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EUROPE INNOVA
Sectoral Innovation Watch

Sectoral Innovation Performance in the Space & Aeronautics Sectors

Final report

Task 1

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Consortium Europe INNOVA Sectoral Innovation Watch

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Europe INNOVA Sectoral Innovation Watch

Detailed insights into sectoral innovation performance are essential for the development of effective innovation policy at regional, national and European levels. A fundamental question is to what extent and why innovation performance differs across sectors. The second SIW project phase (2008-2010) aims to provide policy-makers and innovation professionals with a better understanding of current sectoral innovation dynamics across Europe

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Central to the work of the Sectoral Innovation Watch is **analysing trends in, and reporting on, innovation performance in nine sectors** (Task 1). For each of the nine sectors, the focus will be on identifying the innovative agents, innovation performance, necessary skills for innovation, and the relationship between innovation, labour productivity and skills availability.

Sector Innovation Performance: Carlos Montalvo (TNO)	
Automotive: Michael Ploder (Joanneum Research)	Knowledge Intensive Business Services: Christiane Hipp (BTU-Cottbus)
Biotechnology: Christien Enzing (Technopolis)	Space and Aeronautics: Annelieke van der Giessen (TNO)
Construction: Hannes Toivanen (VTT)	Textiles: Bernhard Dachs (AIT)
Electrical and Optical Equipment: Tijs van den Broek (TNO)	Wholesale and Retail Trade: Luis Rubalcaba (Alcala) / Hans Schaffers (Dialogic)
Food and Drinks: Govert Gijsbers (TNO)	

The **foresight of sectoral innovation challenges and opportunities** (Task 2) aims at identifying markets and technologies that may have a disruptive effect in the nine sectors in the future, as well as extracting challenges and implications for European companies and public policy.

Sector Innovation Foresight: Matthias Weber (Austrian Institute of Technology)	
Automotive: Karl Heinz Leitner (AIT)	Knowledge Intensive Business Services: Bernhard Dachs (AIT)
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Task 3 will **identify and analyse current and potential bottlenecks that influence sectoral innovation performance, paying special attention to the role of markets and regulations.** Specifically, the analysis will cover the importance of the different factors in the propensity of firms to innovate.

Role of markets and policy/regulation on sectoral patterns of innovation: Carlos Montalvo (TNO)	
Katrin Pihor (PRAXIS)	Klemen Koman (IER)

Task 4 concerns **five horizontal, cross-cutting, themes related to innovation**. The analyses of these horizontal themes will be fed by the insights from the sectoral innovation studies performed in the previous tasks. The **horizontal reports will also be used for organising five thematic panels** (Task 5). The purpose of these panels is to provide the Commission services with feedback on current and proposed policy initiatives.

Horizontal reports	
National specialisation and innovation performance	Fabio Montobbio (KITes) and Kay Mitusch (KIT-IWW)
Organisational innovation in services	Luis Rubalcaba (Alcala) and Christiane Hipp (BTU-Cottbus)
Emerging lead markets	Bernhard Dachs (AIT) and Hannes Toivanen (VTT)
Potential of eco-innovation	Carlos Montalvo and Fernando Diaz-Lopez (TNO)
High-growth companies	Kay Mitusch (KIT-IWW)

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Executive Summary

The Space and Aeronautics Sectors are high tech manufacturing sectors. Between Space and Aeronautics Sectors are linkages and parallels. All major systems assemblers are active in both sectors. Examples are EADS but also Boeing, BAE Systems and manufacturers of propulsion systems and other components (e.g. the SAFRAN group). Safety regulation and high performance criteria are crucial for commercial success in both sub-sectors with reliability of equipment being a key factor. The military and defence technology play an important role for innovation in both sub-sectors. There are however also differences. The European Space Sector is internationally structured, but with a main focus in Europe, while the Aeronautics Sector is increasingly globally oriented. In the Space sector national procurement and institutional structures heavily influence the Space markets, but in civilian Aeronautics the share of institutional customers is much smaller. Moreover, the Aeronautics Sector is characterized by a small number of very large firms, a large number of medium-sized companies and a very large number of small companies. The Space Sector is also dominated by a few very large firms, but has a smaller number of SMEs and a large number of small space units within large companies.

Innovation in the Aeronautics and Space Sectors is influenced by trends in the markets and clients that are served. The importance of defence was already mentioned. The turnover changes with political and military tensions. At the same time, at least in some countries, a decrease of defence budgets stimulates more efficient innovation, including the development of dual use technologies (used for both defence and civil applications). In Aeronautics, market trends have included the liberalisation of aviation markets and the privatisation of airlines. Low cost airlines and regional airports have become more important. At the same time, globalisation (e.g. in business and tourism) and emerging economies have increased demand for long distance travel. In Space, the main market trend is that science, defence and governmental applications are now complemented by ever more (downstream) applications that address societal challenges and/or that serve civil markets. Examples are the use of Global Positioning Systems (GPS) for transport and entertainment applications, the use of Earth Observation (EO) to increase efficiency in agricultural and energy sector, the use of satellite transmission for a broad range of telecom and media services. The societal demand - and political pressure - for energy efficient solutions is relevant for Aeronautics and Space, for manufacturing and for downstream markets.

To further introduce the Space and Aeronautics Sectors, it must be mentioned that a number of manufacturing firms also provides services. More than 30% of the firms have introduced a new service. Rolls-Royce has become a well known case study on how maintenance and leasing of goods can lead to services innovation, e.g. using sensors in engines to increase efficiency of maintenance. If manufacturing firms are not active in services, the innovation trajectories for goods and services can still be entangled. The European Galileo network for navigation and positioning is developed (and launched and operated) in coordination with the development of new applications in downstream markets.

In both Space and Aeronautics, the innovation process can involve firms from upstream and downstream markets (and sectors). Examples are defence, automobile, ICT equipment, airports and air traffic systems. Relevant technologies can also come from different sectors and disciplines, e.g. nanotechnology and ICT equipment.

Innovation in the Space and Aeronautics Sectors has been addressed in various studies and policy documents, also in the context of the European INNOVA programme. This study (and this summary) contains a number of updates, insights and details. Given the long term innovation trajectories and life cycles in the sectors, the main innovation issues were already introduced in previous studies. For example, cost efficiency has always been a driver for innovation towards larger aircrafts with more passengers and cargo (both in regional aircrafts and in very large aircrafts). Cost efficiency is also driving energy/fuel efficiency. Fuel prices fluctuate with the long term trend being upwards. To carry fuel also implies weight and space. With environmental concerns and energy efficiency becoming more important, cost efficiency is no longer the only reason to innovate in energy/fuel efficiency and to explore alternative energy sources. Firms want to be green and governments want to stimulate green innovations. Other examples of (persistent) innovation issues - in Aeronautics and Space - are safety, security, and changes in the innovation process due to consolidation of the sector and the (new) roles of the main integrators/assemblers and specialised suppliers of subsystems and components. In Space, innovation issues are still in defence and institutional markets (e.g. Earth Observation) and in new applications for civil markets (e.g. digital broadcasting, telecom and navigation). Relatively recent innovations are micro satellites and commercial space travel.

Two main statistical sources for this study are the Community Innovation survey (CIS) from Eurostat and the AeroSpace and Defence Industries Association of Europe (ASD). CIS does not differentiate between Aeronautics and Space, which implies that CIS figures mainly provide indications for Aeronautics, since this sector makes up 94% of ‘the’ aerospace sector. Furthermore, recent CIS data on the sector does not include data from two key countries: the United Kingdom and Germany. ASD data is more comprehensive, but follow different definitions and methodology. This makes it difficult to compare data and to analyse the sector in more detail.

The Space and Aeronautics Sectors continue to be very innovative. 85% of the firms is engaged in intramural R&D. Total R&D expenditures are between 21% and 11% of total turnover (depending on the countries include in the sample), which is between six and three times higher than the average of all manufacturing firms. More than 50% of the firms introduce new products, services and/or processes. Training is a source of innovation for more than 70% of the firms (this figure is 49% for all manufacturing sectors). Another important source of innovation is acquisition of machinery. The R&D intensity of the sectors fits the picture of long term investments with spillovers to other sectors.

The Space and Aeronautics Sectors make up around 2% of added value and employment of all manufacturing sectors, but the relevance is broader. In addition to spillovers, it can be mentioned that defence is not just an economic matter and that Space (e.g. satellites) serves regions where other infrastructures are not available (e.g. oceans and remote areas). The relative importance of defence and civil markets fluctuates, and is different for Aeronautics and Space. In Aeronautics, defence/military markets make up around 40% of total turnover. In Space, defence/military markets are part of the broader category of institutional/public markets. This market is between 55 and 60% of total space revenues.

R&D and innovation activities also materialise into revenues from new products. In 2004, 14% of turnover came from new or improved products that were introduced during 2002-2004 that were new to the market. This percentage is slightly higher than for all manufacturing firms. A possible explanation is that the short term, market impact of innovation in Space and Aeronautics is only part of the total impact. As mentioned above, the technology trajectories and life cycles are long. A three year time lag - that is used in CIS - is probably too short to capture the impact of space and aeronautics innovations.

Within Europe, there are clear differences between countries and between regions. Three countries - the United Kingdom, France and Germany - provide for around 80% of the sectors' added value. Reasons include scale advantages, the (tacit) knowledge that is required, collaboration in clusters, government support, linked to defence and to public research institutes.

Five more countries play a substantial role in specific parts of the Space and Aeronautics Sectors: Italy, Spain, Sweden, Belgium and the Netherlands. In addition, Austria, Poland, Czech Republic and Hungary can be mentioned. The concentration in three countries is reflected in the export figures. 56% of turnover is export, e.g. the sales of Airbus aircrafts to a wide range of countries, and the sales of components to large assemblers in the UK, France and Germany.

Differences between parts of Europe are difficult to comment on. As mentioned above, two key countries are missing in the latest CIS data (e.g. due to confidentiality concerns). Still, a general picture emerges that firms in the West and North of Europe are more innovative than countries in Southern Europe and - especially - in Central and Eastern Europe (including the New Member States). Still, compared to other sectors, the differences are modest, as are the differences between small, medium and large firms. The Space and Aeronautics Sectors can be rightfully labelled high tech sectors.

International competition in Aeronautics (manufacturing) is changing only slowly, with the US and Europe being the largest players. US government and US-based firms invest more in R&D than their European colleagues. This is also reflected in patents, the main mechanism to secure Intellectual Property Rights in the Aeronautics Sector (in Space secrecy is often used). For many years, US-based firms and research organisations have been filing more patents than their European peers. In addition to the US and Europe, Canada and Japan continue to invest in aeronautics innovation (e.g. Bombardier from Canada and Mitsubishi from Japan). The investments and market shares of firms from the BRIC countries are increasing, but from a low starting point. Global collaboration is getting more important. Examples are trading of technologies and patents between the US, Europe and

China, global sourcing networks and Airbus and Boeing having established production facilities in China.

A similar picture emerges for Space, although with less international collaboration than in Aeronautics. NASA continues to drive space innovation in the US. China and other countries increase investments in space. China now has the financial means to accelerate space programmes. The Russian GLONASS GPS system is being restored. The Indian Space Research Organisation (ISRO) is developing and operating new satellites for earth observation, navigation and telecommunications.

International collaboration within Europe is well above the average of all manufacturing sectors. 76% of firms in the Space and Aeronautics Sectors cooperate with international partners, from inside or outside their own enterprise group. As mentioned above, the international structure of the sectors is also reflected in high export figures. Cooperation involves firms but also research organisations. 22% of firms cooperate with international universities, government or research institutes. Depending on the country sample, the figure for all manufacturing sectors is around 9%.

International collaboration appears to have been stimulated by European research programmes such as the programmes by the European Defence Agency (EDA), the European Space Agency (ESA) and the Framework Programmes (e.g. FP5 and FP6). 58% of the firms in the Space and Aeronautics Sectors receive European funding. This percentage is higher than for national funding (50%) and local and regional government (34%). Also in categories such as small firms and/or firms from Central and East Europe, more than 50% of the firms receive public funding. The importance of public funding is in line with the general notion of high tech sectors with long term investments, with uncertain outcomes and spillovers to other sectors.

With respect to international or European cooperation, the European Technology Platforms and Joint Technology Initiatives (JTIs) can be mentioned. For example, Clean Sky is one of the largest JTIs. From the perspective of government, public funding for innovation serves to increase firms' incentives to innovate, but also steers innovation in certain directions. Energy efficiency is one of the priorities. In addition to Clean Sky, we can also mention SESAR (pan-European air traffic management) and space innovations in Earth Observation (e.g. to prevent environmental degradation) and navigation (e.g. for traffic management).

The R&D intensity of the sectors is mirrored in the composition of the work force. Surveys by the industry association (ASD) indicate that 35% of the jobs in Aeronautics are high skilled jobs, including graduates, engineers and managers. In the Space Sector, 53% of the employees have at least a master's degree. An analysis in the UK revealed that the present workforce is ageing. In combination with rapid innovation in the sector, this poses challenges in terms of volume and skills of new staff, e.g. professional (experiences) engineers, craft, management, software, systems design, modelling, and the interface between emerging technologies and regulatory requirements (e.g. fuel efficiency, safety and emissions).

A number of policy issues has been touched upon above. Public funding is highly relevant and fits the characteristics of the sectors. It may require public support to trigger incremental and - especially - radical innovation. Policy makers could also continue initiatives to address international competition and collaboration, skills, and the specific situation of SMEs and the different regions in Europe. As mentioned above, public funding can also steer innovation programmes towards environmental challenges. Considerations related to defence and non-dependence of Europe will continue to be relevant. For both Aeronautics and Space, growth could come from civil markets, e.g. systems and applications for Galileo. Especially in these markets, a broad range of policies is relevant. This includes R&D and innovation policy, to SME and entrepreneurship policies, and regulation of markets and products, e.g. regulation related to safety, security, environmental and liability.

1. Introduction

The Space and Aeronautics Sectors qualify as high-technology sectors (e.g. Hollanders et al., 2008). The sectors belong to the most innovative sectors in Europe. This section will start with a brief characterisation of innovation within the Space and Aeronautics Sectors, taking into account the two sectors Space and Aeronautics and stressing current developments related to innovation. A general classification of the sectors, their function to other sectors and the economy, emerging trends, key technologies and challenges will be discussed.

1.1 Statistical definition of the sectors

The Space and Aeronautics Sectors are statistically represented by NACE 35.3 (Rev 1.1), which includes the manufacture of aircrafts and spacecraft. Table 1.1 presents the statistical definition of the sectors according to NACE and Eurostat.

Table 1.1 Statistical definition of the space and aeronautics sectors

NACE (Rev 1.1)		**Included**	**Not included**
D	Manufacturing		
D 35	Manufacture of other transport equipment		
D 35.3	Manufacture of aircraft and spacecraft	Manufacture of: – Aeroplanes for the transport of goods or passengers, for use by the defence forces, for sport or other purposes – Helicopters – Gliders, hang-glides – Dirigibles and balloons – Spacecraft and spacecraft launch vehicles, satellites, planetary probes, orbital stations, shuttles – Parts and accessories of the aircraft of this class: • major assemblies such as fuselages, wings, doors, control surfaces, landing gear, fuel tanks, nacelles, etc. • airscrews, helicopter rotors and propelled rotor blades • motors and engines of a kind typically found on aircraft • parts of turbojets and turbopropellers – Aircraft launching gear, deck arresters, etc. – Ground flying trainers	Manufacture of: - Parachutes - Military ballistic missiles - Ignition parts and other electrical parts for internal combustion engines - Instruments used on aircraft - Air navigation systems

Source:ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=ACT_OTH_CLS_DLD&StrNom=NACE_1_1&StrFormat=HTML&StrLanguageCode=EN

The activities not included (see Table 1.1) in the statistical definition of the sectors, but nevertheless relevant for the sectors, show the strong linkages between the Space and Aeronautics Sectors and other sectors, in particular the Electrical and Optical Equipment Sector (e.g. in relation to instruments and electrical parts). Although NACE separates some activities from the Space an Aeronautics Sectors, these activities are often included in the data and studies presented by the industry itself.

Statistically, the Space and Aeronautics Sectors are treated as a whole, but there are good reasons to analyse the sectors separately. For example, the European Space Sector is internationally structured, but with a main focus on Europe, while the Aeronautics Sector is increasingly globally oriented. In the Space Sector national procurement and institutional structures heavily influence the Space markets. In Aeronautics, the share of institutional customers is much smaller. Moreover, the Aeronautics Sector is characterised by a small number of very large firms, a large number of medium-sized companies and a very large number of small companies. The Space Sector is also dominated by a few very large firms, but has a very small number of SMEs and a large number of small space units within larger companies. Despite these differences, both sectors are also heavily interlinked. All major European system assemblers are active in both sectors and both sectors went through a consolidation process in the past 10 to 20 years. Both sectors are high-tech sectors characterised by very long technology and development times. Safety regulation and high performance criteria are crucial for commercial success in both sectors with reliability of equipment being a key-factor. Military and defence technology and requirements play an important role for innovation in both sectors. While performance improvement and reliability (reliable, but also faster, bigger, better) is a main driver in civil and military markets, the commercial markets for Space and Aeronautics are increasingly driven by societal challenges from the environment and climate change.

This report presents the analysis of the innovation performance and innovation system characteristics of the Space and Aeronautics Sectors. As much as possible, both sectors will be discussed separately, but commonalities between both sectors will be addresses as well. Where relevant, linkages with developments in other sectors will be taken into account as well.

1.2 Main characteristics of the sectors

The Space and Aeronautics Sectors (NACE 35.3) consisted of 2,312 companies in EU-27 in 2006, generating a turnover of EUR 89.1 billion. In 2006, the sectors realised EUR 29.96 billion of value added, which represents a share of 1.75% of the total value added of all manufacturing sectors. The sectors counted 382,200 employees, which is a share of 1.18% of the total employment in all manufacturing sectors (Eurostat, 2009a). The share of the sectors' employment and also value added in all manufacturing sectors is unevenly distributed in EU Member States, with much higher shares EU Member States as the United Kingdom, France and Germany (see also table 1.2). The apparent labour productivity in 2006 amounted to EUR 78,000, which is one and a half time as high as for the manufacturing sector in total (EUR 49,700).

Looking at the two sectors, Space and Aeronautics, data from the AeroSpace and Defence Industries Association of Europe (ASD) show that in 2008 the Aeronautics Sector was responsible for 92.9% of the turnover, while the Space Sector contributed 7.1%. Also in terms of employment, the Space Sector represented about 6.8%, while the Aeronautics Sector employed 93.2% (ASD, 2009).

The Space and Aeronautics Sectors are dominated by three countries: United Kingdom, France and Germany. These three countries have the largest number of aerospace enterprises and are home to the largest aerospace companies. Moreover, they have a long history in aerospace research with large and important aerospace research institutes and substantial public civil and military funding for aerospace programmes. The United Kingdom represents 33% of the sector's value added in EU-27, followed by France (25.3%) and Germany (21.5%). At substantial distance follow Italy (8.2%), Spain (3.7%), Sweden (2.1%), Belgium (1.5%) and the Netherlands (1.2%). All other Member States have a substantial smaller share in the sectors' value added. Also in terms of employment, the United Kingdom leads. In the United Kingdom, France and Germany the Space and Aeronautics Sectors contribute to the non-financial business economy more than the EU-27 average. Although Sweden represents only 2% of the EU-27 sectors' value added and employment, this country is rather specialised with regard to employment in the sectors (see table 1.2). The dominance of a few countries in the sectors has been very stable over the past years, although the internal rankings can differ. For example, in 2004 Germany had a higher share of EU-27 value added than France (22.2% and 18.5% respectively), while in 2006 France performed better than Germany (Eurostat, 2009a). Table 1.2 presents the main results for several Member States in 2006.

The Space and Aeronautics Sectors are relatively R&D-intensive. There is no total amount of R&D expenditures for EU-27, but Table 1.2 presents some data for the countries dominating the sectors in terms of value added and employment. Five countries representing 85.6% of the sectors' value added in EU-27 spent EUR 6.7 billion on R&D in 2006. Especially in the two most specialised EU-27 Member States, United Kingdom and France, the sectors contributed significantly to the R&D of all manufacturing sectors (see Table 1.2).

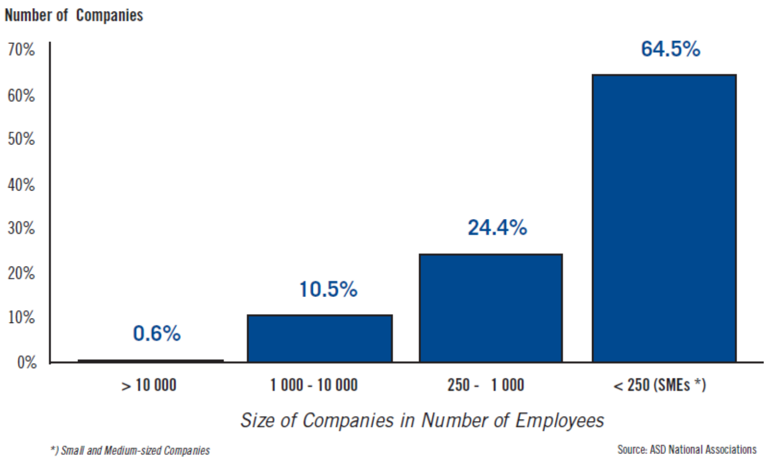
Table 1.2 Dominance of Member States in Space and Aeronautics Sectors, 2006

Country	Share of EU-27 sector value added (%)	Share of EU-27 sector employment (%)	Value added specialisation ratio (EU-27 = 100)[1)]	Employment specialisation ratio EU-27 = 100)[1)]	R&D expenditure (EUR million)	Share of manufacturing R&D Expenditure (%)
United Kingdom	33%	26.1%	173.7%	190.7%	1752.1	23.3%
France	25.3%	24.3%	179.5%	214.8%	2458.1	16.5%
Germany	21.5%	20.2%	105.2%	121.7%	1853.7	4%
Italy	8.2%	8.75%	73.4%	74.8%	n.a.	n.a.
Spain	3.7%	4.1%	38.6%	38.2%	416.6	12.4%
Sweden	2.1%	2.5%	74.9%	120.3%	255.9	3.9%
Belgium	1.5%	1.6%	56.5%	85.9%	n.a.	n.a.
The Netherlands	1.2%	1.3%	25.3%	34.1%	n.a.	n.a.

Source: Calculations based on Eurostat Structural Business Statistics Note: 1) Relative specialisation ratio is the country's share of Space and Aeronautics in its non-financial business economy in value added or employment divided by the same ration for EU-27, values above 100% indicating a relative specialisation in relation to EU-27 average.

While the Aeronautics Sector is characterised by a small number of very large firms and a large number of small firms, the Space Sector has fewer SMES, but a large number of small space units within larger firms. Figure 1.1 presents the structure of the sectors in 2007.

