Software intensive systems in the future

Final report

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Summary

1. Introduction

1.1. Definition of the study

This study is dedicated to software intensive systems (SIS), and to the quantitative evaluation of current and future situation and impact of software activities in the world economy.

Public authorities from France and the Netherlands as well as the ITEA Office commissioned two independent consulting companies to conduct the study: TNO and IDATE. This study first analyses the methods to define and measure software intensity. Then, based on an in-depth study of key industrial sectors, it provides software intensity estimates for 2002[1] and its potential evolution through 2015. It finally addresses the likely impacts of SIS on the overall activity (growth, employment) as well as on some major societal trends.

A main goal of this study is to investigate the internal development of software, in both ICT and non-ICT sectors, and to analyse the current and future importance of software development for the European industry. **Six key industrial sectors have been selected**: **automotive, aerospace, medical equipment & automation (non-ICT sectors) and telecom equipment & consumer electronics (ICT sectors).**

The goal of the ITEA programme (a Eureka cluster), is to develop pre-competitive cooperation and create synergies between all SIS (Software Intensive Systems) players in Europe. Today, ITEA is the leading trans-national co-operative R&D programme in Europe.

1.2. Description of this report

This study is dedicated to software intensive systems, and concentrated on analysing the current and future situation and impact of software activities in the world economy, particularly software developed internally by industrial sectors. **A software intensive system is any product or service whose functionalities are dependent upon software or even defined by it.** A more precise definition is provided in chapter 2, which also describes main characteristics of software and discusses the differences between ICT sector and SIS.

The first part of the study examines the issue of how to assess the economic value of software activities in the world economy, particularly software developed internally by industrial sectors. Chapter 3 provides a critical analysis of the existing measurement methods for software activities, showing that they likely result in strong underestimation of the value contributed by software in European industry generally. This critical analysis is developed in more detail in the appendix. A significant effort has been dedicated to develop a methodology providing a more realistic estimate for this value. A first model was developed and is presented in Chapter 4, but it was not possible practically to collect sufficient data from industry to put it into real use.

A second model was then developed and allowed us to provide detailed estimates per industrial sectors, as well as forecasts up to 2015. In that methodology, **software intensity is measured as the percentage of R&D expenses dedicated to software.** It is fully described in detail in Chapter 5.

The second part of the study focused on implementing the second model on six key industries : automation, automotive, consumer electronics, aerospace, medical equipment and telecommunication equipment. For each of these sectors, we estimate software intensity in 2002 and produce forecasts for 2015. Chapter 6 presents the results for each industry sector, as well as examples of relevant software involved in those industries at the product or at the process level and background information (regulation, competition societal trends, R&D trend, …) explaining the development of software in those industries. Chapter 7 describes the main conclusions based on results analysis.

[1] 2002 has been selected as it is the most recent year for which consistent worldwide industry figures exist

1.3. Calendar of the study

The study as a whole has been divided into two phases.

Phase 1 from January 2005 to June 2005 was dedicated to investigating existing data, developing a model and collecting company data, mostly from the automotive sector which was been selected as the test sector for validating our method and first estimates. Estimates have been made also for other sectors, but based on much less information that was obtained directly from companies in these sectors. At the end of this phase, it was decided to develop and use the second model based on software intensity, since it was not possible to collect enough data to use the first model. During phase 1, the decision was made to select 6 industrial sectors : automotive, aerospace, medical equipment and automation (non-ICT sectors) and telecom equipment & consumer electronics (ICT sectors).

Phase 2 from July to October 2005 was dedicated to the gathering, collection and consolidation of data for the six sectors. This work implied a large number of interviews with industry persons, mostly in charge of R&D and software development. They were followed by construction of estimates and forecasts for each industrial sector. Then, based on results analysis, conclusions are presented on the importance of software development for the European industry.

2. Software intensive systems

2.1. Definition

We used as a start the following definition for software intensive system : A software intensive system is any product or service whose functionalities are dependent upon software or even defined by it. By 'dependent' we mean simply that the product or service either would not function at all, or otherwise would function in a very different way without electronic systems operated by software. We finally adopt the more general definition developed by Carnegie Mellon University.

A software intensive system is a system where software represents a significant segment in any of the following points : system functionality, system cost, system development risk, development time. Examples are numerous : an ECU (Electronic Control Unit) in a modern car, processing engine for digital or mobile TV. Software is much more than a simple production input or raw material.

To a large and increasing extent, software defines the attributes and functionalities of many products and services. Moreover, software can play a role not only in providing functionalities, but also in producing them. Much software is developed primarily for the purpose of increasing the efficiency and quality of production and distribution processes (e.g. simulators, etc.).

However, despite the obvious economic significance of software, determining its actual economic value is no straightforward task. Moreover, we need to understand not only what the economic value is at the moment, but also what it is likely to be in the future. Most of the indications are that the trend for the next 10 years is for software to claim an increased portion of total product investment.

2.2. Software and ICT sector

ICT sector has been defined in 1998 by OECD. The ICT definition (official 1998 OECD definition), in terms of ISIC (International Standard Industrial Classification of All Economic Activities) Revision 3 codes is described in the following figure

Figure 1 : ICT sector definition (Source OECD)

Manufacturing

3000 manufacture of office, accounting and computing machinery

3130 manufacture of insulated wire and cable

3210 Manufacture of electronic valves and tubes and other electronic components

3220 Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy

3230 manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods

3312 Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment

3313 Manufacture of industrial process control equipment

Services : goods related

5150 Wholesale of machinery, equipment and supplies

7123 Renting of office machinery and equipment (including computers)

Services : intangible

6420 Telecommunications

7200 Computer and related activities

The common knowledge behind the ICT (information and communication technologies) sector definition is that it is producing ICT goods (including software, computers, telecom equipment, IT and telecom services) and selling them, and that all other sectors are end-users. Software is in that sense considered as ‘producer good’ – i.e. packaged software developed and marketed as a discrete product.

However, the SIS domain is not covered by the ICT definition. Considering the panel of participants from various ITEA projects, it is obvious that **the main contributors to software development are much broader than those from the software market**. ICT sector does not cover a large part of embedded and distributed software R&D efforts. This study, by considering both ICT and non ICT sectors, make visible the important volume of software development done outside of ICT sector.

3. Estimating the economic value of software

3.1. Characteristics of software

It is well understood that all Information and Communication Technology (ICT) products and services are dependent upon software. Often not so well appreciated is the very high and increasing software dependency of a huge variety of goods and services as produced in all economic sectors[2]. Modern automobiles, aeroplanes, financial services, medical diagnostic devices, machine tools, wristwatches or washing machines will not function without the software that is embedded in them.

Software is **an intermediate good** in that it does not produce value in and of itself. Rather, it enables the production of value by some other means. Moreover, software is usually found nested within other intermediate goods, as for example with a controller for an automotive electronics part. Thus, the controller is an intermediate good that depends upon another intermediate good, namely software.

When software is developed as a ‘producer good’ – i.e. packaged software developed and marketed as a discrete product – its economic value can be calculated similarly to any other product or service. The situation is far more complex for customised and/or embedded software as developed for a much broader variety of products and services.

An important point is that once a software has been developed, its production value is almost nil. So even if software represents a key part of the product, its cost per product unit sold may be almost nil, and will vary widely depending on the number of product units sold. We decided therefore to **rely more on R&D expenditures than on production expenditures**.

One should note that software cost characteristics (no reproduction cost) imply different behaviours depending on the structure of the vertical industry or the leadership in a specific market.

When developed internally, software costs are not proportional to the volume of units sold (otherwise, except for some open source software, software is based on a licence per unit). The bigger producers will therefore share the internal software expenses over a large number of units. As they sell more products, the software cost per unit decreases. Leaders therefore generally invest more in software (e.g Nokia for mobile phones) than challengers, as they have a clear economic benefit to do so.

Based on the same principles, high volume industries are also generally willing to develop common platforms, at least for the less differentiating functions, because it allows to reduce the overall bill of software by sharing costs over a larger number of products. On the other hand, low volume industry players have generally to develop by themselves all the software they need as there are generally no viable or specialized third parties (not enough volume) able to provide them.

Software has also other characteristics impacting the estimation process. Various business models are currently proposed for purchased packaged software (licence but development of services models) but also for software bundled with a specific product (very often free). **The value of software is therefore more related to the value added** and the cost than to the price.

Software involved in SiS is not necessarily visible in the product, as numerous tools (simulators, CAD) are now required to get a finished product. Therefore, software direct cost per unit is not a good measure. We decided to **focus on both product level** (mostly embedded software) and **process level** (mostly development and testing tools) to get a better estimate of the SIS.

[2] The ITEA roadmap describes in detail how software contributes to application domains and basic enabling technologies see http:\\www.itea-office.org

3.2. Available statistics and their relevance with SiS

The intermediate and nested characteristics of software create enormous problems when it comes to estimating the economic value of software (whether in terms of products or of GDP contribution). The main problem is a serious lack of relevant and dependable data. At the present time, we have basically two sources of data that are relevant to making value determinations, but each has its own inadequacies when it comes to software :

- ***System of National Accounts (SNA) data*** – These data are collected by national statistical agencies for the purpose of monitoring national income and expenditure in order to inform economic and social policy. National data form the basis of statistical analysis at the international level – e.g. by the OECD. The SNA data have the advantage of being longitudinal (collected over long periods of time) thus in principle allowing more statistically rigorous determinations of economic impacts. **But for our purposes they have the disadvantage of being collected on a sector basis according to a nomenclature that does not reflect the current composition of advanced industrial economies.**

  In particular, SNA data from most countries do not yet capture data on the service sectors or on intermediate goods like software. For example, some countries collect data on the telecommunication and computing industries primarily in terms of the manufacture of equipment. The figures provided by firms in these industries may incorporate value that is added specifically by software activity, or by customer services, but typically the data are not disaggregated to the degree necessary for us to see the exact contribution of these individual activities to GDP.
- ***Industry data*** – These data are collected typically by companies, industry associations, professional bodies and market research organisations. Governments collect them as well, but normally on an occasional, case-specific basis. The advantage of these data is that they may give a more accurate picture of industry segments at a specific point in time. The disadvantages are that they are almost always cross-sectional (covering only one point in time or very short periods of time) and that often the methodologies are not consistent from one data set to another, or indeed even given. This greatly reduces the reliability of economic estimates based on such data. Moreover, **industry statistics only address market size and likewise do not disaggregate specific intermediate inputs, like software.**

At this time, neither type of data is adequate to estimate the economic value of software, even within the ICT producer sector, let alone in the economy as a whole.

4. A first model for estimating the value of software to producers

Even though the data collection problems mentioned above, it is possible nevertheless to *estimate* the value of software within reasonable parameters by examining the software intensity of various industries. Software intensity is basically a cost measure and it can be determined from company-level information about all of the expenditures they make that are solely or mainly directed at procuring, integrating and developing software relative to individual product groups.

Figure 2: The cost estimation process

C1	+	C2	+	C3	=	software value to producers
First intensity estimate		*Second intensity estimate*		*Third intensity estimate*		
expenditures on producer software		**Add: procured custom software expenditures**		**Add: internally developed (own account) software**		
costs of generic software		**costs of software services & custom software**		**software labour costs**		

The estimation process is illustrated in figure 1. Ideally, information would be available in three categories, each geared to a specific type of software input (based on different indicators). The final estimate would be the sum of these indicators. However, in practice we do not expected that all firms will be able to provide all three types of data to the same extent or always in comparable form. Moreover, in some cases the levels of investment and/or trends may have to be inferred from more qualitative analysis of changes in industry, market and product characteristics.

C1 and C2 can be approximated by using existing data on market size, both for the packaged software market and for IT services. There is a strong relationship between these two figures, as buying software programmes is usually associated with much greater spending on IT services (customisation of the software, further *ad hoc* development of procured software, services of software engineers and technicians etc.).

The data estimated for the five sectors are concentrated on C3 estimates, considered mainly as own account software internally developed software. Data about software investment published by OECD tend to show that own account software represents the same level of investment than purchased software, but these data do not distinguish between sectors.

The first phase of the study proved that it was not possible to obtain from each industry enough data to provide a reliable estimate for C1,C2 and C3 covering with enough confidence all sectors. As a result, we do not use this model in the second phase, but developed one for which data collection was realistic within the context of this study.

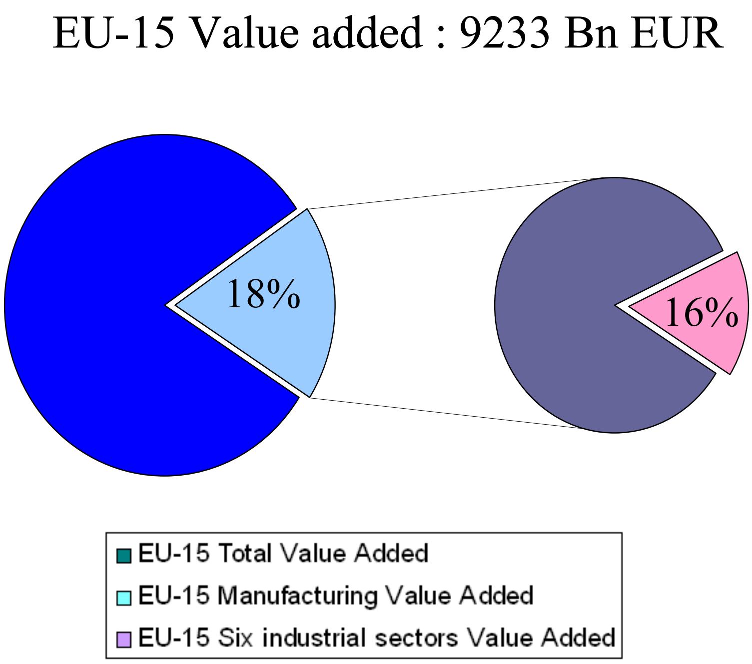
5. Methodology used for collecting data and providing estimates and forecasts

5.1. Selection of industrial sectors

6 key industrial sectors have been selected. They are automation, automotive, consumer electronics, aerospace, medical equipment and telecommunication equipment. In Europe, they represent in terms of value added 16 % of the total European manufacturing industry, which includes many other sectors such as food products, wood, chemicals and pharmaceutical. The manufacturing industry is also one of the key contributor to the EU-15 value-added (18%). The following figure resumes for EU-15 the respective values of total GDP, total manufacturing value added and value added of the 6 considered sectors.

Value added of the sectors mentioned above takes into account value added of the OEMs (Original Equipment Manufacturers), but also value added of Tier-1 (and Tier-n) suppliers relevant to the sector. For instance, in automotive, industry players like Daimler-Chrysler and Bosch need to be considered.

Figure 3 : Compared EU-15 total GDP, total manufacturing value added, and 6 sectors



considered

Source : Groningen Growth and Development Centre, Eurostat, IDATE

Table 1 : Breakdown of European GDP

Sector	% of European GDP
Manufacturing/Energy	18%
Services	21%
Building/Commerce/Transport	20%
Education/Health/Administration	20%
Real estate/Finance	17%
Agriculture	3%

Source : EITO

Those sectors are not only representative in terms of value-added but also in terms of employment with more than 3.5 million jobs in Europe.

Table 2 : Employment and ICT Skills in Europe in the 6 sectors studied

Sector	ICT Skills	Total Staff (Europe)
Aeronautics	30.2%	414 000
Automation	N/A	ND
Automotive	21.2%	2 000 000
Consumer Electronics	44.8%	233 000
Medical Equipment	31%	386 000
Telecom Equipment	47.8%	451 000
Total of the 6 sectors	N/A	3 484 000

Source : IDATE

This study addresses only the six sectors mentioned above but we expect that similar results would be obtained for other sectors. One basis for this hypothesis is the ranking of industries according to their share of broadly defined **ICT-skilled** employment, published by OECD[3] in 2005. As seen in table 1, the sectors selected are neither the top sectors nor the bottom sectors. For instance, sectors like financial services have a better ICT skill ranking as it indeed requires a lot of programming skills from traders who build numerous models on C++. **The 6 sectors selected are in that way representative of what could be obtained to measure software intensity** when looking at other sectors.

We expect that ICT skills imply in many cases a significant level of software skills. Automotive ranks relatively low with 21%, but there are a large number of sectors above 20%, such as manufacture of coke, refined petroleum and nuclear fuel, manufacture of chemicals and chemical products, collection and distribution of water, publishing, manufacture of equipment and others. We expect that sectors with a high level of ICT-skilled employment are developing an important volume of software. This has been validated by the 6 sectors studied.

Those sectors were also chosen to provide an **appropriate balance between ICT sectors and non-ICT sectors, and between low-volume industries and high volume industries**.

The sectors analyzed present different characteristics :

- Aerospace and medical equipment (expect for the recent Point-of-Care products which may become near mass markets products) are low volume markets with a limited number of strong players for each market segment. This concentration level explains the strong involvement of all players regarding software.
- telecom equipment (devices and professional equipment, carrier equipment only in a lesser extent), automotive and consumer electronics are high volume markets and even mass markets. Middlewares have been developed or are currently under development for those specific industries, but market leaders pursue also internally some initiatives.

