European KNOWLEDGE INTENSIVE Services based on Earth Observation

"Doing business with the help of GMES"

S.Galant, T.Pagano, A.Vaféas

TECHNOFI

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FOREWORD

Does Earth Observation or GMES mean something to you?

Have you ever thought of using satellite observation technologies to start a new service activity?

Please read through this booklet.

This guide is made of modules to help you better understand the intricacies and growth prospects in the area of Earth Observation, leaning on the European GMES infrastructure.

Based on the most recent literature available on the topic, it will provide you with a few golden rules to embrace the fate of tens of European SMES that have now access to world markets, thanks to the superior technology Europe has put in place over the past thirty years in space infrastructures.

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CHAPTER 1

GMES, AN OPPORTUNITY FOR MORE KNOWLEDGE INTENSIVE SERVICES IN EUROPE

This introductory chapter focuses on the main features of Earth Observation markets and the structuring role of the GMES infrastructure for Europe in the coming decade.

I. Background

The advent of a European Space industry in the early 70's was driven by the development of the ARIANE launcher and the needs for both Defence and civilian satellites:

- **Communications links were the prime movers**, since Defence end-users needed to cover the whole earth, whereas communication links must be available on a 24/365 basis, in endangered areas
- **Observation systems came next**, mixing both meteorological applications and observation needs (in the visible, infra-red and radar domain), involving defence, civilian and scientific applications.

Yet, over the past twenty years, the European Space industry, like the European aeronautic industry, has migrated from prominently defense-based investments and applications to an increasingly wider spectrum of commercial activities.

Innovative commercial services have been given birth using large scale space infrastructures: this is the case for **earth observation-based services**, resulting in major advances, for instance, in meteorological forecasts, environmental monitoring or risk mitigation strategies after significant industrial or natural disasters have occurred.

The major challenge for the whole value chain of the resulting downstream service players remains to capture all or part of such application markets, leaning on robust business models that will remain attractive, whatever other competitive solutions may do.

However, both public decision makers involved in space infrastructure investments AND industrial players using such infrastructures are facing a **dilemma**[1]**.**

On the one hand, the European Earth observation industry was born to meet strategic needs "of public interest", including defense, security, environment monitoring, meteorology and even basic science. Investments in the critical space infrastructures are then based on very long decision making processes, requiring lengthy inter-governmental consultations: the life cycle of any new Earth Observation program development is a minimum **of 15 years** between idea inception and the end of the satellite infrastructure. Moreover, decisions are driven by technological excellence to make these infrastructures reliable, with performance requirements very often near the limits of the best available technologies.

On the other hand, the learning curves of the service industry involved in environmental activities, together with the growing demand for more service applications, drive these technologies towards standardized and open applications. These new application segments are

[1] Ghiron F., European Parliament , ITRE Mini-Hearing on Space, 16 JULY 2007

regulated by **much shorter life cycles** (say 5 years) facing competition coming from other technologies, event though satellite infrastructures become affordable enough to capture part of some emerging service markets, often related to regional development. The business landscape may then change very rapidly, narrowing the satellite infrastructure capabilities to a small part of the whole value chain, since exhibiting lower performances than new ground based or air borne systems.

A key issue for Europe will therefore be to link public interest, large scale infrastructure investments with the needs of regional, highly innovative, local services using such infrastructures.

In the USA, linking both markets relies significantly on the Defense application "driving belt", where innovative companies:

- can " spin slow" on the public market side, which is well structured and gets more than five times the money that Europe is investing in R&D for Defense applications
- are able to "spin fast" on private markets since most of the critical R&D has been paid for by the public sector.

Europe must therefore invent another way of linking both wheels, through other support schemes to start-ups and SMEs that take into account specific European features:

- Within the "public interest" segment, the few remaining space players will continue operating with a technology push approach, since technology excellence remains a prerequisite. They will capitalize more and more on their satellite based knowledge to develop downstream applications on their own or with public support: the risk is that they can block the access to data since owning part of the IPR.

- Within the mass market segment, tens of SMEs will continue striving to develop innovative service activities based on a market pull approach. Many of them will not belong to the space community: their offer will target niche markets, with the possibility of missing clear interfaces with the upstream satellite data providers. They may even develop new services for their regional customers using US Earth Observation data, whereas European Earth Observation data do exist for the same application, but are not formatted to be made accessible and affordable.

The GMES environment will need to bring dedicated answers to such SMEs, which will have to prove to be as efficient as the US environment has shown to be. Fortunately, the GMES public support scheme has understood the above dilemma, as depicted below.

II. The GMES environment

Since the late 90's, it is under the impetus of the European Commission that the **GMES (Global Monitoring for Environment and Security)** space infrastructure has been progressively put in place using the European Space Agency expertise and the space industry development capabilities.

The Council Resolution of 16 November 2000 on a European Space Strategy (2000/C 371/02)[2] decided to build a complete information system capable of giving the state of our environment and its short, medium and long term evolution.

GMES (Global Monitoring for Environment and Security) 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. GMES may have some homeland security applications in the coming years.

The first set of **pilot services** (also called **Fast-Tracks**), developed under GMES, funding will be operational by 2008 followed by the development of an extended range of services which will meet more end-users' requirements.

Moreover, since the World Summit on Earth Observation in Washington, held in July 2003, GMES is the European participation in the world-wide monitoring and management of Earth. This decision was completed in Brussels in February 2005 by the adoption of a 10 year implementation plan of an integrated Global Earth Observation System of Systems (GEOSS) at international level.

