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EU SPACE POLICY AND ITS POTENTIAL FOR EU INDUSTRIAL SECTOR COMPETITIVENESS

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EXECUTIVE SUMMARY

This study prepared by TNO analyzes a part of European Space Policy and Programme under three main themes: space related applications and market players; benefits from the European Space Policy and Program; and governance aspects and policy implications. As instructed by study's administrators, the report concentrates on two primary sectors of interest – Global Navigation Satellite Systems (GNSS), including Galileo, and Earth Observation, including the Global Monitoring for Environment and Security initiative (GMES). In addition, the report covers, albeit in fewer detail, access to space and European launcher programme and contains a general analysis of European Space Programme (including a view from international perspective).

Global Navigation Satellite Systems GNSS

GNSS offers a wide range of applications, including road traffic and transport domain, location based services (including personal location based services), civil aviation, maritime, agriculture, electricity networks, etc. The key applications are fleet management, telematics and advanced driver assistance systems, and personal location based services. The position of Europe in these sectors is only satisfactory in fleet management. Challenging is the absence of Europe in the sector of personal location based services. However, Europe is well-positioned to develop new applications in these sectors while R&D for Galileo gets increasingly more attention.

European Framework Programme is an important contributor to promoting innovation in Galileo/EGNOS and the accompanying services. However, within FP7, attention for *applications* is at a very low level while it is concentrated on the upstream sector. The €400 million that are added to the overall Galileo budget need to remain strictly reserved for Galileo/EGNOS innovations. On-going coordination with ESA to attune research activities is necessary as well.

GNSS downstream markets lack major players covering the entire value chain; firms are smaller and have narrow specialization. There is, however, a tendency towards market consolidation as manifested by the recent wave of mergers. The market for PNT devices is in full flux, with difficult to control developments disrupting existing market structures (such as GPS-chipsets in mobile phones). Road applications are perceived to be the major inroad to expanding the market.

One may expect the continuation of the merger trend which will allow the firms to capture the entire value chain and offer additional value by a combination of services to individual consumers. Both road applications and personal LBS are competition-driven markets without much government involvement. Thus it is the sector where market forces seem to work quite well. Notwithstanding the fact that stakeholders in the automotive industry are cooperating in many different ways (for instance, consortiums for research projects combining forces within Europe), a still unfulfilled role for public agencies remains in the area of policy issues related to GNSS and road applications, such as standardisation and interoperability.

The ***Galileo/EGNOS*** program will enhance the range of possible applications with satellite navigations compared with existing GNSS: Open Services (same as in the other GNSS), Commercial services, Safety of Life Services, Public Regulated Services, and Search and Rescue Services.

The direct revenues of Galileo and EGNOS during 20 years of exploitation are expected to be between €4.6 billion and €11.7 billion, plus €50-60 billion of indirect revenues.

Bringing Galileo to full operational capability runs along four phases: a definition phase, a development phase, a deployment phase and ultimately an exploitation phase. The first two phases have been financed fully by the European Commission. The deployment and exploitation phase was intended to become a shared exercise between the European Commission and a concessionaire but this approach failed to materialise. In addition, the programme was suffering from chronic and prolonged delays due to disagreements among partners. Galileo experience offers a number of lessons:

- Public Private Partnerships (PPP) can lead to monopolistic situations, which should be avoided.
- Common will within the European Community is indispensable for successful project negotiations.
- In the space sector, delays can lead to high costs and a loss of the comparative advantage.
- For PPP in high-tech high-risk environment to work, a step-by-step, adaptive approach to project development should be used, when the Government reduces inherent uncertainties thorough a clear definition of public vs. private good and the role of initial public customer; shaping the markets by means of advanced elaboration of market arrangements, financing and revenue sharing mechanisms and risk-sharing measures; interactive strategy; and smart cost-benefit analysis even if only partial in scope. This is important for the preparation of the upcoming exploitation phase.
- Institutional and procedural harmonization is crucial for projects in multi-institutional setting.

The new management structure of the Galileo/EGNOS programme is well-organised and exhibits the inclusion of the lessons learned of the previous phases. A number of issues remain, however, problematic. They include the necessary build-up of expertise within the European Commission, ESA, and GSA to manage the programme activities and establishing procedures for the involvement of Member States, third countries and ESA. In addition, it remains to be seen if the amended budget proposal is realistic, given the low contingency budget. Since the EGNOS system will be fully operational by early 2009, a high priority should be given to the assignment of the concessionaire and the certification process.

The technical development path of the integration of Galileo, GPS and other GNSS moves into the direction of a 'system of systems', with common accuracies up to a few centimetres. The European Union should start to discuss the modifications needed to realise this ambition.

The European Radio Navigation Plan still needs to be completed. In developing the plan, attention is asked for the role of the GNSS infrastructure as a critical infrastructure. eLoran seems to be the appropriate candidate for European-wide back-up system in case of failure of GPS/Galileo.

Earth Observation

Earth Observation (EO) applications serve a variety of purposes in such fields as: natural resource management, energy, land monitoring, environment, cartography, natural hazard prevention and mitigation, agriculture and food security, meteorology, and homeland security.

Innovations and R&D needs related to EO services are largely determined by two major trends: increasing consumer-pull using virtual globe platforms (e.g. Google Earth), and encapsulation of EO-services in Integrated Applications, such as control rooms.

Earth Observation remains a relatively small market with the 2005 global revenues of € 1.3 billion, including € 0.4 billion in Europe, with almost 50% of total revenues stemming from meteorological applications. The upstream sector for Earth Observation is predominantly institutional, dependent on public funding. Emerging commercial observation satellites are developed in the framework of PPP and are still dependent on public funding, e.g., Spot Image and RapidEye. The downstream EO industry in Europe is rather fragmented causing upward pressures on costs for downstream companies due to the dominant market position of the upstream enterprises. In addition, small company size makes it difficult to offer standardized and integrated solutions for customers and hampers industrial collective actions. However, in recent years, some consolidation in European EO industry with forward value chain integration and cross-sectoral acquisitions has been progressing.

The start of the ***GMES Programme*** in 2001 has given a strong impetus to the integration of Earth Observation value adding. The 2007 Munich Roadmap further defined the structure and components of GMES as it relates to the service portfolio and to the data infrastructure.

Essential for the development of downstream services is access to raw data in terms of cost and continuity. The fundamental question whether raw data are a public good and therefore should be freely accessible at any time to anyone is debated. One option is to use the U.S. model declaring raw EO data free and open to access, while processed data should to be paid for. As for data continuity, the European Commission will procure the necessary data (space and *in-situ*) for the Core Services. However, no such formal decision has been taken regarding the Downstream Services.

Another issue is whether some restrictions to data access based on security, privacy, and other grounds, should be specified. In any case, access procedures should be specified clearly and in detail, so the private sector can develop business models in advance. It is important to maintain a coordinated approach between GMES and the INSPIRE process on data access policies and standards definitions.

The main policy issues in the EO sector include market organization, administrative simplification, procurement principles, access to data, customership of public institutions and regulatory framework:

- ***Maturation of supply and demand sides:*** The challenge is to speed up the maturation process in Europe on both supply and demand side. The recent consolidation wave is a signal that the industry itself is preparing for the next phase. The time is right for crucial customer groups like governments to embrace large-scale EO applications. When governments will achieve a unified demand in an EU context, this will raise demand on the one hand and will enable standardization (and economies of scale for the industry) on the other.

- ***Private user and transparency:*** At the same time, there is a pressing need to expand the private user segment of the market. Transparency should be enhanced by means of efficient organisation of the user community and a clearer definition of users' needs. As well as for the identification of funding schemes and resulting business models. This is especially important for Downstream Services, which are tackled only indirectly by the GMES programme. One important effort in this direction is the BOSS4GMES Integrated Project.

- ***Creating a level playing field:*** A level playing field for both integrated companies and SMEs should be created by revising procurement processes with clear terms of reference. As in GNSS, measures to lower barriers for entry for SMEs in the EO market should be employed, including awareness raising, open tenders, incubators, and administrative burden reduction.
- ***Network promotion:*** In order to balance out the power of large conglomerates, there is a need of strengthening of existing networks and stimulation of new networks among SMEs.
- ***Procurement principles:*** As a flagship of the European Space Programme, GMES highlights the need for institutional and procedural harmonisation among the Programme participants, and especially between its leaders – the EU and ESA. The procurement principles of the GMES Sentinel programme differ to a great extent from EU principles and are inferior to the new procurement principles of Galileo. In effect, there are two sets of rules that apply to different parts of GMES programme – EU's and ESA's.
- ***Customership of public institutions, EO as a tool for policy enforcement:*** EO programmes are highly dependent on the government as the initial and the primary customer. Private demand for EO services, although developing, won't approach the scale of GNSS. Therefore, it is imperative to define in advance the scope and structure of publicly acquired processed EO data and services. Application of EO services and data for implementation and enforcement of policy should be part of decision making processes and budgets of public bodies on every level. The funding for GMES is coming from FP7, which seems rather insufficient limiting possible role of different European actors. Funding under other Directorates General representing users needs to be added. Investment in GMES should also include education and awareness raising. Currently, the awareness of the European citizens about GMES is not as high as about Galileo.
- ***Regulatory framework: towards a single market:*** Standardisation, including the development of standard data definitions, certification and the interoperability of systems is a very important channel of the public support for the industry. IPR protection is a sore issue for EO application development, especially by SMEs. Two problems need special attention: easing the administrative burden of IPR protection for the SMEs and the unification of the European IPR regime. Progress towards a harmonized common export control regime will help intra-community trade in sensitive products as well as strengthen European export position while protecting security interests.

Access to space

The core activities in the European launcher programme consist of the continuing exploitation of the heavy launcher Ariane 5 and the initiation of the exploitation of the medium launcher Soyuz (in partnership with Russia) and the small launcher Vega. Europe will be able to cover the whole launch market with these three launchers -- heavy, medium and small. The EU currently occupies a dominant position in the market launching more than half of communication satellites, which represent the bulk of the commercial launch market. However, the EU faces serious and growing international competition.

Access to space has long been the core objective of ESA, with two main goals – independence and cost effectiveness. While independence was achieved, the cost of access to space did not go down in the last 40 years, in sharp contrast to steeply declining costs in other high tech industries.

The reduction of cost of access to space should be given a high priority. It can be achieved through innovation and a smart use of existing technology coupled with international partnerships. On the regulatory front, the regulations have to account for potential hazards of launch activity; thus the importance of environmental, safety, security regulations and legal accountability mechanisms.

The industrial organization of the European launch sector is characterized by a dominant position of just four companies which use the services of hundreds other companies as contractors. This configuration of the industry is not uncommon in aerospace and defence industries everywhere in the world. The very nature of the sector operating under high fixed costs of production (most importantly, R&D), small series, and increasing returns to scale creates a tendency towards restricting competition and poses serious difficulties in achieving ESP goal of avoiding both the creation of monopolistic structures and overcapacity. This requires the attention of the European regulatory authorities in the four main policy areas, such as the regulation of cartels involving the control of collusion and other anti-competitive practices; regulation of monopolies or preventing the abuse of the dominant market position; the control of proposed mergers, acquisitions and joint ventures involving large companies with a scrutiny of potential harm from vertical integration; and control over direct and indirect state aid given to companies.

Achieving these objectives may call for some specific actions, for instance,

- require major contractors to use open-system architectures (i.e. setting standards of system interfaces that a number of contractors can meet) in designing space systems;
- make sub-tier competition a specific source-selection criterion; and
- explore opportunities for greater cooperation with international partners.

In addition, ESA/EC acquisition program managers should scrutiny prime contractor teaming and supplier choices, devise acquisition strategies to promote alternative concepts and new supplier entry, and monitor some technological areas for the impact of vertical integration.

European Space Programme – overall perspective

Elaboration and implementation of a European space policy has since 1975 been a purpose of the European Space Agency. Now, the EU considers a space policy as its area of responsibility as well. Today ESA remains the main executor of the joint European Space Policy, along with the EU and national space agencies.

The report ***compares and contrasts ESA with NASA***. The fundamental difference between NASA and ESA is that the former is a national space agency while the latter an international association of national space agencies. Much smaller budget of ESA forces the Agency to concentrate on innovative and highly effective missions, which is in line with once famous NASA policy ‘faster, better, cheaper’.

The U.S. Government acts as a very powerful initial customer -- much more powerful than institutional customers in Europe -- thus offering competitive advantages to U.S. companies. Services that are considered public goods, like the free GSP signal or free earth observation raw data, offer opportunities for U.S. downstream industries. ESA provides a limited volume of free public services.

Probably the most important difference between NASA and ESA is not the size of the budget but the industrial policies and therefore the effects on the national space industries. ESA has to seek support from member states and uses the fair industrial return policy as an instrument to facilitate Members' investments.

However, fair return contradicts the EU Competition and state aids policy. ESA's business arrangements lead to higher transaction costs for participation in international space programmes, especially for SMEs which are further tied to their home markets. While space market in the U.S. is a single national market, space markets in Europe are geographically segmented. A few lessons from NASA experience may be useful for the future ESA and EU space programme:

- ***Operations and management structure:*** The top-down management structure of NASA offers a number of advantages and efficiency gains, requiring, however, careful cultivation of internal checks and balances – may it be in the form of governance structure guaranteeing mutual checks or in the form of corporate culture enabling critical feedbacks – which was not fully achieved by NASA. Nevertheless, ESP can benefit from a stronger and more centralized space organisation guided by the EU principles.
- ***Funding and development programmes:*** While having a much larger budget than ESA's, NASA executes its budget in accordance with a comprehensive long-term strategy based on programmatic goals expressed in Presidential vision and enters into contracts with space industry based upon principles of open competition. At the same time, ESA programmes are shaped by its member states through complex interactions among national industrial interests, national space agencies and research institutes; the principle of fair return underpins interrelationship between programmes and budgets. ESA can benefit from more straightforward and transparent budgetary principles promoting open competition, similar to other EU programmes, as well as a comprehensive formulation of future space programmes.
- ***Markets:*** The United States have the benefit of large-sized private and institutional home markets. In Europe, national markets are predominantly the home markets of national space industries, which have limited possibilities to extend their markets to other countries due to regulatory issues, financing, and even export controls on dual use technologies. Thus a single European space is yet to be developed which can be an overarching long-term goal, with regulatory harmonization and common oversight agencies. In addition, the role of the EU as the launching customer can be strengthened.
- ***Relations with private sector and public functions:*** In its founding act, NASA is commissioned to encourage the fullest commercial use of space. NASA makes contracts with space industry under the conditions of a nation-wide legal framework regarding private law and IPR. NASA's policy to claim IPR for every technological innovation developed under its programmes, however, causes some frustration in the private sector and may also hamper co-innovation processes. This may be not the example to follow. NASA still has to reinforce its policy to insource technology, in addition to its long-standing practice of outsourcing operations. The strategy of outsourcing operations is very relevant for ESA.With its own body of knowledge and research centres, NASA acts as a national authority on space technology, testing technologies and approving them for commercial application. The future ESA might take up this public function of technology and testing and standardization on a European level.

- ***Public vs. private good:*** The U.S. Government clearly defines space-related public goods, such as raw data and information of the EO or the GPS signal, which gives considerable advantages to private market development. The EU should overcome any ambiguities in the classification of the future space-related services.
- ***EU-ESA institutional harmonisation:*** The Framework Agreement which entered into force in May 2004 was a landmark event in the EU-ESA relations. However, the Agreement does not dispense with the need to conclude specific agreements for particular projects and envisions five different cooperation models to be specified by negotiations. Analysis of these models demonstrates that the Framework Agreement does not put forward ready-made practical solutions against institutional divergence of the two parties.

The current ESA program document *Agenda 2011* envisions ESA becoming an Agency of the EU by 2014, which leads to changes in ESA's industrial policy rules and procedures, decision-making process, and funding mechanisms. Since the EU and ESA operate on different principles, the incorporation of ESA into the EU system is likely to be a lengthy and complex process. It is necessary to ensure a smooth transition process of ESA and avoid disruptions that may be caused by changing rules and policy principles. With the goal of ESA of becoming an EU Agency, the EU should consider formulating and carrying out a program of institutional harmonisation with ESA. The EU should actively cooperate with ESA on the intended amendment of ESA Convention, both in the long-term perspective and in the short run, when this issue will be discussed by the ESA Council of Ministers. The EU need to establish a leadership in shaping a legal and regulatory framework for a coherent space policy in Europe, at least in regard the most important regulatory aspects, entailing both international and national regulatory frameworks.

Common policy and regulatory issues

The report analyzes the following policy and regulatory issues that are common for the sectors under consideration and that should be given a high priority:

- Institutional harmonisation between main actors (the EU, ESA, national space agencies) on the basis of EU rules and regulations;
- The role of government as the initial customer;
- Standardisation and interoperability;
- Steps to reduce uncertainties in the high risk space application markets, such as: Advance characterisation of future products (public vs. private goods) and shaping the markets (regulations, revenue sharing mechanisms, envisioned business models);
- Intellectual Property Rights: On one hand, possible royalties charged by the Government should be decided upon early on. On the other hand, application developers, and especially SMEs, need assistance in protecting their IPR and reducing the associated administrative overload.
- Privacy policies;
- Export controls and their unification (since space technologies are mostly dual-purpose technologies);
- Developing business models and upgrading business skills available in SMEs. (This issue is especially important for Earth Observation.)

1. GLOBAL NAVIGATION SATELLITE SYSTEMS[1]

1.1 Introduction

Global Navigation Satellite Systems are configurations of satellites with a full coverage of the Earth, which basically provide Positioning, Timing and Navigation services. Today, one GNSS is fully operational (the US Global Positioning System) with another one operational with limited capacity (the Russian Global Navigation Satellite System). The market for satellite navigation services is expected to grow considerably in the years to come. The European Union has announced in 1999 the construction of a European-based GNSS, called Galileo. Galileo is a thirty satellite constellation with a number of technological improvements over the present-day GPS constellation, resulting in improved accuracy and availability of the services. Galileo will be the first fully civilian-based GNSS, which raises a number of important issues relating to its market position and the expected role of the (European) government. In realising Galileo, a number of political barriers had to be removed in the past few years, reason to verify the viability of Galileo and the application service industry that should profit from Galileo and that should deliver a competitive boost to Europe.

A survey on European awareness for GNSS developments and especially Galileo revealed that awareness of satellite based navigation is relatively high in Europe: 68% of over 25,000 respondents from EU-27 countries indicated they were familiar with the concept of satellite navigation (DG Energy and Transport, 2007). 20% of the respondents indicated they already used satellite navigation applications while 15% indicated that they had plans to purchase satellite navigation applications. 40% of the respondents were aware of the Galileo project, while 80% deemed an independent position of Europe in GNSS market being indispensable. Support for additional funding of Galileo, if needed, was also widespread. 63% agreed with the requested €2.4 billion to realise the deployment of the Galileo and EGNOS system. According to respondents, useful services of satellite navigation were helping people with disabilities, search and rescue of lost persons, time schedule of public transport, weather forecasts and indication of nearby restaurants/hotels and theatres. As such, European respondents valued the opportunity Galileo offers to provide assistance to specific user groups.

1.2 Applications and markets for GNSS

1.2.1 GNSS applications

The potential application domain of GNSS is large and encompasses a multitude of commercial and public sectors. The market for satellite navigation products and services at present grows at 25% per annum (EC, 2006a). Within Europe it are Galileo and the European Global Navigation Overlay System (EGNOS) which function as flagship projects for the European Union and which should contribute to a European competitive position and innovative stance with respect to satellite navigation infrastructure, products and services. Today, applications are mainly GPS-based, being the single satellite navigation system in place for many years and functioning since 1995 in full operational capability. Most present applications are thus based upon GPS. Satellite navigation systems provide Positioning, Navigation and Timing services. Due to localisation technologies, based on very accurate triangular measurements of the signals being received from different satellites, they enable the localisation of a device with a precision of a few tens of metres up to a few centimetres.

[1] For this study, two interviews have been conducted. We gratefully acknowledge the contribution of Prof. J.A. Spaans and Mr. W. Ploeg (Netherlands Department of Traffic and Transport).

Box 1.1. Examples of GNSS applications

The Federal State of Mecklenburg-Western Pomerania has created a Research Port in Rostock. Participating organisations are DLR, Fraunhofer Inatitutre, EADS, Marine Soft, University of Rostock, the Hochschule Wismar and Telematica e.K. The Research Port Rostock facilitates a number of research projects:

ALEGRO – Development of a local maritime supplement system to support high-precision Galileo applications and services in Rostock. Development of real-time kinematic technology (RTK) for Safety of Life applications using the performance potential of future Galileo system.

InnoMAG – Innovative Maritime Applications of Galileo. Development of marketable products, systems and services; standardization and certification of EGNOS and Galileo services; integration of Vessel Traffic Management in Information Systems

GAMMA – Galileo Augmented Motion in Maritime Application. Reference model for goods handling in Rostock Sea Port; Galileo-based quality management in the fresh-market fruit production; intelligent container on the basis of Galileo and RFID

The European Progeny project supports SMEs in developing innovative applications based on Galileo/EGNOS technology (Progeny, 2008).[2]

BEAR – Bear Ethology Around Rumania. The BEAR consortium (Geostrategies Ltd, ICAS, University College London and VECTRONIC Aerospace) exploits the full potential of Galileo in difficult environments such as urban canyons and mountainous areas. A number of bears will be tracked in the Transylvanian mountains which are covered by forests, in order to improve safety for people in these regions (each year 20 people are killed or seriously injured by bears).

GADEM – Galileo Atmospheric Data Enhancement Mission. The GADEM consortium (GeoZup, Kayser-Threde, UniGraz) wants to provide a continuous, near real-time, independent world-wide measure of atmospheric data in order to improve correction of navigational errors caused by signal delays in Earth's atmosphere. By providing realistic datasets the projects contribute as well to the improvement of climate models.

GLECIA – Ground Local Elements Continuity Improvements on Airports. The GLECIA consortium (M3 Systems, SkySoft Portugal, ComNova) aims at developing an integrated system for the surveillance of airport vehicles, taking benefits of GNSS-based tracking and additional sensors for poor visibility areas. WLAN positioning technology will be combined with Galileo/EGNOS positioning accuracy.

HeliCity - The HeliCity consortium (SkySoft Portugal, Euro Telematik A.G., Septentrio) aims at improving the guidance and situational awareness of helicopter pilots under bad weather circumstances due to the availability of improved positioning performance, accuracy and level of integrity.

NAVELEC – Navigation for electrical networks. The NAVELEC consortium (PEPITe S.A., Université de Liège, Deling, M3 Systems) will show the added value of Galileo solutions for operating and controlling continent-wide electrical power systems. The synchronisation capacity of Galileo would prevent blackouts due to time precions measurements.

SARHA – Sensor Augmented EGNOS/Galileo Receiver for Handheld Applications in Urban and Indoor Environments. The SARHA consortium (TeleConsult Austria, Ecole Polytehnique Fédérale de Lausanne, u-blox AG, OECON GmbH, Dynatronics AG) will combine modern satellite navigation receiver with augmented sensors. It will show the reliability and robustness of this approach for personal mobility applications in unfavourable environments such as urban canyons and indoor.

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[2] PROGENY (2008). SME project brochure. http://progeny.galileoprojects.eu/67.0.html?&no_cache=1&dlpath=Galileo_Workshop_for_SMEs#

Tracking the location of a device over time enables calculation of velocity and direction of the device, thereby offering a host of navigation services. Determining the location is based upon a very accurate synchronisation of the clocks on board of the satellites. With this synchronised time satellite navigation systems provide timing information. Satellite navigation systems can thus be seen as an *enabling technology*, enabling the provision of a broad range of services on the basis of capturing the signals provided by the satellites.

The range of (potential) services runs over a multitude of societal sectors. A very important application domain is road traffic and transport. This encompasses road navigation, electronic tolling, fleet management systems, advanced driver assistance systems, incident detection and intelligent infrastructures. Within Europe, almost all 240 million vehicles could profit from the benefits of navigation systems, driver assistance and additional services as electronic payment and insurance options[3].

Location based services are another interesting application domain. Personal services (where to find a tourist hot spot, a good restaurant, a hotel, your friends, etc.) can be attached to information concerning the location of a specific person. These services encompass guiding services, information services, aiding services, communication services. Especially with the advent of mobile phones equipped with GNSS chipsets personal location based services will continue to expand and to become integrated with 'ordinary' communication facilities. Worldwide, 2 billion mobile phones are in place, half a billion mobile phones are sold each year, and this number is expected to increase to a billion per year in 2020 (EC, 2006). The 24 million GPS equipped units of today will have grown to 55 million GPS equipped units in 2012 (Xiaofeng, 2008).

Rail infrastructures are usually equipped with costly equipment along the rail tracks. Maintenance costs are high for ground based equipment. Satellite navigation technologies save money and can improve efficiency of the train monitoring and control systems in use; Europe's 150.000 kilometre of rail is used by some 100.000 passenger and 500.000 freight wagons. Using satellite navigation improves train and track control, safety measures, international cooperation and could even improve comfort in offering timely information about curves in the rail tracks.

Europe's aircraft force consists of 15.000 civilian aircrafts and 30.000 smaller private planes, experiencing a growth of 4% a year (doubling in 20 years). By using satellite navigation it becomes possible to reduce the time between departing and landing airplanes, and the departing and landing process itself can be guided, resulting in steeper slopes of landing and departure. Ground vehicles at airports can be tracked thus enhancing safety at the airport itself. Coupling between ground and flight systems becomes possible. The Galileo integrity signal warns when integrity of signals can not be guaranteed, thus improving the safety of the system.

Maritime applications run from guidance of vessels in the neighbourhood of seaport, vessels on inland waterways, safety and rescue operations of vessels and people in distress at open sea, monitoring and control of containers in open sea and in ports, thus improving logistic processes. In Europe alone, each year 40 million containers arrive in one of its sea ports. GNSS can assist fishing fleets in locating fishing grounds for fish that might be of interest, according the quota rules. Satellite navigation can be of help for oil and gas companies who are seeking for newly to be explored gas and oil fields at sea and who are exploiting existing fields, by offering precise positioning information.

[3] The market characteristics of these applications will be detailed in section 2.1.3

Pipe laying, pipe surveys, underwater constructions, rig and platform services are aided with precision information which is accurate up to 0.5 to 1 metre. And for inland waterways, satellite navigation can be of assistance in detecting underwater obstacles, or for pipe and cable laying activities.

On the basis of the reform of the European fisheries policy there is a need for Vessel Monitoring Systems which enable the identification of vessels, larger than 15 m. Speed, course and position needs to be provided in a track record of the vessels. Satellite navigation offers a powerful tool to comply with the new regulatory framework.

Within agriculture, precision farming is assisted with satellite navigation technologies, which enable crop yield measurements, or a fine-tuned system of variable fertilizer spreading, based on soil composition and crop yields. In combination with RFID it enables tracking and tracing of animals and animal movements, this being obligatory for sheep and goats within the European Union since January 1, 2008.

Timing information of satellite navigation systems is used for synchronising electricity networks. By using electronic mapping systems it is possible to reduce power outage time by 20%. In these maps, several critical nodes (many thousands) of the electricity networks are visualised, enabling quick alerts when specific nodes malfunction. Workers in the field can also be offered assistance, thereby improving efficiency of their activities.

All applications in use today are based upon the open service model of GPS and GLONASS. The signal is offered for free, and applications can be built upon the characteristics of the signals. Galileo will however offer a broader range of services:

- ***Open Services (OS)***, which are basically free of charge for the user. These open services are similar to the services offered through GPS or GLONASS.
- ***Commercial services (CS),*** which use higher data rates, have improved accuracy and offer access control through encryption of the data channels. These commercial services typically provide services when accuracy or reliability/integrity is of utmost importance, such as in laying pipelines, in precision farming, in future assisted driver applications (curve assistance or proximity driving). The market for commercial services is still under development, but it is stipulated that this market represents only a minor fraction of the total satellite navigation application market (see Hein, 2008).
- ***Safety of Life Services (SoL),*** which provide integrity information; a user is warned when a specific satellite or the system itself should not be used for navigation. Aircraft landings and critical operations with helicopters, operating under bad weather conditions, are supported with this feature. When the signal of a specific satellite or the system itself is compromised, for whatever reason – this is broadcasted within a time delay of 6 seconds.
- ***Public Regulated Services (PRS),*** offering dedicated services to public organizations such as transborder controls, customs services, fire brigades and police, being embedded with anti-spoofing and anti-jamming functionalities.
- ***Search and Rescue Services (SaR),*** which locate distress beacons and implement a return signal; these will be part of the international COSPAS-SARSAT system, directed at signalling need for help in maritime, air-based and – since 2003 – personal distress situations. This service will make use of the return link of Galileo, thereby representing a unique feature of the Galileo system.

Galileo will enhance the range of possible applications with satellite navigations. It remains however to be seen whether the strategy Galileo will pursue is an economically profitable one. Concerns are raised regarding the intended taxation of Galileo chipsets (which would increase the price of Galileo receivers) and to the business models behind the commercial and the public regulated services. The initial business models that have been drafted a few years ago (EC, 2001) need to be updated in order to get improved insight in the cost-benefits of the possible strategies. The added value of Galileo will clearly demonstrate in improved accuracy, service continuity and systems integrity, alone and in combination with GPS and/or GLONASS. However, uncertainties remain high on the modes of revenue sharing and potentially profitable business models that will facilitate the development of Galileo Commercial services. The emphasis should be placed on developing sound business models for the various service categories Galileo offers, this being an important need of the application providers.

1.2.2 Innovative potential and R&D needs

The services presented in the previous section have to demonstrate the economic viability of Galileo. Most applications use the signals offered by satellite navigation systems and enrich them with additional information or communication facilities, such as GIS, electronic maps, wireless networks, telecommunication networks, software-based tooling, databases and the like. The largest part of these services will be offered by a wide range of private parties. These companies – most of them being SMEs – follow their own innovation strategies in developing new products and services and combining forces to get a greater share of the market (as for instance the combination of TomTom with Tele Atlas and Nokia with Navteq). Application providers do not belong to the 'traditional' part of the European space industry. They act on sometimes highly competitive markets. We will return to their position in the value chain in section 2.1.3.