Figure 1.1 Structure of the European Space and Aeronautics Sectors in 2007

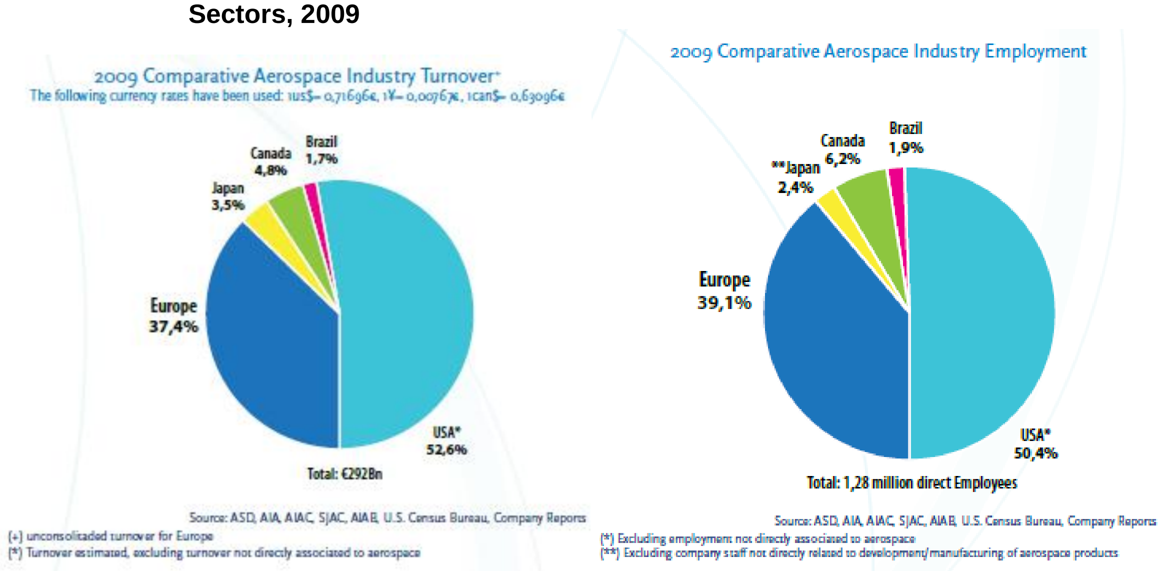


Source: ASD (2008)

The Space and Aeronautics Sectors are essentially assembly industries, relying on external suppliers of goods and services in manufacturing air- and spacecrafts. When looking at intermediate consumption as a percentage of production value, it is clear that the sectors depend on 2nd and 3rd tier suppliers. In the United Kingdom, France, and Germany, between 60% and 70% of the production value comes from intermediate consumption. In Belgium this share amounts even to almost 100%, while in Spain 78% of the production value comes from intermediate consumption (Eurostat, 2009b).

The Space and Aeronautics Sectors are still highly concentrated in the EU and the United States. Figure 1.2 gives an indication of the comparative industry turnover and employment for Space & Aeronautics as calculated by ASD (2010). Although the current Space and Aeronautics Sectors are mainly concentrated in Europe and the US, other important countries in the sectors include Japan, Canada and the emerging BRIC countries (Brazil, Russia, India and China). In 2009, Japan had a turnover of EUR 10,220 million, employing 30,700 people and Canadian aerospace firms realised a turnover of EUR 14,016 million with 79,360 employees (ASD, 2010).

Figure 1.2 Comparative Industry turnover and employment in the Space and Aeronautics Sectors, 2009



Source: ASD (2010)

The Brazilian aeronautics companies realised a turnover of EUR 4,964 million in 2009, with 24,320 employees (ASD, 2010). The Brazilian aeronautics industry is dominated by Embraer and its suppliers. Embraer ranks fourth in the ranking of top-performing companies in the Space and Aeronautics Sectors (Aviation Week, 2009). Embraer is especially strong in regional aircrafts and has 45% of the market for regional aircrafts with 30 to 60 seats (AIAB, 2009).

Public data about the size of the Russian Space and Aeronautics Sectors are not available. In 2007, the market share of Russia in the worldwide Aeronautics Sector is estimated at less than 1%. The Russian aeronautics industry is transforming from a weak, fragmented industry to a strong competitor for US and the EU. In 2005, the Russian industry produced only 10 civil airplanes per year, while the demand for air traffic is growing substantial. In 2006, the Russian government started a consolidation process leading to the creation of United Aircraft Corporation (UAC). UAC wants to be the world's third largest aircraft manufacturer by 2015. UAC and belonging Russian aeronautics companies like Sukhoi sign cooperation agreements with Western aeronautics companies for design, manufacturing and sales and marketing. Moreover, Russian companies are increasingly supplying materials, parts and engineering services for Western commercial aircraft and engine manufacturers and Western companies are opening design centres in Russia (Office of Aerospace and Automotive Industries, 2008). The first new Russian commercial aircraft is Sukhoi's SuperJet-100, a regional aircraft with 75 to 96 seats. Some 40 global companies from Thales to Goodrich to Boeing are contributing parts to the aircraft and Italy's Alenia owns a 25% stake in the project (Financial Times, 14 July 2008). Russia is an established space power and after the challenging period in the 1990, it started to rebuild its space capabilities. Russia plans to invest heavily in the space industry, tries to limit foreign investments and continues to consolidate the space industry (Rathgeber, 2009).

For India, public data on the size of the Space and Aeronautics Sectors are lacking as well. The Indian aerospace industry has historically been dominated by government controlled enterprises, with the most prominent Hindustan Aeronautics Limited (HAL). Since 2001, domestic and foreign private investments have been allowed, followed by further liberalisation of the market in 2008, stimulating new players to enter the sector. The industry is growing rapidly, driven by the strong increase in demand for air traffic. India is positioning itself as a manufacturing hub, a preferred destination for manufacturing components. Western aeronautics companies are opening research, design and manufacturing centres in India and they are entering agreements with Indian companies and R&D centres. The Indian government uses offset policy to make sure that Indian procurement of aircrafts from foreign suppliers is partly compensated with foreign investments and outsourcing to the Indian aerospace industry (PricewaterhouseCoopers, 2009). India aims to develop into a major space player as well. The space programmes focus on space applications for civil and military every day uses (e.g. telecommunication), but new priorities are now on space exploration and commercially attractive space activities (Rathgeber, 2009). The Indian Space Research Organisation (ISRO) is developing and operating new satellites for earth observation, navigation and telecommunications.

National statistics about the Chinese Space and Aeronautics Sectors are not available in the present annual Statistical Yearbook of the National Bureau of Statistics in China. The Chine Aerospace industry consists of about 200 firms, which belong to the state-owned Aviation Industry Corporation of China (AVIC). Between 1999 and 2008 AVIC I and II existed. AVIC I focused on large- and medium-sized aircrafts, leasing and general aviation aircraft, while AVIC II produced small aircrafts and helicopters. In 2008, both companies merged again to improve efficiency and being able to compete at global level. In 2008, AVIC had about 400,000 employees. In 2006, the China's Aerospace industry created a value added of USD 3,300 million and spent USD 420 million on R&D (Hollanders et al., 2008). After several decades of knowledge transfer from Western manufacturers to Chinese suppliers, China is investing heavily in its aeronautics industry to become a competitor in the worldwide market and to address the strong growth in domestic demand for air traffic. China focuses on the regional aircrafts market as well as the large civil aircrafts. Also in Space, China is investing heavily to accelerate space programmes, not only for human spaceflights, but also for satellite systems and applications. China is also collaborating internationally, in particular with emerging economies and the African continent. The industrial base is undergoing a restructuring process and China plans to create a new centre for aerospace industry in the city of Shenzhen (Rathgeber, 2009)

In order to sell aircrafts to China, Western companies use offset agreements, which arrange that some part of the production is outsourced to Chinese subcontractors. These offset arrangements are a prerequisite to sell aircrafts to China, but it allows for producing components at relatively low costs as well. For example, Airbus has established a joint-venture and opened an assembling line in China to assembly A319s and A320s for Chinese and Western customers. Nevertheless, the collaborations and offset agreements have also resulted in substantial technology transfer, supporting China to become an important competitor. Western companies are becoming aware that in the future they will face competition from Chinese manufacturers when they seek to expand their share of the global aircraft market. MacPherson (2009) predicts that this will happen mid 2020s. Despite this threat, major Western aircraft manufacturers identify China as the single most important market for aircrafts in the coming 20 years, as well as a huge pool of highly skilled engineers. They acquire parts from China, open up research, design and engineering centres in China, and co-partner with Chinese manufacturers to co-produce aircrafts in China. Western companies like Airbus are convinced that their continuous efforts to innovate and focus on technological leadership will help them to compete and protect their intellectual property (Perett in Aviation Week, 2009; Financial Times, 14 July 2008; Office of Aerospace and Automotive Industries, 2008; Council on Foreign Relations, 2007).

2 Innovation performance

2.1 Innovation performance of the sectors as revealed by CIS-4 survey results

The sketch of the innovation performance of the Space and Aeronautics Sectors is based on non-anonymous results of the CIS4 survey. The non-anonymous CIS4 database includes data for 20 European countries. Some countries which are rather relevant for the Space and Aeronautics Sectors are missing in the database, including for example the United Kingdom, Germany, the Netherlands and Belgium. For confidentiality reasons, it was not possible to break-down the Space and Aeronautics Sectors in the separate sectors Space and Aeronautics. As the Space Sector is only representing about 7% of the Space and Aeronautics Sectors in terms of employment and turnover, the CIS4 survey data will likely say more about the Aeronautics Sector than the Space Sector. Section 2.2 presents data on these sectors using other sources than CIS4.

2.1.1 General innovation activity

Table 2.1 presents some general indicators describing the innovation activity in the Space and Aeronautics Sectors. The data reveal that the Space and Aeronautics Sectors are rather innovative. About 50% of the companies are engaged in any innovation activity (introducing a new product, process or service on the market). The sectors are also very R&D intensive when compared with the average for all manufacturing sectors. Almost 85% of the companies are engaged in intramural (in-house) R&D, compared to about 22% for the average of all manufacturing sectors. Companies in the Space and Aeronautics Sectors also spend a substantial larger share of their turnover on R&D: 20.9% in 2004 compared to only 3.7% for the average of all manufacturing sectors. Aerospace companies do not only invest relatively large amounts in R&D, but they are also very active in providing training: almost three quarter of the firms arranges training for their employees, compared to almost half of the companies on average for all manufacturing sectors.

Aerospace companies are also more than average engaged in the market introduction of innovations (43.4% compared to 33.6%). Almost 40% introduced a new or significantly improved product and 30.6% introduced a new or significantly new service. Also new or significantly improved production methods are introduced, by almost 35% of the Aerospace companies. Over 40% of the Aerospace companies are engaged in activities (e.g. market research and launch advertising) for the introduction of the new products and services.

The Aerospace companies in the country group ‘West and North’ are the most active in carrying out intramural R&D; 89.1% of the companies are engaged in intramural R&D, closely followed by the companies in country group ‘South’ with 84.1%. In the country group ‘Central and East’ somewhat less companies are engaged in intramural R&D (70%). While the level of engagement in intramural R&D is almost the same for companies in ‘West and North’ and ‘South’, the Aerospace companies in the country group ‘South’ spend twice as much on R&D (30.1% of the turnover compared to 16 and 17.1%

of the turnover). The companies in country group ‘South’ are also more engaged in the acquisition of machinery than companies in the other groups (85.4% compared to 78.1% for ‘West and North’ and 57.9% for ‘Central and East’).Training of employees is especially present in country group ‘North and West’; 80.9% of the companies are engaged in training, compared to 66.3% of the companies in ‘South’ and 50.4% in ‘Central and East’.

While the companies in the country group ‘Central and East’ realise about the same level of market introductions of new or significantly improved products, these companies really lag behind with regard to the introduction of new services and production methods; 13.1% and 14.2% compared to respectively 40.3% and 37% for the companies in the country group ‘West and North’. The gap between the market introduction performance of the companies in the country groups ‘West and North’ and ‘South’ is much smaller, except for the introduction of new services. In introducing new services, the companies in the country group ‘West and North’ perform much better than companies in the country group ‘South’ (40.3% compared to 25%).

On average, almost 11% of the companies in the Aerospace Sector export. There is a big difference in exporting between the three country groups. Companies located in the country group ‘West and North’ hardly export, while more than 50% of the companies located in ‘Central and East’ export their good and services to another country. The data present a somewhat distorted picture here, as some European countries with prime manufacturers (and which export complete aircrafts) are not included. The substantial export activities of companies in ‘Central en East’ support the indication that manufacturing of components and sub-systems is increasingly done by suppliers in this area.

Table 2.1 General innovation activity in the space and aeronautics sectors, per country group

	Country group					
Indicator	**West and North[1)]**	**Central and East[2)]**	**South[3)]**	**Country group Aerospace AVG[4)]**	**Total AVG[5)]**	**GAP[6)]**
General innovation activity (introducing new product, service or process)	51.1%	45.6%	52.4%	50.6%	n/a	n/a
Introduced onto the market a new or significantly improved good	40.5%	35.1%	36.8%	38.4%	n/a	n/a
Introduced onto the market a new or significantly improved service	40.3%	13.1%	25.0%	30.6%	n/a	n/a
Introduced onto the market a new or significantly improved method of production	37.0%	14.2%	41.8%	34.6%	n/a	n/a
Engagement in intramural R&D	89.1%	70.0%	84.1%	84.5%	21.5%	393%
Total R&D expenditure / Total turnover in 2004	16.0%	17.1%	30.1%	20.9%	3.7%	559.5%
Engagement in training	80.9%	50.4%	66.3%	71.3%	48.6%	146.7%
Engagement in activities for the market introduction of innovation	45.9%	41.3%	40.6%	43.4%	33.6%	129.2%
Engagement in acquisition of machinery	78.1%	57.9%	85.4%	77.4%	75.8%	102.1%
Export (EU or outside EU)	1.1%	56.0%	4.9%	10.9%	n/a	n/a

Notes: 1) Country group 'West and North' includes Sweden, Norway, Denmark, Luxembourg and France; 2) Country group 'Central and East' includes Czech Republic, Hungary, Romania, Bulgaria, Estonia, Latvia, Lithuania, Slovak Republic and Slovenia; 3) Country group 'South' includes Spain, Portugal, Greece and Italy; 4) Weighted average for the total Space and Aeronautics Sectors, based on weighted frequencies for the three country groups; 5) Average for all manufacturing sectors, based on a Core NACE including all countries in the sample; 6) Gap as % of the total AVG, calculated as Aerospace AVG / Total AVG.
Source: Eurostat CIS 4

When considering the size of the companies in the Space and Aeronautics Sectors, Table 2.2 shows that large firms are the most active in R&D. Almost 90% of the large firms engage in intramural R&D, compared to 75.6% of the small firms and 87.7% of the medium sized companies. Medium sized firms active in intramural R&D are the most R&D intensive; they spend the largest share of their turnover on R&D (28.9%). Large firms spend 20% of their turnover on R&D, while small firms spend 16.3%. Large companies are more heavily engaged in training and in the acquisition of machinery than small and medium sized firms (13 to 14 percentage points more). Although the medium sized firms are the most R&D intensive, this does not result in more innovation activity than for the other firm sizes. Moreover, the small firms are almost equally active in introducing innovations on the market, while they are substantially less active in intramural R&D than the medium sized firms.

When looking into more detail, large firms are driving the introduction of new products, services and production methods on the market. Twice as much than companies in the other categories large companies introduced a new product or service on the market. Moreover, large firms introduced new production methods three times more than small and medium sized companies. The medium sized companies are more active in selling their products and services outside their home country; twice as much as small and large companies. Combined with their high R&D-intensity, this could indicate that medium sized firms are often highly specialised suppliers at the tier 1 or 2 level, producing components for the sub-system integrators.

Table 2.2 General innovation activity in the space and aeronautics sectors, per firm size

	Firm size group					
Indicator	**Small**	**Medium**	**Large**	**Firm size Aerospace AVG[1)]**	**Total AVG**	**GAP**
General innovation activity (introducing new product, service or process)	35.8%	43.1%	89.3%	58.3%	n/a	n/a
Introduced onto the market a new or significantly improved good	28.0%	32.9%	65.2%	43.6%	n/a	n/a
Introduced onto the market a new or significantly improved service	19.4%	27.3%	57.7%	37.0%	n/a	n/a
Introduced onto the market a new or significantly improved method of production	21.5%	27.1%	70.7%	41.6%	n/a	n/a
Engagement in intramural R&D	75.6%	87.7%	89.9%	84.5%	21.5%	393%
Total R&D expenditure / Total turnover in 2004	16.3%	28.9%	20.0%	20.9%	3.7%	564.9%
Engagement in training	65.8%	65.3%	79.6%	71.5%	48.6%	147.1%
Engagement in activities for the market introduction of innovation	46.4%	36.1%	45.4%	43.5%	33.6%	129.5%
Engagement in acquisition of machinery	73.4%	71.6%	84.6%	77.6%	75.8%	102.4%
Export (EU or outside EU)	8.4%	19.3%	8.2%	10,9%	n/a	n/a

Note: 1) Weighted average for the total Space and Aeronautics Sectors, based on weighted frequencies for the three firm size categories
Source: Eurostat CIS 4

2.1.2 Introduction of new products

As mentioned before, the CIS4 data mainly say something about the Aeronautics Sector and not so much about Space. Two-third of the companies in the Space and Aeronautics Sectors introduced a product that was new to the market (Table 2.3). This is substantially higher than in average for all manufacturing sectors (62.2% compared to 11.2%). The intensity of introducing products that were new to the market was almost equal in the three country groups. However, 88.3% of the Aerospace companies in the country group ‘Central and East’ introduced products that were new to the firm, which is almost twice as much as the companies in the other two country groups. In addition, firms in ‘Central and East’ realised more turnover from products new to the firm (23.75%) than from new to the market (6.9%). Combined with the previous analysis that these firms introduced more new products than new processes and services, this could indicate that firms in the ‘Central and East’ countries are mainly catching up by adopting and copying industry-wide innovations.

Despite the rather high level of new product introductions, most of the turnover is still realised by unchanged or marginally modified products. In the country group ‘West and North’ 80.5% of the turnover was realised by existing products, while only 6% came from products that were new to the firm and 13.5% came from products that were new to the market. For companies in the country group

'South', the new products contribute a bit more to the total turnover; 13.3% of the turnover was realised by products new to the firm, while 17.4% came from products that are new to the market. A possible explanation is that the short term, market impact of innovation space and aeronautics is only part of the total impact. As mentioned above, the technology trajectories and life cycles are long. A three year time lag, which is used in CIS4, is probably too short to capture the impact of space and aeronautics innovations. Table 2.3 presents the findings for the various country groups.

Table 2.3 Introduction of new products in the Space and Aeronautics Sectors, per country group

	Country group					
	West and North[1)]	**Central and East[2)]**	**South[3)]**	**Country group Aerospace AVG[4)]**	**Total AVG[5)]**	**GAP[6)]**
Did the enterprise introduce a product new to the market	62.8%	64.9%	60.0%	62.2%	11.2%	555.4%
Did the enterprise introduce a product new to the firm	46.7%	88.3%	48.7%	53.8%	12.5%	430.4%
% of turnover in new or improved products introduced during 2002-2004 that were new to the market	13.5%	6.9%	17.4%	13.8%	11.2%	123.2%
% of turnover in unchanged or marginally modified products during 2002-2004 that were new to the firm	6.0%	23.7%	13.3%	11.2%	12.5%	89.6%
% of turnover in unchanged or marginally modified products during 2002-2004	80,5%	50,3%	57,3%	68,0%	72,9%	93.3%

Notes: 1) Country group 'West and North' includes Sweden, Norway, Denmark, Luxembourg and France; 2) Country group 'Central and East' includes Czech Republic, Hungary, Romania, Bulgaria, Estonia, Latvia, Lithuania, Slovak Republic and Slovenia; 3) Country group 'South' includes Spain, Portugal, Greece and Italy; 4) Weighted average for the total Space and Aeronautics Sectors, based on weighted frequencies for the three country groups; 5) Average for all manufacturing sectors, based on a Core NACE including all countries in the sample; 6) Gap as % of the total AVG, calculated as Aerospace AVG / Total AVG. Source: Eurostat CIS 4

When considering the size of the companies, almost an equal share of small, medium and large firms introduced a product which is new to the market (59.6 to 64.2%). Nevertheless, a larger share of small firms introduced a product new to the firm (66.9%), compared to medium sized firms (38.3%) and large firms (49.1%). All firm sizes realised most of their turnover by existing products; large firms a bit more than small firms (72.6% compared to 60.9%). As a relatively larger share of small firms introduced a product that is new to the firm, this size category also realises more turnover from this type of products (18.2% compared to 7.5% and 7.7% for medium and large firms). The share of turnover coming from products that are new to the market is almost equal for the three different size categories. Table 2.4 present the finding for the various firm size categories.

Table 2.4 Introduction of new products in the space and aeronautics sectors, per firm size

	Firm size					
	Small	**Medium**	**Large**	**Firm size Aerospace AVG** [1)]	**Total AVG**	**GAP**
Did the enterprise introduce a product new to the market	59,6%	62,1%	64,2%	62,2%	11,2%	466.1%
Did the enterprise introduce a product new to the firm	66,9%	38,3%	49,1%	52,5%	12,5%	420%
% of turnover in new or improved products introduced during 2002-2004 that were new to the market	12,7%	14,5%	14,3%	13,8%	11,2%	123.2%
% of turnover in unchanged or marginally modified products during 2002-2004 that were new to the firm	18,2%	7,5%	7,7%	11,2%	12,5%	89.6%
% of turnover in unchanged or marginally modified products during 2002-2004	60,9%	69,9%	72,6%	68,0%	72,9%	93.3%

Note: 1) Weighted average for the total Space and Aeronautics Sectors, based on weighted frequencies for the three firm size categories
Source: Eurostat CIS 4

2.1.3 Intellectual property rights

In general, 38.2% of the companies in the Space and Aeronautics Sectors secure their intellectual property rights; their efforts in securing intellectual property rights are much stronger than on average for all manufacturing sectors (see Table 2.5). Especially in applying for a patent, Aerospace companies are more active than on average. Although the CIS4 data indicate a high patent activity for aerospace companies, representatives of the Space Sector in the sectoral innovation panels of the SYSTEMATIC consortium mentioned that secrecy is also widely used to secure intellectual property. This can not be found in the CIS4 data, as industrial secrets are not mentioned in the CIS survey.

Companies in the ‘West and North’ and the ‘South’ group (46.1% and 38.8% respectively) are substantially more active in securing their intellectual property rights than companies in the ‘Central and East’ group (11.0%). This matches the results that these companies were less active in R&D than companies in the other country groups and that they introduced more products that are new to the firm than new to the market.

Applying for a patent is chosen mostly, especially companies in ‘West and North’ (49.2%), followed by companies in ‘South’ (34.2%). Claiming copyright is the least favourite option, with 8.5% of the companies in the country group ‘West and North’ and ‘6% in ‘South’. Registering an industrial design is done by 26.8% of the firms in ‘West and North’ and by 15.2% of the companies in ‘South’. Claiming copyright and registering an industrial design appears not to be an option for companies in ‘Central and East’, although 7% of the companies in this country group register trademarks. However, this is far less than companies in the ‘West and North’ (20.8%) and ‘South’ (11.8%).