The upcoming GMES structure will bring the added-value that is expected to amplify EO (Earth Observation) services throughout Europe:

- It **harmonizes space data availability** for further downstream uses;
- This harmonisation favours the **interplay between ground, airborne and satellite data** to allow for a full coverage of earth and ocean.

Therefore, in the next ten years, GMES will offer a stable infrastructure framework from which new services can be given birth, based either on **new knowledge** gathered through the environment observation and monitoring, and/or **on new ways** of using existing knowledge to answer questions in a more affordable way.

KEY FINDINGS AND PROSPECTS
• Europe has gained autonomy since the late 70's at delivering observation infrastructures linking air and space borne technologies • The GMES programme is from now on the European participation in the world-wide monitoring and management of Earth • The upcoming GMES structure will bring the added-value that is expected to amplify EO (Earth Observation) services throughout Europe

[2] This was followed by the Communication from the Commission to the Council and the European Parliament, "***Global Monitoring for Environment and Security (GMES), Outline GMES EC Action Plan***", (Initial Period: 2001 – 2003), and the Communication from the Commission to the European Parliament and the Council "***Global Monitoring for Environment and Security (GMES): Establishing a GMES capacity by 2008 - (Action Plan (2004-2008)***) »

CHAPTER 2

THE TECHNOLOGIES INVOLVED IN GMES

This chapter describes the space-born sensor technologies that are involved in Earth Observation or that will be used for the GMES future infrastructures. It also mentions some of the competing technologies, that can be satellite or air borne, and even ground based, complementing or competing against space borne technologies.

III. Satellite imagery for Earth Observation (EO)

Earth Observation is one of the oldest satellite applications. From Earth orbits, one can observe aspects of the Earth not observable from the ground and get information regarding the surface, the atmosphere, the oceans, and the soil near the surface. Although space imagery is not the only means for studying the Earth, it represents one of the most promising techniques, allowing:

- The analysis of any given zone very frequently;
- The analysis of any part of the world without the authorisation required for airborne systems;
- The observation of very wide surfaces in one shot.

Many satellites are now in orbit to observe the Earth and several systems have been implemented on a private basis[3]. Commercial observation satellites are relatively new. The industry grew up when restrictions on satellite imagery technologies were relaxed at the end of the cold war. The first Earth observation satellites were launched thirty five years ago. The NOAA-A/Landsat 1 satellite (1972) was the forerunner with its resolution in the 100-m range, paving the way to better and more satellites.

Since the availability of a Russian analogue KVR-1000[4], the limit of **geometric resolution** of non-classified earth observation imagery has continuously improved. With the successful

[3] Source: INVESAT Wiki and "Possible scenario for future mission in earth Observation", CNES, Daniel HERNANDEZ

[4] The KVR-1000 instrument carried on the COSMOS satellites provides black and white images with a resolution of 2 m and covering a surface area of 40 km x 160 km. Cosmos is the name of a series of satellites which were launched by the Soviet Union and are being launched now by Russia. The first of them was launched on March 16, 1962.

launch and operations of the **Space Imaging**[5] **IKONOS II** satellite[6] in 1999, the "metric" resolution is now available on a commercial basis. Meanwhile, Europe and other countries are providing similar systems, while exploring other domains of the electromagnetic spectrum, such as **radar imaging.** The SPOT family, with five satellites, the latest launched in 2002, has contributed developing the **commercial market for space imagery of the Earth**. Its **geometrical resolution** has continuously improved: 100m for the first NOAA-A satellite down to 10m for NOAA-K, 10m for SPOT 1 (in 1986) down to **about 3m for SPOT 5.** Other satellites have been launched over the past 2 or 3 years with performances down to 0.7 m resolution, but with less wide field of view than SPOT or Landsat.

[5] Space Imaging and Orbimage are now GeoEye (see section 3.6)
[6] IKONOS is a commercial earth observation satellite that collects high-resolution imagery at 1- and 4-meter resolution It provides imagery beginning January 1, 2000. The company GeoEye distributes IKONOS imagery under the product name CARTERRA

Along with the improvement in resolution and size of images, **the amount of data to be transmitted from the satellite to ground stations has tremendously increased,** requiring efficient data compression algorithms. Also, on-board memory capacity and volume have increased over time tremendously, whereas power consumption has greatly decreased. The costs of earth stations, necessary to receive and preprocess data from satellites, have also decreased thanks to improved antennas, improved transmitters on board satellites and improved receivers within ground stations[7].

Though, most of the operators or distributors of earth imaging systems are private enterprises, the vast majority of customers for the very high resolution data are governmental bodies, especially military and security agencies. It is to meet the increasing need of US intelligence customers on Very High Resolution (VHR) space data and to reduce the costs of operations that the US Presidential directive of April 25, 2003 further eased previous restrictions on the commercial collection of space imagery. It requested US federal agencies to purchase satellite information from commercial companies. The **National Geospatial Intelligence Agency** (NGA) awarded a first NextView contract to the US company **DigitalGlobe**[8] for the delivery of VHR space imagery to the US army. Intentionally, the contract would allow DigitalGlobe to finance its next generation satellite system, called WorldView[9]. A call for a second NextView contract was awarded to the US company Orbimage.