Another part of the innovative potential of Galileo is within the Galileo programme itself. A part of the funding of Galileo and EGNOS stems from EU Framework Programmes. In the recent fine-tuning of financing of Galileo and EGNOS, an amount of €400 million over the seven years of Framework Programme 7 – which runs from 2007 till 2013 – has been included in the total budget needed for Galileo. The objective of the Galileo FP7 programme is to create economic value, to ensure system competitiveness, to maximise public benefits and to foster international relations. The annual budget for the Space activities within FP7 is roughly equivalent to the annual budget dedicated to space activities within FP6 and is about €60 million annually. In FP6, activities were focused on the deployment of local components, on standardisation and certification and user segments. In FP7, two themes have dedicated resources to Galileo: the Space programme (Theme 9) and the Transport programme (Theme 7). Within the Space programme the focus is on GMES applications and the integration with satellite navigation for the prevention and management of critical situations and emergencies. Within the Transport programme the focus is on aeronautics, but the work programme for 2008 does not exhibit any specific attention for applications. FP6 projects cover different service domains of Galileo (from Open Services to Search and Rescue services). Scientific and fundamental aspects of the Galileo programme are covered in a number of research projects covered by GJU previously and GSA at present (such as the development of reliable and accurate satellite signals for a variety of application domains, with an eye on fundamental problems related to clocks, atmospheric disturbances in signal propagation, measurement techniques, receiver equipment and the like). A first colloquium on these aspects was held in October 2007, sponsored by ESA (ESA, 2007).

Innovation within the Galileo programme is thus secured by the relation with the European Seventh Framework Programme, and specifically the research programme on Space and on Transport. The European Commission attempts to involve market parties through consultation processes. It recently started one concerning the Open Service (GSA, 2008).

The European Space Agency has had a great share in innovative projects from 2001 till 2006 to which ESA members participate. It covered activities in personal Location Based Services, road, aviation, rail, waterways, multimodal transport and remote asset tracking, emergency management and indoor positioning. Most of these activities have ended in or before 2006. Today, ESA is still active in a project on road management (ARMAS) and on the development of innovative space receivers. Overall, navigation was about 12% of the 2006 ESA budget (€ 2.9 billion). Funding for navigation applications in national space programs is modest. In France, for instance, only €32 million on a total of €1071 million is devoted to 'general public', including satellite navigation.

We want to conclude that innovation in satellite navigation services in Europe is embedded in European R&D programmes, especially FP6 and FP7 and GJU/GSA projects. Public attention for innovation in satellite navigation applications is however relatively modest, compared to other space segments. Innovation in European research programmes focuses on the GNSS system itself. Innovation in application domains is mostly left over to private parties. They are, however reluctant in taking up major challenges in application domains, being engaged with day-to-day competition in – GPS-based – products and services.

1.2.3 GNSS Market characterisation

1.2.3.1 Market drivers

The GNSS market is driven by a number of different factors (GJU, 2005, pp. 24-30):

- Technological factors
- Political and regulatory factors
- Social factors
- Economic and industrial factors

Technological factors relate to the on-going miniaturisation of micro-electronics and the advances that are made in receivers. GIS and digital mapping have made considerable progress in recent years, amongst others through lowering costs of storage capacity and improved imaging facilities. The on-going evolution in mobile technologies – now in the process of implementing third generation UMTS devices, of which an increasing part will be equipped with satellite navigation applications – is favourable to the dissemination of satellite navigation services. And, last but not least, the technological advances which are put forward by Galileo stimulate innovation by the other GNSS actors (within GPS and GLONASS).

Political and regulatory factors relate to specific regulations and directives which may enforce specific services and products. The urge for more efficient and safe transport networks, in Europe enforced by DG TREN, is such a driver. New directives in fisheries policies, in environmental monitoring and in agriculture are another. In the USA it is mandatory for all public providers of communication services to facilitate emergency (911) calls, the UK has regulated that all its ambulances will be equipped with satellite navigation applications to facilitate the ordering of ambulances to the appropriate places within the timeslot required, and Germany is enrolled in a road tolling system for trucks since 2005. These policy enforced activities drive use of satellite navigation applications.

Social factors relate to the increasing demand for electronic gadgets by consumers and the increasing sophistication of these demands, serving several purposes at once. An important driver is the socio-economic changes in mobility patterns, due to a combination of factors (crowded cities, improved means of transport, economic growth) which are related to the change in work patterns and which induce a growing demand for location services, with people living and working at different places and people travelling ever more over the years, visiting places more abroad and more unknown to them. Another driver is the concern for transport and personal safety which enforces innovation of in-car electronics, traffic management and travel information services.

The last category relates to globalization, leading to the emergence of global players, an example being Nokia which has offered its services to the equipment manufacturers of GLONASS receivers. Production of equipment along the value chain (micro-processors and antennas – receivers – navigation systems – platforms) is global as well, leading to competition on prices, quality and additional services. A final contributing aspect to the on-going industrial development is the relatively high replacement rate, leading to a voluminous replacement market.

1.2.3.2 Examples of typical players

Major players in the satellite navigation industry partly overlap with major players of other clusters. The sector has shown a vivid pattern of mergers and joint ventures in the past decade leading to a number of prime contractors for the European space industry. A typical example is ***Thales Alenia***, which is the result of a recent take-over by Thales of two joint ventures: one between Alcatel and Finmeccanica and another between Alcatel Alenia Space and Telespazio. In 2007 Thales Alenia had 7200 employees spread over 13 industrial sites in five different countries (France, Italy, Spain, Belgium and the USA). It is the prime contractor for EGNOS, leading a team of 50 partners in 11 European countries. It is responsible for several aspects of the GIOVE-B test satellite, launched successfully 27th of April 2008, amongst which the power system, the Remote Thermal Unit and the Clock Monitoring control Unit, the ground mission segment of both GIOVA-A and –B, and the assembling phases of the satellite. More information about Thales Alenia is provided in the section on Earth Observation. Another major player is ***EADS Astrium***. Astrium, being a full subsidiary of EADS, has a turnover of €3.5 billion in 2007, with 12,000 employees in five countries (France, Germany, Spain, the Netherlands and the United Kingdom). Divisions of Astrium are Astrium Space Transportation, Astrium Satellites for spacecraft and ground segment and Astrim Services for the provision of satellite services. Astrium provided the Hydrogen Maser, a precision clock on board of the GIOVE-B test satellite and bear responsibility for the development, installation and test of the Ground Satellite Control Station at Fucino (Italy) and the InOrbit Test station in Redu (Belgium). Further information on EADS Astrium can be found in the chapter on Earth Observation.

The Galileo consortium that bid for the concession on the Galileo systems development phase comprised some major other European companies, such as HISPASAT and Inmarsat. ***Inmarsat*** is a relatively small organisation of some 400 staff members, situated in London and dealing with the Global Maritime Distress and Safety System of the International Maritime Organisation and providing the GMDSS to ships and aircrafts for free, as a public service,. Inmarsat plc is the commercial branch of the organisation, founded in 1979, originally fully as an intergovernmental not-for-profit organisation. It hosts a total of 12 communication satellites. It was part of the Galileo Industries consortium and was to become the lead company overseeing the systems operations of Galileo.

HISPASAT is a Spanish organisation, established in 1989 in order to become the leading satellite operator in Spanish and Portuguese language markets. As of today, it operates six satellites at three different orbital positions providing advanced telecommunication services for businesses, broadband access to Internet and interactive services related to video conferencing, video on demand, content distribution and topics as tele-training, providing a turnover of €500 million. HISPASAT is part of the Spanish company Galileo Sistemas y Servicios which is a founding member of the European association called Galileo Services. HISPASAT will operate the Ground Control Segment of the Galileo/EGNOS system from its premises at Arganda del Rey. This GCC will expand over the years from a Search and rescue centre to the third full Ground Control Centre, combining 18 satellite earth stations as well.

Galileo Services combines the efforts of some 20 European companies dealing with the provision of services using the Galileo/EGNOS signals. Galileo Services comprises companies of all parts of the value chain, from delivering the equipment and the platforms in order to receive the Galileo services to the services themselves. Many of the services provided today relate to GPS. In relation with the GSA (formerly the GJU) innovation projects are running that aim at using the full potential embedded in the multitude of diversified Galileo signals.

Septentrio Satellite Navigation NV being one of the companies engaged in Galileo Services, is a spin off of the Belgium Interuniversity Micro Electronics Centre (IMEC), a university research centre active in the field of developing new generation micro-electronics. Septentrio is situated at Leuven, Belgium. It delivers high-end dual frequency GNSS receivers. Its experts develop high-performance navigation algorithms and expertise in satellite navigation applications. It participates in a number of EU and ESA-funded projects such as the Locoprol project, a project dedicated to providing a cost-effective vital fail-safe train location system as part of the European Train Control System, and MARUSE, a project dedicated to the development of Galileo/EGNOS services in the maritime domain (dedicated to security, availability, integrity and continuity of services).

An overview document of the GSA identifies 68 SMEs active in the field of providing Galileo products and services (GSA, 2007).[4] These SMEs are spread out all over Europe (14 countries are covered, including Lithuania, Slovenia and Czech Republic), covering all parts of the value chain – from antennas to geographic information systems, market development, regulatory issues and training and relating to all conceivable fields of applications (rail, maritime, aviation, road, LBS, tourism, etc.).

Skysoft Portugal is a Portuguese firm with a turnover of €3,3 million and some 60 engineers in a number of application domains (Aeronautics, security & defence; Space; Mobility Telematics & Business Solutions). It is developing applications for road, maritime and aeronautics markets. Skysoft delivers GPS/Galileo software signal receiver simulators, an Enhanced Signal Generator, and participates in preojects on traffic management and billing for open road tolling (RITA) and road user charging solutions (ARMAS) at the vehicle and control centre levels. It participates in various Galileo-related projects: SWIRLS (Galileo/GPS-receiver for the professional market); ANASTASIA (Airborn e New Advanced satellite Techniques and Technologies in a System Integrated Approach); GUTD (GNSS and UMTS Technologies Demonstrator); AGILE (Applications of Galileo in LBS Environment) and others.

[4] GSA (2007). *Galileo, Innovation through SMEs*, GSA Catalogue of SMEs, 1 November 2007.

Finally, companies such as ***TomTom*** uses GPS signals for its route navigation systems. TomTom is a Dutch company delivering advanced solutions to route navigation issues. Over the past five years the number of employees of the company grew from 75 to 1,078 (fifteenfold increase from 2003-2007). Revenues of the company in the same period grew from €39 million to 1,737 million (45 fold increase!) with profit raising from 6€6 million to €317 million (fifty fold increase!). These staggering figures are cooling down in the last two years. TomTom is in a process of acquiring TeleAtlas for €1.8 billion, for which it expects to get green light from the Commission in the months to come. The product portfolio of TomTom becomes more diversified but is primarily based on route navigation products, a market which is expected to grow with more than 50% in 2008 to a market of 38 million TomTom units. Research and development expenses are €60 million in 2007, being 16% of yearly revenues.

1.2.3.3 Market prospects

An ESA 2007 market analysis differentiates five macro segments (Government, Road, Professional, Consumer and Transport) with a total of seventeen distinct market segments (Euroconsult, Helios and Bertin, 2007). Table 1.1 compares the revenues of Europe within fourteen of the seventeen identified sectors with worldwide markets. For the three remaining segments no information was provided in the study. Most of these segments have already been described in section 1.2.1. A newly introduced segment is scientific applications which refer to the use of satellite navigation applications for scientific purposes, such as geodesy research or surveying the earth surface. This relates closely to specific GMES applications (see chapter 2). Workforce & Asset Management relate to providing workers with mobile devices, for instance, police and fire brigades.

Table 1.1: Revenues in satellite navigation services. 2005 figures

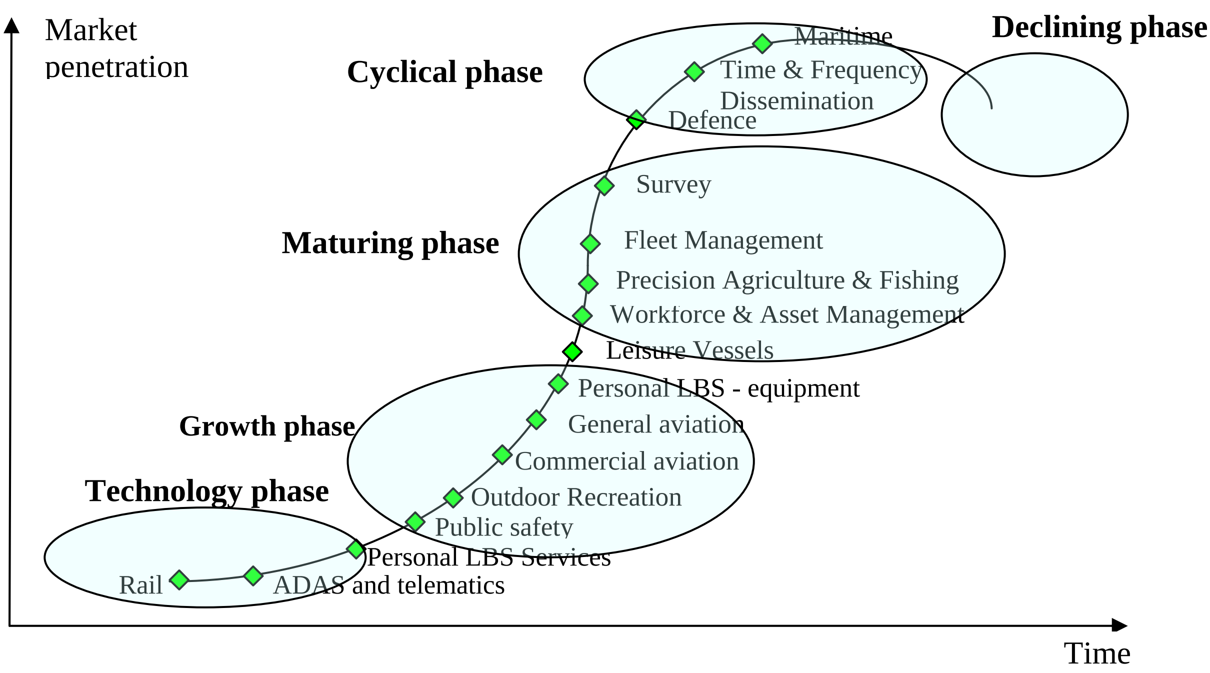
		Worldwide [m€]	**Europe [m€]**	**Share of Europe [%]**	**Annual growth rate**	**Growth rate of Europe relative to world**
Government	Public safety	n/a	n/a	n/a	n/a	n/a
	Defence	387	93	24%	~20%	-
Road	Fleet management	1730	420	24%	~45%	o
	Telematics & Advanced Driver Assistance Systems	5406	876	16%	~20%	-
	Traffic management	n/a	n/a	n/a	n/a	n/a
Professional	Scientific	n/a	n/a	n/a	n/a	n/a
	Precision agriculture & fishing	900	160	18%	~10%	+
	Workforce & Asset management –	1100	180	16%	~30%	o
	Time & Frequency dissemination	270	75	28%	~25%	-
	Surveying	1900	300	16%	~15%	-
Consumer	Leisure vessels	98	24	24%	~5%	o
	General aviation	125	32	26%	~5%	-
	Outdoor recreation	286	26	9%	~30%	-
	Personal Location Based Services	3850	-	0%	~85%	-
Transport	Commercial aviation	410	110	27%	~5%	+
	Maritime	125	30	24%	~5%	o
	Rail	28	16	57%	~10%	+

Source: Euroconsult, Helios and Bertin, 2007.

Table 1.1 shows that a few segments have already global revenues exceeding €1 billion yearly. The position of Europe in these sectors is only satisfactory in fleet management. Challenging is the absence of Europe in the sector of personal location based services. Total worldwide revenues in 2005 were € 17.3 billion, of which road transport had the largest portion: € 8 billion. The key driving applications for satellite navigation are fleet management, telematics and advanced driver assistance systems, and personal location based services. Overall, growth rates in Europe are comparable to worldwide figures, except for personal location based services.

The segments vary widely when considering their maturity. Figure 1.1 shows the market segments positioned in the traditional growth curve. The figure shows a number of segments to be already close to the declining phase while a number of other services have only recently begun. For the different phases, different regulatory measures are foreseen. The technological phase could for instance be supported with the aim to realise new applications and markets. The segments in the maturing phase could be supported by providing access to new markets and applications.

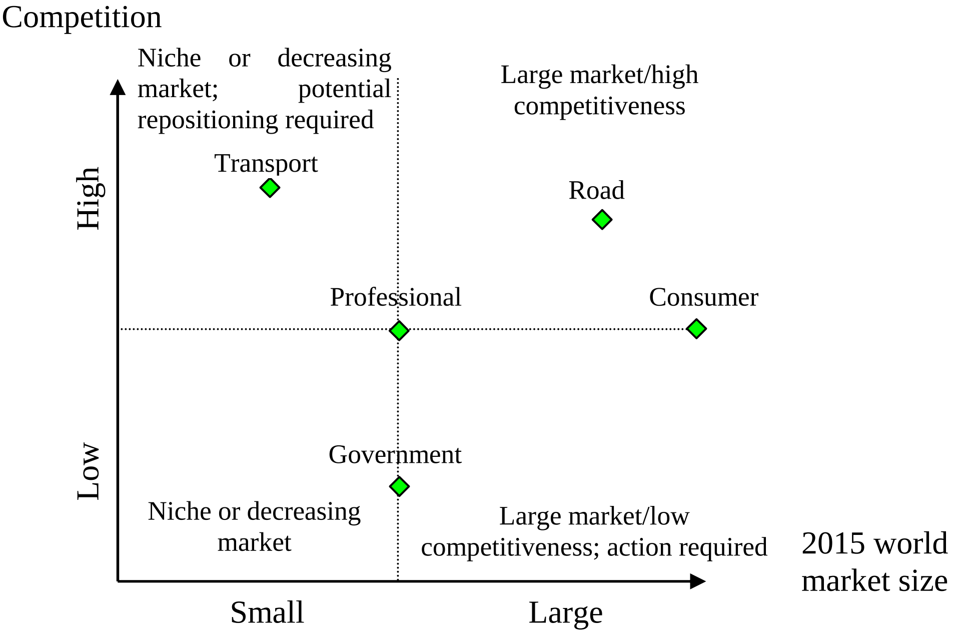
Figure 1.1: Positioning of satellite navigation market segments



Source: adapted from Euroconsult, Helios and Bertin, 2007

Another perspective is presented in Figure 1.2, which positions the five macro segments relative to size and competition. The figure shows the road and the consumer market to be highly competitive markets in which relatively large companies operate, while transport is in a highly competitive market with relatively small companies. The first is indicated as a market in which market forces should have the opportunity to structure the market while in the second situation (transport, which encapsulates rail, maritime and commercial aviation) public intervention may be required to enable growth from a niche market to a mature and large market.

Figure 1.2: Positioning of macro-segments in competition versus company size



Source: Euroconsult, Helios and Bertin, 2007

According to the ESA assessment on the downstream value-adding sectors of space based applications (Euroconsult, Helios and Bertin, 2007) an important difference between the European and the worldwide market on space-based applications is the smaller size and the lower specialisation in the private market that is visible in the European market, and the absence of a defence industry setting initial standards and activities. Worldwide, most companies operate on several segments and along the value chain. In Europe, hardly any actors can be found controlling the entire value chain. Overall, specialisation in Europe (having a focus on specific satellite navigation applications) is slightly less than worldwide.

The ESA study concludes with an analysis of the strength and weaknesses, opportunities and threats to the European satellite navigation application market. This conclusion is presented in Table 1.2. It states that Europe is overall well-positioned to develop new GNSS based applications in several segments, especially in road telematics and fleet management, while R&D for Galileo gets increasingly more attention. The ESA analysis is optimistic regarding the development of the (personal) location based services market, presuming high involvement of European MNO's. A major weakness is the high specialisation in the applications market, the lack of major players and a weak position for military suppliers. The study considers the newly accessed European countries to be important drivers of new 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 and – in one specific application domain – the prominence of the railway control system ECTS for the next 20 years, hindering novel satellite based applications.

Table 1.2: SWOT analysis of the European industry position

Strengths	Weaknesses
- Strong presence in European supply of GNSS services within Europe, strong telematics and fleet management competitiveness - Galileo R&D has focused attention on GNSS and promoted new applications - European MNO's and ASP's have begun to strongly develop the LBS market	- Limited number of significant suppliers in several segments (outdoor recreation, leisure vessel, general aviation, commercial aviation, military) - Very limited access to the market by military suppliers - European industry contains many companies competing only in one segment with large international cooperation that dominate value chains
Opportunities	**Threats**
- Greater interest and R&D activity on Galileo promoting its early use and adoption - Very strong take-up in vehicle navigation devices and higher than average consumer awareness - Economic development in Central and Eastern Europe with low level of existing infrastructure	- Continued conservatism towards future investments in LBS will lead to a reduction in lowering of prices for terminals in fleet management, telematics and customer applications Threats from strong privacy lobby in some regions - Majority of markets is in the US for several markets (leisure vessels, PA).It is difficult for the European industry to penetrate - ETCS will dominate the critical safety rail market in Europe for the next 20 years

Source: Euroconsult, Helios and Bertin, 2007

A first conclusion on the market position of Europe is that opportunities can be found in specific market segments which have not been capitalized yet within Europe, while they start to blossom worldwide. Europe has to catch up in two important markets: satellite navigation for road applications and for personal location based services. These are both high volume markets but in different technology maturing phases. Personal location based services and telematics/advanced driver assistance systems are the most promising, while fleet management is maturing but still shows very high growth figures.

A second conclusion is that the market for applications of satellite navigation within Europe has not matured sufficiently yet and faces a number of shortcomings to cope with international major players. For one, Europe does not have these major players, controlling the entire value chain. It is hard to see how this could be enforced by European policies. For another, Europe should primarily rely on market forces in a number of promising segments (road, personal location based services) while providing proper economic (opening up new markets, for instance in eastern European countries), social (dealing with social concerns such as privacy), and regulatory (offering the appropriate innovative structure) incentives.

A third conclusion relates to the predominantly civilian nature of the European Galileo project. Contrary to the United Stated and Russia (and China), the European effort is almost exclusively driven by civilian considerations. Though some countries (France) want a more outspoken role for military use of Galileo, the prevailing approach is that Galileo should be a civilian driven and carried project. This approach has its consequences in terms of market developments which – contrary to the United States and Russia – lack government as a launching customer and 'venture capitalist'.

Other measures (to which we will return in section 2.3 and 2.5) will be needed to mitigate weaknesses that have been observed and that can be corrected.

Market size: The role of the European Union as a political entity will be framed by the expected revenues for Europe as a whole. These revenues are not only phrased in economic terms but cover a broader set of issues (geo-political, social). To start with the economic incentive, the main issue is whether Galileo can be legitimized by reference to the market potential of all the application domains. Most studies present staggering revenues which can not be ignored. The largest market for satellite navigation applications is to be found in the business-to-consumer (B2C) market (55% worldwide, Europe 35%) while in Europe the business-to-business (B2B) market still is dominant. Market perspectives for satellite navigation can be found in various studies, with varying figures. The ESA 2007 study expects a sustained growth of satellite navigation applications until 2015 with figures growing from €17 billion worldwide in 2005 to €60 billion in 2015 worldwide, to which the road sector will contribute €28 billion. Europe will show a comparable trend, with growth figures for the LBS market from almost absent now to €800 million in 2015. Another European study by Galileo Joint Undertaking, published in 2005, expects a worldwide market of €276 billion in satellite navigation products and services to be realised in 2020, of which €98 billion will be service related and the remainder, €178 billion, will be product oriented. This arises from a market of €30 billion in 2005 (€23 billion-worth of products and €7 billion-worth of services). To specify the contribution of Galileo to these economic revenues, a more detailed presentation of the Galileo project itself is required. We will turn to this in section 2.2.

As was shown above, typical GNSS downstream markets lack major players covering the entire value chain; firms are smaller and have narrow specialization. There is, however, a tendency towards market consolidation as manifested by the recent wave of mergers. For instance, TomTom is a process of merger with Teleatlas, and Nokia -- with NavTeq. The market for PNT devices is in full flux, with difficult to control developments disrupting existing market structures (such as GPS-chipsets in mobile phones). Road applications are perceived to be the major inroad to expanding the market. Telematics and Advance Driver Assistance Systems are expected to be the lead market for the GNSS applications, together with personal LBS.

Although it is difficult to find definite trends in the literature, one may expect the continuation of the merger trend which will allow the firms to capture the entire value chain and offer additional value by a combination of services to individual consumers. Both road applications and personal LBS are competition-driven markets without much government involvement. Thus it is the sector where market forces seem to work quite well.

Notwithstanding the fact that stakeholders in the automotive industry are cooperating in many different ways (for instance, consortiums for research projects combining forces within Europe, such as ERTICO), a still unfulfilled role for public agencies remains in the area of policy issues related to GNSS and road applications, such as standardisation and interoperability. Other government roles could include offering test bed environments for new applications and relieving the burden of preparing R&D proposals for public funding together for SMEs. These recommendations can be found in other parts of the text.

1.2.4 GNSS trends and developments.

The satellite navigation applications are made possible by global navigation satellite systems. At present, one system is fully operational: the US Global Positioning System and one is partly operational: the Russian Global Navigation Satellite system (GLONASS). Galileo will be the third GNSS, the Chinese Compass/Beidou II system the fourth.

The US-based Global Positioning System (GPS) had its first operational satellite launched thirty years ago, in 1978, and had reached Full Operational Capability in 1995 with 24 satellites. It started to modernise its GPS programme from 1999 onwards, leading to a fully modernised and upgraded system in 2013-2014 (Sahid et al., 2006). Modernisation encapsulates additional civilian and military signals to improve positioning accuracy, signal availability and systems integrity. A major improvement was realised in May 2000 when the so-called ‘selective availability’ of the GPS signal was de-activated.[5] Before, the GPS-signal could be degraded by the USA, in order to decrease the positioning accuracy. Today, it is acknowledged that there is no option of returning back to the situation before May 2000. Selective availability has been switched off permanently. As of February 2007, GPS consisted of 30 operational satellites.

The Russian Global Navigation Satellite System (GLONASS) was initiated in 1976, and had reached a complete constellation with 26 satellites in 1995. Due to the unravelling of the former Soviet Union, the satellite constellation was reduced to only eight operational satellites in 2001. August 20, 2001, president Putin announced the federal ‘Global Navigation System’ programme, targeting for an upgrading of the existing GLONASS. India joined the Russian programme as partner. Present day satellites are second generation Uragan-M satellites which will be subsequently replaced by third generation Uragan-K satellites. GLONASS is expected to be fully operational at the end of 2011. Today, the GLONASS system consists of 16 satellites of which two are under maintenance (Spaan, 2008). There is however concern about the viability of the GLONASS system given the restricted lifetime of the satellites. Their guaranteed service lifetime is about three years, although in practice they function on average about four and a half years (GPS figures ten and twenty years respectively). With a production capacity of only six satellites annually, there is a danger of running short on satellite capacity in the near future (Oberg, 2008).

The European Galileo system has been announced February 9, 1999 by the European Commission. The original planning of the system has been adapted several times. Today, two satellite has been launched, GIOVE-A (28 December 2005) and GIOVE B (27 April 2008). Full Operational Capability is foreseen not before 2013 with a strict launching schedule in the years 2011-2013 with a constellation of 27 operational satellites and three spare ones.

Other countries are working on satellite navigation systems as well. China is developing a stand alone system called Compass/Beidou II, with one satellite in orbit (the 2007 figure). Information about the constellation is scarce. Japan intends to develop the Quasi-Zenith Satellite System to secure visibility of the Pacific region (with a constellation of three satellites).

Next to these stand-alone systems so-called satellite based augmentation systems (SBAS) are deployed which offer additional accuracy on top of existing GNSS. The USA has its Wide Area Augmentation System which is fully operational; Europe will deploy the European Global Navigation Overlay System (EGNOS) which will be fully operational by April 2009. Japan is developing the Multi-functional Satellite Augmentation System (MSAS). China has deployed together with Nigeria the NigComSat-1 for providing correction information for the African continent. India plans a similar system for the Asian continent, using the geostationary satellite Gagan. WAAS, EGNOS and MSAS will be interoperable. The function of these SBAS is to improve accuracy from the signals provided by the global navigation satellite systems from ~10 m to ~1-2 m typically. EGNOS will provide integrity signals for SoL services.

[5] Interestingly, selective availability has been set off because there was a shortage in military receivers during the Gulf War so that the military started to use civilian GPS receivers.

Technological differences between GPS, Galileo and GLONASS are manifold, and range from the clocks used to synchronise the signals to the number of satellites used for full coverage and the orbits in which the satellites are installed. The main difference is however the different coding of the signals. GLONASS uses a coding scheme on the basis of different frequencies (Frequency Division Multiple Access or FDMA) while GPS and Galileo use a coding scheme which is based on coding the signals themselves (Code Division Multiple Access or CDMA). Europe and the USA have agreed to make Galileo and GPS fully interoperable and compatible (on the so-called L1C signal), and guarantee each other that both satellite systems have the ability of Positioning, Navigation and Timing (PNT) services to be used separately or together (compatibility), and that PNT-services can be used together for improved performance (interoperability, see Avila-Rodriquez et al., 2007, p. 44). GLONASS has indicated that it will introduce CDMA in its system to be compatible with GPS and Galileo. Until this is to occur, receivers need to implement both kinds of signals if it is to use signals of all three systems. This makes integrated GLONASS/GPS/Galileo receivers more expensive. It is expected that there will be no single Galileo receivers but integrated GPS/Galileo receivers only that are able to use the signals of both systems to improve accuracy.

Though Galileo and GPS are based on the same signal, they are different in certain respects as well. Galileo is the first fully civilian satellite navigation system. GPS produces both civilian and military signals. The accuracy of the Galileo-signals is higher, though it remains to be seen whether this is still the case when GPS is fully modernised. Galileo provides a return link signal which is of special interest in Search and Rescue situations. Accuracy of Galileo in so-called ‘urban canyons’- canyons formed in cities due to high buildings - is higher than GPS. Galileo offers an authentication service which enables a device to authenticate itself. Galileo also has a broader array of services to offer than GPS, and intends to charge users for specific dedicated services.

Notwithstanding differences between the three main global navigation satellite systems, it is generally acknowledged that together they will provide a more robust and stable system which provide enhanced accuracy, enhanced continuity of services and improved systems integrity. A total of more than 80 satellites will span the globe. Within this constellation, there is a specific role for the Galileo-GPS constellation due to the agreement reached between the USA and Europe about compatibility and interoperability between both systems. Before GPS will be fully modernised, Galileo offers a broader range of possible services, which can lead to additional revenues in targeted domains. On the other hand, Galileo is the single system which does not provide all services for free. This might hamper the competitive position on Galileo.

1.3 Galileo experiences and lessons learned

1.3.1 Initial phases and lessons

The preceding sections have indicated the economic and competitive environment of present day satellite navigation market. In this section we will pay attention to the processes and factors which are influential to the development and deployment of the Galileo system itself.

