDMs (I) in FP7 projects it can be seen that most of the 9 projects involving major E players also involve major IDMs – the level of connectivity between major Equipment and IDM players is good.
- Looking at connectivity of significant Design companies with major IDMs in FP7 projects it can be seen that 75% of the 8 projects involving significant Design companies also involve major IDMs – the level of connectivity between major Design and IDM players in FP7 projects is good from the Design company viewpoint.

- Looking at connectivity of major IDM companies with major OEMs in FP7 projects it can be seen that 28% of the 43 projects involving major IDM companies also involve major OEMs – this is not unreasonable as IDMs can sell directly to the market in their own right.

Figure 6 – Linkages between major Industry players involved in FP7 projects



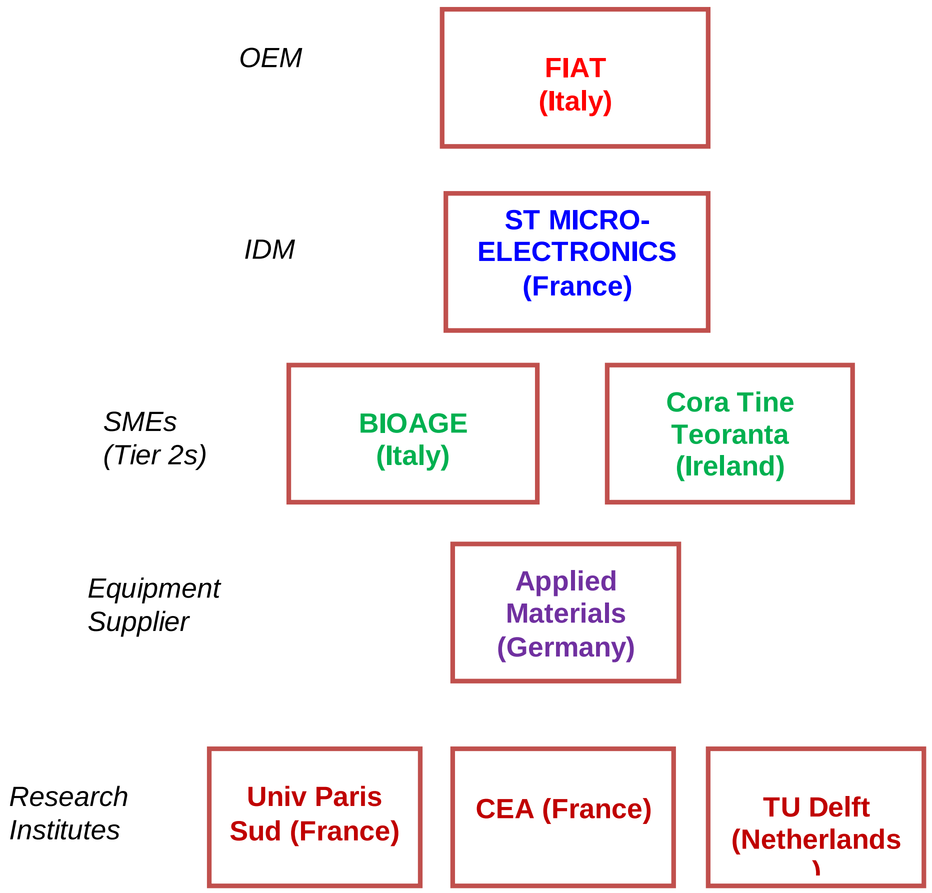
- There is only 1 FP7-only project (1% of projects) where major Equipment, IDM and OEM companies are all involved (E-STARS), but this reflects the low involvement of major Equipment (E) players overall (9% of projects).

The example of the E-STARS project is shown below in Figure 7, a complete emerging supply chain spanning all parts of the Nanoelectronics value chain. Although a specific major design company is not included in the consortium, design activities are covered by the IDMs and research institutes.

Figure 7 – E-STARS FP7 project emerging supply chain

E-STARS
Efficient smart systems with enhanced energy storage
ICT-2007.3.6 Micro/nanosystems
Project Acronym: E-STARS
Contract Type: Collaborative project (STREP)
Start Date: 2008-06-01
Duration: 36 months
Project Cost: 4.03 million euro
Project Funding: 2.6 million euro

Aim:
To develop an enhanced sensing and communication capability on an autonomous smart micro system powered by a new 3D high capacity integrated micro battery.