IV. Earth Observation using satellite based technologies: added value and future challenges

Earth observation is the application in which satellites have gained market share in becoming indispensable to meet several public services needs. The general trend towards « faster, better, cheaper » solutions has affected this domain: today, operational satellites with sizes in the mini range are operational[10] giving private players the opportunity to invest in satellite constellations. Although satellite data may remain **less accurate** than conventional observations under certain circumstances, their **great advantage** is a **broad geographical coverage**. The future challenges[11] for improved satellite data collection and sales lie in the following system parameters:

- **The geometric resolution of "images":** improvements in geometric resolution and swath for new satellites will come directly from solid state physics progresses on cameras;
- **The data access time:** i.e. the time needed to make a requested image available to a user. It depends upon the ease of access to existing data stored in archives and the response time of space systems to new request for information.
- **Improved data processing performance:** the final user is not buying bits or images, but « information » usable directly by him. Data processing software must be improved to process raw data and build services adapted to users' needs.

[7] Source : op. cit.
[8] See section 3.6
[9] The WorldView satellite will provide the NGA with imagery, and also be available for commercial uses such as city planning, homeland security or forestry management. Selected under a contract known as NextView, WorldView implements a new level of partnering between the U.S. Government and the remote-sensing industry. The NextView contract allows the NGA early participation in the development cycle for the next generation of U.S. commercial satellite imaging capabilities. Together, the imaging constellations will be capable of collecting more than 4.5 times the imagery of any current commercial imaging system.
[10] Hernandez D. "Possible scenario for future mission in earth observation", CNES,
[11] OECD, "*Space 2030 Tackling Society's Challenges*", 2005 and INVESAT Wiki

- **Accuracy and reliability of data:** satellite signals tend to vary over time, while most missions are very often prototypes with quite a short life time (*e.g.* the ENVISAT mission should last for only a little over five years). The development of revolutionary high-resolution geostationary satellites may make possible continuous and detailed observation of large areas of the Earth (*e.g.* areas prone to natural disasters). In the meantime, the guarantee to have stable data over a very long period of time is a prerequisite for new ventures to launch commercial activities using such data.
- **Space data in integrated information systems:** lower engineering costs are making direct broadcasting of data more easily achievable. This, in turn, will enhance the opportunities for developing EO applications. Yet, some applications, such as emergency services, will remain difficult to address because system reactivity is not real time.

It is to address the above challenges that concerted actions of the EC and the ESA have triggered major evolutions in the EO industry:

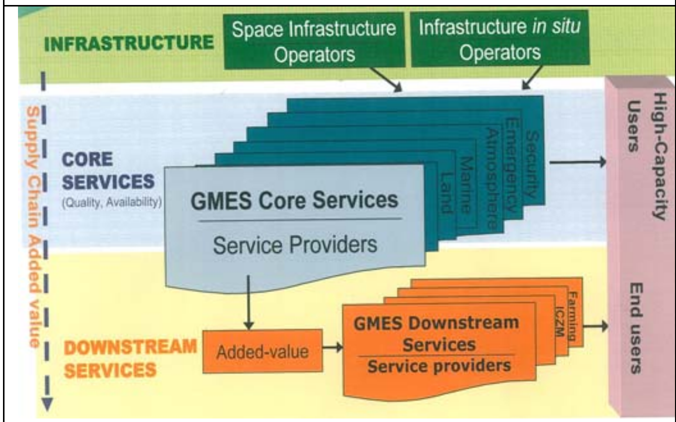
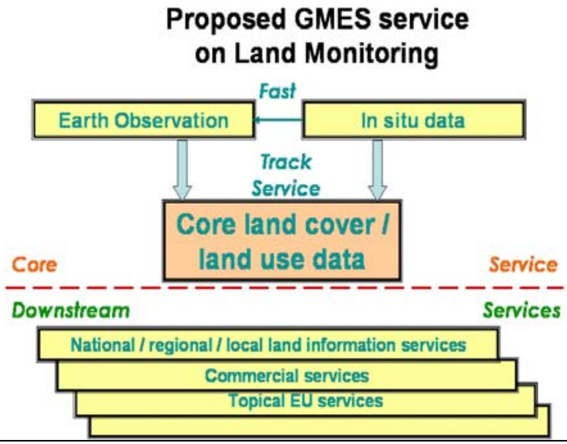
- **Upstream data processing**, coupling Earth Observation and in-situ data, will be developed into a set of core services (also called ***fast track services***[12]). They are supposed to structure downstream applications based on **data of guaranteed validity and continuity over time**;
- By 2008, **three fast track services,** dealing with **land monitoring, marine services and emergency response,** will be available. Further services are expected later on dealing with atmospheric monitoring, external border surveillance and crisis prevention;
- **Coordinated availability of data** will most probably **lower their costs**, leading to standard pre-processed models (for instance, digital elevation models for the whole EU-27).

The overall GMES architecture, implemented by the EC, ESA and industry is depicted below in view of meeting several high level objectives for Europe:

- observation of the state and evolution of the *global environment*
- monitoring for the EC 6th *Environmental Action Plan*
- support to *EC Common Policies* (Agricultural, Fisheries and Regional Development)
- aid to *civil protection* for prevention, monitoring and assessment of *natural and man-made hazards*
- assistance to *development and humanitarian aid*
- support to the EU Common Foreign and Security Policy (CFSP) and other policies relevant to *European citizens' security*

It uses the specific example for Land monitoring.

