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THE COST OF NON EUROPE IN THE FIELD OF SATELLITE BASED SYSTEMS

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Directorate General for External Policies of the Union
Directorate for Interparliamentary Delegations and Policy Department
Policy Department External Relations

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STUDY

Abstract:

In recent years the European Union has become increasingly aware of its security and defence environment as it has taken on a growing international profile such as in relation to negotiations with Iran or in regional crisis management operations from the Balkans, Indonesia to the Democratic Republic of the Congo. According to the EU's landmark 2003 European Security Strategy these challenges are described as diverse in their form and in their objective, ranging from classical military hotspots to less conventional security threats targeting our societies. It is therefore to be expected that the EU and its Member States will want access to the full range of capabilities, including space-based capabilities, to successfully carry out its security and defence roles. Space technologies have evolved to become central enabling assets in modern defence and security systems. Space based assets use a “neutral” environment, i.e. outer space, to locate sensors or communication devices. In turn, space-based systems provide unique capabilities at all levels of the so-called “information chain”. Such systems provide unique capabilities for data acquisition worldwide, for long-range transmission and for focused dissemination of the information to users on the ground. Space applications can also be used for “security” in the broadest sense. For instance, at the EU level initiatives are being developed to respond to new security requirements, whether it concerns the constant monitoring of our planet or tackling more immediate threats such as terrorism or responding to vulnerable critical infrastructures in Europe and its neighbourhood. Space assets can also help monitor suspect industrial installations in the context of verification and disarmament activities. In such cases, both civil and military planners need access to information from space-based systems. Responding to natural and man-made crises also requires a capability to exploit large flows of complex data for a range of civil and military actors. Helping to fill the security requirement gap requires, an all-inclusive European security architecture that integrates both civil and military systems, and space-based and non-space based technologies.

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Introduction
The role of space for defence and security

In recent years the European Union has become increasingly aware of its security and defence environment as it has taken on a growing international profile such as in relation to negotiations with Iran or in regional crisis management operations from the Balkans, Indonesia to Democratic Republic of the Congo. According to the EU's landmark 2003 European Security Strategy these challenges are described as diverse in their form and in their objective, ranging from classical military hotspots to less conventional security threats targeting our societies.

Space-based systems for defence purposes

Space technologies have evolved to become central assets in modern defence and security systems. Space based assets use a “neutral” environment, outer space, to place sensors or communication devices. In turn, space-based systems provide capabilities at all levels of the so-called “information chain”. These include capabilities for data acquisition worldwide, for long range transmission and for focused dissemination of information to users on the ground.

Data acquisition and transmission performed by satellites are viewed as a key feature of modern defence and security operations. Repeated passes over spots of interests in any part of the world and the ability to transmit the information in real-time define the main advantages of satellites for any security or defence-user community. From a military perspective, the use of new space-based systems is progressively changing the way military operations are conceived and conducted.

There are three kinds of satellite applications – observation and data collection, telecommunications and navigation – that are traditionally mentioned considering their renewed strategic importance. The efficiency of each of these applications depends on characteristics, such as:

- the quality of situational awareness which relies on precise and certified information obtained from satellites,
- the responsiveness of the system which allows up-to-date collection of information,
- the timeliness and persistence of the information system.

Military intelligence or combat operations demand the highest standards regarding such characteristics. In such cases, the level of technical performance required will determine the use of dedicated military satellites because commercial or civilian systems cannot provide adequate precision and security (even if they can act in some cases as complementary assets).

Satellites are often referred to as “force multipliers” or “enablers” – a means of increasing the efficiency and effectiveness of military operations. Space-based technologies radically improve the management in real-time of information flows which give an unprecedented advantage in modern conflicts. Information coming from space allows commanders in distant headquarters to locate on-screen, in real-time, the location of their forces and those of their opponents, and to guide weapons precisely to their targets. This means that soldiers need to be equipped with sophisticated personal communications devices. It also allows the transmission of so-called “value-added information”: the ability to mix different forms of information sources, to make the information relevant for the user.

Today, the combination of intelligence information (imagery and listening) with positioning and guidance data gives a qualitative edge to armed forces with access to space technology.

Space-based systems for enlarged security needs

Space applications can also be used for “security” in a broader sense. At the EU level initiatives are being developed to respond to new security requirements, whether it concerns the constant monitoring of our planet or deals with more short-term threats such as terrorist actions, insufficiently secure industrial

installations or critical infrastructures and in its neighbourhood. Space assets can also help monitor suspect industrial installations, contributing to verification and disarmament operations. In such cases, both civil security and military planners would need access to information from space systems.

Responding to natural and man-made crises also require a capability to exploit large flows of complex data for a range of civil and military actors. Helping to fill the security requirement gap requires an all-inclusive European security architecture that integrates both civil and military systems, and space-based and non-space technologies.

The need for a better organized European defence space-based architecture that can handle enlarged security challenges

Whilst the United States has defined and considered space as a unique, integrated strategic sector, European member-states have developed several systems to fulfil their needs. These European systems have been developed at the national level as part of individual Member States defence priorities.

More recently, a convergence of needs and the strengthening of CFSP/ESDP along with the financial imperative for cooperation because of over-stretched defence budgets have led to a growth in cooperative programmes amongst EU member states. France has played a central role in this evolution, as a leading space actor, with a high investment and a specific defence policy[1]. Other Member States such as Italy, Germany, the United Kingdom and Spain are developing significant space-based systems for defence and security, contributing to bilateral or multilateral framework agreements based on the exchange of capabilities and raw data.

To capitalize on existing programmes, future European collaborative programmes will need to be structured according to two main principles:

1. Any space-based system architecture will have to be developed according to operational needs and will have to recognize the specificities of the military user communities before addressing broader security needs. This implies that such an architecture will have to address:

- security and confidentiality issues;
- the robustness of its components in strenuous military contexts;
- the guarantee of high levels of performances (above that available on the market)

2. It will also have to follow a user-based approach by:

- taking into account the specificity of the different user-communities;
- developing user-friendly and interoperable systems and interfaces allowing diverse user communities to interact efficiently without compromising on security.

General remarks collected for this study highlight the need for a European architecture that will foster interoperability between the user-communities and different member states. Such a European space-based architecture will have to be studied carefully to benefit from the diversity of the existing and planned European systems in a realistic manner. This perspective raises the issues of cooperation between different national military systems, as well as between military and civilian/ commercial systems that can provide complementary capabilities.

[1] France budgets amount to an average of 50% of the 1 Billion Euros devoted annually in Europe to military space programmes.

Part One

Satellite systems for defence and security in Europe

Chapter I

European requirements for improved defence and security capabilities

Since the nineties, the European Union's institutions have engaged in the difficult task of defining the military and security missions that may confront Europe, as well as the kind of European armed forces needed to fulfil these missions.

For instance, in 1992, the Petersberg declaration, subsequently incorporated into the Amsterdam Treaty in 1997 identified the following military tasks *to include*:

- humanitarian relief and rescue;
- peacekeeping;
- crisis management, including peacemaking.

The first "Headline Goal" was finalised at the European Council in Helsinki (1999) to prepare European military capabilities accordingly:

- rapid deployment has to be ensured by up to 60,000 troops to deal with all Petersberg tasks.
- access to Nato assets

Whilst the treaty of Nice adopted by the Council in December 2000 created permanent political and military structures, referring to a Political and Security Committee made up of member states representatives, a new "2010 Headline Goal" was endorsed in June 2004 (following the adoption of the European Security Strategy in 2003), introducing a broader range of missions, including notably:

- joint disarmament operations
- support brought to third countries in combating terrorism
- the security sector reform
- border control
- demobilisation and reintegration

A particular accent was put on the necessity for the European Union Member States to be able "to act before a crisis occurs", underlining the necessity to possess the relevant information tools for monitoring conflicts. In parallel, the "Headline Goal 2010" also calls for improved interoperability of national systems, organizations and procedures for better coordination of equipment as well as better command arrangements and defence planning.[2] This approach has been embedded in key EU security and defence concepts[3].

A report made public by the European Space Agency (ESA) in October 2006 pointed to gaps affecting the information-gathering process as reported by a panel of defence and security user communities[4]. These experts concluded that decisive improvements will have to be made in the field of data collection and processing, data transmission capabilities and integrated tools mixing Earth Observation, mapping, telecommunication and navigation techniques.[5]

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[2] Council of the European union, 'Headline Goals 2010' (Brussels, 17-18 June 2004), available at the address : http://ue.eu.int/uedocs/cmsUpload/2010%20Headline%20Goal.pdf

[3] European Council, 'A Secure Europe in a Better World', Javier Solana (Brussels, 12th December 2003), 'A Human Security Doctrine for Europe – The Barcelona Report of the Study Group on Europe Security Capabilities', presented to the EU High Representative for Common Foreign and Security Policy (Brussels, 15th September 2004).

[4] European Space Agency, 'European Space and Human Security Working Group Report' (October 2006). See also previous key documents such as : Council Resolution, 'A European Space Strategy' (16th November 2000, 2000/C371/02); Council of the European Union, 'ESDP and Space' (November 2004, 11616/3/04); EU Military Committee, 'Generic Space Systems Needs for Military Operations' (6091/06); Committee for Civilian Crisis Management, 'Generic Space Systems Needs for Civilian Crisis Management Operations' (10970/065);

[5] 'European Space and Human Security Working Group Report', Quoted Report., pp.18-24.

Based on lessons learned from the most recent conflicts and documented in these reports, the following technical domains have been identified as requiring corrective actions:

- telecommunications: insufficiently reliable and secure wide bandwidth communications. This insufficiency is considered as “undermining both the security of the personnel deployed and their efficiency”;
- earth observation derived imagery and mapping: insufficient “high/very high resolution regularly updated imagery which is compatible with the available ground systems”; improvement of Weather forecast capabilities for fast developing storms/fogs is also mentioned.
- SIGINT/ELINT space capabilities: increased intelligence capabilities are required as “ground-based signal intelligence is not always sufficient.”
- tracking, positioning navigation, search and rescue capabilities: limitations are related to possible GPS signal degradation and to an insufficient “combination of positioning and telecommunication capabilities”.6

In the field of security, a Group of Personalities set up by the European Commission and supported by the High representative for CFSP established a list of security threats for the European citizen and recommended increasing the security research in fields such as :

- protection of critical infrastructures,
- border control,
- civil Defence/protection,
- disaster management,
- law enforcement against trafficking,
- treaty verification.

The development of related capabilities in the following domains is mentioned to deal with those threats:

- intelligence means,
- assessment and analysis means,
- surveillance capabilities (for maritime security, border control or critical sites protection),
- secured communications capabilities.[7]

A Preparatory Action in the field of Security Research (PASR) launched in 2004 by the European Commission and supported by a European Security Research Advisory Board (ESRAB) has confirmed these security needs[8] which has resulted in a larger share of the 7th Framework Programme for R&D devoted to the security research.

All these exert studies/expert groups confirm that Europe is now facing a diversity of defence and security challenges that requires primarily flexible and high quality dedicated information systems. It is also recognized that space assets can bring both a unique and complementary contribution to these defence and security information systems.

Chapter II
Identifying the European Union's needs for use of space applications for European Security and Defence Policy (ESDP)

[6] *Ibidem*, pp.25-29.

[7] European Communities, ‘Research for a Secure Europe, Report of the Group of Personalities in the Field of Security Research’ (2004); http://cordis.europa.eu/documents/documentlibrary/ADS0003351EN.pdf

[8] European Security Advisory Board ‘Meeting the Challenge: The European Security Research Agenda’ (September 2006); ec.europa.eu/enterprise/security/doc/esrab_report_en.pdf

The level of use of space applications for defence and security in Europe can only be defined with reference to a comprehensive political and military framework. In a simplified manner, this framework is composed of:

1. European military operational or security requirements. Considering the documents surveyed above, the scale of needs for the years to come can vary from European security related monitoring functions or "low intensity" humanitarian interventions to full scale "Petersberg Tasks".

2. The phases of a military operation. Such phases highlight the different uses of space systems during any operation. A simplified typology can be presented as:

- strategic surveillance and monitoring of the situation: this phase will deal with possible preventive security or low level management of an emerging crisis. It mainly requires adapted intelligence tools.
- political-military consultations and planning stage: this phase covers the early planning stage as well as the emergency planning stage. It requires more focused and timely intelligence.
- deployment of forces (civil or military): requiring reinforced intelligence, telecommunication and other protective means in the case of military operations, both for the projected forces and for the Operational Headquarters.
- the conduct of operations: this tactical level phase can be considered as the most capability demanding for military related operations. In theory, the tactical nature of the operations creates a rupture in the use of intelligence and telecommunication systems due to heavy requirements in precision and timeliness, both for information collection and dissemination. In the case of high intensity operations, this tactical phase challenges very strongly the use of space systems considered alone.
- the disengagement of the forces: a careful monitoring of the local situation is required during the disengagement phase. In a military situation, a good knowledge of the local situation will help optimize the number of necessary troops on the ground, contributing to an efficient management and protection of the personnel engaged. It requires focused and timely intelligence
- post-crisis and reconstruction period: in order to prevent the re-emergence of a crisis and to bring an efficient help to the reconstruction or the restoration of a normal situation after a catastrophe, a sustained monitoring capability can be maintained.

3. The different situations confronting European defence and security forces may be presented as the result of the combination of these different missions and phases (See Figure 1 below).

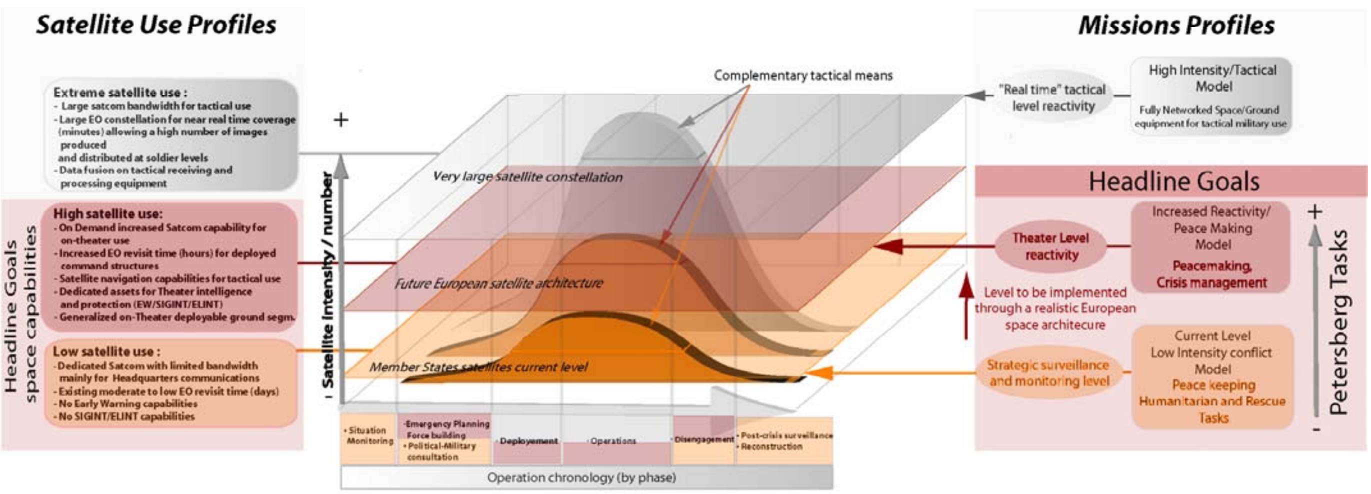

Fig.1 : Fulfilling the "Headline Goals":
Finding the right balance for satellite use
(Synoptic scheme)

According figure 1:

- the lower profile corresponds to the current level of use of space systems made in Europe for defence and security. Composed of a few national high resolution observation and telecommunication satellites, the current space architecture available to Europe only serves low level security and defence missions based on moderate monitoring and long-term surveillance missions. While this space system already helps Europe assess the seriousness of some security crisis situation, it clearly does not answer more demanding missions.

- the middle profile can be proposed as a roadmap for shaping a European space based architecture that is adapted to the security and defence requirements based on the most recent security research and corresponding to the capability needs stated in the latest European Union military committee capability documents for civilian crisis management and military operations9. It will require better coordinated high performance Earth Observation satellites for surveillance, detection and identification as well as more capable telecommunications satellites. It will also improvements in other key space capability shortfalls such as in the field of Electronic intelligence and ballistic missile early warning. Navigation and time synchronization will also be able to take advantage of the used based on the Galileo system when online within the next 5 years.

- the highest profile is only provided as a reference for high intensity military operational model which exceeds current ESDP requirements and that would require a significant increase in the number of satellites used.

Our analysis therefore argues that:

- a European space architecture can be developed to fulfil yet unanswered on-theatre needs.
- the “Petersberg tasks” associated to the “Headline Goals” concept provide a robust roadmap allowing to step up from the existing Member States current satellite level to a more integrated European Satellite Architecture.
- the need for space systems can be generally characterized as following a “Bell curve” due to an increasing demand on space systems during the conduct of operations (with a surge for the telecommunication needs during the operations and with an extensive use of Earth Observation satellites for the monitoring of the theatre and its environment).
- very high intensity operations and full tactical needs remain hardly satisfied by space systems alone considering the timeliness and the intensity of operations (revisit). Space systems can act then as support (telecommunications) or as secondary monitoring capabilities (Earth Observation).
- the need for increased space capabilities is especially strong during specific phases of a military operation, including the “political military consultation and planning phase” and the “disengagement” phase as outlined above.

Chapter III
Space-based capabilities and their use for defence and security

Satellite Earth Observation, telecommunications and navigation/positioning/time synchronisation services contribute directly to enhancing the performance of defence and security forces. They are key technologies that make up the so-called “Information chain” that relies on the following steps:

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[9] Council of the European Union, ‘ESDP and Space’ (November 2004, 11616/3/04); EU Military Committee ‘Generic Space Systems Needs for Military Operations’ (6091/06); Committee for Civilian Crisis Management ‘Generic Space Systems Needs for Civilian Crisis Management Operations’ (10970/065).