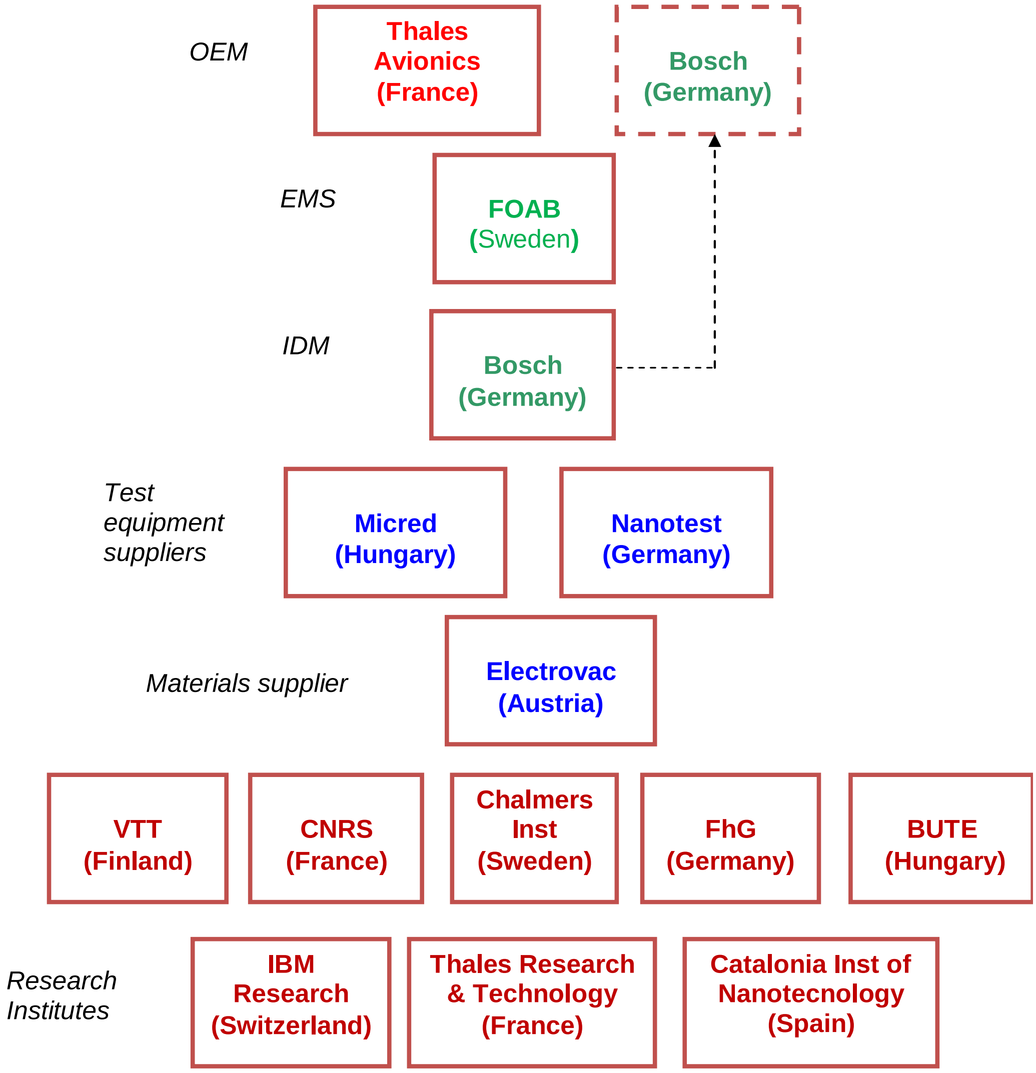


In projects funded directly by the Nanoelectronics Unit, there are only four projects involving a major IDM and a major OEM. One of these projects (NANOPACK), on further detailed investigation, includes material suppliers and test equipment providers and hence constitutes a complete supply chain as shown below in Figure 8.