[12] Fast Track Services are GMES services that have been identified as first candidates for "fast track" treatment, with the objective of being operational by 2008. This selection has been performed on the basis of the following criteria: their maturity, uptake by user communities and long term sustainability of demand and supply. As a result, three "fast track" services have been identified: Emergency Response Core Service; Land Monitoring Core Service; Marine Core Service. (source GMES web site)

<table>
<tr><th>Overall GMES architecture</th><th></th></tr>
<tr><td>
</td><td>
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<tr><td>Source : European Commission</td><td></td></tr>
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V. New satellite systems or air-borne sensors?

The following section illustrates the difficulties observed in choosing the most appropriate sensors for data acquisition and processing to fulfil the needs of a given business.

Measuring the sea water colour allows to map, for instance, phytoplankton concentrations. To get an accurate idea of the colour of the water[13], spectral data - usually collected by satellite-borne ocean colour sensors - are used. Traditional ocean colour sensors collect light in a small number of relatively broad spectral bands[14]. This is appropriate for mapping, for instance, phytoplankton (represented by chlorophyll-a concentration) in ocean waters. However, for costal waters, the optical complexity of both the sea and the atmosphere necessitates as much spectral information as possible to distinguish between the various optically active substances unambiguously. Hyperspectral sensors are the appropriate instruments. The first generation of hyperspectral imaging sensors was airborne.

However, airborne image spectrometry has some disadvantages compared with satellite based image spectroscopy (for instance the reduced swath). A new generation of satellite sensors and platforms, with a spectral and spatial resolution intermediate between airborne and traditional satellite imaging spectrometers, has begun to appear. These satellite-based hyperspectral imaging spectrometers reduce the gap between space and airborne imaging spectroscopy. The CHRIS sensor mounted on the small, low-cost PROBA satellite is a European prototype now operational. Although image acquisition and analysis are still in a test phase, the high spatial and spectral resolution and pointability have proved their potential. Thanks to the high resolution, small features, which were only visible on airborne images before, become now detectable. The table below summarizes the options available in late 2005 on the matter.

[13] Barbara Van Mol, Kevin Ruddick " The Compact High Resolution Imaging Spectrometer (CHRIS): the future of hyperspectral satellite sensors. Imagery of Oostende coastal and inland waters" *Proceedings of the Airborne Imaging Spectroscopy Workshop - Bruges, 8 October 2004*

[14] varying from 8 bands for SeaWiFS to 15 bands for MERIS and 16 bands for MODIS

Ocean Color Sensors[15]	Hyperspectral satellite sensors	Hyperspectral airborne sensors
COCTS (HaiYang-1) MERIS (ENVISAT-1) MMRS (SAC-C) MODIS-Aqua (Aqua) MODIS-Terra (Terra) OCI (ROCSAT-1) OCM (IRS-P4) OSMI (KOMPSAT) SeaWiFS (OrbView-2)	FTHSI (MightySat II) Hyperion (EO-1) ARIES-I (ARIES-I) CHRIS (PROBA) NEMO (COIS) (launch delayed so far)	AVIRIS HYDICE PROBE-1 Casi HyMap EPS-H DAIS 7915 DAIS 21115 AISA ATIS

VI. Air-borne sensors

The alternatives to satellite are direct observations and /or measurements directly on the ground or from airborne sensors. They most often complement each other and do not compete. The smaller the distance the better the resolution; but, the smaller the swath the more difficult it is to make frequent observations of remote areas. Some applications require extremely high geometric resolution, but many are dedicated to wide coverage or frequent observations. Airplanes or helicopters are adapted to extremely high resolution image of not too wide surfaces and in areas that are not too remote. Satellites are appropriate when wide coverage is required with sufficiently high resolution. Of course, satellites are an indisputable solution if the zone is not easily accessible.

In the future, it is expected that earth observation from satellites will have to face some competition coming from **aerial observation technologies**. Indeed, the increasing digitisation of aerial data and the technical improvement of those systems may make them better than satellites for mapping small areas. Competition will involve airplane, helicopter or UAV: **Unmanned Aerial Vehicles (UAVs)** are remotely piloted or self-piloted aircraft that can carry cameras, sensors, communications equipment or other payloads. They are used effectively in a reconnaissance and intelligence-gathering role since the 1990’s.

VII. The Future GMES infrastructure and data provisions

The sentinels 1, 2, 3, 4, 5 satellites

The ESA Sentinels, composed of five satellites, constitute the first series of operational satellites responding to the Earth Observation (EO) needs of the GMES program. Sentinel-1, expected to be launched in 2011, includes applications such as marine – vessel detection, oil spill mapping and wind products – and sea ice mapping. Sentinel-2 and 3 satellites, scheduled for launch in 2012, will support land and ocean monitoring, while Sentinel-4 and 5 will be dedicated to meteorology and climatology through atmospheric chemistry.