[3] New Perspectives on ICT skills and employment 22/4/2005

Table 1 : Ranking of industries[4] according to their share of broadly defined ICT-skilled employment 2002

NACE 2-digit	Industry	Share (%) 2002
	>30%	
72	Computer and related activities	84.2
66	Insurance and pension funding, except compulsory social security	74.8
67	Activities auxiliary to financial intermediation	67.9
65	Financial intermediation, except insurance and pension funding	69.2
30	Manufacture of office machinery and computers	57.1
74	Other business activities	50.4
40	Electricity, gas, steam and hot water supply	45.1
32	**Manufacture of radio, television and communication equipment and apparatus**	**44.8**
70	Real estate activities	46.1
73	Research and development	41.3
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles	42.7
23	Manufacture of coke, refined petroleum products and nuclear fuel	35.2
31	**Manufacture of electrical machinery and apparatus, n.e.c**	**35.3**
24	Manufacture of chemicals and chemical products	35.9
71	Renting of machinery and equipment without operator and of personal and household goods	31.4
41	Collection, purification and distribution water	26.2
33	**Manufacture of medical, precision an d optical instruments, watches and clocks**	**31**
64	Post and telecommunications	32.6
35	**Manufacture of other transport equipment**	**27.2**
	10-30%	
91	Activities of membership organisation, n.e.c	28.6
29	**Manufacture of machinery and equipment, n.e.c**	**26.9**
22	Publishing, printing and reproduction of recorded media	26.4
62	Air transport	18.5
75	Public administration and defence; compulsory social security	23.6
63	Supporting and auxiliary transport activities; activities of travel agencies	22.1
34	**Manufacture of motor vehicles, trailers and semi-trailers**	**19.7**
21	Manufacture of pulp, paper and paper products	21.9
92	Recreational, cultural and sporting activities	22.3
25	Manufacture of rubber and plastic products	18.4
50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	18.1
27	Manufacture of basic metals	17.1

[4] Industries for which the share was significant only

NACE 2-digit	Industry	Share (%) 2002
26	Manufacture of other non-metallic mineral products	19
28	Manufacture of fabricated metal products, except machinery and equipment	16.7
17	Manufacture of textiles	12.9
15	Manufacture of food products and beverages	14.7
36	Manufacture of furniture; manufacturing n.e.c	14.9
45	Construction	14.5
52	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	14
18	Manufacture of wearing apparel; dressing and dyeing of fur	10.4
60	Land transport; transport via pipelines	11.2
90	Sewage and refuse disposal, sanitation and similar activities	14
20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	9.5
	<10%	
80	Education	8.8
93	Other service activities	8.6
85	Health and social work	8.3
55	Hotels and restaurants	7.2
1	Agriculture, hunting and related services activities	2.9

Source: OECD

The study does not address the services sector. For instance, telecom equipment industry does not take into account carrier internal expenditures regarding services (broadband or wireless). **A specific study would be needed to understand the services sector value added regarding software**. We expect that the software intensity of the services sector would be less important (with may be the exception of financial services), as it generally relies less on R&D.

5.2. Estimation of software intensity

As mentioned above, **software intensity is measured as software R&D expenses compared to total R&D expenses for each sector.**

Most of the study resources were dedicated to the estimate of software intensity in 2002 and its forecasts in 2015. Data were collected from industry people in charge of R&D and/or of software development. These data include all software expenses whether subcontracted or internally developed.

Given that it would be impossible within the scale and scope of the study to generate the kinds of data necessary to actually ‘measure’ the economic contribution of software, we rely instead on estimations that are calculated using the best available indicators, consistent with the basic principles of value measurement. Our estimation model is a heuristic device, developed in order to obtain reasonably reliable estimates for six major industrial sectors – automation, aerospace, automotives, consumer electronics, medical equipment and telecom equipment .

We have selected 2002 as the reference year because the most recent OECD data are reasonably comprehensive to this date. This reference year allowed us to use both aggregated data from OECD but also industry data disclosed by ITEA Partners as well as by various industry and consultancy offices and IDATE and TNO partners.

We have selected 2002 – 2015 as the reference period for estimating the likely growth in software value. The choice of 2015 for investigating the future was based on the existence of an in-depth study led for the whole automotive industry and aimed at the period 2002-2015.

5.3. Implementation of the methodology

It was a two phased process : we first developed with a few companies estimates based on their internal data and on their views about their competitors. Then we consolidated these data with interviews with other industry leaders, sector analysts and professional organisations. A total of 30+ interviews was conducted with main players of each market.

Looking at ITEA Board members gives already a good overview of the 6 sectors analyzed as they represent a global turnover of 352 Billion EUR (from which 158 in Europe) and global employment of 1,45 million jobs (more than half in Europe). They also spend almost 24 Billion EUR regarding R&D. Those companies were therefore interviewed to get a first approach of the different markets. Investigation was complemented by interviews of other major players in the different sectors (Airbus, Renault, Peugeot, Schneider, etc…) and of industry associations and industry experts.

Table 3 : Turnover and R&D expenditures of ITEA Board companies

	Revenues (M€)	Revenues /EUR (M€)	net income (M€)	R&D expenditure (M€)	gross margin	R&D
Alcatel	12 265	7 860	281	1 587	37,2%	12,9%
Nokia	29 267	8 780	4 330	3 733	38,0%	12,7%
Bull	1 139	980	41	54	27,7%	4,7
Siemens	75 167	42 000	3400	5 063	28,8%	6,7%
Daimler Chrysler	142 059	47 400	2466	5 658	19,4%	4%
Bosch	40 007	27 400	1675	2 898	20,0% (e)	7,2%
Thomson	7 994	*2 398*	508	285	21,0%	3,4%
Thales	10 300	6 275	729	1 850	23,0%	3,5%
Italtel	541	508	12	88	35,0% (e)	16,3%
Barco	672	315	47	67	43,1%	10,1%
Philips	30 300	13 335	2836	2534	33,5%	8,3%
Telvent	1 687	1 125	52	23		
Total	351 398	158 376	16 377	23 840		

Source : ITEA Board members Annual reports

Table 4 :General and R&D employment of ITEA Board companies

	Employees	Employees/ Europe	Employees (R&D)	Employees (R&D)/EUR	Corporate R&D	Corporate R&D/EUR
Alcatel	55 718	33 400 (e)	16 000	9 600 (e)	900 (e)	540 (e)
Nokia	55 505	35 750	20 722	13 347 (e)	1 200	773 (e)
Bull	7 531	6 477	743	700	na	Na
Siemens	419 200	274 000	43 600	30 500 (e)	na	Na
Daimler Chrysler	384 723	215 000	31 900	19 140 (e)	2 900	2100 (e)
Bosch	242 350	172 000	22 000	17 600 (e)	1 200	1 000 (e)
Thomson	49 000	16 600	3 000	1200	500	300
Thales	55 476	48 300	20 000	17 000	550	500
Italtel	2 334	2 150 (e)	984	984	na	Na
Barco	4 389	2 000 (e)	856	380 (e)	na	Na
Philips	161586	69 242	20400	10500 (e)	3700	2775 (e)
Telvent	9 318	5418	377	377	5	5
Total	1 447 130	880 337	180 582	121 328	10 955	7 993

Source : ITEA Board members Annual reports and estimates (e)

5.4. Results

In order to translate this percentage in expenses expressed in euros, we developed the following estimates :

- Sector turnover (worldwide, European, USA)
- Sector value added (worldwide)
- Sector R&D expenses (worldwide)

Our goal was not to produce statistics, but to obtain “good enough” value for these figures. Our detailed choices and computing rules for these figures are given in annex.

The basic method was to obtain sector turnover in 2002 based on consultancy and industry report, to compute from it value added of the sector. R&D expenses are based on OECD data (the ANBERD data base). We spent time discussing with OECD experts, and with industry experts, trying to figure out the most probable figures. In order to validate the data, the calculations were checked at both intermediate and final stages for coherency with OECD data, national data and industry data (where available). Data collected directly from companies in the six sectors (under a non disclosure agreement) contributed to this coherency check.

Note that a key factor of uncertainty is the precise definition of each sector, and the coherence of turnover and value added data. The ISIC classification is used by all National Statistics Institutes for countries belonging to OECD, but these Institutes may interpret differently the same sector definition. Moreover, 25 % approximately of manufacturing industry is not part of OECD, including Asian countries like China. For each industrial sector taken into account, we have given the ISIC definition. Data about Automotive or Aerospace (Aircraft and Spacecraft) are collected in a relatively coherent way. It is probably not the case for Medical Equipment. For each sector we provide the definition we have followed.

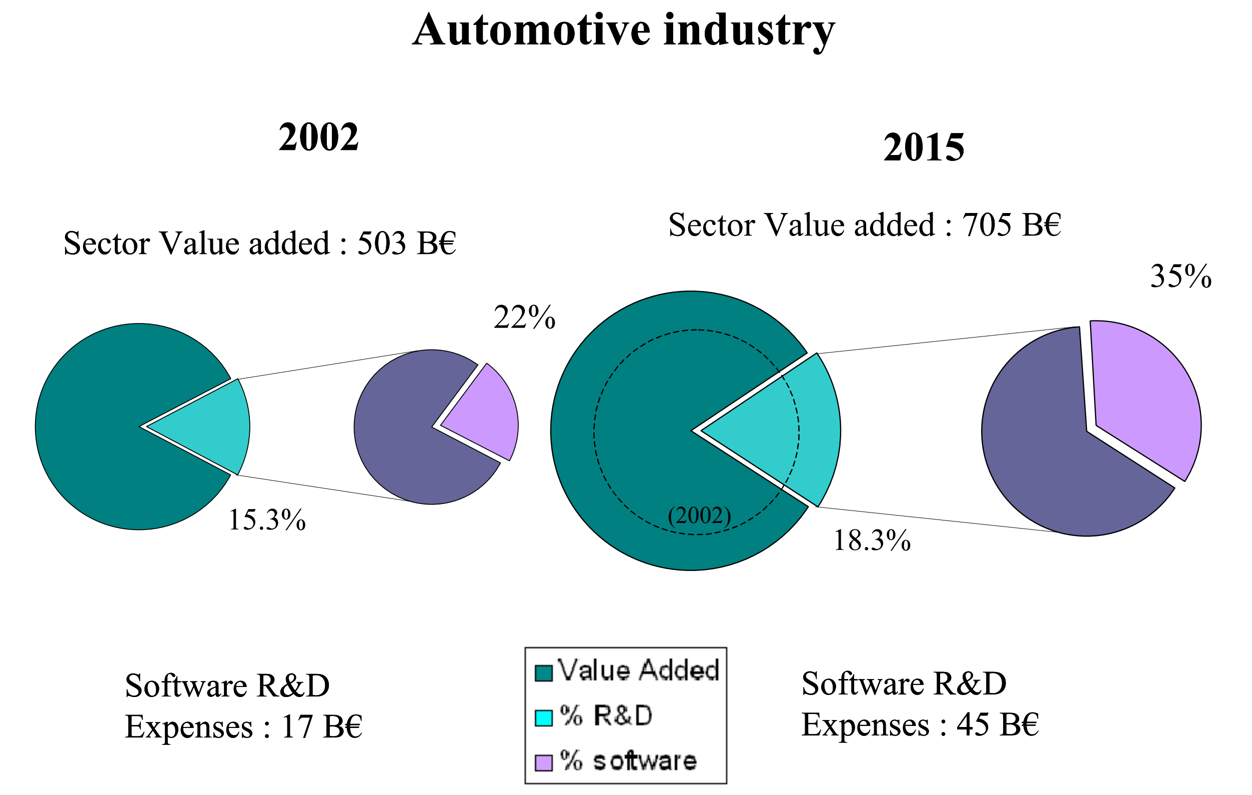
Most of the sectors as defined by OECD include OEM, and suppliers (i.e. for automotive Daimler-Benz and Bosch). Value added was used in order to avoid double counting.

6. Data per sector

6.1. Automotive industry

Sector definition
The definition of the sector is related to class 34 – namely, the manufacturing part. This class includes the manufacture of motor vehicles for transporting people or goods. The manufacture of various parts and accessories, as well as manufacture of trailers and semi-trailers, is included also. So, the class includes both suppliers of different components (for instance Bosch, Valeo, etc…) as well as vehicle OEMs (for instance Daimler-Chrysler, Renault, etc…). The maintenance and repair of vehicles are classified in class 5020. The definition used does not include any trade activities and services (retail, wholesale, resale of used cars, financial services, customer support services).

Software intensity



Software R&D growth of 165% over the period 2002-2015

Software intensity is still relatively low in the automotive industry as hardware and above all mechanical components are still predominant. But the total market is already huge and expanding, which translates in a strong software R&D spending in total value. Software intensity should almost double within the next decade, as investments shift to embedded systems.

R&D effort		
	2002	**2015**
Software intensity in R&D (as % of sector R&D)	22%	35%[5]
R&D intensity (as % of value added)	15.3% (derivated from OECD)	18.3%
Product level	Software is mainly present in a car through an E/E system. A car electric/electronic system is a composed of several ECUs (Electronic Control Unit) linked by busses. ECUs are used to control a great number of components of the car from power transmission to brakes and even some parts of the engine. The number of ECUs in a car is poised to grow, ranging from 7 for a basic car up to 70 for a premium car. 50 to 70% of development costs of an ECU is related to software[6]. Within the next five years, premium cars are expected to host a cumulated amount of up to gigabyte of binary code of software deployed via a set of interconnected embedded platforms[7] (current level being in the 100 megabytes range). A car could represent up to 100 million lines of code by 2010[8]. The applications are not any more limited to classical embedded control systems, such as air bag control software, but cover a broad range from mission critical embedded systems in the X-by-wire[9] field, driver assistance to infotainment and personalization in the Man Machine Interface area.	
Process level	Industry players are also investing in CAD simulators developed internally to reduce time-to-market (from 36 months now to an expected 18 months in 2015) and development costs (vehicle crash tests). To achieve this goal, the industry need virtual prototypes of new cars. Main development tools are more and more bought from third parties like ETAS, dSpace, Vector or Mathworks. Today, processes, methods and tools for embedded software are mainly capable to deal with the software of one single ECU whereas a typical car will need 10 to 15 ECUs.	

Employment	
Total staff	Around 2 million jobs in Europe in 2002 regarding production (representing 6% of total manufacturing employment10)
ICT Skills	21.20% (OECD)
Software staff (software developing staff)	More than 25% of total engineering staff of suppliers 10 to 17% of total engineering staff for OEMs
Perspectives	1.2 million new jobs expected in Europe over the period 2002-2015[11], from which 50% should be related to electronics and software (this will be the only increasing employment category for OEMs)

[5] Average scenario representing a 1%/year increase for software spending in the R&D global budget until 2015. Acceleration of software use in the car from 2010 will have is impact limited in value by standard platforms like AUTOSAR. 35% could represent a first plateau as some mechanical components will still be needed.

[6] BMW, ICSE Workshop 2004

[7] ICSE 2005 Workshop

[8] IBM, Challenges for the automotive industry in a on demand environment, 2004

[9] X-by-wire (a.k.a Fly-by-wire or Drive-by-wire) means that one or more of the primary vehicle systems is operated by electronic controls instead of traditional mechanical linkages.

[10] The automotive industry represents also 7% of total manufacturing output in Europe. Sources : ACEA, EU

[11] Mercer, FAST 2015

IT Spending	
Western Europe (2004)	5.15 B€ (+4.4% CAGR)[12] Growth mainly about software-related products and services, especially in PLM/DPM
USA (2002)	14.19 B€ [13] 75% of IT expenditures related to software (24% product, 51% service)
Key processes involving IT	SCM (Supply Chain Management), PLM/PDM (Product Lifecycle/Design Management) + CRM as OEMs are moving downward the value chain

Market size		
Worldwide market	**2002**	**2015**
Market size	968 B€[14]	1 355 B€[15]
Value added	503 B€[16]	705 B€
Geographical market breakdown (turnover)	**2002**	
Western Europe	271 B€ (28%[17])	
USA	194 B€ (20%)	
Rest of World	503 B€ (52%)	

[12] 1€ =1.2433$ (change 2004) US 6.4B$

[13] change 2002 US 13.4B$

[14] As mentioned in the definition of the sector, this does not take into account any downstream activities, consisting mostly of trade (retail and wholesale of new cars, resale of used cars, financial services, maintenance and repair services, parts and accessories, etc…). Those activities are not software intensive and require very few internal developments. The overall market size would at least double for 2002.

[15] 40% growth over the period 2002-2015, ie around 3% CAGR

[16] Calculations are mainly done around manufacturing value added because there is almost no software R&D involved on other segments of the value chain (raw materials, service providers)

[17] Source : VDA (for market shares only)

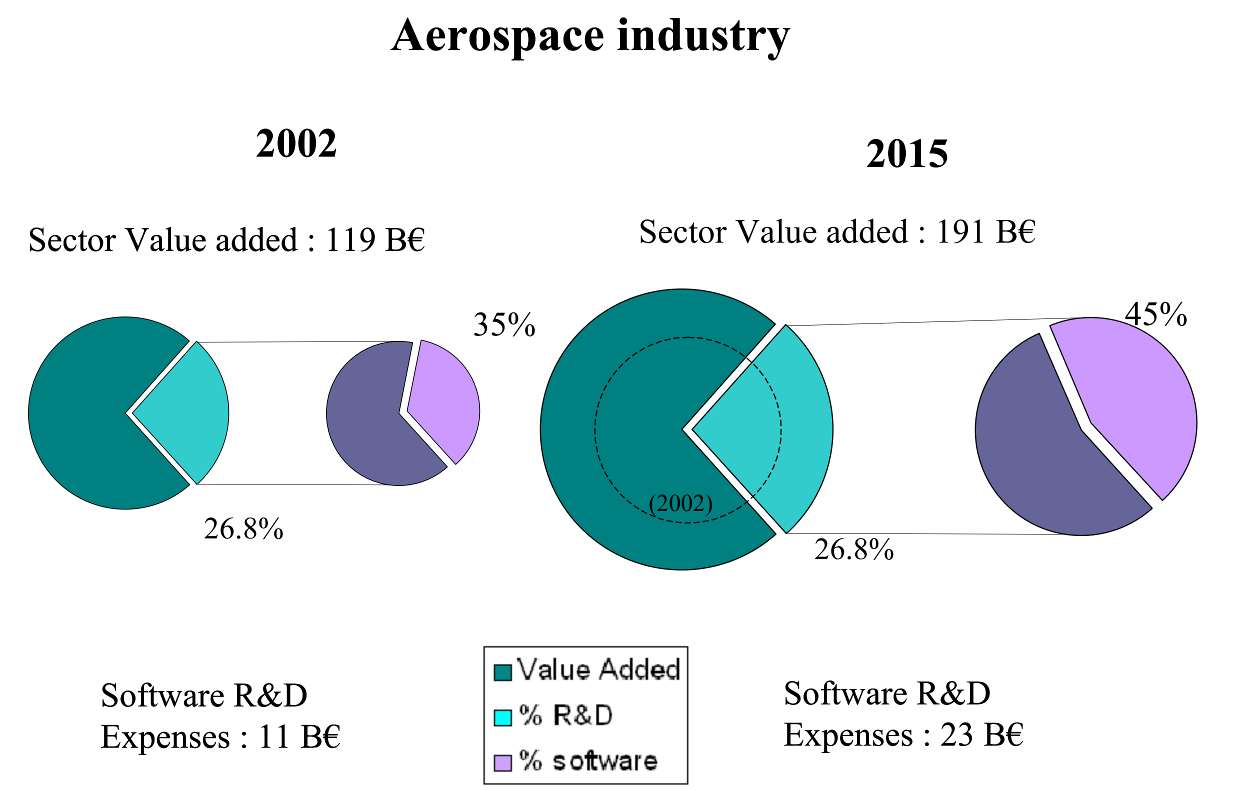
Major evolutionary trends	
Actors	Consolidation is expected to continue in the automotive industry, leaving only a few major OEMs and tier 1 suppliers. OEMs are moving downward the value chain, closer to the client (sales, financial services, customer support, …) and outsourcing most of the development and productions to suppliers. Meanwhile, they're keeping focus on the most critical technologies that are crucial to the success of their brands, especially design and electronics. Initiatives like BMW Car IT (dedicated entity in charge of IT for the car) are more and more common. OEMs may even take back the leadership in the integration of systems. Software is still mainly developed by Tier 1 suppliers for their ECUs (more than half of the total expenses in software in the automotive) and by software specialists (3Soft, Vector, …). OEMs contribution (chiefly integration) to software is a bit low but reaches up to 20%.
Societal effects	Strong growth of electronics in the automotive industry is expected over the coming years due to several key drivers : - economic issues, regarding for instance fuel consumption - regulations, especially to improve road safety (project eCall[18]) and to protect the environment (reduction of CO2 levels, etc ..) Comfort requirement and specific demands from end-user (entertainment, telematics, …) have still limited impact so far, except for the japanese market.
R&D	80 to 90% of innovation is related to electronics and software, from multimedia components to more traditional ones (chassis, body, engine, …). It is almost impossible to split software contribution from hardware contribution. Software has a key role to enable interconnection of systems and ECUs, providing thus new functionalities for instance in the security and safety field. One of the major drivers of the adoption of software is the capacity in the future to provide preventative maintenance. Using wireless networks, a bug could be patched automatically over the air. Software intensity may reach a plateau in the next decade (35 to 40%) as mechanical elements will still be needed. Software expenses should also be reduced when standardized platforms like AUTOSAR (an initiative involving BMW, PSA, Volkswagen or Siemens) will be available.