Bringing Galileo to full operational capability runs along four phases: a definition phase, a development phase, a deployment phase and ultimately an exploitation phase. The first two phases have been financed fully by the European Commission.

The deployment and exploitation phase was intended to become a shared exercise between the European Commission and a concessionaire. Unfortunately, this approach failed to materialise. The concessionaire deemed the risks to be unacceptably high.

It also took considerable longer than expected to select a location for the headquarters of the consortium and to appoint a chief executive officer who would be in charge of the whole operation at the side of the concessionaire. The differences encountered during the negotiation process led the European Commission to abandoning the concessionaire procedure in May 2007. The failure of the negotiation process has led to reconsidering the governance, management and budget structure of Galileo and EGNOS. In a number of subsequent stages, the European Commission, the European Parliament and the European Space Agency have reached an agreement about financing, management, procurement, and governance of the European Space Programme dedicated to Galileo and EGNOS. In a meeting of November 29 and 30 and December 3, Council Conclusions were drawn which dealt with management, governance and procurement of Galileo and EGNOS (Council 2007). These were reiterated in an approach formulated by the Council of the European Union in a proposal at the 4th of April 2008 (Council, 2008a and 2008b).

In its explanatory statement for the European Parliament (European Parliament, Session document A6-0133/2008), the European Commission offered five lessons learnt from the early debacles of Galileo. Briefly, they consist of the following:

- Public Private Partnership principle (PPP) is an important form of cooperation but PPP that lead to monopolistic situation, either through mergers and consortia or procurements rules should be avoided.
- Common will within the European Community is indispensable for successful negotiations.
- The PPP model does not work under non-calculable risks presented by unknown technology. The Government should take over such projects.
- There is a need for a new methodology of cost-benefit analysis that can assess potential costs/benefits of numerous applications on an unknown market, along with multiplier effects.
- Delays in the decision making and execution in projects with fast-evolving technology lead to high costs and a loss of the comparative advantage.

Lessons 1, 2, and 5 are commonsensical and clear. A new methodology of cost-benefit analysis that can assess potential costs/benefits under this much uncertainty (Lesson 4) will not be forthcoming in the foreseeable future, if ever. On lesson 3, history shows that private sector is able to take some (sometimes even large) risk presented by unknown technology, which is often non-calculable, and the Government should not be a risk-lover either. In case of projects in the high-tech high-risk environment, a step-by-step, adaptive approach to project development should be applied, with the Government reducing inherent uncertainties with the means in its disposal, such as:

- A clear definition of public vs. private good and the role of initial public customer;
- Shaping the markets by means of advanced elaboration of market arrangements, financing and revenue sharing mechanisms, and risk-sharing measures;
- Interactive strategy with industry;
- Interactive and smart cost-benefit analysis even if, by necessity, only partial in scope.

This is very relevant for the preparation for the upcoming exploitation phase, which should progress early on. Yet another lesson that we would like to add is that institutional and procedural harmonization is crucial for projects in multi-institutional setting.

1.3.2 Financing

Due to the newly arisen situation after the failure of the public private partnership approach an assessment has been made of the involved financial commitments needed for the various phases of the Galileo programme. The initial limits of European contribution to Galileo have been revisited, given the withdrawal of private investments and the adjusted estimations concerning the design, deployment and exploitation phase of Galileo. Table 1.3 presents an overview of the calculated costs of realising Full Operational Capability of Galileo and EGNOS (EC, 2007b).

Table 1.3: Estimated budgetary costs of Galileo and EGNOS

GALILEO AND EGNOS PROGRAMMES	COSTS (M€)
Galileo Full Operational Capability	
Satellite and launchers	1,600
Ground control infrastructure	400
Operations	275
Systems Engineering	150
Procurement Agent management costs	195
EGNOS	
Exploitation and operation	330
Support to the Commission	
Project management support and advisory services	27
Contingencies	428
Grand total	3,405

Source: EC, 2007b, p. 3.

These total costs should be compared to the initial €700 million which the European Union would contribute to the concessionaire (who would be responsible for investing another €1,400 million, leading to total estimated costs of €2,100 million). Cost overrun for realising Full Operational capability is thus €1,305 million. Other costs which are not within this figure are the costs already made in the definition phase (€133 million; finalised in 2001), the development phase (not yet finalised, costs being estimated at €1,502 million) and the costs invested for realising full operational capability of EGNOS (€520 million). Figures of the last two cost items are from a recent UK House of Transport study (House of Transport, 2007, p. 9).

The German space expert Günter Hein has made an assessment for the European Parliament of the requested funds of €3.4 billion for the deployment phase. The calculations provided by ESA and the European Commission have been analysed together with the calculations as presented in an industrial proposal (Hein 2008, pp. 9 ff). Correcting for the various assumptions on which the calculations were based (the number of satellites in reserve, the number of Ground Control Centres and the use of different launchers), the conclusion of Hein is that the proposition of the European Commission represents “a reasonable best ceiling price according to present knowledge” (Hein 2008, p. 10).

The budget of €3.4 billion includes contingencies in the range of €428 million which may be used to cover budget overruns of the In Orbit Validation programme.

The European Commission has proposed to use the standing internal financial regime to enable funding of the additional costs. This has been approved by the European Parliament and the Council in a decision on 18 December 2007 (CEU, 2008a, p. 8).

This budget is composed of €1,005 million initial budget, added with €2,000 million through a review of the current financial framework of the EU and a sum of €400 million which is made available from the Seventh Research and Development Framework programme. Member States and third countries or international organisations may provide additional funding to the programme.

Though the budgetary issue seems to have been settled with the approval of additional means to the Galileo/EGNOS programmes, a number of issues are still open. First, up till now cost overruns have been part and parcel of the Galileo/EGNOS programmes. In a critical review of the UK House of Transport budget overruns of 30% per phase up till now are reported (House of Transport, 2007, p. 9). The amended budget proposal implies a budget increase of more than 60% compared to the initial budget of €2,100 million. Since space activities are high risk activities, and contingency budget is restricted to about 14% (€428 million) it remains to be seen whether this is sufficient. Second, the exploitation phase is not included in the budget proposal. Again, according to the UK House of Transport, these could be as much as €7,960 million during the twenty year exploitation.

As the Council on Transport, Telecommunications and Energy acknowledges in its proposal for an amended regulation, these kinds of risks are usually carried by public actors, not by the market (Council, 2008a). There is a risk that market parties will not take up the challenge of full involvement in the exploitation phase of Galileo. A third issue is the option of shared revenues. In the proposed amended regulation it is stated that "[a] revenue sharing mechanism may be provided for in any contract(s) concluded with the private sector"(article 9.2). This will not negatively influence the budget to be invested but it may be detrimental to the overall incomes of the Galileo services.

1.3.3 Management and governance

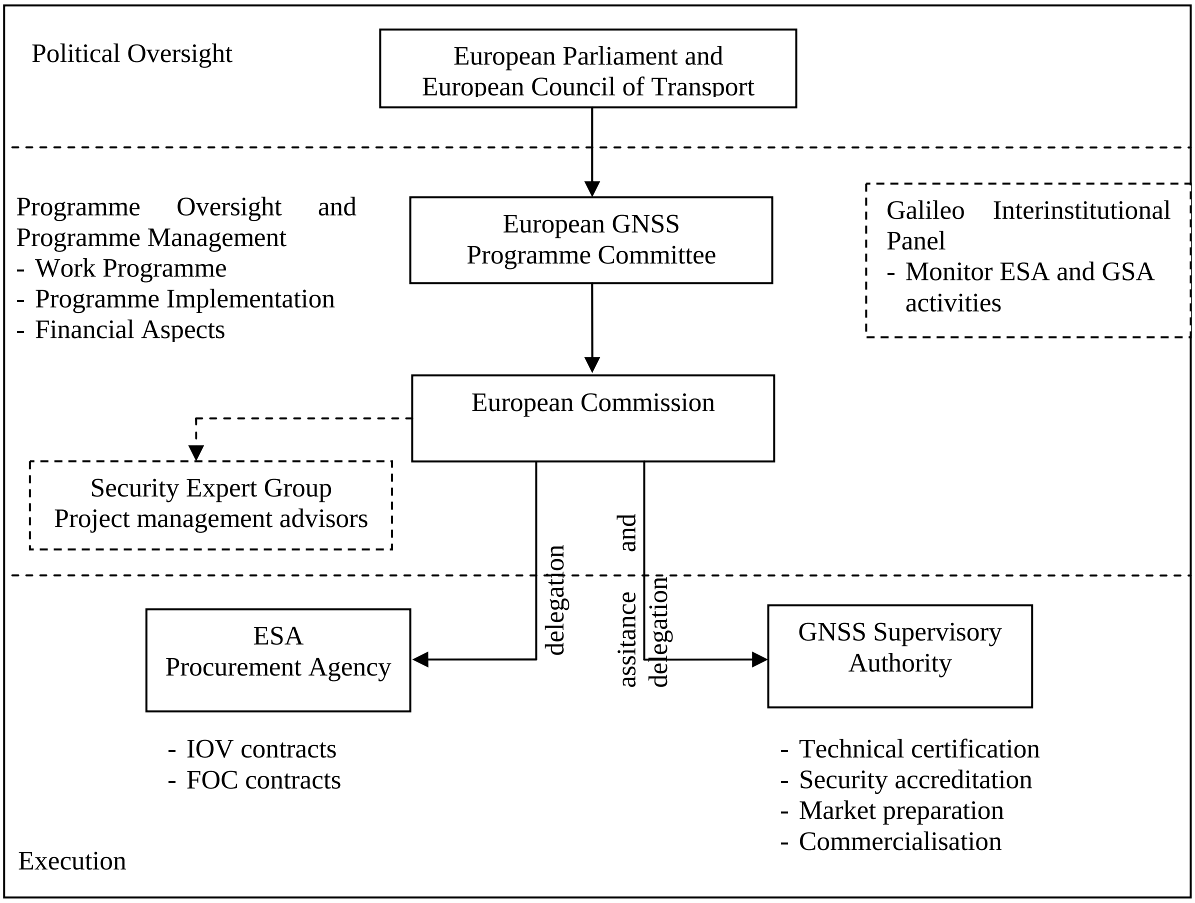
Due to the failure of the negotiation process with the intended concessionaire a new management structure for the Galileo programme had to be revised. The role of the Galileo Supervisory Authority had to be revised, since its primary role was the supervision of the concession. After negotiations on specific parts of the management structure, the proposal for the amended regulation (European Parliament, 2008; Council, 2008a) presents the management structure as depicted in 1.3.

Three layers of management can be discerned: political oversight, programme oversight and execution. Political oversight is executed by the European Council of Transport and the European Parliament. Programme oversight is executed by the European GNSS Programme Committee who monitors the European Commission. As stated in the amended regulation "[i]n view of the importance, uniqueness and complexity of the European GNSS programmes" there is a need for close co-operation of the European Parliament, the Council and the European Commission. To foster this co-operation a Galileo Interinstitutional Panel (GIP) will be installed, composed of three representatives from the Council, three from the Parliament and one from the Commission which will meet regularly (four times a year) with the aim to follow closely:

- the progress on the implementation if the European GNSS programmes

- the International Agreements with third countries
- the preparation of satellite navigation markets
- the effectiveness of the governance arrangements
- the annual review of the work programme

Figure 1.3: Management structure for Galileo-EGNOS programme.



Source: Adapted from Hein 2007, p. 4.

The main issue is however the roles and responsibilities of the GNSS Supervisory Authority. Its role is transferred into an Authority which shall accomplish the following tasks:

- Ensure security accreditation and the operation of a Galileo security centre;
- Contribute to the preparation of the commercialization of the systems;
- Contribute to the promotion of applications and services in the satellite navigation market;
- Ensure that the components of the systems are certified by the appropriate, duly authorized certification bodies.

The European Commission will be assisted by two expert groups, one on security issues and another on project management issues.

The role of ESA as procurement agency is described in the section 1.3.4.

The management structure of the Galileo/EGNOS programme is well-organised and exhibits the inclusion of the ‘lessons learned’ of the previous phases.

A number of issues remain however problematic, and may have adverse impact on the continuation of the programme. The first is the build-up of expertise within the Commission and within ESA to manage the programme activities. For the Commission this implies a new unit will have to be established and needs to be equipped with 30-40 experts on the Galileo/EGNOS programme activities. On the side of ESA a unit will have to be build up for the operational challenges at hand. Again, this will require recruitment in the order of 30-40 people (Hein, 2008).

Even when recruitment of expertise is not the problem, getting the units up and running may cause additional delay (of a number of months). Second, a similar argument goes for the GSA. Personnel will have to be recruited, and working procedures will have to be formulated. GSA's activities are however less time critical than the activities of the Commission and ESA in running the programme. Finally, involvement of Member States, third countries and international organizations is welcomed but procedures for involvement will have to be settled since the usual approach of ESA (fair geographical return) is not allowed.

1.3.4 Procurement

In the new situation, ESA will be responsible for the procurement of all elements of the Galileo/EGNOS system. In order to have maximum competitive power and to optimally stimulate innovation practices, the EC-ESA Delegation Agreement on procurement strategies encompasses a number of guidelines (Hein 2008, p. 7):

- The work to be done is subdivided in six work packages (systems engineering support; ground mission infrastructure completion; ground control infrastructure completion; 26 satellites, to be delivered in three batches; launchers; operations).
- All work packages are open to maximum possible competition, including advancement of contribution of SMEs and new entrants.
- Any legal entity may bid as prime contractor on a maximum of two of the work packages.
- A minimum of 40% of each bid has to be subcontracted to parties not part of the prime contractor.
- Wherever appropriate the principle of dual sourcing will be applied in order to avoid risks and dependence of single competitors.
- Non-European partners may be invited when this would have clearly demonstrated advantages in terms of quality and costs.
- Integrated risk management structure.
- Due to the strategic nature of the European GNSS programme, special attention will be given to security and export control requirements (EC 2007b, p. 12)

According to Hein, a number of issues still have to be resolved or clarified such as the procurement of the three separate batches of 26 satellites (including the launching segment) and the involvement of SMEs which so far have not been settled (Hein 2008). Another, more difficult to tackle, issue is the risk in the procurement strategy itself, which relates to the competences that need to be build up by ESA and EC (see previous section) and to the organisation of the space industry. For a cost-efficient and qualitatively high standard of operation one needs the best of the industrial world to participate and to be closely linked to the requirements of the space programme.

ESA suggests to collaborate with national agencies and to discuss with industries their role in securing expertise in the field of system and management tasks (ESA, 2008).

1.3.5 Legitimizing Galileo

With the failure of the concessionaire construction in 2007, the increased budget claims for Galileo, the shifting time frame in the realisation of the Full Operational Capability of Galileo, and the on-going changes in worldwide satellite navigation systems (modernization of the existing systems and the realisation of novel ones), the need to legitimize additional investments to realise Galileo increases as well. Both the European Council and the European Parliament have emphasized the need for an independent European satellite navigation system and have expressed their political support to the Galileo system.

The motivations for this political will can be found in a number of arguments:

- Being independent of foreign satellite navigation systems such as GPS
- Offering a basis for the European space industry
- Offering a basis for European innovation and economic growth

Dependence on GPS or GLONASS means that at all times European based services will have to rely on foreign and military based systems. This might provoke international tensions in times of international crises, military conflict or political challenges. Even though the 'switch on/switch off' button of GPS has been permanently removed, thus ensuring quality of services irrespective of international situations, the mere dependence on military systems is undesirable. This is a strong geo-political argument for creating a European-based GNSS system.

The European space industry is active in a number of space segments. It had a turnover of €5 billion and employs about 30.000 people (ASD Europe, 2007; 2006 figures). Since 1997, the commercial space market has exhibited a sharp decline from €2.4 billion (1997) to €1.8 billion (2006). The institutional market has compensated for this cyclical behaviour of the commercial market by increasing its share from €2.7 billion in 1997 to €3.1 billion in 2006 (ASD Eurospace 2007, p. 3-4). Institutional support for the space market is thus essential to keep the European space market a viable market.

As indicated in section 1.1, the application market of Galileo is a promising market. Galileo offers a number of additional features on top of GPS. It offers increased accuracy, higher data rate capacity and specific features to prevent jamming and spoofing in its commercial services, it offers Safety of Life features and Search and Rescue services, with a unique feature as a return link to facilitate tracking down boats, airplanes and people in distress, and it offers the opportunity to a specific branch of public regulated services. At this point in time it is however not possible to indicate the precise commercial added value of Galileo. Some argue that most of the economic value that is usually attributed to Galileo can also be realised without Galileo and with using existing – foreign – satellite navigation systems (see e.g. House 2008, p. 14 ff). Notwithstanding this critical approach of Galileo as a source of innovative and competitive capacity for European players, Galileo can be seen as a novel infrastructural element within Europe, offering opportunities to a wide array of firms throughout the European Member States, including the States which have started co-operation with ESA or have the intention to do so.

1.4 Regulatory framework

In December 2006, the European Commission has launched a consultation process on a number of regulatory issues concerning the further development of Galileo and EGNOS (EC, 2006a).

The aim of the consultation process was "to launch a discussion on what the public sector can do to create an appropriate policy and legal framework for supporting the development of satellite navigation applications, beyond the financial support for research and the creation of infrastructure" (EC, 2006a, p. 2). The regulatory issues covered privacy, security, standardisation and certification, frequency policy, intellectual property rights and the existence of regulatory barriers to market introduction of applications. Other issues that were covered in the consultation process relate to the role of SMEs, international cooperation and the role of research and innovation. The results of the consultation process should become public in the fall of 2008. A conference has been announced to take place in June 2008 which will cover the results of the Green Paper consultation.[6] The following discussion is thus based on an analysis of other sources, not only directly related to Galileo.

1.4.1 Standardisation and certification

Standardisation is a prime issue within Galileo, to secure compatibility and interoperability of Galileo with other navigation systems (satellite-based, wireless networks, telecom-based). From the start of the Galileo-project, attention has been given to standardisation. The Galilei-project (2000-2002), accomplished by a consortium of the European space industry, has analysed the legal and regulatory framework needed for Galileo. A number of EU-projects have dealt with different aspects of the standardisation process. The subject has been an important element of FP6. November 2007, a European call for tenders on various aspects of standardisation and certification issues has been closed. The tenders included standardisation issues of application domains (aviation, maritime, LBS), frequency regulations including interoperability and compatibility, and specification and standardisation of receivers (GSA, 2008). Cooperation has been sought with domain specific standardisation bodies such as the International Maritime Organisation (IMO), the International Civil Aviation Organisation (ICAO), the International Association of Lighthouse Authorities (IALA) and the European Road Transport Telematics Implementation Coordination Organisation (ERTICO). A study about the role of the European Commission in promoting a European Radio Navigation plan, concluded that the European Commission should drive standardisation and certification issues with Galileo/EGNOS as key projects, based on economic and social incentives, creating a level playing field for competitors on navigation equipment and services (Sage and Ives, 2006).

1.4.2 Intellectual property rights

Unlike GPS, Galileo is based on expected revenues from offering satellite navigation signals. Even the Open Service will not be entirely free of charge, since the Commission might charge equipment manufacturers and service providers with (marginal) costs to use the Galileo signals. Intellectual property rights generation can be based upon charging the manufacturing devices, such as the chipsets and the user terminals, and the service providers, of commercial services, safety of life services (especially aircraft), public regulated services and search and rescue services. But also offering open services could be subject to charging (marginal) costs for delivering the service, using Galileo coded signals.

[6] See http://www.galileoconf.eu/welcome_en.shtml

The business models behind the charging mechanisms are not known, yet. It is expected that revenues will be sufficient to cover the public expenses of EGNOS/Galileo (see section 1.5). Through IPR licenses, certification of original receivers and devices can be guaranteed. Charging specific services is only viable when the services are considered to have added value which surpasses the fee to be paid. A number of issues concerning IPR have to be dealt with.

The most important one is the strategic issue whether IPR is an appropriate means to drive innovation or whether it might hamper innovation. The second one is the uncertainty that exists today concerning the kind and height of IPR royalties that have to be paid. The third is the status of the US-EU agreement on interoperability and compatibility of GPS/Galileo signals, and its impact on charging licenses for equipment and services, used for open services. Fourth, there is a problem with IPR when services developed for Galileo might enter into foreign hands, for instance through cooperation of Galileo with third countries. Fifth, it can not be excluded that coded signals will be cracked. American scientists did so with the coded signals of GIOVE-A. They argued that this was not an illegal action (Newswise, 2006). Though the coded signals of Galileo will be harder to crack, it is not impossible, given budget and time resources. This might impact IPR issues. Finally, high monetary and labour costs of obtaining patents and non-harmonised patent regime in the EU prevent many SME from ensuring the adequate protection of their IPR.

1.4.3 Privacy

Privacy is regulated by a number of European directives, especially 95/46/EC which presents the generic privacy framework, and 2002/58/EC which deals with electronic communication. Satellite navigation applications may infringe upon privacy rights of citizens, due to the ability to track and trace the position of individual citizens and to follow individual movements. Just as in case of other emerging technologies such as RFID, specific satellite navigation applications may be very privacy sensitive, such as electronic toll collection. The European directives and the national laws apply where appropriate. Privacy concerns may impact upon the realisation of privacy sensitive applications and may lead to less than optimal adoption or delay of certain applications. Appropriate measures need to be taken in order to profit from satellite navigation applications without interfering with personal privacy more than strictly necessary. International regulations are important given the trans-border character of satellite navigation applications.

1.4.4 Other regulatory issues

In attempting to create a beneficial level playing field which is attractive for different kinds of stakeholders and countries the European Commission has announced a number of regulatory measures and mechanisms. A very important one is the procurement strategy (see section 1.3.4). This strategy has a number of attractive elements. Problematic remains the involvement of SMEs, a more generic problem in Europe. Procurement rules hopefully have sufficient power to indeed attract SMEs.

Another issue is the role of government as ‘launching customer’. Though most parts of the space sector are driven by public interests, the overall value of Galileo exceeds the direct public interests. It relates especially to the Public Regulated Services that are of prime interest to the public authorities. Their economic value is however far less than what is expected from open services, both in direct benefits and in indirect benefits. The content and scope of PRS is however far from determined yet. A discussion is going on whether PRS should be enforced (through regulations and directives) or only should be encouraged.

A third issue deals with risk sharing in new technologies with uncertain technological outcomes and revenue streams. The Commission, the Council and the Parliament acknowledged that they can not expect private parties to share the risks of the deployment of Galileo (Council, 2008a). The European Union will have to bear the financial uncertainties and risks. Some mechanisms are in place to attract private parties in all phases of the Galileo (and the EGNOS) project.

First, though the European Union will be the owner of all tangible and intangible assets coming forth from the Galileo investments, revenue sharing mechanisms will be initiated for all conceivable contracts with private parties, if deemed necessary. Second, the exploitation phase can be organised as a public private partnership. This is to be decided after the midterm review of the programme to be held in 2010. For private parties to participate, the development of revenue sharing mechanism and public regulated services framework should be sped up in order to reduce the current financial uncertainties of the Galileo program. Reducing these uncertainties in a fast and timely manner is essential to secure the participation of the private sector.

1.4.5 Summary

The regulatory framework of the EGNOS/Galileo programmes is well in place. Some issues are however still open for debate. First, standardisation issues are well taken care of but this does not conceal the complexity of the approach with numerous standardisation organisations involved on all conceivable application domains, all with their own specificities. Second, intellectual property rights are the cornerstone of the policy to cover the expenses of Galileo/EGNOS. The policy itself is however contested both in relation to the US-EU agreement and on the possibility that IPR will be denied without legal consequences. Third, the procurement strategy is well-thought and is an appropriate attempt to prevent monopolies and to involve SMEs in all phases of the programme. It needs however to be awaited whether the strategy is sufficient to realise the policy ambitions. Fourth, creating certainty about incentive structures for private parties to participate in Galileo services requires offering transparent procedures regarding revenue sharing mechanisms and cost models. Fifth, though generally acknowledged as not being a prime concern, privacy concerns need to be well addressed since it may adversely impact on the adoption of satellite navigation applications.

1.5 Benefits and expected revenues from the space programme

1.5.1 Expected revenues

The market of satellite navigation system will be influenced by decisions made about the satellite systems delivering the signals on which market applications will be based. GPS offers its civilian signal for free. The European Commission has presented its expectations with regard to the direct commercial benefits of Galileo and EGNOS during 20 years of exploitation (see Table 1.4). It expects the total revenues to be €9.1 billion (bandwidth: €4.6 billion - €11.7 billion). Revenues over the five Galileo services (first column) will mainly come from special use of Open services and Public Regulated Services. In terms of charging mechanisms, it expects more than half of the revenues from taxation on hardware (terminal manufacturing and receiver manufacturing). And in terms of sectors more than half of the revenues will be generated by road transport and public regulated services.

Table 1.4: Galileo and EGNOS revenues over 20 year exploitation period

Per service		**Per charging mechanism**		**Per sector**	
Open service – normal use	0%	Terminal manufacturing	46%	Road transport	30%
Open service – special use	54%	Governmental clients	29%	Public Regulated Services	29%
Public Regulated Services	29%	Service providers	14%	Mobile telephony	17%
Safety of Life	10%	Receiver manufacturing	7%	Profession services	9%
Commercial services	7%	End-users	4%	Aviation	5%
Search and Rescue	0%			Others	10%
Total	**100%**		**100%**		**100%**

Source: EC, 2007a

On top of the direct benefits, the Commission expects the additional value of Galileo to be €50-60 billion, spread over new services to users, increased performance and innovation (€15-20 billion) and benefits for the private market through an increased share in the total GNSS market (€35-40 billion). Some of the figures are contested, for instance the expected revenues of Public Regulated Services (House of Transport, 2007, p. 12). Discussion on PRS is till going on. Development of PRS is part of the sovereignty of the Member State. As of today, there is no clear business plan towards developing PRS.

1.5.2 Benefits

Besides these financial and economic benefits, Galileo and EGNOS represent strategic and geo-political benefits. Strategic for Europe as a whole, since the 'footprint' of Galileo and EGNOS is supranational and enable all Member States to participate in innovative activities that are socially and economically beneficial. It enables European companies to develop new services which can be deployed in other regions as well. The geo-political benefits relate to the independent position Europe acquires vis-à-vis other regional powers, such as the United States, Russia and China. Galileo already works as a leverage to start cooperation with a host of other countries, notably the US and China.

1.6 Policy options and their impact on market development

On the basis of our findings a number of policy options can be identified. These are thematically structured and grouped together.

1.6.1 Innovation

Innovation is key to the Galileo/EGNOS project. The European Framework Programme is an important contributor to promoting innovation in Galileo/EGNOS and the accompanying services. Within FP7, attention for applications is at a very low level, both within the Cooperation theme on Transport (theme 7) and in the Cooperation theme on Space (theme 9). The work programme 2008 on Transport does not contain topics related to space applications. The work programme 2008 on Space is directed towards satellites, equipment (clocks), signals etc. There is a need to redirect the budget in the direction of the development of satellite navigation applications. With the new budget rules for Galileo one needs to secure that the €400 million that are added to the overall Galileo budget will strictly remain reserved for Galileo/EGNOS innovations. On-going coordination with ESA to attune research activities is necessary as well.

Up till now, involvement of non-European countries in R&D activities has been insignificant, with a possible exception of the modest contribution of China. This needs improvement to remain involved in worldwide developments and to keep future markets outside Europe open.

1.6.2 Involvement SME/market parties

Involvement of SMEs in European R&D projects is of particular concern. Administrative overload prohibits engagement of SMEs in major projects. Application providers are reserved in participating in long term research endeavours. Galileo Services offers an interesting inroad to interested industries but does not cover many SMEs in application domains. The role of Galileo Services could be strengthened and formalised. In order to attract SMEs different strategies have to be pursued. Awareness raising through awards and prizes, such as the annual Galileo Masters Competition, hosted by the German DLR, the German Anwendungszentrum Oberpfaffenhofen and SYSTEMS (the annual German technology fair), needs to be improved and strengthened.

Ideas for establishing Galileo Competence Centres, such as is the case in the Netherlands, is another approach to attune SMEs and to lower entrance barriers. With respect to involvement in FP7 projects, open tenders should be used in order to reduce the administrative burden for SMEs. The use of incubators (such as the German Anwendungszentrum Oberpfaffenhofen) to guide SMEs in acting successfully for European tenders and projects should be considered.

The market characterisation of Galileo/EGNOS applications in Europe shows a diversified and less specialised playing field than in the USA. Application providers are dealing with day-to-day business. Uncertainty in Galileo business plans is an important barrier for developing new services. Uncertainty is high with respect to the timing of Galileo/EGNOS events. A number of services, such as PRS, are still in its very infancy, and do not offer solid business cases for application providers to step in. Though EGNOS should be fully operational early 2009, uncertainty about the precise configuration of the certification and standardisation procedures of EGNOS prevents application service providers to start developing new services. Specialised services, based on SaR and SoL, require clear and unambiguous directives, which should be phrased in a technology neutral manner. An example is the apparent problem about the integrity signal that is differently organised for WAAS/EGNOS/MSAS and Galileo and that is contradicting the USA-EU agreement on compatibility and interoperability of Galileo/GPS. These ambiguities need to be resolved in order to convince application service providers to step into a high risk market. The International Committee on GNSS should take a position on this issue. In order to prevent market failure, actions reducing uncertainty about technological and operational dimensions of the Galileo/EGNOS configuration should start as soon as possible.

1.6.3 Standardisation/certification

The annual conference on certification and qualification issues CERGAL offers a platform to show progress on certification and standardisation issues. Due to the different application domains, certification procedures have to be attuned to each of the domains separately. This implies complex and sometimes lengthy procedures. There is a need to ease the certification and quality assurance procedures. Most of the application domains have their own standardisation and certification bodies (water, air, and rail). The road sector and personal Location Based Services – which are two of the most important application domains – lack an international governmental forum to address these issues. For the road sector this could be detrimental, for instance for the introduction of a European wide system of road pricing. The overall approach towards certification should be to opt for a reserved attitude: restrict certification to critical processes and equipment. Try to develop lean and mean procedures that can be implemented quickly.

Regarding standardisation processes, there is a general feeling that the process of standardisation could be more professionalised involving more professional experts and reducing the number of governmental officials. This could speed up standardisation processes and lead to more tight processes. The standardisation processes itself should refrain from adopting specific technological perspectives and should be formulated in a technology neutral manner. Open standards are a point in respect since these might promote innovative development in a wider community to the benefit of all.

1.6.4 GNSS and e-Loran as a European critical infrastructure

The European Radio Navigation Plan, for which initial studies have been performed, still needs to be completed. In developing the plan, attention is asked for the role of the GNSS infrastructure as a critical infrastructure.