[15] more information on these sensors can be found on www.ioccg.org

- **The Sentinel-1 series of satellites:** it will address the issue of data continuity for Synthetic Apertur Radar data at large. The immediate priority is to ensure such continuity for C-band data. Under the current scenario, provision of ENVISAT data to feed SAR-based services is likely to cease in the 2008-2010 timeframe. In order to meet the need for continuity, and taking into account the availability of Radarsat-2, the first Sentinel 1 satellite should be launched before the end of the ENVISAT operations. The experience with ERS, ENVISAT and RADARSAT constitutes the basis for the Sentinel-1 mission requirements and concept.
- **The Sentinel-2 Superspectral series of satellites:** it will replace the numerous services of high strategic important and economic value are currently being provided based on data from the SPOT or Landsat series of satellites. It is necessary to provide continuity and thus guarantee the availability of data to service providers and users. Enhancement as required by the growing user demand for higher service quality shall be considered. Activities related to the accommodation of the IR sensor on Sentinel 2 will be added during the second part of the definition study.
- **The Sentinel-3 Ocean series of satellites:** it will provide on an operational basis, data in support of services that have been developed since 1991 with ERS, and ENVISAT. The altimeter part of the mission will further complement that of Jason and others to contribute to a worldwide operational oceanographic service. Taking into account the global context and in particular the European needs, capabilities and plans, the Sentinel 3 should include first the elements which, being well defined and already exploited on a near operational basis, have no guaranteed operational continuity beyond ENVISAT. These elements are the high inclination altimeter and the visible-infrared element for ocean colour and sea-surface temperature based products.
- **Sentinel-4/-5 Atmospheric Chemistry family of satellites:** the EC's White Paper on Space (COM(2003)673 identifies atmospheric monitoring as an area of high priority for GMES including real time services related to atmospheric chemistry, pollution, ozone and aerosols. Sentinels -4 and -5 will be space-based systems operating from geostationary (GEO) and low Earth orbit (LEO) respectively. The requirements derived from the need to monitor the implementation of the Montreal and Kyoto protocols, and the requirements of the Global Atmospheric Watch.

R&D on core services / fast track services

R&D on the core services and fast track options is mainly covered by EC and ESA funding[16]:

- **EU-funded Integrated Projects developing pre-operational GMES services (Enterprise and Industry Directorate General)**: GEOLAND, MERSEA, PREVIEW, GEMS, LIMES
- **ESA GMES Service Elements**: Forest, Land, TerraFirma, Risk-EOS, Respond, GMFS , MARCOAST, Polar View, MARISS, PROMOTE
- **Network of Excellence in support of security applications under GMES**: GMOSS
- **Other Projects in Support of GMES Activities**: OASIS - ORCHESTRA - WIN - ASTRO+ - HUMBOLDT - BOSS4GMES - OSIRIS

[16] see http://www.gmes.info/180.0.html and http://www.gmes.info/98.0.html?&no_cache=1&page=0&what=2

VIII. Conclusions

KEY FINDINGS AND PROSPECTS
a. GMES is a European system whose funding and objectives are well designed and accepted by the Member States[17] b. There is a long-term perception on data availability from the Sentinel series, each satellite being dedicated to specific observation areas c. In parallel, R&D to harmonize raw data preparation and delivery is performed to provide Value Added Services (VAS) with stable, high quality data streams for their own end-user applications d. The technical framework conditions are therefore set via significant public funding to convince SMEs and start-ups launch EU services with the insurance of raw data delivery on time and within pre set costs.

[17] ESA/EC decisions on Sentinel's Satellites, September 27th 2007

CHAPTER 3

THE MARKETS GENERATED SO FAR BY EARTH OBSERVATION

This chapter focuses on the markets that have been generated so far using Earth Observation in Europe. It gives the commercial background and a summary of the quantitative available data on such market growth.

IX. Background

In the next coming decade, the value chain of the EO sector will be relying on the GMES systems.
GMES (Global Monitoring for Environment and Security) involves observation data received from Earth Observation Satellites AND air borne or ground based facilities, which are coordinated, analysed and prepared for end-users according to the architecture depicted in the previous chapters.

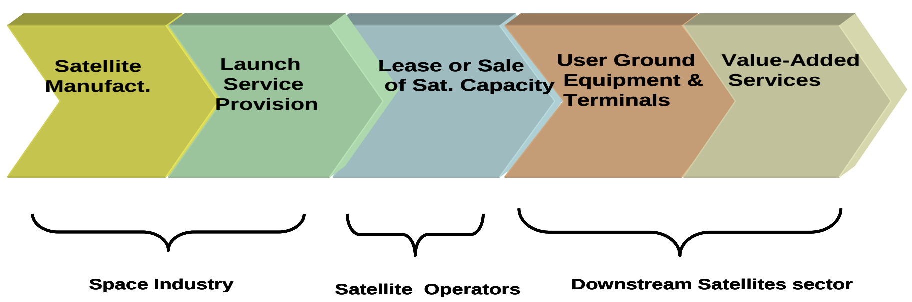
Earth Observation (EO) deals, broadly speaking, with the acquisition and exploitation of data acquired from remote (aircraft or satellite-based) observations of the Earth. It covers a diverse range of remote sensing applications, including weather forecasting, the environmental monitoring area, surveillance as well as numerous scientific applications in the atmospheric, land and ocean domains.

Value-Added Services (VAS) are defined as any business process meeting anyone of the following criteria:

- enhancing or upgrading the space signal;
- targeting specific end-users with dedicated applications;
- combining several applications at once.

Value-Adding companies (VAC) are companies that work with raw or semi-processed data from remote sensing instruments, and convert the data into information that brings value to end-users.