Figure 8 – NANOPACK FP7 project emerging supply chain

<u>**NANOPACK**</u>
Nano-packaging technology for interconnect and heat dissipation
ICT-2007.3.1 Next-Generation Nanoelectronics Components and Electronics Integration
Contract Type: Collaborative project (Integrated Project)
Start Date: 2007-11-01
Duration: 47 months
Project Cost: 11.03 million euro
Project Funding: 7.4 million euro

Aim: to develop new technologies and materials for low thermal resistance interfaces and electrical interconnects by exploring systems such as carbon nanotubes, nanoparticles and nano-structured surfaces using different enhancing contact formation mechanisms combined with high volume compatible manufacturing technologies such as electro-spinning.



It should be noted that the material and equipment companies in this NANOPACK project are relatively small players who are only involved in one or two projects overall and therefore are not visible in the analysis performed earlier which focused on the major industry players. This is in line with the findings that there are a large number of small companies (>400) which participate in only one project (see earlier). Hence, apparent gaps in the supply chain coverage are importantly being filled by small companies, but further detailed analysis would be needed to identify how well the supply chains they are involved in are being nurtured by the EU programmes.

6. BENCHMARKING NANOELECTRONICS PROJECTS

Table 9 below compares the EU public funding for Nanoelectronics with other market sectors and relates this to the EU turnover for products and services in these sectors. The funding for R&D reflects the maturity and nature of the different market sectors:

- The Automotive and Aerospace markets are mature and the R&D programmes are driven by leading industry players, with significant OEM Private Venture (PV) funding investment. EU investment is focused on specific themes reflecting societal needs such as low carbon transport and more efficient vehicles.
- The Security market is fragmented and it can be difficult to justify industry PV funding investment. Hence R&D programmes tend to be driven by national government requirements and funding.
- The Nanoelectronics market is relatively immature but rapidly growing. Hence the need for significant national and EU investment in R&D.

Table 9 – EU funding levels and market share for various sectors

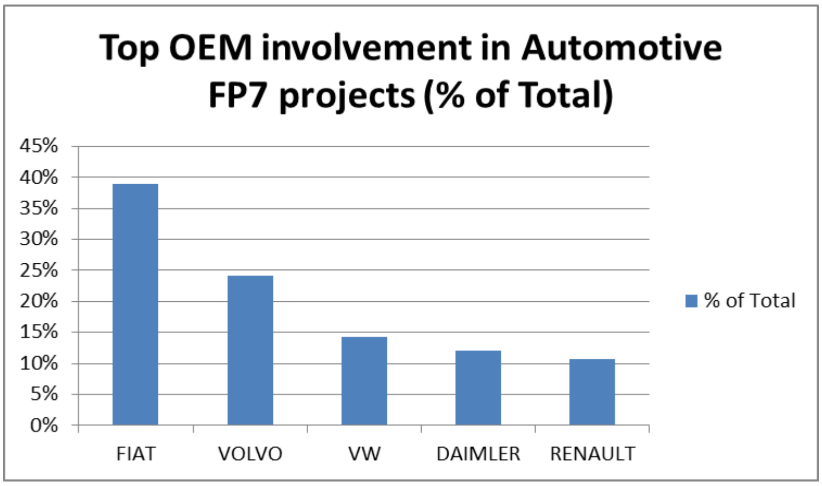
Sector	FP7 Projects – EC contribution (€ p.a.)	Other Funding Streams – Total Costs (€ p.a.)	EU Turnover (€ p.a.)
Automotive	200M	20B (OEM PV)	550B
Security	320M	Mainly national funding programmes	79B
Nanoelectronics	115M (plus 35M ENIAC)	910M (EUREKA)	30B
Aerospace	350M	230M (CleanSky) +12B (OEM PV)	105B