The European Commission has identified the PNT-infrastructure (Positioning, Navigation, and Timing) as a critical infrastructure in 2005 (EC, 2005). Several regions (USA, Russia, and China) have indicated their inclination towards using Loran-C and eLoran as ‘back up’ systems in case of failure of GNSS. Europe still falls short in this respect. eLoran seems to be the appropriate candidate for European-wide back-up system in case of failure of GPS/Galileo. Actions should be started in broadening the activities of the European eLoran Forum and researching the adoption of eLoran as part of the PNT-critical infrastructure and as back-up for the Galileo/GPS infrastructure.

1.6.5 IPR issues

Uncertainty about how the European Union will deal with IPR issues might prevent application and service providers and equipment manufacturers to invest in development of Galileo/EGNOS- products and services. The European Union claims to be the owner of all assets related to Galileo. This implies that the European Union might charge the use of the Galileo coding signals in Galileo receivers by means of taxation. This approach could hamper the development of Galileo-receivers, and make them more costly and less competitive towards single GPS receivers. Also the potential risk of the transfer of EU suppliers IPR to third countries is not solved. Again, uncertainty about the European approach should be lifted in order to stimulate a European market.

1.6.6 Institutional developments

Due to the failure of the concessionaire approach, a new situation has arisen. The European Space Agency will act as the procurement agency for the Galileo programme. To this end, ESA has to build up expertises in the field of risk management, and financial management. It will do so in close cooperation with EU DG TREN who bears responsibility for the overall Galileo programme. To reduce complexity in the process, the position of ESA within the EU will be reviewed. One issue to be solved is the fact that normal ESA procedures of fair geographic returns may not be used.

GSA will become an agency within the European Commission with a set of tasks and responsibilities. In the near future GSA will have to focus on the build up of the required expertises and competences to organise the certification process, to tackle security issues and to develop market perspectives. In the coming years, the option of a public private partnership for the exploitation phase will be back on the agenda, with consequences for the tasks and responsibilities of GSA. This should be timely prepared.

There are still some difficult to tackle financial issues. Uncertainty remains regarding the number of spare satellites needed and the need to upgrade ground stations (especially the third SaR ground station situated in Spain). These financial uncertainties will have to be clarified to enable a proper judgement of the budgetary constraints of the programme.

1.6.7 Other issues

The revenues the European Union expects from the Galileo/EGNOS system are based on the idea that the European Union is willing to pay the infrastructure but not the exploitation and the services provided on the infrastructure. As such, this position is clear and unambiguous. In practice, it must be doubted whether this is a realistic attitude. When considering Galileo/EGNOS as a driver of innovation and as a beneficial instrument to align European companies to worldwide GNSS service development, this position of Europe should be reviewed.

It is planned that the EGNOS system will be fully operational and certified early 2009. Though activities have started to find a concessionaire, the assignment of the concessionaire and the certification process should be tightly kept on schedule. This should have high priority.

There is a shortage of curricula dealing with space issues in Europe, with only a limited number of Master courses and no Bachelor courses (Spaan, 2008). Interaction of academia with industry is scarce. Young people need to be attracted to space issues in order to secure the European knowledge base over the years. And networks of academia and industry need to be expanded. Europe should play a role in creating European-wide courses on space issues (including satellite navigation services) and in fostering networks between academia and industry.

Finally, the technical development path of the integration of Galileo, GPS and other GNSS moves into the direction of a ‘system of systems’, with common accuracies up to a few centimetres using global Real Time Kinematic networks.[7] To be prepared on the promises of these enhanced accuracies, the European Union should start to discuss the modifications needed to realise this ambition.

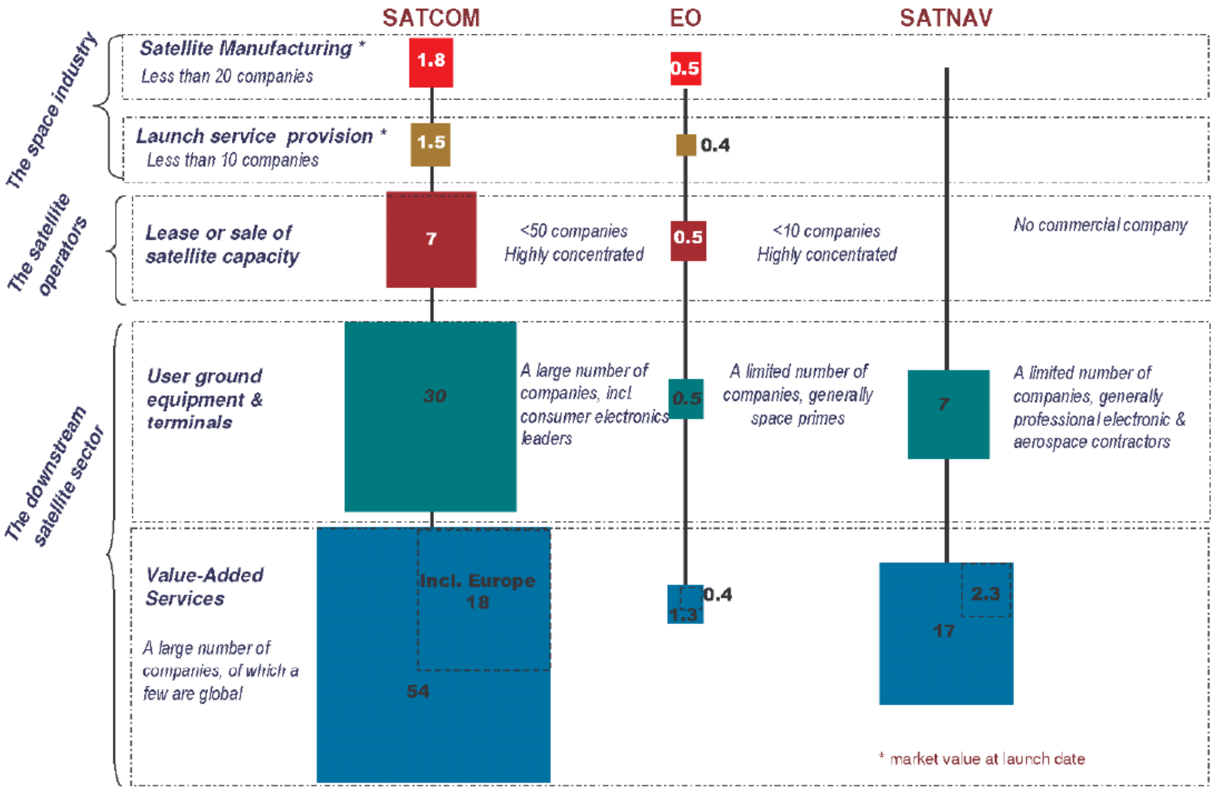
[7] We want to express our gratitude to Prof. Spaans for pointing at this policy option.

2. EARTH OBSERVATION

2.1 Introduction

Earth Observation (EO) 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. The EO Service Industry comprises 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 EO Service Industry is an extremely diverse sector. 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.

Figure 2.1. The 3 value chains in commercial satellite applications in 2005 (in billion Euros)



Source: adapted from Euroconsult, Helios and Bertin, 2007

As compared to Satcom and Satnav, revenues in value added services of Earth Observation in Europe make up little less than 2% of total downstream revenues, comparable to a worldwide reference (Euroconsult, Helios and Bertin, 2007).

The EO Service Industry has got a strong impetus from 2001 onwards by the adoption of the GMES (Global Monitoring for Environment and Security) program by the ESA and EU Councils (COM (2001) 609 final). GMES is the European initiative for the delivery of reliable data and timely services dealing with environment and security. GMES involves observation data received from Earth Observation Satellites and ground based data, which are coordinated, analysed and prepared for end-users.

2.2 Applications and markets for Earth Observation

2.2.1 Earth Observation applications

Earth Observation originally has been rooted in the domains of Defence and Security and scientific research. When restrictions on satellite imagery were relaxed at the end of the cold war and ICT-industry could deliver hardware solutions capable of processing, transmitting and storing huge amounts of data, applications in various market sectors grew rapidly. EO Service Industry has developed a product portfolio which is highly diverse and varied, serving a wide range of markets and uses. Most of these products (80%) use, in addition to EO data, data from either ground or aircraft-based sensors and 40% of the products use all three data sources (ESA, Booz Allen Hamilton, Vega (2004)). Earth Observation data are involved in these products as a prime ingredient, allowing:

- The observation of large geographical areas at once, thereby facilitating a wide, synoptic observational coverage.
- The observation of any given geographical area frequently, thereby facilitating repetitive measurements with a minimum of logistical efforts.
- The observation of any part of the world in a systematic way, thereby facilitating uniform observations from one location of the globe with respect to any other.

These data are acquired from remote observations from the earth, using sensors which are capable to measure intensity of emitted or reflected radiation over specific parts of the electro-magnetic spectrum. The sensed signal can either be used to derive an image, like in photography, or its signature can be used in processing algorithms to derive bio-geophysical parameters, like for instance photo-synthetic activity of plants, wave height, chlorophyll-activity of ocean water, ground subsidence, etc. Characteristically, the thus derived parameter is not a direct but an indirect measurement, thus in most cases necessitating the involvement of in-situ data for calibration and the assimilation of data sources via some level of modelling to arrive at geo-physical values (70% of the products use data-assimilation) (ESA, Booz Allen Hamilton, Vega, 2004).

The products currently available are highly diverse and varied, serving a wide range of markets and uses. For instance, over 30 products are offered in Europe and Canada in Natural Resources Management and 25 in Ocean Services (ESA, Booz Allen Hamilton, Vega (2004)). This makes comparing and clustering the products and market performance of the EO Service Industry on a higher level quite difficult, illustrated by the different aggregation levels in recent industry surveys.

Text Box 2.1 – Earth Observation Applications

Energy – The renewable energy sector relies on local data on solar irradiance, biomass stock and wind profiles at a global scale. Due to their global coverage and frequent overpass, satellites are invaluable in delivering these data. Meteosat Second Generation provides solar irradiance data every 15 minutes thus enabling large energy companies to maximize grid efficiency. Synthetic Aperture Radar (SAR) instruments on boards ESA's ERS-2 and Envisat satellites can provide high resolution 100-metre data on the wind field. Decade-long data archives can be exploited to assess characteristics of local wind regimes and solar irradiance for site selection of wind farms and solar energy production.

Agriculture and food security – Remote sensing is actively used to monitor crop production worldwide. FAO uses remote sensing to assess food security in order to be prepared for relief actions. Another application relates to precision farming which makes use of high resolution satellite imagery to derive health indicators of plant stock. Farmers use these data to decide at what locations there is shortage of nutrients or soil moisture.

Natural Hazards – Synthetic Aperture Radar (SAR) on board ESA's satellites ERS1/2 and Envisat have been used to develop a technique for mapping and monitoring ground motion over large areas. Currently, Italy is embarking on a program to process images covering the entire country in order to map and monitor subsidence and landslide prone areas.

Ocean and maritime – Maritime transport relies heavily on oceanographic and meteorological conditions. Local data on wind and wave regime worldwide are derived from operational satellites and stored in database for planning maritime transport and off-shore activities.

Air Quality - For instance, a subscription SMS-service providing local current and near-future air quality conditions is of high value for respiratory disease sufferers. This service makes use of the regionally measured amounts of NO2 and Ozone by Envisat's sensors. It is already available in the London area.

2.2.2 Innovation potential and R&D needs

Earth Observation is a high tech sector evolving around innovative applications which are continuously being developed and put in use stimulated by the strong scientific background of space missions. The general trend towards "faster, better, cheaper" solutions has profoundly influenced this domain: new satellites in operation today are much smaller than the conventional ones (cf. ESA's PROBA-satellite, SSTL satellites), which offers the private players an opportunity to invest in satellite constellations. The future of satellite data collection and its commercial use hinges on the development of the following system parameters:

- Improved sensors/imagers (spatial resolution, spectral resolution);
- The data access time, i.e. the time needed to make a requested image available to a user;
- Improved data processing performance, i.e. to increase the value of raw EO data by turning it into reliable, usable information for end-users;

- Accuracy and reliability of data;
- Space data in integrated information systems compatible with the information systems of end-users.

New developments in optronics and miniaturized sensors (MEMS) increase capacities of future satellites considerably, both regards spectral bandwidth and spatial resolution. Over the past 20 years, sensor development has resulted in 100-fold increase in spatial resolution while satellites have become lighter.

Another development relates to the operation of constellations of satellites, either conventional or mini-satellites, such as ‘RapidEye’ and the Tandem-mission of TerraSAR-X. Employing constellations of satellites increases spatial and temporal resolution significantly. The fact that ‘RapidEye’ is a commercial undertaking strengthens the case for the commercial viability of EO solutions.

Innovations and R&D needs related to EO services are largely determined by two major trends:

- Increasing consumer-pull using virtual globe platforms (e.g. Google Earth, Virtual Earth) for various geo-information services
- Encapsulation of EO-services in Integrated Applications, such as control rooms.

Both trends are indicative of vertical and horizontal integration of services. However, European success will more than ever be determined by data availability, data continuity, and data procurement, since commercial viability of these services hinges on guaranteed delivery and competitive value adding. Application development for GMES are supported by FP7 with the budget envelope for the period from 2007 – 2013 of € 1.2 billion, which includes the costs of data procurement. The emphasis is on the development of applications in satellite-based monitoring and early warning systems, management of environment and security, and integration with satellite communication and navigation.

2.2.3 Earth Observation market characterization

2.2.3.1 EO Upstream Sector

Earth Observation value chain is depicted in figure 2.2 and comprises the following segments:

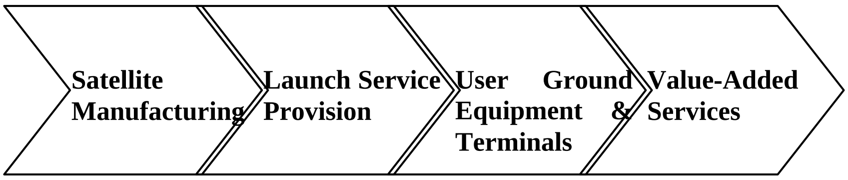
- Satellite manufacturing;
- Launch Service Provision;

Together taken as the ‘upstream sector’ and:

- User Ground Equipment & Terminals
- Value-Added Services

Together taken as the ‘downstream sector’.

Figure 2.2. Earth Observation Value Chain



The 'Upstream-sector' for Earth Observation can be characterized as predominantly institutional, dependent on public (national and multilateral) funding arrangements. In 2003 75% of the 63 launches performed worldwide were accounted for by public funding (OECD (2004)). In the past there has been a clear distinction between military and civil observation satellites as well as between civil and commercial satellites but this distinction is becoming less clear. Examples of dual use are to be seen for instance in Italy with the launch of the constellation of Cosmo-Skymed satellites, both for military as well as for civil use. Another example is the ClearView and NextView contracts awarded by the US Department of Defense National Geospatial-intelligence Agency (NGA). These enabled companies like Digital Globe and GeoEye to bring their own Earth Observation Satellites into orbit and become world leaders in commercial high-resolution optical imagery.

Overall the Earth Observation market is experiencing a significant growth with 199 satellites to be launched over the time span 2007 – 2016 compared to 69 satellites for 1996-2007. This growth is driven by the following factors:

- Support from governments, investing in new satellite capabilities and Global Observational Programs;
- A growth of the commercial Earth observation market with private sector led initiatives or public-private partnerships (PPP's);
- By emerging programs developed by about 29 additional countries developing their own earth observation capability.

Support from governments has always been a major driver for the manufacturing and launching of Earth Observation Satellites. This has been driven by military needs and by R&D-programs which increasingly focused on issues of Global Change over the last 15 – 20 years. The relatively high-cost of observational programs has resulted in the development of large satellites with a large number of sensors on board performing dedicated observations on e.g. ozone, sea level, and sea temperature. Examples of these satellites are NASA's Terra-satellite and ESA's Envisat. The continuous development of applications based on data obtained by these satellites has resulted in solutions which are either commercially viable or politically necessary. Enforcement of multilateral environmental policies often demands global observation solutions.

This is where programs like GMES come into play and influence the scope of long-term satellite manufacturing by putting more emphasis on data continuity instead of new and innovative observational capabilities. While ESA is still developing its Earth Watch program, including the development of dedicated Earth Observation Satellites capable of observing changes in soil moisture and sea salt concentration (SMOS) or the global gravitational field (GOCE) at an unprecedented precision, it is also embarking on a program dedicated to fulfil the ambitions laid out by GMES. To this end ESA will manage the development of the Sentinel-program, consisting of a suite of 5 satellites, each instrumented for specific purposes.

Sentinel-1 will ensure continuity for C-band SAR-data and will support applications regarding oil spill mapping, wind and wave products and subsidence mapping. Sentinel-2 and -3 will support land and ocean monitoring through the continuity of multi-spectral, Infra-Red and altimeter data. Sentinel-4 and -5 will be dedicated to meteorology and atmospheric studies. The Sentinel-program already envisages replacement of these satellites in due time, thus guaranteeing the continuity of data.

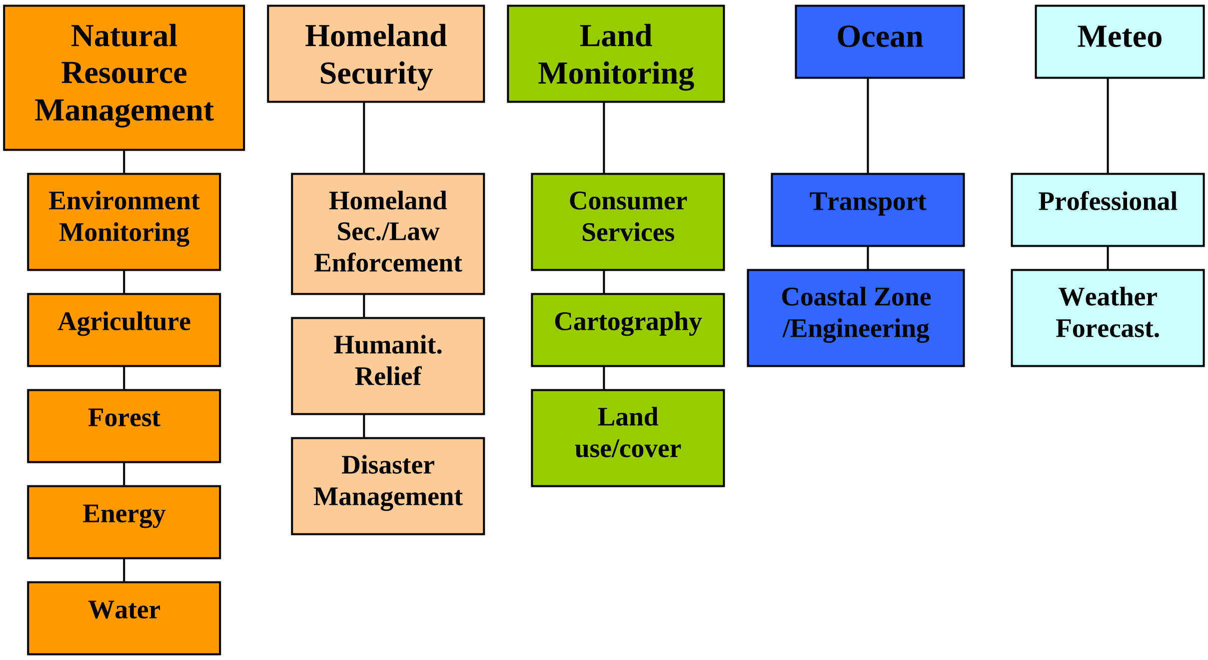
Commercial observation satellites are still relatively new and are still mostly to some degree dependent on public funding. Spot Image, a subsidiary of CNES and dedicated to earth observation, imaging and value added services, is an early example of commercial earth observation. CNES developed for its own account the SPOT satellites and launched them into orbit. The operation of the satellites was then transferred to Spot Image for a royalty fee (ESPI, 2007a). More recent Public-Private-Partnerships (PPP's) are TerraSAR-X which was launched in 2007 and the RapidEye-project. Both these initiatives have been backed up by the German Space Agency (DLR) in cooperation with private companies like EADS Space (TerraSAR-X) and Vereinigte Hagelversicherung (RapidEye). NGA's NextView and ClearView programmes in the US are based on a different risk-sharing principle. The US Government guarantees minimum revenue for several years subject to delivery of useful data (images) and ensuring priority of data access. The supplier bears all technical risks, including launch failure and in orbit failure of the satellite. The supplier gets all additional income from other customers (ESPI, 2007a). The introduction of Google Earth and Microsoft's Virtual Earth has recently strongly influenced business-models and client base for these entrepreneurial earth observation initiatives.

Apart from commercial or government-backed PPP-initiatives, miniaturisation of satellites and sensors is influencing the upstream earth observation sector. Over the years, small satellites have become more and more capable as regard to optical and spatial resolution, on-board memory storage and rate of data transmission. This created a business for affordable satellites (minisats), costing around € 5 – 10 million. These satellites are particularly attractive for new countries, previously not equipped with satellite technology and willing to acquire satellite capability and monitoring capacity for inland purposes (mapping, disaster management). Surrey Satellite (SSTL) from the UK has already been successful in developing and delivering small satellites to countries as Nigeria, Vietnam and Turkey (Euroconsult, 2008).

2.2.3.2 Markets and market segmentation

In a recent study, commissioned by ESA, on the downstream value-adding sectors of space based applications, Euroconsult, Helios, and Bertin (2007) identified five macro market segments each subdivided further into specific markets; see Fig. 2.3.

Figure 2.3. The 5 market segments in downstream value added Earth Observation applications



Source: Euroconsult, Helios and Bertin, 2007

The customers and end-users can be divided into two categories:

- **Public customers**, comprising local, regional, national and European public services and agencies which require up-to-date and reliable information on the natural and built environment in support of their public responsibilities.
- **Private companies**, which use Earth Observation to increase their competitiveness.

Public and governmental bodies are the most important customers of EO products and services, particularly in the product segments cartography/security, land use/land cover, oceanography and natural resources monitoring (Galant et al. (2007)). Customers in the private sector focus on products for natural resources management (agriculture, fishing and forestry), oceanography (energy), whereas transportation and communication companies are interested in applications for cartography/security, land use/land cover and oceanography. Barriers to market development in the private sector are the high cost of EO data, uncertainty about continuity of EO data as compared to terrestrial solutions, and the lack of knowledge about EO potential within customer groups (Galant et al. (2007)).

Revenues, profitability and competition

Total global revenues of the Earth Observation Service Industry amounted € 1.3 billion in 2005. European industry contributed € 0.4 billion with almost 50% of total revenues stemming from meteorological applications (worldwide reference equals to about 40% of total revenues). The second largest market segment worldwide is 'Homeland Security' (made up by applications regarding 'Homeland Security/Law Enforcement', 'Humanitarian Aid' and 'Disaster Management'). 'Homeland Security' worldwide revenues in 2005 stood at about €0.5 billion, 80% of which was generated in the United States.

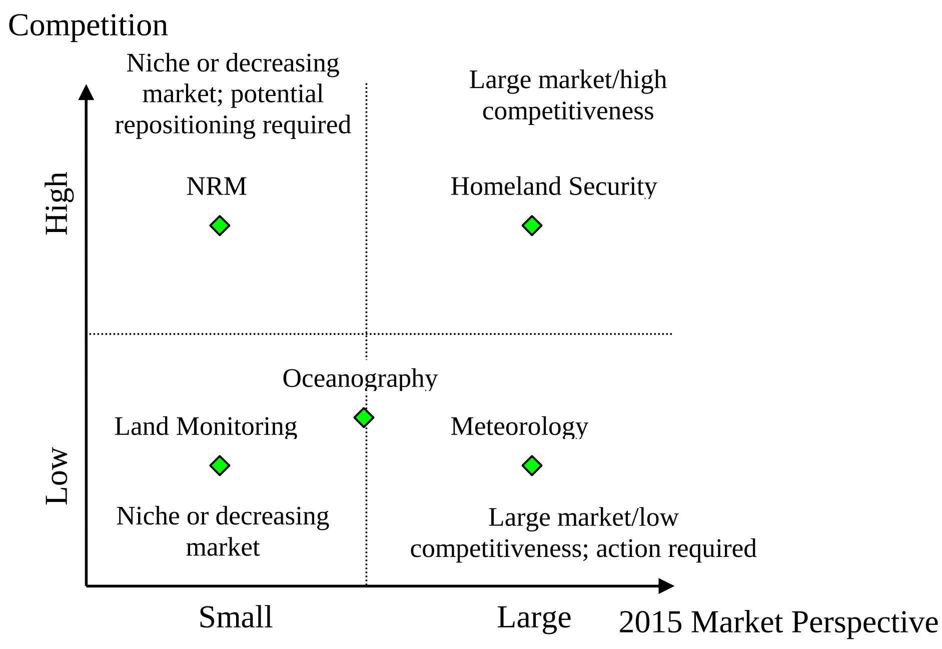
Considering the period 2000-2005, the Earth Observation Service Industry showed a low growth in Europe, ranging from 2% to 5%, see fig.), except for 'Homeland Security' for which a growth figure of 10% is presented by Euroconsult, Helios and Bertin (2007). 'Land Monitoring' and 'Natural Resource Management' are low revenue/low growth segments whereas 'Meteorology' is a low growth/high revenue segment.

However, revenues per product are relatively low, with the great majority of the products generating less than € 0.5 million per year. Less than 10% of the products qualify as the high value products (more than € 2 million per year). For a high-tech industry the revenue per employee is relatively low, namely € 107,000 (ESA, Booz Allen Hamilton, Vega, 2004).

The companies' revenues are composed of 78% of sales and 22% of development financing funded by public bodies. The level of public spending tends to increase, whereas the level of private spending is quite stable (ESA, Booz Allen Hamilton, Vega, 2004). Nevertheless, private spending is vulnerable to macroeconomic cycles (ESPI 2007-year report). Product groups with high profitability are "Homeland Security", and "Natural Resource Management". The latter category, however, is highly profitable in the U.S. and not Europe, due to the fragmented structure of European industry. Low profit margins affect meteorology, oceanography and land monitoring. European companies have a competitive position in mostly low profit areas like meteorology. They also have a strong position in natural resources monitoring but, in this segment, fragmentation hampers profitability on the company level (Galant et al. 2007).

This results in a variable market perspective for the European EO Service Industry in 2015 (see fig.2.4). The European EO Service Industry has a highly competitive positioning in meteorology, which, as a mature market, is forecasted to experience lower growth than other segments. In 'Homeland Security', European companies have a low competitive positioning even though the market is anticipated to show the highest growth perspectives. 'Natural Resources Management' is a niche market, where European companies enjoy a highly competitive positioning, especially regarding 'Energy and Agriculture'. 'Land Monitoring' has the weakest competitive positioning and lowest market perspectives.

Figure 2.4: Competitive Positioning of European/Canadian Companies in EO Service Industry



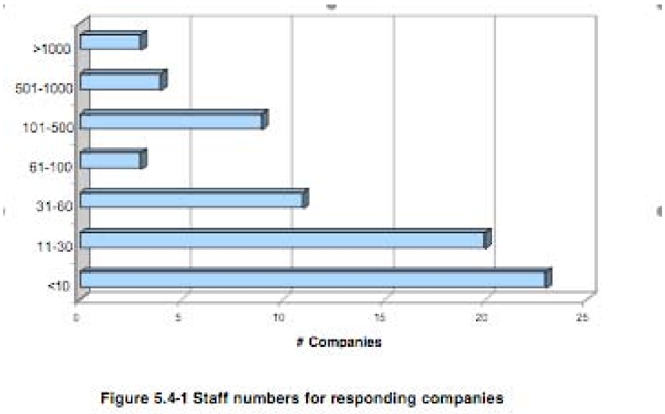
Source: Euroconsult, Helios, Bertin, 2007

2.2.3.3 Industry profile

The majority of companies in the earth observation industry is small (less than 30 full time employees) and are from academic provenance. Almost 75% of the companies employ fewer than 60 people, and almost 60% of the companies employ fewer than 30 people (see Figure 2.5). The EO industry has a higher proportion of small companies than the high tech industry in general. (ESA, Booz Allen Hamilton, Vega, 2004)

Recent years show a consolidation in European EO industry, with forward chain integration and even cross-sectoral acquisitions. Forward chain integration is visible in the acquisition of EO companies by upstream space companies, who, in this way, ensure an integrated chain of infrastructure and applications leading to economies of scale. Cross-sectoral acquisitions involve, for instance, energy companies and engineering consultancies, which insure in this way the insourcing of EO applications vital to their future competitiveness.

Figure 2.5: Staff numbers of Earth Observation companies



Source: ESA, Booz Allen Hamilton, Vega, 2004

According to the survey of ESA, Boos Allen Hamilton, Vega (2004), the main operational centres of earth observation industry are located in France and Germany. Italy, the Netherlands and the UK also make significant contributions, and Finland has more operations than one would expect based on its modest GDP and population. There is however not much multinational representation. The companies are typically small, mostly working in a single location and operating on a local basis.

The number of employees in the sector is estimated at about 2,900 in the ESA Member States. The larger companies tend to have a smaller percentage of staff dedicated to EO work than the small or medium sized companies, because in larger companies EO products and services are a part of a larger portfolio. EO staff is highly specialized, with a higher educational level in general and more doctorate level staff than on average in the high tech industries.

Effects of fragmentation: The EO industry itself (downstream) is fragmented. This may cause upward pressures on costs for downstream companies due to the dominant market position of the upstream enterprises. The same applies to the delivery of raw data and images.

The small size of most of the European EO companies causes two obstacles. First, it makes it problematic to offer standardized and integrated solutions for customers. Small companies that do not team up horizontally -- alliances are limited -- must develop a close relationship with customers in order to meet their needs.

This process is labour intensive and therefore costly, squeezing profit margins. Cooperation, joint ventures, or alliances are ad hoc. Second, it hampers collective actions needed.

To increase acceptance among target groups, the EO products and services should be certified. Collective efforts should be made to develop new and existing markets by showing potential benefits of the EO products.

The Internet offers new business models for SMEs. For instance, it can be used for new platforms for data and information exchange that bring together a broad array of providers and users, making the platform attractive for business. This business model requires an independent enterprise or organization acting like a market or platform director, bringing together supply and demand.

The high-tech character of the industry determines certain specific features of the market and poses some requirements on regulatory framework. On the demand side, a high level of uncertainty about costs and benefits, characteristic for high-tech industries in general and EO in particular, often results in reluctant customers. This reluctance also counts for the crucial institutional markets.

Examples of typical players: As mentioned before, the European EO Service Industry is highly diverse, ranging from very small companies developing highly dedicated products to a small number of large companies. We describe here a small number of typical players who operate at a European to global scale: Spot Image, EADS Group, Telespazio, Thales Alenia Space.