Table 2.5 Securing intellectual property rights in the space and aeronautics sectors, per country group

	Country group					
Indicator	**West and North[1)]**	**Central and East[2)]**	**South[3)]**	**Country group Aerospace AVG[4)]**	**Total AVG[5)]**	**GAP[6)]**
General intellectual property rights	46,1%	11,0%	38,8%	38,2%	n/a	n/a
Applied for a patent	49,2%	3,7%	34,2%	37,0%	15,9%	232.7%
Claimed copyright	8,6%	0,0%	6,0%	6,4%	4,5%	142.2%
Registered an industrial design	26,8%	0,0%	15,2%	18,7%	17,4%	107.5%
Register a trademark	20,8%	7,4%	11,8%	15,7%	16,0%	98.1%

Notes: 1) Country group 'West and North' includes Sweden, Norway, Denmark, Luxembourg and France; 2) Country group 'Central and East' includes Czech Republic, Hungary, Romania, Bulgaria, Estonia, Latvia, Lithuania, Slovak Republic and Slovenia; 3) Country group 'South' includes Spain, Portugal, Greece and Italy; 4) Weighted average for the total Space and Aeronautics Sectors, based on weighted frequencies for the three country groups; 5) Average for all manufacturing sectors, based on a Core NACE including all countries in the sample; 6) Gap as % of the total AVG, calculated as Aerospace AVG / Total AVG.
Source: Eurostat CIS 4

When considering the size of the companies, large firms are the most active in securing intellectual property rights; 57.7% of the large firms compared to 37.7% of the medium sized firms and 14.3% of the small firms. The differences between the three size classes are more substantial than one would expect given the almost similar share of companies introducing a new product to the market in the three size classes. Large firms are also more active in applying for a patent; 60% compared with 31.4% of the medium firms and only 10% of the small firms. A main reason for this big difference between the size categories is that applying for a patent is a very complex and costly process, which can hardly be carried by smaller companies.

Claiming a copyright is the least favourite option; 15.1% of the large companies have claimed copyright, while none of the small and medium sized firms have done this. Registering a trade mark is a bit more popular by small firms than by medium sized firms (8.5% compared to 2.5%), but again substantially more large firms have chosen this option (28.4%). About one quarter of the large firms has registered an industrial design; this is twice as much as the small and medium sized firms. Table 2.6 presents the findings for the size categories.

Table 2.6 Securing intellectual property rights in the space and aeronautics sectors, per firm size

	Firm size					
Indicator	**Small**	**Medium**	**Large**	**Firm size Aerospace AVG**[1)]	**Total AVG**	**GAP**
General intellectual property rights	14,3%	37,7%	57,7%	38,2%	n/a	n/a
Applied for a patent	9,8%	31,4%	60,0%	36,0%	15,9%	226.4%
Claimed copyright	0,0%	0,0%	15,1%	6,3%	4,5%	140%
Registered an industrial design	11,8%	14,3%	25,2%	18,0%	17,4%	103.4%
Register a trademark	8,5%	2,5%	28,4%	15,4%	16,0%	96.3%

Note: 1) Weighted average for the total Space and Aeronautics Sectors, based on weighted frequencies for the three firm size categories
Source: Eurostat CIS 4

2.1.4 Cooperation

Cooperating in innovation activities is important in the Space and Aeronautics Sectors; 53% of the companies in these sectors cooperate with other companies when innovating, this is twice as high as the average for all manufacturing sectors. Companies in the country groups ‘Central and East’ and ‘South’ are more or less at the same level, while companies in the country group ‘West and North’ cooperate somewhat less than the sectors average (39.5%). About 95% of the Aerospace companies that cooperate collaborate with national partners, which is almost equal for the three country groups.

The Aerospace companies also cooperate extensively with partners abroad; three-quarter of the collaborating firms cooperate with international partners. Collaborating firms located in the country group ‘Central and East’ have relatively more international partners than companies from the other country groups (90.6% compared to 69.9% for ‘South’ and 77.6% for ‘West and North’). About 60% of the collaborating Aerospace companies cooperate with other enterprises within their enterprise group. These ties are substantially stronger than in average for all manufacturing sectors (8.7%). This high percentage reflects the consolidation process of the past decade, as well as the fact that several larger aerospace companies have subsidiaries in various European countries. Especially in ‘West and North’, companies collaborate with their enterprise group (70.4%), compared to 30.4% in ‘Central and East’ and 58.8% in ‘South’. Collaborations with national universities, research institutes and government institutions are also important in the Aerospace Sector; about 70.8% of the collaborating companies have joint projects with national universities and research organisations. In the ‘South’ these linkages are more frequently available than in the ‘West and North’ (77.1% compared to 65.4%). Aerospace companies also collaborate with international universities and research institutes, but less frequent than with national partners; 21.5% in average, with 28.3% for the companies in ‘West and North’ and 18.2% for ‘South’. None of the companies located in ‘Central and East’ collaborated with international universities. Three-quarter of the collaborating Aerospace firms cooperated with national suppliers, clients and competitors. This vertical and horizontal collaboration in the value chain is even a bit stronger in ‘West and North’ (83.8%) and ‘Central and East’ (81.3%). Table 2.7 presents the findings on collaboration for the three country groups.

Table 2.7 Cooperation arrangements in innovation in the space and aeronautics sectors, per country group

	Country group					
	West and North[1)]	Central and East[2)]	South[3)]	Country group Aerospace AVG[4)]	Total AVG[5)]	GAP[6)]
Cooperation arrangements on innovation activities	39,5%	56,0%	54,6%	53,0%	25,1%	211.2%
Cooperation with national partners	97,9%	90,7%	93,0%	95,4%	23,0%	414.8%
Cooperation with international partners	77,6%	90,6%	69,9%	76,4%	11,8%	647.5%
Cooperation with international partners outside own enterprise group	75,4%	90,6%	69,9%	75,3%	5,1%	1441.2%
Cooperation with other enterprises within enterprise group	70,4%	30,4%	58,8%	61,7%	8,7%	709.2%
Cooperation with National Universities / Government or research institutes	65,4%	76,8%	77,1%	70,8%	n/a	n/a
Cooperation with International Universities / Government or research institutes	28,3%	0,0%	18,2%	21,5%	n/a	n/a
Cooperation with national suppliers, clients or competitors	83,8%	81,3%	63,2%	76,4%	n/a	n/a

Notes: 1) Country group 'West and North' includes Sweden, Norway, Denmark, Luxembourg and France; 2) Country group 'Central and East' includes Czech Republic, Hungary, Romania, Bulgaria, Estonia, Latvia, Lithuania, Slovak Republic and Slovenia; 3) Country group 'South' includes Spain, Portugal, Greece and Italy; 4) Weighted average for the total Space and Aeronautics Sectors, based on weighted frequencies for the three country groups; 5) Average for all manufacturing sectors, based on a Core NACE including all countries in the sample; 6) Gap as % of the total AVG, calculated as Aerospace AVG / Total AVG.
Source: Eurostat CIS 4

When taking into account the different sizes of the firms in the sectors, Table 2.8 shows that large firms cooperate in innovation almost twice as much than medium sized and small firms. National collaborations are important to all size categories, but especially to the medium sized firms (100%). Almost an equal share of collaborating small, medium sized and large firms have international partners. Strong ties between enterprises within the same enterprise group are mainly relevant for large firms (76% compared to about 40% for medium sized and small firms), which is logical taking into account that these large firms are often groups consisting of several subsidiaries. This holds also for collaborations with national universities and research organisations. Moreover, one third of the collaborating large firms cooperate with international universities and research organisations, while this is not practice for the small and medium sized firms. Horizontal and vertical collaboration in the value chain is also very relevant for the large firms, but even more for medium sized firms (82.5%).

Table 2.8 Cooperation arrangements in innovation in the space and aeronautics sectors, per firm size

	Firm size					
	Small	**Medium**	**Large**	**Aerospace AVG[1)]**	**Total AVG**	**GAP**
Cooperation arrangements on innovation activities	34,8%	40,6%	74,8%	53,0%	25,1%	211.2%
Cooperation with national partners	84,0%	100,0%	98,2%	95,4%	23,0%	415.7%
Cooperation with international partners	71,9%	70,7%	79,9%	76,4%	11,8%	647.5%
Cooperation with international partners outside own enterprise group	71,9%	70,7%	78,0%	75,3%	5,1%	1441.2%
Cooperation with other enterprises within enterprise group	39,6%	42,8%	76,0%	61,7%	8,7%	709.2%
Cooperation with National Universities / Government or research institutes	43,4%	54,5%	86,3%	70,8%	n/a	n/a
Cooperation with International Universities / Government or research institutes	0,0%	0,0%	36,3%	21,5%	n/a	n/a
Cooperation with national suppliers, clients or competitors	62,2%	82,5%	79,8%	76,4%	n/a	n/a

Note: 1) Weighted average for the total Space and Aeronautics Sectors, based on weighted frequencies for the three firm size categories
Source: Eurostat CIS 4

2.1.5 Public funding

Public funding is widely used by Aerospace companies. Again, the CIS4 data give indications about the Aeronautics Sector more than the Space Sector. Over 80% of the firms use public funding, compared to 28.9% for the average of all manufacturing sectors. The importance of public funding is in line with the general notion of high tech sectors with long term investments, with uncertain outcomes and spillovers to other sectors.

Public funding is especially used by companies in 'West and North (97.8%), followed by companies in 'South' (75.1%) and substantially less by companies in 'Central and East' (51.3%). Most funding comes from the central government, reflecting the fact that Aerospace is in many countries considered as a national priority because of its role in national security and its contribution to societal challenges. Over 50% of the companies in 'West and North' and 'South' use national funding, while only 32.2% of the firms in 'Central and East' use national funding. Regional funding is used by about 40% of the firms in 'West and North' and 'South', while only by 5.5% of the companies in 'Central and East'. Public funding coming from the EU is also used; 29.7% of the firms in 'South', while only 7.3% of the firms in 'Central and East'. Funding from the European Framework Programmes is also relevant; over 80% of the companies located in 'West and North' use this type of funding, followed by 42.3% of the companies in 'South' and 11.4% of the companies in 'Central and East'. Table 2.9 presents the findings for the country groups.

Public funding is heavily used by large firms (95.2%) and medium sized firms (86.9%), but less by small firms (53.5%), although still substantially more on average for all manufacturing sectors. Public funding is often available for larger research and development programmes, which will be more difficult for smaller companies to participate in. Funding from the central government is mainly important for large firms (68.6% compared to 26.2% for small firms), more than regional funding, which is more important for medium sized firms (44.5%, compared to 27.9% for large firms). Large firms are also able to use public funding from the EU (44.25), which appears of minor relevance to the other size categories. Moreover, funding from European Framework Programmes is also mainly used by large firms (69.1%), followed by medium sized firms (36.8%) and small firms (4.7%). Table 2.10 presents the findings per firm size.

Table 2.9 Public funding in the space and aeronautics sectors, per country group

	Country group					
	West and North[1)]	**Central and East[2)]**	**South[3)]**	**Country group Aerospace AVG[4)]**	**Total AVG[5)]**	**GAP[6)]**
Any public funding	97,8%	51,3%	75,1%	82,9%	28,9%	286.9%
Public funding from local or regional authorities	40,2%	5,5%	37,3%	33,8%	15,5%	218.1%
Public funding from central government	55,2%	32,2%	51,3%	50,3%	15,4%	326.6%
Public funding from the EU	22,7%	7,3%	29,7%	22,6%	5,8%	389.7%
Funding from EU's 5th or 6th RTD	82,2%	11,4%	42,3%	57,7%	2,6%	2219.2%

Notes: 1) Country group 'West and North' includes Sweden, Norway, Denmark, Luxembourg and France; 2) Country group 'Central and East' includes Czech Republic, Hungary, Romania, Bulgaria, Estonia, Latvia, Lithuania, Slovak Republic and Slovenia; 3) Country group 'South' includes Spain, Portugal, Greece and Italy; 4) Weighted average for the total Space and Aeronautics Sectors, based on weighted frequencies for the three country groups; 5) Average for all manufacturing sectors, based on a Core NACE including all countries in the sample; 6) Gap as % of the total AVG, calculated as Aerospace AVG / Total AVG.
Source: Eurostat CIS 4

Table 2.10 Public funding in the space and aeronautics sectors, per firm size

	Firm size					
Indicator	**Small**	**Medium**	**Large**	**Aerospace AVG[1)]**	**Total AVG**	**GAP**
Any public funding	53,5%	86,9%	95,2%	79,1%	28,9%	273.7%
Public funding from local or regional authorities	31,2%	44,5%	27,9%	33,1%	15,5%	213.5%
Public funding from central government	26,2%	50,8%	68,6%	49,9%	15,4%	324%
Public funding from the EU	1,9%	15,1%	44,2%	22,8%	5,8%	393.1%
Funding from EU's 5th or 6th RTD	4,7%	36,8%	69,1%	39,5%	2,6%	1519.2%

Note: 1) Weighted average for the total Space and Aeronautics Sectors, based on weighted frequencies for the three firm size categories
Source: Eurostat CIS 4

2.2 Economic and innovation performance of the sectors as revealed by other statistical data

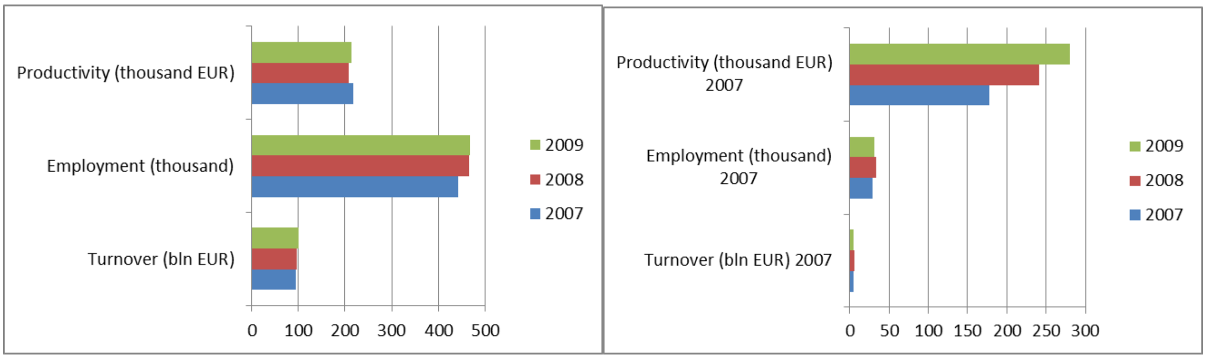
This section analyses other statistical data that complements the analysis above. These statistics will be used to distinguish between Aeronautics and Space, bring more detail to the analysis of the economic and innovation performance in the sectors, and cover additional European countries. An important source of data on the Space and Aeronautics Sectors comes from the AeroSpace and Defence Industries Association of Europe (ASD). The ASD addresses both sectors in its annual facts and figures. In addition, ASD-Eurospace (the space group of ASD) publishes it each year facts and figures dedicated to the Space Sector. The latest Eurospace Facts & Figures covers the year 2009 and includes statistics of member companies in 20 countries. The Facts & Figures of ASD include data on Aeronautics, Space and Land and Naval. This last category includes military land and naval systems and is not included in the data presented in this section. ASD collects the data by using a survey amongst the member companies. The ASD statistics do not include the suppliers to aeronautics, space and defence sectors, whose main interest is not one of these sectors. The Facts & Figures by ASD-Eurospace mainly include turnover and employment data, while the Facts & Figures by ASD also include data on R&D. There are differences in several indicators when comparing the data from Eurostat (Structural Business Statistics) and from ASD. This is mainly because of differences in definition of the sectors, different countries included and different reference years. In general, the figures from ASD are somewhat larger than from Eurostat.

2.2.1 Economic and innovation performance in the Space and Aeronautics Sectors

Turnover, employment, productivity and profitability

In 2009, the Space and Aeronautics Sectors realised a turnover of EUR 105,860 million and employed 499,728 people in Europe. In terms of turnover and employment, the Aeronautics Sector is substantially larger than the Space Sector. The difference between both sectors in productivity is much smaller. Figure 2.1 shows the main data of Aeronautics and Space in 2007, 2008 and 2009. In both sectors the turnover increased slightly in the past three years. Also the employment increased in the same period. In 2007, the labour productivity in Aeronautics was somewhat higher than in Space, but in 2008 and 2009 the labour productivity improved substantially in the Space Sector and passed Aeronautics. The increase in labour productivity is a longer term trend already since the 1980s.This reflects companies' efforts to improve productivity, which is under pressure from, amongst others, global competition and the euro-dollar volatility. The labour productivity in Aerospace is higher than the average rate for the non-financial business economy, but the average personnel costs in Aerospace are also higher. This results in a wage adjusted labour productivity of 131.4% which is below the average rate for the non-financial business economy (151.1%) in 2006 (Eurostat, 2009a).

Figure 2.1 Main indicators for Space and Aeronautics in 2007, 2008 and 2009

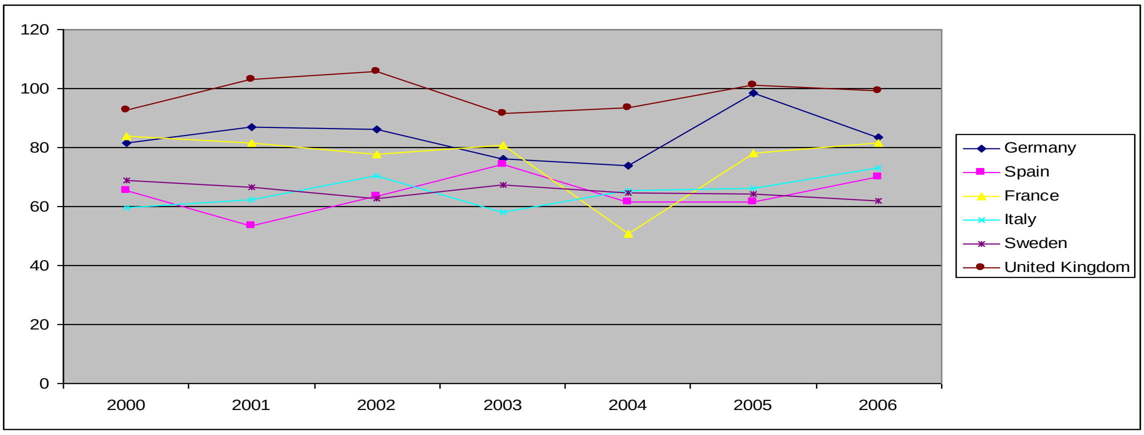


Aeronautics Space

Source: ASD (2008, 2009, 2010)

Figure 2.2 shows the apparent labour productivity[1] in the Space and Aeronautics Sectors for six European Member States. Over the past six years, the United Kingdom had the highest labour productivity, although the sectors experienced a small decrease in 2003. Italy followed more or less the same pattern, but at a lower level. France and Spain experienced a sharp decrease in 2004, but in France this decrease was made up again already in 2005. In Spain, the recover is much slower. Also Germany experienced a small decrease in 2004 and improved its labour productivity substantially in 2005, but the growth was almost lost again in 2006.

Figure 2.2 Apparent labour productivity in the space and aeronautics sectors



Source: Eurostat Structural Business Statistics

According to Eurostat figures (2009a), the Space and Aeronautics Sectors realised a gross operating profit of 8.2% in 2006 (EU-27), which is below the average rate for the non-financial business economy (10.8%). An important reason is the high average personnel costs. According to the ASD data (2010), the operating profit margin reached 5,7% in 2009, which is a substantial decrease from 7.1% in 2008, but a bit higher than the 5.3% in 2007.

[1] Value added per person employed

International trade

In 2007, the sectors had a trade surplus with Extra-EU exports valued ad EUR 41,450 million, while the Extra-EU imports were smaller with a value of EUR 30,267 million (Eurostat, 2009a). In 2006, France, Germany and United Kingdom dominated, accounting together for 84.1% of the exports in EU-27 and 78.5% of the imports. Without surprise, France had the largest trade surplus of EUR 12,100 million, followed by the UK with EUR 5,800 million (Eurostat, 2009a). According to the ASD (2010), the Aeronautics Sector realised 59.5% of its turnover outside the EU, mainly from civil products. In space the picture is not different: France, Germany and United Kingdom account for almost 50% of the space exports from OECD countries in 2004, while the US is responsible for 32% (OECD, 2007a).

R&D expenditures

The Space and Aeronautics Sectors are relatively R&D-intensive. The Eurostat Structural Business Statistics present data, but not for all EU Member States. The total amount of R&D expenditures for the EU is only available for 17 countries, representing 88% of the sectors' value added in EU-27; the companies in these countries spent EUR 6,800 million R&D in 2006 (Table 2.11). These countries together had 49,040 R&D employees in 2006. The three countries that have the largest Space and Aeronautics Sectors in terms of value added and employment (United Kingdom, Germany and France), are also the most important in terms of R&D activities. Other countries that are rather R&D intensive (R&D expenditure as share of value added) include Spain, Sweden and some new Member States such as the Czech Republic, Slovenia and Poland.

The ASD also presents data on R&D expenditures, but for both sectors only data for the year 2006 are available. In 2006, the Space and Aeronautics Sectors spent EUR 11,520 million on R&D. This includes data from companies in 20 countries. The Aeronautics Sector accounted for about 95% and the Space Sector for almost 5% of the R&D expenditures. The R&D/turnover ratio has been rather stable over the years and amounted to 11.3% in 2006. The small and medium sized companies seem to be as R&D intensive as in average for both sectors in total. In 2006, SMEs in the sectors spent 12.9% of their turnover on R&D and this ratio has been stable over the last five years (ASD, 2007).

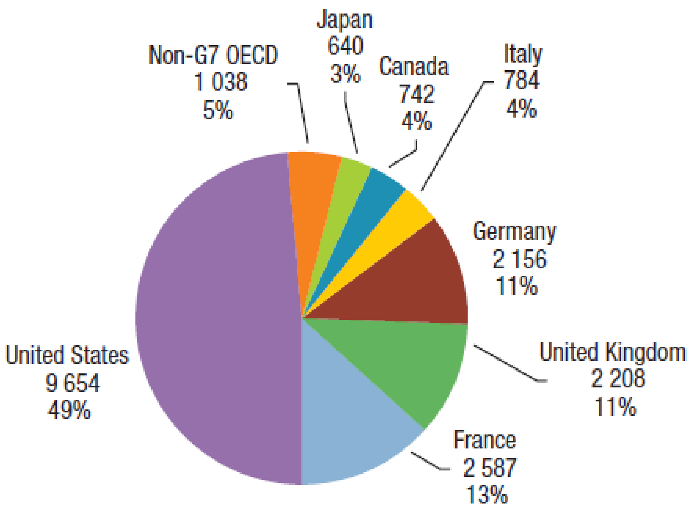
Table 2.11 R&D activities in European member states, space and aeronautics sectors, 2006

	Share of EU-27 sector value added (%)	R&D expenditure	R&D employees	Share of R&D employment in number of persons employed (%)	Share of R&D expenditure in value added (%)
Austria	0.21%	3.7	60	8.6%	5.9%
Belgium	1.54%				
Bulgaria	0.00%	0	0		
Cyprus	0.00%	0	0		
Czech Republic	0.32%	26.7	699	9.2%	28.1%
Germany	21.46%	1853.7	12812	16.6%	28.8%
Denmark	0.32%	0	0	0%	0%
Spain	3.66%	416.6	3071	19.5%	37.9%
Finland	0.15%				
France	25.27%	2458.1	16502	17.8%	32.5%
Greece	0.66%	0	0	0%	0%
Hungary	0.15%	0	0	0%	0%
Ireland	0.49%				
Italy	8.20%				
Lithuania	0.01%	0.1	7	1.6%	1.6%
Latvia		0	0	0%	
Netherlands	1.16%				
Poland	0.79%	14.8	809	5.6%	6.3%
Portugal1)	0.16%				
Romania	0.27%	0.3	65	1.1%	0.3%
Sweden	2.14%	255.9	1473	14.2%	39.9%
Slovenia	0.01%			13.6%	17.7%
Slovakia1)	0.04%	0	2		
United Kingdom	32.97%	1752.1	13540		

Source: Eurostat Structural Business Statistics; data for the year 2006. Note: 1) data for the year 2005

When comparing various OECD countries, the US Aerospace industry spends by far the largest amount on R&D. Figure 2.3 presents the R&D expenditures in the aerospace industry by OECD country in 2002.