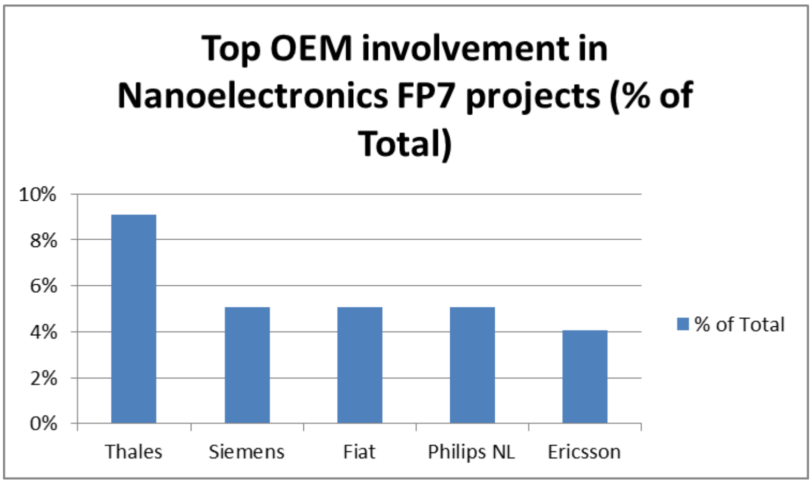
If one compares the level of involvement (in terms of numbers of projects in which they participate) for top OEMs, Tier 1s (IDMs etc) and Research Institutes for Nanoelectronics FP7 Projects with Automotive FP7 Projects funded over the same interval, one finds that:

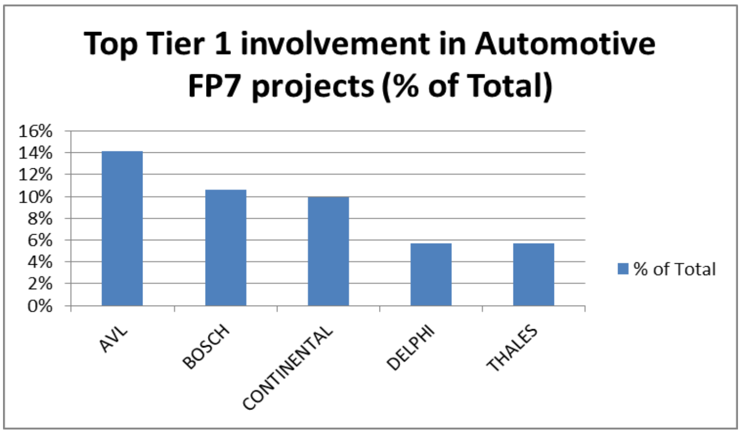
- There are major Automotive OEMs who are involved in far higher numbers of FP7 projects than their Nanoelectronics equivalents: Nokia and Philips for example are not significant players in these FP7 Nanoelectronics projects.
- Top Research Institutes are more extensively engaged in FP7 activities for Nanoelectronics than Automotive.
- The top Nanoelectronics IDM participants and Automotive Tier 1s are involved in similar numbers of FP7 projects.

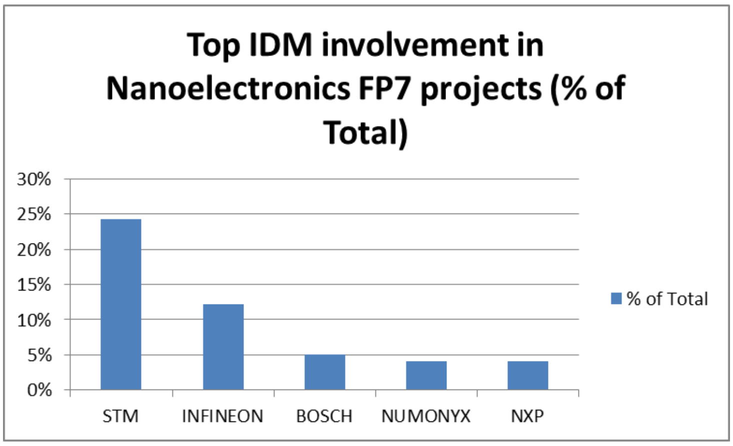
- Involvement of Tier 2 (SME) companies in Automotive projects is estimated to be <1% of all Automotive SMEs. Concerns have been expressed by the EC and major OEMs that the automotive supply chains are too rigid and there are major barriers to increasing SME involvement. Issues of SME involvement in Nanoelectronics projects are discussed below.