[18] Regulation in Europe for all new cars from 2009 to have a "basic" embedded telematic unit for automatic emergency calls. With the obligation to put some electronics (present only at this time in premium cars), OEMs might go directly for enhanced solutions to offer new services.

6.2. Aerospace industry

Sector definition
Aerospace industry includes both civil and military aircraft and spacecraft. It corresponds to ISIC code 353, aircraft and spacecraft. This definition mainly includes : - Civil and military aircraft : (complete systems of and/or airframes for aeroplanes, helicopters and gliders, ground installations,… and their subsystems and parts) - Missiles : (complete systems of and/or airframes for missiles, ground installations,… and their subsystems and parts) - Space : (complete systems of and/or airframes for space vehicles, satellites launchers, ground installations,… and their parts). In this sector definition, maintenance and services are excluded.

Software intensity



Software R&D growth of 109% over the period 2002-2015

R&D effort

	2002	2015
Software intensity in R&D (as % of sector R&D)	35%	45%[19]
R&D intensity (as % of value added)	26.8%	26.8%

[19] Based on experts from the industry

<table>
<tr><th colspan="2">IT spending</th></tr>
<tr><td>Product level</td><td>The aerospace industry is generally broken down into three industry sectors :

Systems and frames : complete systems of and/or airframes for aeroplanes, helicopters, gliders, missiles, space vehicles, satellites, launchers, ground installations and their subsystems and parts.
Engines : Piston engines, turboprops, turbojets, jet engines, propulsion devices and their subsystems and parts
Equipment : Finished products, subsystems and parts, spares also for test and ground-training equipment for installation in aircraft, missile and space vehicles, satellites and launchers.
Production of Aircraft and Spacecraft is defined as a high-technology industry, based on its high R&D level. Software and Software intensive Systems (SiS)[20] are major sources of innovation at product level and major differentiators at market level.
The European level of R&D in 2002 is estimated by the industry at 10.4 B€, (13.9% of turnover)[21]. This is coherent with the OECD Science Technology and Scoreboard.
</td></tr>
<tr><td>Process level</td><td>Major evolutionary trends in favour of software development rely on a greater emphasis :

on the automatic generation of code from specifications and the automatic generation of test scripts form the specification documents.
on realism in the requirement capture and rapid prototyping phases

Software intensive Systems (SiS) will be key differentiators and enablers for tomorrow’s intrinsic aircraft performance, revenue generation of the fleet operators and overall integration of the aircraft in the Air Transportation System. For example, the number of megabyte required to develop software and embedded systems between an Airbus A340 and a A380 doubled from 2000 and 2005. This growth is exponential since 1985.
Globally, SiS contribute to :

advanced performance through examples like active Centre of Gravity (CoG) management, automatic operation at optimum performance for extended period of time and in a wide range of conditions and in the area of safety especially Terrain awareness and warning system (TAWS)
greater integration of functionality, enabling the implementation of more complex control and monitoring concepts.

They also participate in the overall performance of the industry :

reduction in flight crews via performing own monitoring and control processes
operational maintenance benefits, both in the provision of greater amounts of data, during and after the flight, but also in the rationalisation of trades required to service the aircraft
ability of the aircraft to tolerate faults and to therefore operate for extended periods without needing maintenance intervention

The challenges of software activities in the aerospace sector is :

to develop practical cost effective design tools to achieve real software modularity for equipments in limited quantity
to achieve 20+ year life (typical of aerospace and military) with a software intensive equipment.
</td></tr>
</table>

[20] Software includes pure software development activities (coding, test scripts-) while Software Intensive Systems (or Embedded Systems) integrates specific software components in electronic systems.

[21] Source: 2002 Annual report, AECMA

Employment	
Total staff	1 152 000 people worldwide in the sector industry (in 2002)[22]. In Europe, the aerospace industry employed 414 000 people[23].
ICT Skills	Aerospace is classified by the OECD as major ICT player with a share of ICT-skilled employment of 30.2% of total employment in 2003.
Software staff	In Europe, around 90 000 people both in the OEM and supply chain work in software activities for civil aerospace industry[24].
Perspectives	Purely software R&D activities such as programme coding should require less and less staff (automation) in the coming years. At the opposite, embedded systems – that include more specific software applications – will need staff increase (30-50% increase). The job profiles will change in the coming next years but no shortage of software skilled people is expected at least in large corporate.

IT Spending
na

Market size		
	2002	**2015**
Worldwide market		
Market size	213 B€[25]	341 B€[26]
Value added	119 B€	191 B€
Geographical market breakdown (turnover)		
Western Europe	75 B€	153 B€
USA	104 B€	119 B€
ROW	35 B€	68 B€

[22] Source : 2002 Annual report, AECMA

[23] Source: ASD/AECMA

[24] Source: Industry

[25] 2002 Comparative Aerospace Industry (AECMA compilation of data from AECMA,AIA,AIAC, SJAC, US Census Bureau, Company reports)

[26] The annual growth rate 3,7% is calculated based on an average compound annual growth rate of the sector turnover

- USA (1989-2002): 2.1% (source AIA)
- EUROPE (1996-2002) : 6.27% (source AECMA)

and on hypotheses regarding the evolution of the annual growth rate (scenario) of the future market share of the industry by geographical areas at 2015 :

- stable growth aux USA : 2%
- decreasing growth in Europe : 4%
- increasing growth in Asia : 6%

- USA : 35% (49% in 2002)
- Europe : 45% (35% in 2002)
- RoW : 20% (16% in 2002)

The long term growth rate of the industry between 1980 and 2003 currently stands at 4% (2002: 4.2%) : Source ASD 2003 facts and Figures p.10

Major evolutionary trends	
Actors	Civil aircraft industry is dominated by two large players, Airbus and Boeing. In Europe, the national authorities, including defence and space agencies, have approximately one fourth of the market. In the US, they represent one third of the market. Both for US and Europe, half of the production is exported. Defence aircraft industry is mainly dominated by several US players (Boeing, Lockheed Martin, Northrop Grumman Corp.) and European players (EADS, Dassault Aviation, Eurocopter, Sukkoi) but this industry suffers from the decreasing military budgets from the national authorities. In the space sector, the main players, ArianeSpace and International Launch Service, have the largest market share but new players coming from Russia and China constitute new commercial threats with low cost products.
Market trends	The market is cyclical as it depends on the acquisition plans of airlines which fluctuate considerably especially in a period of uncertain economic perspectives and global security concerns. On the defence side, demand depends on the defence budgets and the procurement policies which in turn depend on geopolitical developments and the changing perception of threats. The aerospace infrastructure is becoming more global. Although the United State continues to maintain its position in first-tier integrator companies, global sourcing at the second and lower tiers is rising rapidly as an acceptable option, especially more in the commercial area than in the military. The future value of SiS (Software Intensive Systems) is connected to a great extent to the prospects of large commercial aircraft (greater than 100 seats) and the development of business jet market using turbo-prop driven aircraft. The future market for large commercial aircraft is for 17000 new aircraft over a twenty year period[27] while the business jet market forecast predicts the need for approximately 7500 aircrafts over the ten next years[28]. In the less predictable military market, the number of new programmes is limited worldwide. Potential growth will mainly rely on important programmes of combat aircraft (JSF, Rafale, Eurofighter,…), missiles and unmanned aircraft. In the space sector, the drop in demand for satellite communications has affected both the satellite and the launched business. No significant improvement is expected over the coming years. The resulting fall in orders has caused a severe crisis in the European space industry which traditionally depends more than its competitors on commercial markets. More competition is expected in the launched market form the US (Proton, Zenit, Delta4, Atlas5), Russia (Proton M, China and Japan (H-2A).
Societal trends	All aspects related to surveillance and security like image analysis, archive search, will have a large impact on SiS development. In civil aeronautics, embedded systems have a strong safety critically dimension. One of the key objectives is to decrease the frequency of crashes as the number of transportation flights will increase in the future. New software development are expected with the inception of new communications and multimedia services for passengers (display systems, embedded internet and telecommunications systems,…). An other important issue, is the conquest of space. The expected renewal of space programmes will have an increasing impacts of software and SiS development and activities up to 2015.
R&D	R&D intensity depends on the launch of large civilian or military programmes (see above). Industrial restructuring combined with the development of relevant common programmes within a coherent political framework across European borders is essential for future success of R&D in all aerospace sectors.

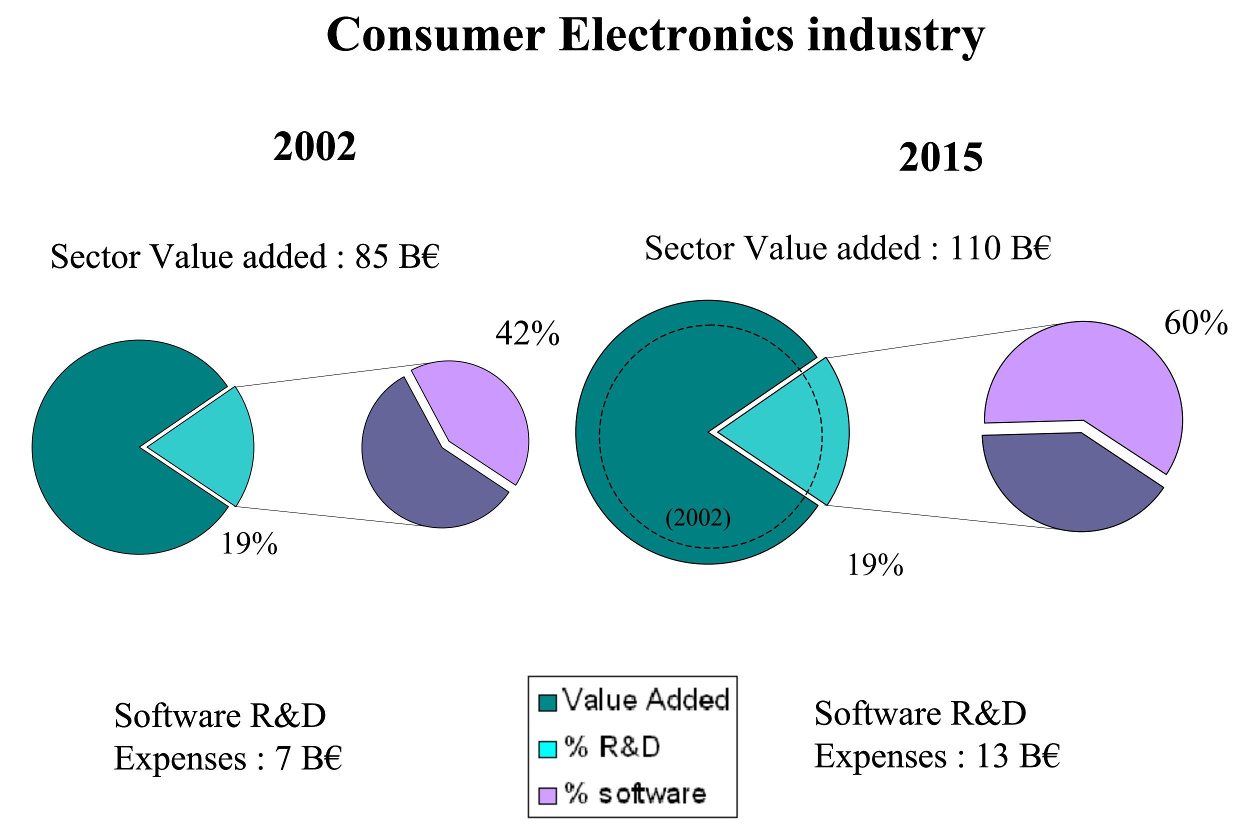
[27] Airbus GMF 2004, http://www.airbus.com/store/mm_repository/pdf/att00002981/GMF2004_full_issue.pdf

[28] Teal Group forecast, c/o http://www.nara-dealers.com/resourcelib/mkttrends/BizOverJune05.pdf

6.3. Consumer Electronics industry

Sector definition
This sector, which do not include PC or mobile handsets, deals mainly with audio and video terminals. Set-top boxes are included. This allows to avoid double counting with telecom equipment or computer market. But there is a general tendency to add mobile phones and portable PCs to the figures. Some companies use the wording "Technical consumer equipment" which describes 4 constituents : communications, information technology, consumer electronics and photographic. In Europe, market size seems to stabilize around 12% for communication, 46% for IT, 35 % for consumer electronics and 7% for photographic.

Software intensity



Software R&D growth of 86 % over the period 2002-2015

R&D effort		
	2002	**2015**
Software intensity in R&D (as % of sector R&D)	42%	60%[29]
R&D intensity (as % of value added)	19%	19%
Product level	The move to digital content is the main factor of change in relation of general hardware performance increase and cost decrease (hard disks, memories, processors, displays). Networking and interconnection issues are also more present. Development of set-top boxes has been very significant. Home networks are appearing or at least interconnected products. For audio and video, we may expect that the move to digital will be completed in 2015. New terminals are appearing such as IPOD or mobile video terminals. The future of interactive TV is still unclear, but applications do develop and become profitable. As a whole, there is a strong uncertainty about what the consumer will accept in terms of complexity (combined uses of digital camera, TV set, PC, mobile phone, set-top box), and what kind of functionalities he may want to find in the same box.. Disk storage will be largely present at home, even if associated to a DVD. The move to high definition and use of flat panel displays will contribute to the sector growth. For sophisticated set-top boxes software represents already 70 % of the R&D expenses Already set-top boxes software is being updated by downloading, without the intervention of the consumer. Downloadable software will probably multiply in the future.	
Process level	A strong move towards software development has started since the last 5 to 7 years. As an example, in January 1999, Sony elected to re-orientate half of its technicians toward developing software for PCs and home appliances. Prior to this, roughly 70% of Sony's technicians were focused on hardware. the company has therefore chosen to re-train a portion of its technical staff and to hire a number of software engineers. A similar policy has been applied by several large European players. So the growth of software employment is often compensated by the decrease in hardware employment.	

Employment	
Total staff (manufacturing)	233 000 in Europe[30]
ICT Skills	44.8 % of employees are ICT skilled
Software staff	
Perspectives	Manufacturing employment is currently decreasing, due mainly to the move of manufacturing to Asia. It may stabilise with the development of new, high value sophisticated set-top boxes, mediacenter and home networks. R&D software activities may grow, but large companies have developed software strategies, while subcontracting hardware manufacturing and even design.

[29] Software intensity is estimated to 50 % in 2005, with a strong increase (8% from 2002 to 2005)

[30] Source IDATE, computed from "Groningen Growth & Development Centre" database

IT Spending
No data

Market size		
	2002	**2015**
Worldwide market		
Market size	152 B€[31]	197 B€[32]
Value added	85 B€	110 B€
Geographical market breakdown (turnover)		
Europe	38 B€	
USA	60 B€	
ROW	54 B€	

[31] Source IDATE

[32] Estimates from industry vary from a flat situation to a 10 % growth. Few previsions went behind 2005 or 2006. The 2% growth is based on the apparition of new terminals, with the usual consumer electronics situation : apparition of a new product with high margin, and then a stabilisation of the market, the increase in the number of unit sold being compensated by the price decrease.

Major evolutionary trends	
Actors	There is a major evolution with the entrance in the sector of companies from software, IT and even communication sectors. Low margin products are being largely manufactured (and even designed) in South Asia. Japanese industry moved already most of its manufacturing in China, and other SE Asian countries. China is playing a very specific role due mostly to its huge market, and also to its development of R&D activities. Software is a major competitive advantage for European players.
Societal effects	For the above market data, the classical consumer electronics definition was used, not taking into account PC and mobile phones. But the convergence is currently taking place, facilitated by several factors such as the apparition of an Internet generation, the permanent decrease of costs, and the availability of a large amount of contents. There is a growing continuity between “classical “ consumer electronics and electronic devices, even if they have different uses for the same functionalities. Today, terminals provide an interface between the PC and television. PCs are sources of content, in competition with “smart” set-top boxes. There is a significant amount of content storage available in the home. The Internet became a common way to obtain content, mainly through peer to peer exchanges. On-line sales are currently increasing. The internet, is an inexhaustible source of content that is shared, legally or not, content stored on personal computers, and possibly in the future on consumer electronic terminals (set-top boxes, home servers). This leads to numerous software development such as content players, data and content management, as well as format conversion and interconnection issues. To protect legal content and copyrights, DRM (Digital Rights Management) is already getting a strong push and more and more implemented on CE devices. Moreover this will allow to download services, id est software in CE equipment, even if the successful services are not evident today. Some of the interactivity used in PC will therefore appear on CE devices. The development of consumer electronics will need to be integrated in a broad vision of the digital household, where people can access the content (legal or self-produced) on every device of the house. Home networking, with technologies like WiFi, is already developing in laptops and some set-top boxes and should soon be present in every major CE device to enable nomadic and seamless distribution of different services. It will rely on commoditised chipsets and software to discover and manage the devices.
R&D	Software is at the heart of the new products. For sophisticated set-top boxes software represents already 70 % of the R&D expenses, and will not grow significantly (possibly 80 % in 2015, but no more). For digital TV, a large amount of R&D has already been done for compression and transmission. Audio is still making progress, but is largely stabilised. Development of networking for all products will imply an increase in software development. The key issues are more customer related and include the relationship with other products : PC, mobile phone, home networks, which open the door to a potentially significant market. Consumer electronics has entered digital convergence, the final result is still unclear, but a global growth of the consumer expenses is largely expected.