Figure 2.3 R&D expenditures in aerospace industry by OECD country, 2002 in millions of US dollars using PPP and percentage of OECD aerospace R&D total.



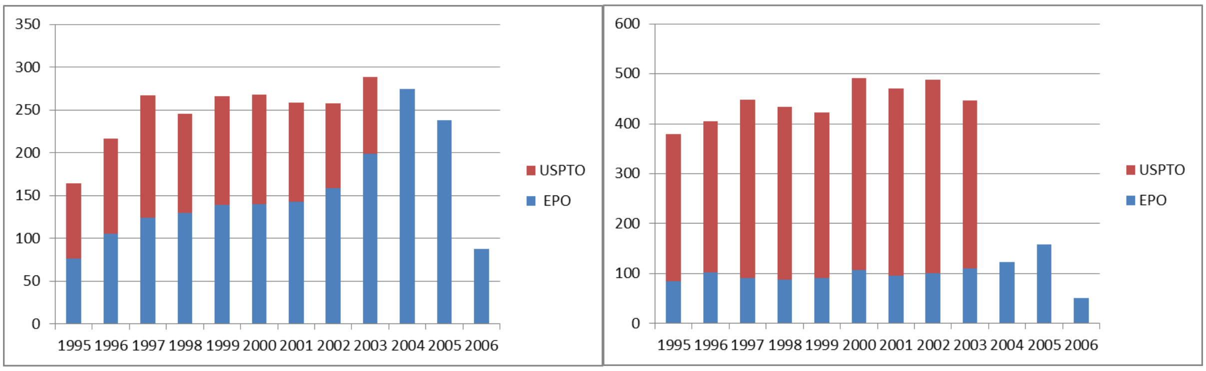
Source: OECD, 2007a

The OECD STAN database containing data on R&D expenditures presents R&D expenditures by Aerospace industry in the United States. In 2006, the US R&D expenditures by the US Aerospace industry amounted to USD 16,367 million, which is an increase of 69.5% compared with 2002.

Intellectual Property Rights

As revealed by the Community Innovation Survey, 38% of the companies in the Space and Aeronautics Sectors (see Section 2.1.3) secure their intellectual property rights in a formal way. Representatives of the Space Sector in the Sectoral Innovation Panel in the SYSTEMATIC consortium mentioned that often secrecy is used to protect intellectual property. This is not visible in the statistics, as industry secrets are not used as a category in CIS4. Patents are therefore not the best indicator for measuring the innovation performance in the sector. Nevertheless, there is no other indicator available and patent activity by companies in the sectors can give a first indication of the innovation in the sectors. Figure 2.4 presents for EU-27 and for the United States the patent applications in EPO and the patents granted by USPTO. The data cover the IPC class ‘Aircraft, aviation, cosmonautics’.

Figure 2.4 Patent performance, 1995-2006 for EU-27 and for US



EU-27 United States

Source: Eurostat Patent Statistics, IPC class B64 Aircraft, aviation, cosmonautics. USPTO patent numbers only available for the period 1995-2003.

Overall, European firms file less patents than American firms. Where European firms file less than 300 patents (EPO and USPTO together) in 2003, US-based firms file almost 450 patents in the same year. Since 1995, European firms have increasingly filed patents with EPO, with a sharp decline in 2006. The number of USPTO patents filed by European firms has decreased over the years.

Between 2000 and 2006, the EU-27 applied in total for 1240 EPO patents (see Table 2.12). Germany and France have the highest shares, followed at some distance by the United Kingdom. Germany and France also have the highest share in the patents granted by USPTO in the period 1997-2003.

Table 2.12 Patents by country in the space and aeronautics sectors

EPO patent applications (2000-2006)			**USPTO patent grants (1997-2003)**		
		% share			% share
EU-27	1240		EU-27	819	
Germany	464	37.4%	Germany	290	35.4%
France	419	33.8%	France	289	35.3%
United Kingdom	157	12.7%	United Kingdom	133	16.3%
Italy	42	3.4%	Italy	29	3.6%
Spain	40	3.3%	Sweden	19	2.3%
Sweden	33	2.7%	Spain	18	2.1%
Belgium	20	1.6%	Austria	13	1.6%
Netherlands	19	1.6%	Netherlands	8	1%
Austria	13	1.1%			

Source: Eurostat Patent Statistics, IPC class B64 Aircraft, aviation, cosmonautics. Only countries with a share of 1% or higher are shown.

In 2006, the highest number of EPO patent applications per million euro spent in R&D can be found in Austria, followed by Germany and France.

2.2.2 Economic and innovation performance in the Aeronautics Sector

Based on ASD statistics (2009), the Aeronautics Sector has the largest share in the Space and Aeronautics Sectors. Turnover in Aeronautics has increased with 19% since 2005; between 2007 and 2008 the growth in turnover was 3%. Employment has also increased in the same period, but at a slower pace. According to ASD, this is due to restructuring and outsourcing of production to improve profitability and increase flexibility in production. Since 1980, the turnover per employee in the Aeronautics Sector has increased in average by 3.9% per year. The Aeronautics' labour productivity has increased with almost 90% from EUR 115,000 per employee in 1991 to EUR 214,000 per employee in 2009 (ASD, 2010). Although the turnover and the labour productivity have increased over the years, the operating profit dropped substantially after 2005. An important reason for this could be the problematic euro-dollar volatility during 2008, especially for companies that do not own assets in US dollar markets. Other causes could be increasing costs of commodities and the increasing development times for complex new programmes (ASD, 2008). ASD reports an organic growth in the operating profit margin from 4.16% in 2007 to 7.1% in 2008, but with a sharp decline to 5.7% in 2009. According to ASD the initial growth was mainly based on the significant improvement of EADS's performance, which represents an important share of the European Aeronautics Sector. The decline in 2009 was due to the fact that large aircraft development programmes moved from development to full production and faced delays and additional costs (ASD, 2010).

Box 2.1 Impact of the current crisis on the Aeronautics Sector

In 2008, the International Air Transport Association (IATA) expected that global passenger traffic will fall by 3% in 2009 and a return to traffic growth above 4% was not expected until 2011. Indeed, during the first half of 2009, the demand for traffic dropped sharply 2009, mainly in the European and US markets (IATA, 2009). In emerging markets, demand for air traffic will continue growing. According to IATA (2008), the fall in air traffic is the biggest since 1991, when air traffic dropped with 2.6% due to recession and after the 9-11 terrorist attack. In general, the aerospace industry is in a better situation compared to other manufacturing sectors like the automotive industries. This is mainly because of a considerable backlog following from the many orders made during the last years. Aircraft operators seem to be optimistic about their markets in the long term and they will need to replace significant numbers of older, less fuel efficient aircraft. Another positive factor is that the military demand has largely been unaffected by the crisis so far, although governments will cut budgets here as well and this will have effects. Financing the aircrafts will mainly come from financiers focused on asset and lending institutions, but these want to see convincing answers from the industry to the threat of the crisis and high fuel prices. Despite the relatively optimistic trends in demand, both Airbus and Boeing experienced more aircraft cancellations than orders in the beginning of January 2009, reducing their backlog. Programmes for new aircrafts to be delivered by 2020 seem to be not affected by the crisis so far. According to industry analysts the aeronautics industry can survive the crisis, but they have to do better in meeting costs and schedule objectives in their programmes. Customers are much under pressure themselves to control costs. In addition, the aeronautics industry will have to pursue more actively new markets and customers in India and the Middle East in order to realise growth (Captain and Coykendall, 2009). Also IATA (2010) considers these emerging markets as the main driver for growth. Although the major primes seem to be able to handle the crisis so far, the suppliers are really hit, mainly because they have very limited access to long term credits (needed to participate in large programmes) as well as to short term credits needed for their day to day operations. An additional complicating factor is that many suppliers are also active in other manufacturing sectors, like automotive, where the crisis is very present, and further threatening their financial situation. Without surprise, the business jet industry is hit hard as well (ACARE, 2009).

Although the economic crisis is still present, especially in Europe and the United States, the current (spring 2011) major issue is the strong increase in fuel prizes. IATA (2010) forecasts a stable increase in the demand for air traffic, but also states that high fuel prices will substantially affect the profitability of airliners, both in terms of operating costs and demand for air traffic, as higher energy prices also affect the economic recovery of main clients.

In 2009, 59.2% of the turnover came from civil markets and 40.8% came from military markets. In 2009, 72.8% of the turnover came from customers other than governments and government agencies. The Aeronautics Sector sells 59.9% outside Europe and 40.5% at domestic markets (ASD, 2010). In 2009, 44% of the turnover of the European Aeronautics Sector was realised by aircraft final products. Commercial aircrafts account for 57% of the aircraft final products, followed by military aircrafts (27%) (ASD, 2010).

The companies in the Aeronautics Sector spent 12.1% of their turnover on R&D activities, which equalled EUR 12.2 billion in 2009 (ASD, 2010). The share of turnover spent on R&D remained stable over the past few years. Two third of these R&D expenditures is financed by the industry itself, while one third came from government funding. Table 2.13 presents the main indicators for the Aeronautics Sector.

Table 2.13 Economic and innovation performance in the Aeronautics Sector

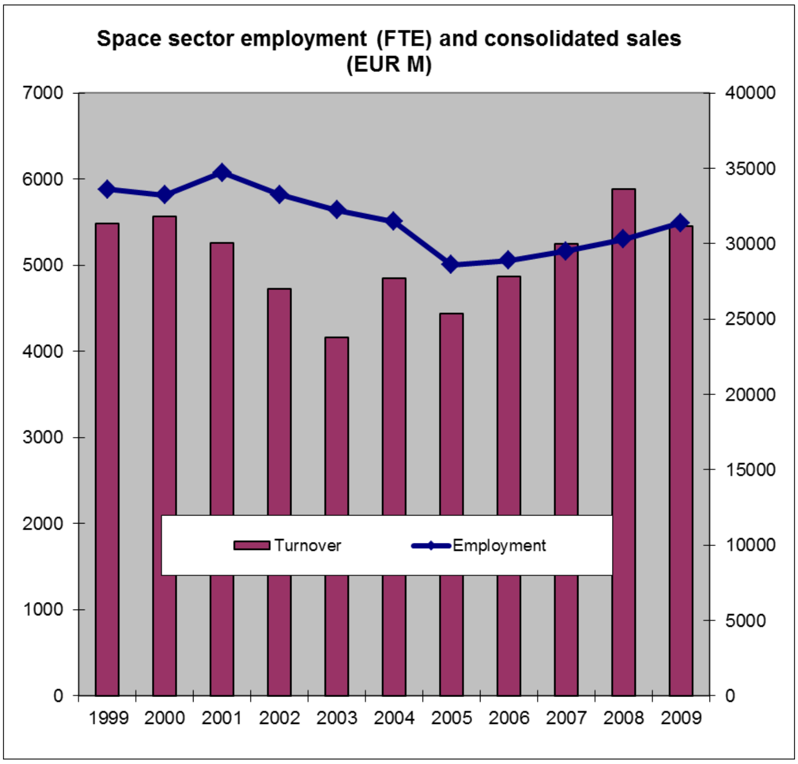
	2005[1)]	**2006[2)]**	**2007[3)]**	**2008[4)]**	**2009[5)]**
Turnover (in EUR M)	81,600	90,500[6)]	94,500	97,300	100,400
- % of Civil in turnover		69.2%	57.9%	60.1%	59.2%
- % of Military in turnover		30.8%	42.1%	39.9%	40.8%
- % of domestic in turnover		48%	44%	41.2%	40.5%
- % of export in turnover		52%	56%	58.8%	59.5%
- % of governments in turnover			22.4%	19.3%	27.2%
- % of other customers in turnover			77.6%	80.7%	72.8%
Operating Profit	6.9%	4.5%	4.16%	7.1%	5.7%
Employment	430,000	448,000	442,100	446,900	468,300
Labour productivity (turnover / employees)[9)]	189,767	202,009	217,753	214,000	214,000
R&D Expenditures (in EUR M)	10,037[7)]	10,430[7)]	11,700	11,300	12.200
% of R&D of turnover	12.3%	11.83%[8)]	12.4%	12%	12,1%
% of R&D financed by companies		55%	71%	68.3%	65.3%
% of R&D financed by (national and European) governments		45%	29%	31.7%	34.7%

Sources: 1) ASD (2007c) Facts & Figures 2006, Belgium (based on 20 countries: EU15, Czech Republic, Poland,Bulgaria Norway, Switzerland and Turkey); Edelstenne, C. (2007) ASD Press Conference on Key Figures for 2006, Brussels, 4 June 2007; 2) ASD (2007c) Facts & Figures 2006, Belgium; 3) ASD (2008) Facts & Figures 2007, Belgium (based on 21 countries: EU 15, Czech Republic, Poland, Bulgaria, Norway, Switzerland and Turkey); 4) ASD (2009) Facts & Figures 2008, Belgium (based on 20 countries: EU 15 minus Luxembourg, Bulgaria, Czech Republic, Poland, Norway, Switzerland and Turkey); 5) ASD (2010) Fact & Figures 2009, Belgium (based on 20 countries: EU15 minus Luxembourg, Czech Republic, Bulgaria, Poland, Norway, Switzerland and Turkey; 6) The turnover for 2006 was adjusted from EUR 88,200 million in the Facts & Figures of 2006 to EUR 90,500 million in ASD (2008) Facts & Figures 2007, Belgium; 7) own calculation using publicly available data on turnover and share of R&D of turnover; 8) as included in: ASD (2007c) Facts & Figures 2006, Belgium, does not take into account the adjusted figure for turnover in: ASD (2008) Facts & Figures 2007, Belgium; 9) own calculations by dividing turnover by employment.

2.2.3 Economic and innovation performance in the Space Sector

The Space Sector is the smallest sector in the Space and Aeronautics Sectors. Turnover increased steadily from EUR 4,400 million to 5,457 million in 2009. Figure 2.6 shows a decline in the period 2001-2003. An important reason for the decrease in turnover in the period 2001 – 2003 is the telecommunications market downturn, resulting in fewer satellites ordered. Since 2005, direct employment in the Space Sector has increased slowly, from 28,584 FTE to 31,369 FTE in 2009. This increase comes after several years of decreasing employment figures, caused by industry restructuring (vertical and horizontal integration) and less favourable market conditions at the beginning of the century (ASD-Eurospace, 2009).

Figure 2.6 Employment and turnover in the EU space sector, 1999-2009



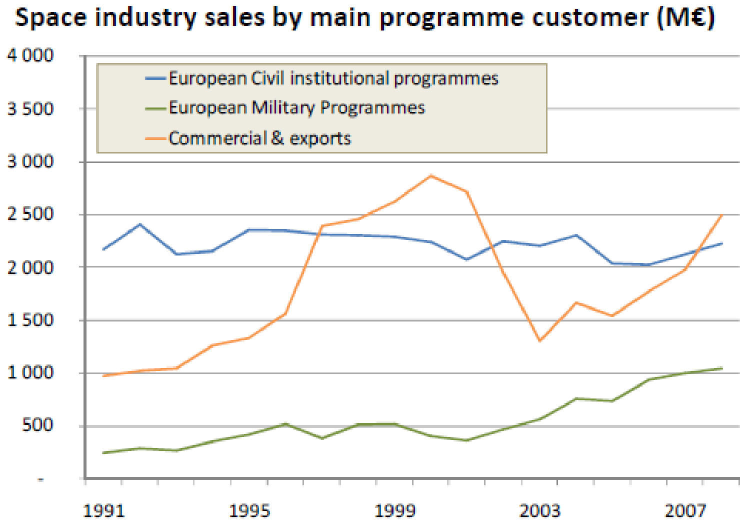
Source: ASD-Eurospace (2009 and 2010)

More than 70% of the sector's employment is concentrated in four large industrial holdings (EADS, Finmeccanica, Safran and Thales). Less than 5% of the companies in the sector are SMEs, but small space units within larger companies represent 20% (ASD-Eurospace, 2009).

The turnover in the Space Sector comes from two main types of customers: institutional customers and commercial programmes & exports. Institutional customers include the European Space Agency, national space agencies, public satellite operators and military procurement agencies. In 2009, institutional customers represented 59% of the turnover and commercial customers represented 41%. The contribution of the European civil institutional programmes (from ESA, national space agencies, Eumetsat and EC) remained relatively stable over the period 1999-2009, while the size of the

European military programmes (e.g. Sicral, SAR-Lupe) have grown steadily since 2001. The commercial markets, the commercial satellites in particular, appear to be far more cyclical. In the 1990s the commercial satellite sector grew significantly, but since 2001 this market has declined sharply. Only since 2006, the turnover from commercial satellites has been increasing again, but is still behind the levels of 2000. Figure 2.7 presents the trends in turnover in the Space Sector.

Figure 2.7 Trends in turnover in the space sector, by main programme customer, 1991 – 2008



Source: ASD-Eurospace (2009)

The Space Sector designs, develops and produces three main categories of products: launchers, satellites (and space crafts) and ground systems. The satellites and spacecraft segment is the biggest, representing 69% of the sector's sales and employing 68% of the sector's workforce. The satellite segment in Europe has two large system integrators: Thales Alenia Space and EADS Astrium. The satellite segment covers a broad spectrum of space activities: telecommunications, science, Earth observation, navigation, and space infrastructures. Medium and small system integrators have been established in Germany, the UK, Belgium and Sweden, but the share of SMEs is in general very small, mainly because of high risks and high entry barriers. The launchers segment represents 22.4% of the total turnover and employs 20% of the total workforce. For the Ariane programme there is one single prime contractor (EADS Astrium), one reference motorist (Safran) and about 40 European subsystem and equipment suppliers, of which 25 are highly specialised in Ariane subsystems and components. There is almost no possibility that newcomers can enter the market, mainly because of long development cycles and exploitation phases and the difficulty to implement any change in the qualified definition of the launcher systems. The ground systems sector only represents 10% of the sector's employment and turnover[2]. Companies focus on the design, development, manufacturing and operations of ground systems (e.g. control systems) (ASD-Eurospace, 2009).

[2] Ground systems in the consumer-end of the market, uplink/downlink services (e.g. for TV broadcast) represent a much larger market, but are not included here.

Table 2.14 Economic and innovation performance in the space sector, 2005-2009

	2005	**2006**	**2007**	**2008**	**2009**
Turnover (in EUR M)[1)]	4,432	4,867	5,242	5,885	5,457
- % of institutional markets (civil and military) in turnover	60.3%	60.5%	59.6%	55.5%	59%
- % of commercial and exports in turnover	37.2%	37%	37.7%	42.4%	41%
Employment (direct)	28,584	28,872	29,506	30,301	31,369
Labour productivity (turnover / employees)[2)]	155,052	168,571	177,658	194,218	173,962
R&D expenditures (in EUR M)[3)]		548			
% of R&D of turnover[3)]		14.43%			

Sources: ASD-Eurospace (2009) *The European Space Industry in 2008 – facts & figures*, 13th edition, rev. 1, July 2009, Paris; ASD-Eurospace (2010) The European Space Industry in 2009 – fact & figures, 14th edition, September 2010, Paris
1) The division between in institutional and commercial markets does not sum up to 100%, because a small part of the turnover cannot be allocated to one of these two categories; 2) Own calculations, dividing turnover by employees; 3) ASD (2007c) Facts & Figures 2006, Belgium

There are hardly any data available on the business R&D expenditures in the Space Sector; data collections are only available for Space and Aeronautics Sectors together. Only for 2006, there are data about the expenditures on R&D and share of turnover spent on R&D (see Table 2.14). While the R&D-intensity rate in the Space Sector is higher than in the Aeronautics Sector (14.43% compared with 11.83% in 2006), the size of the total R&D expenditures in Space is much smaller than in Aeronautics and has a share of only 4.8% in the R&D expenditures of the total Space and Aeronautics Sectors.

The OECD provides data on the public space research and development budgets (GBOARD), but this also includes government funding for R&D performed at higher education institutes, non-profit institutions and governments and it does not separate the public funding available to business enterprises in space. According to the OECD (2007a), the total government budgets of OECD countries for space-related R&D amounted to USD 16,400 million in 2004. Table 2.15 provides an overview of the public space R&D budgets in available European countries.

Table 2.15 Public space R&D budgets in Europe

Country (latest year)	**Public space R&D budgets (GBOARD) in millions of current US dollars using PPP**
Austria (2006)	15
Belgium (2005)	172
Czech Republic (2005)	10
Denmark (2006)	28
Finland (2006)	31
France (2004)	1,567
Germany (2005)	924
Greece (2005)	16
Hungary (2005)	17
Ireland (2005)	12
Italy (2005)	902
Netherlands (2006)	98
Portugal (2006)	3
Romania (2006)	10
Spain (2005)	322
Sweden (2006)	25
United Kingdom (2004)	206

Source: OECD, 2007a

2.3 Innovation performance, developments and innovation trajectories – a firm perspective

Pressure to decrease development and delivery times and costs

The Space and Aeronautics Sectors develop highly complex systems including many different components and building on many different scientific disciplines and technological fields. The development of new air- and spacecrafts takes long development times and often processes are associated with high technological and financial risks. Delays in development and delivery schedules as well as cost overruns are important issues in the sectors and put much pressure on the industry to improve development and delivery schedules and to reduce costs.

Box 2.2 Fighting delays

Delays in developing and manufacturing new aircrafts are causing painful headaches for CEOs of aircraft manufacturers. Delays have always been there in the industry and are an important cause for disappointing profit margins. Despite all kinds of approaches, such as concurrent engineering and outsourcing to risk-sharing partners, all manufacturers face the problem of delays in their programmes. Boeing, for example, has struggled with the delivery of its new flagship 787 Dreamliner. Boeing had received record-breaking orders for this aircraft, but the production has been slowed down, mainly because of problems in the supply chain. Boeing has outsourced complete components and subsystems to global suppliers, but lost control on its supply chain as suppliers could not fulfill their contracts with Boeing. Although Boeing is still convinced that it can win competitive advantage when using a global supply chain, it also wants to reconsider its supply chain as well. Airbus struggled with delays as well. Its military transport aircraft A400M has been delayed by a year already. Delays in programmes cause huge costs, not only from additional investments needed to solve technical problems, but also from penalties and compensation claims from the customers waiting for the new aircrafts (Financial Times, 14 July 2008).