- imagery and data collection
- imagery and data transmissions for centralized information and/or exploitation
- information dissemination to the civil security/military forces on the ground

In this respect, requirements exist today for:

- more and better coordinated space based all-weather day/night Earth Observation capabilities for ground forces,

- **increased capability for space based telecommunication systems that can transmit large volumes of information on the ground:**

- **better integration of space-based navigation/localisation data that provide better and more efficient situational awareness to ground forces,**

- more signals and electronic intelligence space-based capabilities for planning secure military operations.

1. Earth Observation by satellite

Satellite Earth observation techniques provide permanent and long range surveillance for constantly refreshed situation monitoring and terrain mapping. Observation satellites are the only tools that can provide a global, homogeneous and uo-to-date picture of the whole planet, whether it addresses environmental research or the study of human activity. These satellites can “overfly” and provide regular images of almost any territory on the Earth, which allows the mapping of territories and infrastructures or the surveillance and monitoring of human activities and natural events without infringing upon national sovereignty. When operating at Low Earth Orbits (so-called LEO situated at an altitude between 300 and 1000 km), they can be precise enough to observe small objects down to one meter or below, offering unrivalled military intelligence or security monitoring. Furthermore, observation satellites have expanded into other fields in recent such as meteorology or oceanography leading to a high interest beyond military security users.

The following criteria can help sort out the different capabilities provided by Earth observation satellites:

- detailed reconnaissance, detection and identification: high precision (which depends on a good ability of the satellite to separate two objects on the surface of the Earth – this capacity is called the “ground resolution”) can be attained either by lowering the altitude of the satellite, or by equipping the platform with more powerful optical instruments. An efficient system must have high precision and a large instantaneous field of view. This allows combining a good reconnaissance and identification capability with a capability to quickly “scan” large areas of interest and thus produce useful reactive information.

- detailed observation: in order to complete the information obtained from an observed object, it is necessary not only to actually “see” the object, but also to collect information in other bands of the electro-magnetic spectrum. This piece of information can be obtained from high-technology sensors (called multispectral[10]) which multiply the frequency bands in which data are collected. The higher the number of frequencies, the better the “spectral resolution” and the quality of information obtained. In some instances, high spectral performances can largely improve the detection of objects and assist civil security forces or tactical commanders in the field.

[10] Even called “hyperspectral” when it involves several tens of different bands.

- frequency of updated imagery or data: sent by satellites to users is crucial to determine the actual operational use of the satellites. Crisis situations generally require the information to be updated frequently and to be constantly accessible. Tactical level requirements will be very demanding, whereas more intelligence oriented requirements will be less demanding. Considering the nature of the operations as shown in Figure 1, the required level for refreshed information by all weather, day and night, will be a few minutes and several hours, or even days. This performance directly depends on the ability of the satellites to pass over the same location in the shortest time (the revisit time) which, in turn, depends directly on the number of satellites in orbit. The availability of fresh data or imagery depends both on the agility of the satellite platform (the new French optical satellite programme called Pleiades has very high agility capacities) and on the number of satellites in orbit. The highest number of satellites, the shorter the revisit time and the fresher the information collected for the user. For this reason, earth observation satellites can be operated in constellations whereby several satellites complement each other to reduce the delays in obtaining data. The delay in obtaining information from space has to respond to the operational requirements as expressed by the users.

Specific mapping applications offering different levels of precision and data enrichment must take into account these characteristics.

2. Telecommunications by satellite

In the field of security and defence, satellite telecommunication systems often constitute the only means to set up a fully functional "information chain". They remain unique in their capacity to cover most of the world, with a particular ability to provide services when other capabilities (terrestrial networks, cellular phones, etc.) are absent or destroyed.

Satellites can be used to transmit data to distant headquarters as well as to disseminate information in the field to different units. Recent experiments conducted under the auspices of the European Commission's "Preparatory Action for Security Research" (PASR) have shown the usefulness of satellite-enabled local networks for civil security forces deployed in remote areas.[11] Criteria for assessing the performances of telecommunications space-based systems differ from the ones used for the Earth Observation satellites; whereby:

- telecommunication satellites predominantly use geostationary orbits (at an altitude of 36,000 km) which allows four of these satellites to offer a permanent worldwide coverage. In this respect, the telecommunication satellites do not have the revisit constraints of Earth Observation satellites. Geostationary telecommunication satellites already provide permanent coverage while only a few projects for Low-Earth Orbit (LEO) telecommunication satellites have emerged for specific applications such as satellite mobile phones or terminals. It should be noted that the latter are also often connected to terrestrial networks resulting in increased performances.

- the performances of such satellites are often determined by the frequencies and bandwidth for the associated applications. Satellite communication frequency range includes UHF (Ultra High Frequency) in addition to SHF (Super High Frequency) and EHF (Extremely High Frequency)[12]. UHF and SHF use NATO interoperable standards (between Europe and the United States, for intra-European cooperation). The higher frequencies (EHF for Extremely High Frequencies) are almost exclusively used by military forces considering their inherent capabilities. Such frequencies allow the transmission of large volumes of data at very high rates. In addition, such frequencies offer robust and

[11] As demonstrated in February 2006 in Poland during field experiments organised under the auspices of the ASTRO+ project supported by PASR.

[12] The frequencies of modern telecommunication satellites are composed by the UHF bands (300-3000 MHz), the SHF band (3-30 GHz) and the EHF (> 30 GHz). See Annex for specifications.

secure telecommunication links particularly suitable in situations where telecommunications must be guaranteed and protected.

- these satellites can also be used to relay information from earth observation satellites and thus provide the user with more immediate information. Innovative optical transmissions (i.e. laser-based transmissions) of large volumes of information at very large rates have been experimented. In this field, European industries have already established themselves as world leaders by demonstrating the first functional optical inter-satellite link between the SPOT 5 and the ARTEMIS satellites (SILEX experiment). SILEX / ARTEMIS validates the use of so-called *Free Space Optics Communication* (FSOC) for communication between geostationary satellites and Low Earth orbit Earth Observation Satellites. More recently the same capability has been demonstrated between a satellite and an airborne platform. The LOLA *(Liaison Optique Laser Aéronautique*) programme from the French military procurement agency has validated this system using optical communication to both unmanned and manned aircrafts using the same technology as SILEX. This "world first " demonstration has put Europe at the forefront of space telecommunications techniques, opening new horizons for the transmission of large volumes of data under highly secured conditions[13].

Only a few countries have been equipped with EHF or optical systems[14] given the complexity of the technology used and given the complexity of the technologies involved and their costs.[15] New technology improvements have also been demonstrated[16] such as the generation of enlarged mobile networks on the ground, thus creating new possibilities for mobile forces to set up quick and flexible local telecommunications systems in any situation and location.

3. Navigation and positioning for security: the role of Galileo

Navigation satellites represent the only system allowing users with a positioning and time synchronisation capability anywhere in the globe. Recent military conflicts as well as day-to-day security or rescue operations have demonstrated the usefulness of such systems in improving the coordination and the tempo of any operation conducted at sea, in the air or on the ground.

In addition to navigation, such systems also provide a precise time reference which will become a standard in a number of distributed information systems, for communication, energy distribution, banking, etc.

According to current estimates, by 2012, following a joint EC/ESA initiative, Europe will have a new Global Navigation Satellite System (GNSS), called Galileo[17]. This system will consist in a constellation of 30 satellites allowing users to know with extreme accuracy their position as well as access to advanced navigation services.

Currently European users, including defence, use the only available GNSS system, i.e. the American Global Positioning System (GPS). GPS provides two different services, an open one for all users and a restricted one (GPS-M) dedicated to US forces and their allies. It has been developed according to US Department of Defence requirements and the ultimate control of the GPS system is in the hand of the US supreme authorities (National Security Council); it is explicitly foreseen that GPS services can be disrupted by US authorities according to specifics security situations.

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[13] Allowing for example to use high volume space telecommunications for direct connection with drones (also called UAV for Unmanned Aerial Vehicles) that usually consume most of the bandwidth available in recent military operations.
[14] Only France has experimented successful space optical techniques today.
[15] See Annexe for detailed specifics on telecommunication satellites.
[16] Via the *Inmarsat-4* satellite family.
[17] For precisions see Gasparini, G. and Lindström, G. ‘The Galileo satellite system and its security implications’, EU-ISS occasional papers, n°44 (Paris, April 2003)

Despite its widely known and publicly acknowledged civilian character, the European Galileo GNSS system has intrinsic security implications and uses. Possible hostile uses of the positioning signal must be expected and should be avoided by a strict control on access by the supervisory authorities, thus allowing disruption and manipulation of its service as needed.

Moreover, the Galileo "Public Regulated Signal" (so-called PRS signal) in particular can be compared to the US GPS-M signal. Therefore, the use of the PRS signal by military and security forces cannot be excluded. A coordinated use of GPS and Galileo would compliment the capability offered by each of the systems and would enhance the user performance of both the U.S. and the European navigation systems.

The optimal configuration would be a dual-capable PRS and GPS-M system, thus incrementing precision and availability. However, a critical decision needs to be made regarding accessibility to PRS receivers. The PRS signal and receivers should be reserved to military force with a high level of security clearance. Police and Public Safety services do not need constant access to the PRS level of accuracy and should be granted access to the remaining Galileo services[18].

4. Space based signal and electronic intelligence capabilities

Electronic or communications intelligence (ELINT/COMINT) from space are an increasingly used for security and military operations. This specific activity can be considered as allowing a remote "observation" of command and control systems, including for example air defence radars or tactical military communications.

Such technical data are mainly used for the planning of military operations (providing a better knowledge of the adversaries capabilities, allowing them to enhance effects and minimize casualties) and during the operations. More largely such data can also contribute to broader security needs such as for surveillance and monitoring of illegal activities or trafficking.

Chapter IV
The strategic dimension of the space sector: access to space, independence of information.

In Europe, space programmes have been developed separately by several member states. France has been a pioneering European member states in this domain, creating the French Space Agency CNES in 1961. Out of almost 28000 people working in the space sector in Europe, around 11000 are employed in France either by CNES or by leading space industries[19].

This nationally oriented activity has included an access to space programme with the Ariane Launcher family programme which has largely relied on previous national investments and resources. Fundamentally, the requirement for autonomy in access to space, first nationally oriented but soon becoming European, has been at the origin of the Ariane programme.

Following the same logic, the earth observation programme took shape in Europe during the same period of time. Initially under the aegis of France (with the Spot satellite family inaugurated in 1986), and then shared by an increasing number of European countries.

[18] In addition to the Public Regulated Service, they include:
- the open access service addressing mainly the mass market;
- the commercial service intended for professional users requiring guaranteed performances;
- the safety-of-life service for applications where human life is at risk, hence requiring integrity of information;
- the search and rescue service to localise distress events and initiate rescue operations.

[19] ASD-Eurospace Fact and Figures, June 2006

It remains that this interest does not necessarily reflect a view widely shared by all of the EU member States. Still, the last years have seen the birth of new projects in European States traditionally barely interested by such programmes (some examples are given further below).

Generally, a stronger interest exists for national telecommunication satellites (Satcom), although only a few countries (France, Italy and the UK) have military dedicated systems. Once more however, new projects are emerging in Germany and in Spain allowing them to join the club of the European Satcom States, offering the perspective of a virtual European Satcom architecture for military and security purposes (the main programmes are described below).

Part Two
Trends in existing space systems for defence and security in Europe

Both civilian and military space systems have been developed in Europe for more than 20 years. The main European focus for civilian programmes has been through the European Space Agency (ESA). The ESA has worked to incrementally Europeanise national efforts. The ESA has a mandate for civilian scientific or experimental programmes and did not extend to national defence related programmes which have remained out of its mandate.

Other cooperation efforts between national space programmes are now underway and represent a new trend towards extended European cooperation in the field of space for "non defence" security dealing with issues such as civil security, law enforcement or critical infrastructure protection.

The European Union's rules forbid its budget to be used for defence related programs. Paradoxically, a number of existing or planned national and cooperative programmes are now being considered as having dual missions, i.e. civilian and military and fit the Union's objective of improving the "security of the citizen". It is particularly the case with the so-called "flagship" programmes represented by GMES (Global Monitoring for Environment and Security) and Galileo (the European navigation satellite programme) managed jointly by the European Commission and the ESA.

The gradual convergence of such dual-use programmes will be necessary to create a new European architecture for space based systems that can make the most of scarce national resources for common European objectives in the area of security. In addition, such an architecture would optimize the use of scarce national resources and therefore would make a European space based architecture more cost effective.

Chapter I
National security and defence: Earth observation programmes

1. The French experience

(a) Spot/Hélios family

Two families of Earth Observation (EO) satellites have been used in France for more than 10 years. The first family, the "SPOT" satellite series inaugurated in 1986, has been devoted to environmental remote sensing and monitoring applications. The limited ground resolution of the system have kept the military use of this service at a relatively low level. In addition, imagery proved expensive and ad hoc availability contributed to a lack of interest from the military. Subsequent modifications have been introduced whereby the current SPOT-5 satellite serves both civilian and military interests. With the French MoD financing 50%, the SPOT-5 HRS (High Resolution Stereoscopic) instrument delivers high resolution data allowing a High-Rate production of 3D-Digital Terrain Modelling (DTM), serving both civilian uses (urban planning, disaster management, etc.) and military purposes (mission planning, fly-over preparation, targeting, etc)[20].

The military satellite family started with the Launch of Helios-1 in 1995 which radically improved the perception of the usefulness of space-based assets by military users. As a consequence, the level of imagery demanded has dramatically increased over the years, rapidly exceeding capabilities. In a few years, the creation of a dedicated asset for military purposes has indeed helped convince the users of the benefits of space systems reserved for military and security users.

The Helios series has largely been shaped by the specificities of the Cold War for national French purposes. Therefore, Helios has primarily been conceived as a "strategic level" system allowing the highest political and military authorities to gather information for the benefit of intelligence and French nuclear forces. As

[20] The instrument is now used jointly by the French MoD and the commercial operator, Spotimage.

result, the Helios system is a strictly “closed” information system with a very high level of classification of imagery (“Defence Secret” level).

A further evolution was introduced in the second satellite, Helios 1-B in 1999, which enables the operational chain of command to use the system for military planning purposes.

The Helios 1 generation was based on a centralized structure (even if operationally shared between France, Italy and Spain). The main mission planning, processing and archiving centre was located in France while the two other centres situated in Italy and Spain were locally responsible for data collection and tasking orders.

The Helios 2 generation with ground segments was put into service in October 2003 (for the H1 version) and mid-2004 (for the H2 version) and has additional its main centres in Belgium and in Germany. Furthermore, 15 distant “cells” are part of the operational locations enabling the users to get linked to those cells functioning as “mini-centres”. In addition, new links with theatre deployable stations are now possible. These incremental changes allow tasking orders directly from distant cells and to exploit the produced data in the operational centres.[21]

(b) Pleiades constellation

Pléiades is now part of a collaborative Franco-Italian effort to develop satellites in the field of optical (Pléiades) and radar (Cosmo-Skymed) imagery. While studies for a successor of the Spot series to establish a constellation of satellites providing high-resolution multi-spectral as well as radar imagery had been started by CNES in the nineties, a parallel effort was undertaken by the Italian Space Agency with the Cosmo-Skymed programme for a constellation of radar satellites. The convergence of views led the Ministries of Research and Technology in the two countries to initiate in March 2000 a study for increasing cooperation between the two national programmes and has subsequently led to the “Torino Agreement” signed on the 29th January 2001.

The Pléiades system, as the successor to the SPOT satellite series has a dual-use objective. In this respect, security classification issues are important as intelligence and surveillance missions are considered as being part and parcel of the programme. Pléiades will be used in both civilian and in military modes, and by French and Italian communities, which has reinforced the need to deal with bi-lateral security issues.

The system has also taken advantage of existing multi-national cooperation on the Spot and Helios programmes, where Austria, Belgium, Spain and Sweden have agreed to share the costs and possible benefits from the programme. In return these countries have been assured of an access to the resources in proportion to their investment.

The decision to go-ahead with a dual-use system such as Pleiades was based upon technological developments that enabled Pléiades to fulfil some of the most stringent military requirement specifications. The Pléiades system relies on a specific high-performance satellite-bus equipped with:

- the last generation optical-fibre gyroscopes
- a high-agility “mosaic” capability allowing 6 to 8 images of the same site in the same passage
- a high power solar cells
- a high data rate transmission system[22]

In this respect, the Pléiades system represents a real departure from the SPOT-5 generation technologies.

[21] See Annex for specifications
[22] Refer to annex for a summary of the system performances.

2. New developments in the Earth Observation sector

(a) Italian Cosmo-Skymed SAR satellite constellation

An increase in the number of external operations for the Italian armed forces and a desire to have better “situation awareness” of the Mediterranean basin, led the Italian Government to complement its initial access to the Helios-1 imagery. Due to its technical complementarity with optical imagery, a radar satellite project was selected initially for civilian monitoring of the Mediterranean basin and then extended for the use of the Italian Ministry of Defence.

This project, called Cosmo-Skymed (standing for Constellation of Small Satellite for the Mediterranean basin Observation) will be associated with the French Pleiades programme to build the ORFEO programme (See below).

(b) The German Sar-Lupe programme

With the end of the Cold War and the reunification, new operational requirements have been identified for intelligence capabilities in Germany. A more active role in external operations, following the transformation of NATO, as well as a need for autonomous intelligence capabilities for national purposes have triggered an interest for Earth observation space assets. Existing German industrial competence in the radar sector encouraged the German government to invest in a national satellite radar observation programme in the early 1990’s. An initial Franco-German cooperative option for a joint programme including a German radar component (called Horus) was abandoned due to projected costs.