6.4. Medical equipment industry

Sector definition

Medical Equipment is part of ISIC 33 (ISIC 33.11), which includes also precision and optical equipment. It can also be defined as in the EU Medical Devices Directive (93/42/EC) but with a different scope. The latter definition excludes In Vitro Diagnostics (IVD). We used the definition of the directive and include IVD

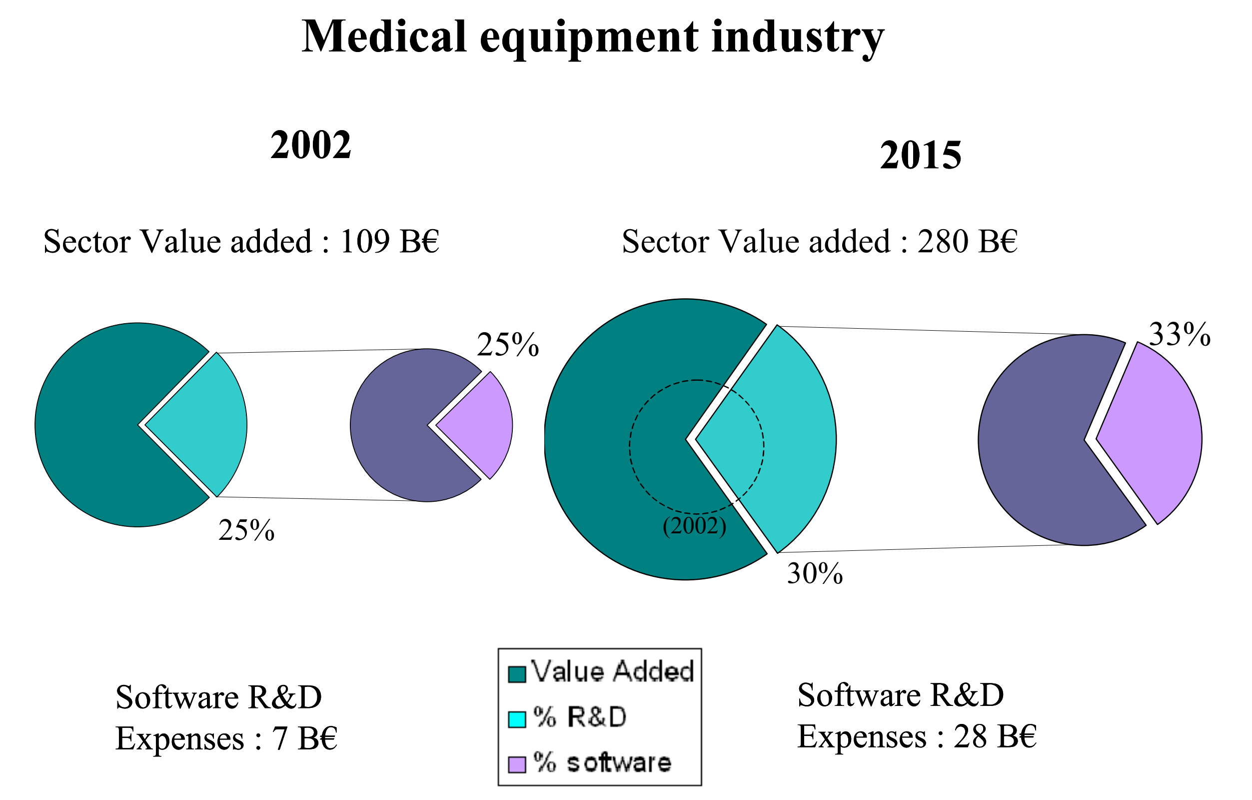
A Medical Device is defined in Directive (93/42/EEC) as ; Any instrument, apparatus, appliance, material or other article, whether used alone or in combination, including the software necessary for the proper application, intended by the manufacturer to be used for human beings for the purpose of :

- diagnosis, prevention, monitoring, treatment or alleviation of a disease, an injury or a handicap.
- investigation, replacement or modification of the anatomy or of a physiological process.
- control of conception

Medical devices include a broad range of surgical devices and equipment used in cardiovascular, orthopaedics, respiratory, ophthalmic, neurology, urinary, infection and more.

The main market segments do not share the same characteristics regarding software intensity : In Vitro Diagnostics (23 B€, some software), Orthopaedics (17 B€, almost no software) and Imaging (15 B€, a lot of software)[33]. Medical equipment consists also of other numerous smaller segments (many niches less developed at this time, requiring generally more R&D, but not necessarily more software).

Software intensity



Software R&D growth of 300 % over the period 2002-2015

Medical equipment will become one of the most important contributor to software R&D spending by 2015, with an average level of software intensity. This level is limited by the massive usage of other technologies.

[33] DTI, evaluation of six market segments of the medical device industry

R&D effort		
	2002	**2015**
Software intensity in R&D (as % of sector R&D)	25%[34]	33%[35]
R&D intensity (as % of value added)	26%	30% (f)
Product level	Major widespread medical products relying on software include imaging (scanners, X-rays, positron emission tomography, ...), infusion pumps[36], monitoring devices (EEG, etc…), pace-makers or implantable cardioverter-defibrillators. Physicians and surgical teams also use numerous tools and simulators in computer assisted surgery (training and real life) to more precisely position their instruments and also in the meantime document the procedure. Innovative IVD sub-segments such as molecular diagnostics for the lab business Software is also a key component of the fastest growing market segment of telemedicine and telemonitoring with small portable equipments (monitoring devices). Patient self-testing OTC (Over-The-Counter) and POC (Point-of-Care) have also shown high growth rates above 15%, for products like home glucose testing. In the next ten years, the market will also focus on early diagnosis and digitized patient information.	
Process level	Integration of medical equipment is becoming more and more important in the hospital. These devices have to handle patient data and provide ways to manage electronic ID of the patient through the information systems of hospitals. Some software specialists have also emerged (see Dyadem, AgileMD) to provide software tool for conducting a Failure Mode and Effects Analysis of manufactured medical product preventing patient injuries, costly product recalls, and down time in production department. Those products are mainly PLM (Product Lifecycle Management) applications for medical devices.	

Employment	
Total staff	Europe : 386 000 (source Eucomed) USA (2002) : 349 000 (source : AdvaMed), up from 253 000 in 1990
ICT Skills	31% in 2002 (source OCDE)
Software staff	ND (survey of Eucomed to be published in October 2005) Can reach up to 60% of R&D staff for major providers
Perspectives	Software-related employment should more than triple (worldwide)

[34] This is an average figure for the whole medical device industry. This figure would be close to 40-50% for more software intensive systems like imaging. Some products are very software dependent (imaging, respiratory, radiotherapy, …) as other are not all (orthopaedics, …). Orthopaedics R&D is mainly driven by materials and design.

[35] A scenario of evolution of an increase of almost 0.5%/year of software share in R&D as software will only be one of the key technology gaining importance in medical products.

[36] A high end infusion pump represents 200 000 lines of code, half of it is in the user interface

IT Spending
No data

Industry market size		
	2002	**2015 (f)**
Worldwide market		
Market size	184 B€[37]	471 B€[38]
Value added	109 B€	280 B€
Geographical market breakdown (turnover)	**2002**	
Western Europe	55 B€ (30%)	
USA	79 B€ (43%)	
ROW	50 B€ (27%)	

[37] Source : Eucomed

[38] CAGR estimated at +7.5%/year

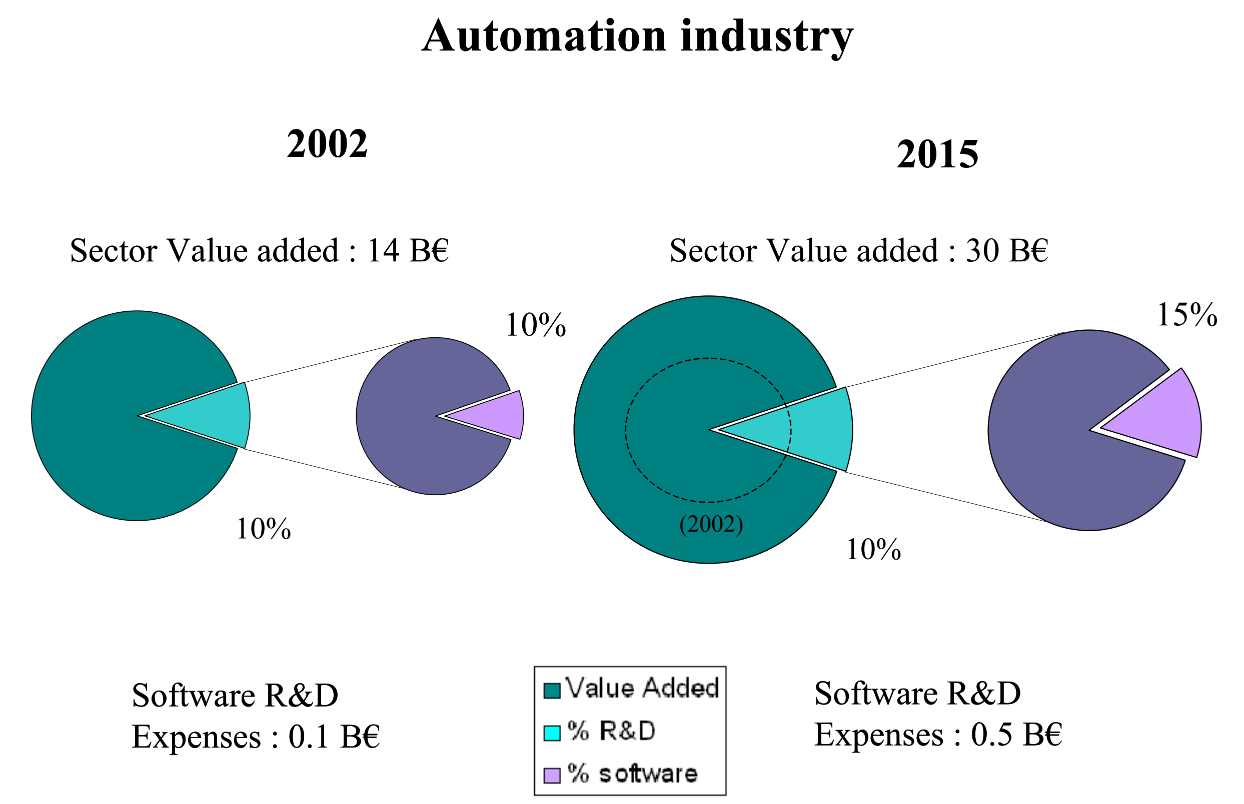
Growth rate of 8% per year (Frost and Sullivan), 10% (Deutsche Bank), 7% (Arthur D Little for DTI)

Major evolutionary trends	
Actors	High capital equipment like scanners or MRI software is mainly developed in-house by big companies (GE, Philips, Siemens) and require substantial R&D investments. Even if the market is important in value, it represents few devices in volume. Those big companies are therefore expected to remain the biggest contributors to software development for their products, but only for the most strategic components and for the design. The rest is generally outsourced. Their equipment need also to be integrated in the information systems, which is sometimes done by third parties. New small portable equipment are expected to become a "near" mass market in the coming years and will rely more on third-party providers for software (device control, etc…). Vendors are beginning to sell complete solutions that include not only the diagnostic equipment but also the data storage servers as well as the interface software. Imaging is for instance more and more provided with PAC system (Picture Archiving and Communication), requiring strong IT capabilities. All market segments have experienced a strong consolidation, with top 5 players of each segment representing 60 to 80% of the market. The top 40 companies (more than 20 000 in total) represent 80-85% of the market (source : DTI). Unlike automotive, the medical device industry is generally composed of only a couple of layers between the primary suppliers and the ultimate manufacturer. Major medical device providers have established close strategic partnerships for some of their electronic activities with major IT providers, especially for the lab business (ex : Roche with Hitachi).
Societal effects	The demand for medical devices is influenced by an increasing patient population (aging population but also extension of lives of very ill people) and the focus on health care cost and preventative therapies. Those devices enable improved remote monitoring of patients with chronic diseases or life-threatening conditions at a lesser cost (eliminating trips to the doctor). Infusion pumps can also reduce the number of medical errors. Healthcare providers are facing a staffing shortage, whose impact can be lessened by automating some tasks with the help of technology and software and in the meantime reduce errors and enhance patient safety
R&D	R&D intensity has been permanently increasing and may be expected to continue. Medical device equipment has evolved from a device engineering industry to a convergent industry based on a set of technologies including material, electronics, biotechnologies, nanotechnology and software. Manufacturing is no more seen as a core competency. As software is only one part (even if a major one) of the technologies involved in medical equipment, it is estimated to represent between 25 to 30% of innovation. This is an average figure for the whole industry and it can soar to 70% for products like imaging.
Challenges	Main technical challenges to overcome are standardisation of user interfaces and interoperability of systems from different providers. Only a few standards have been introduced so far, mainly regarding the electronic patient files or Electronic Health Record (EHR). Reimbursement is still a condition for the development of this market, as some countries favour the best price over the long-term cost savings. The market has also to face strict regulation from government agencies like FDA for software-directed treatment or approval of some innovative technology.

6.5. Automation industry

Sector definition
This sector has not a single and well accepted definition and covers several quite different industries and products. Most figures are based on interviews and should be considered as rough estimates. We concentrated on Industrial control, which is also called automation for discrete industries[39]. Industrial Control may be defined as all equipment used in order to monitor, manage or pilot manufacturing equipment. It includes : - variable speed drivers and soft starters, products to be found around electric engines. The worldwide market may be estimated to 3 B€. Typically a speed driver may manipulate several hundreds of variables - Home Machine Interface used to control machines and production lines. The worldwide market may be estimated to 1.5 B€. It relies on industrial PCs, tactile displays and specific hardened hardware - Machine Control : mostly actuators and sensors. The worldwide market may be estimated to 4 B€, with a significant growth - Programmable Logic Controllers. They are now small computers with a lot of software needed to program them. Software workbench may include several million lines of code. The world market may be estimated around 8-10 B€. - Ethernet connectivity : a market with a high growth. The world market may be estimated around 800 000 B€ in 2002, but may double in 3 to 4 years. This will lead to a global market around 20 B€, with a high level of uncertainty.

Software intensity



Software R&D growth of 400 % over the period 2002-2015

[39] Automation for process industries (oil and gas, chemical, pulp and paper, power,…) are not considered. Its market size may be estimated to the double of industrial control market.

R&D effort		
	2002	**2015**
Software intensity in R&D (as % of sector R&D)	10%[40]	15%[41]
R&D intensity (as % of value added)	10%[42]	10%
Product level	The evolution of products are towards more connectivity, a move towards some form of plug and play (limited first to equipment replacement), more safety in terms of functioning. Decrease of power consumption, decrease of down time are among the goals in the domain. Equipment will be more and more connected in what could be named a global plant. Maintenance will be more complicated and more critical. Another tendency is towards more distributed intelligence in control. Programming software becomes a key factor of choice. The increase in complexity is a major tendency, which implies large maintenance issues, opening a market to systems. At an even higher level, there may be connections between complex manufacturing systems and ERP software such as those provided by SAP. This may open a market for IT services companies. The industry is providing an increasing range of services along with their equipment, such as performance or maintenance service, as users are focusing on return on investment.	
Process level	The lack of standards lead to software development which are mainly internal. Software work bench are specific to a family of automates, id est to a company. But, there are companies developing software modules like CoDeSys in Germany. The software market will probably grow, with the growth of the size of software needed, but with the lack of standards as a severe limitation.	

Employment	
Total staff (manufacturing)	na
ICT Skills (manufacturing)	Na
Software staff (software developing staff)	na
Perspectives	A growth in software development is a current tendency, which will continue. In almost all subsectors, software, although one of the smallest segment, is expected to have the highest growth.

IT Spending
NA

[40] Software percentage is higher for high end PLC, where it may be above 50 %. It is much lower in machine control (around 5%). It is significantly increasing in networking applications.

[41] Materials and mechanical issues are and will stay a critical part of the sector. Increase in software will come mainly from new functionalities.

[42] Estimates

Market size		
Worldwide market	**2002**	**2015**
Market size	20 B€[43]	42 B€[44]
Value added	14 B€[45]	30 B€

Major evolutionary trends	
Actors	The market is characterised by a significant number of very large players, such as Rockwell, Siemens, Honeywell, ABB, Schneider, but also a large number of small specialty companies. Automation companies are relying on a large amount of internal production, due to partly to the lack of standardisation. As the market is fragmented into different products, one may see relatively frequent sales and buys of specific plants and small companies. Added to the “classical” automation suppliers, one find companies coming from the networking equipment, and companies more dedicated to software development. Agreements and cooperation between IT services companies and automation companies are increasing.
Societal effects	Automation is critical to increase productivity, reduce waste and reduce cost from the supply chain. The productivity increase is a key factor for maintaining industry competitiveness, and is expected to be the main contributor to GDP growth in the future. Protecting the environment is also a key issue. Automation sector addresses the whole manufacturing industry, including aerospace, automotive, telecommunication and electrical products. Oil, petrochemicals, water utilities and electric power are among the largest market segments. There is a global move in that domain from a product provider to a solution provider. This is a basic tendency, that will have continuous effects. For equipment the move towards more complex and more sophisticated control systems is critical to improve productivity and efficiency. It implies that software will have an ever increasing role. Another consequence is that maintenance and diagnosis are more and more complex, both for continuous and discrete process. Besides, costs of shut down become higher. There is a need to diagnose rapidly problems, or even to anticipate. There is growing demand for manufacturing safety. Manufacturing interoperability is also a key issue, allowing for a more efficient manufacturing management, and therefore in productivity and safety gains. For high end control equipment, intelligence is more and more distributed. One speaks about “collaborative automation”. Networking is one of the fastest growing sector. It may lead in the future to “global manufacturing” , allowing for control and maintenance from remote control centres (even not in the same country or continent). A step further will lead to the interconnection between manufacturing systems and ERP systems.. This will be a difficult process since specialists from both side do not speak the same language, but already, there is an increase in partnership with IT services or even software producers.
R&D	There are large software developments with hundreds of people working for specific work bench development for a limited lapse of time. But the general tendency is a constant growth of software development. As users are focusing on return on investment, RPM (Real-Time Performance Management) are currently developed.