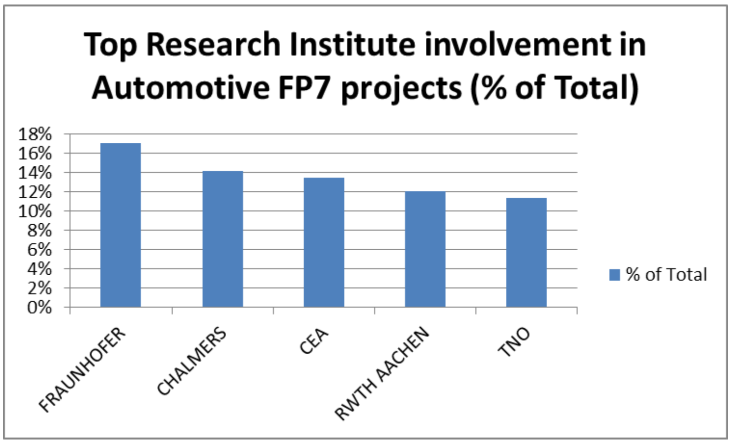
The involvement of the major players in EU-funded Automotive and Nanoelectronics projects is illustrated in the diagrams below, which show the proportion of FP7 Automotive and Nanoelectronics projects they are respectively involved in.

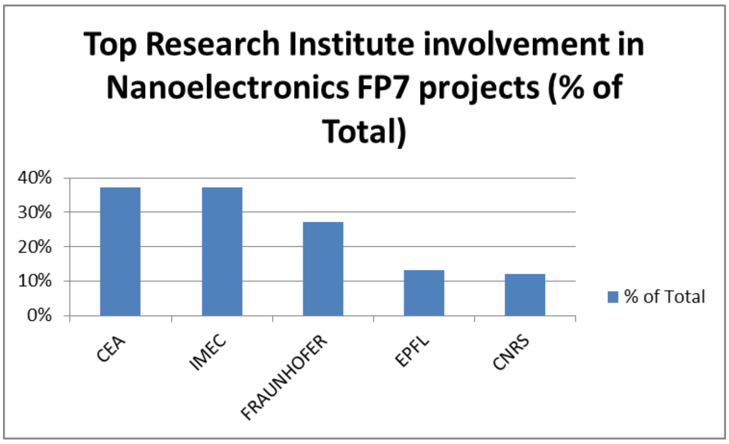





Top Tier 1 involvement in Automotive FP7 projects (% of Total)
16%
14%
12%
10%
8%
6%
4%
2%
0%
AVL
BOSCH
CONTINENTAL
DELPHI
THALES
% of Total


Top IDM involvement in Nanoelectronics FP7 projects (% of Total)
30%
25%
20%
15%
10%
5%
0%
STM
INFINEON
BOSCH
NUMONYX
NXP
% of Total


Top Research Institute involvement in Automotive FP7 projects (% of Total)
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
FRAUNHOFER
CHALMERS
CEA
RWTH AACHEN
TNO
% of Total


Top Research Institute involvement in Nanoelectronics FP7 projects (% of Total)
40%
30%
20%
10%
0%
CEA
IMEC
FRAUNHOFER
EPFL
CNRS
% of Total

When one looks at the type of Automotive FP7 projects being funded, the higher level of involvement of OEMs and lower level of involvement of key Research Institutes is consistent with the higher focus on applications in the Automotive FP7 Programme, which is developing projects driven by top-down OEM requirements. The Nanoelectronics FP7 projects are more driven by Research Institutes and IDMs, and there is a complex 'long tail' of niche companies involved in one or two FP7 projects, with key roles in some of the emerging supply chains being formed. SMEs appear to be key players here, particularly in Design and Equipment, but the publicly available data used in the study do not identify SMEs and therefore it was not possible to analyse the effects of the programme on SMEs. There appears to be an opportunity for FP7 to support value-adding Nanoelectronics collaborative links between SMEs and other supply chain partners that is less evident in the automotive domain, where some SMEs find it difficult to get new innovations into OEM supply chains.

If one compares Nanoelectronics and Automotive related projects that have been contracted during the same (FP7) period, using FP7 funding instruments specifically aimed at innovative SMEs, Research for SMEs/ SME Associations (CAPACITIES) and EUROSTARS for Research performing SMEs (EUREKA), the number of projects being funded with automotive applications is far higher than in Nanoelectronics (see Table 10.)