After the break-up of Yugoslavia, Germany decided to get equipped with an independent operational surveillance and intelligence programme in order to assert German positions in coalitions. The programme SAR Lupe was announced with the goal to develop nationally a radar satellite programme while keeping open options for cooperation. The decision was made for a purely military programme, which reflected a more limited interest for dual-use systems in Germany.

(c) The UK SSTL programmes and Topsat Satellite

In 1996 Surrey Satellite Technology Ltd (SSTL), a British firm created in 1985 by the University of Surrey, proposed to develop an Earth observation constellation based on low cost small satellites allowing medium ground resolution. In 2000, the MOSAIC programme (Micro Satellite Applications in Collaboration) was launched with support from the British government which allowed SSTL to develop a class of EO satellites for several national governments (Algeria, Nigeria, Turkey and China) for disaster monitoring. The national partners formed the DMC consortium (Disaster Management Constellation) based on a common agreement for building a coordinated constellation allowing 5% of the operational time of national satellites to be devoted to disaster monitoring.

However, moderate performance meant the SSTL satellites have mainly specialized on area monitoring for environmental purposes. A new business unit coordinated by SSTL called DMC Imaging International was formed in November 2005. Its aims to provide rapid imagery both for commercial and for humanitarian users, while adhering to the principles of the “International Space and Major Disasters Charter”. Following this experience, SSTL will act as the platform supplier to the German RapidEye project which consists in a constellation of 5 satellites primarily devoted to agricultural monitoring and markets. Built in cooperation with MDA Corp. (Canada) and Jena Optronics GmBH, these satellites have now reached the integration phase and the ground segment has been developed.

Whilst mainly delivering medium to high resolution civilian applications, the SSTL small satellite family is an evolving capability that exists in Europe and which offers an example of a cooperative arrangement for future architectures.

(d) Other programmes

A SAR satellite programme, TerraSAR-X, has been funded by the German Ministry of Education and Research and built by the German Space Agency, DLR, and the industrial firm EADS Astrium. It will provide 1m resolution X-Band radar imagery for a large customer basis ranging from scientific users to commercial users. An evolution of TerraSAR-X (Tandem –X standing for TerraSAR-X Add-on for Digital Elevation Measurement) is envisioned by DLR with EADS Astrium. This programme will increase the performance in X-band radar imaging by using an additional radar platform (TerraSAR class) jointly with the first TerraSAR-X.

In 2006, the Spanish Government authorised the SEOSAT programme (Spanish Earth Observation satellite) to be financed in the framework of the European project GMES. The Spanish satellite will be developed under the auspices of the ESA and will provide GMES with an additional capability.

In December 2005, the Swedish armed forces started to investigate an Earth Observation capability for military and security purposes. The objective is to allow Sweden to manage national and international crisis with high performance capabilities worldwide. The Swedish Space Corporation, along with the private firm SAAB Space (and in collaboration with Nanospace, a subsidiary of the University of Upsalla), has initiated a dual-use satellite project called SVEA, available to the armed forces as well as other customers involved in crisis management situations. This mission is itself derived from the European Space Agency SMART-1 platform largely conceived in Sweden, showing the dual-use possibilities raised by high technology European-made civilian programme.

3. Cooperation in EO sector

(a) Hélios 1 and 2 cooperation framework: lessons learned

Helios-1 and 2 cooperation can be seen as a model for a new type of inter-governmental agreement. Nations have decided to cooperate to develop a space system with each participating nation agreeing to share a common resource (i.e. without buying satellites for their own use only). The Helios-1 cooperation scheme is based on the notion of proportionality between the cooperation rights and the percentage of initial national investments in the programme. France, Italy and Spain have collaborated in the development of the Helios-1 series with respectively 78,9%, 14,1% and 7% of the investments[23]. In 2004, the consolidated user experience has shown that associated national tasking orders were respectively 41%, 11% and 7%, with a commonly tasked imagery amounting to a level of 42% of the tasking orders. These figures clearly demonstrate a strong convergence in the use of imagery over a 10 year period[24].

(b) Bilateral agreements

Cosmo-Skymed/Pléiades: the French-Italian agreement

An Inter Governmental agreement between France and Italy was formally agreed on the 29 January 2001. This so-called "Torino Agreement" aims at establishing a dual system comprising an optical component under the leadership of France (the Pléiades programme component) and a radar component with 4 satellites

[23] Helios-2 is mainly financed by France (95%) with the participation of Belgium (2.5%) and Spain (2.5%). Italy has been included afterwards in the Helios team following a specific agreement signed in June 2005. Specific agreements for Helios-2 data exchanges have also been signed with Germany (SAr Lupe) and Italy (Cosmo-Skymed).
[24] In 1995-96, the level of cooperative taking was levelling at a figure of less than 5%.

and the dedicated ground segment under the leadership of Italy (the Cosmo-Skymed programme component). The Inter-Governmental Agreement enshrines the dual-use character of the programme and the definition of principles for adequate resource[25] sharing, imagery ownership and diffusion[26] under a cooperative effort named ORFEO (standing for Optical and Radar Federated Earth Observation). The general management of the Agreement is ensured by a Steering Group composed of French and Italian Representatives.

Given the civil-military nature of the programme, two ways of accessing the programme have been envisioned, whereby:

- the defence institutions will have direct access to the satellites and receive and process the data on dedicated sites,
- non-defence users will have to go through a civilian operator[27] to have their requests processed and distributed.

It is envisioned that 40% of the resources of ORFEO will be devoted to institutional cooperation, and less than 10% (50 images a day) being reserved to cooperative defence[28].

The ORFEO ground segment will include several user centres located in France, Sweden, Spain and possibly Italy. Each of these centres will be able to deal with task orders including image acquisition and product generation. They will be linked to a dual use centre located in France. The ORFEO ground segment will include two dual use centres. The secure dual use centres will be located in Toulouse performing command and control activities. It will also host the defence cooperation function and establish a tasking order planning reflecting the priorities given by the defence users.

As far as the Cosmo-Skymed segment is concerned, both the programming centre and the command and control centre will be located in Italy. Special protected zones will be created for each country for processing data classified "National Defence Secret" and others for data classified "Shared Defence Secret".

The Franco-German agreement

In the context of the signature of the BOC document with France in 1999, Germany decided to complement the future SAR data with optical imagery coming from the French Helios Satellite. Following a Franco-German declaration made in Mayence in June 2000, a bi-lateral exchange agreement between SAR Lupe and Helios II was signed on July 30, 2002 (the so-called Schwerin agreement).

(c) The state of an operational EU asset to support CFSP in particular ESDP: the case of the Satellite Centre of the European Union (EUSC)

The use of Earth observation satellites by Europe for military ends, originated in the Western European Union.

After having organized a range of activities on space, the WEU then moved on to tackling the question of observation satellites as a European instrument for the verification of arms control treaties and, in particular, that on Conventional Armed Forces in Europe (CFE). The Gulf War illustrated European weaknesses to deploy information systems and raised political interest in programmes like Hélios in a number of European countries.

[25] The notion of "resource" being defined in term of satellite tasking
[26] IAF Congress, 'The Pleiades Optical High Resolution Program', (Valencia, Spain, October 2006, IAC-06-B1.1.04)
[27] Under discussions between the French space agency (CNES) and the private operator SPOTIMAGE.
[28] 'The Pleiades Optical High resolution Program', Op.Cit.

More fundamentally, the WEU faced the challenge of heterogeneity among its member countries, whether it concerns their financial resources or their political and strategic approaches. In May 1997 it was decided to reinforce the Centre's field of activity and the Centre was transferred to the European Union in July 2001.

Since it was transferred to the EU, the Political and Security Committee exercises political supervision over the activities of the Centre and issues guidance to the Secretary-General/High Representatives on the Centre's priorities. The SG/HR gives operational direction to the Centre, without prejudice to the responsibilities of the Board and of the Director of the Centre.

Today, the mission of the EUSC is to support the decision-making of the European Union in the context of the Common Foreign and Security Policy (CFSP) and in particular of the European Security and Defense Policy (ESDP), including European crisis management operations by providing analysis of satellite imagery and data.

The Centre's also trains specialists (such as imagery analysts, end-users of imagery-based products) and develops concepts on standardization and interoperability of imagery analysis and computing and communication systems.

The Satellite Centre's priorities reflect the security concerns defined by the European Security Strategy, namely monitoring regional conflicts, state failure, organized crime, terrorism and the proliferation of materials and weapons of mass destruction. The Centre gives, for example, support to EU operations such as the EUFOR in Bosnia and Herzegovina. The Centre is also an important Early Warning tool, facilitating information for early detection and possible prevention of armed conflicts and humanitarian crises. The Centre carries out the following tasks:

- general Security Surveillance over areas of interest,
- support to humanitarian and rescue tasks,
- support to peacekeeping tasks,
- tasks to combat forces in crisis management (including peacemaking),
- treaty verification,
- arms and Proliferation control (including Weapons of Mass Destruction),
- contingency planning,
- support to Exercises,
- other activities, such as judicial inquiries.

As the only existing CFSP/ESDP operational agency using space assets, the EU SATCEN is perceived as a key European-level stakeholder for GMES Security domain that could contribute substantively to meeting GMES' operational deadlines. Therefore, it is today an active second pillar participant in the GMES Advisory Council. As the Security dimension of GMES increases the Centre is also participating in several GMES projects in order to develop new pilot services for GMES in the security domain (e.g. on border control and maritime security). An example of EUSC products in 2006 included support to FRONTEX addressing the illegal entry of persons to the EU through the Canary Islands by boat from the African coast. The EUSC will also take part in FP7 activities related to Space and Security.

Given the growing awareness of the usefulness of space in support of Maritime Surveillance and the fact that the second pillar is increasingly addressing maritime security (e.g. EDA Maritime Surveillance study, EUMS Maritime Dimension study, etc) and the importance of Maritime Security for GMES, the Centre's involvement in space support to maritime surveillance is growing. However, it is an area that needs to be developed if it is to provide operational services.

In order to maintain and expand European Union Satellite Centre's activities, a series of objectives need to be addressed to guarantee its operational efficiency and role within European Security and Defence policy. These objectives include:

- recognition of EUSC as the leading provider of high quality and relevant geospatial intelligence services that customers need in support of CFSP/ESDP,

- full integration of EUSC capabilities in ESDP operations
- recognition of EUSC as an essential partner in the EU GeoInt community and a key operational tool for European Union in its external relations
- increase the business efficiency of the Centre
- recognition of the EUSC as an Agency relevant for the European Space Policy, in particular for the security domain of GMES.

(d) Future trends: from BOC to MUSIS

Since 1999, steps have been made regarding cooperation in the field of Earth Observation as shown by a five-country[29] agreement entitled “Common Operational Requirements for Global European Earth observation System by Satellites” (more commonly known by its French acronym BOC - Besoin Opérationnel Commun). The document, that remains classified, was signed in 2001 by the participating countries among which Greece has enlisted more recently.

While the BOC document represents a first step to harmonize operational requirements and national programmes, the 6 countries (plus Sweden as an observer country) have decided to deepen their cooperative endeavour by engaging in a collective definition of the future generation of observation satellites. The future system, to be called MUSIS (Multinational Space-BaSed Imaging System for Surveillance, reconnaissance and observation) should respond to the whole range of data collection requirements, from the political to the military.

Such an architecture would benefit from the technologies and orbits used by national systems with in the following areas:

- intelligence and targeting,
- improvement of the detection of activity indicators on limited zones of specific interest,
- improvement of all-weather day/night revisit capabilities with an increased reactivity as seen from the military users,
- improvement of environmental data production

In this respect, MUSIS will cover a wide range of data collection techniques, which should improve the use of these data.

(e) Defence forces/MoD, a user for civilian security space program.

As discussed, a new European initiative, GMES, was announced in 1998 for environmental monitoring.[30] This programme has been enlarged to the security of “individuals and nations”. In 2001, a report by the *Joint Task Force*, confirmed the importance of the « S » of GMES. Some excerpts of the Task Force report include:
“The security and dual use dimensions of GMES have not been adequately investigated so far [which must lead to] establish an appropriate dialog between the Directorate General of the Commission, the Secretariat of the European CFSP, ESA and relevant authorities in Member States [and] determine the future role of ESA with respect to these issues.” [31] In particular, GMES should take into account the “Petersberg Tasks” and civil security missions including operational forecasting, hazards mitigation, damage assessment and rescue operations, health and food problems with some predicting capabilities. Beyond the humanitarian dimension, other possible uses of GMES can also be envisioned in the field of security, in particular as a contribution to the verification of disarmament treaties.

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[29] Belgium, France, Germany, Italy and Spain; France and Germany having initiated the idea.
[30] ASI, BNSC, CNES, DLR, EARSC, ESA, Eumetsat, European Commission, ‘Global Monitoring for Environment and Security: A Manifesto for a European Initiative’ (1998).
[31] ‘Joint Task Force Report’ (September 2001).

In November 2005, a so-called GMES “Fast Track” service was agreed in three areas:

- land monitoring,
- global maritime services,
- and to set up of a dedicated information infrastructure.

The GMES project also envisions the development of “Sentinel” satellite programmes. These Sentinel satellites will be regrouped in four families:

- C-band radar satellites (Sentinel-1) to be orbited between 2008 and 2010,
- high spectral sensitivity satellites (Sentinel-2) also envisioned for launch during the 2008-2010 period,
- maritime surveillance satellites (sentinel-3),
- atmospheric satellite satellites (Sentinel 4 and 5).

Technically, these satellites could be considered as complementary systems for a future security and defence space architecture. However, from the system point of view, it would be inappropriate to consider GMES at this stage as a possible substitute for dedicated military systems. In particular, a number of security and defence users mention the necessity to ensure a secure distribution of sensitive data in a collective GMES user architecture that would remain basically opened. In the same vein, it is mentioned that the GMES architecture would have to guarantee the authenticity of the data distributed for security and defence purposes.

Today, the current GMES development process shows that the program cannot be regarded as a fully deployable part of any future European space architecture for security and defence. Until now a relatively cautious approach has been adopted for a project whose dual aspects are recognized as potential contributors to the field of defence and security.

It should also be highlighted that a number of military-oriented space systems are also able to contribute to the GMES missions. Their inherent capabilities, especially for Earth observation, would indeed enhance the performance of GMES, provided that their collective management could be agreed.

Chapter II
Telecommunication satellites

1. Telecom satellite technologies for defence, a service often based upon civilian systems.

Military and security communities are increasingly relying on commercial systems to provide larger and larger bandwidth necessary for complex military systems. For example, it is now well-known that roughly 80% of the satellite telecommunication needs of the United States during the second Iraqi Conflict has been satisfied by the use of leased commercial satellite channels.

Current so called Milsatcom architectures are mainly conceived as comprising to levels of services:

- The “general purpose service” is destined to ensure non protected military communications (routine communications, day-to-day support or personnel communications) that can be transited through reasonably reliable and guaranteed commercial service. Nowadays, international organisations like Intelsat can be considered as principal operators for the U.S. military. These services are usually provided as support in the SHF portion of the spectrum allowing a reasonably wide band useful for high volumes of transmissions.
- The “hardcore service” deals with highly protected military transmission. For this reason, it is observed that higher frequencies (in the EHF region) are used as they simultaneously provide more capability with enhanced security and robustness for the users. The complexity in mastering the

related technologies makes these hardly accessible and non viable for any developing commercial business. Robust SHF capabilities are also available to answer core military needs.[32]

In Europe, only a few countries have developed EHF capabilities. It must be noted that two of these countries, namely France and the United Kingdom, are nuclear countries and must ensure as such most secure communications in this context.

2. Main existing systems: French, Italian, Spanish and UK systems

In the field of telecommunications, each of these countries has developed national space capacities, although the nature and the scale of the efforts have differed.

- The United-Kingdom uses the Skynet system (managed under special conditions by the private firm *Paradigm*), a constellation of three dedicated satellites with worldwide coverage for the British armed forces. Technically, this Skynet family has formed the backbone of the NATO Satcom effort with the NATO Satcom series. In August 1998, the British government decided to develop Skynet V, a new generation of military telecommunication satellites, under a so-called "Private Finance Initiative" (PFI), whereby the system is fully dedicated to the national authorities in times of crisis, but the managing organization can commercialise the capability for the rest of the time (see Paradigm/Skynet approach description below).

- The French armed forces have first used the civilian satellite platform, Telecom-2, which was carrying military transponders. The UK and France first signed an agreement in 1995 to extend the coverage of their systems and to lend each other their capabilities in case of a defect in one or the other. France signed other agreements of this kind with NATO in 2000 and Spain in 2001. Dependence on a civilian system has required the French Ministry of Defence to pay for capabilities even when they were not needed. This extra cost, and new requirements for higher data rates and more robust telecommunications, has prompted the French military authorities to opt for a new military dedicated system. This military-only programme, Syracuse III, is consisting of two satellites, one launched in 2005 to ensure service continuity, and the other launched in 2006 to ensure full coverage. A third satellite is planned by 2010.[33]

- Italy, with its satellite SICRAL-1 has also some limited capacities. It must be noted that SICRAL-1 is designed for a 10 years lifetime (until 2011) while a second model, SICRAL-1 B should be launched at the end of 2007 with a lifetime until 2019. A new generation satellite, SICRAL-2 would be operational starting from 2011.

- Spain has launched in March 2006 its own dedicated telecommunication military satellite, Spainsat, developed by the US firm Loral, and operated by Spanish the ministry of defence. It must be noticed that the contract with Loral implied the construction and the launch of a second Spainsat-class satellite as a possible back-up capacity. This second satellite, XTAR-Europe is operated by the Spanish operator Hisdesat in collaboration with Loral, today providing to the US and Spanish authorities (and other possible customers) additional capacities. This arrangement follows the Paradigm model already mentioned for the United Kingdom.

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[32] For example, a total of 600 stations are envisioned to be in service in 2014 for French core military use. Complementary needs are covered by commercial agreements with ASTEC-S and INMARSAT capabilities. In the future, the Ka band could be used to extend these latest capabilities.