[43] Studies by consulting societies mention 30BUSD in 2007 for automation for the discrete industries

[44] An average growth of 6% has been selected . It does not take into account the future high level products. The increase will be much higher for connectivity systems. The market for connectivity may double between 2003 and 2006 (industry source).

[45] Estimate based on value added equal to 2/3 of the turnover

6.6. Telecom equipment industry

Sector definition

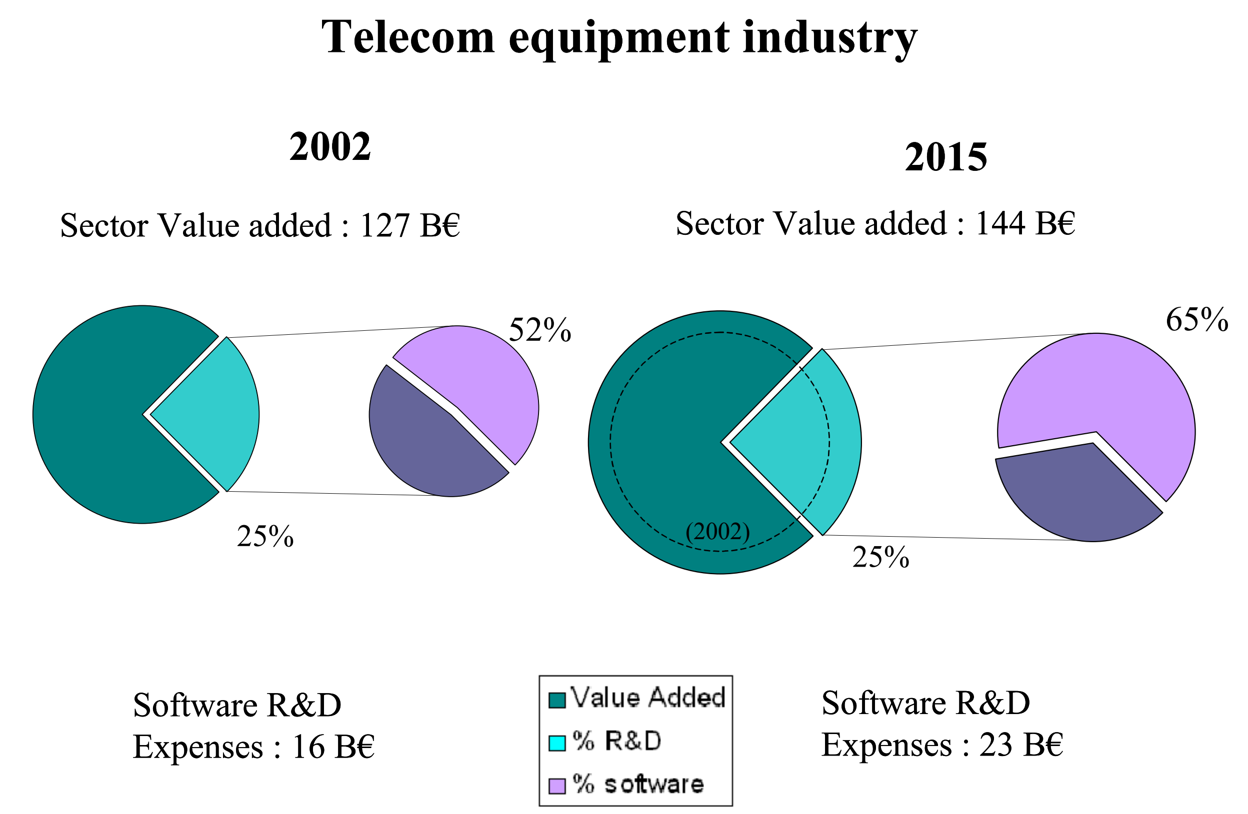
The telecom equipment sector is included in ISIC code 3220. This classification includes television and radio transmitters, but this is a much smaller market than telecom equipment.

Our sector definition will encompass three main market segments :

- infrastructure equipment (mainly for carriers) which includes both fixed and mobile/wireless equipments to handle voice, data and multimedia communications,
- professional equipment (PBX, LAN solutions, …)
- CPE (Consumer Premise Equipment) with mainly fixed and mobile handsets but excluding set-top box or home gateways (see consumer electronics).

This sector only encompasses telecom equipment. It does not include telecom services, generally provided by telecom operators like BT or France Telecom, which also develops some software applications.

Software intensity



Software R&D growth of 44 % over the period 2002-2015

Software intensity is already very high in the telecom equipment and will continue to improve over the next decade, as hardware should still suffer strong price erosion and software will gain value from the deployment of full IP architecture.

This industry is already part of the "so-called" ICT sector and is more and more converging with the IT industry itself, which can be seen when looking both at the products/solutions but also at the players involved.

R&D effort		
	2002	**2015**
Software intensity in R&D (as % of sector R&D)	52%	65%[46]
R&D intensity (as % of value added)	25%	25%[47] (f)
Product level	Beginning with the move to digital switching, telecommunication equipment has been highly software intensive for a long time now. Telecom manufacturers can provide a broad range of products related to software. In the infrastructure area, if optical and routers are more relying on hardware and components (maximum of 20% of software), some of the telecom equipments are heavily dependent on software like DSLAM (software is around 50% of the value) or are even mainly software embedded in some cheap hardware like soft switches (software is around 80% of the value and its part is still increasing). Mobile infrastructure (BTS, MSC, HLR, etc…), which is half of the market of network equipment for carriers, is also highly software dependent (more than 50%) Emerging products, especially those designed to implement the full IP scenario, are also generally very dependent on software like VoIP solutions (Voice over IP), media servers, NGN (Next Generation Network) or IMS (IP Multimedia Subsystems) future products. Core networks won't need that much of software and it will be implanted as full IP on full optics. But interoperability at the MAN level (Metropolitan Access Network) with existing networks will require software. For professional equipment, widespread migration to full IP products will be slow as enterprises won't throw away previous investments (average replacement cycle between 3 and 5 years). IP PBX (Private Branch eXchange) have already developed well, outpacing traditional PBX sales. Regarding devices, most recent wireless phones have more and more IT capabilities as smartphones have acquired PIM (Personal Information Management) and camera capabilities and will soon integrate new components like tuner requiring software applications for management and display of channels. On those high end handsets, BOS (Bill of Software, i.e. software bought from third parties) represent generally only 10% of hardware costs, but internal developments related to software (customization of user interface, management of network protocols, etc…) can reach up to 60% of total project development. Depending on the volume[48] of the product (which is closely related to the market share of the manufacturer and the generation of the product), software can account in total from 20 to 50% of a high end wireless handset.	
Process level	Telecom manufacturers use some simulators, for instance FPGA development tools or VHDL, and even pure software compilers. Those tools are usually bought from third parties which are software specialists. But some of them are still developed or at least customized in house, especially for low volume products. Testing is also a key process using intensively software (up to 5% of total R&D costs).	

[46] This growth of software intensity will be more a consequence of lower costs of hardware for existing products till 2010. For new products, software intensity will grow until some standardisation is in place, at least for the mass market products like wireless handsets. We estimate software will gain 1%/year of R&D expenses. From 2010, software growth will accelerate as full-IP will be in place, representing a 0.5%/year growth of R&D expenses. But hardware price erosion should slow down. Software should then gain also 1%/year (including the 0.5%/year hardware due to price erosion) and reach a plateau around 2015.

[47] No growth of R&D is expected in general by industry players as they have all experienced setbacks in the past. A decrease could even occur if telecom equipment manufacturers decide to outsource more outside of their own industry to pure software players, whose R&D is not taken in account in this sector.

[48] It should be noted that software intensity will always be higher for high-end handsets (more software involved) but also for the smallest manufacturers (in market share) and for new generation products (but no necessarily high end) as software internal development costs are shared on lower volumes.

Employment	
Total staff	451 000 in Europe[49]
ICT Skills	The sector has one of the highest percentages of ICT skills employment, with a value close to 50%. OECD : 47.8%
Software staff	Around 50 to 60% of total R&D staff, ie around 10 to 15% of total staff. Can reach up to 75% of R&D staff for most advanced players.
Perspectives	No high growth is expected here with a progressive switch of hardware specialists to software-related tasks. At least 60% of new jobs in R&D will require software skills. Software-skilled employees in the telecommunication industry over the next decade will be critical to cover activities such as systems engineering, system and software architecture, embedded systems, communication and systems standards, specification and solution integration.

IT Spending
No data

Industry value chain		
Worldwide Market	**2002**	**2015**
Market size	226 B€[50]	257 B€[51]
Value added	127 B€	144 B€
Geographical market breakdown (turnover)	**2002**	
Western Europe	62 B€	
USA	60 B€	
ROW	104 B€	

[49] Source IDATE, computed from "Groningen Growth & Development Centre" database

[50] Source IDATE, Multiclient study EQTEL 2005 (to be published in 4Q05)

[51] Global CAGR: 1%. Growth is expected to be 0% CAGR (or even slightly declining) for the infrastructure equipment for carriers (1/3 of the market). Growth will only rely on professional equipment like PBX (1/4 of the market) and especially on wireless handsets due to widespread adoption in emerging markets of low value devices. (Source IDATE)

Major evolutionary trends	
Actors	Frontiers between telecom activities and IT are blurring as some major IT companies are now also providing telecom equipment parts (full device or just some components) like Sun, HP, BEA, Microsoft (IPTV, …) or LogicaCMG. Juniper was a software company at its origins. Telecom equipments are already very dependant on third parties products like databases (Oracle, MySQL, …) or embedded operating systems (VxWorks, Linux, WindRiver, …). Telecom equipment manufactures are even getting more in the software area, as shown by acquisitions in 2004 (70 to 80% of acquisitions of the industry were societies whose primary activities are related to software). They have also developed close relationships with IT providers to sell bundled solutions. Development of the mass market products like wireless handsets require open standard platforms, generally produced by third parties specialized in software (Microsoft, MontaVista, …) and provide opportunities for the emergence of new players at the infrastructure/middleware level (Symbian) or at the application level. Those players are generally dedicated purely to software and are not accounted in this sector. They're taking a business previously operated by carriers with proprietary solutions. For both low volume and high volume products, telecom manufacturers are generally in charge of the integration of the applications, the design specifications and the user interface. Only standard components are bought or done in open source. They still have to develop internally at least for integration and some advanced in-house low volume products can represent up to 50 million lines of code in the infrastructure market segment[52]. But, for a lot of telecom products (handsets, IPTV, VoD, …), software strategy is and will continue to be determined by operators. In todays communication industry differentiation versus competitors and added value for customers is mostly based on services relying on software in networks. It is important to note that the leaders of high volume products, like NOKIA for handsets or CISCO, have invested heavily in software, especially in the user interface and configuration management which are perceived as key differentiators. They hope to offset with new flexible software capabilities the impact of the commoditization of hardware. Smaller actors with lower volumes, tend to outsource more. Manufactures of low volume products do not follow the same pattern and have to do most of the software by themselves (independently of their market position) as their no standard platforms and no one to outsource to.
Societal effects	Regulation (not in place at this time) on new products and services to guarantee interoperability (for instance for interdomains in NGN) and security could impact the adoption of software in telecom products. This impact should nonetheless stay limited as interoperability will probably be forced directly by the market and telecom operators. The evolution of style of life (need to be always connected to communicate … but also to ensure safety or to provide alternatives to work remotely) has been so far the strongest driver for the adoption of software, which main role is to hide the complexity and to provide improved usability. Migration could be slower than expected by some people because of the necessary trade-off between new features and complexity for the user. New entertainment experiences could also impact the telecom market as a whole and the adoption of software in particular (see consumer electronics). Population aging situation, more especially in Europe, will drive to more and more remote service (for instance for medical activity, see medical equipment). This will only be achieve if telecommunication network recreate this "virtual reality" with telecom modules embedded (like those of Siemens or Wavecom) in other products.

[52] In 2004, a typical smartphone represents 2.5 million lines of code (applications included), of which 0.2 for communications. A basic handset was only 0.2 million lines of code in 1999.

	In the future, products and systems will be so complicated that the users (especially at the consumer level) will need product specific on-line services to use them effectively. Those services will done with software.
R&D	Almost 100% of innovation in telecom equipment is related to electronics. Most innovations are including or related to software. Software allows to flexibly adapt systems to a variety of needs and new usage profiles (e.g., in software-defined radio, classic hardware-based antenna and receiver design is replaced with flexible software and signal processing solutions). Standard and patent policies are key to drive fair and positive competition and as such support R&D employment in this field, especially in Europe. Innovation comes generally first with a hardware component (camera, etc…), not necessarily new, which then needs to be supported by new software functionalities (album management, editing, etc…). Software also enables to provide new features by linking already in-use sensors and components. More and more software R&D will be handled by non-telecom equipment manufacturers, as innovation will be in the application space than in the equipment space. The industry is indeed squeezed by both IT companies, offering anything from middleware to application, and chips providers, offering protocol layers and reference design (TI, Qualcomm, Intel). Software is also key to allow convergent products, which have to be able to work under different configurations and different types of network (management of handover for instance between cellular and Wi-Fi technologies) or protocols (management of NGN core networks and existing MAN. It will allow remote management and reconfiguration. Some projects are also handled in open source models, which might translate on the software R&D expenses level of the industry itself (less licences costs but more integration). Open source, as the general movement for openness and reuse of modules, could have a major impact on telecom equipment industry expenses.

The study does not address the telecom services sector, but only telecom equipment. Telecom equipment industry does not take into account carrier internal expenditures regarding services (either broadband or wireless). Those players have nonetheless a certain amount of internal software development. A specific study would be needed to understand the telecom services sector value added regarding software (and the services sector in general).

7. Conclusions

7.1. A high level of software intensity outside the software industry

Key findings of the study stress the critical impacts of software on European industry competitiveness in industrial and manufacturing sectors, which are not considered primary “software sectors”.

Table 2: Estimates for 2002 of software R&D effort worldwide

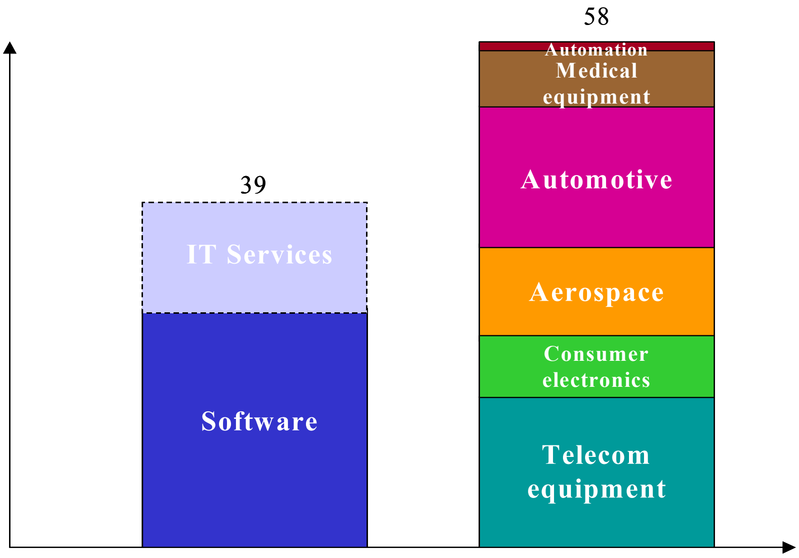
2002	R&D expenses (Billion EUR)	Software R&D expenses as a percentage of total R&D expenses	Software R&D expenses (Billion EUR)	WW market size (Billion EUR)	Value added (Billion EUR)
Aerospace	32	35%	11	213	119
Automotive	77	22%	17	968	503
Consumer Electronics	16	42%	7	152	85
Medical Equipment	28	25%	7	184	109
Telecom Equipment	32	52%	16	226	127
Automation	1	10%	0.1	20	14
TOTAL	**187 Billion EUR**		**58 Billion EUR**	**1763 Billion EUR**	**957 Billion EUR**

Source: IDATE

In 2002, the total software R&D effort (whether developed internally, subcontracted or bought) in the six economic sectors is much larger than the corresponding effort from packaged software as a ‘producer good’. The 6 sectors spent 58 billion EUR in software R&D in 2002, which is more than double the software development expenses by packaged software producers (27 billion EUR). Even if we add IT services software development, which represent 12 billion EUR, the 6 sectors still have 50% more software development.

Based on the estimated level of software intensity in the six sectors, the total number of software R&D jobs in the six sectors represents an **impressive level of employment of 640,000 jobs worldwide in 2002**, with an average worldwide man-year cost estimated at 90 000 Euros.

Figure 4: Software development expenses worldwide from IT services, packaged software and the industrial sectors in 2002



Source: IDATE

ICT sectors have a stronger share of software intensity (in percentage) than the sectors such as automotive, aerospace or medical equipment are not classified as ICT, but are among the largest software developers. The amount spent in software R&D by these sectors is explained by the critical impact of software on each sector. It points out that, to a large and increasing extent, software defines the attributes and functionalities of many products and services. The existence of specific software needs has been recognised by large IT services companies, which developed specific activities by sector. Even packaged software producers (SAP, ORACLE) have an increasing effort towards industrial sectors.

Software impact on the six industries is already very strong, whether we look at the amount of software included in the product or at the tools to design or simulate it.