- ***Spot Image:*** The SPOT (Satellite pour l'observation de la terre) programme was designed and developed by the French space agency CNES in cooperation with Belgium and Sweden. The CNES owns and operates the SPOT satellite system. Worldwide commercial activities are anchored by private companies: SPOT IMAGE Corporation (US), SPOT IMAGE (France), and SATIMAGE (Sweden). Spot Image distributes geographic information from EO satellites on a worldwide basis; its operations are fully dedicated to EO. Spot Image designs its own tools to give users quick and easy access to Spot data. Primary markets for Spot Image are: defence, agriculture, forestry, energy, infrastructure, disaster management, marine surveillance, and cadastre. Spot Image is a partner of the GEOLAND Integrated project, focusing on developing and demonstrating reliable, affordable and cost efficient European geo-information services, supporting the implementation of European directives and their national implementation related to land cover and vegetation. Shareholders are CNES, EADS, Telespazio, the Swedish Space Corporation, the French National Geographic Institute and the Belgian government. The revenues over 2005 amounted € 67.5 million. According to press reports Spot Image had to revise its business model due to the growing importance of web based delivery systems.

- ***EADS Group:*** The EADS Group includes the aircraft manufacturer Airbus, the world's largest helicopter supplier Eurocopter, and EADS Astrium -- the European leader in space programmes from Ariane to Galileo. Part of their operations is dedicated to EO products and services. EADS Defence & Security Division provides EO services for coast watch, marine surveillance for oil-spill detection, and fishery and aquaculture. EO services are part of a larger portfolio.

Infoterra is a subsidiary of EADS Astrium, with offices in Germany, France, the UK, and Hungary. Infoterra Germany holds the exclusive commercial exploitation rights for the new German radar satellite TerraSAR-X and supplies data as well as radar-based geo-information products. The company has gained a leading role in the European GMES initiative and in the aforementioned GEOLAND Project. Infoterra France focuses on the development of information services for agriculture, environmental protection, and risk management. The company is recognized as market leader in cartographic image processing. It is a pioneer in terrain modelling based upon SPOT images, multi-sensor processing systems and geo-information services for precision farming and risk management. Infoterra France coordinates the EC-project PREVIEW (PREVention, Information and Early Warning pre-operational services) aiming at providing new or enhanced information services for risk management in the areas of atmospheric, geophysical, and man-made risks. These services include, for instance, early warning systems for landslides and flooding, crisis support for more effective rescue operations, and building risk maps to improve prevention.

EADS Fleximage targets defence and homeland security markets and specializes in image analysis. The company provides integrated systems in tactical and strategic image intelligence, crisis management and surveillance. Fleximage developed the MIC system (Mapping and Intelligence Centre), which produces reports and maps from many types of images (optical/radar satellite images and airborne scanned images). The MIC system can be interfaced to sub-systems like GPS, video surveillance and secure radio communication.

- ***Telespazio:*** Italy-based Telespazio offers all satellite applications (space, telecommunication, multimedia, and infomobility) and EO products and services. In the latter business area the company offers all commercial activities, from the acquisition and processing of satellite data to development and sale of software and products. Telespazio addresses the following markets: land use control, civil protection, disaster management, cartography, agriculture, and geomarketing. Like Infoterra, France Telespazio is a major participant in the PREVIEW project. Telespazio is the coordinator of the LIMES project (Land and Sea Integrated Monitoring for Environment and Security), aiming at defining and developing prototype information services to support security management at EU and global level in the areas of: organization and distribution of humanitarian aid & reconstruction, surveillance of EU borders, surveillance and protection of maritime transport of sensitive cargos, and protection against emerging security threats. Telespazio is a joint venture between Italian Finmeccanica (66.6%) and French Thales (33.3%), and has branches in France and Germany.

- ***Thales Alenia Space:*** A 100% subsidiary of Thales Group, Thales Alenia Space is a market leader in geostationary weather satellites with expertise in low orbit EO. Apart from that, Thales Alenia Space is:

  - the prime contractor for the COSMO-SkyMed dual use EO satellite system for the Italian Space Agency and the Ministry of Defence;

  - a key player in GMES;

  - a major partner is EO systems such as SPOT and Pleiades (for CNES), the Envisat environmental monitoring satellite, the SMOS soil moisture and ocean salinity mission (for ESA) and Radasat2 (for the Canadian Space Agency);

- the world leader in high performance optical and radar payloads;
- the prime contractor for high resolution optical instruments (Meris, Envisat, and, Vegetation (SPOT) for environment; IASI (Metop) for climatology; Pleiades for high resolution observation; and Helios 1 and 2 for military applications;
- the prime contractor for high resolution radar instruments for military observation (SAR Lupe for Germany; COSMO-SkyMed for Italy, Kompsat5 for South-Korea).

Thales is deeply involved in GMES initiatives through participation in ESA MarCoast (leading partner; marine and coastal environment information services in Europe), Mersea (operational oceanography), Astro+ and LIMES (security), Maris (maritime safety), risk management, information infrastructure and positioning.

Aforementioned key players have the size and the integrated structure to be able to coordinate large technological and market development projects, supported by national, EU, and ESA funding. A broad range of SMEs in different European countries have managed to develop their own programmes and services for customers. We describe one example of such a SME.

- ***RapidEye – Kayser-Threde, Germany:*** The RapidEye business concept was initiated by Kayser-Threde, a German space technology SME with the support of the German space agency. The overall goal was to provide solutions for clients whose needs for geo-spatial information require large area coverage, repetitive monitoring and frequent revisits. RapidEye's key market segments are agricultural and forest resource management, energy, land use monitoring, and cartography. The system provides guaranteed data availability, rapid response after unforeseen events, continuous monitoring, and low-cost information. The system is technologically based upon a constellation of five identical EO satellites, using optical sensors only and guaranteeing high spatial and high temporal resolution. With this transparent business proposal Kayser-Threde managed to team up technical partners (system supplier and value-adding partners), government support, and, most importantly, financial support from different sources (launching customer, banking consortium, public bodies). Together they provided a budget of € 160 million. Launching customer and co-financer is Vereinigte Hagelversicherung, an insurance company. The share of insurance companies in the global space revenues is estimated at about US$ 0.85 billion (ESPI, 2007a). In 2007 Kayser-Threde was acquired by Germany's OHB Technology AG.

In the U.S., the acquisition of Space Imaging by Orbimage in 2006 created the largest commercial remote sensing company in the world: GeoEye. The space industry in the last decade has witnessed an increasing competition. The most visible and direct effect of this phenomenon is the multiplication of consolidation, mergers and the formation of strategic alliances. This has led to a shrinking number of prime contractors. The first wave of consolidation occurred in the 1980s and 1990s. Now the second wave is being witnessed in major space faring countries in order to improve the global competitiveness of domestic industrial base (ESPI 2007a).

2.2.4 Earth Observation trends and developments

OECD (2004) described the EO market as much smaller and highly competitive compared to GNSS markets and upstream developments. It is not only EO industry itself that is very competitive but EO products and services also have to compete with aerial photography and land-based surveys based upon the combination of global navigation satellite systems and

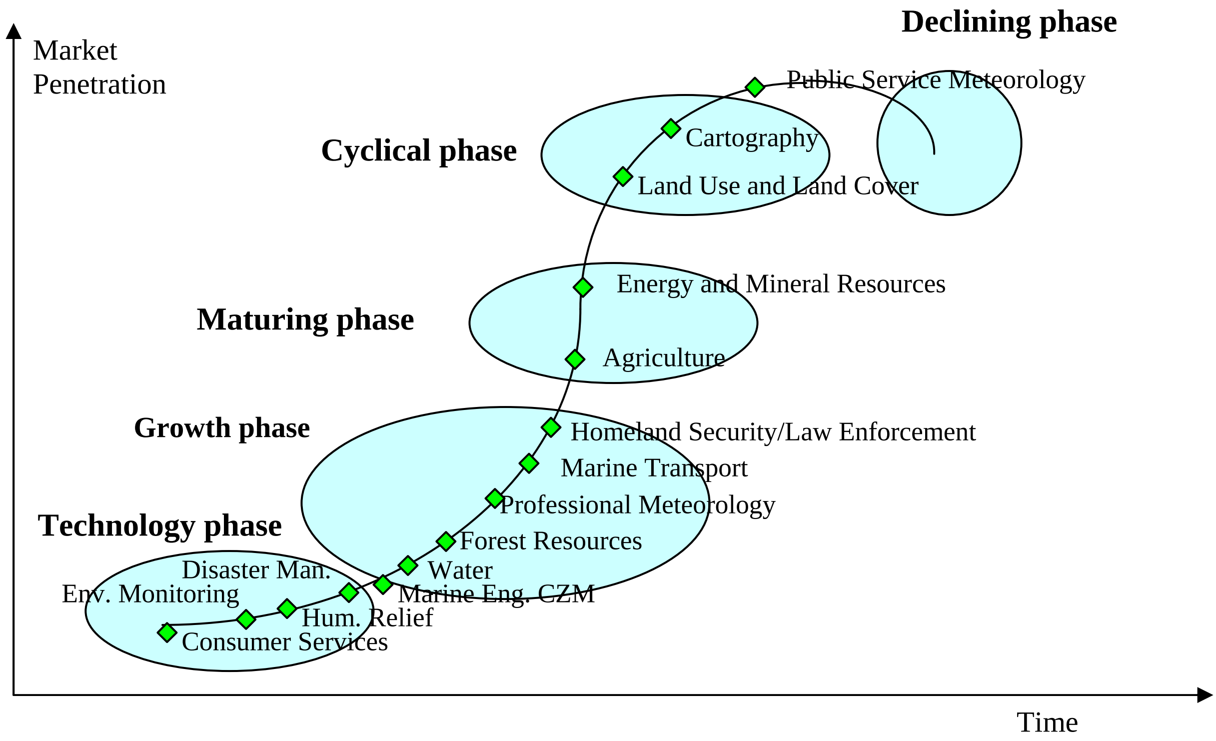
GIS. International competition has a tendency to increase, due to the entry of low-cost players from emerging economies. The industry was in its infancy when government restrictions on satellite imagery technologies were relaxed at the end of the cold war. Currently, the economic prospects of industry are rather uncertain.

In three OECD-scenarios – 'smooth sailing', 'back to the future', and 'stormy weather'- the demand for EO services is expected to increase. Applications to strengthen domestic security (including measures dealing with natural and man-made disasters and extreme weather conditions) are important in all three scenarios. Still, EO firms find it hard to generate sufficient revenue from their activities to cover the high costs of the launching and operating EO satellites.

It is useful to view the growth potential of the EO applications in the framework of technology life-cycle. Fig. 2.6 gives a graphic representation of level of maturity of EO-segments as compared to the technology life-cycle. The level of maturity of EO segments varies considerably and a large number of segments fall in the emerging phase where market take-up is still in its early stages (Euroconsult, Helios and Bertin, 2007). The distribution of EO application along the technology life-cycle looks as follows:

- Consumer services, disaster management, humanitarian relief, environmental monitoring, water resource management and forest resource management are considered segments which are still in the technology phase.
- Homeland Security/Law Enforcement, Professional Meteorology and Marine Transport are market segments in the growth phase. Except for Marine Transport, Europe is considered to lag behind the USA in these market segments.
- Agriculture and Energy are considered mature segments where market penetration has evolved considerably, both in public and in private markets.
- Cartography, Land Use/Land Cover and Public Service meteorology are in a cyclical phase.

Figure 2.6: Positioning of earth observation market segments



Source: adapted from Euroconsult, Helios and Bertin, 2007

Apart from these markets, there are a number of niches and potential applications on the horizon which include:

- Ground Motion/Subsidence mapping,
- Health,
- Mobility,
- Air quality and Climate.

Consumer services, related to the recent advent of virtual globes (Google Earth, Microsoft Virtual Earth) might have a strong pull-effect on EO Service Industry and could lead to new applications and business models in this sector (Galant et al., 2007).

Another emerging trend relates to integrated applications, combining Satnav, Satcom and Earth Observation in dedicated applications. Prospective applications might evolve around services needing timely, accurate information for situational awareness and which demand an effective communication: homeland security, disaster alert and management, crisis management, and maritime security.

2.3 Global Monitoring for Environment and Security (GMES)

2.3.1 GMES Services

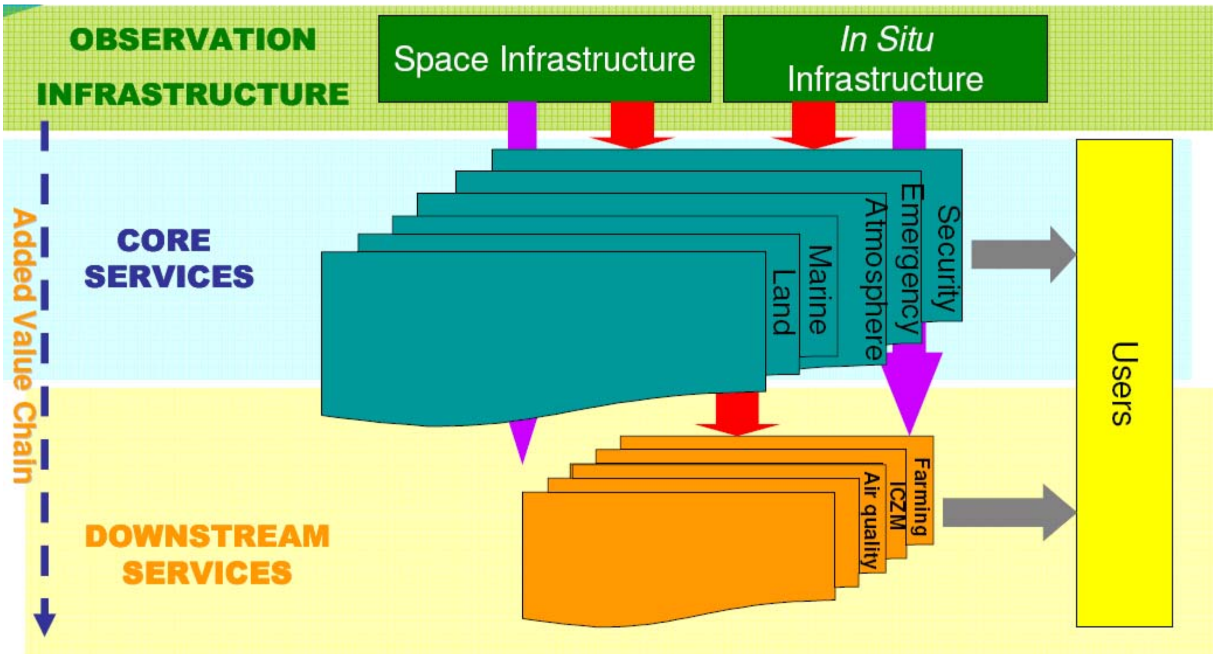
The start of the GMES Programme in 2001 has given a strong impetus to the integration of Earth Observation value adding. The Munich Roadmap, put forward in the framework of the German EO Council Presidency in 2007, further defined the structure and components of GMES as it relates to the service portfolio and to the data infrastructure (space and in-situ). Figure 2.7 shows the overall GMES architecture. From the outset GMES relates to the following objectives:

- GMES is the European solution to respond to the needs of citizens in Europe to access reliable information on the status of their environment.
- GMES addresses in particular the European policy makers' need of better monitoring the earth system for targeted environmental and security management.
- GMES is an important European asset for international co-operation and partnerships.
- GMES provides technological and scientific opportunities.

Depending on their users and scope GMES distinguishes between Core and Downstream Services:

- ***Core Services*** provide standardized multi-purpose information common to a broad range of EU policy-relevant application areas and through which important economies of scale could be derived. They also support European institutional actors developing, implementing or monitoring European policies or in their participation in international commitments.
- ***Downstream Services*** generally serve specific (trans-) national, regional or local information needs. The corresponding information products may be derived from products of the Core Service or be based on data directly provided through the observation infrastructure.

Figure 2.7: Overall GMES Architecture



The actual GMES Perimeter encloses the Observation Infrastructure and the Core Services; the Downstream Services might be supported for a relatively short time horizon, but should evolve in a sustainable service in itself after a relatively short time (couple of years).

Core Services have been defined by Implementation Groups for Land, Marine, Atmosphere and Emergency. The Land-Core Service will comprise of a Land Cover Mapping at EU-level, approximately 20 classes at 1ha resolution and a 3-5 years update and an ‘Urban Atlas’ of major European agglomerations, approximately 23 classes at 0.25 ha resolution and a 3 year update (Land Monitoring Core Service Implementation Group (2007)). The Marine-Core Service will comprise the regular mapping of geophysical state variables (sea surface height, temperature, salinity, currents, surface winds, surface waves, sea ice), biophysical state variables (attenuation of solar radiation) and biogeochemical state variables (Clorophyll-a) (Marine Core Service Implementation Group (2007)). Emergency-Core Service will be focused on rapid mapping services to support early warning up to damage assessment just prior to an emergency event up to a few weeks after (Emergency Response Core Service Implementation Group (2007)). Services are to be delivered regarding natural disasters and man-made disasters on the EU level and for the rest of the world. The Atmosphere-Core Service will focus on products for near real time updates of “Climate Change/Forcing”, “Air Quality” and “Ozone/UV/Renewable Energies” (GAC/2007/11).

The Core Services and Downstream Services are currently implemented by DG-RTD under the 7th Framework Programme for Research and Technology. The budget envelope for the timeframe 2007 – 2013 totals € 1.2 billion and includes the costs for data procurement.

2.3.2 Observation Infrastructure

The observation infrastructure is an important component of GMES and consists of a space component and an in-situ component. The Space Component employs both (1) dedicated missions designed to supply data for GMES Services (so-called Sentinels) and (2) European national missions, missions operated by European intergovernmental agencies, and non-institutional missions. Commercial providers may also contribute to the data supply for the GMES services.

The in-situ component uses air-, sea- and land-based systems collecting measurements compliant with GMES service requirements, and in particular established capacities.

As partner in GMES, ESA has taken responsibility for data continuity in the GMES Space Component by starting a program for dedicated earth observation. This program consists of the commissioning of five dedicated satellites, called Sentinels, which will guarantee user needs as far as it relates to the GMES Core Services. The budget envelope for the Sentinel-programme totals € 2.7 billion.

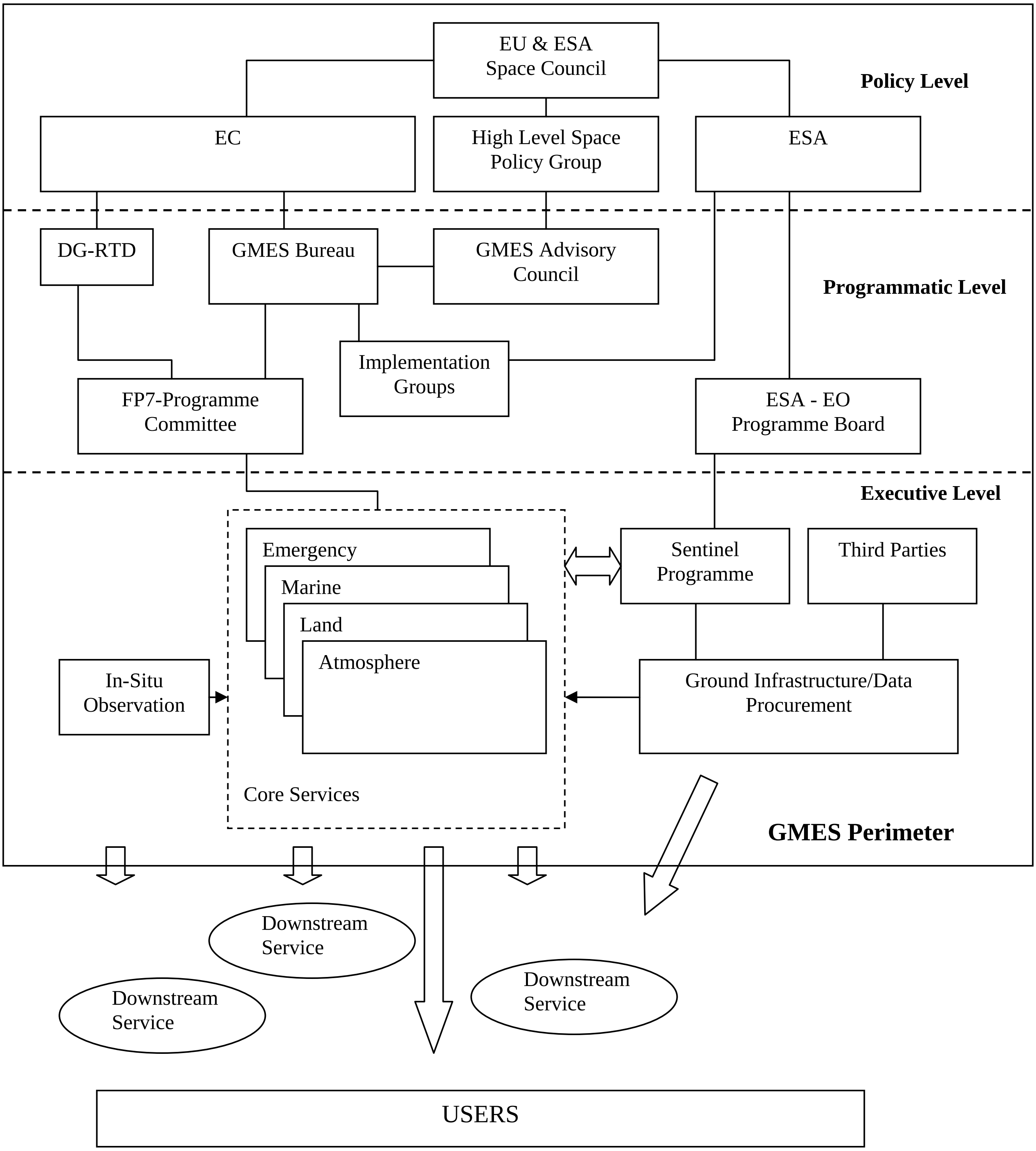
Apart from the Space Infrastructure, the in-situ component will be an important part for the realisation of services. Currently, European Environmental Agency heads the GMES In Situ Observation Working Group which will advise on and support the bottom-up process of assessing relevant *in-situ* observation and external service capacities at Member State, European and, when necessary, international levels. The GMES In Situ Working Group consists of representatives of the member states as well as representatives from relevant organisations at EU-level (GMES Bureau, JRC, DG-ENV, Eurostat), Implementation Groups (Land, Marine, Emergency, Atmosphere) and coordinating bodies (EEA, EUMETNET and possibly others). Within the 7th Framework Programme Research and Technology, budget will be allocated to the GMES In Situ Observation Working Group.

2.3.3 Management Structure and Governance

Currently, the management of GMES is in an evolutionary state from an initial management structure (see fig. 2.8) towards a sustainable governance structure. The current management structure of GMES is organised around three levels: policy, programmatic, and executive.

At the policy level, decisions are made in the EU/ESA-Space Council, supported by the High Level Space Group consisting of members of the supportive institutes. At the programmatic level, the GMES Advisory Council brings together EU/ESA Member States, the European Commission and ESA, as well as other stake-holders included on an ad-hoc basis, such as the relevant international organisations (e.g., the EEA, EUMETSAT, European Maritime Safety Agency, EU Satellite Centre, etc.) and the representatives of the industry, end-users, service providers, research organisations, and academia.

Figure 2.8. Current Management structure for the joint EU/ESA-GMES Initiative



The primary missions of the GMES Advisory Council, in particular in the early phase of GMES implementation, are to:

- Provide strategic advice to the GMES Programme Office concerning the long-term implementation of GMES services, creating favourable conditions enabling the development of services, stressing the user driven orientation of GMES, the need for interoperability, data harmonisation and avoidance of duplication of efforts;
- Foster the co-ordination among, and the complementary role of European and national activities, thereby encouraging the creation of a "GMES partnership", as outlined in the GMES Communication;
- Facilitate consensus-building in the relevant community (ies) around the development of a GMES capacity, in particular in relation to "initial services", and taking account of the "GMES final report for the Initial Phase" and of the GMES Communication.

The European Commission's GMES Bureau was set up with the primary objective of developing a federated and structured demand for Earth Observation EO data and information and ensuring the delivery of fast track EO services by 2008. At the same time, the Bureau is also pushing forward on medium-term issues such as the GMES governance structure and longer-term financial sustainability. Ultimately, the Bureau's tasks include developing proposals for managing GMES service provision beyond the Commission. This will include other EU institutions and bodies, Member States and intergovernmental organisations such as ESA, EUMETSAT, and EUSC. The structure of the Bureau is unique, gathering staff from the Commission's Directorates-General for Enterprise and Industry, Research, Environment, Information Society, Agriculture, Rural Development, Fisheries and Maritime Affairs, as well as the Joint Research Centre.

The ‘Implementation Groups’ are composed of representatives of the various user communities for the Core Services ‘Land’, ‘Marine’, ‘Emergency’ and ‘Atmosphere’. Each Implementation Group has analyzed the main issues related to the implementation of the Core Services, including the scope of the service and its potential evolution, its functionality and architecture, its main structure and governance principles, as well as its requirements regarding observation infrastructure and data needs, data integration and information management issues.

The ‘Munich Roadmap’ states that the “GMES governance scheme needs to ensure ownership of the initiative by its users through effective involvement of the European Union and its Member States in decision making”. Currently, the governance scheme is still under discussion and a final proposal is expected the end of 2008. According to the Munich Roadmap, the GMES governance scheme will have to perform integrating and harmonising functions, such as:

- Update existing and implement new GMES services;
- Monitor and support the evolution of Core and Downstream Services;
- Monitor and respond to cross-cutting observation infrastructure needs;
- Establish data and information access policies including legal issues;
- Federate new users and their information needs;
- Manage GMES information quality and branding; and
- Act as interface at international level.

In any one scenario, two issues will have to be addressed with certitude. The first issue relates to data procurement. As has been reported on EO Service Industry, a main barrier that prevents the EO Service Industry from growing in the private sector are the relatively high costs of EO data and the uncertainty about the continuity of EO data. Whilst the latter barrier is supposed to be lifted by the Sentinel-program, the former still needs special attention.

As for now, the European Commission will procure the necessary data (space and in-situ) for the Core Services. However, no such formal decision has been taken regarding the Downstream Services. The second issue relates to maintaining a level playing field for the EO Service Industry since only a small number of European companies and institutes will be involved in the Core Services. This might have a negative impact on companies willing to enter the scene for Downstream Services.

2.4 Regulatory framework

- ***Access to raw earth observation data***: Essential for the development of downstream earth observation services is the access to and price of raw data, like imagery. The fundamental question whether raw data are a public good and therefore should be freely accessible at any time to anyone is fiercely debated. The outcome will have consequences for European EO industry.

  The EO industry in the U.S. has various competitive advantages over the European industry. The Information Act guarantees free access to basic raw earth observation data. Processed data, however, have to be paid for. The 1992 Land Remote Sensing Policy Act stimulated rapid growth of space-based environmental programs. The 1998 Commercial Space Acts forced US Government and its agencies like NASA to purchase remote sensing data, service, distribution and applications on a commercial basis. This also gave industry an impulse.

- ***Standardization and interoperability:*** Barriers are believed to result from the lack of interoperability of space-based systems. Many valuable and cost-effective uses of existing space-based capabilities cannot be implemented because the various systems cannot communicate and interconnect. Interoperability would allow cost-effective integration of diverse types of information. However, developing and implementing standards requires centralized coordination (OECD 2004).

- ***Intellectual property rights***. Intellectual property rights protection is absolutely essential for the development of high tech industries, since it supports technological advances. The EO industry suffers from deficiencies in this area that harm the industry in three different ways (Galant et al. 2007; OECD 2004):

  - By hampering the commercial exploitation of technologic innovations and driving away potential private investors;
  - By complicating the development of technical standards and certification, which are essential to assure interoperability of systems and to convince potential customers of the benefits of EO applications; and
  - By impairing new knowledge dissemination thus holding back the collective learning process.
  - The fact that EU lacks a unified IPR-regime is an obstacle for international market development for SMEs. SMEs now tackle this by opting for small-scale, close-nit cooperation.

- ***Export controls:*** Because of the dual nature (civil and military) of space technology, upstream as well as downstream, governments may want to control the international transfer of technology on security grounds. This might interfere with business opportunities (OECD 2004). In the European context, this confines local EO industries for this moment to local markets, as the European Security and Defence Policy and especially its relationship with space policy are not quite developed.
- ***Funding and the government as the initial customer:*** Public customers form the largest part of the demand side. European suppliers of EO products and services depend on public funding for technological development. This makes the industry less vulnerable to macroeconomic cycles compared to industries that depend entirely on private customers. However, small institutional EO market in Europe limits the development of the industry. In addition, it is difficult for companies to survive without or with few private customers because of slow government procurement processes on different levels. Comparing European EO industry to its American counterpart, it appears that the American EO industry has a more balanced match between public and private customers, with a higher share of private customers.

  Dependence on public funding for technological development and customership is quite common in EO industry in different countries. Applications for defence and homeland security purposes have made specialized EO service providers in the U.S. highly competitive worldwide. Initial customer is a necessary and effective catalyst for the development of products and services in the high-tech sector. The role of the government as the initial customer should be specified in detail early on in every programme giving the industry a clear signal about the minimal guaranteed demand.
- ***Business models and business skills:*** Firms' strategies should carefully balance technological advancement with solid business and marketing models. Although European EO industry has been able to survive for already two decades, most segments appear to be in their infancy, with more focus on technological advances and less on market development and cooperation within the industry. Industry's highly educated staff has a strong technology orientation. The EO industry boasts a higher level of overall education and larger numbers of Ph.D.-level staff than the high-tech industry on average. Nevertheless, it is the insufficient business strategizing that hurts the bottom lines in the end and slows down the industry dynamics. The European Association of Remote Sensing Companies established in 1989 focuses on an adequate coupling between the EU-program GMES and the industry. The EU can help with targeting EO companies in SME business development programs. Like in GNSS sector, measures to lower barriers for entry for SMEs should be employed, including awareness raising, incubators, open tenders, and administrative burden reduction.

2.5 Benefits from the space programme

In their study 'Space 2030 – Tackling Society's Challenges' (OECD, 2005), OECD analysed the specific contribution space might make to addressing five major challenges to be faced in coming decades: those related to the state of the environment, the use of natural resources, the increasing mobility of individuals and products and its consequences, growing security threats and the shift towards the information society.

Space technology can help improve our understanding of the complexities of climate change and ecological processes and provide valuable input for the formulation of sounder environmental policies. It can also support the effective implementation of policies aimed at reducing greenhouse gas (GHG) emissions (at national and regional levels).