The Value chain of the EO sector



X. Two classes of main customers

Roughly speaking, EO customers and / or end-users are made of:

1. **Public,** i.e. regional, national, European public services and agencies, which require up-to-date and reliable environmental information on European and global land, air and sea areas. Depending on the needs of end-users , such as urban communities or the European Environmental Agency , the area of interest could cover small towns or the entire globe[18];
2. **Private**, i.e. representatives of industrial companies, which can purchase EO services in order to increase their competitiveness (for instance, water utilities, insurance companies, oil companies, electric power producers, chemical manufacturers, mining industries), trading companies, which may speculate on the price evolution of agricultural products (they use extensively remote sensing to estimate the world production level for each product – rice, cotton, wheat, etc)

Today, the majority of the **demand for EO services is driven by the public sector**. Typically, governments and other public bodies at all levels (regional, national, and international) are the dominant customers of EO products, thereby generating the majority of revenues. Only the **energy (oil, gas and minerals) market has a strong private presence**, mainly due to weather forecast applications for oil and gas off-shore exploitation.

The barriers that **prevent the EO industry from growing in the private sector are several**:

- Relatively **high cost of EO data** ;
- **Insufficient availability[19] and continuity of EO data** compared to terrestrial solutions (including aerials);
- **lack of knowledge about the EO potential to tentative customers**. There is a need to improve the general awareness about EO services, which places a high burden on the marketing of EO companies.

XI. The main market segments

The EO downstream Value-Added Services sector is an extremely **diverse sector,** addressing a wide range of applications:

- EO products have applications in support of important **public responsibilities**, such as natural resource management, land cover and urban planning, weather forecast and climate change monitoring.
- From a **commercial perspective,** they can be used by a growing number of businesses, ranging from insurance companies whishing to estimate the cost of a natural disaster, to farmers willing to use precision farming techniques.

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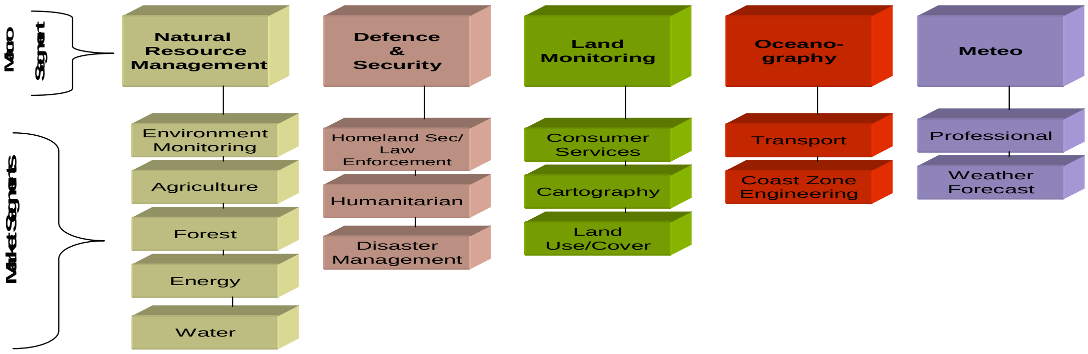
[18] The demand for certain services, such as those related to treaty monitoring, comes only from European or national government-level ministries, requesting the high level of information for their administrative work.

[19] With respect to data supply, almost a third of products have no alternative if one of their data supplies fails. This is a risk which the VACs have little or no influence over. Customers will be wary of adopting new services for which the supply of EO data is not secure. Industry will not invest until there is a commitment that ensures long-term continuity of this supply (source: "*The State and Health of the European and Canadian EO Service Industry*" Technical report, September 2004, ESA, Booz Allen Hamilton , Vega) .

Overall, five market macro-segments can be identified: Natural Resource Management; Defence and Security; Land Monitoring; Oceanography; and Meteorology. These macro-segments can be divided further as shown below.



The level of maturity of the above segments is far from being uniform, in any of the five macro segments[20]:

- **Emerging markets: consumer services, disaster management, humanitarian relief, environment monitoring, forest resources, marine engineering**, etc. are in the **technology or emerging phase,** still heavily dependent on government funding for development;

- **Growth markets: Homeland Security/Law Enforcement and Professional Meteorology** are key segments[21] in a **growth phase**, where Europe lays behind the USA;

- **Mature markets: Agriculture and Energy** ;

- **New market cycle: Cartography, Land Use/Land Cover and Public service meteorology** are in a **cyclical phase,** requiring support for transition.

XII. The geographical sales split[22]

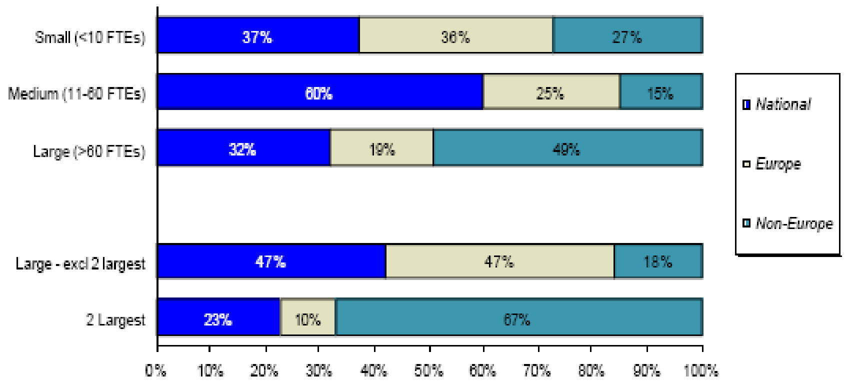
The bulk of EO Value Added Service **sales by European players are made within Europe**. Markets outside Europe are still a small part (15%) of the typical customer base for European VACs (see exhibit below).