At the process level, software is key for a “dematerialised” design, making use of simulation and CAD tools (Computer Aided Design), which has proven to be faster and more efficient (time spent, money, error chasing…) especially for cars and airplanes. In automation, software contributes to increase productivity and decrease cost by using more sophisticated and integrated process control, obtaining decrease of power consumption or of downtime.

At the product level, software may be considered as a tool to **manage the increasing complexity of new devices and networks**, and also to hide this level of complexity as much as possible from the final user, in order to reach a level of complexity “acceptable to the user”. It is therefore **a powerful tool for differentiation and innovation**. Software contributes to manage the increase in complexity implied by a more interconnected world, and to answer the multiple requests for new functionalities. In airplane and automotive, it allows the exchange of information between the different types of control units. In consumer electronics, it is a key part of new devices.

7.2. A strong increase of software effort in all sectors over the next 10-15 years

7.2.1. Forecasts for 2015

Table 3: Forecasts for 2015 : Software R&D effort worldwide

2015	R&D expenses (Billion EUR)	Software R&D expenses as a percentage of total R&D expenses	Software R&D expenses (Billion EUR)	WW market size (Billion EUR)	Value added (Billion EUR)
Aerospace	51	45%	23	341	191
Automotive	129	35%	45	1 355	705
Consumer Electronics	21	60%	13	197	110
Medical Equipment	84	33%	28	471	280
Telecom Equipment	36	65%	23	257	144
Automation	3	15%	0.5	42	30
TOTAL	**EUR 324 Billion**		**EUR 132 Billion**	**EUR 2 663 Billion**	**EUR 1460 Billion**

Source: IDATE

The forecasts for 2015 show a strong global increase in the size of software development for all sectors considered, from 58 BEUR to 132 BEUR. This increase will be well above the market growth and almost twice the growth of general R&D expenses. So there is an obvious evolution towards more software development in these sectors in the future, meaning that software development is a key and increasingly strategic factor for industry competitiveness overall.

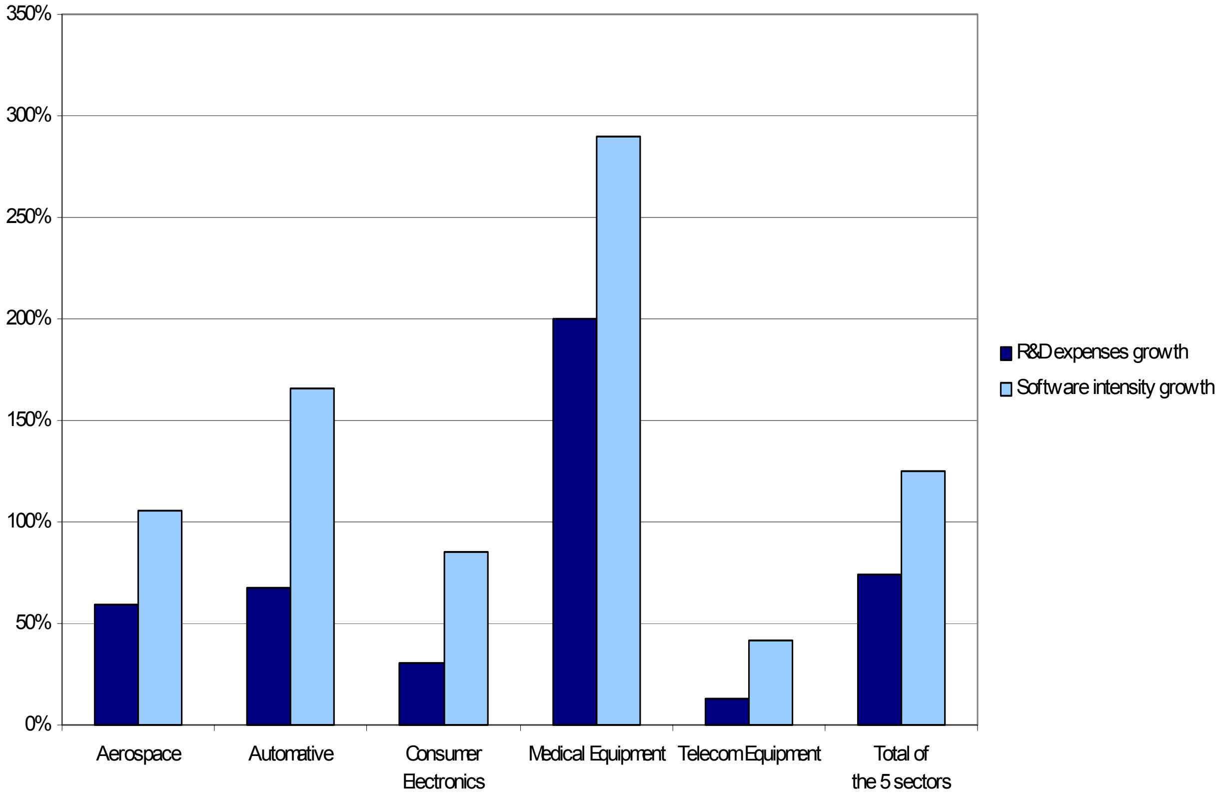
In all sectors, R&D expenses, expressed in percentage of the revenues, will be stable, or in a few cases increase slightly. **The software development increase will therefore be mainly the consequence of the increase of the percentage of software expenses in the total R&D budget**. The growth is also related to the growth of the market size. This level of increase differs according to the sectors, and their current situation.

There will probably be some kind of upper limit to the percentage of software R&D expenses, compared to overall R&D expenses, **but this limit will not be reached in the next 10 years** except for some specific products.

Software growth is a general trend at the manufacturer's level to differentiate its products or services. **But it will also be pushed by (and will enable) a large number of societal requests from the end-users**. In automotive, it provides answers to new regulations concerning road safety or protection of the environment. In Consumer Electronics, software provides benefits from the shift to digital while keeping product use as simple as possible. In aerospace, security and surveillance are key issues. The demand for medical equipment is influenced by an increasing patient population (aging population but also extension of lives of very ill people) and the focus on health care cost and preventative therapies. Software may represent 70% expenses for products like imaging.

This growth of software intensity will be more important in non-ICT sectors, as these sectors will begin to catch up with ICT sectors which are already well-advanced regarding software development. Nonetheless, ICT sectors will still keep their leadership on software intensity in the next decade.

Figure 5 : Compared growth of general R&D and software intensity over the period 2002-2015 for the 5 main sectors



Source : IDATE

The growth level of each sector depends of the specifics of the sector and are strongly related to the growth of the market and of the R&D. It also depends of the technical limitations of the sector and the presence of other key technologies (mechanical for the automotive industry, biotechnology for medical equipment industry).

7.2.2. Growth scenarios for software R&D effort

Companies will probably implement this needed increase of software effort by a mix of different methods, which have all already been observed (and possibly new ones) :

- Creating new jobs,
- Retraining current hardware specialists, which has been typical in the consumer electronics industry,
- Subcontracting the development to an IT services company,
- Creation of new software companies providing the same needed software to industry such as Symbian or OpenTV,
- Buying the non-critical parts as software COTS (Commercial-Off-The-Shelf) using a component based development method

Evolution of the mix will basically depend on industrial decisions about the needed capabilities to differentiate them from their competitors. Companies will have to operate a classical trade-off between making things or buying them. They will have to determine which parts/components should be owned (or bought from an IT service) in order to operate and which parts may be used from another organisation (usually in order to minimise costs).

Internal development will continue for low volume products, as in some medical equipment. So job creation will be both internal and external, by the development of new software products and companies.

Given these remarks, if we translate the growth of software expenses in 2015 in employment, **a rough estimate obtained by translating expenses into manpower, leads for the 6 sectors between 150 to 200 000 “new” jobs in Europe.** Overall worldwide employment in software R&D for the six sectors should represent approximately 1.3 million jobs in 2015.

7.3. Strong impact for European industry

European industry is lagging behind in the packaged software industry. Few European companies are competitive internationally with the likes of Oracle, Microsoft and others (SAP being a notable exception). **But Europe is ahead, or at least has a competitive position in the 6 industrial sectors studied for this report**, all of which are highly software intensive. For instance, Airbus and Daimler-Chrysler are strong players in aerospace and in automotive, Nokia or Alcatel are leaders of some market segments of the telecom equipment markets; Philips (medical equipment, consumer electronics) and Siemens (medical equipment, automotive) are very well-positioned in several of the sectors studied.

Given that Europe is very competitive (when both looking at market size and market players) in some of the most software intensive markets and that software intensity is already at least two times bigger outside of the primary software industry, **Europe's level in software development is clearly underestimated when looking only at the packaged software industry**.

The European leaders in those different 6 sectors have already adopted major initiatives around software (spin-offs, training of employees to gain software skills, dedicated software R&D center, association of market players to develop standards or middlewares) which have contributed to maintain or improve their competitiveness on the market. ICT leading players consider that their value added in the coming years will mostly comes from software functionalities.

There is obvious evolution towards more software development in these 6 sectors in the future (both ICT and non-ICT), meaning that software development is (already) now a key and increasingly strategic factor for European industry competitiveness overall.

As software will continue to be a source of differentiation and to be necessary to develop new products or supply new services, **Europe will need to invest more resources for software development outside of the software industry to at least stay competitive** (or even improve) in the 6 sectors studied.

The study only addressed the 6 sectors studied and only through the manufacturing industry point of view. Especially, it did not take into account **the services sector** (financial, healthcare, media and telecommunication, tourism and transportation, …), which has become one of the **primary industry of the Western economies** and is poised to grow even more. With few exceptions, these sectors does not necessarily involve a lot of R&D, but they rely heavily on software and SIS at least for their vertical process, as they deliver services or service-oriented products (most of their value is in the service) based on software. **A follow-up of the study on the services sector, applying the same methodology, would therefore be needed to understand the impacts on the European competitiveness.**

Software intensive systems in the future

Annex

TNO/IDATE

September 2005

Summary

1. Introduction

This paper is divided into two parts. The first one includes details analysis and theoretical development, developed during the phase 1 of the study (Chapter 2 to 6). The second part (Chapter 7) provides all the data used for building final estimates.

2. The characteristics of software

It is well understood that all Information and Communication Technology (ICT) products and services are dependent upon software. Often not so well appreciated is the very high and increasing software dependency of an immense variety of goods and services as produced in all economic sectors. Modern automobiles, aeroplanes, financial services, medical diagnostic devices, machine tools, wristwatches or washing machines will not function without the software that is embedded in them. Indeed, as products and services achieve ever higher levels of technological sophistication, the more software intensive they become.

However, despite the obvious economic significance of software, determining its actual economic value is no straightforward task. Moreover, we need to understand not only what the economic value is at the moment, but also what it is likely to be in the future. Most of the indications are that the trend for the next 10 years is for software to claim an increased portion of total product investment.

Software is an intermediate good in that it does not produce value in and of itself. Rather, it enables the production of value by some other means. Moreover, software is usually found nested within other intermediate goods, as for example with the operating and application software on a personal computer. Thus, the computer is an intermediate good that depends upon another intermediate good, namely software.

When software is developed as a ‘producer good’ – i.e. developed and marketed as a discrete product – its economic value can be calculated similarly to any other product or service. The situation ifs far more complex for customised and/or embedded software as developed by or for a broader variety of products and services.

Software is much more than a simple production input or raw material. To a large and increasing extent, software defines the attributes and functionalities of many products and services. Moreover, software can play a role not only in providing functionalities, but also in producing them. Much software is developed primarily for the purpose of increasing the efficiency and quality of production and distribution processes (e.g. simulators, etc.).

In either role, software has special economic characteristics owing to the fact that, once developed, it costs virtually nothing to reproduce. For mass-produced items, software is reproduced often millions of times at very little cost per copy. However, as it is the functionality of the software that determines its value, the price of software does not always equal its marginal cost. Development costs often can be recouped quickly, leading ultimately to high returns on investment. By contrast, for products with limited production runs and/or unique characteristics, the production and marginal costs can be virtually the same.

These characteristics have generated many diverse business models. There are many types of software, each with its own specific value propositions. For example, software can be embedded into a product or bundled with a product such that the hardware and software are sold together. Or it can be sold separately and installed on existing hardware, where typically also it can be changed or upgraded. Software can be accessed directly from the hardware or remotely from a server inside or outside of the enterprise (e.g. via the Internet).

In some cases, software is sold as a market commodity that provides various generic functions. But in many cases, especially where highly differentiated and customised functionalities are concerned, software is an asset of the producing enterprise. For this reason, many enterprises that are not producers of traded ICT products or services as such are nevertheless highly significant software developers. Indeed, most industrial software is developed directly either by the users themselves, and/or by contractors.

As a result, software can be commercialised in many ways. It can be sold as a discrete product which the user installs in a device. Or, it can be embedded in specific devices or components subject to a licence fee. In either case, the customer usually will pay a licence fee (individual, per site, per seat or usage-based). Increasingly, with the widespread use of high speed Internet facilities, some application software is provided for a rental subscription fee – in Application Service Provision (ASP) mode – thus enabling more flexible and cost effective access and upgrading. Some software is even distributed without an explicit price point – either its value is not calculated as a portion of the product or service price (e.g. when embedded in a product), or it is distributed freely in order to generate a critical mass of users who will then purchase goods and services related to the software (like the general open source model).

Even in the case of packaged software, software vendors are getting more and more revenues from the services (maintenance, customization, integration etc.) than from the software itself. SAP service revenues now represent more than a third of its revenues. Moreover, new business models are emerging around the SaaS concept (Software sold as a Service) and for the open source software concept where generally there are no licensing fees.

Software business models must be taken into account when trying to determine its economic value. Some segments of the market will be visible in that the user will be aware of the software, either through direct sales (including software licences and services) or indirect sales from third parties (software services). But other software will be invisible in that its presence and function will be transparent to the user. The economic value of some types of visible software can likely be measured similarly to any type of industrial output. But the value of other types of invisible software likely can only can be estimated based upon sector-specific assessments of its procurement and development costs, set against assessments of its share of the total value-added in a given product or service.

3. Why is an estimate of the overall economic value of software necessary?

3.1. Actual value and measurable value

It is virtually certain that the actual value of software to the economy is many times its current measurable value. Furthermore, it is certain that much of this extra value is being produced in firms that are not part of the ICT producer industry as such.

A software intensive system is any product or service whose functionalities are dependent upon software. By 'dependent' we mean simply that the product or service either would not function at all, or otherwise would function in a very different way without electronic systems operated by software. Seen in this light, a great many goods and services are software intensive systems, even though the software element may be completely invisible to their users.

A general impression of software intensity can be gained by looking at software spending as a proportion of total IT spending. As shown in Table 1, recent figures from the US indicate that for several key industries, most of the IT spend is taken up not by hardware but by software systems and IT services (largely software intensive).

Table 1 : US business spending on software and IT services as a % of total IT spending

Industry	Software spending (as % of IT spending)	IT Services spending (as % of IT spending)
Global	20%	53%
Finance	16%	63%
Manufacturing	24%	60%
Healthcare	23%	46%
ICT	25%	50%
Automotive	24%	51%

Source : IDC (2003) from CEBIT America

The problem for determining the economic value of software is that although the "invisible" part is every bit as important economically as the 'visible' part, nowhere does it show up in economic statistics. However, if we adopt a "software intensity" perspective, European R&D in general is cast in an entirely different light. We must consider that a substantial proportion of R&D in most key industries is actually software development and that software contributes a significant portion of product or service value-added.

Moreover, as more products and services increase their software intensity, increasing portions of the R&D budgets of all innovating firms will be devoted to software development.

This observation has obvious implications for the way we perceive the R&D process, who participates in which aspects of it and how value from R&D is generated. These implications are clear enough for companies when planning R&D expenditure and configuring R&D initiatives, whether internally or in collaborative ventures. But the software intensity issue has especially important implications for governments as they plan policies to stimulate the R&D environment and enhance overall industrial competitiveness.

In particular for publicly-funded and co-funded R&D programmes, the software intensity issue implies that targeting resource allocations solely or mainly at ICT producer goods may by-pass some of the most significant engines of ICT development and commercialisation. It may also fail to take into account closer collaboration between ICT producers and their customers in industry as a whole. This can create a suboptimal situation for both ICT producers and ICT intensive industries alike.

3.2. What do we mean by ‘economic value’?

The economic value of software can be conceptualised in two related ways :

- value to the producer in terms of the proportion of total product value contributed by software,
- value to the economy in terms of the contribution of software to GDP.

In this paper we will comment mainly on the value of software to producers. Our task is to show how software contributes to the value contained in a product or service and to give examples of the proportions of product value that can be attributed to software in different industries. Calculating software value-added in GDP terms is at present practically impossible owing to the fact that the official national statistics do not specifically identify or measure a wide enough scope of software activity.

GDP is an aggregate of value-added produced at the sector level. National value-added can be calculated in several ways, but the basic formulation is :

value-added = sales minus costs of procured inputs

At the company level, value-added is really the sum of operating profits, labour costs and assets. In other words, in value-added terms, not only profits but also the jobs and assets created by the company all constitute value to the economy as a whole, thus :

value-added = profit + labour costs + assets

In principle, these two value-added formulations produce roughly the same result. However, the latter formulation is important in determining the value-added of intermediate goods like software in that it generates indicators that can be used to assess the composition of value for any product or product grouping. For example, we can estimate the proportion of software activity by determining the proportion of employees and assets that are linked directly to producing or integrating software, as compared to other production inputs.

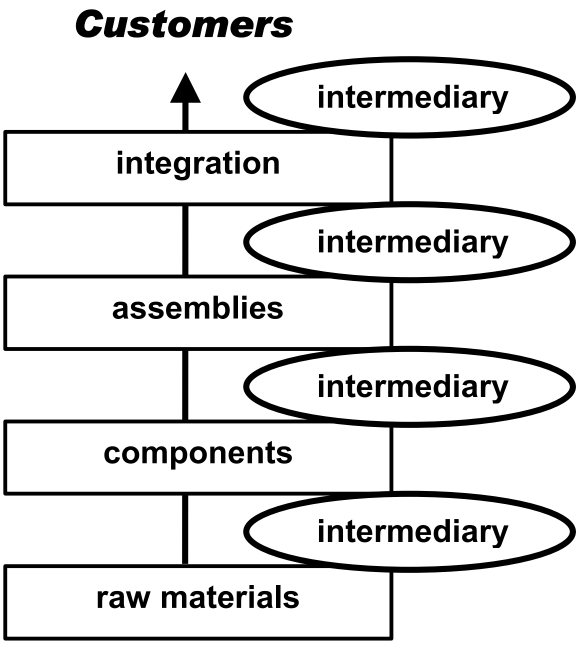
Thus, determining the value of software to producers requires a value-added assessment process, but one that is geared to the types of information that can be obtained from companies that produce software, either as a product in its own right or as a component of other products.