[33] The current operational service contract envisions the maintenance of 18 secure (anti-jamming transponders) until 2018.

The French, Italian and British capabilities, pooled together, have been chosen by NATO to provide a first so-called “Satcom Post-2000” architecture for SHF communications. Again, the multiplication of national capabilities has ended up with a credible collective resource, giving birth with both a European and a NATO resource.

3. New service-based approach for telecommunications: the NATO Satcom contract, Paradigme/Skynet procurement

The recent NATO servicing contract illustrates how much European cooperation could help answer large needs in the field of satellite communications. Indeed, the current NATO servicing contract is fed by the addition of the capabilities provided by separate national military telecommunication satellites, each of them being dimensioned in order to answer maximum crisis requirements levels at national level. Usually unused, some “extra capacities” can then be devoted to servicing the NATO forces. In this particular case, the new service based approach used for the NATO Satcom Post-2000 contract is based on the addition of capacities available from the British Skynet, the French Syracuse and the Italian Sicral satellites. (Existing European Systems providing the NATO Satcom post-2000 SHF service, see Annex pag. 69.)

According to NATO Satcom V service contract valued at 815 million EUR, the SHF service is provided to NATO during the 2005-2019 period in a proportion of 45% by the Skynet satellites; 45% by the Syracuse satellites and 10% by the SICRAL satellite[34]. The service in itself would possibly mobilize an average of one third of the existing capabilities of each satellite (as accounted by the number of transponders used in the relevant frequency band).

Relevant from the operational point of view, these added national “extra capacities” demonstrate similar capability planning procedures for each of the three member States. Basically, a “routine” capability forms the bulk of the telecommunication operations, mainly in the SHF band, with the addition of other kind of capacities either in UHF of EHF bands according to specific national needs. This cooperative evolution shows that possibilities exist to conceive common capabilities based on common needs (as already explored in the framework of the Earth Observation “BOC” – see above-). A common service architecture can also be envisioned, as it has been demonstrated both by this NATO model but also by the UK Public-Private partnership organized by the British MoD with the private contractor Paradigme. In particular, possible cooperation for Ka band systems are being studied by ministries of Defence and space agencies from Belgium, from France, from Italy and from the United Kingdom.[35]

4. The new German project SatcomBw

Starting from 2009, two new German military dedicated satellites will be launched for an operational life of about 15 years. Signed in July 2006 with EADS Astrium as the prime contractor, the contract will be managed by Milsat Service GmbH, a joint venture established for this purpose by EADS Astrium (74,9%) and ND-Satcom (25,1%), a subsidiary of the commercial satellite broadcasting firm, SES ASTRA. Milsat Service GmbH will have the German Ministry of Defence as its direct customer, also helping to provide the German military with commercial transmissions, for example by using Intelsat satellites when possible.

These satellites that will be NATO compatible, will provide sufficient capabilities for transmitting a range of communications, from telephone calls to multimedia connections. To this end, these satellites will carry both UHF and SHF transponders.

Two types of terminals will be available:

[34] SICRAL would also provide a UHF service, with Skynet as a back-up.

[35] French Ministry of Defence, ‘Let us make more space for our defence: strategic guidelines for a space defence policy in France and in Europe’ (Paris, February 2007) p. 20.
http://www.defense.gouv.fr/defense_uk/content/download/59558/563200/file/20061219%E2%80%A2int%C3%A9rieur%20VAng%E2%80%A2070103.pdf

- Large terminals with all telecommunication possibilities will serve as node for local on-theatre communications and for installing fixed data networks.
- Smaller portable terminals will also be able to use broadband services such as video and internet access. These terminals will be delivered in large numbers.

Milsat GmbH will deliver the terminal, an extension of anchor stations in Germany and a new central network management and facility.

The development cost until 2009 is estimated at around 950 million EUR for the German Government while The 10 year service contract is expected to generate a revenue valued at 180 million EUR for Milsat GmbH.

5. The access of "non-space" countries to telecommunication services for defence

Paradigm secure communications, an EADS subsidiary, has positioned itself as a leading service provider for military telecommunication satellites in EU. Its business base is a contract with the UK but then the company was able to foster services contracts for Portugal and the Netherlands. The main business idea of Paradigm was to sell an inclusive service, the customer not being proprietary of the assets. Those existing contracts clearly define a model for access to military satcom for countries who do not own systems. Paradigm is a "service" oriented business contract but other forms of agreement could be fulfilled, for example within a public framework where some countries who own the technology could accept to share it with another compensation mechanism.

6. Other on-going programmes: Athena-Fidus , DRS/Artemis

Other programmes must be mentioned as providing dual telecommunication capabilities:

- The Franco-Italian Athena-Fidus agreement signed on 22 June 2006 by the Heads the French and the Italian Space Agencies aims primarily to answer the needs of the Ministries of Defence while keeping opened options for civil security uses of highly performing capabilities. Envisioned for launch in 2010, the Ka band Athena-Fidus satellite would provide the most highly capable civilian technologies (allowing in particular large transmission and multimedia uses) based on standardized civilian telecommunications and allowing the use of commercially derived low-cost terminals. Belgium would be interested in participating to the project.

- The possibility of *Data Relay Satellites* (DRS) has also been demonstrated via the ESA experimental satellite ARTEMIS launched in 2001 and allowing inter-satellite links (crosslinks). Such capabilities demonstrated for Earth Observation satellites like the ESA satellite ENVISAT or like SPOT 4 will largely increase the availability of the data by accelerating their transmission to the ground. In addition, highly sophisticated high data rate laser links have also been demonstrated not only for inter satellite connection but also for establishing links between satellites and airborne platforms. These latest developments, only mastered in Europe, clearly bring a qualitative improvement when compared to previous telecommunications flexibility limitations.

- New developments for mobile terminals capabilities have also been operationally tested through the last generation Inmarsat-4 satellite family (in orbit since 2005) with possible key operational consequences for the military and security uses. New networking capabilities can indeed be envisioned by using satellites only, offering specific user communities the possibility to set up reactive local networks in any crisis situation. According to industry, these new technologies are expected to bring a strong added-value to the use of telecommunication satellites in the field of security by the next few years.

Chapter III
Developing space technologies: early warning and ELINT French experimental systems

1. Early Warning Demonstration programme

One particular application of satellite Earth observation consists in the surveillance of ballistic missile capabilities and early warning associated functions. This activity relies on infrared optical observation means, usually placed on a geostationary orbit (or on very elliptic orbits) and calibrated for the monitoring of the thermal emission produced by the ballistic missiles engines. Thanks to the localisation of the thermal emission, the space system allows the determination of the missile launching site missile and, possibly, its trajectory and its final expected impact zone. Such a system can contribute to the protection of targeted populations and can also provide intelligence regarding the proliferation of weapons of mass destruction.

In Europe, no such operational monitoring and early warning system exists as of today. However, a exploratory activity has been started by France in 2004 under the form of a 124 Million Euro MoD demonstrator programme called “Spirale” and awarded to EADS Astrium SAS as the prime integrator, and Alcatel Alenia Space as the payload developer. This programme includes the conception and the development of the space segment which will be composed of 2 micro-satellites (120 kg-class) envisioned for launch in 2008 on an elliptic orbit. These micro-satellites will have as a prime mission to collect terrestrial backgrounds in infrared mode and test the ability to detect missiles signatures in selected bandwidth. In addition the demonstrator will comprise a specifically developed ground segment.

2. French ELINT perspectives

Electronic intelligence capabilities are contributing to the global intelligence performance with specific uses regarding the military operations, during the mission planning phases or during the operations. ELINT systems can be terrestrial, sea, air or spaceborne. In this field, the French government has decided to finance a space demonstrator called ESSAIM and composed of 4 micro-satellites (120 kg-Myriade platform family – see above) flying in controlled formation allowing a frequent revisit time. Launched in 2004, this programme developed by EADS Astrium is maintained by CNES and is transmitting its data to the DGA’s weapons electronic centre located near Rennes. One of the missions of the programme is a better characterisation and mapping of the terrestrial electromagnetic environment in the military communications domain.

Another demonstrator, ELISA (ELInt SAtellite) is envisioned for launch in 2010. This DGA programme awarded to the French firms EADS Astrium and Thales will consist in developing 4 micro-satellites (ESSAIM class) operating on a sun-synchronous orbit with the objective to identify radars emitters worldwide. This experiment should start in 2010 for a 3 year long experiment in orbit.

While requiring a strict control of the dissemination of the data due to their “intelligence” content, technical as well as industrial cooperation in the ELINT/SIGINT domain is not perceived as presenting fundamental differences with the cooperation envisioned under the MUSIS model. Such cooperation has been recently mentioned by France as a possibility in the framework of MUSIS.[36]

Chapter IV
First perspectives for a future European space-based architecture

This description of past collaborative programmes or on-going projects gives a first view of what could be the definition principles of a realistic European architecture. The following areas seem to be particularly crucial for a balanced and acceptable “system of systems”:

[36] Op. cit. ‘Let us make more space for our defence...’, p. 23.

1. Closer civilian and military needs and technologies, but enduring differences

While it is clear that technological advances, both in the observation and in the telecommunication field, render more and more possible and interesting the use of dual systems or services for civilian and military, it remains no less clear that some technical differences will remain to satisfy specific military needs.

- First, these differences result from more performance demanding military requirements, either regarding the precision and freshness of the imagery obtained or in the field of real time high data rate telecommunication capabilities that are not developed for civilian use. In a number of applications, dual use technologies will thus necessarily remain conceived as complementary means rather than as prime systems.

- Second, some security and confidentiality issues attached to the use of some high performance space systems will also remain as a structuring factor.

It is then widely recognized that technological advances have made dual-use technologies more ready to answer a large part of the security and the military needs. In the same time, some differences are also acknowledged in some very specific areas regarding the technology employed and in the use of this technology.

2. Possible progresses for a European cooperative scheme: evolutionary rather than revolutionary

A large margin of manoeuvre exists today to make the cooperative schemes evolve in a decisive manner. Past experiences with multinational cooperative projects (exemplified by the Helios programme for example) have shown that, at least in the case of monitoring activities, a large part of the data requested nationally were indeed of mutual interest. Most of the time, those requests could be shared for a better optimized use of satellite and ground segment resources. New arrangements should then be found to better organize at least part of this activity for military and security purposes.

Beyond this step, on-going projects (such as the Franco-Italian Pléiades-Cosmo programme) or architectural studies (such as MUSIS) show a promising way forward, with advanced cooperation structures organized early-on, even before the actual definition of the space systems. It is noticeable that such projects already consolidate respective national responsibilities and competences (by organizing in the case of MUSIS the breakdown between the different national parties for the future imagery and the radar capability conceptual studies).

From these experiences, any progress will be evolutionary rather than revolutionary given the still limited number of member States involved in these efforts to date, and considering the still complex issues attached to the sharing of sometimes sensitive information and data. However, recently expressed national political readiness to deepen the cooperation for former very sensitive domains, such as high level precision imagery or even some ELINT capabilities[37], can give a new impetus for a more integrated space and ground segment architecture.

3. The concept of an integrated European space-based architecture: an answer to the need for a better utilization of dispersed resources

In the framework of the possibilities evoked above, there is a general view that an architecture integrating European space-based systems is needed to make the most of scarce and dispersed resources:

[37] *Ibidem*, pp.22-23.

- o The current level in Europe of Earth observation systems with military performances makes those systems easily saturated in the case of multiple crises occurring on different geographic theatres.

- o It is also clear from lessons learned during the last decade that more intensive tactical use of such satellites, especially Earth observation and telecommunication, cannot be fully covered by existing national or multinational assets alone. Even if progresses have been made lastly for data distribution, existing systems remains limited in number and can hardly ensure the level of freshness needed for being fully useful at the tactical level. Furthermore, any tactical-class information implies more stringent priority management procedures between the partners and may complicate the sharing of information compared to more routine situations.

- o As shown above on Fig.1, it is also crucial to consider the nature of the military operation (as well as its different phases) to measure the level of readiness of existing space systems as seen from the user side. The military and security ambitions underlying the most demanding "Headline Goal" require some level of responsiveness that cannot be fulfilled through existing systems and arrangements alone.

- o In addition, it must be noted that new European Member States will be more inclined to take their full part in any European military or security operation if some level of security is guaranteed by an operational European space-based information system ready to deliver shared strategic level information, possibly complemented by more focused information coming from national or multinational systems. In this respect, it is clear that "Non-Europe" in the field of space based systems could also result in a relatively weak political and military attractiveness of any future ESDP architecture.

4. What preliminary options for a balanced European architecture?

In order to bring a genuine added value compared to existing programmes and structures, the efficiency expected from different institutional solutions regarding the operational use of the assets must be assessed.

In the field of Earth Observation

The main principles presented above, based on the lessons learned from current arrangements, lead to three generic scenarios with consequences for the military and security uses. To be coherent with the principles already mentioned, any of these scenarios must first address the most constrained military perspectives. The results will have then to be nuanced by considering the possibilities offered for less constraining enlarged security perspectives.

- o Option 1 - One industrial player and one centralized European user center: an ambitious but difficult option

Such a scenario would envision both a complete rationalisation of the industrial offer at the European level, while it would consider in parallel to build a unique and fully shared exploitation and user segment for military and security purposes.

Such an option can be presented as a legitimate objective that would symbolise a reinforced ESDP. It would also, at first glance, offer the opportunity to better rationalise the equipment and procurement policies by fostering the interoperability of the systems and by limiting possible duplications.

However, lessons learned from cooperation, especially in the field of Earth observation, raise several objections from an operational perspective. While it has been confirmed that technical possibilities exist today to share information systems (even if these systems deal with sensitive data), procedural difficulties would remain high as far as the availability of the data and the priority management between the partners are concerned. Conflicting usage and priorities are already presented as a central issue today, especially as soon as some harmonization is required between the partners for planning more tactical level missions.

The resulting efficiency and cost effectiveness of such a "do-it-all" approach is largely questionable considering the complex techniques and procedures necessary to deal with the usage and priority conflict management.

Considering this approach for dealing with security issues only can be an option (by reinforcing for example the role of the Satellite Centre in this area) that would imply further studies in three areas:

- It would rest with the European Union ESDP related authorities to strictly detail what levels of benefit would be expected from increased investments in the security only area.
- Such a scenario would imply that modernized links would be established with more restricted military space cooperation to preserve a necessary synergy.
- Such a scenario would have to pay attention to the political possibility to rationalize the industrial offer at a time when similar systems are under development in different countries

o Option 2 - One industrial player and distributed national user centres: a challenging path

Such a solution would keep the objective of lowering the cost of independent procurement policies by rationalising the industrial offer while avoiding procedural difficulties by focusing on the modernisation of the cooperative procedures between national centres.
This option can be viewed as a welcome simplification when compared to the solution of an integrated user architecture. At the institutional level, this scenario would be based on an incremental progress compared with existing solutions and arrangements, with the goal to better organize exchange of data and imagery as well as better organize the tasking and priority management existing procedures. In particular, the use a large part of the high resolution imagery produced (either by dedicated satellite systems, or by civilian or commercial systems integrated in the technical architecture) could be more collectively planned and exploited. This is obviously true for security issues, but can probably be equally true for a number of military intelligence cases. It is generally recognized that, compared to the first scenario, such an approach would guarantee a more simple and fluent process at the price, however, of a lower level coordination.

A difficulty certainly remains considering the rationalisation of the offer side issue as mentioned for the previous scenario. By now, such an obstacle would need a strong political commitment of all the partnering member states to be overcome.

o Option 3 - *A diversified industrial offer and cooperative national and EU user centres: a pragmatic European "step by step" approach with a "cost-effectiveness" objective*

A European "step by step" approach would bet on a situation where incremental progress would be made starting form a situation where:

- national industrial leading firms would continue to conceive satellite systems
- the option of modernising the cooperation between national centres would be valued
- an increased role of a European user structure (such as the EU satellite Centre) in the field of security would be promoted.

Such an option would benefit from cooperative efforts underway by building on first return of experience (Helios 2-SAR Lupe, Pleiades Cosmo in particular) to transition from still nationally-based systems to more cooperative and integrated space and ground segments. A first step would consist in an extension of those architectures by increasing common satellite tasking procedures as well as common exploitation of the

imagery. This could be regarded as a prolongation of the current MUSIS option, with an enlarged interoperability capability as far as the ground segment is concerned while the space segment would be conceived as fully complementary, forming by itself a virtual multi sensor space architecture.

Such and European integrated space based system could also fully benefit from existing high performance non-military systems exploited by a European exploitation centre for security requirements. In consequence, links should be perfected between the national user centres and the European security exploitation centre to increase the performances of the global architecture. For example, such architecture could formally envision the European Union to enter a MUSIS-like partnership (via the EU Satellite Centre for example) through an ad-hoc arrangement based on the following main guidelines:

- a more active participation of the European Union in the current multinational cooperation would be promoted;
- the exploitation of civilian data made for security reasons by the EU centre should be used to benefit the global MUSIS-like architecture performance
- on the reverse, secured distinct data access and distribution procedures should be maintained between the national partner “core team” on the one hand and the European user centre on the other when dealing with national intelligence level related data.

This “step by step” approach may appear a balanced way forward that may benefit from reflections that have already been engaged for future systems at the horizon of 2015 to 2020. This option would consist in reinforcing choices and principles that seem to be widely accepted now, avoiding any possible blocking issue, either from an operational perspective or from a national industry point of view. An increased level of integration between partnering states on the one hand, and between their national user centres and a European structure devoted to the use of satellite data for security issues is likely to forge new cooperative security habits between user communities and help reinforce in a second step more integrated approaches.