[20] Source : Euroconsult, Helios and Bertin , "Assessment of the Downstream Value-Adding Sectors of Space Based Applications" – Final Presentation, ESA HQ , March 21st, 2007
[21] See also revenue structure section
[22] The ESA, Booz Allen Hamilton, Vega study covers the European and the Canadian Earth Observation industry. However, the main centers of operation for the surveyed companies are located in Germany and France. Frequency of responses from these countries were almost twice as high as the next group of countries with significant EO activity (i.e. Belgium , Canada, Italy, the Netherlands and the UK). Source: *ESA, Booz Allen Hamilton, Vega (2004), op. cit , page 9*

Source: Vega, Booz Allen Hamilton, ESA[23]

While big players are able to address European or world- wide market demands, small players are mainly focused on regional markets, where they started business, very often spinning off from local public research laboratories.
Large VACs generate far more international sales, particularly intercontinental sales. This is, in fact, heavily influenced by the two largest VACs, which have the size, turnover and profit figures which allow taking new market risks (see exhibit below).

Geographical sales split by VAC size



Source: Vega, Booz Allen Hamilton, ESA

This geographical split of sales demonstrates that the nature of services is not constrained by regional or national boundaries.
However, small VACs have difficulties in gaining access to potential buyers in distant export locations, mainly because of marketing and sales costs.

[23]Source: *"The State and Health of the European and Canadian EO Service Industry" Technical report, September 2004, ESA, Booz Allen Hamilton, Vega*

XIII. The revenue structure

As shown below, at world level, the total revenues of the sector amounted to 1,3 billion EUR[24] in 2005, with Europe[25] accounting for 0.4 billion EUR. Revenue generation is concentrated in two market segments:

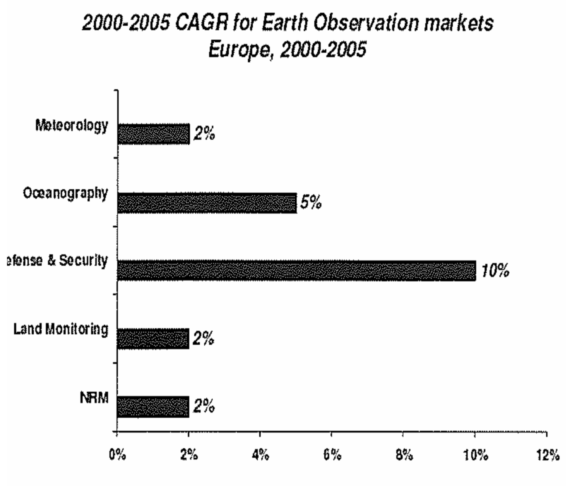
- **Meteorology,** which generates half of the sector revenues in Europe (0,2 billion EUR);
- **US spending on Homeland Security**, where Europe is lagging behind the US spending (0.44 billion EUR in US against only approx. 0.050 billion EUR in Europe).

	Europe (billion EUR 2005)	World (reference region) (billion EUR, 2005)
Total EO market revenues	*0.4*	*1.3*
Meteorology market segment revenues	*0.2*	*0.5*
Defense and security market segment (government spending)	*0.050*	*0.49*

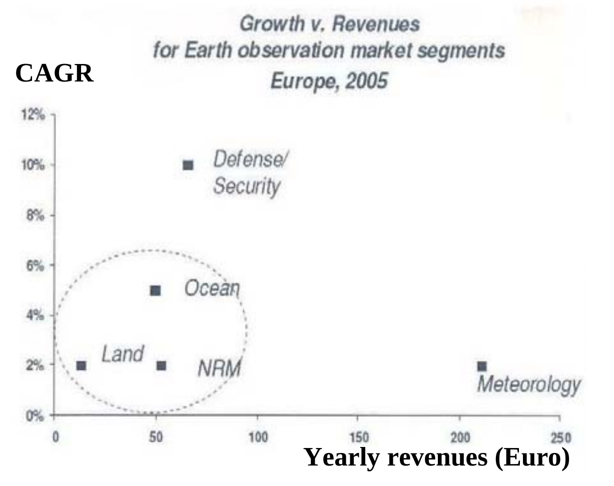
Source: Euroconsult, Helios and Bertin[26]

European market segments usually have a smaller size than comparable US markets.
At world level[27], several markets are still in an emerging phase, with 3 markets at around the EUR 50 million revenue range: NRM (Natural Resource Monitoring), Land monitoring and Oceanography.

With regard to past growth, a **low growth** rate (ranging from 2% to 5%) was recorded by the majority of the market segments over 2000-2005 in Europe, except for **Defense and Security**, which registered a **10% CAGR**[28]. Defence and Security, Ground motion/subsidence mapping (disaster management), and Marine transport are niche areas, which have promising profiles. Meteorology is a low growth/high revenue segment, which is dependent on public spending. Land and NRM are low revenues, low growth segments. **Defence and Security will become a key driving application in Europe** thanks to GMES.