OECD (2005) illustrates these benefits by taking forecasting El Niño as an example. Observations from TOPEX/Poseidon and Jason missions provide the data to predict El Niño-events months in advance. This results in agriculture benefits of USD 450-550 million a year. Remote sensing could be useful for control programmes that monitor either sources of fossil fuels themselves or the myriad sources of actual emissions.

Recent analysis of data coming from ESA's ENVISAT for instance showed methane emissions from tropical forests to be much higher than known earlier. Since methane is a much stronger GHG than CO2, these results have an immediate impact on climate models. PriceWaterhouseCoopers (2006) estimated the largest benefits of GMES to be related to reduce uncertainties in the context of climate change and a consequent improvement in international action to reduce climate change impact. These benefits could amount to more than 5 Billion Euros by 2030 (PriceWaterhouseCoopers, 2006).

In the fields of natural resources management benefits are to be seen with respect to management of energy resources, water management, forestry management and agriculture. Steering the energy system away from fossil fuels will be extremely difficult, given the huge amount of resources that have been devoted to its development. As the importance of the renewables sector grows, the idea has arisen of using satellite data to better exploit various energy sources. Space data are currently used to develop "sunshine" databases (SODA) and databases on wind fields over oceans and near-shore areas. Accurate information on snow melt is extremely important for managing hydropower. In Norway, snow-melt run-off is predicted using temporal satellite data on snow coverage. Recently, biomass mapping using satellite data has been an important application in the field of energy management. The general denominator in all these applications is that renewable energy resources, due to its uneven spread in space and time, need a close monitoring if it is to be effectively used in today's power grids. Here the great benefit of Earth Observation comes in, as it is capable of regularly measuring the relevant variables globally. Economies of scale might play an important role if benefits from space technology are to be maximized. For instance in Forestry-applications and Agriculture-applications real benefits are seen due to the fact that Earth Observation is capable to deliver detailed, local information over large areas at once. This helps especially where large estates have to be managed since it becomes at once clear where resources have to be allocated or certain types of actions have to be taken (e.g. irrigation or fertilization).

OECD (2005) mentions the likely increase of risk faced by our societies in future in the study on "Space 2030 – Tackling Society's Challenges". These risks relate to political risks, economic risks, demographic risks, environmental risks, mobility risks and technological risks. Many of these risks are interrelated. Space-based technology has certain advantages as:

- Communicate anywhere in the world whatever the state of the ground based network.
- Observe any spot on earth very accurately and in a broad spectrum of frequencies.
- Locate, at an increasing level of precision, a fixed or moving object anywhere on the surface of the globe.

Regarding Emergency Response, real benefits have been brought by the International Charter "Space and Major Disasters" which aims at providing a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through authorized users. Each member agency has committed resources to support the provisions of the Charter and thus is helping to mitigate the effects of disasters on human life and property. The International Charter was declared formally operational on November 1, 2000. Members include ESA, CNES, CSA, NOAA, ISRO, CONAE, JAXA, BNSC, USGS and CNSA.

An authorized user can call a single number to request the mobilization of the space and associated ground resources (RADARSAT, ERS, ENVISAT, SPOT, IRS, SAC-C, NOAA satellites, LANDSAT, ALOS, DMC satellites and others) of the member agencies to obtain data and information on a disaster occurrence.

Another area where satellites provide benefits relates to Treaty Monitoring. An important application in this regard is the Comprehensive Nuclear Test ban treaty (CTBT) the monitoring of which will be enforced using a system of, eventually, 250 thin-route, very small aperture terminal (VSAT) satellite links to the monitoring stations.

Another example is the use of ozone-sensors (TOMS and OMI amongst others) aboard satellites which support the monitoring for the Montreal Protocol on Substances that Deplete the Ozone Layer.

PriceWaterhouseCoopers (2006) in their study on socio-economic benefits of GMES grouped three categories involved:

- ***Efficiency benefits*** – These relate to improved cost effectiveness of implementing, enforcing or assessing policies that are currently in place. These benefits are projected to extend to around € 312 million per annum by the year 2030.
- ***European policy formulation benefits*** – These relate to improved definition and implementation of new European policies for which GMES information would be used from the early policy formulation stages onwards. Such benefits would materialize only when new policies begin to take effect. The envisaged policies benefiting from GMES relate to Humanitarian Aid, Conflict Resolution, Forestry, Air Quality, Marine, Flooding, Forest Fires and other Civil Security Issues. The benefits are projected to amount to € 2.9 billion per annum by the year 2030.
- ***Global Action Benefits*** – These relate to the use of GMES information in formulating, improving and implementing global policy agreements (e.g. for climate change, desertification, deforestation). Here again, the benefits enabled by GMES will be realized only when and if the international cooperation achieves its objectives. The benefits are projected to total € 7 billion per annum by the year 2030.

These estimates, however, may be rather exaggerated, since the assessment methodology applied did not allow singling out the contribution of GMES to the total programme effect.

2.6 Policy options

First, we summarize the strengths and weaknesses, and the opportunities and threats that the EO industry has to deal with. The demand for EO applications will continue to rise, due to increased global uncertainty in the fields of security, climate safety and food supply and the necessity of fast reactions when safety and security are affected. The industry however is fragmented and searching for a balance between technological focus and market development. Compared to their main competitors (U.S. companies), they face competitive disadvantages regarding:

- The cost and accessibility of data and imagery;
- Clear and open procurement processes;
- Size of both private and public markets;
- Balance in private and public customers;
- Clear customership of public institutions; and
- A common (nationwide in case of the U.S.) IPR regime.

2.6.1 Market organisation: scale, transparency and administrative simplification

- ***Maturation of supply and demand sides:*** As it was stated above, the EO markets are much more dependent on the institutional customer than the GNSS markets, be it the international, national, or regional customer. At the same time, the European EO markets are not very mature – much less so than their counterpart in the U.S. The challenge is how to speed up the maturation process in Europe on both supply and demand side.

  The recent consolidation wave is a signal that the industry itself is preparing for the next phase. The time is right for crucial customer groups like governments to embrace large-scale EO applications. When governments will achieve a unified demand in an EU context, this will raise demand on the one hand and will enable standardization (and economies of scale for the industry) on the other.

- ***Private user and transparency:*** At the same time, there is a pressing need to expand the private user segment of the market. Transparency should be enhanced by means of efficient organisation of the user community and a clearer definition of users' needs. This will especially be relevant for SMEs developing services in niche markets. Transparency is also needed for the identification of funding schemes and resulting business models (Barbance, 2007). This is especially important for Downstream Services, which are tackled only indirectly by the GMES programme. One important effort in this direction is the BOSS4GMES Integrated Project (Building Operational Sustainable Services for GMES) with a total funding of € 20.2 million. It is important to assure the success of this large consultancy project, which should produce important and practical recommendations.

- ***Creating a level playing field:*** A level playing field for both integrated companies and SMEs should be created by revising procurement processes with clear terms of reference. SMEs are *a priori* at disadvantage *vis-à-vis* large integrated companies regarding their ability to deal with administrative overload associated with tender procedures. As in GNSS, measures to lower barriers for entry for SMEs in the EO market should be employed, including awareness raising, open tenders, incubators, and administrative burden reduction.

- ***Network promotion:*** In order to balance out the power of large conglomerates, there is a need of strengthening of existing networks and stimulation of new networks among SMEs. Such networks have been and are being created by the private sector but their further promotion by the public sector will be beneficial.

2.6.2 Procurement principles

As a flagship of the European Space Programme, GMES highlights the need for institutional and procedural harmonisation among the Programme participants, and especially between its leaders – the EU and ESA. For instance, the Procurement principles of the GMES Sentinel programme envision (Spoto and Berger, 2007):

- Open competition, which is restricted to the situations when Prime has to select core team Partners for risky developments, or when a unique expertise is available in Europe.
- Tight geographical return constraints taking the Sentinel 1 industrial set-up and the Sentinel 3 invitation to tender geographical return requirements into account.

- Requirements to ensure fair distribution of activities between Prime / Non Prime companies (target is more than 45% of activities going to the Non Prime companies)
- ESA launcher policy: VEGA baseline launch service.
- Prime responsible for all Satellite external Interfaces.
- Prime Contractor to identify commonality of requirements/design with other Satellite projects; procurement under best practices procurement (ESA control).

"Firm and restrictive requirements" of the geographical return principle will be managed in an integrated way across the Sentinels, during initial negotiations and during best practises sub-contractors selection (ESA 2007).

These principles are a far cry away from EU principles and the new procurement principles of Galileo (see Section 1.2.3). In effect, there are two sets of rules that apply to different parts of GMES programme – EU's and ESA's.

2.6.3 Cost of and access to data: free raw data and imagery

The U.S. counterparts in EO industry have a major competitive advantage due to the fact that raw data and imagery stemming from US government satellites are free. This lowers the input costs for US industry significantly. Almost all EO data in Europe are derived from satellites belonging to European public bodies. The cost of and access to EO data generated by publicly owned satellites therefore is vital for the development of the private EO sector.

One option is to use the U.S. model declaring raw EO data free and open to access, while processed data should to be paid for. Another issue is whether some restrictions to data access based on security, privacy, and other grounds, should be specified. In any case, access procedures should be specified clearly and in detail, so the private sector can develop business models in advance. It is important to maintain a coordinated approach between GMES and the INSPIRE process on data access policies and standards definitions.

2.6.4 Customership of public institutions, EO as a tool for policy enforcement

EO programmes are highly dependent on the government as the initial and the primary customer. Private demand for EO services, although developing, will never approach the scale of GNSS. Therefore, it is imperative to define in advance the scope and structure of publicly acquired processed EO data and services. There is a wide range of public institutions, on different levels, that should be active on the market. These are international/supranational, national public bodies as well as regional/local governments. The role of the two first levels is defined much better than the role of the regional governments. Application of EO services and data for implementation and enforcement of policy should be part of decision making processes and budgets of public bodies on every level.

The funding for GMES is coming from FP7, which seems rather insufficient limiting possible role of different European actors. Funding under other Directorates General representing users needs to be added. Investment in GMES should also include education and awareness raising. Currently, the awareness of the European citizens about GMES is not as high as about Galileo.

2.6.5 Developing regulatory framework: towards a single market

- ***Standardisation and certification:*** Like in GNSS, standardisation and certification is paramount for the sector's health. One important issue is the public support for the industry in formulating and implementing technological standards and interoperability of systems.

  Developing Standard data definitions is another. Certification is also very important to assure product quality and thereby to acquire user trust for the products and services, thus expanding the market. ESA is active in this area with the help of private certification companies, such as DNV.

- ***IPR:*** As was mentioned in Section 2.4 of this report, IPR protection is a sore issue for EO application development, especially by SMEs. Two problems need special attention. One, SMEs need easing the administrative burden of IPR protection. Two, the unification of the European IPR regime will be highly beneficial to create a true common European market.

- ***Export control regime:*** Progress towards a harmonized common export control regime will help intra-community trade in sensitive products as well as strengthen European export position while protecting security interests.

3. ACCESS TO SPACE

Access to space is not the focus area of this report. As previously agreed, it will give only a brief overview of the state of affairs in this sector.

3.1 European launcher program

According to ESA's Agenda 2011, the core activities of ESA in launcher development consist of consolidating the exploitation of the heavy launcher Ariane 5 and the initiation of the exploitation of the medium launcher Soyuz (in partnership with Russia), and the small launcher Vega. In addition, technologies for the next generation launchers are being prepared. In 2006, ESA spent on launchers €523 Million or 20% of the total budget. The construction of the Soyuz launch facilities in Kourou, the development of Vega, and the programme European Guaranteed Access to Space (which includes the construction of Ariane 5 and institutional market promotion for Ariane 5) were the main areas of expenditure. France spent an additional € 381 Million on the launcher program[8]. With three launchers (heavy, medium and light), Europe will be able to cover the whole launch market.

- ***Heavy launcher:*** Ariane 5 is currently the only European launch system designed to deliver payloads into geostationary transfer orbit or low Earth orbit. It is manufactured under the authority of the European Space Agency (ESA) and the French Space Agency (CNES), with EADS Astrium Space Transportation as prime contractor leading a consortium of sub-contractors. The launcher is operated and marketed by Arianespace. Astrium builds the rockets in Europe (facilities in France and Germany) and Arianespace launches them from the Guiana Space Centre. It succeeds Ariane 4, but does not derive from it directly. Its development took 10 years and cost €10 billion[9]. Ariane 5 has been in commercial use since 1999. The current versions of the launcher are Ariane 5 ECA (with 10,500 kg payload capability) and Ariane 5 ES-ATV (up to 21,000 kg). Table 3.1 presents the characteristics of heavy the launchers – competitors of Ariane.

Table 3.1: Heavy launcher characteristics

Heavy Launchers					
Name	Capability to GTO in Tons	Country	Origin/launch organization	Price information millions US$	Remarks
Long March CZ-3B	5.1	China	Great Wall	Not known	
GSLV	2.2	India	ISRO	40-50	
H-IIA	2-3.8	Japan	JAXA Mitsubishi	80-100	
Proton M/Breeze	5.5-6	Russia	ILS	Negotiable	
Zenith 3 SL	6. 1	Russia Ukraine	Sea Launch	90-110	
Atlas 5	4.1-8.2	US EELV	ULA	Negotiable	
Delta 4	3.9-10.8	US EELV	ULA	140-170M	
Ariane 5 ECA	9.6-10.5	European	Arianespace	100-160M	Dual payload

Source: Peter, 2007.

[8] ESA (2007).
[9] European Commission (2007).

- ***Medium launcher:*** In January 2005, ESA signed an agreement with Russia on launching the Soyuz ST vehicle from the Space Centre in Guiana. The Soyuz launch site is currently under construction. The cost of construction is €344 Million, of which Arianespace will pay €121 Million.

  The partners for Soyuz exploitation include Russian TsSKB-Progress of the Russian Space Agency (Roskosmos) which will produce the rockets, Arianespace which will commercialize the launcher, the Russo-French Starzem company which will be the intermediary between the producer and the operator, ESA is the supervising authority of Arianespace, and the French Space Agency (CNES) is the authority responsible of the Soyuz program in Guiana. Although not a European launcher, Soyuz will be under efficient implementation of the EGAS program thanks to the agreements between ESA and the Russian Space Agency. Soyuz ST will have the capacity of 3.2 tons to the geostationary transfer orbit, which puts it in the medium-range category. Soyuz ST will have the human flight capability and this option is taken into account. The Space Centre in Guiana will have facilities necessary for human flight. In addition, by obtaining the right to exclusive commercial exploitation of Soyuz ST, Arianespace prevents the potential exclusive control of this launcher by U.S. rivals, such as International Launch Services/Lockheed.[10] Table 3.2 compares the characteristics of Soyuz with other medium launchers.

Table 3.2: Medium launcher characteristics

Medium Launchers					
Name	Capability to LEO (800KM) Kg	Country	Origin/launch organization	Price information millions US$	Remarks
Delta 2	2 700 - 6 100	US	No longer available for commercial market	60-80	2 185 kg to GTO
Soyuz 2 – 1a	4 350 – 7 480	Russia	Arianespace	40-50	2 780 kg to GTO
PSLV	1 200 – 3 650	India	ISRO	20-25	
Falcon 9	8 000	US	Commercial SpaceX	35	See also p. 23

Source: Peter, 2007.

- ***Small launcher***: Continuing the programme of the Italian Space Agency (ASI), ESA is developing the small launcher Vega with the payload capacity to the low earth orbit of 300-2,500 kg. The launcher will target the growing market of small satellites, which is gaining importance especially in the field of EO. The prime contractor is Italian ELV SpA. Arianespace will exploit the launcher. The program is still in development phase.

  When operational, Vega will be facing a serious competition from low-cost launchers from Russia, India, and China. Another serious competitor would be the low-cost Falcon 1 under development by SpaceX (U.S.). Table 3.3 compares the characteristics of Vega with other small launchers.

[10] Ingold (2006).

Table 3.3: Small launcher characteristics

Small Launchers					
Name	Capability* to LEO kg	Country	Origin/launch organization	Price information millions US$	Remarks
Pegasus XL	190 - 440	US	Air launch Orbital Sciences	20-25	190 kg to 800 km SSO
Taurus 2110	740 - 1 250	US	Orbital Sciences	30-50	First stage from Peacekeeper
DNEPR-I	400 - 3 700	Russia Ukraine	ISC Kosmotras	10-15	Converted strategic missile
Minotaur 4	1 750	US	Orbital Sciences		Converted strategic missile
Rockot	1 340 - 1 850	Russia	SS19 Eurockot	15-20	Converted strategic missile
Cosmos 3M	1 500	Russia		15	
Vega	1 500 – 2 300	Europe	Arianespace	20	Target price
Falcon 1	570 - 670	US	Commercial SpaceX	7	

Source: Peter, 2007.

3.2 Innovative potential and R&D needs

R&D in launcher development continues on the path set out in the 1930s. The main areas of research are solid and liquid propulsion, materials, and control systems. Research and development programs are associated with each of the three launchers discussed and funded by the ESA, EU, national governments, and private firms. For instance, there is a need for a reignitable second stage for Ariane 5 for the launching of Galileo satellites and for bringing geostationary communication satellites directly to their final orbit (instead of geostationary transfer orbit which is currently the case).

Besides the three launchers intended for commercial use, ESA carries out the Future Launchers Preparatory Programme (FLPP) which addresses technologies for future launchers, the Intermediate eXperimental Vehicle, and current launcher evolution. The objective of the FLPP activities is to develop technical concepts for launchers that will satisfy guarantee access to space at an affordable cost while ensuring reliable, flexible and available launch services.

An important goal of R&D is to provide launch systems that can reduce the cost of access to space thanks to smart design, efficient manufacturing, and low cost launch campaigns. New launchers should be globally competitive and not need subsidies. A large-scale production of identical launchers, arguably, increases reliability and reduces cost (which was the strategy for Soyuz)[11].

3.3 Launch market characterization

In 2006, six countries and the multinational consortium Sea Launch conducted total of 66 launches, including: Russia – 25 launches, the USA – 18, China – 6, Japan – 6, Europe – 4, Multinational – 4, and India –1[12]. These launches were carried out by 25 launch systems. The most often used system were Soyuz (Russia) -11 launches, Delta 2 (U.S.) – 6, Ariane 5 (Europe) – 5, and Zenit 3SL (Russia, Ukraine) – 5. The total turnover of the launch industry in 2006 was valued at US$2.7 Billion (including commercial and institutional market), which was about a half of the 2000 level (US$5.3 Billion).

[11] Skaar (2007).
[12] Peter (2007).

There were 21 commercial launches with the estimated revenue of US$1.4 Billion.[13] Europe lead with UD$560 Million, followed by Russia with US$444 Million, the multinational Sea Launch company with US$350 Million, and the U.S. with US$70 Million. Ariane 5 lifted 10 primary satellites and one auxiliary – more than all competitors combined. Arianespace had more than 50% of the global market for communication satellites.

In the historical period from 1994 to 2003, the following four players shared the world market in launch services:

- Arianespace (the Ariane launcher) -- 46%;
- Lockheed Martin (U.S.) and International Launch Services, a joint venture with Khrunichev State Research and Production (Russia) markets (Atlas and Proton) -- 27%;
- Sea Launch -- an international partnership between The Boeing Company, RSC Energia of Russia, Kvaerner ASA of Norway, and SDO-Yuzhmash/PO-Yuzhmash of Ukraine (Zenit 3SL is launched in the Pacific Ocean from a converted mobile oil rig) -- 13%;
- Khrunichev (Russia; the Proton launcher) -- 7%.

In 2005, Lockheed Martin and the Boeing Company formed a joint venture, United Launch Alliance, merging the Delta IV and Atlas V manufacturing, operations, and sales. Two new launcher companies from BRIC countries are to enter the market and challenge the leaders. These are ISRO (India, the GSLV launcher) and China Great Wall Industry Corp. (China, the Long March launcher). Japan seems to be content with its national market. The private U.S. Company Space Exploration Technology (SpaceX) develops a family of low-cost launchers, with cost reduction of 70% compared with current prices. This development is supported both by NASA and the Defence Advanced Research Projects Agency of the U.S. Department of Defence with the goal to reduce significantly the cost of access to space. Other private companies are developing low-cost launchers with a variety of uses in mind, including space tourism and suborbital flights. These companies include Virgin Galactic (offering a 2.5 hour suborbital flight for US$200,000), Kistler and SpaceX (both companies develop a reusable launcher).

3.4 Policy issues

Independent access to space has long been the core objective of ESA. The European Space Program states that "Independent and cost-effective access to space needs to remain a strategic goal for Europe, which will look first to its own launcher resources when defining and executing European programmes, based on cost-efficiency, reliability and mission suitability." Hence two goals have priority in access to space -- independence and cost-effectiveness.

Access to space is vital for obtaining important information for political, economic, and scientific reasons. History shows that space-faring nations can restrict access to space for other nations for political, military, or commercial reasons[14].

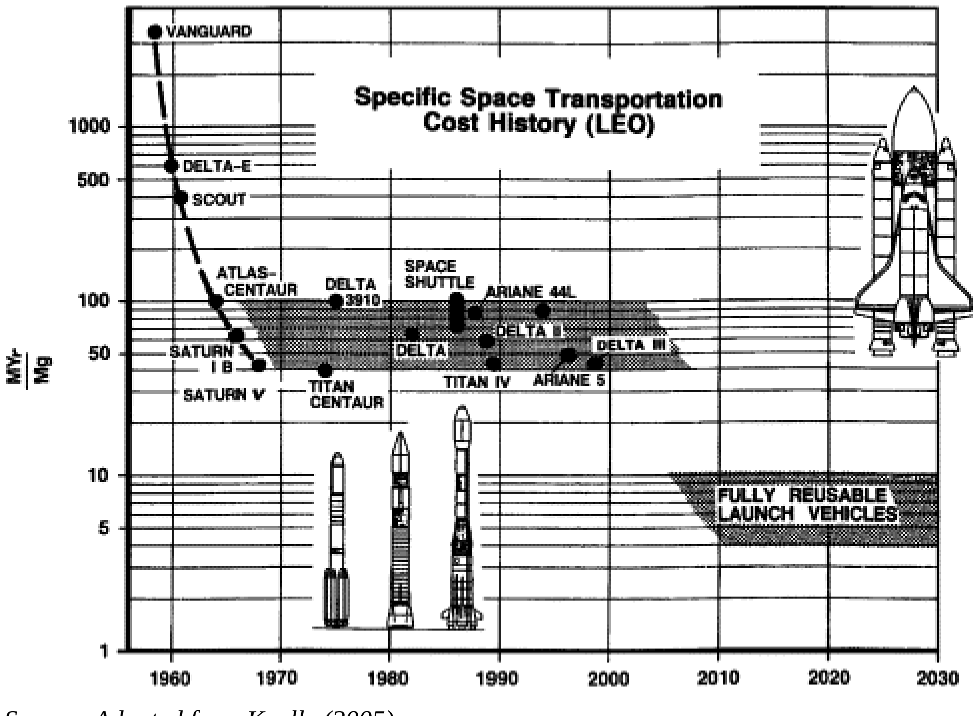
[13] Commercial market is represented mostly by communication satellites.

[14] Europe experienced that first-hand when the United States required guarantees that European communication satellite Symphony will not compete with American communication satellites, as a condition for launching the satellite. That episode was yet another argument in favour of the European Launcher Development Organisation – the predecessor of ESA.

Reduction of high cost of access to space is the most pressing issue for increasing space activities. The cost of access to space has not been substantially reduced in the past decades, as the challenge of reaching the first orbital speed of 7.2 km/sec still looms large.

The historic dynamics of the transportation costs of one metric ton to the low earth orbit expressed in man-years spent is shown on Fig. 3.1, which shows that no real cost reduction occurred in the last 40 years. Saturn V of the U.S. Moon Programme launched in 1968 a payload in the low earth orbit for roughly the same amount of man-years per ton as the latest launch vehicles such as Ariane 5, Atlas V (U.S.) and Delta IV (U.S.). This cost dynamics looks rather disconcerting. Suppose we were to use the same launch vehicles instead of developing new ones. Then we could expect a modest 2% cost reduction per year resulting from the increased scale of operation and gained experience (learning-by-doing) without any major technical improvements. Over 40 years, this annual cost reduction would compound to a cost reduction of 55 %. However, in actuality, no marked cost reduction occurred, in sharp contrast to other high-tech industries where costs have been steadily and speedily going down. For instance, the unit cost of computing measured in constant prices went down by a factor of 50 million from 1964 to 2004.

Fig. 3.1: Historic trend of specific space transportation costs to LEO, in man-years (MYr) per metric ton (Mg); in the logarithmic scale. 1 MYr in 2004 equals €210,000.



Source: Adapted from Koelle (2005).

The reduction of cost of access to space should have a high priority of the access to space program. The current most serious challenge to the strong position of Ariane 5 and the prospective European launchers is the Falcon family of low-cost launchers under development by SpaceX (U.S.). Reducing the cost requires innovation and, even more important, a smart use of existing technology. Launch systems can offer a chance of essential cost reductions compared to Ariane 5 if they are based on established technology, and cost engineering principles are properly and consistently applied[15].

[15] Koelle (2005).

International cooperation offers opportunities as well. Europe should attract the capabilities of Russian launcher companies which have large experience in manufacturing modest-cost launchers.

However, the partnership with Russia for launching Soyuz from the Space Centre in Guiana had experienced serous difficulties leading to delays. Here, again, like in the Galileo program, a pressing need exists to develop partnership models and procedures that provide a smooth programme evolution avoiding the stop-and-go mode and reducing uncertainties associated with other members' decision process.

On the regulatory front, the regulations have to account for potential hazards of launch activity; thus the importance of environmental, safety, security regulations and legal accountability mechanisms. A very important issue is export control regime, since launcher technology is a prime example of dual-purpose technology.

Market structure: The industrial organization of the European launch sector is characterized by a dominant position of just four companies which use the services of hundreds other companies as contractors. This configuration of the industry is not uncommon in aerospace and defence industries everywhere in the world. The U.S., Japan, and the BRIC countries all exhibit similar market structures. This small group of large dominant players forms as a result of high fixed costs of production (most importantly, R&D), small series, and increasing returns to scale; it appears to be a natural market outcome under these conditions. Oligopolistic or monopolistic supplier is often coupled with a monopsonistic customer represented by the institutional market, which, if left unregulated, will result in market failure[16].

Thus the very nature of the sector creates a tendency towards restricting competition and poses serious difficulties in achieving ESP goal of avoiding both the creation of monopolistic structures and overcapacity. While we cannot expect that the nature of the market will change in the future, this requires the attention of the European regulatory authorities in the four main policy areas, such as:

- Regulation of cartels involving the control of collusion and other anti-competitive practices (as per Article 81 of the Treaty of the European Community);
- Regulation of monopolies or preventing the abuse of the dominant market position (Article 82);
- The control of proposed mergers, acquisitions and joint ventures involving large companies (the Merger Regulation) with a scrutiny of potential harm from vertical integration; and
- Control of direct and indirect state aid given to companies (Article 87).

The overarching goal should be the achievement of efficient pricing of goods and services, efficient production costs, efficient levels of output and investment, efficient levels of quality and product variety, curtailing monopoly profit and rent extraction.

Monopolistic structures give rise to efficiency problems in the area of innovation. In situations where spillovers from R&D and innovation can be captured by other firms, regulatory policies that facilitate the internalization of these spillover effects, for example, providing for the recovery of R&D costs in product prices might increase social welfare.

[16] Kovacic, 1994, GAO, 1998, Kramer, 1999, Eland, 2001.

Achieving these objectives may call for some specific actions, for instance,

- require major contractors to use open-system architectures (i.e. setting standards of system interfaces that a number of contractors can meet) in designing space systems;
- make subtier competition a specific source-selection criterion; and
- explore opportunities for greater cooperation with international partners.

In addition, ESA/EC acquisition program managers should scrutiny prime contractor teaming and supplier choices, devise acquisition strategies to promote alternative concepts and new supplier entry, and monitor some technological areas for the impact of vertical integration.

4. EUROPEAN SPACE PROGRAM – OVERALL PERSPECTIVE

4.1 Introduction

Elaboration and implementation of a European space policy has since 1975 been a purpose of the European Space Agency, as stated in Article II of ESA Convention. The EU considers a space policy as its area of responsibility as well. Initially, space found its way into the EU policies through research and development programs, most importantly, the Framework Programs. Later on, space policy and program were explicitly attributed to EU's competencies, earlier in the draft Constitutional Treaty (Article III-155(3)) and then in the Treaty of Lisbon (Article 172a).

An integrated European Space Programme emerged in 2007 following the adoption of the European Space Policy jointly drafted by the European Commission and the ESA Director-General. The most important actors taking part in the Programme are, of course, the ESA and EU (through the FP7 and Trans-European Framework programs). Other international organisations (most importantly, EUMETSAT[17]) and the national space programmes are a part of the European Space Programme as well. As of 2006, national programmes account for approximately 40 % of the overall European space effort (including defence)[18]. France, Germany, Italy, and the UK have the largest national space programs.

Within the EU Member States, most countries support their national space ambitions through joining with ESA activities (Peter, 2007, p. 54). There is a trend towards more investment in ESA at the expense of national programmes. Only France, Italy, Germany and the UK have substantial resources devoted to national space programmes. These are concentrated in the national centres, such as the Centre National d'Etudes Spatiales (CNES, France), the Deutsche Zentrum für Luft- und Raumfahrt (DLR), the Agenzia Spaziale Italiana (ASI) and the British National Space Centre (BNSC). In 2006, France has construed a list of 50 proposals to remain competitive in space industry. For France there is a linkage with defence issues. Germany has indicated space as one of five sectors to invest in. In 2007, it has initiated a new DLR Institute of Space Systems in Bremen. Italy is has increased its space budget by 8% (though not in navigation). The UK formulated an active space policy in 2006.

The indicative budget for the European space programme includes an estimated € 23.2 Billion budget for the ESA, € 2.85 Billion for the EU during the period from 2007-2013[19]. Thus the ESA appears to be the leading agency. Each project in the Programme remains subject to the legal and financial constraints of the body funding it.

4.2 ESA

4.2.1 Structure

The ESA was founded in 1975 as a successor of the European Space Research Organisation and European Launcher Development Organisation. ESA Convention elaborated in that year was ratified in 1980[20]. ESA's purpose, as stated in the Convention is to provide for, and to promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space applications systems:

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[17] The European Organisation for the Exploitation of Meteorological Satellites.
[18] European Commission (2007b).
[19] Ibid.
[20] Krige et. al., 2000.