In the field of telecommunications

Similarly, it is admitted that a European telecommunication military in-orbit infrastructure could be seen as a combination of existing models and innovative ones fulfilling security requirements. It could be composed by:

- several national satellite systems ("hard core" usage, national control)
- a set of European large satellites ("shared" usage), developed in cooperation, using generic design and flexible mission, based on a common requirements set shared between the nations
- commercial satellite providing the European telecommunication system with additional bandwidth

A better interpillar coordination: a sine-qua-non condition

In both case, any of these options would require a better inter-pillar coordination by involving European defence and security authorities in the management of security related programmes (such as GMES) and data. The central role played by the security issues in the organisation of space assets and ground segment architecture that coexists with more defence oriented structures makes such an inter-pillar involvement a pre-requisite for any European space-based architecture.

A future European space-based architecture as described as option 3 will thus have to be based on a narrow cooperation with current multinational efforts.

This cooperation will be made possible once a better inter-pillar coordination is implemented. While the Constitutional Treaty was to remove the main obstacles by allowing “shared competencies” between the Union and Member States, such goals should remain a priority in order to rationalize the security and defence related efforts respectively pushed by the European Commission and by the European Union High

Representative for the Common Foreign and Security Policy. In this respect, any political step favouring a European treaty should consider promoting this orientation.

Part Three
Space, security and defence: policy aspects

Chapter I
The separation between defence and security in space

Defence organisation support to security operations: the defence contribution to the "security of the citizen"

The "security of the citizen" is a growing concern of European institutions. The Solana paper "A secure Europe in a better worlds: European security strategy" published in 2003 illustrate the need to define an holistic approach with a mix of defence functions, civil protection and police functions to cope with new multi-dimensional threats that cannot be defined as simply internal or external. Terrorism is the main example of such threats, even if others cases can be made. Following these conceptual and political evolutions, the European Commission has taken into account this need for new tools for the security mission, fostering the security research policy. There is an ongoing effort from the European Commission to develop technologies in order to face the security needs expressed. The European Commission deals with the civilian side of the security, while defence missions are fulfilled by others institutions such as the EU Military Council, supported by the European Military Staff or in the framework of a cooperation with NATO for organisational/ operational requirements, EDA and OCCAR being in charge of the development of technological and procurement programs. As far as crucial relationship between the European Union and ESA, the Space Council plays a pivotal role in terms of coordination of policies and resources.

To become more efficient, there should be an evolution within the security sectors to adopt a new functionalist approach merging defence and security, reflecting the modern needs of complex security and defence scenarios; it remains to be proved that this can be done on the basis of the current pillars and treaties. A clear indication of the impossibility to really divide defence and security is illustrated through a basic analysis of the defence forces within the framework of pure civilian operations: for example during the Tsunami crisis, all the European member states have deployed their rescue teams using MoD resources, mainly navy ships, that supported the main logistics tasks also with key protection capabilities. In the case of natural disasters, each member states rely on its defence organisation for support. Some new specific security scenarios, such as NBC threat or disruption of critical networks, calls for a defence involvement in the definition of the protection and reaction, defence organisation being very often the only one able to develop resilience procedures, an heritage from the cold-war plans and structures, a nuclear attack being the closest scenario to a large scale disruption event. Therefore defence institutions provide a key contribution to all the security policies. Building up on this mixed functionalist approach, we can observe how space technologies have been often divided between defence and civilian, with a security category recently developed. Defence space assets are already part of the security when they contribute to support defence organisation action within some security operations (cf Tsunami rescue operations). A further step could be to determine if those mixed functions necessarily shape a dual use approach for space technologies applied to defence.

Dual-use approach versus defence-only systems: examples and limits

The classic vision for space technologies has been to separate defence systems from non defence systems. This paradigm is a French one, where earth observation and telecommunication can be considered as strategic, because it contributes data acquisition and command chain of the French nuclear dissuasion. It is also the case in Germany for the Sar-Lupe system, because of a strong political concern about carefully dividing military from civilian activities.

Existing space defence assets clearly fulfil MoD's needs, having been developed (proprietary systems) or defined (contract services such as telecom) for defence purposes. Nevertheless, some dual-use systems have been developed such as the Cosmo-Skymed / Pléiades EO constellation (see above) able to exchange data. Italy has pushed for a dual use approach from the beginning of the program. This dual use approach correspond to budget constraints (on the Italian side the constellation is financed by both the Mod and the Ministry of Research through ASI) because the MoD alone could clearly not afford the system. There is also an interest from the national space agency, ASI, co-founder, in developing technologies and services for security, relying for example on a partnership with the Civil Protection. In the Italian case we observe a cooperation framework between MoD and ASI in order to match financial resources and widen the community of user, reaching effectively the security users.

This future system has different level of priorities and security procedures, managed by the defence organisation. This example is highly illustrative of an evolution of the space defence assets that could foster the development of a security community

A "space defence" model open to enlarged security users rather than a civilian model?

Civilian space organisations such as the ESA, but also the European Commission during the past years have enlarged the spectrum of their space projects to security. This is the case of the ESA/EC program GMES (Global Monitoring for Environment and Security). After demonstrating the validity of different kind of monitoring and data transmission technologies, the next step is to foster operational services to fulfil the needs of the European users. Several ongoing projects are dealing with those aspects, for example LIMES[38]. Within this logic, Defence is often perceived as a "piggy back" reality: an organisation that can contribute to data, technology, or use the data coming from foreseen civilian systems. Clearly, this space civilian logic also obeys to a division of the tasks between the institutions, as EC and ESA cannot openly work on the Defence side.

If we think in terms of foreseen security users taken into consideration by those projects, they are very often Ministry of Internal Affairs or organisations such as police, firemen, civil protection or cost-guards. They also need strong security procedures to rely on a system that could provide data which engage their action, often translated into a justice procedure. Confidentiality and robustness must be also guaranteed. Therefore, envisioned security users for space systems need specific features, control and security procedures, distribution network and priority management which are similar to the needs expressed in Defence organisations. This is why existing defence organisations which manage space assets and data have also to be considered within the security cluster, as they are the base of the development of security services within the EU : there is no such thing as a "EU" security organisation but they are EU defence organisations, systems and procedures to build-up the next steps. Member-states bilateral agreements are the strongest framework, reflecting the reality and the legacy of budget investments, but key EU institutions like EU satellite Centre (Torrejon), EU military staff and EDA could play a growing role for the development of space capabilities for an enlarged space security and defence framework.
From a Defence perspective, any "dual-use" philosophy is regarded as a complementary possibility giving the opportunity to optimise some "non hardcore" elements. Any fully relevant dimensioning of the "dual-use" capabilities will have to be based on precisely defined corresponding Defence and Security needs. Optimisation cannot apply in an analytical void and the efforts tending to better define the needs must be pursued. These efforts must be based on reference "user models" built according to the nature of the envisioned missions and to the level of performance it demands. In the Earth Observation field, additive national programmes can help fill the needs (for example, as revisit time is concerned) if properly dimensioned by the user requirements.

[38] Land/Sea Integrated Monitoring for European Security, an Integrated Project in the framework of the FP6 GMES call on Security.

Chapter II
Future trends

1. Industrial aspects

Earth Observation perspectives:

Earth Observation data sharing is not a technical problem. Industrial assessments (as collected during interviews) of possible cooperative architectures are confident that technology may already produce fully operational systems. Multiple access systems may help mitigate the political sensitiveness attached to multinational data sharing **but technology cannot be a substitute for a lack of political will.**

The MUSIS (Multiple Users Space Information System) project linking six Member States (BOC countries) and one observing MS (Sweden) can be a starting point providing a political impetus in Earth Observation data sharing. Still it must be realized that sharing will not be replaced by mutualisation as national requirements remain at the core of national efforts to devise a cooperative system.

The cost-savings possibly drawn from such a streamlined architecture may reach significant levels compared to the today cost situation, provided this architecture give an opportunity to enhance normalisation wherever possible.

Telecommunications:

From the industrial point of view, the SHF band forming the bulk of the common "routine" operations (the same SHF services forming the basis of the NATO contract) could benefit from a common technical development for each of the national satellites involved, reserving the national specific developments for the more specific UHF or EHF capabilities. According to the industry, such a common development would prevent adding specific national development costs and could even create some level of scale economies permitted by the possible production of recurrent satellite models that would only differ marginally according to national customisation.

Two kinds of cooperative development can be taken into account:

- Some cooperative perspectives could be based on the production of generic satellites allowing for a large part common technical developments (for the SHF/UHF part for example) and leaving room for more specific developments answering limited national needs (in the EHF band for example). Such simplified satellite families would give an opportunity to lower the cost at the industrial level given the commonality of the platforms and of the telecommunication payloads (at least for a large part of it). Such possibilities are often mentioned by the industry.

- New technologies such as the Software Defined Radio (SDR) are also viewed as potentially helping such an evolution. Such software-based technologies will potentially contribute to the simplification of the new generation of satellite telecommunication systems by enhancing the interoperability of the systems. At the difference of the "generic satellite" approach, this "software based" logic would especially impact the user-side of the telecommunications, while not affecting issues like specific antennas developments. In this respect, it must not be expected from software-based technologies that they would solve all the specific technical issues associated to military telecommunication hardware. They must rather be seen as favouring the building an satellite telecommunication architecture by improving the user-side interoperability of cooperative systems.

While addressing different ends of the Satcom issue, these perspectives are not mutually exclusive and show the margin of progress that remain for an improved European telecommunication architecture with sizable downsized costs.

As expressed in meetings organized with the industry for the report, the following remarks can be made:

- A sizable cooperation can be envisioned at the hardware level for the telecommunication architecture. This cooperation present the better perspective for overall production costs reductions as it would prevent the systematically duplicated technical developments exiting today. More user-oriented cooperative systems can also be generalized (such as SDR) to improve the interoperability of these systems. At last, a “European Satcom roadmap” should be proposed on a model similar to what has been organised in the EO domain (BOC).

- Similarly, the Earth Observation area can benefit both from an industrial cooperation at the space segment level and from a better organized user-segment. In this perspective, flexible cooperative solutions should be preferred by promoting the different existing multilateral initiatives and by allowing the participant Member States to benefit from their investments, engaging them to sign MoUs aiming at developing common EU capabilities.

- The interoperability between EO and Telecommunication systems must be addressed from the conception of the programmes. Experiments like ARTEMIS or the experiences of EUMETSAT etc show that these issue are technically addressable. Specific military issues remain to be addressed specifically in this respect.
- Cost-savings can only result from a significant level of normalization/standardization policy that has to be supported at the European level. As it has been the case in the civil telecommunication domain, normalization must be addressed as a strategic issue by the political entities forming the European Union, among them the European Parliament.

- The normalization/standardization strategy will be all the more successful if sustained by a dynamic European market that will help industry to consolidate its investments and business plans regarding any standardization process engaged at the European level. Its organisation will also have to be supported by concerted efforts from the relevant European institutions (European agencies, European Commission). This measure would mirror what has already existed for long for the civilian telecommunications.

- The creation of European test-beds should also be considered to help solve the operational issues linked to the interoperability issues.

2. Economic aspects

(a) Current State

As described in the table below, during the next 5 years European Member States will procure significant space capabilities either for national purposes or multilateral needs. However, it should be noted that, despite agreements that allow some form of cooperation between the different platforms and systems, as well as that enable a limited sharing of raw data, there is no single European system envisaged (with the exception of Galileo)[39].

Publicly available economic data on these national programs are not always comparable because each contract is designed to a specific customer. However, the data presented below provides estimates taking into account the satellite procurement and launch costs (even if launch services are often procured under separate contracts), as well as the cost of the basic dedicated ground segment. Operational costs are usually not included, with the exception of the UK’s Skynet V contract. Nevertheless, the operational and

[39] The actual spending of European nations and their contribution to common ESA and EC programs is in the Annex, table pag. 85-86.

maintenance costs to sustain a complex system over its whole life-time can be as high as the initial investment. It remains particularly difficult to separate R&D spending because it is not necessarily itemised under space programs and the definition of R&D can vary from country to country. Moreover, data concerning costs and investments are not always available using open sources, therefore estimates concerning the cost of each system can vary because platforms are often quite different in terms of capabilities and technology incorporated.

According to known national plans, in the next 5 years the total number of dedicated security communication satellites will increase from the current 7 deployed to 10 as new platforms are launched after a 5 to 10 year period of procurement that started in most cases in the early 2000. Currently, European Member States are spending about 500 million Euro per year over a 15 year period of service for such capabilities. To keep to the 2012 level of 10 platforms, only 3 satellites should be replaced in the period 2012-2017, while by 2022 there will only be 3 legacy satellites still operating.

As far as observation is concerned, according to publicly available information the current low capability (3 satellites) will increase significantly to 12 satellites of different kinds. This is because 4 different national programs will reach maturity by 2012. However, given the relatively short in-orbit life of each platform (5 to 7 years) there availability will drop back to the present level by 2017 and no platforms would be orbiting by 2022. The 10 year funding for observation capabilities is currently estimated at about 500 million Euro per year. (For procurement of Space Systems, see Annex table pag. 70.)

Some estimates have been made in the recent years to quantify the cost of a collective European effort based on current or planned programmes. A first estimate was published in October 2001 by the Space Bureau of the French Joint Chief of Staff[40] which provided some initial budget estimates that would have to be devoted by Europe and with an indication of the French share (modelled on the level of French contributions in the framework of ESA). As a whole, such a scheme was considered to amount to around 32% of the annual investment made in ESA (First estimate of the cost of a European military space capability, see annex pag 70.)

Since then, different figures have been proposed. A recent expert report mandated by the European Commission entitled the "Report of the Panel of Experts on Space and Security" (the so-called SPASEC Report) published in March 2005 called similarly for an active European Security and Defense space policy that would make the most efficient use of national programmes both military and commercial. In particular the Spasec Report 'strongly recommends that the security applications of space be highlighted in the forthcoming European Space Program" and that "this programme should be fully harmonised with other national and commercial programmes so as to obtain maximum synergy and affordability that would offer an enhanced capability for all aspects of security.'[41]

The Group Report to the European Commission delivered its own figures, recommending the following investment by categories for a credible military space effort:

- telecommunications : 600 M€ annually
- observation: 600 M€
- signal Intelligence: 200 M€
- early Warning: 200 M€
- space Surveillance: 100 M€
- generic ground segment : 12 M€
- interoperability and standards: 40-50 M€

[40] Brig. General Gavoty, D. [The Space Bureau Chief at the French Joint Armed Forces Staff] , 'L'espace militaire: un projet fédérateur pour l'Union Européenne', *Revue Défense Nationale*, October 2001, pp.79-96.
** The Galileo figures were giving an estimate of what would be the cost of a jam-resistant signal that would enhance the operational value of Galileo.*
[41] European Commission, 'Report of the Panel of Experts on Space and Security', (Brussels, March 2005), p.41. http:/europa.eu.int/comm./space/news/article_2262.pdf

- technology Research: 250 M€
- new Applications: 200 M€

Such estimates would result in the budget devoted to military space in Europe increase from 1 Billion Euro in 2004 to 2 Billion Euro from 2012 onwards[42] (Cost Estimates of European Space System for ESDP, see annex pag. 71.) Based on the capabilities considered in earlier estimates, these figures have been endorsed by a larger part of the industrial community [43]. The common understanding is that 2 billion Euro would represent a threshold for Security and Military space support in what can be considered as a medium level of investment. These workings and declarations are clearly reinforcing the case for a European solution allowing in selected fields of applications to prevent unnecessary national duplications. Obviously, such a package of programmes largely remains a theoretical goal for now requiring fully harmonized national defence policies and views. Thus, selected areas in this list should be worked out more precisely, favouring first those applications that are the less national-specific. For industry, the European institutions should reassess the fraction of the European budget devoted to space for defence and security. In particular, a target of 1,5% of national defence budgets for the main participating Member States could be a decisive target.

The estimates mentioned above can be considered gross indicators of how two different stakeholders with specific agendas in mind would like to see the European space sector evolving.
However, they both lack a direct check against foreseen needs and a clear indication of the methodology used to calculate such figures.

(b) Matching needs and money: a proposal

Any capability-driven budget estimate is particularly complex and fundamentally affected by the initial assumption made; for the purpose of this study, we assume that, in the next 15 years:

- the process of transformation of military instruments towards NCW will continue
- the European security involvement in remote areas will increase
- European internal security will require substantial surveillance capabilities
- the cost of security-dedicated space systems will not change dramatically

Currently the main European countries are deploying a number of satellites serving their national purposes. However, given the relatively short in-service life of the platforms, in particular in the observation field, the relatively rosy situation reached in 2012 will not be sustainable as satellites reach their operating deadline in the following 5-10 years. Given the typical life cycle of space platforms, the political authorities should start immediately to plan and fund the future projects to be deployed from 2012 onwards. Investments in the period 2007-2012 are already determined with a significant level of accuracy while few funds are already foreseen from 2012.

As far as **SATCOM** is concerned, we can foresee a dramatic increase in requirements, as the ongoing process of transformation towards IT-dependent military forces continue. As already mentioned, some of the bandwidth requirement will be satisfied by an increased use of commercial satellites, in particular supporting voice data of a less critical nature. But some critical communication tasks, such as transferring of secret data and imagery or real-time command of troops and unmanned vehicles of any kind cannot be transferred to civilian communications because of the specific security level required and the absolute need of error proof performances (and the technical requirements of bandwidth (mainly EHF nature). A strong R&D effort in future EHF capabilities and secure communication software is therefore needed.

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[42] Spasec Report, op. cit., p.40
[43] ASD-Eurospace, 'Security and Defense Position Paper 2005' (and Annex) in the *Working Groups and Panels* section of the following site: www.eurospace.org.

Satcom capabilities develop approximately in a 15 years cycle. Therefore, despite an initial increase from the actual 7 to 10 satellites available to 5 different European nations by 2012 we should expect a residual capability of only 3 satellites by 2022. Moreover, most of these assets lack significant modern EHF capabilities, a key requirement for their use in support of military and security forces. The need for secure EHF transponders is key and will be further stressed by fielding of UAVs. In addition the fielding of intelligence gathering satellites operating real-time will add further pressure to develop satellite-to-satellite communications, thus developing DRS capabilities.