Value to the producer is basically a product composition measure. It shows how much the producer has invested in each input to a given product group (i.e. the cost of procuring this input and/or of producing it in-house) set against the realisable commercial value of the product as a whole.

The inputs into all products and services can be seen in terms of value-chains or value-systems in which different levels of value are added by different producers at different stages – from raw materials through to finished products. Value can be added also by various intermediaries who facilitate or broker the intake of various inputs into the value system (Hawkins & Verhoest 2002, OECD 2003).

The proportion of value contributed to a traded product or service by any given type of input normally represents the economic cost (and value) of that input to its producer. The value of the whole product is thus cumulative of value-added at each stage. This basic scheme is illustrated in Figure 1

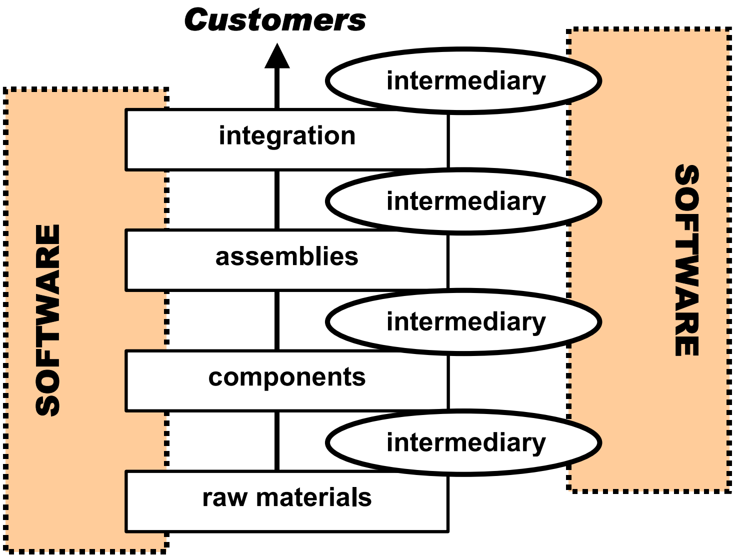
Figure 1 : Stylised value chain or value system relationships



As we noted above, however, software is not a typical input into the value chain. As shown Figure 2, software can intervene at virtually any stage of the value accumulation process. In some cases, the value accumulated in such a chain can be attributed mostly to software. For example, a producer of packaged software mainly develops, procures, integrates and markets software. Thus, we could expect that almost all of the value of the product is software.

For automobile or aircraft manufacturers, on the other hand, we would expect to see software as but one of a much greater variety of value-producing inputs. The question in either case is to determine what these proportions might be. For example, we can look at the case of the Dassault Falcon, one of the world's most advanced corporate jet aircraft. The Falcon incorporates leading edge avionics, flight management and navigation systems that are software-intensive and constitute a considerable portion of R&D costs and product value. However, the Falcon design team also created highly advanced software-based design and production systems especially for this aircraft that required the efforts of over 400 software engineers (le Monde 2005). Systems such as these reduce production costs and speed up delivery schedules, thus enhancing the competitiveness of the Falcon product.

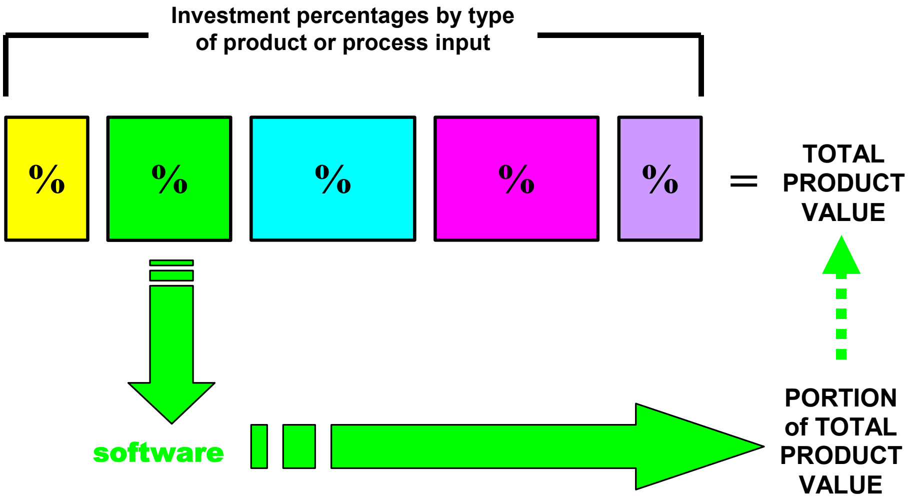
Figure 2 : Software and the value chain



The Falcon case illustrates clearly that the value of software to producers can encompass process as well as product. Thus, in estimating the value of software to producers we must allow for both types of input to the value created by software. We must acknowledge also that in many cases product and process are so interconnected that companies may find it difficult to separate one from the other. At the end of each value-accumulation process is a fully integrated product or service which reflects each of the input investments and embodies all of the value created.

Figure 3 illustrates that once we have a fully integrated product, we can then deconstruct it in terms of the relative size of the various investments relative to the total product value. This then becomes reflected in the price of the product in the market and in the levels of profit that can be realised by producers.

Figure 3 : Software as a segment of total product value



Perceiving industrial products and services as software intensive systems

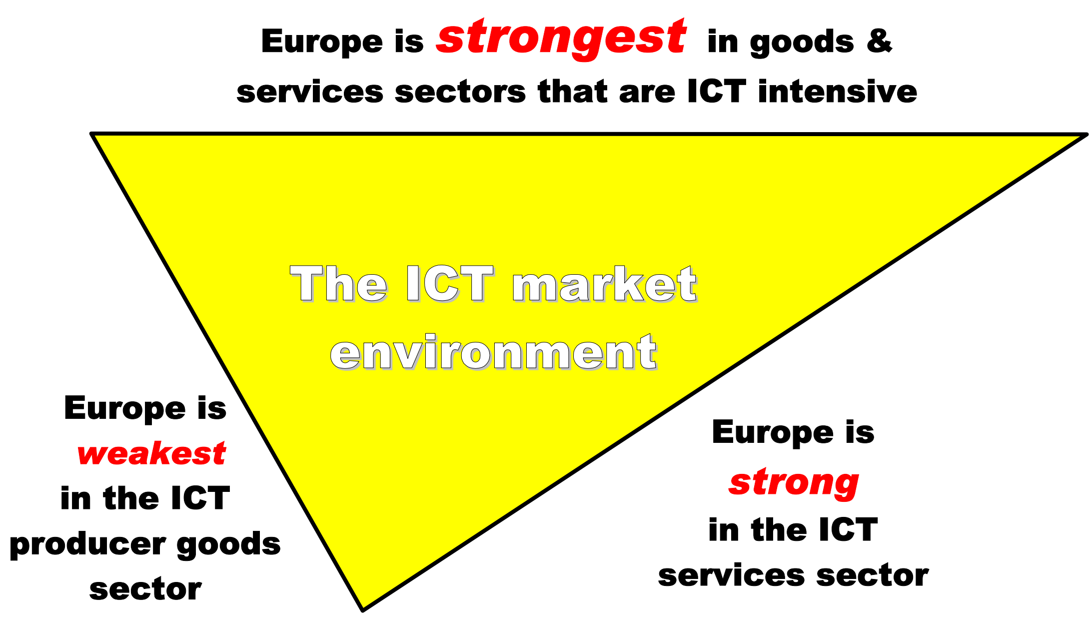
Over the past 10-15 years, the tendency has been for government policies and programmes to focus mainly on the ICT producer sector on the assumption that the R&D function lay mainly with ICT producers. In policy terms, ICT has been viewed largely as exogenous to other industry sectors, which were regarded mainly as customers for ICT goods and services. Thus, the policy emphasis has been upon encouraging both producers and households to invest in ICT in the expectation that expansion in this sector would drive productivity and growth overall.

These assumptions were always problematical. Indeed, there was always a strong a case for the scenario that growth drives ICT development and procurement, rather than the other way around.[1] In this scenario, industrial firms of all descriptions are not passive procurers of ICT, but partners with ICT producers, in some cases even taking the lead in the innovation process. Such a scenario has important implications for how we perceive European competitiveness in the ICT domain and how public resources to support the competitiveness of European firms are allocated.

As shown in Figure 4, ICT producer goods form only one of three basic segments in the overall ICT environment. European firms are active in all three segments, but, on balance, currently the weakest part of the European profile overall is ICT producer goods. Mobile telecommunication equipment and services constitute the one area where Europe still enjoys a market advantage in producer goods vis-à-vis its American and Asian competitors. However, it is no longer certain that this advantage is technological to the extent it was when GSM was the only available digital mobile solution.

Europe's global position regarding producer software is actually relatively weak with only a few players in the top rankings of software vendors. SAP is a leader in Europe and worldwide for ERP (Enterprise Resource Systems). Dassault Systems has also a strong position built around CAD (Computer Aided Design) systems. But these successful companies are really exceptions, even at the European market level.

Figure 4 : Comparative European strengths in industrial sectors



Europe is stronger and more competitive in IT services, even if still lagging behind the USA at world level[2]. It must be considered, however, that many services are specific to local conditions – like language, client proximity or local market knowledge – that usually confer advantages to domestic services suppliers. Of the world's top thirty IT and software providers, only five are of European origin, compared with twenty-two from the USA and three from Japan. As shown in Table 2 and Table 3, European IT services are well positioned in the European market, with some leading players at the regional and national levels (T-Systems, Capgemini, Atos, LogicaCMG, Siemens BS).

[1] Baily, M. N. (2002) "Distinguished lecture on economics in government: The new economy, post mortem or second wind?" *Journal of Economic Perspectives* 16 (2) Spring, pp. 3-22.

[2] O'Mahony, Mary and Bart van Ark (editors) (2003), EU Productivity and Competitiveness: An Industry Perspective Can Europe Resume the Catching-up Process? (Office for Official Publications of the European Communities, Luxembourg).

Table 2 : Ranking of top IT services providers in Europe in 2003

IT Services	Origin	Revenues (billion EUR)
IBM	US	9.920
EDS	US	5.341
AtosOrigin	France	4.735
Accenture	US	4.563
T-Systems	Germany	4.377
Capgemini	France	4.353
Siemens Business Services	Germany	3.413
CSC	US	3.055
BT	UK	2.983
Fujitsu	Japan	2.659
LogicaCMG	UK	1.897
HP	US	1.757

Source : IDATE

Table 3 : Ranking of top application software providers in Europe in 2003

Software provider	Origin
Microsoft	US
SAP	Germany
IBM	US
Oracle	US
Sage	UK
Adobe	US
EDS	US
Dassault Systems	France
Autodesk	US
Datev	Germany

Source : IDATE Digiworld, from PAC

But we could argue that Europe is strongest overall in the production of goods and services of all descriptions that are highly ICT – and software – intensive. This argument is based on the observation that many European firms are highly competitive domestically and/or internationally in many key industries – like automotives, aerospace, medical products, instrumentation, robotics, automation, logistics etc. – that require extensive and sophisticated original design and integration of ICT. Software forms a very substantial share of value-added in these industries. Moreover, the combined market share of European firms in these product groups considerably outweighs that of firms the ICT producer segment and possibly also in the ICT services segment.

Thus, a more accurate picture of the relationship between ICT products and European industry as a whole can be obtained only if we begin to perceive of ICT as an *endogenous* element in industrial R&D and production overall. A key factor in bettering our understanding of this endogenous relationship lies in defining the structural position of software both within the ICT producer sector and in non-ICT producer sectors. This will provide a basis for understanding the significance of software as a producer of value.

Such an understanding is essential for developing industry and policy strategies in Europe because the comparative strengths of ICT production and application in Europe differ from those of the US and Asia. By estimating and comparing the relative value added of software in all three major software development segments – ICT producer goods, ICT producer services and ICT intensive systems, policies programmes and funds can be targeted more effectively.

Problematically, however, although all three segments are software dependent, at present only the ICT producer segment shows up in the official statistics. Even here, the statistics do not indicate the degree to which ICT producer goods are software intensive – only the packaged software segment is measured with any consistency. Before we can devise more efficient public and private sector R&D strategies, a better estimate is required of software value creation *both inside and outside* of the producer segment. But we could argue that Europe is strongest overall in the production of goods and services of all descriptions that are highly ICT – and software – intensive. This argument is based on the observation that many European firms are highly competitive domestically and/or internationally in many key industries – like automotives, aerospace, medical products, instrumentation, robotics, automation, logistics etc. – that require extensive and sophisticated original design and integration of ICT. Software forms a very substantial share of value-added in these industries. Moreover, the combined market share of European firms in these product groups considerably outweighs that of firms the ICT producer segment and possibly also in the ICT services segment.

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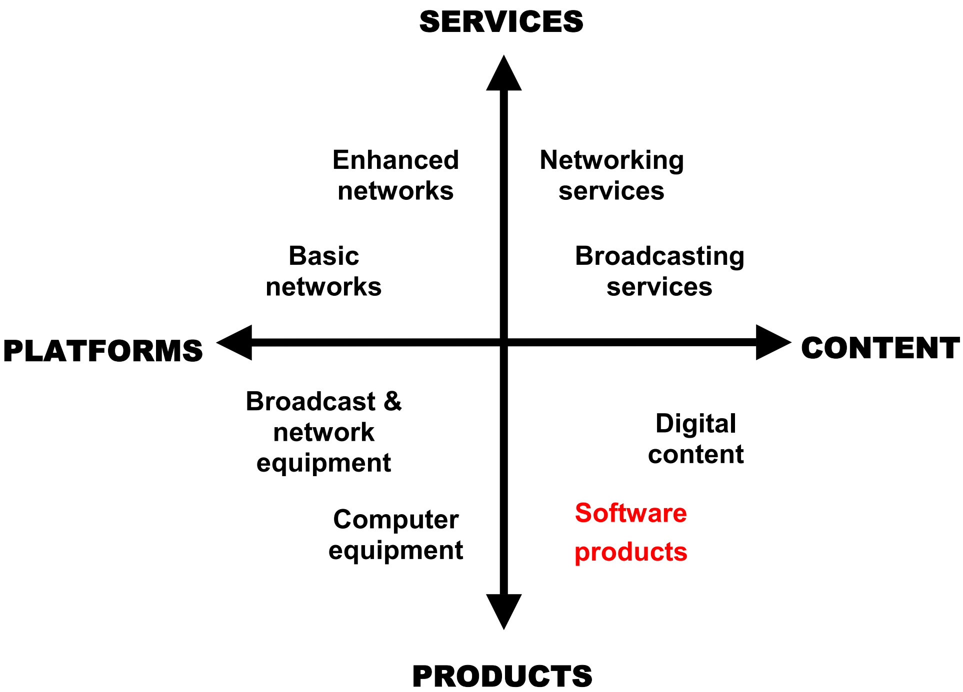
4. Determining the structural position of software in the ICT and non-ICT industries

Before we can examine the challenges of estimating software as a proportion of value-added for industrial products as a whole, *we must first consider its position within the ICT producer industries themselves*. This is partly for the reason that ICT producers now often collaborate with producers of other products and services in order either to customise the functions of generic software programmes or to integrate them into products, services and processes. But also we have to recognise that even within the ICT producer sector, the value of software is often underestimated or left undetermined.

We can begin by mapping out the ICT sector in terms of the basic orientations of its various product groupings. Figure 5 arrays generic ICT product groupings according to their most obvious functional orientations. As shown in the diagram, ICT can be oriented primarily to *services* or to *products*. But ICT products and services can have two basic orientations. One is a *platform* orientation which basically encompasses hardware and network facilities. The other is a *content* orientation which basically encompasses all of the various forms in which digitized information is stored and distributed. On such map, software shows up as a discrete category only in its product (i.e. packaged) form which tends to be oriented more to content.

Figure 5 : A basic mar of generic ICT product groupings



Source : Adapted from Hawkins, Mansell and Steinmueller (1997)

However, as shown in Figure 6, software permeates the entire ICT sector. Some software is packaged and sold on to users who apply it to various devices, but all of the other product groupings in the sector are software intensive systems.

This illustrates the problem that, except for packaged software products, software is typically not separated out as a distinct portion of product value even for most ICT producer goods. For example, most of the value added in a digital switch that provides basic telecom networking resides in its software and most current methods for creating and storing digital content are software intensive. However, the contribution of software as a portion of the value of a switch is normally not disentangled from that of the hardware.

The problem is amplified many times when we consider the application of ICT to industrial enterprises outside of the ICT producer sector. Many ICT producer goods are applied to the production of other goods and services, whether incorporated into commercial and industrial processes or into actual traded goods and services. Some of these ICT goods are identifiable specifically as software or software services, but all of them are software intensive.