- by elaborating and implementing a long-term European space policy, by recommending space objectives to the Member States, and by concerting the policies of the Member States with respect to other national and international organisations and institutions;
- by elaborating and implementing activities and programmes in the space field;
- by coordinating the European space programme and national programmes, and by integrating the latter progressively and as completely as possible into the European space programme, in particular as regards the development of applications satellites;
- by elaborating and implementing the industrial policy appropriate to its programme and by recommending a coherent industrial policy to the Member States.

ESA has 17 Member States: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the UK. Canada is a Cooperating State sitting on ESA Council and participating in decision-making. Canadian firms bid on and receive contracts based, as for Member States, on the fair industrial return principle. The Czech Republic, Hungary, Romania and Poland are involved in the Plan for European Cooperating States that aims at preparing these countries for full membership[21].

European Cooperating States can participate in almost all programmes, with exception for the Basic Technology Programme. Therefore, not all ESA members have a membership in the EU and, visa versa, not all EU Member States participate in ESA. The highest body is the ESA Council, comprised of the representatives of all Member States' national space agencies as well as Canada. The highest administrative position is the Director-General who is assisted by Directors.

ESA is headquartered in Paris and has a staff of 1,900 specialists. Its centres include the European Space Research and Technology Centre at Noordwijk (The Netherlands), the European Space Operations Centre in Darmstadt (Germany), the Centre for Earth Observation in Frascati (Italy), the European Astronaut Centre in Cologne (Germany), the European Space Astronomy Centre in Villafranca (Spain), Guiana Space Centre in Kourou, French Guiana, and ESA Tracking Stations.

The largest centre is the Noordwijk Centre with a staff of 2,500 engineers and scientists working on mission design, spacecraft and technology. The Centre has large test facilities where almost all equipment launched in space by ESA is tested. The mission control centre is located in Darmstadt. Operations for almost all missions are carried out from there. The Guiana Space Centre is the ESA/French space port with the staff of 1,500.

4.2.2 Financing

ESA accounts for about two-thirds of approximately € 5.5 Billion European civil space expenditure (European Commission, 2007a). It has achieved considerable success in facilitating the aggregation of space budgets and building up European space technology and industry.

The 2005 ESA Ministerial Council in Berlin committed itself for ensuring a stable inflation-adjusted budget over the next five years.

[21] Negotiations on the full membership of the Czech Republic have been under way since June 2007.

- The ***ESA budget*** consists of three main parts:
  - The mandatory activities (28% of total expenditure) include the general and associated general budgets and the science program of which the main emphasis is on technological research, and strengthening technical capabilities and infrastructure. The mandatory activities are funded by Member States' and Canada's mandatory contributions according to the scale based on Members' national income (gross national product). The largest contributors are Germany (21.85% of total), the UK (17.70%), France (15.50%) and Italy (12.85%).
  - The optional programs (69% of total expenditure) are financed by the Member and Cooperating States voluntary contributions and by third parties (including the EU) declared on the multi-year basis. The most important are the applications programmes (Earth Observation – GMES – 13% of total expenditure; Navigation program -- Galileo – 11% of total expenditure) and the launchers programme (20% of total expenditure).
  - The third-party programmes (only 3%) are managed by ESA in the interest of third parties and are entirely financed by them.
- ***Industrial return policy:*** According to Annex V of ESA Convention, the distribution of contracts among countries is carried out according to the principle of fair (industrial or geographical) return, which states that, ideally, the amount of contracts awarded to a country equals its financial contribution. When calculating the return coefficients the contracts are weighted according to their technological interest. The coefficients are defined by the ESA Council. This policy instrument was inherited from the days of the European Space Research Organisation. Annex V states that, ideally, the return coefficient should equal one. In actuality, however, it varied from 0.8 in the 1975 to 0.95 in 1995 to 0.9 in the late 1990s. Ministerial Conferences decide on its lower limit. Right now it stands at 0.8[22].

  The principle of fair return was maintained from the time of European Launcher Development Organisation. From the first very start, even since ESA Working Group that preceded ESA formation, this principle was viewed by many within and outside ESA as stifling competition, impeding specialization, and international competitiveness of European industry (Krige et al., 2000, Vol. II, pp. 26-29). At the same time, this policy encourages contributions and guarantees the smaller contributors their share of contracts. With ESA being as an international organisation lacking a strong authority over its members, geographical return provides an important stimulus that facilitates ESA programme financing.

4.2.3 ESA's Achievements[23]

- ***Science:*** This is a mandatory activity of ESA. Given its rather limited resources, ESA concentrated on very innovative missions. A major milestone in the science program was the Horizon 2000 program approved in 1985. Some examples of scientific missions include:

[22] Meaning that the minimal return for county's investment in terms of volume of contracts contracts is set at 80%. Therefore, for some countries the return coefficient will be more than 100%.
[23] Wilson (2005).

- Hipparcos (1989-1993) – first space-based astronomic survey produced the most accurate positional survey of 100,000 stars with distance measurements as well as variability characteristics and binary nature. The Hipparcos catalogue was published by ESA in 1997 and has been fundamentally affecting every branch of astronomy.
- Ulisses (1990 – ongoing) – first-ever characterisation of the particles and fields in the inner heliosphere at all solar latitudes, including the Polar Regions.
- Hubble space telescope (1990 – ongoing) – first photon-counting high-resolution camera for Hubble space telescope (faint object camera).
- Infrared space observatory (1995-98) – world's first infrared observatory providing landmark information to most areas of astrophysics.

- ***Applications:*** The success of the first seven first-generation meteorological satellites (launched in 1977) led to the formation of EUMETSAT in 1986, which took operational control in 1995. The Explore core mission yielded valuable information on Earth radiation, gravity field, ocean circulation, land surface processes and other. Earth watch missions are carried out in the framework of GMES. ESA developed telecommunication capabilities for Europe via the Orbital Test Satellite, European Communications Satellite, Maritime European Communications Satellite, and direct-broadcasting Olympus satellite.
- ***Launchers:*** The Ariane launcher provided to Europe an independent access to space and enjoyed tremendous commercial success acquiring more than a half of the world commercial market for satellites launches to geostationary transfer orbit (used by communication satellites).
- ***Manned spaceflight:*** ESA developed and operated a Spacelab as an integral element of Space Shuttle. Fourteen flights were carried out between 1983 and 1998. Currently, it is a major partner in the International Space Station.

4.2.4 EUMETSAT

EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites) was formed in 1986 with the objective to provide, from space, information that can be used in weather forecasting and climate applications. EUMETSAT is an intergovernmental organisation; its membership currently consisting a total of 30 European States (21 Member and 9 Cooperating States). Activities are mostly funded through contributions based on a scale proportional to the gross national income of the individual Member States. The Council, the supreme body of the organisation, is composed of representatives from each Member State. Each Member state has one vote. Major decisions have to be taken unanimously or with a two-thirds majority representing also at least two thirds of the financial contributions. The Director-General is the legal representative of EUMETSAT. He is responsible for the implementation of decisions by the Council and for the execution of all tasks assigned to the organisation. He heads the Secretariat, which is located at the EUMETSAT headquarters in Darmstadt, Germany. Staff is recruited from the Member States.

On a European level, EUMETSAT is committed to securing its role as one of the main providers of meteorological data and atmospheric monitoring services for the GMES initiative (Global Monitoring for Environment and Security) via the expanding fleet of satellites and Satellite Application Facilities.

EUMETSAT's meteorological satellites already form part of a global satellite system providing essential data coverage of the entire globe, organised by the Coordination Group for Meteorological Satellites (CGMS), and is helping to achieve the objectives of the World Meteorological Organisation (WMO).

4.3 NASA

4.3.1 Origins

The National Aeronautics and Space Administration (NASA) is the successor of the non-military National Advisory Committee for Aeronautics first established in 1915 as a means of improving the quality of airplanes in the United States to help offset foreign competition in the commercial market.

NASA was established in 1958 by the National Aeronautics and Space Act, in order to respond to the Soviet advances in space, as manifested by the launch of the first satellite (Sputnik) in 1957. According to the Act, NASA has a triple duty regarding public and private space activities:

- arrange participation in the field of scientific research;
- provide dissemination of information; and
- encourage the fullest commercial use of space (www.nasa.gov)

4.3.2 Budget

The NASA budget request for the fiscal year 2009 amounts US$17.6 billion. The cost of operations in 2007 amounted US$ 15 billion. In the distribution over the four business lines space operations account for the largest budget:

Table 4.1: The NASA budget

BUSINESS LINES	Cost (US$ Mio)	BUSINESS LINES	Cost (US$ Mio)
Aeronautics research		***Science***	
gross costs	700	gross costs	5,506
-/- earned revenue *	106	-/- earned revenues *	352
net cost	594	net cost	5,154
Exploration systems		***Space operations***	
gross costs	3,217	gross costs	6,443
-/- earned revenues *	29	-/- earned revenues *	301
net costs	3,188	net cost	6,142

Source: NASA: Fiscal year 2007 - Performance highlights

* Earned revenues either come from other government organizations or from the private sector.

Historically, the NASA budget seldom exceeded 1 percent of the federal budget except for a short time during the Apollo program, when, in 1964, it reached 3.85 percent of the federal budget. During the last two decades, the NASA budget has represented about 0.85 percent of the federal budget (President's Commission, 2004).

Budget cuts were relatively severe in the 1970s, as a reaction on the excessive spending in the 1960s, and in the 1990s, due to the downsizing of the space industry in the post-Cold War era and the large federal budget deficits. NASA now employs 80,000 staff, including about 60,000 contractors and about 20,000 civil servants.

4.3.3 Military versus civil applications

In the NASA Act of 1958, the main role for NASA lies in civilian research, development and flight activities in aeronautics and space. The development of space activities for military use was always in the hands of the Department of Defense (DoD). NASA's budget dwarfs the DoD budget for technology and research alone of US$ 73 billion.

In the late 1990s, the Congress got concerned that the DoD paid too little attention to military threats and opportunities coming from space. Under the leadership of Defense secretary Rumsfeld a commission concluded that national security space activities should be recognized as top national security priority. This asked for better cooperation between agencies and departments using space and space activities for civil, commercial, military and intelligence purposes (Anderson 2002).

There is close cooperation between NASA and the DoD in the development of launch vehicles but the two agencies used to develop different systems. An example is the development of expendable launch vehicles, when the DoD developed the Delta, Atlas, and Titan, and NASA developed the Scout and the Saturn.

4.3.4 Institutional organization

The National Aeronautics and Space Administration is headed by an Administrator. The Administrator is responsible for the exercise of all powers and the discharge of the Administration and operates under the supervision and the direction of the President of the United States (www.nasa.gov).

The National Space Council is since 1958 shaping the national space policy, uniting all federal departments or other high-level offices having either a programmatic role or legitimate concern in federal government space activities, including NASA, the Department of Commerce (with the National Oceanic and Atmospheric Administration, NOAA), the office of the director of the CIA and the office of the chairman of the Joint Chiefs of Staff. The council's position is challenged as it is perceived as a vehicle for industrial lobbying.

NASA is comprised of Headquarters in Washington D.C., nine Field Centers located throughout the U.S. and the Jet Propulsion Laboratory (JPL), a federally funded research and development center operated for NASA by the California Institute of Technology. The NASA centers and JPL conduct NASA's programs in exploration, discovery, and research. Important field centers are Kennedy Space Center in Florida (Space Shuttle components and missions), Marshall Space Flight Center in Alabama (Spacelab program, Saturn V launch vehicle for the moon mission) and JPL in California (planetary exploration, environmental research).

NASA needs an extensive network of relations within U.S. Government and with U.S. agencies, like the Department of Commerce (NOAA Weather Satellites, NOAA National Environmental Satellite, Data and Information Services NESDIS), the Department of Defense (Advanced Research Projects Agency, U.S. Strategic Command), Department of the Interior (EOS Data Center -- Landsat data Archive), Department of Transportation (Federal aviation Administration, National Science Foundation), Department of Agriculture, White House Office of Science and Technology Policy, and the Environmental Protection Agency.

NASA also leans on an intensive cooperation with American space and aeronautics industry and space agencies from other countries or regions. A relatively good example of cooperation with governments on different levels (federal, state, local), the industry and universities is the operationalization of earth observation or remote sensing.

The largest NASA missions are presented in Table 4.2:

Table 4.2: Examples of large missions

Mission	***Purpose***	***Timeline***	***Budget/costs***	***Cooperation***
Apollo	human expeditions to the Moon	1961-1972	US $ 25.4 billion	
Space Shuttle	reusable launch vehicle	since 1972	US$ 174 billion when shuttles retire (est. for 2010)	US space and aeronautics industry
International Space Station	permanent presence in space	since 1984	US$ 100 billion when ISS retires (est. for 2010)	international space agencies

Source:Anderson 2002

Since the 1980s, NASA was facing increased criticism. In 1986, the space shuttle Challenger exploded 73 seconds after launch. Investigation committees, both independent and from the Congress, revealed serious problems with decision making processes, management culture and ability to cope with technical problems that individual engineers detected. In the 1990s, NASA was confronted with the downsizing of space industry and budget cuts on the federal level. NASA's response was to reinvent itself with the implementation of the low cost innovation strategy 'faster, better, cheaper'. However, this policy led to some adverse effects, with more failures and delays (Anderson 2002). In 2003 the space shuttle Columbia disintegrated on re-entry. The investigation board on this disaster again revealed faulty decision making processes and conflicting goals united in the same function.

The last NASA restructuring took place in 2004 when President's Commission on Implementation of U.S. Space Exploration Policy stated that "NASA needs to transform itself into a leaner, more focused agency by developing an organizational structure that recognizes the need for a more integrated approach to science requirements, management, and implementation of systems development and exploration mission".

4.3.5 Operations

The 2006 NASA Strategic Plan is derived from the 2004 vision of President George W. Bush on the civil space program. This presidential vision is perceived as the most ambitious since the announcement of the Apollo program. Essential in the 2004 presidential vision is the exploration of the moon, Mars, and beyond.

Goals of the Presidential vision on American civil space program, 2004
* returning the Space Shuttle safely to flight
* completing the International Space Station (ISS)
* phasing out the Space shuttle when the ISS is completed (about 2010)
* sending a robotic orbiter and lander to the moon
* sending a human expedition to the moon as early as 2015 but no later than 2020
* conducting robotic missions to Mars in preparation for future human expedition
*conducting robotic exploration across the solar system.

The aim with this space exploration vision is to help the U.S. protect its technological leadership, economic vitality, and security. The dividends will come in the form of more knowledge on Earth and space, new jobs in current and new industries, and a higher level of domestic, international and economic security. Rejuvenation of space exploration is expected to boost American competitiveness and technological leadership (President's Commission 2004). The vision forced NASA to refocus on exploration and the development of spacecraft and launch vehicles and to find a balance between these new tasks and the traditional tasks in civil aeronautics research (NASA 2006).

The direct subordinance of NASA to the White House helps with fast changes in organizational structure and processes when space policy requires changes. One example is the fast turnaround within NASA after the publication of the presidential space exploration vision and the advice of the President's Commission on the Implementation of Space Exploration Policy. Remarkable, however, is the fact that different investigation boards revealed repeatedly weaknesses in decision making, management culture and management structure that NASA has not been able to alleviate for more than two decades.

4.3.6 Relations with private sector

The provenance of NASA, as an offspring of the National Advisory Committee for Aeronautics, provided strong technical 'in-house' expertise. However, the first Administrator, T. Keith Glennan, laid the basis for an intensive relationship between NASA and private enterprise with his ideology of small government. The Armed Services Procurement Act (ASPA) of 1947, securing the longstanding relationships between DoD and the industry, was extended to NASA. By the end of the Glennan era (1958-1961) 85 percent of NASA's US$ 1 billion budget was going to the industry. The 1961 presidential decision to take man to the moon boosted cooperation between NASA and the industry, as well as universities. This led to the 'triple helix model' -- the nexus of regional industry, government, and knowledge institutions. Supposed positive externalities in regional-economic development facilitated political support on state and national level, which was important to expand the NASA budget at that time.

Several principles have been applied as incentives for the industry to improve price/quality balance, timeliness, cost effectiveness and competitiveness during NASA's history. The procurement process was always based upon open competition. From 1963 onward, incentivizing contracts replaced traditional arrangements, with incentives for cost reduction and performance improvement after contract execution. The President's Commission on the Implementation of U.S. Space Exploration Policy in 2004 advocated the use of monetary prizes to increase competitiveness and technological performance, as well as the use of NASA's contractual authority, and the assurance of appropriate property rights.

The Republican presidencies in the 1980s gave the privatization of government space activities an impetus, including the Landsat program, the operation of expendable launch vehicles, and operation of additional Space Shuttle orbiters. In 1984 NASA established the Office of Commercial Programs, aimed at fostering new commercial high-tech ventures, new commercial applications of existing space technology and the transfer of existing space programs to the private sector. In the 1990s, the insourcing dimension was added, emphasizing that NASA should not only conduct research to identify and test techniques and then outsource production and operation to the private sector. The agency also should access as much of private sector technology as possible and implement these technologies in its architectures and systems (Lambright 1996).

In 2004, President's Commission on the Implementation of Space Exploration Policy clearly stated that space activities should be primarily private: "In NASA decisions, the preferred choice for operational activities must be competitively awarded contracts with private and non-profit organizations and NASA's role must be limited to only those areas where there is irrefutable demonstration that only government can perform the proposed activity." The two-sided strategy of insourcing technologies and outsourcing operations was reinforced.

One of the most successful examples of outsourcing is communication (Echo 1, TIROS, Telstar) and weather satellites. After having been developed and launched, the operational responsibility was turned over to the private sector and to the National Oceanic and Atmospheric Administration.

4.3.7 Exchange of technology and data/declassification

The NASA Scientific and Technical Information Program is essential to help NASA avoid duplication of research by sharing information. It provides dissemination of NASA research results but it also collects STI from all NASA centers and from 50 countries worldwide (www.nasa.gov).

In regard to IPRs, the NASA Act of 1958 claims all inventions as NASA property. A quick search in the worldwide patent database shows more than 7,500 hits with NASA as applicant or inventor (www.espacenet.com). Industry is allowed to use these inventions under license.

The data that are collected by American earth observation satellites are free, due to the Information Act under which all government information is freely accessible to every citizen and enterprise.

The existing U.S. export control regime has a severe impact on the U.S. industry. The main problem is identified in the length of time it takes to obtain an International Traffic in Arms regulations (ITAR) approval (Bini 2007). Especially enterprises that produce satellites are affected. The Wassenaar Agreement on export controls for conventional arms and dual-use goods and technologies reinforced ITAR internationally. Space industry in countries that did not sign the agreement, finds itself in a favourable economic position (for instance, in BRIC countries). Some enterprises and countries have developed 'ITAR-free' space craft, including European Alcatel. In 2004, the ESA established a program to develop production lines that could substitute (parts of) systems that were previously only delivered by American industry.

4.3.8 Contrasting NASA and ESA

The fundamental difference between NASA and ESA is that the former is a national space agency while the latter an international association of national space agencies. As a national agency, NASA has a clear focus on national economic, technological and defensive targets, which are translated into long-term missions and committed budgets. The prime focus of ESA is to promote cooperation between member states' national space agencies and to enhance the effectiveness of national space research programmes and national space industries and thus implement a European space policy.

Other large differences include, of course, the budget disparity: the NASA budget is a few times larger than the ESA budget. However, the small budget of ESA forces the Agency to concentrate on innovative and highly effective missions, which is in line with once famous NASA policy 'faster, better, cheaper', at least in the part of 'cheaper'. At the same time, NASA is subject to criticisms about high-budget low-efficiency projects[24].

[24] Including, the US$150 billion Space Shuttle programme and, to a lesser extent, the US$ 100 billion International Space Station programme deemed as mistakes by current NASA Administrator Griffin.

Their management structure and principles differ fundamentally: NASA operates with a strong top-down management structure while ESA operates with a bottom-up structure where consensus is vital for decision making. Turnarounds in European space policy are therefore more difficult to implement. Nevertheless, NASA seems to grapple with the same organisational and management problems over and over again.

The large size of the market allows the U.S. Government act as a very powerful initial customer; much more powerful than institutional customers in Europe. This offers advantages to U.S. companies in the innovative fields, where the market structure is not yet established.

Services that are considered public goods, like the free GSP signal or free earth observation raw data, offer opportunities for U.S. downstream industries. ESA provides a very limited volume of public services, with an uncertainty in the characterization of the space applications as private or public goods.

Probably the most important difference between NASA and ESA is not the size of the budget but the motives and therefore the effects on the national space industries. ESA has to seek support from member states and uses the fair industrial return policy as an instrument. This is being reinforced by the bottom-up decision making structure with the ESA Council as the highest decision making level. The national space programs have been preserved and their embedding in a European space research framework has ensured both national sovereignty and opportunities for national space industries. Development of business models for international markets is still a difficult undertaking, with legal and regulatory systems in Europe in need of harmonisation. ESA business arrangements lead to higher transaction costs for participation in international space programmes, especially for SMEs which are further tied to their home markets. Therefore, while space market in the U.S. is a single national market (with a usual caveat about lobbying in Washington), space markets in Europe are geographically segmented. The main differences are presented in Table 4.3. A few lessons from NASA experience may be useful for the future ESA and EU space programme:

- ***Operations and management structure:*** The essential difference between NASA and ESA regarding management structure and operational coordination is the US top down versus the European bottom up management principle. ESA had no choice but to adopt its bottom up management structure due to its goal to coordinate national space programmes, redistribute funds and guarantee support for its existence and aims. The top down management structure of NASA simplifies the coordination of large space programmes, like the Apollo or Space Shuttle programmes. However, this structure requires a careful cultivation of internal checks and balances – may it be in the form of governance structure guaranteeing mutual checks or in the form of corporate culture enabling critical feedbacks. Otherwise, as NASA experience shows, this structure is also vulnerable to management lock-ups which may lead to technological and financial failures. Nevertheless, ESP can benefit from a stronger and more centralized space organisation guided by the EU principles.

- ***Funding and programmes:*** While having a much larger budget than ESA's, NASA executes its budget in accordance with a comprehensive long-term strategy based on programmatic goals expressed in Presidential vision. NASA defines programmes and enters into contracts with space industry based upon principles of open competition.

  At the same time, ESA programmes are shaped by its member states, with some exception for the relatively small mandatory programme. The national programmes, in their turn, are shaped through networks and interaction between national industry, national space agencies and research institutes. The principle of fair return reinforces this interrelationship between programmes and budgets.

ESA can benefit from more straightforward and transparent budgetary principles promoting open competition, similar to other EU programmes, as well as a comprehensive formulation of future space programmes.

- ***Markets:*** The United States have the benefit of large-sized private and institutional home markets. On the federal level, the institutional market is unified and can serve as a launching customer when needed, providing important economies of scale. In Europe, the individual member states lack this market power. National markets are predominantly the home markets of national space industries, which have limited possibilities to extend their markets to other countries due to regulatory issues, financing, and even export controls on dual use technologies. Thus a single European space is yet to be developed which can be an overarching long-term goal. This market should feature regulatory harmonization and common oversight agencies. In addition, the role of the EU as the launching customer can be strengthened.

Table 4.3: Comparison between NASA and ESA

	NASA	**ESA**
Year of establishment	1958 (National Aeronautics and Space Act)	1975 (ESA Convention)
Budget	US$ 17.6 billion	€ 2.9 billion
Focus	– civilian scientific research – -encourage commercial use of space, economic vitality – -technological leadership – -national security	– -provide for and promote cooperation between European states in space research and technology for peaceful purposes – -implement European space policy
Organization	Operates under supervision and direction of the President of the U.S. (top-down structure)	17 full member states, 5 cooperating states. Decision making unit: ESA Council (bottom-up structure)
Strategy	insource technologies into NASA systems, outsource operations to private sector	implementing long-term European space policy, coordinating European and national space programs
Network	tight, established and formal network with other governmental agencies, private sector enterprises and research institutes	network on national and international political level. Networks with private enterprises and research institutes are expected on national (operating) level
Industry relations	privatization → promotion of industry and nation-wide competition	principle of fair industrial return → promotion of contribution from member states → segmentation of space markets
Legal framework	– outsourcing legally supported by contracts and IPRs – freedom of government information guarantees low cost access to basic information products of space activities – export controls affect US industry	– ESA Convention 1975 is framework for ESA-cooperation. Harmonization of ESA and EU institutions is one goal of the Framework Agreement 2003. Agenda 2011 envisions ESA becoming an EU agency in 2014. – Complex and non-unified legal and regulatory frameworks for industry within EU (contracts, IPRs, etc.)

- ***Relations with private sector and public functions:*** In its founding act, NASA is commissioned to encourage the fullest commercial use of space. NASA makes contracts with space industry under the conditions of a nation-wide legal framework regarding private law and IPR. NASA's policy to claim IPR for every technological innovation developed under its programmes, however, causes some frustration in the private sector and may also hamper co-innovation processes. This may be not the example to follow.

  NASA still has to reinforce its policy to insource technology, in addition to its long-standing practice of outsourcing operations. The strategy of outsourcing operations is very relevant for ESA.

  With its own body of knowledge and research centres, NASA acts as a national authority on space technology, testing technologies and approving them for commercial application. The future ESA might take up this public function of technology and testing and standardization on a European level.

- ***Public vs. private good:*** The U.S. Government clearly defines space-related public goods, such as raw data and information of the EO or the GPS signal, which gives considerable advantages to private market development. The EU should overcome any ambiguities in the classification of the future space-related services.

4.4 Institutional relationship between the EU and ESA

The European Space Policy and Programme stands out from other nation's space policies in its international character. The Program is carried out by a number of independent actors with different regulatory frameworks and *modi operandi*. That makes the execution of the program rather complicated compared with a single-nation space programs. An important prerequisite of the success of the program implementation is the realignment of relations between the EU and ESA. An *ad hoc* approach would not be effective, as the early experience with the early delays in the Galileo project have demonstrated.

After earlier attempts towards formalizing EU-ESA relationship (including the 1998 Resolutions on reinforcing mutual strategy), the Framework Agreement was signed in November 2003 and entered into force in May 2004. That was a landmark event in the EU-ESA relations. The development of an overall European Space Policy is the main stated goal of the agreement. The other goals include establishing operational arrangements for cooperation targeting five main aims: access to space, taking into account EU policies, support of sustainable development, economic growth and employment, optimizing the use of expertise and resources, achieving greater coherence of research and development including the network of technical centres. The Agreement covers a broad range of cooperation issues and establishes the Space Council.

The Agreement establishes that the cooperation will be based on full respect for the institutional settings and operational frameworks of the two organisations. Financial contributions shall be governed by financial provisions of each party. The European Community reserves the right not to apply the fair industrial return principle. In fact, this principle contradicts EU competition law and procurement policy (which stipulate open EU-wide biding process) and state aids limitations envisioned by EC Treaty. (It is also in conflict with WTO Agreement on Government Procurement.)

The Agreement does not dispense with the need to conclude specific agreements for particular projects. In Article 5, it provides different cooperation models to be specified by negotiations. These models include:

1. Management by ESA of the EC's space-related activities, in accordance with latter's rules;
2. Participation by the EC in an optional program of ESA;
3. Carrying out of activities which are coordinated, implemented and funded by both parties;
4. Creation of bodies charged with pursuing initiatives complementary to research and development activities, e.g. management and infrastructures; and
5. Carrying out of studies, organisation of specific seminars, conferences, and workshops, training of scientists and technical experts, sharing of equipment and access to facilities.

Analysis of these models demonstrates that the Framework Agreement does not put forward ready-made practical solutions against institutional divergence of the two parties (Smith and Hörl, 2007; Olla, 2008). Rules for specific implementation of these models are not provided in the Agreement and are left for subsequent negotiations. For instance, in the first model (ESA's management of EC's activities), the specific arrangements for the implementation of joint projects have to be negotiated separately. In the second model (participation of the EC in ESA's optional program), procurement could not be based on the fair return, since it is not compatible with EU regulations. In addition, arrangement for EC's voting rights has to be negotiated. The third model (coordinated activities) does not provide guiding principles for such activities. The fourth model (creation of bodies) leaves to further negotiations to determine institutional and organizational structures of such bodies.

A successful implementation of the European Space Policy and Program underscores the need for a closer institutional relationship between the EU and ESA. The Wise Men Report to the ESA Director-General (Bild et al., 2000) suggested that ESA should become the EU space agency. This is one of possible institutional realignment models and certainly the most far-reaching. Other models include (Hobe, 2004; Smith and Hörl, 2007):

- A partnership between two independent organisations when the partners define their distinct policy areas by a treaty;
- An arrangement under which the EU is responsible for making political decisions which ESA will be implementing; and
- A membership of the EU in ESA.

The Galileo program discussed in Chapter 1 is an example of the EU-ESA cooperation programmes in which ESA is the executive organisation.

Agenda 2011 envisions ESA becoming an Agency of the EU by 2014, which leads to changes in ESA's industrial policy rules and procedures, decision-making process, and funding mechanisms. Since the EU and ESA operate on different principles, the incorporation of ESA into the EU system is likely to be a lengthy and complex process. *An active EU participation in this process is essential for guaranteeing the desired outcome.* ESA's Agenda 2011 sets out steps of ESA's evolution towards institutional harmonisation with the EU:

- In the short term, ESA Convention amendment at the next Council of Ministers in 2008;
- In the medium term, the increase of membership to 22 countries or more by 2011;
- In the long term, becoming an EU Agency by 2014.

On the concrete level, ESA is working on the modification of its industrial policy rules and procedures, decision-making process, funding mechanism and coordination between ESA and national programs, and resources and industrial policy. The following main principles of industrial policy evolution are envisioned:

- the maintenance and utilization of competencies;
- respect for national priorities as reflected by the contribution scales;
- and an adequate return for Members' investments.

Technology strategy and plan aim at supporting competitiveness and innovations (Worms and Walter, 2006). ESA is gradually modifying its procurement policies using the concept of hierarchy of industrial return. Return is defined at different levels:

- the overall level that includes all programmes;
- individual programmes;
- and the programme elements.

A greater flexibility of return is now allowed at the lower levels. Nevertheless, a balanced overall return is the first priority of the hierarchy of return rules. Hence the overall level of return close to one continues to be the ideal outcome (with the minimal level of return set at 0.8) (von der Dunk, 2007). In addition, more weighting factors have been introduced to weigh technological value with the purpose to increase the importance of technological considerations in industrial restructuring. The new procurement plan will include procurement per Member State targeting specialisation of centres of competencies. However, this policy fails to bridge the gap with EU laws and regulations. This issue has to be resolved if ESA is to become an EU Agency.