We can therefore foresee an additional need of some 2-3 satellites (each with capabilities comparable with current Skynet or Syracuse platforms, budgeted at 70 m€ per year per 15 years of service) already in the next 5-10 years, with a significant increase to reach the level of 18 satellites by 2022. Thus, renovating in 15 years the whole fleet with modern satellites. The proposed additional 8 dedicated platforms over the 2012 level, mainly with significant EHF capabilities and DRS features, is due to the foreseen increase in number of missions abroad and the simultaneous introduction in service of non-space platforms and assets that will need an extensive use of bandwidth to operate jointly and real-time (UAVs in particular). 18 in-orbit platforms would guarantee a global coverage with 6 satellites in-sight from any part in the globe, that could be considered enough to support net-centric enabled operations, real time command and control and continuous transfer of data collected by observation and intelligence-gathering satellites (DRS function).

In order to reach an intermediate level of 12 communication satellites by 2012, 2 additional satellites budgeted at 1 Billion € each should be procured in the next 5 years, while 3 platforms will need replacement by 2017. In the period 2017-2022 we foresee 6 new acquisitions beyond the replacement of 4 further satellites that will terminate their life. This will imply moving from the present budget of about 500 Million € per year over 15 years (excluding operating costs) to about 900 Million € per year over 15 years (2007 Million €).

Observation and intelligence-gathering capabilities developments are strictly connected with the external dimension of ESDP. As the European Union gets involved in risky and geographically distant missions, as well as surveillance operations of borders and treaty compliance, the all-weather (24h-365d) real-time access to information worldwide becomes a key instrument both for decision making as well as strategic and tactical use. Observation capabilities develop approximately in a 5-10 years cycle. Therefore, despite an initial increase from the actual 3 to 12 satellites available to 3 different European nations by 2012, we expect a residual capability of only 3 satellites by 2017 and no assets by 2022. We foresee a need for an additional 2 satellites (each with capabilities comparable with current Cosmo-Pleiades platforms, budgeted at 550 million€ per year per 10 years) already in the next 5-10 years. With a 2017-2022 increase to reach the level of 16 satellites by 2022, therefore replacing completely in the next 15 years the fleet with new satellites.

The proposed additional 2 dedicated platforms over the 2012 level, with SIGINT-ELINT capabilities, is required to cover a total gap in the inventory of European assets, where space electronic intelligence is not currently available. The final level of a mix of 16 in-orbit platforms of different kind (optical and radar observation, as well as signal and electronic intelligence). In order to reach an intermediate level of 14 intelligence gathering satellites by 2012, 2 additional satellites should be procured in the next 5 years, while as much as 9 platforms will need replacement by 2017. In the period 2017-2022 we foresee 4 new acquisitions beyond the replacement of 3 further satellites that will terminate their life. This will imply moving from the present budget of about 650 Million € per year until 2012 to about 750 Million € in the period 2012-2017 and 850 Million € per year per ten years from 2017 on (2007 Million €).

The estimates provided above are consistent with the initial assumptions made. Any changes to the assumptions such as a significant increase or reduction of system's costs, or a different choice in terms of technology, or different operational needs, can move the budget up or down. Moreover, should the procurement authority move to a full life-cycle approach, thus budgeting since the very beginning the in-service costs, the figure would increase quite dramatically, as operational and maintenance over a long period can equal the procurement costs. It remains to be seen whether the additional resources to maintain

or improve the capabilities would come from direct investment from nations or by pooling of resources at the European level. This remains a fundamental political issue because it will determine the ownership of the systems and therefore its political guidance. (For more on Cost Impact, an estimate; Number of Dedicated Military Communication Satellites; Dedicated Military Communication Satellites; Number of Military and Dual Intelligence Gathering Satellites, see annex pag. 71 and onwards.)

Of course the sum of national assets does not provide a comparable capability given by a single space constellation with the same number of platforms. It is specifically the integration of data and services that guarantees the multiplier effect typical of space assets. Moreover, the fragmentation of spending in a number of different projects is bureaucratically expensive and generates unnecessary duplications in operational terms (such as un-coordinated movement of observation satellites over the same territory), in particular in the ground station segment (multinational programs so far requires each nation to develop its own ground segment, as in the case of Helios I). It remains very difficult to estimate a figure of how much European countries could save if they choose to pool their national spending, as the capability outcome would be radically different. Moreover, the gain would not be only purely in economic terms, as a single constellation would by nature provide a far better operational asset than even a larger (in terms of platforms) availability of un-coordinated national satellites. Interoperability would also be enhanced because the governance structure would be simplified and the sharing of data and capabilities would become the rule not the exception.

However, the alternative is not just between spending more wisely in a pooled European effort versus wasting money on national projects that are by nature less capable and efficient, as they cannot guarantee the global coverage needed by current and future requirements. The alternative today is between guaranteeing future funds for a common effort or being left without any significant space capability by 2022. This is because most European countries, with the partial exception of France, do not seem in the position of spending enough resources even to replace the same level of capability that will be reach by 2012.

Therefore, the option that European governments and institutions faces today is between building a single space constellation, common since its start in the R&D phase, or being left without significant capabilities. This is of concern when one considers the increasing needs that derive from the development of ESDP engagement in distant areas, as well as obligations deriving from treaty-compliance measures and the need to guarantee a better surveillance at the EU borders.

3. Estimating the global effect of the Distribution of Costs: what perspectives of economies of scale through more Europeanization of EO and telecommunication defence and security space systems?

The two cases considered in this study, namely Earth observation satellites and telecommunication satellites respectively, are presenting different cost formation schemes. Consequently, the global impact possibly derived from a more intense « Europeanization » of these programmes must be judged independently.

While most of the exact figures associated with current experiences in the military space cooperation project remain restricted, some orders of magnitude can be inferred from the general literature. Basically, the total cost of an operational space system is composed by the cost of the development and launching of the satellites; the cost of a dedicated ground segment specifically developed for ensuring secure transmission, processing and dissemination of the information; and the recurring functioning and maintenance costs over the complete system’s life cycle.

Taking into account this aggregate and considering possible cooperation schemes in Earth Observation and telecommunications, the effects of Europeanizing the programmes will translate into very different cases.

3.1 Earth Observation

- 3.1.1 Space segment
  - *Context:*

Referring to Earth observation cooperative experiences to date (more particularly Helios II/Sar Lupe cooperation, Pleiades/Cosmo cooperation as referred in the present report), most of the developments made on the space platforms and their payloads remains nationally owned and seem to present very few possibilities of technical and financial sharing. Up to present, the conception and the development of advanced orbital Earth observation systems remain dominated by national intelligence needs and by proprietary high technology issues. Confidential specifications as well as an increasing industrial competitiveness issues has most often resulted in close production cycles for the most advanced spacecrafts.

Other possible economies of scale might be induced from national specialization in precisely delimited technical fields, avoiding possible duplications. Such a European rationalization could theoretically be promoted to reduce the cost of a European space radar capability by a magnitude of around 300 to 500 millions Euros (i.e. part the price tag of one of the two existing national systems assuming they can be merged in a common European programme). However, it must be reminded that Europe is not yet in position to limit the number of its Earth observation systems due to the enlargement of its defence and security missions (maritime surveillance, border control, enlarged military missions), so that existing different national systems in the field of radars for example (The German SarLupe and the Italian Cosmo-Skymed programmes for example) can hardly present a convincing case for demonstrating duplication.

In addition, even if European non-national companies can be active providers of central elements of national space systems (as it is the case of the Franco-Italian company Thales Alenia space for the German SarLupe radar payload), this does not generally imply neither intergovernmental cooperation nor technical sharing at the level of satellite construction for the most advanced military systems. Indeed, Earth observation space systems have remained nationally owned, basically for two reasons:

- Maintaining an autonomous of the system in order to guarantee the access to the capability with no possibility for other nation to deny this access
- Confidentiality

At a time when foreign, military and intelligence policies still constitute the building blocks of a European CFSP, the application of strict national policies regarding intelligence system definition largely remains the rule.

- *Assessment of relative financial weight:*

According to many sources, the space segment alone represents at least more than half of the total financial investment in the most advanced military Earth Observation system (i.e. around 1 Billion Euros in the case of Helios II for example). This proportion shows how much the cost of the Earth Observation space activity has remained driven by heavy high technology investments made for the space segment itself, in a context where these very focused (and costly) top level technologies have been keeping a strong discriminating status in industrial and strategic terms.

This particular situation of the Earth observation space segment would have a direct influence on any enlarged European cooperation perspective, with a focus on the ground segment rather than on the most advanced satellites and associated payloads.

- 3.1.2 Ground segment

Traditionally, the ground segment can be envisioned as the most "cooperation intensive" cooperative part of multilateral Earth observation space systems. This is being demonstrated by all the current cooperative endeavours in the field, from Helios to Pleiades/Cosmo cooperation.

Different situations exist according to the nature of the considered cooperative programme:

- *Military programmes*

In the case of the current cooperative military space systems, the cooperative part on the ground segment represents today only a fraction of the total cost of the ground segment. This can be judged for example after the following Helios II programme figures presented during the 2004 French parliamentary budget law debate:

	2003	2004	2005	2006	2007	2008
Helios II	101	61	88	86	69	56
Cooperative ground segment (SSO)	4	16	28	9	16	38

Annual budget distribution for Helios II and its associated ground segment over the period 2003-2008 in Million Euros[44]

While the fabrication costs of the first satellite Helios II do not appear on this table as they have been realized before 2003, the ground segment lion's share is reflected in the "Helios II" line. Thus, it is fair to assume an even stronger imbalance between the share devoted to the cooperative ground segment (second line) and the total budget invested in the programme.

From a partner nation's perspective, accessing a cooperative status in such programmes means both (1) subscribing to the system (i.e. participating up to a certain level – a few percentage- to the development/launch/operationalization of the system and receiving in exchange a proportional right to obtain imagery) and (2) buying a dedicated ground segment and its associated equipment and building. In addition, any partner nation must envision investing in personnel specially trained for imagery interpretation and/or processing.

Due to confidentiality constraints, the exact level of investment devoted by existing partner nations to Helios for example remains restricted. While not as high as investments devoted to the space segment itself (see above), it is easy to deduce that any partner nation could directly benefit from pooling its resources with other partner nations facing similar access costs. In this area, Europeanizing the effort would mechanically mean a division of the total ground segment cooperative access cost by the number of pooled partners. Cooperating on this part of the programme would thus present the most promising perspectives for a collective reduction of cost.

It must be noticed that the reduction of costs induced by European cooperation on the ground segment (given the current cost structure) would be limited, by construction, to a few percent of the total programme budget. Cooperation would mainly concentrates on the "downstream service" part of the programme. For example, it can be envisioned that a common interface would be developed to provide a more efficient and

[44] « *Avis présenté au nom de la commission de la Défense nationale sur le projet de loi de finance pour 2004* », *Tome III, Défense, Espace, communications et renseignement*, par M. Yves Fromion, Député, 9 octobre 2003. The document can be accessed at : http://assemblee-national.fr/12/budget/plf2004/a1114-03.asp

more easily accessible service to partner nation willing to pool their resources to share information with up-to-date servicing technology[45].

- *Dual-use programmes*

A more complete integration of dedicated ground segments with associated savings could *a priori* be expected for dual-use systems where the requirements cannot be compared with the strict security constraints of a programme strictly designed for intelligence and military purposes. However, the complexity of multinational dual ground segment has not allowed demonstrating the case yet. The example of the dual-use Franco-Italian system equipped with national respective ground segments may not help the programme reach the goal of only a few percent of the total budget devoted to a common ground segment as initially envisioned.

In the context of a greater Europeanization of future Earth observation programmes for security, aiming to develop more common and interoperable ground segments for dual-use systems should appear as a target of choice for cost reduction implementation in the years to come.

- *Assessment of relative financial weight:*

To summarize, the current multinational structure in the field of military Earth Observation makes cooperative information interfaces, common dedicated ground segments and shared specialized personnel the main realistic targets for cost reductions. Assuming that the figures quoted in the table above for Helios II can be taken as a reference for any dedicated cooperative ground segment, it can be hypothesized that an order of magnitude of 100 million Euros could be a realistic objective for cost reduction over the entire life cycle of a Helios/SarLupe class military programme (between 10 and 15% of the ground segment total cost). It must be noted that more savings could be expected from dual-use programmes (Pleiades/Cosmo class), provided a larger part of the ground segment development would be opened to genuine cooperation.

- 3.1.3 Functioning and maintenance costs

Closely associated with the space segment maintenance, those costs must be covered by sufficient national investments that are probably taken into account in the access cost of the partner nation. As an example, according to parliamentary figures published in 2001, Helios II maintenance costs would amount annually to around 30 million Euros[46].

It must be noted that functioning and maintenance costs remain a good candidate for a Europeanization and would require substantial cooperative investment in order to compensate the loss of individual national contribution, thus moderating the economies of scale-effect induced by the pooling of partner nations

3.2 Telecommunications

- 3.2.1 Space segment

  - Context

In the field of telecommunications, the situation of intergovernmental cooperation on the space segment differs radically from what exists in the field of Earth observation.

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[45] Possibly contracted to Industry for competitveness enhancement.
[46] « *Rapport d'information sur le renseignement par l'image, Commission des finances, de l'économie générale et du plan* », Député Jean-Michel Boucheron, 4 July 2001, p.103.

As demonstrated by the most recent European national programmes (namely the British Skynet V, the French Syracuse III and the Italian Sicral programmes), any telecommunication satellite designed for military purpose relies on a dual frequency payload (SHF/EHF). As already explained in this report, the SHF part of the payload can be mainly used for day-to-day and routine telecommunications, while the EHF is reserved to highly protected and efficient telecommunications, possibly used during military operations. In other terms, while technically very challenging and not available on the commercial market, the use of the EHF band remain limited to specific applications and thus does not represent the bulk of the capabilities that are provided by European military satellites today.

It is widely recognized that the EHF part remain the most national sensitive part of such payloads, while part of the SHF band is more and more considered as providing a common service that can be completed by the leasing of commercial wide-band resources (like the ones provided by Intelsat, Inmarsat or other wide-band providers for telecommunications that do not need specifically protected SHF links).

- *Assessment of relative financial weight*

Assuming these considerations, it is commonly acknowledged that the SHF part of military satellites could be a good candidate for common European developments, as it could have been in the case of the three satellite families quoted above. For some experts, SHF development can represent up to 80% of the total price tag of a single operational satellite today. Based on such figures, cost reduction induced by cooperation on the SHF part of the satellite payload could theoretically amount to 500 to 800 million for a 2 or 3 satellite system[47]. More realistically, it has been indicated in France that the tri-nation cooperative *Trimilsatcom* programme envisioned in 1997 would have reduced the cost of the national programme from a total of 2.28 billion Euros today to 1.95 billion Euros, i.e. by 25%. In particular, ground segment as well as the maintenance costs relative shares may be taken into account to explain this discrepancy.

- 3.2.2 Ground segment

In the field of telecommunications, the ground segment mainly consists in receiving stations that can be installed or deployed at each level of the military operations. The more and more intensive use of the higher frequencies, both for technical (wide-band) and for military reasons (anti-jamming and discrete uses), has increased the introduction of small portable receiving equipments for use at the tactical level of operations.

Obviously, would nations intensify their cooperation at the European level, interoperability of the ground segment would be substantial as standard receiving equipment could be developed in common. Innovative techniques such as Software Defined Radio (SDR) could facilitate reaching this goal.

More opened by nature that cooperation in the field earth observation for intelligence, Europeanization of the telecommunication ground segment could indeed represent a good candidate for very substantial cost reductions. Indeed, it is generally acknowledged that the ground segment cost represents roughly half the total cost of a military telecommunication satellite.

- 3.2.3 Functioning and maintenance costs

There is no substantial difference with the characteristics evoked for Earth observation, and functioning/maintenance costs in the field of telecommunication satellites represent a good candidate for cost reduction through cooperation. In addition, it can be assumed that functioning and maintenance costs would basically remain the same whether it is during peacetime and during a military conflict, demonstrating in the latter case an even increased cost/benefit ratio.

[47] Assuming that a modern Satcom programme averages a total budget of around 2.5 billion Euros, half of it being devoted to the spacecrafts and the other half to the ground segment.

4. Synthesis of possible cost reduction distribution by Europeanizing existing Earth Observation and telecommunication satellite programmes

In order to simplify the reasoning, cost reduction effects allowed by promoting stronger European cooperation in the field of Earth observation and telecommunication satellite can be summarized as below.

Two main remarks can be made:

- While Earth observation programmes show real possibilities in the domains of ground segments (cooperative interface, common dedicated ground segments) and functioning/maintenance as preferred area for savings gained from a more intense Europeanization of the programmes, the telecommunication by satellites appear to be the most mature space military sector for economies made all across the board on the European scale.

- In average, savings obtained from a better-organized European cooperation and integration could amount to a few hundreds million Euros on the total life cycle of typical military programmes.

As a conclusion, it can be asserted that the different situations in the two sectors can also be explained by their different status regarding European cooperation:

- To some degree, the Earth observation sector is already giving positive signs of the benefits that can be expected from progresses made through the "Europeanization" of the actors and of their activity. Indeed, it has been demonstrated that some level of specialization (between optical and radar capabilities) has prevented the duplication of similar capacities that could have been developed on a sole national basis in a number of countries. In other terms, the savings allowed by the on-going European integration in the field of Earth observation have already become a reality amounting to a few billion Euros if one considers the perspective of seeing the current BOC nations developing on their own a full range optical and radar satellite capabilities instead of cooperating as it is currently the case. As those savings have already been implemented, this also explains why Earth observation may not appear today as the most promising area in terms of cooperative cost-reduction schemes.