Aeronautics companies have developed a broad set of approaches to improve their performance. The industry has been considerably consolidated in the past decades to improve their capacities to compete and innovate and to reduce the overcapacity. Moreover, companies implemented 'lean' principles and practices, first by just cutting costs and removing unnecessary steps, but also by developing integrated product teams, reducing inventories, coordinating procurement activities, introducing preventive maintenance practices, training employees in quality control practices, and involving suppliers earlier in the design process (Murman et al. 2002; Ecorys, 2009). A next step is the systematic approach of fully integrated product and process design teams, the integration of suppliers into every phase of development, production and deployment, multi-firm collaborative agreements with suppliers and competitors, the further application of advanced ICT systems to facilitate real-time collaboration and complex configuration management tasks, but also the focus on core business.

Box 2.3 Top performing companies in the Space and Aeronautics Sectors

Each year the AVIATION WEEK publishes the industry rankings for the aerospace and defence industry. These rankings are based on the companies' performance in terms of revenues, return on invested capital, asset management, earnings momentum and financial health. The rankings allow comparison of companies' performance within their peer groups. Table 2.16 presents the rankings of the top performing companies in various market segments. Amongst the commercial aircraft builders, EADS ranks first in the 2009 Aerospace & Defence Industry Ranking, followed by Boeing, Bombardier and Embraer. Over the past five years, Bombardier has improved its performance stronger than its peers. Lockheed Martin leads the prime manufacturers in defence, closely followed by EADS and General Dynamics. Goodrich Corp ranks first in the group of engines and equipment manufacturers, as well as in the group of aero structures and components. Rockwell Collins leads the avionics and electronics group and United Technologies ranks first in the group of Maintenance, Repair and Overhaul. Most companies, including EADS, have been able to improve their performance over the past five years; MTU Aero Engines was able to improve its performance with 107.5% over the past five years. Nevertheless, performances of several European companies like Dassault Aviation, Finmeccanica, SAFRAN, SAAB, and Rolls-Royce have worsened in the same period.

Table 2.16 Top performing companies in space and aeronautics sectors

Rank	Company	Rank	Company
Commercial aircraft builders		*MRO*	
1	EADS NV (NL)	1	United Technologies Corp (US)
2	Boeing Co (US)	2	MTU Aero Engines Hldgs AG (DE)
3	Bombardier Inc (CA)	3	AAR Corp (US)
4	Embraer Empresa Brasileira (BR)	4	Rolls-Royce Group PLC (UK)
		5	Safran SA 9FR)
Defence primes		6	Rolls-Royce Group PLC (UK)
1	Lockheed Martin Corp (US)	7	Safran SA (FR)
2	EADS NV (NL)		
3	General Dynamics Corp. (US)	*Aerostructures / Components*	
4	Raytheon Corp. (US)	1	Goodrich Corp (US)
5	Boeing Co (US)	2	Spirit Aerosystems Holdings Inc
6	BAE Systems PLC (UK)	3	Woodward Governor Co
7	Thales (FR)	4	Triumph Group Inc.
8	Northrop Grumman Corp (US)	5	Hexcel Corp
9	Dassault Avaiation SA (FR)	6	Zodiac Sa (FR)
10	Finmeccanica SPA (IT)	7	BE Aerospace Inc. UK)
		8	Curtiss-Wright Corp
Avionics / Electronics		9	Moog Inc.
1	Rockwell Collins Inc. (US)	10	Barnes Group
2	Raytheon Co. (US)		
3	Honeywell International (US)	*Engines / Equipment*	
4	L-3 Communications Holdings Inc (US)	1	Goodrich Corp (US)
5	Thales (FR)	2	United Technologies Corp (US)
6	Northrop Grumman Corp (US)	3	Honeywell International (US)
7	Finmeccanica SPA (IT)	4	MTU Aero Engines Hldgs AG (DE)
		5	Zodiac Sa (FR)

Source: Aviation Week, 2009. Ranking based on the companies' performance in terms of revenues, return on invested capital, asset management, earnings momentum and financial health.

In 2007, EADS realised a loss of 0.3%, while Boeing realised a profit margin of 9.5%. However, in 2008 EADS's operating profit increased substantially to EUR 1,790 million from minus EUR 881 million in 2007. In the same period, Boeing's operating profit dropped from USD 12,990 million to USD 10,600 million. While the US industry had to deal with strikes and delays, EADS delivered the largest amount of aircrafts ever. EADS's performance has been very volatile in the last decade and industry analysts wonder whether the positive results in 2008 are the result of the Power8 programme and indicate a structural improvement or not. EADS faces many challenges in several of their programmes as well as an expected downturn in demand for civil aircrafts in the short term. The first results for the first half year of 2009 confirm these worries; revenue for the first six months of 2009 went up 2%, whiles earnings before interest and tax fell 23% and net profit went down 6%, mainly reflecting unfavourable foreign-exchange fluctuations and further delays in the military A400M programme. The second quarter of 2009 is stronger than the first quarter (http://www.dowjones.de/site/2009/07/eads-2q-profit-up-but-warns-of-future-a400-million-costs.html).

According to industry analysts, European aerospace companies suffer from high volatility in performance and poorer performance over the longer term, especially in comparison with the more consistent performance of US companies. Important causes for this include the absence of a unified European defence market and decreasing defence budgets, very complex multilateral programmes, a fragmented supply chain (especially in aero structures and electronics), strong vertical integration among larger companies, government-subsidized national champions, problematic cash flows, and high legacy costs from having been government-owned conglomerates (Gelain, 2009, in Aviation Week; Ecorys, 2009).

In the Space Sector, the institutional market has always been the main source of funding. However, the institutional funding level has been rather stable over the past decade and for growth the European Space Sector has to compete on the global commercial market. The commercial market is mainly based on the satellite communications and launch services segments, which are dependent on the health of industries using the satellites, e.g. telecommunications and which are very competitive markets. Moreover, there is increasing competition from very advanced satellites from the US (where the government invests six times more in space than Europe) and India and China are entering the lower costs satellites with lower performances, but which are acceptable for some customers. In addition, Europe is also depending on US manufacturers, as they are the sole suppliers of key components. Other influences on the competitive position of the European Space Sector come from countries that are further rationalising their industrial base to improve their competitiveness and from high vulnerability to exchange rate risks. The geographical contribution rule (juste retour principal[3]) followed by ESA does not help much either. It allows Member States putting their national interests above the European interests, delaying projects. In addition, the geographical distribution rules makes it attractive for suppliers to be located all over Europe, getting some Member States to support their local space companies so they can offer lowest prices to the system integrators. This leads to a very competitive market for suppliers (Peter, 2008).

Also in the Space Sector there is pressure from both institutional and commercial markets to decrease development times and to lower costs. Especially in the launchers segments costs need to be reduced. It is the only space segment where costs have so far not fallen over time (Poliakov et al., 2008). Several smaller launchers expected to come online over the coming years are expected to reduce these costs and lead to many smaller launches. Using more COTS (Commercial off-the-shelf) components and standardised modules could help to reduce the development times, to achieve non-dependence and to have more standardisation, which helps to lower the costs (Skaar, 2007; Interviews with Boele and Blaauw, 2008 and 2009). Concurrent design and engineering contribute as well to decreasing development cycles and lowering costs in both the downstream and upstream parts of the Space Sector (Interviews with Boele and Blaauw, 2008 and 2009). For example, ESA has the Concurrent Design Centre, which allows experts from different disciplines to design and engineer parts and applications concurrently, by using advanced ICT tools.

[3] Juste retour principal: the principle that the proportion of contracts under a particular programme awarded to firms from a given country is in proportion to the funding that country has contributed to the programme

Moreover, competition could be increased by granting third parties access to space infrastructure and data to provide related services (EO & GNSS). The development of smaller and hence cheaper satellites (such as micro-satellites) offers new opportunities to SMEs, bringing more competition. Another important issue is the uncertainty and risk caused by the lack of a globally accepted judicial system. This needs to go beyond the current rudimentary system in place and especially establish rules on ownership and liability to be able to resolve cases such as the recent satellite crash (Iridium / Russia) in an independent court system. This would help to reduce investment risk of commercial actors.

Innovation in complex networks

The Space and Aeronautics Sectors have not only went through an ongoing horizontal consolidation, but also the vertical relations have been reshaped (ACARE, 2009; Ecorys, 2009). Although the number of prime system integrators is limited (in civil aeronautics only two global competitors exist) the industry uses a broad, deep, multilayered and multifaceted supplier base. About 60 to 80% of the end-product value comes from the supplier base (Murman et al., 2002).

Box 2.5 Global sourcing and currency risks

Global sourcing is also a way to diversity currency risks in addition to efficiency increases and financial hedging strategies. While EADS generates 70 percent of its turnover in US dollar, it only procures 41 percent of its inputs in the US dollar (Mundt, 2007). With future turnover even expected to reach 80 percent US dollars, this poses a considerable foreign currency exposure for EADS, that it aims to diversify by increasing its sourcing from firms located in countries operating with US dollars. The foreign currency exposure, but also lower labour costs, can also trigger the relocation of production activities in the sector. EADS expects by 2020 China, India, Russia and South Korea as important production locations, with Brazil, Israel and Canada as additional possible candidates (Mundt, 2007).

In order to improve their performance, the prime manufacturers now concentrate on product and system integration and the management of the supply chain is now their core competency. They increasingly become a total system integrator with a life cycle value provide role, coordinating programmes, taking care of final assembling, and interacting with the markets. According to a recent study by Ecorys (2009), the current phase in vertical evolution of the Aeronautics Sector is characterised as creating a cooperative supply system. EADS, for example, initiated Vision 2020, which aims for increasing global sourcing, for market access, risk management, lower production costs, and access to rare resources. EADS aims to outsource 50% of the aerostructures work to risk-sharing partners for the A350, compared to 30% with the A380 (Financial Times, 14 July 2008). Suppliers are involved in the design and development of new products. More responsibilities and associated risks are increasingly shifted to suppliers, moving them up in the production chain from sub-system integrator to system integrator. Firms are linked together as suppliers, customers, partners, and even competitors of each other. As the primes are facing increasing financial pressure from airlines and the financial markets as well as from stronger competition from emerging countries like China, India and Russia, they will urge suppliers to reduce costs, improve the technological level and guarantee higher quality and service levels (ACARE, 2009; Ecorys, 2009). On the one hand, they source products through open IT platforms allowing suppliers to compete openly (Montalvo et al.

2006). This increases competition for suppliers stimulating innovation. On the other hand, primes are seeking for long term, stable and reliable relationships with fewer suppliers and are even outsourcing the design and manufacturing of entire components to external suppliers (e.g. the wing of the Boeing 787) (ACARE, 2009; Murman et al., 2002; Ecorys, 2009). Consortia of competing suppliers are increasingly formed to share the risks of new developments. This is especially relevant for small and medium supply firms, otherwise they are simply too small to meet the prime's requirements. By passing on responsibilities and risks to suppliers and urging them to take over the role of sub-system integrators, the role of these suppliers to innovation has become more important. SMEs do not only need to improve their cost-efficiency, they also need to invest in R&D and innovation. This requires from these SMEs new capabilities and capacities (Mundt, 2007). More cooperation or even consolidation at supplier level is necessary to build up these capabilities. In the development of Galileo, the difficult position of SMEs in carrying risks and making pre-investments was acknowledged. The procurement rules were adapted in order to enable SMEs to participate.

Shifting activities to suppliers can bring efficiency advantages, but can also contain many risks. Coordinating the complex value chain of many suppliers turns out to be very difficult and prime manufactures have already faced serious delays resulting from problematic deliveries by suppliers. Supply chain management will increasingly become a crucial capability for the sectors.

High-tech and R&D intensive, but also conservative?

As mentioned before, the Space and Aeronautics Sectors are very R&D-intensive, with Space a bit more intensive than Aeronautics. Technological developments are essential ingredients to improve the competitiveness of the sector. However, the question is whether the extensive R&D activities can also lead to truly radical and breakthrough innovations. Especially aeronautics finds itself in the specific phase of Utterback's (1996) classification of innovation life cycles. The specific phase is characterized by the existence of a dominant design (Murman et al., 2000). The aircraft configuration of present aircrafts looks rather similar to the first jet commercialized in the 1950s. This dominant design is the result of critical technology breakthroughs stemming from military investments during World War 2. Innovations in the development of an aircraft have resulted in substantial improvements of performance and a sharp decline in the costs. Developments in aerodynamics, structures and materials, control systems and propulsion technology have been the main contributors. The shift from aluminium to composite materials is already a major change and will continue with developing the functional applications of composites (e.g. structural health monitoring and repair, noise reduction and shape control). Nevertheless, the sector is a rather conservative industry, focusing on continuous improvement of conventional configurations mainly incremental and process-oriented innovations, which are often integrated in existing product lines.

There are various reasons for this orientation on incremental and process innovations. Current air- and spacecrafts are complex systems with many interdependencies and even small modifications can be a complex and costly undertaking. This means that the industry tries to reduce the huge risks as much as possible by concentrating on multi-applicable technological solutions, developing systems of relationships and by focusing on specific niches. Another reason is the long break even periods and the small markets. National markets are simply too small to reach break even, but many governments impose direct and indirect barriers on the acquisition of aircrafts, limiting market expansion. The sector's cash flow profile is rather problematic because of heavy investments in the long development process and returns only available in the long term. Only very large firms can work under such cash flow patterns, leading to a small number of large prime contractors. Under these conditions, the need for radical innovations is seen as less urgent. Another important issue is the importance of standardisation and regulations. Driven by strict security and safety requirements, the industry has to deal with very detailed international certification procedures to meet airworthiness standards for aircrafts and components. These strict procedures can limit the possibilities for fast adoption of more radical technological solutions (Ecorys, 2009; EC, 2009a).

Although the incremental innovations are leading, the Aeronautics Sector also sees the need for breakthroughs in aircraft configurations and types, especially to address the need for environmentally friendly aircrafts. New technologies are developed in various sub disciplines, including aircraft configurations, aerodynamics, structures and materials, propulsion, fuels, and aviation and navigation.

Box 2.6 Largest R&D spending companies in the Space and Aeronautics Sectors

The EU Industrial R&D Investment Scoreboard present annually R&D spending data for 2000 companies from EU and non-EU countries reporting major R&D investments. EU companies include the parents companies that have registered offices in an EU country. This scoreboard includes data on the R&D financed by the company's own funds and excludes government funding for industry R&D activities. Table 2.17 presents the top 10 EU and non-EU companies in Aerospace and Defence. The European Aeronautics Defence and Space Company (EADS) is by far the largest R&D performing company in Europe and invests also more in R&D than Boeing, the largest R&D spending company outside Europe. Although EADS has its registered office in the Netherlands, the R&D activities take place in other European countries. Finmeccanica is ranked second in the EU list of companies and spends EUR 800 million more than the number two on the non-EU list, the US company United Technologies. Both EADS and Finmeccanica belong to the top 20 largest R& spending companies in the EU; seven European Space and Aeronautics companies belong to the top 100 of largest European R&D performing companies (see also Table 1.19). Compared with the Scoreboard of 2005 (reporting on 2004), there have been some changes in the ranking. Finmeccanica, SAFRAN (Snecma in 2005), Rolls-Royce moved up one or two places, but BAE Systems lost 5 places in the ranking, with sharp decreasing R&D expenditures from EUR 1,568 million in 2004 to EUR 239.62 million in 2007. Three companies included in the top 10 were not included in the 2005 Scoreboard. Finmeccanica is by far the most R&D intensive organisation, with regards to the R&D/Net Sales ratio and the amount of R&D per employee. The sharp decline in R&D expenditures by BAE Systems has also impact on the R&D intensity; its R&D/Net Sales ration dropped from 12.2% in 2004 to 1.2% in 2007.

Eight of the ten largest R&D spending companies outside Europe are registered in the United States of America. The other two companies are located in Canada and Brazil. The Brazilian company EMBRAER was not included in the ranking of the 2005 Scoreboard. The positions of the other companies in the ranking have not changed that much compared with 2004. The largest R&D spending companies in the USA are less R&D intensive than their European counterparts. They spent a smaller share of the net sales on R&D and their R&D expenditures per employee are also lower.

Table 2.17 Largest R&D performing companies

				R&D Investment	Net Sales	Employees	R&D/ Net Sales Ratio	R&D per Employee
Rank (2004)	**Company**	**Rank in top 1000 list EU**	**Country**	**2007**	**2007**	**2007**	**2007**	**2007**
European companies								
				EUR M	**EUR M**	**#**	**%**	**EUR thousand**
				8.093.89	**126,391**	**519,148**	**6.4**	**15.6**
1 (1)	EADS	12	The Netherlands	2,701.00	39,123	116,493	6.9	23.2
2 (3)	Finmeccanica	16	Italy	1,955.00	11,916	58,700	16.4	33.3
3 (4)	SAFRAN	30	France	887.00	11,494	52,515	7.7	16.9
4 (6)	Rolls-Royce	40	UK	618.12	10,123	38,600	6.1	16.0
5 (5)	Thales	43	France	584.00	12,296	61,195	4.7	9.5
6 (na)	Dassault Aviation	72	France	265.03	4,085	12,136	6.5	21.8
7 (2)	BAE Systems	78	UK	239.62	19,482	83,000	1.2	2.9
8 (8)	SAAB	110	Sweden	147.73	2,436	13,337	6.1	11.1
9 (na)	Zodiac	113	France	145.19	2,478	17,402	5.9	8.3
10 (na)	MTU Aero Engines	180	Germany	88.80	2,576	7,092	3.4	12.5
Non-European companies								
		Rank in top 1000 list non-EU		**R&D investment 2007**	**Net sales 2006**	**Employees 2007**	**R&D / Net sales ratio 2007**	**R&D per employee**
1 (1)	Boeing	19	USA	2,633.26	45,406	159,300	5.8	16.5
2 (na)	United Technologies	49	USA	1,147.69	36,879	225,600	3.1	5.1
3 (2)	Lockheed Martin	61	USA	824.86	28,632	140,000	2.9	5.9
4 (4)	Northrop Grumman	125	USA	367.29	21,909	122,600	1.7	3.0
5 (5)	Raytheon	133	USA	343.35	15,339	72,100	2.2	4.8
6 (6)	General Dynamics	154	USA	294.11	18,668	83,500	1.6	3.5
7 (8)	Rockwell Collins	188	USA	237.34	3,020	19,500	7.9	12.2
8 (7)	Goodrich	225	USA	191.51	4,470	23,400	4.3	8.2
9 (na)	EMBRAER	237	Brazil	177.64	3,588	23,734	5.0	7.5
10 (9)	Bombardier	377	Canada	95.07	11,973	59,385	0.8	1.6

Source: EU Industrial R&D Investment Scoreboard 2008

Also in Space, current mechanisms seem to address mainly incremental innovations (Summerer, 2009). The space market is a quasi monopsony market with a governmental monopsonist. Governments control most space activities, mainly because of the strategic importance of some space-based services and space assets. Enhancing scientific knowledge and the importance of space activities for stimulating innovation and high technology developments, also in other sectors, are important reasons as well. Space is a risky business, leading to a risk-adverse culture, which leaves little freedom for innovation that is not strictly needed for achieving mission success. Moreover, there are very high entry barriers and the very lengthy processes between new concept and its implementation in a space mission and few flight opportunities leave little freedom for new ideas, technologies and methods. This leads to mainly incremental innovations. This effect is further strengthened by the lack of essential ingredients for a free, competition-driven, commercial market, and thus also innovation-stimulating effects. Although institutional funding is relatively stable, a real market is absent; hence, there is no incentive for industrial and private sector investments in innovation. Summerer (2009) argues that during the last 25 years not a single radically new major programme has been introduced into the governmental space sector. And this, according to Summerer (2009), will likely continue in the coming years. This is because the basic assumptions are still valid: Space activities are of strategic importance and very expensive and there are not enough sufficient commercial incentives for the private sector to make the required upfront investments.

Nevertheless, there are some signs that disruptive innovations can occur. A good example is the development of very small satellite. They are much simpler and cheaper to build, address a different, still marginal, market, are non-competitive in the traditional space market, offer lower profit-margins, but offer new freedom for new entrants with new business models. Another disruptive innovation area is the development of fully private space activities: space tourism and sub-orbital space flights, which are developed in a radically new approach by entrepreneurs (Summerer, 2009)

Service innovation

While it takes at least 10 years to develop a new space- or aircraft, these aircrafts are then normally produced for 25-20 years and services for another 30 years. The life-cycle of an aircraft model is hence as along as 70 years (TuE, 2007). This also implies a long service and support life. As maintenance expenses during the long life-cycle of aircrafts are much higher than the acquisition price, aircraft operators are seeking for solutions to decrease the maintenance costs. They used to have in-house maintenance facilities, but aircrafts operating companies are increasingly focusing on their core activity of running aircraft fleets. Aircraft operators are increasingly transferring the maintenance and support activities to manufacturers and independent MRO providers. Manufacturers are offering now combined offerings of a product and customised services. A good example of this is Rolls-Royce which offers fixed costs maintenance, whereby operators pay for the hours they fly a plane and Rolls-Royce provides a specified level of service. Rolls-Royce uses real-time engine diagnostics allowing managing the engine on-wing and reducing the time engines to be in the workshop (Aviationtoday, 1 June 2006). Over 50% of Rolls-Royce’s sales come from maintenance services (Shifrin in Aviation Week, 2007). This combination of physical products with add-on services such as maintenance has been an important trend in the past and is expected to continue. Systems assemblers, increasingly move to the provision of customised life cycle support services and solutions, often through partnerships with others. But this also means that producers retain operating risks of the products they sell. However, such business models might help customers adopt more innovative and risky products, posing a potential stimulus for innovation, as risks for customers can be managed.

Box 1.6 Maintenance, Repair and Overhaul
In 2007, 52% of the all MRO activities were outsourced by aircraft operators, but in engines even 75% was outsourced. Of these 75% outsourced MRO, OEMs were had the largest share with 44%, while independent MRO providers had a share of 13% and Airline Third Parties were responsible for 18% (Michaels, 2008). According to a study by the US Office of Aerospace and Automotive Industries (2008) the introduction of composite parts in new aircrafts will decrease the amount of maintenance work required. However, in the engine MRO segment, demand is expected to increase as new engine technologies are increasing the costs of maintaining the engine. Moreover, demand for MRO services of all kind will grow in Asia, due to the strong increase in air traffic in this region. This is confirmed at the North American MRO Convention in 2008 (Doan, 2008).

Another example of the further integration of products and services is the development of Space ‘hardware’ in combination with new applications and services in downstream markets. The European Galileo network for navigation and positioning, for example, is developed in coordination with the development of new applications using this network.