Table 10 – Comparison of Automotive and Nanoelectronics SME led R&D projects contracted during FP7

Area of Activity	Total Number of R&D Projects	Capacities: Research for SME/SME Association Projects	Eureka: EUROSTARS Projects	Total R&D Projects for innovative SMEs (No, % of total)
Automotive	141	5	7	12 (9%)
Nanoelectronics	191	1	0	1 (<1%)

This suggests that additional SME support measures might need to be considered in future Framework Programme instruments for Nanoelectronics to encourage SME-led innovation in products and services, as have been implemented in other parts of FP7, e.g. Security, NMP. There are a few Nanoelectronics Equipment projects that involve SMEs and Research Institutes working together in partnership e.g. SEAL, but these are collaborative R&D projects with SMEs performing R&D rather than having R&D performed on their behalf (as in the Capacities/ Research for SMEs Programme). There are a variety of SME support measures being employed across the EU and in the US that have features that might be useful to consider e.g. UK Small Business Research Initiative, US Small Business Innovation Research programme, and the different funding regimes in Member States in the EUREKA programme.

7. **CONCLUSIONS AND RECOMMENDATIONS**

The roles of the major supply chain players and their participation in projects has been studied to help to understand how well FP7 and other EU R&D programmes connect to the market and facilitate technology transfer. It is not concluded that 'good' projects should always include all elements of the supply chain, but that there should be a mix of projects that includes major Industry players in key roles who are well placed to exploit the results.

The conclusions and recommendations from the above analysis are shown below in Table 11, which summarises the issues facing organisations in the Nanoelectronics industry across the supply chain, the results of the analysis of their involvement in FP7 and related programmes together with the issues raised, and recommendations on how these issues might be addressed.

The main recommendations are summarised here:

1) The FP7 Nanoelectronics Programme should be integrated as closely as possible with ENIAC and CATRENE (also see 13 below) – to enhance technology transfer to product/ systems suppliers.
2) Consider mechanisms to provide funding for key participants from key MS with limited involvement in ENIAC and/or CATRENE (e.g. ARM).
3) Simpler rules for participation should be considered such as a reduced number of partners (2-3), which would reduce bureaucracy and allay fears of IP leakage in large consortia.
4) Consider specific programmes aimed at strategically important societal problems with 100% funding and/or payment on deliverables (cf ESA, DARPA).
5) Consider incentives used by the UK Technology Strategy Board (TSB), which could encourage Industry involvement in FP7. For example:
    a. Limit Research Institutes to no more than 30% of project funding
    b. Disallow Research Institute participation without a national Industry partner.
6) Consider specific Industry-only project calls for strategic topics.
7) Consider mandating use of EU manufacturing facilities or technology transfer route to EU product suppliers.
8) Consider mandating particular types of participants (e.g. IDMs) in selected FP7 projects.
9) Improve access of SMEs to FP7 programmes by use of SME-specific measures – to address issues facing SME sub-system providers such as Packaging, Assembly & Test (PAT) SMEs.
10) Improve access of SMEs to FP7 programmes by use of SME-specific measures – to address issues facing SME Design Houses and Design Tool Suppliers.
11) Consider developing a new instrument to build on the successful elements of the old Semiconductor Equipment Assessment (SEA) initiative, which enabled fully-funded prototype equipment purchase, to encourage manufacturing-driven innovations and links between researchers, SMEs and fabs. Cost is a significant barrier to implementing the same model as before, but there could be scope for a more creative approach if cost sharing is approached more flexibly:
    - e.g. focusing the support funding on the prototype equipment (100% of the cost without profit) with required matching eligible costs provided from other sources such as personnel from other project partners testing the equipment, effectively pooling costs and support across the participants.
12) Develop joint international programmes with key export market areas such as US, Far East focused on Equipment and take-up by end-users. For example, a joint EU-US SEA Initiative including US fabs based in EU, may encourage take-up and potential export of EU equipment to their main fabs in US.
13) The FP7 Nanoelectronics Programme should be integrated as closely as possible with ENIAC and CATRENE (also see 1 above) – to enhance technology transfer from Research Institutes.
14) Consider mandating participants at various parts of the supply chain being involved in specific projects.