Source: Euroconsult, Helios and Bertin



Source: Euroconsult, Helios and Bertin

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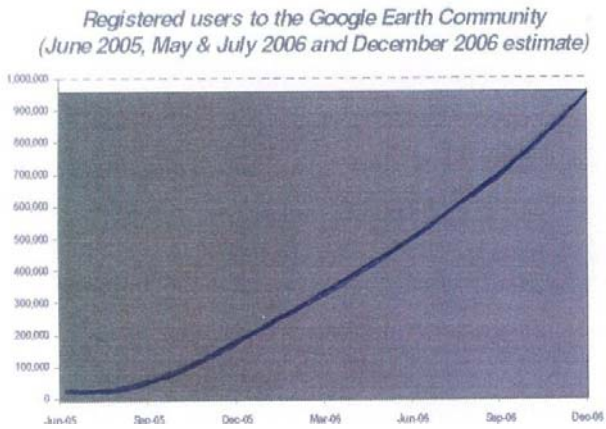
[24] 1,3 billions include 0,4 billion EU + 0,9 billion US
[25] Europe includes ESA/EU countries (including Canada)
[26] Euroconsult, Helios and Bertin , "Assessment of the Downstream Value-Adding Sectors of Space Based Applications" – Final Presentation, ESA HQ , March 21st, 2007
[27] EO data are derived from revenues of US and European/Canadian companies only, for which the geographical split is not available
[28] Compounded Annual Growth Rate

XIV. EO markets: business prospects based on past growth observations

The following new market segments should experience high growth rates in the coming decade:

1. **The Consumer service segment (web-based applications) is perceived as promising by the VA industry thanks to the virtual globe[29]concept which is expected to open-up new markets**. This segment benefits from the **strong support of complementary players, large IT and web companies,** such as Microsoft and Google. The exposure of satellite imagery to the mass market is already spawning new applications involving EO, for instance in real-estate, tourism and insurance. The Google versus Microsoft "battle to purchase images" should be mentioned: the provision of data for free is expected to change the Value-Added market. The figure below shows the growth of end-users of the Google Earth Community (for the period July 2006-December 2006).



Registered users to the Google Earth community
Source: Euroconsult, Helios and Bertin

2. **Homeland Security applications** shows also promising growth prospects. In the US, where Defence and Homeland Security is identified as a key driver for the demand of EO products and services, the DoD is committing increasing funds for R&D in Homeland security (280% since 2001) and is ensuring the future of high-resolution data missions with NGA **(**National Geospatial-Intelligence Agency)[30] projects. GMES will progressively deal with similar concerns in Europe. The Network GMOSS has been preparing the specifications of demands in that area, whereas the Integrated project LIMES is addressing the security of European harbours.

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[29] A **virtual globe** is a 3D software model or representation of the Earth or another world. A virtual globe provides the user with the ability to freely move around in the virtual environment by changing the viewing angle and position. Compared to a conventional globe, virtual globes have the additional capability of representing many different views on the surface of the Earth. These views may be of geographical features, man-made features, such as roads and buildings, or abstract representations of demographic quantities, such as population.

[30]The **National Geospatial-Intelligence Agency** (**NGA**) is a federal agency of the US Government whose primary function is collection, analysis, and distribution of Geospatial Intelligence (GEOINT) in support of national security. NGA is part of the Department of Defense (DoD), but has also responsibilities to customers outside the DoD. Microsoft Corp. and the NGA have signed a LoU to advance the design and delivery of geospatial information applications to customers. NGA will continue to use the Microsoft Virtual Earth platform (as it did for Katrina relief) to provide geospatial support for humanitarian, peacekeeping and national-security efforts. The Virtual Earth platform is an integrated set of online mapping and search services that deliver imagery through easy-to-program APIs.

3. In the **marine sector**, growth is expected to be driven by the marine transportation and hydrocarbon extraction industries, with an increasing need for better information in more hostile environments. Such needs can be better met by new satellite observations and the increasing capacity to use radar and altimeter data in operational products, together with advances in ship-tracking, through satellite navigation and radar technology.

4. In the **energy sector**, for which no specific GMES development has been launched, the advent of renewables energy use in Europe will initiate new applications of EO data:
    - Solar radiation data will help permitting and siting photovoltaic farms (see for example the SODA web service)
    - Radar data about wind power will help the permitting and siting of off-shore wind farms
    - Spectral radiation data will support the growth monitoring of biomass crops used for biofuels production.

KEY FINDINGS and PROSPECTS

- **Overall EO market growth will remain low if past business models are used,** (below 10% yearly growth rate). Although improving, the factors supporting a strong market take-off (mature organisation of suppliers, products standardisation[31] etc.) do not appear to be fully met yet ;
- **Defence and Security is the only segment with over 10% yearly growth, and may continue so over the next decade**, provided it gains the necessary level of government support;
- **Oceanography is anticipated to be the second highest growing market, with 5% - 10% growth,** since it enters into a growth phase[32];
- **Consumer service segment (using web-based applications) is perceived as a promising segment** since virtual globes are expected to open-up new application markets as shown by Google Earth ;
- **Opportunities exist in other niche markets**, i.e. Ground Motion/Subsidence Mapping (Disaster Management), Environment monitoring, etc;
- **There is an unbalanced mix of public and private clients:** governments and other public bodies are still the dominant customers.

[31] According to a previous study, there are **high levels of product customisation** (almost 40% of the studied services are customised for every delivery) suggesting that **both demand and services are not yet mature enough to reach a common, stable point of exchange**. As a consequence, the procurement, production and delivery of EO services process is likely to be characterised by **very frequent supplier-customer interactions**. However, there is evidence that the industry is trying to **move towards more standardised offerings** (*The State and Health of the European and Canadian EO Service Industry*" Technical report, September 2004, ESA, Booz Allen Hamilton , Vega)**.**

[32] Key market drivers are increased levels of shipping activity and marine hydrocarbon exploration worldwide, together with advances in ship-routing through satellite navigation and radar technology