Central role of government as sponsor, customer and regulator

The national and European governments play a central role in the Space and Aeronautics Sectors. The governments are at the same time customer, regulator and sponsor. Governments are customer as they develop procurement programmes for their military and space needs. Governments are regulator as they are responsible for the broad set of regulations relevant to the sector. These regulations concern for example safety, environment, trade issues and ‘single sky’ issues. The governments are also sponsor as they provide a substantial amount of funding for R&D and innovation in the sectors.

Public subsidies to innovate are very high when compared with other sectors. To some extent, this is because of R&D and innovation for defence and other institutional clients. The main rationale for public subsidies is the need for large scale, capital intensive, long term research programmes with medium to high risks and substantial spin-offs to other sectors. European programmes are very important. Especially in the three leading aerospace countries (France, UK and Germany) national governments perceive national R&D subsidies crucial as a complement to European subsidies and for giving their national firms a ‘head start’ in technology trajectories. This mainly concerns sectoral, vertical programmes, as opposed to many other sectors that benefit from horizontal programmes and support schemes (Reid and Peter, 2008). Nevertheless, the possibilities become limited with EU single market rules and WTO rules. The share of institutional customers and funding in the total sales of the Space and Aeronautics Sectors has been decreasing for several decades now, despite some incidental increases. However, the decrease of institutional and in particular military budgets has stimulated the development of dual use technologies (used for both defence and civil applications).

Experts see public money in the form of subsidies and grants as the only way to stimulate innovation in the sectors (Cleff, et al., 2008), This is also reflected in the way how innovation is financed in the commercial and military segments. The military often pays firms up front to develop a new product compared to the commercial sector where R&D investments have to be earned back on the product. This passing of risk to the customer in the military segment allows much more risky / innovative projects, which generate spillovers to civil applications as well. However, while institutions can take this risk, commercial actors are unlikely to do so, posing a barrier to innovation in the commercial segment. One third of companies face problems due to high innovation costs. About 26% of the companies perceive economic risks as excessive, while 20% of the firms see a lack of appropriate sources of financing (Hollanders, et al., 2008). Internal financing of innovation is problematic for firms failing to significantly yield more than the average 5% operating surplus (Cleff, et al., 2008). Venture capital and bank loans are not really an option. The long technology and product development times pose a substantial business risk as investments can often only be recovered after years of development. This makes it very unattractive for private, commercial investors. As a result, firms rely on public programmes to finance innovation.

ECO efficiency

Society and governments in general consider aviation as very polluting sector, putting much pressure on the Aeronautics Sector to limit the environmental impact of aviation and to improve the eco-efficiency. On the one hand, aircrafts should become more energy-efficient, using less fuels and using alternative fuels. On the other hand, aircrafts should produce less CO2 emissions and noise. The United Nations intergovernmental Panel on Climate Change (UN IPCC) estimates that aviation is responsible for 2% of worldwide man-made CO2 emissions and this share could increase to 3% in 2050, given the expected strong increase in air traffic. Using less fuel and lowering the expenses on fuel is not only in the interest of the global climate, but is a main priority for airlines and aircraft manufacturers, as fuel covers 30 to 40% of an airline's operating expenses (Airbus, 2007b). Strong business performance and strong environmental performance are two sides of the same coin. Aircraft operators and manufacturers have to work with a broad set of strict regulations and standards concerning noise and emission levels. The European Commission has extended the EU Emissions Trading Scheme (ETS, will apply from 2012 on) to aviation and this puts additional pressure on airlines to improve their eco-efficiency. The societal concerns as well as the strict regulations urges the Aeronautics Sector to develop cleaner and quieter aircrafts with a greener life cycle from design and manufacturing to dismantling and recycling. In this way, eco-efficiency is a main driver for innovation in the Aeronautics Sector. Eco-efficiency is the main priority in the Strategic Research Agenda of the Advisory Council for Aeronautics Research in Europe. European aeronautics companies are working together with universities, research organisations, airlines and other stakeholders in the major Joint Technology Initiative Clean Sky aiming at reducing emissions and noise. Another initiative SESAR focuses on developing a new pan-European Air Traffic Management system, which should contribute to more flight efficiency. The industry is also working on alternative fuels, like second and third generation biofuels, but also hydrogen and fuel cells. In addition, research efforts focus on, aerodynamic improvements, improved propulsion systems, next generation composite materials, and nanotechnology in devices used in aircrafts (Airbus, 2007b; Boeing, 2008a).

Climate change is not only forcing manufacturers to build cleaner and quieter aircrafts, but it provides also opportunities in the satellite market. Decision makers and the public increasingly ask for sound data on the environment coming from earth observation and remote sensing applications. This will stimulate the development of new technologies and applications for earth observation and remote sensing (OECD, 2008).

3 Carriers of innovation

3.1 Workforce and talent

The ASD (2008) presents a breakdown of the employment in the European Aeronautics industry by activity. 57% of the employees in the Aeronautics industry work in production and 20% work in R&D. Taking into account the breakdown by qualification; data show that highly skilled jobs including graduates, engineers and managers represent 35% of all jobs in the Aeronautics Sector, followed by manual workers who account for 33% of all employees. Another 32% of the employees has an education below university level and includes technicians, draughtsmen, craftsmen, secretaries, etc. Employees in the Space Sector in general have higher qualification levels than in the Aeronautics Sector. According to ASD-Eurospace (2009), 53% of all employees in the Space Sector have at least a master's degree, while 22% have a bachelor's degree from university. 13% of the employees received an education at a Higher Vocational School. The workforce in the Space sector is dominated by older men; 77% of the employees are male and two-third of the men is older than 40 years, while 32% is older than 50 years.

The data from ASD and ASD-Eurospace show that knowledge is of key importance to the Space and Aeronautics Sectors. According to Hollanders et al. (2008), the sectors are characterised by strong knowledge accumulation and research capital is the sole driver of innovation in these sectors. Based on the Revealed Technological Advantage[4], European countries including Austria, Italy, Spain, Germany, France and Sweden have technological leadership in the Space and Aeronautics Sectors. Moreover, human capital and high skilled employees contribute to the improved total factor productivity growth through innovation. Especially the combination of formal skills acquired in education and learning on the job (occupation) makes the largest contribution to innovation and productivity growth.

Despite this strong knowledge accumulation and technological leadership, the Space and Aeronautics Sectors face some important challenges with regard to the workforce. The main worry is about skill shortages, especially in relation to engineers (Ecorys, 2009). The UK Sector Skills Council for Science, Engineering and Manufacturing Technologies (SEMTA) prepared a Sector Skills Agreement for the UK aerospace industry in 2006. This Sector Skills Agreement describes the current state of the UK aerospace industry and analyses the workforce development and skills requirement in the sectors. The analysis shows that the present workforce is ageing and many employees will retire within five to ten years time. At the same time, replacement by younger engineers is problematic because the supply of newly educated engineers is decreasing and the younger and more experienced engineers are in high demand in all manufacturing sectors. In the United Kingdom, the study reports hard-to-fill vacancies for professional engineers, skilled trades (craft) and machine operatives. There is especially a lack of good qualified applicants with work experience. The industry reports skills gaps, especially in management, professional, craft and operator/assembler levels. Skills gaps for technical engineering

[4] Revealed Technological Advantage compares the share of Aerospace patents in total patents for a given country with the same share for all countries in the sample.

skills are the most significant. The supply of young people will be insufficient to meet the necessary skills requirements, which implies that it is also needed to focus on upskilling and effective redeployment of the adult workforce. The insufficient supply of highly skilled and experienced staff will be further accentuated by the move of higher value added workload from first tier companies and OEMs to Tier 2 companies. Leading first tier aerospace companies and OEMS are reducing the proportion of operators in their workforce mainly through changes in technology and working practices. The trend towards high performance and lean working will put pressure on Tier 2 companies and below to deal with more higher value added workload, which will require more high-grade technicians and graduate skills.

Technical skills are essential to the sectors, especially the following technical skills are considered as important by the UK Space and Aeronautics Sectors:

- Software systems, modelling and simulation, especially for navigation, flight, weapons and radar;
- Systems design and modelling, advanced manufacturing design and simulation, advanced electrical systems design;
- Systems and systems integration including more complex high integrity systems;
- Advanced materials engineering and assembly techniques;
- Diagnostic and prognostic techniques;
- Skills to support emerging technologies, particular in relation to regulatory requirements for fuel efficiency, safety and emissions.

With regard to the more personal and generic skills; the sectors foresee the following skills requirements:

- Communication skills;
- IT skills;
- Customer handling skills;
- Team working skills;
- Supply chain management skills;
- Project management skills;
- Process excellence skills and lean manufacturing skills.

The industry also acknowledges that the sectors might be not so attractive to applicants. Employment in the sectors is often considered as insecure, mainly because of the highly cyclical nature of the sectors and the dependency on external events (e.g. government spending, security and safety incidents) (SEMTA, 2006; AIA, 2008; Ecorys, 2009). Labour costs are high in the sector and are an important instrument in lowering the productions costs. Especially relevant is labour flexibility. Although, national labour policies in Europe can make it difficult to adapt the workforce size to the production levels, European firms have increased the number of temporary contracts and systems for exchanging employees between firms. In addition, firms have automated substantial parts of their operations. Another attempt to reduce costs and the vulnerability to exchange rates is to offshore work to cheaper locations, resulting in a loss of medium and low-skilled employment (Ecorys, 2009).

To address the skills gaps and lack of engineers, several actions are needed. The Aerospace Innovation and Growth Team (AeIGT) in the UK has identified the following actions to address the skills gaps in the UK Space and Aeronautics Sectors:

- Enhance continuous learning practises throughout the industry;
- Communication with universities to supply undergraduates with an appropriate foundation of skills;
- Adoption of an aerospace-oriented technician apprentices programme to supply appropriately trained technicians;
- Establishment and enhancement of Teaching Centres of Excellence to provide specialised post-graduate training and continual professional development to industry personnel;
- The fostering of a certified high standard of engineering through Professional Registration of appropriate technical personnel.

To support the match between supply and demand, to attract workforce and to strenghten the motivation of young academics, more cooperation between various stakeholders is needed. Aerospace clusters offer opportunities to develop and expand cooperation in cross-sectoral and transnational education and training programmes, in programmes to exchange trainees, and in cros-sectoral and transnational workforce recruitment.

Box 3.1 Hamburg Qualification Initiative

In 2000, the Hamburg aviation cluster established the Qualification Initiative Aviation Industry, which aims to develop the supply of a skilled workforce to the Aeronautics industry in short, medium and long term. In this initiative, universities, vocational training institutes and industry collaborate to develop new ways of recruiting and new, international programmes for education and trainingand to create a large number of apprenticeships for aeronautics engineers. The Qualification Initiative is also focusing on transnational cooperation. It established an exchange of training programmes and trainees between the aeronautics clusters of Hamburg and the French Aerospace Valley of the Midi-Pyrénées and Aquitaine (http://www.luftfahrtstandort-hamburg.de/index.php?id=67&L=1).

Box 3.2 European Student Aerospace Challenge

In 2006, the European Student Aerospace Challenge was initiated by Dassault Aviation and student associations and was soon joined by Astronaute Club Europeen (ACE), EADS, ESA, Safran, Thales, GIFAS, as well as the International Astronautical Federation (IAF). The European Student Aerospace Challenge started as an answer to the problem of attracting highly skilled young engineers to the sectors. It aims to bring students and the industry together, to train students in team-working and project-leading skills, and to offer students the experience of working on an ambitious large scale project. The subject of the Challenge was initiated by the ACE and focuses on designing and developing a new suborbital craft. The Challenge is basically a contest among students and their universities and schools, working on various parts of the suborbital crafts. The best projects win awards. In 2006-2007, 15 teams with 82 students participated, while in 2007-2008 16 teams participated with 103 students. In 2008-2009, 15 teams with 80 students are involved (http://www.studentaerospacechallenge.eu/).

3.2 Customers, users and consumers

The Space and Aeronautics Sectors have very different types of customers. The two main types of customers are institutional and commercial customers. Institutional customers include governmental agencies at European, national and regional level (e.g. ESA, national space agencies). Institutional customers can order products and programmes for civil and military applications, while commercial customers are active in civil applications.

The role of institutional customers has always been substantial. In Aeronautics, the share of government customers in the industry turnover amounted to 50% in the 1980s, but since the 1990s this share has dropped to around 19.3% in 2008 (ASD, 2009). In Space, however, institutional customers remain the first and their share is stable at around 60% of the industry sales. In Aeronautics, the military segment has lost market share over the past 30 years, while the civil market segment has increased its share from 30% in 1980 to 60.1% in 2008. In Space, the sales from military programmes have grown significantly, from EUR 0.5 billion in 1999 to a little over EUR 1 billion in 2008. This growth was mainly supported by major applications such as telecommunications (Sicral, Syracuse, Skynet) and observation (SAR-Lupe, Helios). Military programmes have a share of around 30% in the total turnover in Space coming from institutional programmes (ASD-Eurospace, 2009). Table 3.1 presents the division of turnover for the various types of customers in Space and Aeronautics.

Table 3.1 Turnover in space and aeronautics, by customer and application

Aeronautics turnover in EUR million (2008)	97,300	Space turnover in EUR million (2008)	5,885
Institutional	19.3% = 18,779	Institutional: 60% = 3,531	Civil: 68% = 2,401
Commercial	80.7% = 78,521		Military: 32% = 1,130
Civil	60.1% = 58,477	Commercial: 40% = 2,354	
Military	39.9% =38,823		

Source: ASD, 2009; ASD-Eurospace, 2009

The role of institutional customers, especially in the military market segments, as procurers of leading edge technology have an important impact on innovation in the sectors. In the military segment, 56% of the R&D funding comes from governments, while in the civil market segment 85% of the funding comes from the industry. Military customers have often been a lead user and are most interested in obtaining a performance advantage and technical lead and preserving national security. For civil customers, the needs are very different and these customers are mainly focused on safety, reliability, comfort, efficiency and life-cycle cost reductions.

Table 3.2 highlights the needs of customers for the two sectors Aeronautics and Space for civil and military applications.

Table 3.2 Needs of customers by sectors and potential for lead market

	Aeronautics	Space
Civil	Airlines / leasing firms are main customers: main focus on safety, comfort and life-cycle cost reductions → low lead user potential	Telecom firms / Research institutes are main customers for satellite launches: main focus on cost reductions and reliability → little potential as lead user
Military	National military: main focus on high performance, technical lead, national procurement → lead user	National military: main focus on leading edge technology, national procurement to preserve national security → lead lead-user

With the focus on leading edge, high performance technology the military segment provides the most opportunities for radically new innovations to originate. Furthermore, the military and space segment is willing to take higher risks to push out technology boundaries, providing a lead user role (e.g. small air vehicles, unmanned aircraft, space robots etc.). On the other hand the civil aircraft segment has low lead user potential as customers are risk averse in the sectors with commercial pressures aligned to realising efficiency gains compared to other segments. The exception could be 'green technology' (e.g. avionics, efficient engines, alternative fuels).

3.2.1 Aeronautics

Air traffic has grown over the last decades despite external crisis, such as the Gulf crisis, Asian Crisis, attack on WTC and SARS. Since 1970s the world annual traffic increased from 500 billion to 4,200 billion revenue passenger kilometres in 2006 (Airbus, 2006). Forecasts from ICAO, Boeing and Airbus predict an annual average passenger traffic growth of 4 to 5% per annum. Airbus (2007b), for example, predicts world traffic to reach 11,528 billion RPKs in 2026.

Airbus (2007b) expects that traffic growth will mainly come from hub-to-hub traffic and hub-to-secondary cities traffic. Growth from hub-to-hub traffic will mainly benefit from organic growth, generated by existing routes, while growth from hub-to-secondary cities will mainly benefit from new routes. Routes between secondary cities will not provide much growth opportunities. Nevertheless, Alenia Aeronautics, a European manufacturer of regional aircrafts expects that in the near future (beyond 2010) 50% of the take offs and landings in Europe will be made by regional aircrafts (Franzoni, 2008).

Although growth in air traffic is expected in the long term, insufficient capacity of airports and air traffic management systems can put limits on the air traffic growth in the short term. Also a worsened economic situation and more stringent environmental regulations and environmental charges can hinder the growth in air traffic.

Emerging economies stimulating traffic growth

A main driver for the growth in air travel is coming from emerging economies and especially from the Asia-Pacific region, already representing a share of 26% of the world traffic in 2005, but expected to increase this share to 32% in 2025 (Airbus, 2006). The Asia-Pacific region demand will take over the

North-America demand, which is currently the largest market for air travel. The growth in the Asia-Pacific region will mainly come from continued economic development of China and India, deregulation in India, continuing high traffic growth rates for domestic China and China's international outbound traffics, as well as the growing importance of Low-Cost-Carriers in Asia (Airbus, 2007b; Boeing, 2008a). Despite the high growth figures for Asia-Pacific air traffic, by 2026, the volume of traffic will still be larger in the US and Europe.

Asia-pacific airlines operate the world's largest long-range aircraft fleet and this will remain the most important type of aircraft in the future as well (Airbus, 2006). According to PWC (2006), manufactures see the Asia-Pacific market as a major market for new aircrafts. The major airframe and engine suppliers are not only interested in the Asia-Pacific market, but also in the local suppliers, because of low cost advantages. In turn, the governments in this region are interested in the OEMS, as it offers opportunities to procure work for and to develop their own local aerospace industries. These governments support the procurement of the new aircrafts, becoming risk sharing partners in the development of new aircrafts, but in return they will require from the OEMs that they outsource development and manufacturing to their own local aerospace industries. This will help improving the position of the local aerospace industries (PwC, 2006).

Box 3.3 Demand for air traffic in China

The Chinese market for air traffic is the fastest growing market worldwide. While in 2000 the number of passengers amounted to about 83 million, in 2007 this number reached already 202 million. In 2006, the China's fleet size was 600 airplanes; in 2009 this number has doubled. Also in the coming 15 years, China will remain the most important growth market for Chinese airlines, but also for European and American prime contractors. The number of airports is expected to increase from 97 to 197 and the number of passengers will likely increase with 14% annually. It is estimated that the number of large airplanes will rise to 3,088 and the number of regional jet will increase to 939 in 2020. An important factor that can hinder the development is the lack of lack of captains and pilots. Liberalisation of aviation offers opportunities for new, private airlines. The first private airline (Spring Airlines) was established in 2004 and is now the biggest private airline of China. These private airlines compete heavily with the large public airlines, mainly by cutting overhead costs, higher load factors, choosing efficient routes saving fuel, and using internet as booking system. The private airlines are developing into low cost carriers. Western manufacturers like Airbus and Boeing consider China as a growth market and establish joint-ventures and build new factories in China. Smaller manufactures see opportunities as well, mainly because of the creation of extra airports and extension of the regional aviation routes. The Western manufacturers have initiated training centres for training new captains and pilots. Nevertheless, serious competition could also be expected to come from China. China is developing its own aircrafts (AJR21), which is first of all a technological prestige project, but which could lead to serious competition for the Western manufacturers by the mid 2020s. The Civil Aviation Authorities of China (CAAC) is established by the Chinese government to ensure that the Aeronautics Sector in China remains a Chinese industry (Airbus, 2007; Boeing, 2008a; NRC, 2009; MacPherson, 2009).

The Middle East is also a fast growing market for aircraft manufacturers. Major investments are being made in transportation and visitor facilities and due to its central world location, the Middle East serves as a connection point for on-stop airline services. More over, the region serves as an important cargo traffic hub, with Europe as the largest air cargo partner. As a result, air traffic growth in the Middle East has been much stronger than the average growth rate (Boeing, 2008a; Rolls-Royce, 2007; Airbus, 2007b).

Rationalisation and the growth for Low-Cost-Carriers around the world

The major national airlines were the traditional major customers of aircrafts, but Low-Cost-Carriers are becoming major customers (PWC, 2006). The global market for air traffic is for 20% served by more than 100 Low-Cost-Carriers (LCC). In North America, LCCs have share of 23% and are still growing. In Western Europe the LCCs are beginning to mature with a market share of 30%, but there are growth opportunities on eastern and southern routes in Europe. In Latin America, LCCs have a market share of 20% and in Asia their market share increased drastically from less than 5% in 2004 to 12% in 2007. It is expected that Asian LCCs will especially grow on intra-Asian markets, depending on the pace of deregulation ('open skies') (Airbus, 2007). It is expected that the LCCs will grow 2% per annum faster than the global network airlines. Nevertheless, network airlines (global, major, small) will remain dominant with 75% of the total worldwide traffic. In addition to the LCCs, another growing customer group includes the aircraft leasing companies. Leasing is increasingly getting important for airlines, as traditional funding sources (cash flow and secured debt) are getting scarce (PWC, 2006).

Eco-efficiency is a main driver

With air travel contributing 2% of global man-made emissions (UN IPCC), aviation is under constant pressure from governments and society to improve the eco-efficiency of flying. Moreover, the increasing fuel costs force manufacturers to design aircrafts using less fuel. Fuel can account for 36% of the airline's operating expenses. Since 1987, the fuel consumption of the world fleet decreased with 37% (Airbus, 2007b). Also noise levels and emission of CO2 are important environmental impacts and the aircraft manufacturers have been able to reduce the levels of noise and emission drastically in the past 40 years (Boeing, 2008a; Airbus, 2007b). The aircraft manufacturers are involved in several initiatives and programme to improve the eco-efficiency of aviations. Airbus, for example, participates in the Advisory Council for Aeronautics Research in Europe (ACARE), which has ambitious goals for improving the eco-efficiency of aircrafts by 2020. Another initiative is Clean Sky, which is a Joint Technology Initiative, for developing cleaner aircraft technologies. Boeing spends 75% of the R&D expenditures on developing cleaner aircraft technologies (Boeing, 2008b). Efforts are not only put into developing cleaner aircraft technologies, but also in developing sustainable fuels and in improving air traffic infrastructure and air traffic management systems. Despite these efforts, pressure on industry to improve the environmental performance is growing. Society has often objections against new airports and runways. The European Commission wants to include aviation in the Emissions Trading Scheme, which allocates CO2 allowances for companies. It is estimated that the ETS would increase the operating costs of the airlines substantially. This could force airlines to replace their older aircrafts faster by newer, more energy-efficient aircrafts, but also to purchase larger planes to increase load factors, to change flight paths and to reduce flight speed.

Demand for different types of aircrafts

The prime contractors like Airbus and Boeing, as well as large subsystem integrators and suppliers of engines and equipment (e.g. Rolls-Royce) publish market outlooks with a time horizon of 20 years. The main trends in these various forecasts are rather similar, although the forecasts for specific types of aircrafts can differ a bit. Rolls-Royce (2007) expects that between 2007 and 2026 60,262 new aircrafts will be needed, mainly driven by the growth in air traffic and the need for replacing old aircrafts. The estimations by Rolls-Royce include all types of aircrafts from very light business jets to large freighters. Airbus and Boeing publish forecasts for aircrafts with 50 or more seats, ranging from regional jets and props to very large aircrafts. Table 3.3 presents the forecasts from Rolls-Royce, Boeing and Airbus for various types of aircrafts.