Figure 6 : Software permeation of the ICT product environment

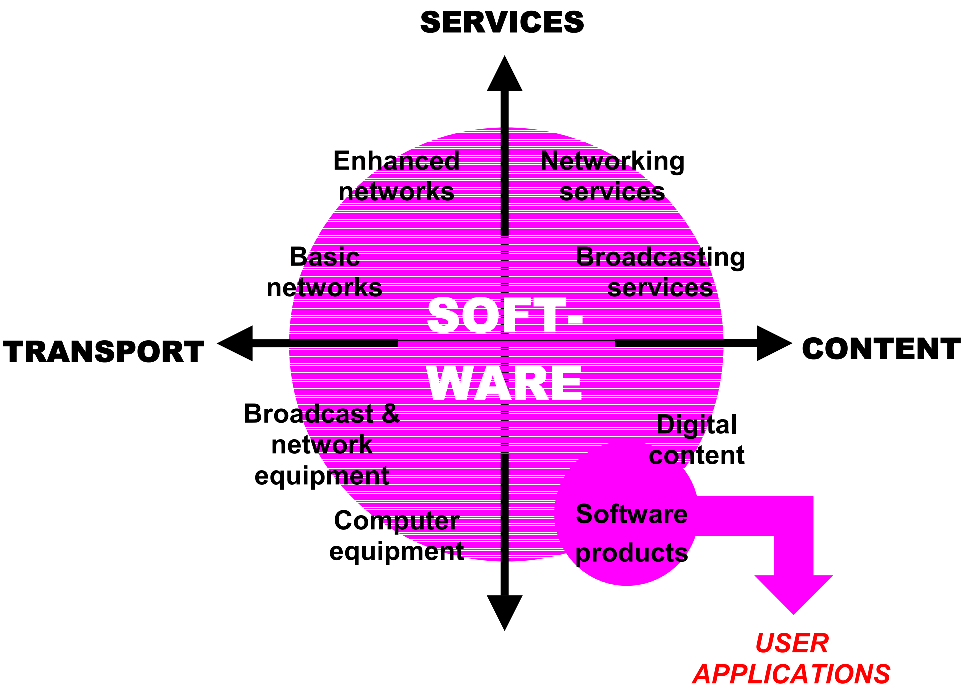


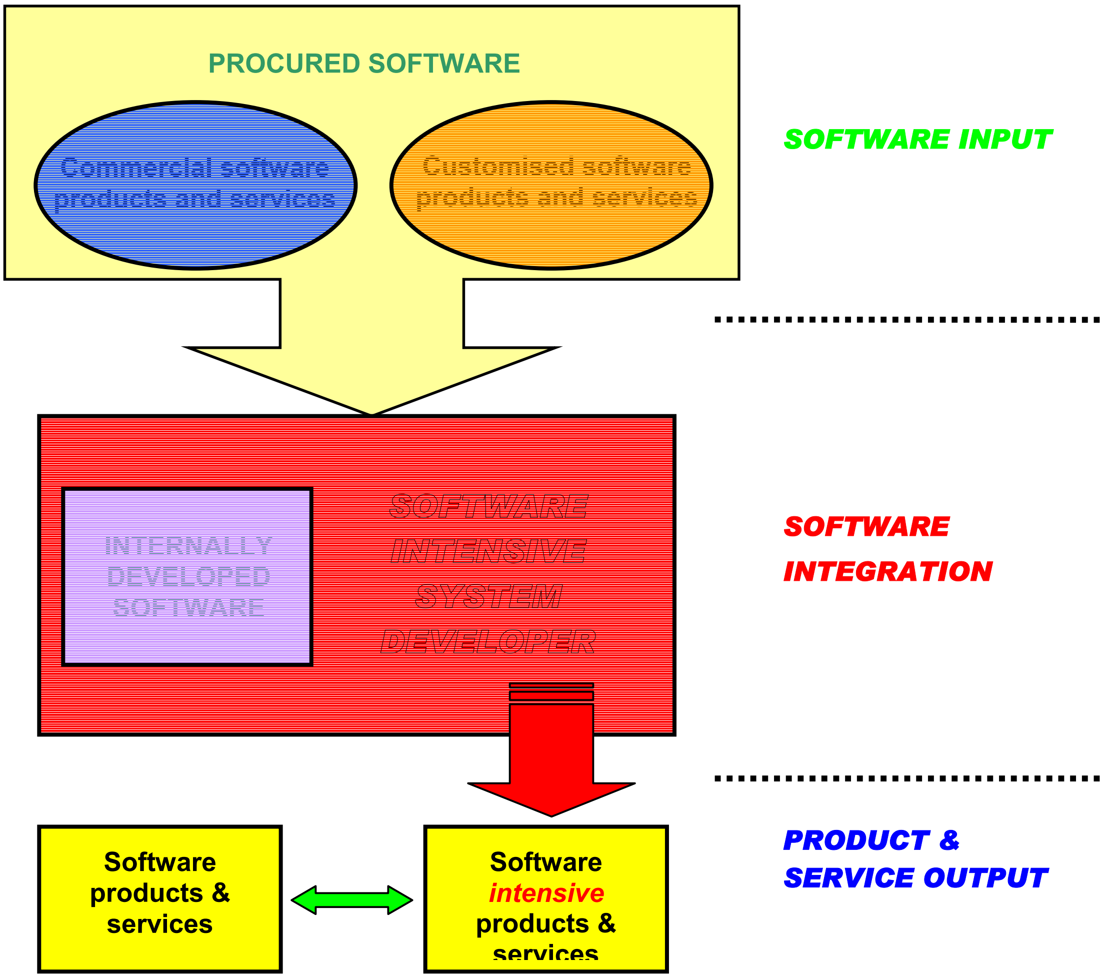
Figure 7 illustrates how software from many sources can be incorporated into the production of any software intensive system in any industry. Some types of software are procured inputs from external sources. These come mainly in the form of commercial software products and services (the self-same software products from Figure 5 and Figure 6). But other software is not available as a commodity and must be imported into the development process via contractors who write code that is customised for the needs of a particular software intensive system.

The enterprise producing the system integrates all of these imported inputs. But the integrator can also develop software internally. Often the incentive to do so lies in the importance of retaining IPR protection on critical system components. The entire process can yield two types of outputs :

- a software intensive system in which the software is embedded,
- an integrated software product and/or service that can be marketed in its own right.

Close relationships can exist between these outputs, as where the user requires active access to a software product in order to operate and/or maintain the system. Figure 7illustrates the very close relationship that can exist between ICT producers and non-ICT producers in the development of software intensive systems. In determining the economic value of software, it is important to consider all of the arenas in which software can be developed and applied.

Figure 7 : Software inputs and outputs for a software intensive system



5. Estimating the economic value of software

The intermediate and nested characteristics of software create enormous problems when it comes to estimating the economic value of software (whether in terms of products or of GDP contribution). The main problem is a serious lack of relevant and dependable data. At the present time, we have basically two sources of data that are relevant to making value determinations, but each has its own inadequacies when it come to software :

- ***System of National Accounts (SNA) data*** – These data are collected by national statistical agencies for the purpose of monitoring national income and expenditure in order to inform economic and social policy. National data form the basis of statistical analysis at the international level – e.g. by the OECD. The SNA data have the advantage of being longitudinal (collected over long periods of time) thus in principle allowing more statistically rigorous determinations of economic impacts. But for our purposes they have the disadvantage of being collected on a sector basis according to a nomenclature that does not reflect the current composition of advanced industrial economies.

  In particular, SNA data from most countries do not yet capture data on the service sectors or on intermediate goods like software. For example, some countries collect data on the telecommunication and computing industries primarily in terms of the manufacture of equipment. The Figure 8provided by firms in these industries may incorporate value that is added specifically by software activity, or by customer services, but typically the data are not disaggregated to the degree necessary for us to see the exact contribution of these individual activities to GDP.

  Some progress is being made to rectify these inadequacies, particularly in the United States where for several years the industry census has included specific intermediate categories. The categories are still somewhat limited and the time series is still too short to give other than a flavour of the likely impacts of intermediate goods and services. Nevertheless, analysis of these data to date indicates clearly that when measured separately the economic contributions of software and services are significant.

- ***Industry data*** – These data are collected typically by companies, industry associations, professional bodies and market research organisations. Governments collect them as well, but normally on an occasional, case-specific basis. The advantage of these data is that they may give a more accurate picture of industry segments at a specific point in time. The disadvantages are that they are almost always cross-sectional (covering only one point in time or very short periods of time) and that often the methodologies are not consistent from one data set to another, or indeed even given. This greatly reduces the reliability of economic estimates based on such data. Moreover, industry statistics only address market size and likewise do not disaggregate specific intermediate inputs, like software.

At this time, neither type of data is adequate to estimate the economic value of software, even within the ICT producer sector, let alone in the economy as a whole. Our own assessment of the present coverage of data on the ICT producer industries is summarised in Table 1, which illustrates the degree to which ICT product and service groups (as taken from Figure 5 and Figure 6) are concordant with SNA data categories and/or covered to any significant extent in the available industry data.

True to their orientation to more traditional manufacturing industries, the relevant SNA data are mainly concentrated in the platform product areas and in content products like packaged software and pre-recorded media which can be measured as discrete product outputs. The industry data fare better in the scope of their coverage, but likewise concentrate on discrete product markets with virtually no methodological or analytical continuity between data from different sources.

Both official national statistics along with most statistics collected at the industry level tend to measure value-added at quite highly aggregated levels. Except for packaged software, which is visible as a product in its own right, it is impossible to determine from currently available official or industry statistics exactly what percent of the value of an industry or product group is contributed specifically by software (whether procured or own account).

Table 4 : Matching available data to software value-added determinations

Functional orientations	ICT product groupings	Statistical concordance with SNA date (longitudinal)	Coverage in relevant industry data (cross-sectional)
Platform Services	Basic networks	+	+
	Enhanced networks	-	+
Content services	Broadcasting services	-	++
	Networking services	-	+++
Platform products	Broadcast & network equipment	+++	+++
	Computer equipment	+++	+++
Content products	Digital content	++	+++
	Software products	+++	+++

'-' indicates little to no coverage at all and ''+++' indicates highest available level of coverage

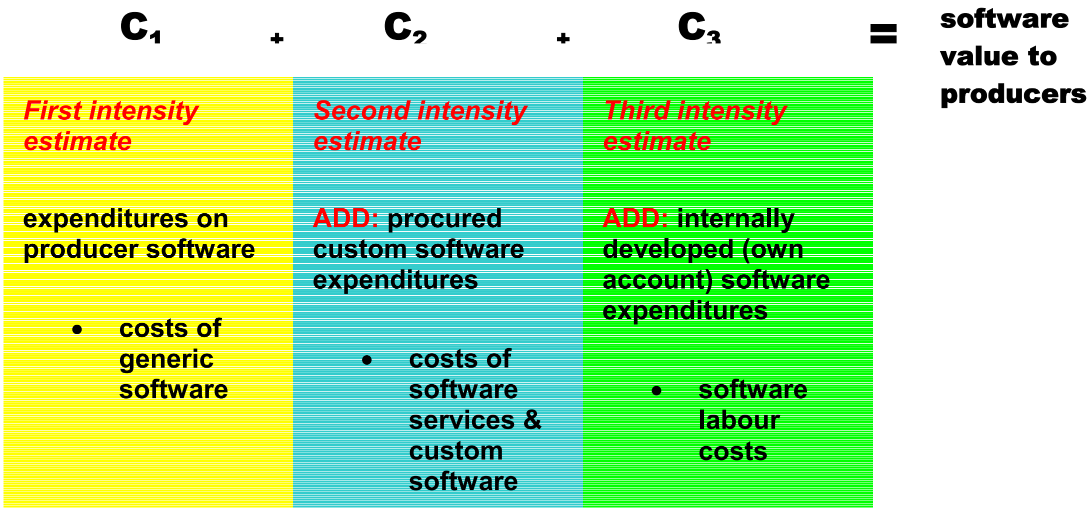
6. Estimating the value of software to producers

Allowing for the data problems, it is possible nevertheless to *estimate* the value of software within reasonable parameters by examining the software intensity of various industries. Software intensity is basically a cost measure and it can only be determined from company-level information about all of the expenditures they make that are solely or mainly directed at procuring, integrating and developing software relative to individual product groups.

From our basic formula for determining product value-added (profits + labour costs + assets) indicators such as software procurement costs, proportion of employment costs, and software-related assets could be derived. These give the total expenditure on software-related activities which can then be expressed as a portion of the total investments that relate to the product in question.

The entire estimation process is illustrated inFigure 8. Ideally, information would be available in three categories, each geared to a specific type of software input (based on different indicators). The final estimate would be the sum of these indicators. However, in practice we do not expect that all firms will be able to provide all three types of data to the same extent or always in comparable form. Moreover, in some cases the levels of investment and/or trends may have to be inferred from more qualitative analysis of changes in industry, market and product characteristics.

Figure 8 : The cost estimation process



C1 versus C2

C1 and C2 can be approximated by using existing data on market size, both for the packaged software market and for IT services. There is a strong relationship between these two Figure 8, as buying software programmes is usually associated with much greater spending on IT services (customisation of the software, further *ad hoc* development of procured software, services of software engineers and technicians etc.).

As shown in Table 2 (above), IDC estimates that in the US in 2004, each dollar of software revenues produced on average more than 2.5 dollars in services. The table compares software spending and IT services spending in several key industries. IT services spending includes also networking and communication services, but we may assume that more than 50 % of IT services involves software development. So a first order estimate would be that the market for subcontracted software is higher than the market for software as a product. In order to get more precise estimates, it is necessary to do a more in depth analysis of the exact content of IT services.

Estimating C3

Following their recommendation that software (SNA93) be characterised as a capital asset, the OECD and Eurostat established a joint task force (Oct 2001- Oct 2002) to determine country differences in concepts and measurements. One of the findings was that in some countries, software investment was strongly underestimated.

The OECD source data date from 1999 and were published in 2003. As yet, no update is available. However, these data have not been used for our estimates except as indicators of clear growth tendencies in the various software segments.

Table 5 : The value of software from different sources

		Purchased					
		CPA72.2		Total			
Country	Year	Investment ratio	% of 72	Investment ratio	% of GDP	Own-account % of GDP	Total % of GDP
Czech Republic	99	0.64	57	0.36	1		
Denmark	97	0.58	61	0.36	0.8	0.4	1.3
Finland	95					0.4	
France	98	0.51	50	0.25	0.6	0.8	1.5
Greece	98			0.7	0.3	0.2	0.5
Italy	98	0.48	50	0.24	0.5	0.4	0.9
Netherlands	98			0.39	0.9	0.9	1.8
Spain	96			0.75	0.6	0.3	0.9
Sweden	99	0.87	55	0.45	1.7	1	2.7
United Kingdom	99	0.51	50	0.23	0.8	0.8	1.7
Australia	98/99				1.1	0.7	1.8
Japan	99				1.3	0.6	1.9
Canada	98	0.95	46	0.41	0.8	1	1.8
United States	97			0.37	1.2	0.9	2.1

Source : Measuring investment in software STI Working paper 2003/6 DSTI/DOC'2003
Nadim Ahmad

As illustrated in the Table 5, the relevant finding of this task force for our C3 estimate is that the level of own-account software is approximately equal to the level of purchased software. Therefore, a first rough estimate would be that C3 is at the same level of magnitude as C1. Indeed, we expect that for industries with a high level of ICT development, this percentage is probably higher. Unfortunately, the OECD data do not distinguish between industrial sectors.

A recent ranking of industries according their share of broadly defined ICT-skilled employment in the EU15 in 2003 supports the previous assumption (New perspectives on ICT skills and employment (DSTI/ICCP/IE(2004)10/FINAL). These data show that a large number of manufacturing sectors have a share of ICT-skilled employment above 30 %.

They include :

- Manufacture of radio, television and communication equipment 47.8%
  (includes consumer electronics) (NACE 32)
- Manufacture of electrical machinery and apparatus (NACE 31)............................ 38.0%
- Manufacture of medical, precision and optical instruments (NACE 33)................. 33.2%
- Manufacture of other transport equipment... 30.2%
  (includes aerospace) (NACE 35)

Slightly under the 30% level, we find :

- Manufacture of machinery and equipment (NACE 29) .... 27.4 %
- Manufacture of Motor Vehicles (NACE 34)... 21.2 %

These data do not include any definite Figure 8 about software, but they suggest strongly that internal software development in manufacturing industries – which is not classified as software development activity as such in the SNA – is highly significant.

7. Building of final sector estimates

7.1. Estimates for 2002

Worldwide turnover for each sector is evaluated by using consultancy reports. Sources are given in the main report.

Value added estimates

OECD does not provide worldwide value added data for each of our six sectors. So we have defined an ad hoc computation. For each sector we eliminated the services and commercialisation revenues (not taken into account in OECD data), by subtracting a percentage of the market size represented by services and commercialisation. Then value added is obtained then by subtracting 'bought in' materials and services. Strictly speaking, value-added is a macroeconomic measurement that is heavily dependent upon the exact definition of the sector that is employed. Value-added measurements always include OEM production, but may or may not include suppliers. This issue is sector specific.

The final value added obtained has been checked for consistency with data available from OECD, as well as data from national organisations, such as the "DTI Value Added Scoreboard 2005".

The following tables provides the percentages used.

Table 6 : Estimates of value added

	Worldwide market BEUR	Substracting services revenues	Manufacturing production in BEUR	Percentage of basic input (raw material,bought services;..)	Manufacturing production - basic inputs = value added
Aerospace	213	80%	170.4	70%	119
Automotive	968	80%	774.4	65%	503
Consumer Electronics	152	80%	121.6	70%	85
Medical Equipment	184	85%	156.4	70%	109
Telecom Equipment	226	80%	180.8	70%	127
Automation	20	90%	18	80%	14

R&D value estimates

They are based on R&D intensity, id est the ratio of R&D expenses compared to value added of the sector, as given by OECD.

Table 7 : R&D intensity in 2002

	2002 R&D intensity
Aerospace	26.8%
Automotive	15.3%
Consumer Electronics	19.0%
Medical Equipment	26.0%
Telecom Equipment	25.0%
Automation	10.0%

Source : IDATE, from OECD

7.2. Forecasts for 2015

Growth of the turnover up to 2015 has been estimated through interviews with industry leaders and existing forecasts. For each sector, the growth value and the sources are indicated (when coming from industry).

Growth of Value Added has been taken as similar as the growth of turnover.

Based on discussions with industry, R&D intensity has been kept constant, with two exceptions : Medical Equipment and Automotive, with both a slight growth.

Table 8 : R&D intensity in 2015

	2015 R&D intensity
Aerospace	26.8%
Automotive	18.3%
Consumer Electronics	19.0%
Medical Equipment	30.0%
Telecom Equipment	25.0%
Automation	10.0%

Source : IDATE

Evaluation of software intensity for each sector is the result of interviews with industry leaders and specialists.

8. Interviews and documents

All discussion with industry and provision of data by industry has been based on a non-disclosure agreement. Here is a list of the companies met or interviewed. Several interviews (up to 3) have taken place in some cases with the same company. Some companies (Philips, Siemens, etc…) are involved in two or more of the sectors addressed with separate divisions. Sometimes we have met both R&D manager and software manager. The total number of interviews is above 30.

This does not include working meetings with members of ITEA Office.

Table 9 : List of companies, associations and organisations met

Airbus
Alcatel
Barco
Bosch
Cap Gemini
Cegelec
Daimler-Chrysler
Enertec
Eucomed
Gifas
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Nokia

OCDE
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