15) Increase flexibility in existing collaborative projects to bring in new partners rapidly and with minimum bureaucracy.
16) Other FP7 themes have specific SME support measures, e.g. NMP, Security. The Nanoelectronics programme should consider introducing specific SME measures, such as:
    a. SME topics mandating 50% of funding to SMEs and/or an SME Coordinator
    b. UK-like Small Business Research Initiative (SBRI) calls providing 100% funding for small consortia (1 or 2 partners) addressing societal problems, building on lessons from the US Small Business Innovation Research (SBIR) Programme.

Table 11 – Conclusions and Recommendations

Supply Chain Position	Summary	Issues	Recommendations
1. Product/ system suppliers	Market-leading OEMs are involved in FP7 in line with the numbers of 'Application' projects being funded, but there are significant gaps, e.g. Nokia, Philips.	• The pull-through to market of know-how being developed in FP7, e.g. by Research Institutes, relies on the linkage with the Joint E/C/M Programmes. This is a problem as certain MS are only slightly or not at all represented. • How can FP7 be made more attractive to market-leading OEMs not currently involved? • How can the output of FP7 projects be made available to other OEMs who do not currently participate?	**1) The FP7 Nanoelectronics Programme should be integrated as closely as possible with ENIAC and CATRENE (also see 13 below).** **2) Consider mechanisms to provide funding for key participants from key MS with limited involvement in ENIAC and/or CATRENE (e.g. ARM).** **3) Simpler rules for participation should be considered such as a reduced number of partners (2-3), which would reduce bureaucracy and allay fears of IP leakage in large consortia.** **4) Consider specific programmes aimed at strategically important societal problems with 100% funding and/or payment on deliverables (cf ESA, DARPA).**
2. Sub-system provider • including Electronic Manufacturing Services (EMS) 3. Integrated Device Manufacturer • including Fabless	Major EMS companies are not involved, although there are many SMEs involved in PAT that are present in single projects only. Also, IDMs may be doing R&D on this in-house. Major EU IDMs participate far less in FP7 than Joint E/C/M Programmes – especially important for More than Moore. STM and Infineon dominate participation, others are less visible.	• How can involvement of major EMS companies be increased? • How can PAT SMEs be supported more effectively? • There are major inhibitors to important EU Manufacturing IDMs wanting to be involved in FP7. How can more support be provided to EU manufacturing capability? • How can the EU 'Fabless' capability be developed via involvement in	**5) Consider incentives used by the UK Technology Strategy Board (TSB), which could encourage Industry involvement in FP7. For example:** **a. Limit Research Institutes to no more than 30% of project funding** **b. Disallow Research Institute participation without a national Industry partner.** **6) Consider specific Industry-only project calls for strategic topics.** **7) Consider mandating use of EU manufacturing**

4. Foundry	Fabless design companies are not visible – lack of major EU market players (not in world Top 10).	FP7? This may be exacerbated by lack of involvement of UK industry (including fabless players) in FP7 and Joint E/C/M Programmes.	**facilities or technology transfer route to EU product suppliers.** **8) Consider mandating particular types of participants (e.g. IDMs) in selected FP7 projects.** **9) Improve access of SMEs to FP7 programmes by use of SME-specific measures (see later under 'General').**
5. Design House 6. Design Tool Supplier	Major design companies low involvement in FP7 and Joint E/C/M Programmes reflects fragmented market and higher involvement of EDA SMEs. SME role is especially important here.	• How can the SMEs in this part of the supply chain be supported, many of which participate in only 1 or 2 FP7 projects over 3-4 years if at all?	10) **Improve access of SMEs to FP7 programmes by use of SME-specific measures (see later under 'General').**
7. Processing and Metrology Equipment Manufacturer 8. Materials Supplier	There is low consumption in EU and the large export market in US/ Asia is difficult for SMEs to access. The 'ICT Man' Report dated April 2011 recommended that the EU implement a 'Manufacturing Equipment Assessment in Europe' initiative to develop the global use of European manufacturing equipment and increase the implementation of manufacturing facilities in Europe by supporting bilateral assessment between equipment suppliers and users.	• How can SMEs be helped to develop innovative equipment solutions with a view to these being taken up by fabs in EU and beyond? • How can SMEs be incentivised in EU programmes to form partnerships with US and Far Eastern players to help them get into these markets?	**11) Consider developing a new instrument to build on the successful elements of the old Semiconductor Equipment Assessment (SEA) initiative, which enabled fully-funded prototype equipment purchase, to encourage manufacturing-driven innovations and links between researchers, SMEs and fabs. Cost is a significant barrier to implementing the same model as before, but there could be scope for a more creative approach if cost sharing is approached more flexibly:** **e.g. focusing the support funding on the prototype equipment (100% of the cost without profit) with required matching eligible costs provided from other sources such as personnel from other project partners testing**