For some years now, ESA is carrying out a reform of financial management in the direction of improved planning in a multi-year framework, increased transparency and better internal cost management, compliance to external financial reporting standards (Pittarelli, 2004). The new financial policy system, in use since 1 January 2006, helps ESA to adapt to the environment when most countries face restrictions in their national budgets and their contributions need to be justified and used as efficiently as possible. ESA is also concerned with developing new funding mechanisms involving the EU and other parties. This is an important area where dialogue with the EU is very important. The reform of the decision-making process aims at fair representation of interests for different types of programmes, namely, solidarity type programmes, leadership type programmes, national programs, and joint programs with the EU.

Overall, given the goal of ESA of becoming an EU Agency, the EU should consider formulating and carrying out a program of the institutional harmonisation with ESA. The EU should actively cooperate with ESA on the intended amendment of ESA Convention, both in the long-term perspective and in the short run, when this issue will be discussed by the ESA Council of Ministers. Shaping a legal and regulatory framework for a coherent space policy in Europe is a monumental important task involving many aspects, including, *inter alia*, exports controls and scientific policy coordination (Kuzmann and Reuter 2004; Pisano, 2006; Bini, 2007) It entails harmonisation of international and national regulatory frameworks[25]. *The EU need to establish a leadership in this area, at least in regard the most important regulatory aspects.*

[25] Treaty of Lisbon, however, does not include the harmonisation of the laws and regulations of the Member States into EU competency.

5. CONCLUSION

In this chapter, we summarise the main findings of the study, with an emphasis on policy and regulatory issues. The chapter is organized in the same fashion as the report, with GNSS and Earth Observation as the main themes, followed by access to space and the European Space Program in general.

5.1 GNSS

Applications and markets

GNSS offers a wide range of applications, including road traffic and transport domain, location based services (including personal location based services), civil aviation, maritime, agriculture, electricity networks etc.

Total worldwide revenues in 2005 were € 17.3 billion, of which road transport had the largest portion: € 8 billion. The key driving applications for satellite navigation are fleet management, telematics and advanced driver assistance systems, and personal location based services. The position of Europe in these sectors is only satisfactory in fleet management. Challenging is the absence of Europe in the sector of personal location based services.

Europe is overall well-positioned to develop new GNSS based applications in several segments, especially in road telematics, fleet management, and the (personal) location based services, while R&D for Galileo gets increasingly more attention. A major weakness is the high specialisation in the applications market, the lack of major players and a weak position for military suppliers. The study considers the newly accessed European countries to be important drivers of new 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, and the threats posed by social concerns such as privacy.

GNSS downstream markets lack major players covering the entire value chain; firms are smaller and have narrow specialization. There is, however, a tendency towards market consolidation as manifested by the recent wave of mergers. The market for PNT devices is in full flux, with difficult to control developments disrupting existing market structures (such as GPS-chipsets in mobile phones). Road applications are perceived to be the major inroad to expanding the market.

One may expect the continuation of the merger trend which will allow the firms to capture the entire value chain and offer additional value by a combination of services to individual consumers. Both road applications and personal LBS are competition-driven markets without much government involvement. Thus it is the sector where market forces seem to work quite well. Notwithstanding the fact that stakeholders in the automotive industry are cooperating in many different ways (for instance, consortiums for research projects combining forces within Europe), a still unfulfilled role for public agencies remains in the area of policy issues related to GNSS and road applications, such as standardisation and interoperability.

Innovation

European Framework Programme is an important contributor to promoting innovation in Galileo/EGNOS and the accompanying services. Within FP7, attention for applications is at a very low level, within the Cooperation theme on Transport and the Cooperation theme on Space. The work programme 2008 on Transport does not contain topics related to space applications.

The work programme 2008 on Space is directed towards satellites, equipment (clocks), signals etc. There is a need to redirect the budget in the direction of the development of satellite navigation applications.

With the new budget rules for Galileo one needs to secure that the €400 million that are added to the overall Galileo budget will strictly remain reserved for Galileo/EGNOS innovations. On-going coordination with ESA to attune research activities is necessary as well.

Galileo

The Galileo/EGNOS program will enhance the range of possible applications with satellite navigations. It will offer a broader range of services than existing GNSS – GPS and GLONASS: Open Services (same as in the other GNSS), Commercial services, Safety of Life Services, Public Regulated Services, and Search and Rescue Services. The added value of Galileo will clearly demonstrate in improved accuracy, service continuity and systems integrity, alone and in combination with GPS and/or GLONASS. The direct revenues of Galileo and EGNOS during 20 years of exploitation are expected to be between €4.6 billion and €11.7 billion, plus €50-60 billion of indirect revenues.

Bringing Galileo to full operational capability runs along four phases: a definition phase, a development phase, a deployment phase and ultimately an exploitation phase. The first two phases have been financed fully by the European Commission. The deployment and exploitation phase was intended to become a shared exercise between the European Commission and a concessionaire but this approach failed to materialise. In addition, the programme was suffering from chronic and prolonged delays due to disagreements among partners. The Galileo experience offers a number of lessons:

1. Public Private Partnerships (PPP) can lead to a monopolistic situation.
2. Common will within the European Community is indispensable for successful negotiations.
3. In the space sector, delays can lead to high costs and a loss of the comparative advantage.
4. For PPP in high-tech, high-risk environment to work, a step-by-step, adaptive approach to project development could be used, with the Government reducing inherent uncertainties thorough a clear definition of public vs. private good and the role of initial public customer; shaping the markets by means of advanced elaboration of market arrangements, financing and revenue sharing mechanisms and risk-sharing measures; interactive strategy; and smart cost-benefit analysis even if only partial in scope.
5. Institutional and procedural harmonization is crucial for projects in multi-institutional setting.

The management structure of the Galileo/EGNOS programme is well-organised and exhibits the inclusion of the ‘lessons learned’ of the previous phases. A number of issues remain however problematic, although, and may have adverse impact on the continuation of the programme. They include the necessary build-up of expertise within the Commission, ESA, and GSA to manage the programme activities and establishing the procedures for involvement of Member States, third countries and ESA. In addition, since up till now cost overruns have been part and parcel of the Galileo/EGNOS programmes, it remains to be seen if the amended budget proposal is realistic, given the low contingency budget.

Involvement of market participants

The market characterisation of GNSS applications in Europe shows a diversified and less specialised playing field than in the USA. Application providers are mostly dealing with day-to-day business without forward-looking. Uncertainty in Galileo business plans is an important barrier for developing new services. Uncertainty is high with respect to the timing of Galileo/EGNOS events.

A number of services, such as PRS, are still in its very infancy, and do not offer solid business cases for application providers to step in. Though EGNOS should be fully operational early 2009, uncertainty about the precise configuration of the certification and standardisation procedures of EGNOS prevents application service providers to start developing new services. Specialised services based on Search and Rescue and Safety of Life require clear and unambiguous directives, which should be phrased in a technology neutral manner. An example is the apparent problem about the integrity signal that is differently organised for WAAS/EGNOS/MSAS and Galileo and that is contradicting the USA-EU agreement on compatibility and interoperability of Galileo/GPS. These ambiguities need to be resolved in order to convince application service providers to step into a high risk market. The International Committee on GNSS should take a position on this issue. In order to prevent market failure, actions reducing uncertainty about technological and operational dimensions of the Galileo/EGNOS configuration should start as soon as possible.

It remains to be seen whether the strategy Galileo will pursue is an economically profitable one. Concerns are raised regarding the intended taxation of Galileo chipsets (which would increase the price of Galileo receivers) and to the business models behind the commercial and the public regulated services. However, uncertainties remain high on the modes of revenue sharing and potentially profitable business models that will facilitate the development of Galileo Commercial services. The development of revenue sharing mechanism and public regulated services framework should be sped up. The emphasis should be placed on developing sound business models for the various service categories. The initial business models that have been drafted a few years ago need to be updated in order to get improved insight in the cost-benefits of the possible strategies. Reducing these uncertainties in a fast and timely manner is essential to secure the participation of the private sector.

The evolved procurement strategy looks well thought through and appropriate. It aims at preventing monopolies and involving SMEs in all phases of the programme. It needs however to be seen whether the strategy is sufficient to realise the policy ambitions.

Involvement of SMEs in European R&D projects is of particular concern. Administrative overload prohibits engagement of SMEs in major projects. Application providers are reserved in participating in long term research endeavours. Galileo Services offers an interesting inroad to interested industries but does not cover many SMEs in application domains. The role of Galileo Services could be strengthened and formalised. In order to attract SMEs different strategies have to be pursued. Awareness raising through awards and prizes, such as the annual Galileo Masters Competition or establishing Galileo Competence Centres is another approach to attune SMEs and to lower barriers for entry. With respect to involvement in FP7 projects, open tenders should be used in order to reduce the administrative burden for SMEs. The use of incubators to guide SMEs in acting successfully for European tenders and projects should be considered.

Standardisation/certification

The annual conference on certification and qualification issues CERGAL offers a platform to show progress on certification and standardisation issues. Due to the different application domains, certification procedures have to be attuned to each of the domains separately. This implies complex and sometimes lengthy procedures. There is a need to ease the certification and quality assurance procedures. Most of the application domains have their own standardisation and certification bodies (water, air, rail). The road sector and personal Location Based Services – which are two of the most important application domains – lack an international governmental forum to address these issues. For the road sector this could be detrimental, for instance for the introduction of a European wide system of road pricing.

The overall approach towards certification should be to opt for a reserved attitude: restrict certification to critical processes and equipment. Try to develop lean and mean procedures that can be implemented quickly.

Regarding standardisation processes, there is a general feeling that the process of standardisation could be more professionalised involving more professional experts and reducing the number of governmental officials. This could speed up standardisation processes and lead to more tight processes. The standardisation processes itself should refrain from adopting specific technological perspectives and should be formulated in a technology neutral manner. Open standards are a point in respect since these might promote innovative development in a wider community to the benefit of all.

IPR issues

Uncertainty about how the European Union will deal with IPR issues might prevent application and service providers and equipment manufacturers to invest in development of Galileo/EGNOS- products and services. The European Union claims to be the owner of all assets related to Galileo. This implies that the European Union might charge the use of the Galileo coding signals in Galileo receivers by means of taxation. This approach could hamper the development of Galileo-receivers, and make them more costly and less competitive towards single GPS receivers. Also the potential risk of the transfer of EU suppliers IPR to third countries is not solved. Again, uncertainty about the European approach should be lifted in order to stimulate a European market. Another issue is the IPR protection for SMEs: high monetary and labour costs of obtaining patents and non-harmonised patent regime in the EU prevent many SME from ensuring the adequate protection of their IPR.

Privacy

Although generally acknowledged as not being a prime concern, privacy concerns need to be well addressed since it may adversely impact on the adoption of satellite navigation applications.

GNSS and e-Loran as a European critical infrastructure

The European Radio Navigation Plan, for which initial studies have been performed, still needs to be completed. In developing the plan, attention is asked for the role of the GNSS infrastructure as a critical infrastructure. The European Commission has identified the PNT-infrastructure (Positioning, Navigation, Timing) as a critical infrastructure in 2005. Several regions (USA, Russia, China) have indicated their inclination towards using Loran-C and eLoran as 'back up' systems in case of failure of GNSS. Europe still falls short in this respect. eLoran seems to be the appropriate candidate for European-wide back-up system in case of failure of GPS/Galileo.

Institutional developments

Due to the failure of the concessionaire approach, a new situation has arisen. The European Space Agency will act as the procurement agency for the Galileo programme. To this end, ESA has to build up expertises in the field of risk management, and financial management. It will do so in close cooperation with EU DG TREN who bears responsibility for the overall Galileo programme. To reduce complexity in the process, the position of ESA within the EU will be reviewed. One issue to be solved is the fact that normal ESA procedures of fair geographic returns may not be used.

GSA will become an agency within the European Commission with a set of tasks and responsibilities. In the near future GSA will have to focus on the build up of the required expertises and competences to organise the certification process, to tackle security issues and to develop market perspectives. In the coming years, the option of a public private partnership for the exploitation phase will be back on the agenda, with consequences for the tasks and responsibilities of GSA. This should be timely prepared.

There are still some difficult to tackle financial issues. Uncertainty remains regarding the number of spare satellites needed and the need to upgrade ground stations (especially the third Search and Rescue ground station situated in Spain). These financial uncertainties will have to be clarified to enable a proper judgement of the budgetary constraints of the programme.

It is planned that the EGNOS system will be fully operational and certified by early 2009. Though activities have started to find a concessionaire, the assignment of the concessionaire and the certification process should be tightly kept on schedule. This should have high priority.

The technical development path of the integration of Galileo, GPS and other GNSS moves into the direction of a 'system of systems', with common accuracies up to a few centimetres using global Real Time Kinematic networks. To be prepared on the promises of these enhanced accuracies, the European Union should start to discuss the modifications needed to realise this ambition.

Education

There is a shortage of curricula dealing with space issues in Europe, with only a limited number of courses. Networks of academia and industry need to be expanded. Europe should play a role in creating European-wide courses on space issues (including satellite navigation services) and in fostering networks between academia and industry.

5.2 Earth Observation

Earth Observation applications serve a variety of purposes in such fields as: natural resource management, energy, land monitoring, environment, cartography, natural hazard prevention and mitigation, agriculture and food security, meteorology, and homeland security. Innovations and R&D needs related to EO services are largely determined by two major trends:

- Increasing consumer-pull using virtual globe platforms (e.g. Google Earth, Virtual Earth) for various geo-information services
- Encapsulation of EO-services in Integrated Applications, such as control rooms.

Earth Observation remains a relatively small market with the global revenues of € 1.3 billion, including € 0.4 billion in Europe in 2005, with almost 50% of total revenues stemming from meteorological applications. Revenues per product are relatively low, with the great majority of the products generating less than € 0.5 million per year.

The upstream sector for Earth Observation is predominantly institutional, dependent on public (multilateral, national, and, to some extent, regional) funding. Emerging commercial observation satellites are developed in the framework of PPP and are still dependent on public funding, e.g., Spot Image supported by French Space Agency and RapidEye supported by the German Space Agency. Commercial earth observation programs in the U.S. draw on U.S. Government guarantees for the minimum revenue subject to delivery of useful data (images) and ensuring priority of data access. The supplier bears all technical risks, including launch failure and in orbit failure of the satellite. The supplier gets all additional income from other customers. The recent success of Google Earth and Microsofts's Virtual Earth has strongly influenced business-models and client base for these entrepreneurial earth observation initiatives.

The downstream EO industry in Europe is rather fragmented. This may cause upward pressures on costs for downstream companies due to the dominant market position of the upstream enterprises. In addition, small company size makes it difficult to offer standardized and integrated solutions for customers and hamper industrial collective actions. However, in recent years, some consolidation in European EO industry with forward chain integration and cross-sectoral acquisitions has been progressing.

GMES

The start of the GMES Programme in 2001 has given a strong impetus to the integration of Earth Observation value adding. The 2007 Munich Roadmap further defined the structure and components of GMES as it relates to the service portfolio and to the data infrastructure (space and in-situ). GMES distinguishes between Core and Downstream Services. Core Services provide standardized multi-purpose information common to a broad range of EU policy-relevant application areas and through which important economies of scale could be derived. The also support European institutional actors. Downstream Services serve specific (trans-) national, regional or local information needs. Their information products may be derived from products of the Core Service or be based on data directly provided through the observation infrastructure. Organizational structure is in place with GMES Bureau developing a federated and structured demand for EO data and information and ensuring the delivery of fast track EO services by 2008. The governance scheme is still under discussion and a final proposal is expected the end of 2008. In any one scenario, two important issues will have to be addressed:

Access to data

The commercial success of Earth Observation applications is determined by data availability, data continuity, and data procurement The Sentinel programme is supposed to ensure data continuity but the cost of access in not yet determined. The European Commission will procure the necessary data for the Core Services. However, no such formal decision has been taken regarding the Downstream Services.

A level playing field for the EO Service Industry

Only a small number of European companies and institutes will be involved in the Core Services, which might have a negative impact on companies willing to enter the scene for Downstream Services.

Estimated socio-economic benefits from the programme are quite high. Benefits relating to improved cost effectiveness of implementing, enforcing or assessing policies that are currently in place are estimated at € 312 million per year till 2030.

Benefits from improved definition and implementation of new European policies are assessed at € 2.9 billion per year till 2030. Global Action Benefits arising from formulating, improving and implementing global policy agreements are projected at € 7 billion per annum by the year 2030. These estimates, however, may be rather exaggerated, since the assessment methodology applied did not allow singling out the contribution of GMES to the total programme effect.

Speeding up the maturation process of European EO industry should be two-sided -- from the industry and from customer groups at the same time. The recent consolidation wave is a signal that the industry itself is preparing for the next step. Crucial customer groups like governments have to embrace large-scale EO applications. Regulatory frameworks for the optimization of markets need to be reshaped:

- Create a level playing field for both integrated companies and SMEs by revising procurement processes with the clear terms of reference;
- Decide in advance on the cost of raw data stemming from satellites belonging to government agencies;
- Be clear about the role of the public bodies (international, national, and regional) as the initial customer;
- Speed up the unification of the European IPR regime; and
- Support the industry in formulating and implementing technological standards and interoperability of systems.

Like in GNSS sector, measures to lower barriers for entry for SMEs should be employed, including awareness raising, incubators, open tenders, and administrative burden reduction.

Intellectual property rights

The EO industry suffers from the insufficient protection of IPRs with serious consequences. First, it hampers exploitation of EO products and therefore makes EO industry unattractive for private investors. Second, since firms are reluctant to disclose detailed product specifications for the fear of IPR infringement, there is a dearth of explicit information needed for standardization, certification, interoperability of systems and providers, and collective learning processes within the industry.

Standardization and interoperability

Barriers are believed to result from the lack of interoperability of space-based systems. Interoperability would allow cost-effective integration of diverse types of information. However, developing and implementing standards requires centralized coordination.

Export controls

Export control regime confines local EO industries to local markets, as the European Security and Defence Policy (ESDP) and especially the relationship between ESDP and space policy are not quite developed.

Business models and business skills

Firms' strategies should carefully balance technological advancement with solid business and marketing models. However, it appears that this balance in tilted towards the former in most European EO firms.

The European Association of Remote Sensing Companies established in 1989 focuses on an adequate coupling between GMES and the industry. The EU can help with targeting EO companies in SME business development programs.

5.3 Access to space

The core activities in the European launcher programme consist of the continuing exploitation of the heavy launcher Ariane 5 and the initiation of the exploitation of the medium launcher Soyuz (in partnership with Russia) and the small launcher Vega. Europe will be able to cover the whole launch market with these three launchers -- heavy, medium and light.

Currently the EU occupies a dominant position launching more than half of communication satellites, which represent the bulk of the commercial launch market. Nevertheless, it faces serious international competition, mostly from the U.S. and U.S.-Russia partnerships. A numbers of new players are to emerge soon including China and India, and a number of private U.S. companies developing low-cost launchers.

Independent access to space has long been the core objective of ESA, with two main goals – independence and cost effectiveness. While independence was achieved, the cost of access to space did not go down in the last 40 years (in neither Europe nor the U.S.), in sharp contrast to steeply declining costs in other high tech industries. The reduction of cost of access to space should have a high a high priority. It can be achieved through innovation and a smart use of existing technology coupled with international partnerships within and outside the EU.

On the regulatory front, the regulations have to account for potential hazards of launch activity; thus the importance of environmental, safety, security regulations and legal accountability mechanisms. A very important issue is export control regime, since launcher technology is a prime example of dual-purpose technology.

The industrial organization of the European launch sector is characterized by a dominant position of just four companies which use the services of hundreds other companies as contractors. This configuration of the industry is not uncommon in aerospace and defence industries everywhere in the world. The very nature of the sector operating under high fixed costs of production (most importantly, R&D), small series, and increasing returns to scale creates a tendency towards restricting competition and poses serious difficulties in achieving ESP goal of avoiding both the creation of monopolistic structures and overcapacity. This requires the attention of the European regulatory authorities in the four main policy areas, such as the regulation of cartels involving the control of collusion and other anti-competitive practices; regulation of monopolies or preventing the abuse of the dominant market position; the control of proposed mergers, acquisitions and joint ventures involving large companies with a scrutiny of potential harm from vertical integration; and control over direct and indirect state aid given to companies.

Achieving these objectives may call for some specific actions, for instance,

- require major contractors to use open-system architectures (i.e. setting standards of system interfaces that a number of contractors can meet) in designing space systems;
- make subtier competition a specific source-selection criterion; and
- explore opportunities for greater cooperation with international partners.

In addition, ESA/EC acquisition program managers should scrutiny prime contractor teaming and supplier choices, devise acquisition strategies to promote alternative concepts and new supplier entry, and monitor some technological areas for the impact of vertical integration.

5.4 European Space Programme – overall perspective

Elaboration and implementation of a European space policy has since 1975 been a purpose of the European Space Agency. Now, the EU considers a space policy as its area of responsibility as well. Today ESA remains the main executor of the joint European Space Policy, along with the EU and national space agencies. ESA possesses an important infrastructure of centres and other assets and boasts important achievements in its history.

ESA's budget has been stable over a few years and includes the mandatory (28%) and optional (69%) parts. The distribution of contracts among countries is carried out according to the principle of fair (industrial or geographical) return, which states that, ideally, the amount of contracts awarded to a country equals its financial contribution. The principle of fair return was maintained from the time of European Launcher Development Organisation. From the first very start, even since ESA Working Group that preceded ESA formation, this principle was viewed by many within and outside ESA as stifling competition, impeding specialization, and international competitiveness of European industry. At the same time, this policy encourages contributions and guarantees the smaller contributors their share of contracts. With ESA being as an international organisation lacking a strong authority over its members, geographical return provides an important stimulus that facilitates ESA programme financing. However, the fair return principle is inconsistent with EU competition law and procurement policy and state aids limitations envisioned by EC Treaty.

NASA-ESA comparison

The fundamental difference between NASA and ESA is that the former is a national space agency while the latter an international association of national space agencies. Their management structure and principles differ fundamentally: NASA operates with a strong top-down management structure while ESA operates with a bottom-up structure where consensus is vital for decision making. Turn-arounds in European space policy are therefore more difficult to implement.

Much smaller budget of ESA forces the Agency to concentrate on innovative and highly effective missions, which is in line with once famous NASA policy 'faster, better, cheaper'. At the same time, NASA is subject to criticisms about high-budget low-efficiency projects.

The U.S. Government acts as a very powerful initial customer -- much more powerful than institutional customers in Europe -- thus offering competitive advantages to U.S. companies. Services that are considered public goods, like the free GSP signal or free earth observation raw data, offer opportunities for U.S. downstream industries. ESA provides a limited volume of public services.

Probably the most important difference between NASA and ESA is not the size of the budget but the industrial policies and therefore the effects on the national space industries. ESA has to seek support from member states and uses the fair industrial return policy as an instrument. Development of business models for international markets is still a difficult undertaking, with legal and regulatory systems in Europe in need of harmonisation. ESA's business arrangements lead to higher transaction costs for participation in international space programmes, especially for SMEs which are further tied to their home markets. Therefore, while space market in the U.S. is a single national market, space markets in Europe are geographically segmented. A few lessons from NASA experience may be useful for the future ESA and EU space programme:

Operations and management structure

The top-down management structure of NASA offers a number of advantages and efficiency gains, requiring, however, careful cultivation of internal checks and balances – may it be in the form of governance structure guaranteeing mutual checks or in the form of corporate culture enabling critical feedbacks – which was not fully achieved by NASA. Nevertheless, ESP can benefit from a stronger and more centralized space organisation guided by the EU principles.

Funding and development programmes

While having a much larger budget than ESA's, NASA executes its budget in accordance with a comprehensive long-term strategy based on programmatic goals expressed in Presidential vision and enters into contracts with space industry based upon principles of open competition. At the same time, ESA programmes are shaped by its member states through complex interactions among national industrial interests, national space agencies and research institutes; the principle of fair return underpins interrelationship between programmes and budgets.. ESA can benefit from more straightforward and transparent budgetary principles promoting open competition, similar to other EU programmes, as well as a comprehensive formulation of future space programmes.

Markets

The United States have the benefit of large-sized private and institutional home markets. In Europe, national markets are predominantly the home markets of national space industries, which have limited possibilities to extend their markets to other countries due to regulatory issues, financing, and even export controls on dual use technologies. Thus a single European space is yet to be developed which can be an overarching long-term goal, with regulatory harmonization and common oversight agencies. In addition, the role of the EU as the launching customer can be strengthened.

Relations with private sector and public functions

In its founding act, NASA is commissioned to encourage the fullest commercial use of space. NASA makes contracts with space industry under the conditions of a nation-wide legal framework regarding private law and IPR. NASA's policy to claim IPR for every technological innovation developed under its programmes, however, causes some frustration in the private sector and may also hamper co-innovation processes. This may be not the example to follow.

NASA still has to reinforce its policy to insource technology, in addition to its long-standing practice of outsourcing operations. The strategy of outsourcing operations is very relevant for ESA.

With its own body of knowledge and research centres, NASA acts as a national authority on space technology, testing technologies and approving them for commercial application. The future ESA might take up this public function of technology and testing and standardization on a European level.

Public vs. private good

The U.S. Government clearly defines space-related public goods, such as raw data and information of the EO or the GPS signal, which gives considerable advantages to private market development. The EU should overcome any ambiguities in the classification of the future space-related services.

EU-ESA institutional harmonisation

A successful implementation of the European Space Policy and Program underscores the need for a closer institutional relationship between the EU and ESA. As the flagships of the European Space Programme, Galileo and GMES highlight the need for institutional and procedural harmonisation between the EU and ESA.

The Framework Agreement which entered into force in May 2004 was a landmark event in the EU-ESA relations. The Agreement covers a broad range of cooperation issues and establishes the Space Council. The Agreement establishes that the cooperation will be based on full respect for the institutional settings and operational frameworks of the two organisations. However, the Agreement does not dispense with the need to conclude specific agreements for particular projects and envisions five different cooperation models to be specified by negotiations. Analysis of these models demonstrates that the Framework Agreement does not put forward ready-made practical solutions against institutional divergence of the two parties.

The current ESA program document *Agenda 2011* envisions ESA becoming an Agency of the EU by 2014, which leads to changes in ESA's industrial policy rules and procedures, decision-making process, and funding mechanisms. Since the EU and ESA operate on different principles, the incorporation of ESA into the EU system is likely to be a lengthy and complex process. It is necessary to ensure a smooth transition process of ESA and avoid disruptions that may be caused by changing rules and policy principles. An active EU participation in this process is essential for guaranteeing the desired outcome.

With the goal of ESA of becoming an EU Agency, the EU should consider formulating and carrying out a program of institutional harmonisation with ESA. The EU should actively cooperate with ESA on the intended amendment of ESA Convention, both in the long-term perspective and in the short run, when this issue will be discussed by the ESA Council of Ministers. The EU need to establish a leadership in shaping a legal and regulatory framework for a coherent space policy in Europe, at least in regard the most important regulatory aspects, entailing both international and national regulatory frameworks.

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Glossary

ADAS	Advance Driver Assistance Systems
ALOS	Advanced Land Observing Satellite
ARMAS	Active Road Management Assisted by Satellite
ASI	Agenzia Spaziale Italiana -- Italian Space Agency
BNCS	British National Space Centre
CDMA	Code Division Multiple Access
CERGAL	Certification of GNSS Systems and Services
CGMS	Coordination Group for Meteorological Satellites
CNES	Centre National d'Etudes Spatiales – the French Space Agency
CNSA	China National Space Administration
CONAE	Comision Nacional de Actividades Espaciales (Argentina)
COSMO-SkyMED	Constellation of small Satellites for the Mediterranean basin Observation
COSPAS-SARSAT	Space System for the Search of Vessels in Distress
CS	Commercial Services
DG-ENV	Directorate-General for Environment
DLR	Deutsches Zentrum für Luft- und Raumfahrt – German Space Agency
DoD	U.S. Department of Defense
EEA	European Environment Agency
Envisat	Environmental Satellite (ESA)
EGNOS	European Global Navigation Overlay System
EO	Earth Observation
ERTICO	European Road Transport Telematics Implementation Coordination Organisation
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
ESA	European Space Agency
EUMETNET	European Meteorological Network
EUSC	European Union Satellite Centre
FLPP	Future Launchers Preparatory Programme (ESA)
FDMA	Frequency Division Multiple Access
FP	Framework Programme
GHG	greenhouse gas
GIOVE	Galileo In Orbit Validation Element
GIS	Geographical Information System
GJU	Galileo Joint Undertaking
GLONASS	Global Navigation Satellite System
GMES	Global Monitoring for Environment and Security
GNSS	Global Navigation Satellite System
GOCE	Gravity Field and steady state Ocean Circulation Explorer
GPS	Global Positioning System
GSA	GNSS Supervisory Authority/Galileo Supervisory Authority

IALA	International Association of Lighthouse Authorities
IASI	Infrared Atmospheric Sounding Interferometer
ICAO	International Civil Avionic Organisation
IMO	International Maritime Organisation
IPR	intellectual property rights
ISRO	Indian Space Research Organization
ISS	International Space Station
ITAR	U.S. regulation International Traffic in Arms
JAXA	Japan Aerospace Exploration
JPL	Jet Propulsion Laboratory
JRC	Joint Research Centre
Kompsat5	Korean earth observation satellite
LBS	Location Based Services
LIMES	Land and Sea Integrated Monitoring for Environment and Security
LORAN	Long Range Navigation
MarCoast	marine and coastal environment information services
MEMS	Micro-Electro-Mechanical Systems
Meris	Medium Resolution Imaging Spectrometer (on board Envisat)
Mersea	Marine EnviRonment and Security for the European Area
MIC	Mapping and Intelligence Centre
MSAS	Multifunctional Satellite Augmentation System
NASA	U.S. National Aeronautics and Space Administration
NOAA	U.S. National Oceanic and Atmospheric Administration
OS	Open Services
PNT	Positioning, Navigation, Timing
PPP	Public Private Partnership
PREVIEW	PREVention, Information and Early Warning pre-operational services
PROBA	PRoject for On-Board Autonomy
PRS	Public Regulated Services
SAC-C	cooperative mission between NASA and French, Argentine, Brazilian Danish and Italian space agencies
SAR	Search and Rescue; Synthetic Aperture Radar
SAR Lupe	German military radar satellite
SBAS	Satellite Based Augmentation System
SME	Small and Medium Enterprise
SMOS	Soil MOisture and Sea salt concentration
SoL	Safety of Life
SPOT	Satellite Pour l'Observation de la Terre
SSTL	Surrey Satellite Technology Ltd
RFID	Radio Frequency Identification
TerraSAX-X	German earth observation satellite using X-band synthetic aperture radar (SAR)

TOPEX/Poseidon	joint venture between CNES and NASA to map ocean surface topography
UMTS	Universal Mobile Telecommunication System
USGS	U.S. Geological Survey
WAAS	Wide Area Augmentation System
WMO	World Meteorological Organisation