- The case is different for the military telecommunications. Several countries in Europe have set up similar capabilities (especially in the SHF band) issued from different industrial developments, each with its respective associated costs (up to several hundreds of million Euros). These costs could be significantly lowered by common European developments in the relevant technical domain. This means that a better European integration is achievable in the field of military telecommunication with significant cost reduction effects (up to several millions Euros) at all stage of the possible future programmes.

It is a fact that a strong European coordination has already been fruitful in terms of economic value for the Earth observation, especially by preventing the multiplication of national programmes. It could be improved by a more efficient cooperation between ground segments in the field of dual-use Earth Observation satellites.

Such coordination should also appear as a very promising perspective for future military telecommunication programmes that have yet to get better integrated at the European level.

In any case, these possible cooperation benefits cannot be based only on a static comparison of the costs of the systems of today. They also need to be checked against actual political and operational needs (which are

growing, raising the central issue of the European space capability "sufficiency") to provide a comprehensive view of actual cost-effectiveness for future European space systems.

Fig: Summary of cost reduction opportunities and magnitude in Europe as compared to present situation

	Space segment	Ground segment	Functioning and Maintenance costs
Earth Observation	- Ample room for cost reduction but difficult area for implementation	- Good possibilities for implementing cost reduction but limited effect	- Good possibilities for implementing cost reduction by pooling budgets
	- Most expensive segment but difficulties in reducing cost by sharing construction of highly advanced satellites - Possibility of cost reduction effect by rationalizing individual satellite construction on European scale (but less capabilities to be expected)	- Best possibilities in cost reduction assuming largely increased effort in terms of common development and interoperability for future dual-use systems - Limited savings expected on the total programme life cycle due to relatively smaller budgets in comparison with the space segment budget share (order of magnitude of 100 million Euros) - Possibilities of savings for individual partner nations by pooling budgetary resources for access cost	- Good possibilities for cost sharing on the European scale
Telecommunications	- Good possibilities for implementing cost reduction with substantial possible effect	- Good possibilities for implementing cost reduction with substantial possible effect	- Good possibilities for implementing cost reduction by pooling budgets

	- Good possibilities of cost reduction by sharing the development of part of the telecommunication payload in the SHF domain notably (order of magnitude: several hundreds million Euros)	- Best possibilities in cost reductions due to interoperability objectives allowing savings on half of satcom programmes budgets (order of magnitude: several hundreds of million Euros)	- Good possibilities for cost sharing on the European scale

Chapter III
European cooperation and governance

In origins of "space and ESDP" stem from a long national experience in the defence and security sector. The issue at stake, then, is building a cooperative framework in these 2 sectors taking advantage of what exists at the national level and complimenting it with EU level assets. This will help fill gaps and meet ESDP and European Security needs, as well as to support non-space Member States. Today, space policy for security is not a single policy, but a mix of policies pursued by the Member States, the Space Council, the Commission and eventually the EDA. This range of actors requires better coordination to rationalise governance issues and avoid duplication. The European Constitutional Treaty did not change fundamentally the defence/civilian logic within the different pillars. Nevertheless, it opened the possibility to ***permanent structured cooperation*** in the field of defence, a mechanism that could enhance the cooperation framework at the EU level. Some indicative models can help illustrate the different models available to achieve improved cooperation at the EU level.

1. The different models

The national model

It is based on the exchange of data according to bilateral agreements. Ownership, governance and budgets are strictly national. The pros consists in maintaining national control and a high level of confidentiality. On the other hand, the negative aspect stems from the lack of a synergic approach among different countries. In the EO sector this is clearly the most important trend today. This model shapes existing and next generation systems and is based on a strict compliance to the national sovereignty in terms of control of the information. Today, a MS that wants to benefit from EO data has to provide something in exchange. This is the ultimate logic behind all existing and foreseen agreement in the EO sector. According to this logic, the ownership of systems, even if partial as in Helios agreements, is a minimum fee to pay in order to access data. Non-contributing countries can access data only through some coalition mechanism (on-the-field exchange based on operation agreements for out-of-area missions, or data provided by the European Satellite Centre for main EU operations). This is also the reason why a country such as Sweden is thinking about launching its own system, in order to access the data needed for external operations.

The "service provider" model

This model is based on the pooling of national capabilities and it is accessible to third parts through contracts. The ownership is national, but there is a flexible contract-based approach to manage and sell extra capabilities. There are no problems of governance as far as satcom is concerned, since technology allows data protection and encryption when needed. The pros is the matching of national public and private

resources, while the cons is the fact that it is a functional model for telecom but not for EO. In the telecom sector we can already observe a "service provider" approach where non-technical countries can buy capabilities through service contracts (The Netherlands). In parallel, it exists a widening access to space telecommunication capabilities from other countries (Spain). The telecom sector does not seem to have specific problems to widen its service agreement with non-space countries. The NATO Satcom post 2000 contract based on French, Italian and English systems (see above) already provides to the Alliance a global capacity and gives an example of ongoing resources pooling.

Towards a more "European" model?

The MUSIS six-nations agreement (MUltinational Space-based Imaging system for Surveillance, reconnaissance and observation) is a further step in the early definition of a future European architecture for space-based defence EO, even if its logic is still national. France might be, in the near future, the only country able to develop its own next generation of EO space defence systems. Italy and Germany, which are today the "second players" after France, will have to face important choices in terms of defence budget. Both of them need to deal with an unbalanced budget structure, where the costs of the personnel and external operations are raising while there is a lack of investment in capabilities.

A next generation of national EO programs will probably not be affordable for the defence budgets of those countries, which would leave France alone to pursue its effort. A solution could be found through an agreement between several Member States. Even within such an agreement, the EU could participate as a funding member, gaining the task to redistribute capabilities to all EU countries, including "non-space" ones. We could foresee a model where a "multilateral" European member plays the main role and where EU could invest as other strong Member States partners do. This model, and the following, could also fit with ***permanent structured cooperation*** in the field of defence between several partners. Furthermore, the ESDP cooperation framework can be a key for small countries to access space technologies: they might not have the capabilities or the budget to access space development programs, but their contribution to ESDP could allow them access to space-base information through data sharing policies. It could be a form of intelligent trade-of between defence operational cooperation and technological development, which could be unconnected for the sake of the small countries.

Future option: Multilateral European model

In this model, the ownership is multilateral, while the governance is defined following the level of investment of each country. The cost option is based on a multilateral agreement and a programmed budget. The pros of this model are the budget efficiency and the pooling of resources, while the cons is still the problem to define the access of "non-space" countries. It is not a "paneuropean" logic yet and it will have to face issues in terms of investment/return of investment/access to data.

On the other hand, "non-space" EU MS would certainly be willing to benefit from EO data. They do not have the capabilities to participate to today's bilateral exchanges framework based on ownership. As in the telecom sector, one solution for EO sector could be the pooling of existing MS systems to provide a service contract to "non-space" countries. Currently, and for the near future, the national sovereignty of the different systems makes this option unrealistic. Nevertheless, in order to face the lack of resources and the replacement of the satellite generation about to be launched (by 2020), it is necessary to plan future systems that associate all European countries together. This "composite" model could also benefit from a European funding, together with Member States. For sensitive data such as EO defence, a solution needs to be found in terms of Member States investments towards service. This is a strong obstacle but the budget pressure is real and shall bring innovative solutions which could also describe a real "European" security.

Future option: Common European model

In this last model, the ownership is fully European and the governance as well (through institutions such as EUMS/EUSC). The costs are faced through the European budget. The pros in this case is the European logic of data distribution, corresponding to a common perception and analysis of worldwide security issues, managed by EU institutions and open to all members. The cons is that it is difficult - if not impossible - to

manage, due to existing Member States' "national sovereignty" concerns. Return on investment might be a problem for those countries that traditionally invest a lot in space and defence. Such a model can only be defined after a radical evolution starting from the Member States. ESDP's as a policy development could push towards this model. But a stronger constraint could come from the budget. The need to maintain budget for space technologies could be a realistic drive for a common effort. Today industries rely on national defence markets. If, as we foresee, those national markets tend to fade for budgetary reasons, then many European space industries will lobby for a European investment in that field in order to maintain their technological base.

2. The importance of new research program

Following this logic it is important to develop European research programs for space defence systems. This is the first step to be able to develop common systems when they will be needed. Moreover research programs are difficult to organize because some strong countries that want to master the complete technical chain of know-how and are reluctant to allow new countries on board (they seem then as "free-riding" to master techniques already developed). Nevertheless, there is a need for compromise between existing national capabilities, the need of a specialization at the EU level, and a strong push for new EU countries to access and develop specific technical capabilities which can be later developed into operational systems. Research Programs are a good way to face these complex issues, as they create a framework of specialisation and division of work at the EU level. Even France is fostering this kind of logic through the MUSIS program, as well as developing some LOI-country roundtable initiatives for Early Warning technologies. Complementary to national approaches, the involvement of European Institutions is needed.

3. The potential role of the European Defence Agency (EDA)

The European Defence Agency has already gained weight since its institutional creation. Even if it does not have the personnel and budget resources for an extended European role, EDA is already at a crossroads in defining the responsibilities at the EU level. As a coordination forum and a program agency, it could rely on existing Member States and European structures (such as ESA) to foster the development of European space programs for defence.

Its main tasks for space and defence clusters shall be: define capabilities (with the help of competent MS bodies), to propose development programs and play a key role in the orientation of space-defence research and technologies, through the coordination with national Defence and Space Agencies and ESA.

EDA must be coordinated with the EC on a specific topic: the "security" versus "defence" level : the EC is allocating money to foster security research, but this has to be integrated with the defence effort in the space sector. Some "security" programs shall be transformed in "security and defence" programs. Those issues shall be acknowledged by both the Commission and the Council in order to have an integrated cooperation on specific projects, eventually managed by EDA, in case defence security procedures are needed.

EDA is a unique forum to prepare the future of R&T in defence. MS specific know-how shall not be erased but brought into an organisation in order to organize a brokerage for future technologies involving all the European MS, even those with a small sized – or inexistent - space industry, in order to define common program within the only legitimate framework at a EU level. Moreover, EDA has a mandate to support the strengthening of the defence technical and industrial base which is to be considered strategic for a space sector that could face a budget reduction. This rationalisation effort in terms of future capacities, research and programs for space and defence can provide a second space policy for Europe, added to the already existing ESA civilian programs, benefiting from a high level policy endorsement from European institutions, such as the European Parliament.

Part four
Recommendations for the European Parliament

The European Parliament is in a particularly favourable position to renew awareness amongst European citizens about the necessity for a concept of Future European Space Architecture in accordance with the defence and security ambitions of the European Union. By making the Headline Goals the basis for mid-term thinking, the European Parliament could start a deep political debate, thus making a European perspective in space consistent with these objectives.

Given the profile of the missions envisioned in the Petersberg tasks, and the military capabilities provided by the Headline goals, a Future European Architecture for defence and Security must be developed to fulfil European needs. Both in the EO and in the Satcom field, current assets provide a sound basis for building such a future architecture.

This architecture will have to provide two kinds of improvements, compared to the collection of existing assets:

- improvements in the adaptation of space assets to theatre-use level, in the limits of the requirements elaborated for the Headline Goals. Current space capabilities must be developed to satisfy the current needs at the European level; this will require a substantial increased in the satellite constellation. A cooperative approach for Earth Observation, telecommunications and possibly ELINT capabilities would then directly reduce the overall cost of additional capabilities,
- better technical and procedural sharing of future satellites and ground segments in order to improve their efficiency at the European level and thus their adequacy for the specific requirements.

The two main application fields that remain a priority are telecommunications and Earth observation. In these two fields of activities, important progress has already been made, mainly via intergovernmental agreements. Progresses is also evident at the EU level in the form of GMES.

These can be considered as first steps towards a more complete European architecture. Innovative technical solutions can be implemented to widen the prospects for European “space” and “non space” Member States to improve transmissions and sharing of data. The European Parliament could then promote areas where European progress can be made in terms of telecommunication and Earth Observation data sharing. In this respect, the European Parliament could stimulate debates among space Member States and between them and non-space Member States to identify the level of political agreement for data sharing. In this effort the European Parliament could take into account experience from Helios 2 and possibly from other on-going processes, ranging from the ORFEO definition to the discussions that have led to the BOC agreement and that feed the MUSIS discussions. Initial contacts should be made with the relevant Member States. Furthermore, it is now widely acknowledged by industry that commonalities in the development of space and ground systems would provide cost reductions.

As far as **tax payer needs** are concerned, EU countries need to establish a more cooperative model, multilateral or European, to rationalize their investments and to maintain the capabilities in a period of shrinking defence budgets. Tax payers’ needs are however penalized by national fragmentation in this sector.

Governance needs:
- a dual-use approach in a secure environment. The European Parliament could help to make sure that European defence capabilities in the space sector find their proper place beside civilian or commercial developments. In particular, a well-balanced coexistence between dedicated military projects and complementary civilian assets should be discussed, as well as the necessary protection of scarce resources for military purposes, such as frequency bands.
- developing the role of EU Council institutions and instruments (EUMS, EUSC, EDA) as well as the involvement of the European Commission, thus defining security control and governance over space programs.

- adoption of an inter-pillar approach to solve the issue of a security governance within Europe, reaching an operational level for existing programs such as GMES. Today the space policy for security is pursued by the Commission, Space Council and, eventually the EDA. Indeed, there is a lack of a “security authority” for EU DGs involved in space policy. Nevertheless some of these programs features call for an enhanced security policy and data security level associated to this program, not easily manageable by civilian DGs. The European Parliament could recommend a strong inter-pillar cooperation framework for space and security, where authorities involved in ESDP (Council, EUMS, EDA) should manage directly the security side of those industrial programs. If not carefully taken into account, the lack of a well managed security policy could jeopardize those programs. This is true at the policy level, for security requirements, but also in terms of data management.
- EU institutions such as the European Parliament SubCommittee on Security and Defence Committee could contribute to the debate that a European space security policy is needed, to maintain existing and invest in future capabilities. This is a key issue in dealing with declining national investments. A trade-off has to be established between maintaining capabilities at the price of increasing shared sovereignty on information and systems.
-For smaller countries which have difficulties to plan their access to space technologies because of reduced investment and technology capabilities, a reinforced ESDP framework could provide access to space-based information within operational defence cooperation.

Defence’s users needs are different from country to country, according to their experience in terms of use of space assets. Some countries have already extended experience in terms of use and are able to formulate detailed needs. Others countries (such as new EU members) which did not invest in space owned system, are potential users but still need to access the services. For European space security programs (such as GMES) after the pilot demonstration phase, it is necessary to develop a service distribution in order to launch effectively the program, thus developing existing markets. Governance is a key issue to start this phase.

Finally, **industrial needs** consist in maintaining the DTIB and in contributing to allow access to technology by all EU Member States' industries through specialization. Even if new attempts have been made in making systems compatible, real efforts have still to be seen in the field of common technical developments. Given their technical characteristics, and considering largely similar operational requirements, telecommunication satellites may prove to be the best candidate for cost-sharing reduction. This common development would cover the largest part of the satellite platform and payload construction and should not prevent more specific equipments to be developed at the national level. The European Parliament could promote the regrouping of Agencies and relevant industries in an organisation dedicated to normalisation/standardisation.

In the field of Earth Observation, on-going (Helios 2) and envisioned programmes (ORFEO notable) have demonstrated important progresses in the field of tasking and data sharing. Still, these particular applications may include nationally-restricted tasking and collection activities that will continue to determine the shape of any European satellite and ground segment architecture.