			the equipment, effectively pooling costs and support across the participants. **12) Develop joint international programmes with key export market areas such as US, Far East focused on Equipment and take-up by end-users. For example, a joint EU-US SEA Initiative including US fabs based in EU, may encourage take-up and potential export of EU equipment to their main fabs in US.**
9. Research Institutes and Universities	Research Institutes are well engaged in FP7 but there are important Institutes, e.g. UK universities, EFPL , etc that are far more involved in FP7 than the Joint E/C/M Programmes where major Industry players are more involved.	• How can Joint E/C/M Programme participants be more effectively be connected into FP7 outputs (apart from increasing their FP7 involvement)?	**13) The FP7 Nanoelectronics Programme should be integrated as closely as possible with ENIAC and CATRENE (also see 1 above).**
General	In FP7-only Nanoelectronics projects there are only a few examples with major players covering the complete supply chain. SME involvement is especially important for PAT, Design and Equipment but involvement in FP7 is through a large number of small companies participating in one or at the most two projects. It is not clear how well these companies are linked with the major IDMs and OEMs. Major players need to access innovations developed by small companies and	• How can major players, IDMs, OEMs, etc be encouraged to collaborate across the supply chain with, e.g. equipment, design, packaging suppliers? • There are good examples of supply chains being developed in FP7 projects where SMEs in PAT, design and/or equipment play an important role. However, the strategic involvement of SMEs and the effectiveness of EU support to SMEs via FP7 is not clear. Such SMEs are not significantly involved in	**14) Consider mandating participants at various parts of the supply chain being involved in specific projects.** **15) Increase flexibility in existing collaborative projects to bring in new partners rapidly and with minimum bureaucracy.** **16) Other FP7 themes have specific SME support measures, e.g. NMP, Security. The Nanoelectronics programme should consider introducing specific SME measures, such as:** **a. SME topics mandating 50% of funding to SMEs and/or an SME Coordinator** **b. UK-like Small Business Research Initiative (SBRI) calls providing 100%**

	bring them rapidly into their supply chains. There is only limited involvement of US-owned companies in EU programmes. There is limited UK Industry involvement in FP7 and Joint E/C/M Programmes. UK Universities are involved, but there is therefore a lack of local Technology Transfer in EU Programmes.	other EU support measures targeted at small companies, such as Research for SMEs or EUROSTARS. • Should involvement of US-owned companies in FP7 be increased? If so, how can jobs/ technology/ profits be kept in the EU? IP is an inhibiting issue from US company perspective. • Technology transfer between universities and Industry in UK is not an EU problem but participation of UK Industry in EU projects is also inhibited by lack of involvement in E/C/M Programmes.	**funding for small consortia (1 or 2 partners) addressing societal problems, building on lessons from the US Small Business Innovation Research (SBIR) Programme.** **17) See (12) above.** **18) See (2) above.**

Legal Notices

Disclaimer

This document presents quantitative and qualitative data from various sources. Due to the complexity of the project and the large amount of sources of publicly available data that had to be reviewed during the duration of the project, it was not possible to thoroughly validate all details. The data provided here are complex to interpret, are not exhaustive and may need further development. The views expressed in this publication are the sole responsibility of the authors and do not necessarily reflect the views of the European Commission. The authors and the European Commission accept no liability for any issues that arise from actions that may be taken as a result of reading this report.

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