Table 3.3 Forecasts for aircraft delivery 2007-2026

Aircraft type	Rolls-Royce	Boeing	Airbus
Business Jets (total)	30,389	-	-
Regional aircrafts (up to 100 seats)	6,558		6,153
Single aisles (100 – 200 seats)	15,317		16,620
Twin aisles (total)	7,211		6,765
- Small twin aisles (200- - 250 seats)	2,829		3,867
- Intermediate twin aisle (300 – 350 seats)	3,338		1,615
- Large twin aisles	1,044		1,283
Freighters (total)	787		877
Total	60,262		29,538

Source: Rolls-Royce, 2007; Boeing, 2008a; Airbus, 2007b

The delivery of new aircrafts will be mainly driven by single-aisle and small and intermediate twin-aisle aircrafts, reducing the share of the smallest and largest airplane (very large airplanes) categories. Nevertheless, this does not imply a trend towards smaller airplanes. There is a trend towards larger aircraft in every segment (in terms of seat counts), mainly because of high load factors, growing congestion, rising fuel prices, and greater environmental pressures. Larger aircrafts offer better economic, are more eco-efficient, and offer greater capacity per take-off or landing slot (Airbus, 2007b).

New equipment is not only acquired to accommodate growth, but also to replace older equipment with more eco-efficient, comfortable and lower cost aircrafts. According to Airbus (2007b), about 35% of the passenger aircrafts leaving service are recycled and used by another airline, while 23% will be converted into a freight aircraft and 42% will be withdrawn from use. The large aircraft manufacturers have aircraft recycling programmes (e.g. PAMELA-LIFE), recycling the aircraft's equipment and materials as much as possible.

Taking all developments, requirements and market forces together, the demand from airlines and leasing companies ordering new aircrafts can be summarised as follows: Aircrafts should be absolutely safe, consume less fuel, have lower environmental impact, have lower operating costs, have a higher load factor, and offer more choice and comfort to passengers.

Openess of third markets

The world market for aircrafts, both civil and military, cannot be described as a real competitive market. There are extremely high entry barriers, mainly because of high development costs, long amortisation periods, high economies of scale, and high technological complexity of the products. Moreover, the Space and Aeronautics Sectors are considred as crucial to national security and technological leadership. There are strong interlinkages between the civil and military subsectors and the technological backbone of security systems are not available to the free market. In addition, governments point at positive spillovers to other industries and the contribution to establishing and maintaining a strong knowledge base. These specific characteristics of the Aeronautics markets induce governments to intervene. State intervention can come by means of regulation, standards and certifications, import tarrifs, and by means of direct and indirect financial support.

Both main ‘blocks’ in Aeronautics, i.e. Europe and the USA, intervene in the market with strategic trade policies. Several agreements exist to open up the markets, for example for the mutual recognition of certificates, but also for government funding. Nevertheless, there are also disputes between them, with several waiting for WTO judgement. Also Canada and Brazil have their disputes in relation to regional jets. The emergence of new competitors from China and Russia, where substantial state aid is used as well, can change the USA-Europe relationship and result in even more disputes between various countries. A particular important development is that system integrators seem to source for subsidies around the world by using their international networks of suppliers. These are also supported by their governments resulting in lower manufacturing costs, subsequently passed through to the system integrators (Ecorys, 2009).

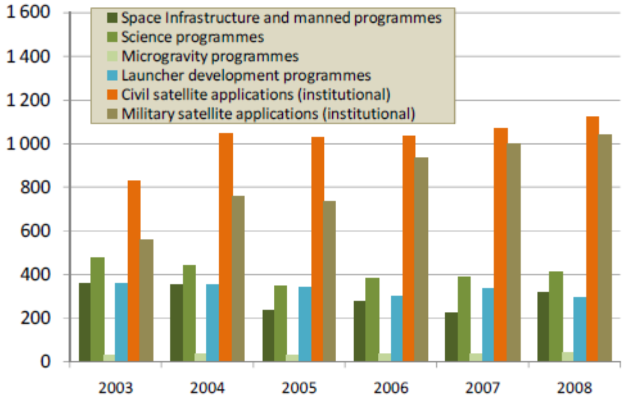
Disputes are very costly processes and more international cooperation and mutual recognition of standards, technical requirements, and certification is needed to reduce bureaucratic burdens and to enable free competition.

3.2.2 Space

The European institutional programmes are a major source for the European Space Sector, representing EUR 3,200 million sales. The expenditures by civil institutional programmes have been quite stable over the past 15 years, while the European military programmes and commercial programmes have been growing since 2003 (ASD-Eurospace, 2009).

The European Space Agency (ESA) is the main ‘customer’ of the European space industry and it has programmes in different activity areas, from satellite applications to launcher and scientific programmes. The European industry sells to ESA for an amount of EUR 1,500 million per year. Civil institutional customers also include other civil institutes, such as national space agencies, Eumetsat and the European Commission. The industry sells an average of EUR 700 million per year to these customers. Military institutional programmes represent a little over EUR 1,000 million of sales, mainly supported by major applications such as telecommunications and observation. Figure 3.1 presents the share of different types of institutional programmes in turnover in the period 2003-2008. The share of satellite applications, especially military, has grown considerably over the past five years, while the scientific programmes have been stable (ASD-Eurospace, 2009).

Figure 3.1 Institutional programmes by type, 2003-2008

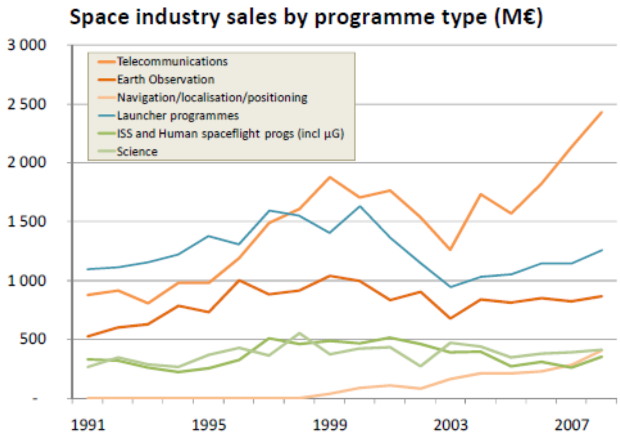


Source: ASD-Eurospace, 2009

Commercial customers include private satellite operators and telecommunications providers that procure from the European industry satellite systems and pay-loads, provided by commercial space transportation companies like Arianespace and other launch operators. Commercial customers represent a space industry sale of about EUR 2,500 million in 2007. This is still behind the turnover realised in 2000 (EUR 2,800 million), after a sharp decrease in the turnover from commercial programmes in 2002.

When looking at the type of applications and programmes, the European space industry was historically based on scientific satellites and launchers. However, satellites for telecommunications applications have become the main source of revenue for the industry. Figure 3.2 presents the sales in the Space Sector by application and programme type. The satellite applications programmes have the largest market share with EUR 3,800 million sales in 2008. Satellite programmes include telecommunication satellite systems, earth observation systems and navigation / localisation programmes. Launcher programmes represent EUR 1,250 million sales and are slowly growing, after a sharp declining at the beginning of the century. Launcher programmes include launcher development programmes, almost exclusively financed by ESA, and operational launch systems, mainly related to Ariane and Arianespace. Scientific programmes are mainly funded by ESA and include satellite systems for earth science and astronomy, spacecrafts, landers and probes for exploration, space station elements, as well as ISS and human spaceflight activities and microgravity experiments.

Figure 3.2 Space industry sales by programme and application type



Source: ASD-Eurospace, 2009

The OECD publication (2005) 'Space 2030' discusses the main trends in space. According to this study the future demand for space applications will be substantial. Especially the downstream segment (space applications) has much better prospects with increasing commercialisation and the increasing demand for satellite services in the areas of earth observation, navigation and telecommunications. Information intensive activities are generally perceived as bright, but prospects of transport and manufacturing activities are uncertain as they depend on the costs of access to space, which is unlikely to fall (OECD, 2005, p.14). The upstream segment suffers from chronic over-supply with higher launch capacity than annual launches and with launch costs not expected to fall in the future, this problem is likely to persist. The same conclusion was drawn by the European Commission in 2004 (EC, 2004).

Factors driving demand especially in downstream segments are related to societal challenges where space applications can help measure effects, monitor and increase effectiveness (OECD, 2005; OECD, 2007b). Societal challenges refer to environmental degradation including natural resources such as water, forestry, but also climate change, related challenges such as the mobility challenge posing high environmental costs, and a perceived need to improve security (terrorism, rouge states). Applications in this context refer to Earth Observation (EO) and Global Navigation Satellite Systems (GNSS). The OECD highlights the role of space applications for monitoring the environment, managing energy use, water management, precision agriculture, the mobility challenge, security and the information economy. Earth observation can for example be used to select locations for renewable energy, assess and monitor water resources, increase the effectiveness of forestry and prevent deforestation, help farmers to monitor crops, monitor treaties and hazardous goods, and help in disaster relief and prevention. In combination with GNSS, applications are thought to tackle the mobility challenge, by increasing productivity, reducing congestion, noise and unnecessary pollution in transport (OECD, 2005).

Global navigation satellite systems (GNSS) allows small electronic receivers to determine their location (longitude, latitude, and altitude) to within a few meters using time signals transmitted along a line-of-sight by radio from satellites. As of 2009, the Global Positioning System (GPS) (USA) is the only fully operational GNSS. The Russian GLONASS is in the process of being restored to full operation. China has indicated it will expand its regional Beidou navigation system into the global COMPASS navigation system by 2015. The European Union's Galileo positioning system is in initial deployment phase, scheduled to be operational in 2013.

An important difference of the European market compared to the global market for space-based applications is the smaller size and the lower specialisation of the private sector, and the absence of a defence industry setting initial standards and activities (Euroconsult, Helios and Bertin, 2007). Nevertheless, according to Euroconsult, Helios and Bertin (2007), Europe is overall well-positioned to develop new GNSS based applications in several segments, especially in road telematics and fleet management, as R&D for Galileo receives more attention. The analysis is furthermore optimistic for markets of (personal) location based services, presuming high involvement of European MNE's. The study considers the new EU member states to be important drivers for economic growth (by uptake of satellite navigation applications), a strong position for road applications and growing interest in Galileo R&D. A threat is the reluctance of business angels to step in, the maturity of some market segments, the obduracy of foreign (especially US) markets, the threats posed by social concerns such as privacy hindering novel satellite based applications. (Poliakov et al., 2008, p. 11)

Earth Observation (EO) is an aspect of space applications that is technologically mature (OECD, 2005). It deals, broadly speaking, with the acquisition and exploitation of data acquired from remote (aircraft or satellite based) observations of the Earth. It covers a diverse range of remote sensing applications, including weather forecasting, the environmental monitoring area, surveillance, as well as numerous applications in the atmospheric, land and ocean domains. Optical imagery includes both Very High Resolution and Medium Resolution market segments. The global remote sensing market is estimated at USD 7,300 million, including USD 1,900 million for Earth imagery (Peter, 2008). Europe's share is estimated at EUR 400 million. The upstream sector for Earth Observation is predominantly institutional, depending on public funding. Commercial observation satellites are often developed in Public Private Partnerships, also depending on public funding. The downstream EO service industry is an extremely diverse industry, comprising companies that work with raw or semi-processed data from remote sensing instruments and converts these data into information that brings value to end-users. The dominant profile of the companies is typically a small, specialised organisation that focuses in one or two thematic and geographical areas with small but growing profitability (Poliakov et al., 2008). There only a few large firms, acting globally (Technofi, n.a.). Mature EO markets are in agriculture and energy, but important growth markets are homeland security and professional meteorology. Emerging EO markets include consumer services (e.g. Google Earth), disaster management, environment monitoring, forest resources, marine engineering and humanitarian relief, although these markets still depend a lot on government funding (Technofi, n.a.).

The satellite telecommunication is by far the most important market for the European satellite manufacturing industry, representing 60% of satellite activities in Europe (ESA, 2009). For example, 62 of the 82 satellites launched by Ariane-5 by the end of 2008 were telecommunication satellites. In 2008, 25 new satellites were ordered, of which two-thirds will replace old satellites and one-third addresses the growth of existing services and the emergence of new services. The satellite services market is made up of three sectors: Direct Broadcast Services, Fixed Satellite Services and Mobile Satellite Services. Satellite telephony and direct broadband services represent 75% of the total worldwide satellite services revenues. Table 3.4 presents the worldwide revenues of satellite services in 2007.

Table 3.4 Global commercial satellite services revenues, 2007

Satellite service	Revenue in USD million
Direct Broadcast Service	57,500
Fixed Satellite Services	14,300
Mobile Satellite Services	2,100

Source : Peter, 2008

Direct Broadband Services consists of direct-to-home television and satellite radio services and represents the largest portion of commercial satellite services. High Definition Television is a major driver in the demand for satellite capacity for new services. Satellite radio is also a fast growing segment, mainly due to the increasing availability of receivers in automobiles, mainly in the US. The Fixed Satellite Services is the most mature market in the satellite industry. Most of the revenues come from the leasing of transponder capacity to commercial and governmental customers for video distribution and broadcasting, as well as high-speed data distribution and internet access. There is high demand in Europe, the Middle East, North Africa, but also in some sectors of the North American market. New national operators that are launching their first satellites are also emerging. The operators have consolidated and four biggest operators (SES, Intelsat, Eutelsat, and Telesat) represent 72% of the global market for Fixed Satellite Services. Mobile Satellite Services include voice and data services using a network of one or more satellites in low-Earth orbit (LEO) and geostationary orbit (GEO). Growth in mobile satellite services is driven by a growing demand for TV and broadband, as well as voice and data services. There are global operators as well as regional operators providing voice, data and paging services. Mobile Satellite Services will increasingly converge with wireless and terrestrial solutions, leading to integrated voice, data and video products (Peter, 2008; Rathgeber, 2009).

Commercial space travel is a very small scale market for space travel, starting with a number of civilians participating in Russian space missions. More affordable suborbital space tourism is perceived commercially viable by several companies, including Space Adventures, Virgin Galactic, Starchaser, Blue Origin, Armadillo Aerospace, XCOR Aerospace, Rocketplane Limited, the European "Project Enterprise", and others (Law-Green, 2007). Most companies are proposing vehicles that make suborbital flights peaking at an altitude of 100-160 km. Passengers would experience three to six minutes of weightlessness, a view of a twinkle-free starfield, and a vista of the curved Earth below. As of November 2007, Virgin Galactic had pre-sold nearly 200 seats for their suborbital space tourism flights. These developments suggest that we are seeing the birth of a nascent commercial space tourism industry, although the way ahead appears very uncertain, with a wide range of economic, technological, political, legal, environmental, financial and commercial issues eventually shaping the rate and direction the industry takes (Crouch et al., 2009).

The turnover from European military programmes in the sector has doubled between 2003 and 2008, amounting to a little over EUR 1,000 million sales in 2008 (ASD-Eurospace, 2009). Since September 11th the security situation has again changed around the globe with growing military expenditure. With emerging powers building up considerable military capabilities (China), and Russia rebuilding its defence sector, a trend towards a multi-polar world is likely to drive future military spending. In the military segment the US can be seen as the technological leader with US agencies as lead users. One of which being the 'Defense Advanced Research Projects Agency' (DARPA) exploring leading edge technological possibilities for military use. However, the US military segment is often restricted to US firms for security reasons, in addition to strict export rules. At the European level, a single military market is lacking, mainly because of separate national programmes targeting national space industries only. At the European level joint public procurement is developed as a tool to stimulate the development of the military segment in Europe in order to counteract this disadvantage compared with the US market.

3.3 Organisations

The Space and Aeronautics Sectors are international sectors, with global sourcing networks and strong international competition. Institutional actors play an important role, as customers, regulators and financers. Moreover, activities in the Space and Aeronautics sectors are concentrated in a few European Member States and regions, around large system integrators with many smaller supplying enterprises. Cooperation between the various actors in the sectors is crucial for innovation, for example with respect to certification and standardisation, education and training, R&D activities, or financing. This section presents several organisations and platforms for coordination and collaboration.

Industry organisations

The AeroSpace and Defence Industries Association of Europe (ASD) is the main representaive organisation for the aeronautics, space, defence and security industries in Europe. This also includes the defence and security sectors for land and naval systems. ASD has 30 member organisations in 20 European countries. Members include major aerospace companies in Europe, as well as national industry associations. ASD was established in 2004, from a merger between three different industry organisations, including AECMA, Eurospace and EDIG. The ASD represents the interests of the aerospace industry in Europe and European public policy and acts as a single point of contact between the industry and relevant stakeholders and institutions. The ASD also coordinates initiatives related to environment, standardisation, skills and training, quality standards, social impact, international trade and cooperation, and the development of SMEs in the sectors. ASD offers quality related services through four affiliated associations: STAN (standards), EASE (supplier evaluation), PRO (quality assessment of special processes and CERT (certification). ASD participates and collaborates in several European programmes and initiatives in research, safety and quality. The ASD, for example, collaborates with the European Commission and institutions from non European (mainly Asian) countries in international programmes on air safety and operational safety awareness. The Aerospace Performance Improvement (API) is an initiative of the European Aerospace Quality Group (EAQG, part of ASD) and the International Aerospace Quality Group (IAQG) and offers the industry best practices on supply chain performance improvement. Other initiatives include ACARE, Clean Sky, SESAR, SETRAS, AeroPortal and Staccato, some of which will be described in more detail in the section on networks. The ASD also represents the European aerospace industry and national associations in the International Civil Aviation Organisation (ICAO), which is part of the United Nations and deals with issues in civil aviation related to safety, security, environment, continuity, operational efficiency, and regulations. The ASD-IMG4 is the aeronautics industry network for research and technology and represents larger manufacturers of aircrafts, aero engines, equipment, and air traffic management systems. The ASD-IMG4 represents the aeronautics industry in the EU civil aeronautics framework programmes and the strategic research agenda. In doing this, it collaborates with AeroPortal as well as with the representative organisations of aeronautics research organisations.

The interests of the Space Sector are specifically represented by the Eurospace, which is the space group of ASD. Like ASD, Eurospace offers information and advice, acts as a liaison between industry and institutional organisations, and coordinates various initiatives related to safety, quality, environment, research, and trade.

Institutional organisations

The European Space Agency (ESA) was established in 1975, as a follow-up of the European Space Research Organisation (ESRO) and the European Launcher Development Organisation (ELDO). ESA includes 18 European countries (and Canada as a cooperating state) and is responsible for developing and executing the European space programme. It aims to provide for European collaboration in space research and technology and space applications for both scientific purposes and operational space applications (e.g. telecommunications, earth observation). ESA's budget for 2009 amounted to EUR 3,592 million and is the main customer for the European Space Sector. In 2007, the European Space Policy was created, unifying the approach of the ESA with the national space programmes. The European Space Policy is the first common political framework for space activities in Europe.

For the military part of the Space and Aeronautics Sectors, the European Defence Agency (EDA) is the main governmental agency in Europe. The EDA was established in 2004 and includes 25 European Member States. The EDA sustains the European Security and Defence Policy and aims to develop defence capabilities, promote defence research and technology, promote armament collaboration, and create a competitive European Defence Equipment Market as well as a strong Defence Technological and Industrial Base. In 2009, the EDA had a budget of EUR 20.7 million, of which EUR 2.5 million was spent on operational projects and studies.

The European Civil Aviation Conference (ECAC) was established in 1955 as an intergovernmental organisation that seeks to harmonise civil aviation policies and practices among its member states. The ECAC is closely related to the International Civial Aviation Organisation (ICAO), which is the global organisation for civil aviation issues.

The European Aviation Safety Agency (EASA) is responsible for the common safety and environmental rules in aviation at the European level. In close cooperation with the national authorities, the EASA monitors the implementation of standards and rules through inspections in the Member States and offers technical expertise, training and research. EASA is the counterpart of the US Federal Aviation Administration (FAA).

Eurocontrol is the European organisation than plans, develops and coordinates the pan-European strategies for air traffic management for civil and military users. Eurocontrol manages the transnational air traffic control centre, offers training for air traffic management officers, and works on developing future air traffic management, in particular the Single European Sky initiative.

R&D organisations and platforms

The EREA, the Association of European Research Establishments in Aeronautics was established in 1999. Members of EREA are national research organisations active in aeronautics research. EREA has two permanent working groups, one on aeronautical research and one on security research, as well as one ad-hoc working group on human resources and skills. EREA is participating in several European initiatives in aeronautics research, including ACARE.

The EASN, the European Aeronautics Science Networks is the European platform for European universities active in aeronautics research. EASN was established in 2008 and includes research groups at universities in 31 European countries. EASN aims to encourage and support research collaborations, mobility of researchers and knowledge and technology transfer, as well as contributing to the development of European research programmes in aeronautics. Another representative group of European universities active in aeronautics and space is Pegasus, which started in 1998. Pegasus aims to encourage collaboration between universities in the field of aerospace engineering and is especially focused on promoting the quality of education and research programmes in space and aeronautics. It has, for example, developed a certificate for graduated engineers in space and aeronautics. Members of Pegasus include 23 universities from eight European countries.

GARTEUR is the Group of Aeronautical Research and Technology in Europe and is based on a Memorandum of Understanding between seven European countries with major research and testing facilities in aeronautics. GARTEUR was established in 1973 and focuses on collaborative research topics mainly for the longer term, both civil and military. GARTEUR brings together industry, research organisations and universities and coordinated over 120 projects since its establishment (http://www.garteur.org/index.htm).

Support for SMEs and entrepreneurs in aerospace

AeroPortal is the main initiative to support SMEs and entrepreneurs active in the Aeronautics Sector. AeroPortal is a joint initiative by ASD and the European Commission and aims at encouraging and supporting the participation of SMEs in the EU's Seventh Framework Programme of Research. AeroPortal provides information about funding opportunities and activities related to aeronautics research in FP7. AeroPortal offers information and support to SMEs and entrepreneurs, provides training and coaching, and acts as an intermediary between aeronautics SMEs, research organisations and other stakeholders (http://www.aeroportal.eu).

INVESAT is an initiative of Europe INNOVA which aims to bridge the gap between SMEs and financial investors in the emerging markets of satellite-based earth observation, navigation, geo-positioning, and telecommunications. INVESAT acts as a mediator between SMES and financing organisators by providing SMEs and entrepreneurs with knowledge required for the development of successful business models, by coaching entrepreneurs, by overcoming barriers for capital investment to invest in new, innovative satellite applications, and by catalysing innovation financing through entrepreneurs' networks.

Another Europe INNOVA initiative in promoting the availability of finance for SMEs and entrepreneurs in Space is FINANCE Space. FINANCE Space stands for Finance Innovation Network Addressing New Commercial Enterprise using Space. FINANCE Space aims to encourage and facilitate linkages between the funding sources of the European Space Sector and innovative enterprises. New space applications offer opportunities for new business services, but finance is often an obstacle. FINANCE Space wants to contribute to the further commercialisation and privatisation of space applications in Europe. While INVESAT is trying to link entrepreneurs to investors and to coach entrepreneurs in attracting investors, FINANCE Space is more dedicated to analysing and identifying the conditions of innovation financing in space and the specific problems related to this. FINANCE Space aims to assist policy makers by formulating policy recommendations on innovation financing in the Space Sector (http://www.europe-innova.org).

The European Space Incubators Network (ESINET) was launched in 2002 and serves as a network of European incubators in space technologies and applications. ESINET aims to support regional incubators in stimulating entrepreneurship and SMEs in space technologies and applications. ESINET includes 27 members from various European countries (http://www.esinet.eu).

KIS4SAT is also funded by the Europe Innova initiative and aims to support SMEs and entrepreneurs in downstream satellite applications by providing innovation business support services, networking services, as well as training (http://www.esinet.eu/DisplayPage.aspx?pid=211). Support to SMEs in the Space Sector is also provided by the NAVOBS Plus programme. The NAVOBS Plus programme aims to improve the participation of SMEs in R&D activities in space applications, in particular related to GALILEO, GMES and satellite telecommunication services (http://www.navobs.com).

Access to finance

Despite the various schemes and initiatives available to SMEs in the Space and Aeronautics Sectors, acces to finance is in general a major challenge in these sectors. Especially since the start of the financial and economic crisis at the end of the first decennium, the capital intensive Space and Aeronautics industry suffers from restricted access to finance. On the one hand, airlines are suffering from the economic crisis with declining passenger numbers, lower freight volumes, decreasing flying activity of corporate personnel and very restricted credit possibilities. This directly impacts the the orders for new aircrafts as well as the possibility for customer financing. Also the aircraft leasing companies run into trouble. On the other hand, suppliers get more risk handed over from prime and first tier manufacturers requiring larger investments, while at the same time the smaller companies have more difficulties getting loans or credits. This directly impacts the delivery of parts and components, delaying the delivering of aircrafts. The financial and economic crisis seems to hit smaller firms in particular; often the important suppliers to the prime manufacturers. The prime manufacturers need to safeguard their supply chain by expanding their network of suppliers or by direct financial support to their suppliers.

3.4 Clusters and networks

The Space and Aeronautics Sectors are high-tech sectors depending on research and highly skilled human resources. Therefore, regional concentration mostly depends on a research friendly environment and the availability of a highly skilled workforce. Organisations participating in a cluster enjoy several economic benefits, including access to specialised human resources and suppliers, knowledge spillovers, pressure for higher performance in head-to-head competition and learning from the close interaction with specialised customers and suppliers.

The European Cluster Observatory (www.clusterobservatory.eu) contains a database with 259 regions, containing 10.000 clusters: intersections of sectors and regions from 32 countries. The clusters are assessed on three dimensions:

- *Size:* if employment reaches a sufficient share of total European employment, it is more likely that meaningful economic effects of clusters will be present.
- *Specialisation:* if a region is more presented in a certain cluster than in the overall economy, this will indicate the economic importance of the regional cluster.
- *Focus:* if a cluster accounts for a larger share of a region's overall employment, it is more likely that spill-over effects and linkages will actually occur instead of being drowned in the economic interaction of other parts of the regional economy.

Based on these three dimensions, clusters are rated with one to three stars (with tree stars being most important). For the ‘Aerospace, Vehicles and Defence, Engines’ sector, the European Cluster Observatory contains 34 clusters. Table 3.5 presents the clusters and the main characteristics of these clusters. The best performing clusters are located in Germany, France and the UK, which are also the most important countries in the sectors in terms of turnover, value added and employment.

Table 3.5 European clusters in space and aeronautics

Cluster	*Employees*	*Stars*	*Innovation*[1)]	*Export*[2)]
Hamburg, DE	19 411	***	High	Strong
Île de France (Paris), FR	23 232	**	High	Very strong
Midi-Pyrénées (Toulouse), FR	18 656	**	High	Very strong
Lancashire (Blackburn), UK	14 806	**	High	Weak
Oberbayern (München), DE	13 957	**	High	Strong
Derbs and Notts (Nottingham), UK	12 639	**	High	Weak
Gloucs, Wilts and N Som (Bristol), UK	10 740	**	High	Weak
Aquitaine (Bordeaux), FR	10 244	**	Medium	Very strong
Schwaben (Augsburg), DE	8 966	**	High	Strong
E Wales (Cardiff), UK	8 557	**	Medium	Weak
Campania (Naples), IT	8 023	**	Low	Weak
Provence-Alpes-Côte d´Azur (Marseille), FR	7 659	**	Medium	Very strong
Podkarpackie (Rzeszów), PL 3)	6 936	**	Low	Weak
Dorset and Somerset (Bournemouth), UK	6 933	**	High	Weak
Hants and Isle of Wight (Southampton), UK	6 002	**	High	Weak
Northern Ireland (Belfast), UK	5 879	**	Medium	Weak
Pays de la Loire (Nantes), FR	5 432	**	Medium	Very strong
SW Scotland (Glasgow), UK	5 151	**	Medium	Weak
Bremen, DE	4 503	**	Medium	Strong
Bucuresti - Ilfov, RO	4 444	**	N/A	Weak
Östra Mellansverige (Uppsala), SE	4 284	**	High	Weak
Madrid, ES	10 241	*	High	Weak
Piemonte (Turin), IT	6 444	*	Medium	Weak
Andalucía (Sevilla), ES	5 227	*	Low	Weak
Darmstadt (Frankfurt am Main), DE	4 890	*	High	Strong
Lombardia (Milan), IT	4 251	*	Medium	Weak
Weser-Ems (Oldenburg), DE	4 242	*	Low	Strong
Tübingen, DE	4 098	*	High	Strong
Région Wallonne, BE	3 704	*	Medium	Weak
Zürich, CH	3 451	*	N/A	Weak
Zentralschweiz (Luzern), CH	2 914	*	N/A	Weak
Stredni Morava (Olomouc), CZ	2 019	*	Low	Weak
Poitou-Charentes (Poitiers), FR	1 932	*	Low	Very strong
Lüneburg, DE	1 519	*	Low	Strong

Source: European Cluster Observatory:
http://www.clusterobservatory.eu/index.php?id=&cluster_ID=2&presentationselect=table

Notes: 1) Innovation: Data is for region, regardless of cluster category. Based on 2006 European Regional Innovation Scoreboard, MERIT; 2) Exports: Data is national export data for the cluster category, regardless of region. Based on International Cluster Competitiveness Project, ISC at HBS; 3) year of data is more than 3 years older than reference year (2006).

Box 3.4 Aerospace Valley Midi-Pyrenees & Aquitaine, France

One of the largest European clusters in aerospace is located in the Midi-Pyrenees and Aquitaine, France. The cluster is active in space, aeronautics and embedded systems and consists of 1,300 partners, employing 8,500 people in research and 94,000 people in industry and services, of which 40,000 jobs are with the manufactures and main equipment suppliers and 50,000 in the subcontracting network. This cluster represents one third to the French employment in aerospace. The cluster hosts six universities and 12 aeronautics engineering schools (Grandes Ecoles) as well as the Aerospace Campus in Toulouse. This Aerospace Campus aims to be the largest European university campus in the field of aerospace and brings together the main institutes in the field of aerospace training and research. The Aerospace Valley association was created on July 13, 2005 and was one of 67 selected Pôles de Compétitivité (competitiveness poles). At present the association has 500 members representing companies, research centres, education and training centres and authorities involved in the sectors. The association aims to crate 40,000 to 45,000 jobs in the next 20 years. The association wants to develop the cluster into a worldwide leading network in aerospace, based on excellence in aerospace research and innovation. The Aerospace Valley association initiates and supports two different types of projects contributing to the development of the cluster. Cooperation projects support R&D collaboration between firms and research organizations in specific business sectors, such as embedded systems, aero-mechanics, and navigation. Structuring projects support the development of education and training initiatives, the development of new R&D centres and other initiatives aimed at the economic development of the cluster. The cluster hosts the global leaders in aeronautics, space and embedded systems, such as Airbus, Zodiac, Safran, Siemens, and Rockwell, as well as network of SMEs working for the major global prime contractors. (http://www.aerospace-valley.com/)

There are several research networks, programmes and collaborations at the European level that stimulate clusters and networks.

European Technology Platforms

In Europe, but also worldwide, companies, universities and other research organisations collaborate in dedicated R&D collaborations and networks. European Technology platforms (ETPs) are important examples of collaborative networks in the European Space and Aeronautics Sectors. ETPs provide a framework for stakeholders, led by industry, to define research and development priorities and action plans, needed for Europe's future growth, competitiveness and sustainability. All ETPs set up a common strategy, a Strategic Research Agenda (SRA), and ETPs aim to build partnerships to share risk, pools of resources and team up to compete worldwide. Accordingly, they play a key role in ensuring an adequate focys of research funding on areas highly reevant to the industry. They provide important input for the Framework Programme 7 (FP7).

There are three Technology Platforms active in the field of Space and Aeronautics: ACARE, ESTP, and ISI. ACARE is the Advisory Council for Aeronautics Research in Europe, established in 2001. ACARE was set up to develop and maintain a Strategic Research Agenda for aeronautics in Europe. ACARE comprises about 40 members, including national research agencies, national aeronautics research organisations, ministries and directorates-general, manufacturers, airports, representative organisations of airlines, as well as regulators and Eurocontrol. The Strategic Research Agenda materialises the vision from the 2001 report ‘European Aeronautics: a Vision for 2020’. The first edition of the Strategic Research Agenda was published in 2002; the second edition was published in 2004. In 2008, an Addendum to the SRA was published and a full review of the SRA is expected in 2010. The SRA is converted into research programmes by the stakeholders who contribute funds, resources and capability to execute the research guided by the SRA. Since the start of the agenda, about 200 projects have been launched from the EU Framework Programmes, worth EUR 2,000 million. In addition two large Joint Undertakings have been started since: the Clean Sky and SESAR. The first edition of the SRA identified five areas of research: Noise and Emissions, Quality and Affordability, Safety and Security, and Air Transport System Efficiency. The second edition further developed the first edition by introducing possible future scenarios in order to identify areas of uncertainty, variance and choice. In the Addendum in 2008, three areas have been chosen for increased priority: the Environment, Alternative Fuels, and Security (website ACARE).

The European Space Technology Platform (ESTP) started in 2005 and was set up to develop the Strategic Research Agenda for space technology in Europe. ESTP has members from 19 Member States, Norway, Switzerland, and Canada. It includes 110 space companies, Eurospace, ESA, national space agencies as well as R&D organisations and universities. The Strategic Research Agenda was published in 2006 and called for increased attention for and investments in space technology. According to the ESTP, the Space Sector is loosing ground, mainly because of insufficient and fragmented funding and Europe’s limited commitment to security-related space activities. The Strategic Research Agenda proposes three main pillars: 1) non-dependence: development of strategic space technologies, needed for Europe’s independence; 2) multiple-use and spin-in: creating synergies with non-space sectors in areas of mutual interest; 3) enabling technologies: developing technologies needed for new space services and applications addressing EU policy objectives, e.g. in security, Galileo and GMES (European Space Technology Platform, 2006).

The Integral Satcom Initiative (ISI) is the Technology Platform related to satellite communications, including broadcasting, broadband, mobile satellite communications, but also other satellite based applications like navigation and earth observation. Presently, ISI had 174 participants from 27 countries, also including the US, South Korea, and Israel. ISI brings together industry, ESA, national space agencies, and research organisations and universities. ISI published its first version of the Strategic Research Agenda end 2005. ISI identified several research themes. Research objectives deal with spectrum availability and higher frequency bands and ISI wants to stimulate and support the development of new satellite technologies in less time and at lower costs which allow more flexible satellite missions, with higher performance and at lower costs. Moreover, ISI works towards the convergence and integration of satellite and terrestrial network, including all internetworking and interoperability aspects. ISI also wants to contribute to the development of urban and in-building coverage and addresses the integration of satellite communications with navigation, earth observation and air traffic management systems. Specific attention is given to Galileo and GMES. ISI promotes harmonisation of the international regulatory framework as well as the development of open standards and international standardisation (ISI, 2006).

While these three European Technology Platforms are dedicated the Space and Aeronautics Sectors, also other Technology Platforms focus on technologies relevant for the Space and Aeronautics Sectors. These Technology Platforms include, for example, Artemis (embedded computing systems), eMobility (mobile and wireless communications), EUROP (robotics), EUMAT (advanced materials), ENIAC (nanoelectronics), and Photovoltaics (European Space Technology Platform, 2006).

The functioning of the ETPs was evaluated in August 2008 by Ideaconsult. The results of an extensive online survey, case studies and interviews among all relevant stakeholders revealed that the ETPs are successful in mobilising industry and academia and creating a momentum on industrial and political level. The study concludes that ETPs are generally considered to be sufficiently open and transparent and successfully involve and represent a broad range of EU-wide stakeholders in their activities. Most stakeholders are satisfied with the strategic work of the ETPs and the coordination role they have resulting in significant synergy effects between industry and academia. Concerning the goal of mobilisation of resources stakeholders indicate positive effects in relation to the increase of EU funding, national funding and also industrial (private) funding in certain R&D areas. Concerning effects on the improvement of framework conditions and the enhancement of a high-skilled workforce, there are positive effects as well. However, the study reveals that ETPs have difficulties in providing evidence about their activities and the results achieved. Despite of this, it seems that innovation performance benefits from these platforms.

Networks

Single European Sky ATM Research (SESAR) is the technological dimension of the Single European Sky (SES), which was initiated in 1999 by the European Commission to reform the architecture of the European traffic management. A reformed European Air Traffic Management (ATM) network will enable sustainable, efficient, safe, fully integrated and cost-efficient air traffic in Europe and will be able to manage the expected strong increase in air traffic. In 2007, the SESAR Joint Undertaking was started and it will last until 2020, from defining and developing a new European ATM to implementing the new system. In 2009, agreements were made with 16 partners for a total amount of EUR 1,900 million for the next seven years. Partners include air navigation service providers, ground and aerospace manufacturing industry, aircraft manufacturers, airports and airborne equipment manufacturers (http://www.sesarju.eu/public/subsite_homepage/homepage.html).

The Joint Technology Initiative Clean Sky aims to develop breakthrough technologies to improve the impact of air transport on the environment. Clean Sky is a large EU initiative with a budget of EUR 1,600 million, equally shared by industry and the European Commission for the period 2008-2013. Clean Sky aims to involve the whole supply chain and encourages the participation of SMEs. Members of Clean Sky come from 16 countries with 54 industries, including 20 SMEs, 17 research centres and 17 universities. The research and development in Clean Sky focuses on six themes or demonstrators: green regional aircraft, SMART fixed-wing aircraft, green rotorcraft, sustainable and green engines, systems for green operation, and eco-design.

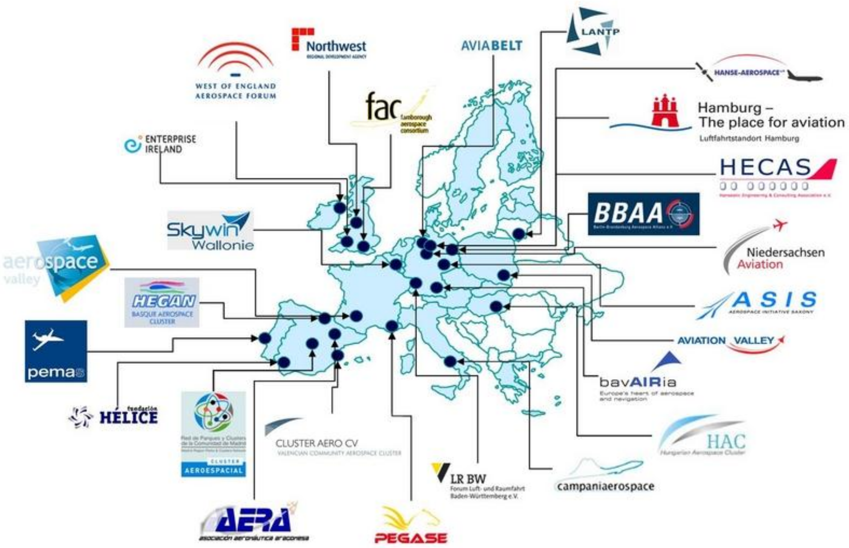
The Air Transport Net is a ERA-Net covering aeronautical research and air traffic management issues. It includes 26 public research institutes and governmental organisations from 17 European states and Eurocontrol. Air Transport Net was initiated by GARTEUR and aims to coordinate aeronautical research at the national and European level.

There are also several networks focusing on the safety and security market segments, which are addressed by the Aerospace Sector as well as other by other sectors (e.g. Electrical and Optical Equipment, Defence Industries). In 2007, the Stakeholders platform for supply Chain mapping, market Condition Analysis and Technologies Opportunities (STACCATO) was established, funded by the EU Preparatory Action for Security Research. STACCATO focuses on the methods and solutions for the creation of a security market and a structured supply chain in Europe. It aims to contribute to the development of a common European Security Equipment Market by identifying common needs and coordinating security research programmes. Another example is SETRAS, which is also focused on the security market and aims to enhance the critical infrastructure protection measures and security standards.

Clusters

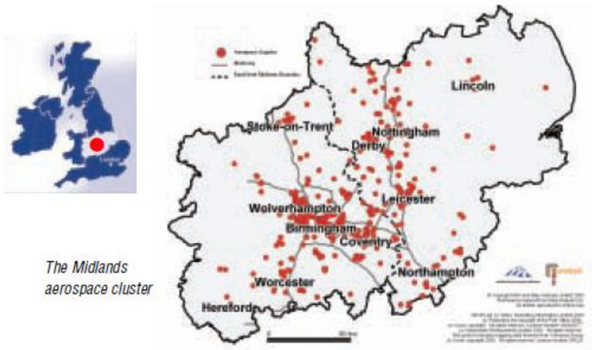
The European Aerospace Cluster Partnership (EACP) is a network of European aerospace clusters and provides a platform for mutual exchange, policy learning and collaboration among these clusters. The EACP has 26 members from 11 countries. Figure 3.3 presents the participating aerospace clusters.

Figure 3.3 Aerospace clusters participating in EACP



Source: http://www.eacp-aero.eu/index.php?id=4

Box 3.5 Midlands Aerospace Alliance, United Kingdom



In 2003, the Midlands Aerospace Alliance was set up to improve wealth creation and employment for companies and people involved in the aerospace industry across the Midlands in the United Kingdom. The Midlands aerospace cluster is located at the centre of England with at the hart of the cluster Rolls-Royce, the world's number 2 manufacturer of aircraft engines. Rolls-Royce accounts for 25% of the 45,000 jobs in the cluster. A second hub in the cluster is concentrated around the companies Goodrich, GE Aviation and Meggit, which supply electro-mechanical systems that control the aircraft's moving parts. A third hub is concentrated around specialist aerospace materials producers including Alcoa, Timet, Advanced Composites and Special Metals Wiggin. In total, about 300 companies are in the cluster making flying parts. In addition, there are many companies that generate their turnover from non-flying parts and services to the aerospace industry, such as specialist design and manufacturing equipment. The cluster does not produce complete aircrafts, but includes all kinds of subsystem integrators and suppliers of components, as well as research organisations, suppliers of equipment for design, engineering, testing and manufacturing. In this way, the aerospace cluster is linked to other sectors, such as automotive, electronics and telecommunications.

The cluster supports the development of a successful, competitive and innovative regional aerospace industry. Important elements in the cluster are geographical proximity, repeated transactions with competitors and collaborators, mobility of human resources among companies and research organisations, but also operating at a great scale without full-scale vertical integrations or mergers. Especially in aerospace cooperation is essential. The long development times and high risks in developing aircraft systems are a too heavy burden on one company alone. Even rivals join forces to win a new project and offer better service, each specialising in a different part of the work. The cluster also stimulates the creation of new companies, providing a network of established relationships and hence lowering entry barriers in this rather closed industry. The Midlands aerospace cluster has developed since the war-time years, building on the development of engines at several engine manufacturing companies, including Rolls-Royce. The Midland Aerospace Alliance supports the cluster by organising networking and knowledge exchange activities, providing expertise and advice for companies, as well as by organising seed funding for new technology development projects. The MAA collaborates with other regional initiatives and helps filter national aerospace initiatives and policy to increase the impact and benefit for the Midlands aerospace cluster. The MAA is supported by Advantage West Midlands and the East Midlands Development Agency (Mair, 2008).

Box 3.6 The Aviation Valley Association, Poland

The Aviation Valley Association was created in 2003 in Podkarpackie in Poland. The Aviation Valley aims to build a strong regional cluster in aeronautics, stimulating the regional development and exploitation of regional potential. The association was established by a group of leading regional enterprises, Rzeszow Technical University and Rzeszow Regional Development Agency. Podkarpackie is located in south-east Poland and has along history of aviation. About 90% of the production in the Polish aeronautics industry originates from this region. The region is also home to some aviation-related R&D institutions. During the 1990s the large state-owned companies in aeronautics had to size down, while at the same time new SMEs were established, which became sub-contractors to large manufacturers in Poland and worldwide. The cluster currently represents 76 companies and employs 22,000 people. The Aviation Valley Association aims to develop a network of subcontractors and a low-cost supply chain, support collaboration between firms and technical universities to stimulate knowledge transfer and innovation in the sectors, to develop relationships with other European aerospace clusters, to attract foreign investments, as well as to act as a intermediary between national, regional and European governments and the industry.

The cluster received funding from the international engine manufacturer Pratt & Whitney, which was already active in that region. Furthermore, the initiative has been supported through INTERREG IIIC ADEP and collaborated with the Oulu region in Finland and the Border, Midland and Western region in Ireland. The Aviation Valley is included in the Regional Innovation Strategy, which aims to support and initiate actions for professional training and conducting research. The Aviation Valley was one of the first clusters in Poland and implemented some basic cluster-building methods and best practices from clusters abroad. It now also transfers experiences with other clusters in Poland and other Central and Eastern European countries. In a case study description for Inforegio, the main success factors of the cluster are discussed. Important success factors for the cluster, according to a case study description for Inforegio, are the active participation of local leaders from private companies and research organisation, the close links with local companies to identify real needs, the good relationships based on trust among the members of cluster, as well as the useful interaction with two clusters abroad which have similar characteristics and the strong link with regional strategic planning and policies. (http://ec.europa.eu/regional_policy/cooperation/interregional/ecochange/goodpractice/1knowledge/1cluster/pl_aviation.pdf ; http://www.dolinalotnicza.pl/pl/)

CASTLE is a trans-national aerospace technologies cluster encompassing three European regional clusters with a strong focus on satellite navigation applications. CASTLE stands for Cluster sin Aerospace and Satellite Navigation Technology Applications Linked to Entrepreneurial Innovation. CASTLE aims to support the three clusters to become competitive in Europe for innovation in satellite navigation applications. The three regional clusters are situated around Munich (Germany), Leiden (The Netherlands) and Prague (Czech Republic). CASTLE is supported by Europe INNOVA (http://www.europe-innova.org).

Another Europe INNOVA cluster initiative focused on space applications is ENCADRE. ENCADRE brings together 16 existing space clusters and operates as and informal platform to support the creation of a market strategy in the field of satellite communication, satellite navigation and earth observation applications, in particular Galileo derived applications. ENCADRE stands for European Network of Clusters for Satellite Applications Development (http://www.europe-innova.org).

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