✦✦✦✦✦✦

ANNEX

List of abbreviations

BOC	Besoin Opérationnelle Commun (document France-Germany, 1999)
CNES	Centre National d’Etudes Spatiales (France)
CFE	Conventional Forces in Europe
DGA	Délégation Générale pour l'Armement (France)
DMC	Disaster Management Constellation
DoD	Department of Defence (USA)
DRS	Data Relay Satellite
DTM	Digital Terrain Modelling
EC	European Commission
EHF	Extremely High Frequencies – 30/300 GHz
ELINT	ELectronic INTelligence
ELISA	ELInt SAtellite
EO	Earth Observation
ESA	European Space Agency
EUISS	European Union Institute for Security Studies
EUMS	European Military Staff
EUSC	European Satellite Centre
GNSS	Global Navigation Satellite System
GPS	Global Positioning System (USA)
HRS	High Resolution Stereoscopic
Ka	Kurtz-above band - 20/30 GHz band
Ku	Kurtz-under band – 12/18 GHz band
LoI	Letter of Intent
MoD	Ministry of Defence (UK)
NBC	Nuclear, Biological, Chemical
NCW	Network Centric Warfare
PFI	Private Finance Initiative
PRS	Public Regulated Service
SAR	Synthetic Aperture Radar
SATCOM	SATellite COMmunications
SDR	Software Defined Radio
SHF	Super High Frequencies – 3/30 GHz
SIC	SIlicon Carbide - lightweight mirrors
SIGINT	SIGnal INtelligent
UAV	Unmanned Aerial Vehicle
UHF	Ultra High Frequencies 300/3000 MHz

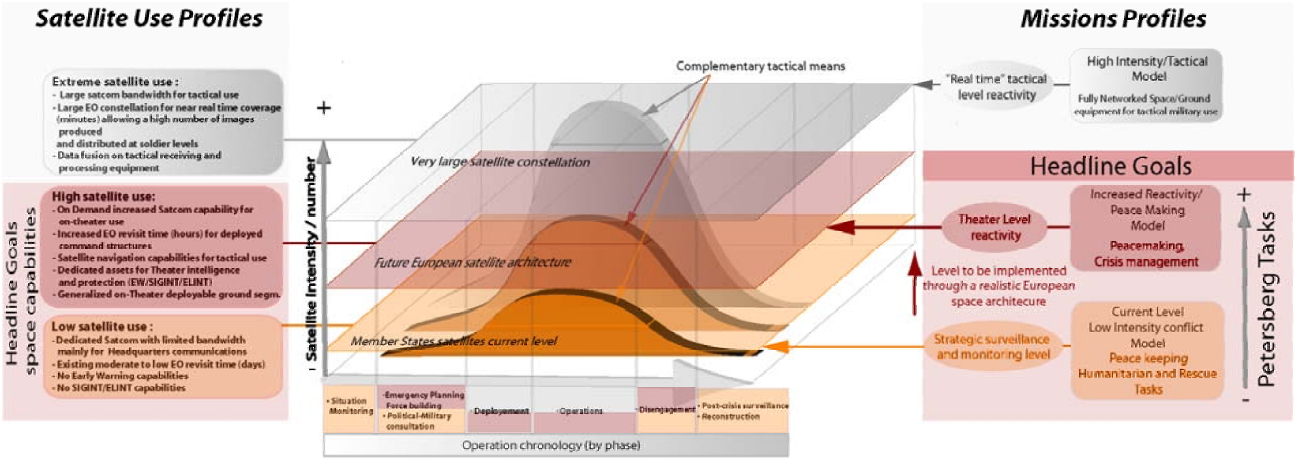


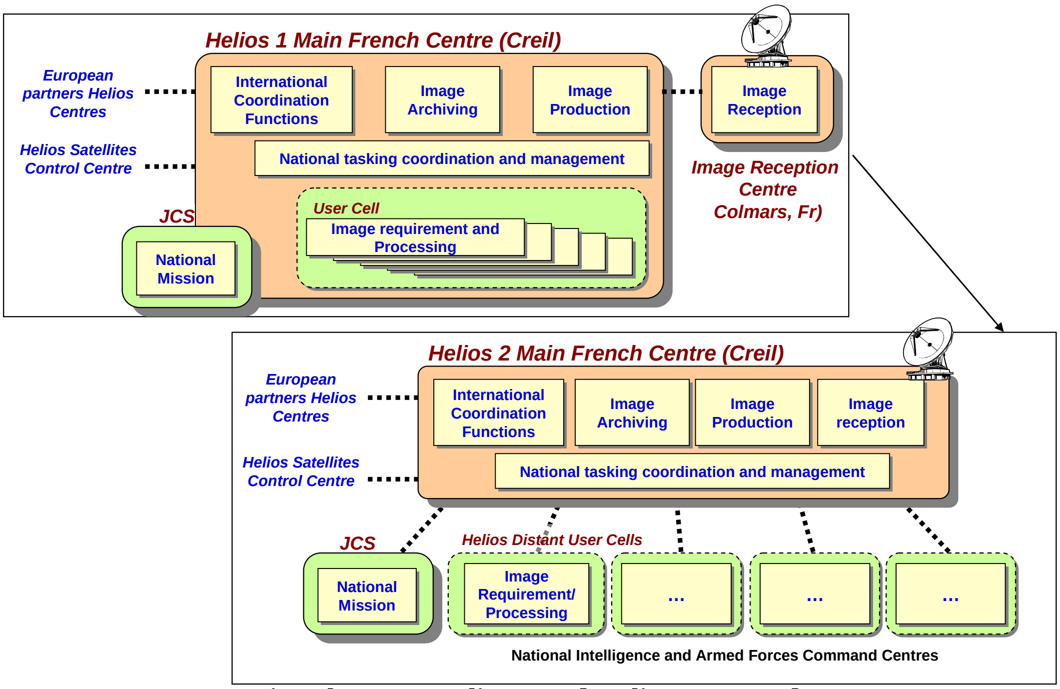
Fig.1 : Fulfilling the "Headline Goals":
Finding the right balance for satellite use
(Synoptic scheme)

EXISTING SATELLITE PROGRAMS

TYPE	SYSTEM	(# satellites) and year of launch	COST M€	LIFETIME Years
Communication				
	Syracuse 3	(3) 3A : 2005 3B : 2006 3C : 2010	2300	12
	Sicral I (S1B:EHF)	(2) S I A : 2001 S I B : 2007	675	10
	Sicral II (EHF)	(1) S II: 2011	n.a.	15
	Skynet 5 (EHF)	(3) S 5 A, B: 2007 S 5 C: 2008	3600 (include 15ys service)	15
	Satcom Bw	(1) 2009	340	15
	Spainsat	(1) 2006	415	15
Observation				
radar	COSMO SKYMED	(4) From 2007 every 8 months	890	5
	SAR-Lupe	(5) from 2007 every 6 months	370	10
optic	Helios II	(2) H II A : 2004 H II B : 2008	1800	5
	Pléiades	(2) P 1 : 2009 P 2 : 2010	400	5

FRANCE	**Helios I**	**Helios II**	**Syracuse**	**Pléiades**
Objective	Earth observation	Earth observation	communication	Earth observation
year of launch	H I A 1995 H I B 1999	H II A 2004 H II B 2008	Télécom 1 A: 1984; 1B: 1985; 1C: 1986. Télécom 2A: 1991; 2B: 1992 ; 2C: 1995 ; 2D: 1996 Syracuse 3: 3A:2005; 3B:2006; 3C:2010	P 1: 2009 P 2: 2010
Budget (M€)		1800	Syracuse 3: 2300	400
Partners	Italy – Spain	Belgium-Spain-Greece (2007)-Germany (2002)	-	Italy (ORFEO) Sweden, Belgium, Spain, Austria
Weight		4200kg	3725kg	940kg
industries	EADS Alcatel Alenia Space	EADS Alcatel Alenia Space	Alcatel Alenia Space Thales	EADS Alcatel Alenia Space
performance		Capacity IR Bigger agility than H 1 100pictures/day	SHF EHF Jamming-resistance High data transfer	20 km swath at Nadir Data storage: 600gb Optic component Great agility Stereoscopic acquisition
Orbit	sun-synchronous	geosynchronous	geosynchronous	sun-synchronous
Altitude	675 km	675km		695km
Image resolution	Classified data (believed to be submetric)	Classified data (Believed to be around 50 cm)		70cm
Launcher	Ariane 4	Ariane 5G+	Ariane 5	Ariane

- Helios 1 and 2: They derivate from SPOT remote sensing satellites and they are built by EADS Astrium. SPOT1 and its derivates were born as a civil mean of earth observation characterized by HRV (high-resolution visible) imaging instruments and HRS instrument (SPOT5) that provides stereoscopic coverage to produce digital elevation models very rapidly. This capacity is in great demand by various MoD especially for programation of cruise missiles. The re-use of SPOT 4's platform for HELIOS I and SPOT 5's platform for HELIOS II has optimized both these military observation programs.



Comparison between Helios-1 and Helios-2 Ground segments

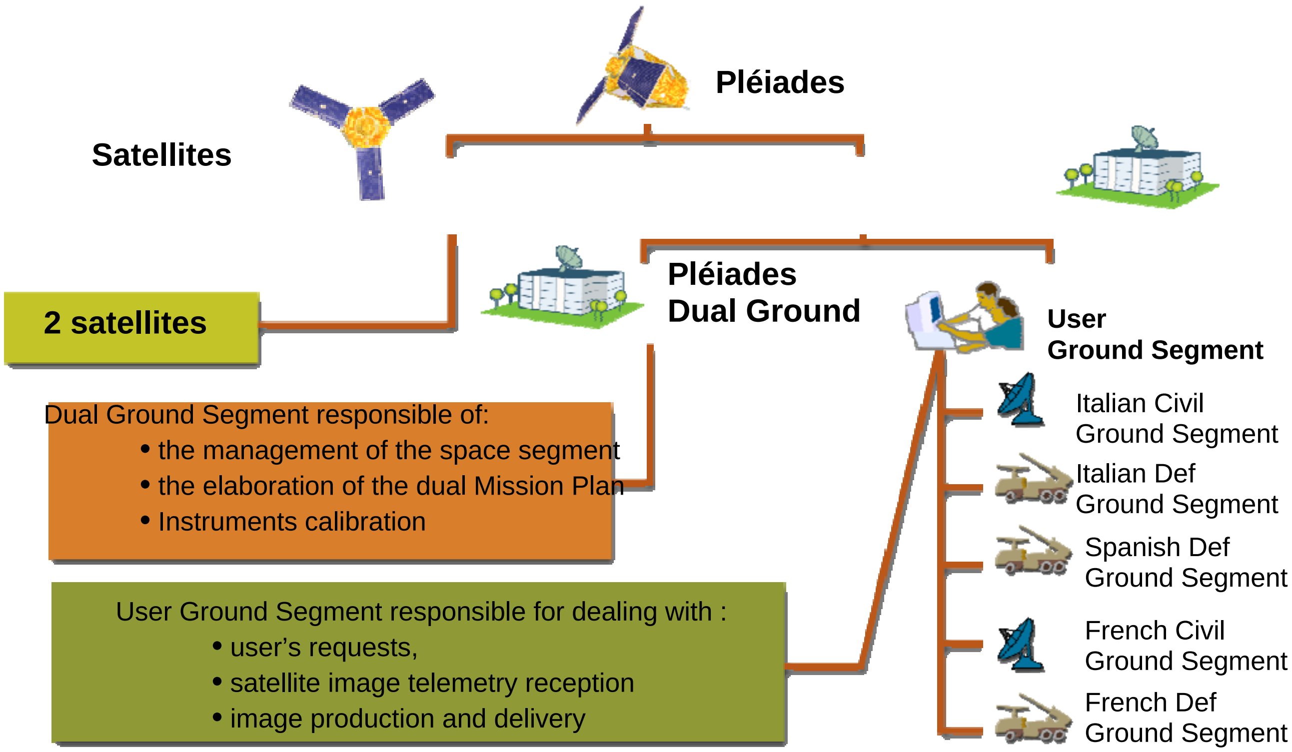
(Source: EADS Astrium in FRS Colloquium, The use of Space imagery for Defence, Paris, 9-2004)

At the performance level, a better organized decentralized infrastructure has allowed multiplying the processing power of the Helios system by 4 in 8 years with a corresponding archiving capability multiplied by a 100 factor with an associated cost divided by 3. This infrastructure performance increase must be considered as one element among other improvements gradually brought by the introduction of several technological upgrades such as:

- fully automatic imagery generation,
- already prepared and ortho-rectified imagery for direct interpretation use,
- Ready-to-merge DTM / other source imagery techniques,

all of this allowing an increased imagery production rate.

- <u>Pléiades</u>: the Pléiades programme managed by the French Space Agency (CNES), consists in two high resolution[48] optical 1 ton-class satellites, the first of which is envisioned ready for launch in 2009, the second following 18 month later. The Programme also comprises a dedicated ground segment for receiving, processing and archiving the data.



The Pleiades programme structure (Source CNES)

[48] With a 0.7m resolution.

ITALY	**SICRAL I and II** Sistema Italiano per Comunicazioni Riservate ed Allarmi	**COSMO SKYMED** Constellation of four small satellites for Mediterranean Basin Observation
Objective	Military Communication 1 satellite	Radar Earth Observation – 4 satellites
Year of launch	2001; S 1 in 2005 and S 2 in 2010	From 2006 every 8 months
Budget (M€)	500	890
Partners	-	France (Pléiades- ORFEO)
Weight	2500kg	1700kg
Industries	Alenia space (70%), Fiat avio (20%), Telespazio (10%)	Alcatel Alenia Space
Performance	Multipayload and multitransmission: EHF UHF SHF	Synthetic Aperture Radar (SAR) - X band - High resolution Till 1800 images/day Optic day and night sensors - three-dimensional SAR images
Orbit	geosynchronous	sun-synchronous
Altitude	36000km	620 km
Image resolution	<1m	< 1m
Launcher	Ariane 44L	Delta 2

- Cosmo-Skymed: The system will be composed by a constellation of 4 satellites allowing a 12 hour revisit time. Each satellite will be able to collect 75 radar images a day with a sub-metric ground resolution; 375 radars images a day with a medium resolution.

Three “response time” modes are typically envisioned: Routine response time (72 h), Crisis response time (36 h), Urgent response time (18h), to deliver 5 types of products: Spotlight 1 (military only), Spotlight 2 (submetric resolution with a 10X10km swath), Stripmap Himage (5X5m resolution with a 40X40 km swath), Stripmap PingPong (15X15m resolution with a 30X30km swath), Scansar Wideregion (30X30m resolution with a 100X100 km swath) and Scansar Hugeregion(100X100m resolution with a 200X200km swath).

In addition, the SAR radar technique will allow Cosmo-Skymed radars to be used in a moving target indicator mode with specific applications for maritime surveillance. Besides, a number of applications raging from the conception of 3D-digitial terrain modelling to change detection techniques will be envisioned both for civilian and for military uses.

UK	Skynet	TOPSAT
Objective	Military communications	Earth Observation
Year of launch	S 1 A and B: 1969 1974 S 2 A and B: 1974 S 4 A B and C: 1989 1990 S 4 stage 2 D E and F: 1998 2001 S 5 A B C: 2007	2005
Budget (M€)	3600 contract in 2003	20,8
Partners	-	-
Weight	S4: about 1500kg S5: about 5000kg	120kg
Industries	BAE Dynamics ; Matra Marconi Systems; Astrium	Consortium lead by QinetiQ Others: SSTL, Rutherford Appleton Laboratories (RAL) and InfoTerra
Performance	-instantaneous voice, video and data transmission -UHF and SHF payloads -Secure satellite control link -Anti-jam capability -Multiple, steerable spot beams -Switchable connectivity -Support to legacy terminals	-low cost, low mass, microsatellite -three-band multi-spectral images -covering area of 17x17 km -mobile and fixed ground stations -imagery delivered direct to the local user in real time
Orbit	geosynchronous	Sun-synchronous
Altitude		706km
Image resolution		2.8 m panchromatic
Launcher	S1 and 2: Delta S4 Delta, Titan and Ariane S5 Ariane	cosmos

Paradigm Secure Communications (EADS affiliate) has been chosen by the UK MoD in 2002 for its military communications (Skynet 5) in the form of a service provision contract, procured under a Private Finance Initiative (PFI). The Paradigm team consists of industry leaders within the communications field including Logica, General Dynamics Decision Systems (formerly Motorola IISG), Cogent DSN, Serco, Cable & Wireless and SEA; with support from Stratos for Inmarsat services.

The company is tasked with delivering secure military satellite communications (Milsatcomms) to UK armed forces around the world. For the first time in history Milsatcomms will be provided by a contractor worth around 3 billion euros over 20 years. This particular kind of contract implies that the military customer pays an annual service fee and leaves hardware acquisition to the contractor This is the largest private finance initiative (PFI) of its kind.

GERMANY	**SAR-Lupe**	**Satcom Bw**
Objective	Military Radar Observation – 5 satellites	Military communications
year of launch	From 2006 every 6 months	2009
Budget (M€)	300	339
Partners		-
Weight	770kg	2500kg
Industries	OHB-System AG	Alcatel Alenia Space, Astrium
Performance	Synthetic Aperture Radar S and X band transmitter	SHF UHF Ku-band transponders
Orbit		geosynchronous
Altitude	500km	
Image resolution	<1m	
launcher	Kosmos 3M	Ariane 5 (if launched with other satellites) or Soyuz (if launched alone)

SAR Lupe: SAR Lupe will consist in a constellation of 5 SAR satellites placed on 3 different orbital planes at an altitude of 500 km allowing both “stripmap” and “spotlight” images. The first satellite was launched on December 19, 2006. The S-band radar satellites built by OHB-System AG will have a 1 meter ground resolution capability. The total constellation is planned for being in orbit starting from the end of 2008, with a first operational capability obtained as soon as the summer of 2007 with the launch of a second SAR-Lupe satellite. The control centre will be hosted in the German Space Agency installations of Oberpfaffenhofen, Germany, providing SAR products both for national uses and for the exchange programme with France.

SPAIN	**Spainsat**
Objective	Military communications
year of launch	2006
Budget (M€)	415
Partners	
Weight	3700kg

Industries	Space Systems/Loral
Performance	X-band and Ka-band transponders.
Orbit	geosynchronous
Altitude	
Image resolution	
Launcher	Ariane 5

Other planned or Future Earth Observation Programmes

Countries	Name	Class	Resolution	Launch	Data Ownership
Germany	TerraSar-X	X-Band Radar	1 m	2007	Infoterra
Germany	Tandem-X	X-Band Radar	3D-Modelling	2007	Infoterra
Spain	SEOSAT	Optical	1 to 2 m	2010	Swedish MoD
Sweden	SVEA	Optical	2,5 m	2010	Spanish Government

Experimental programs:

FRANCE	**SPIRALE** Système Préparatoire Infra-Rouge pour l'Alerte	**ESSAIM**	**CERISE** Caractérisation de l'Environment Radio-electrique par un Instrument Spatial Embarque - Surveillance
Objective	Early Warning – 2 microsatellites	Electronic intelligence – 4 microsatellites	Electronic intelligence
year of launch	2008	2004 with Helios 2A	1995 with Helios1
Budget (M€)	124	100	13
Partners	-	-	-
Weight	120 kg each	120 kg each	50kg
industries	EADS Asrtium (prime) and Alcatel Alenia Space	EADS Astrium	Alcatel Alenia Space
Performance	8Gb mass memory each satellite ; IR to detect ballistic missiles	15 orbits; 6 over fly on the same point in 24h	500MHz-20GHz band. Broadband radiometric measurement
Orbit	sun-synchronous		sun-synchronous
Altitude	36000km max	680KM	
Image resolution			
Launcher	Ariane 5	Ariane 5G	Ariane 4

Cerise: is an electronic experimental instrument that has been launched and operates attached to Helios 1 satellite. It has been hit and damaged in 1996 by a space debris.

EVOLVING EUROPEAN COOPERATION

Country	Cooperation Agreements
Belgium	- Helios – 2,5% quota - MUSIS - Syracuse 3A leasing
Germany	- Helios – SAR-Lupe - MUSIS - Syracuse 3A leasing
Greece	- Helios – 2,5% quota - MUSIS
Italy	- Helios – 2,5% quota - MUSIS - Cosmo Sky med-Pléiades (ORFEO)
The Netherlands	- Paradigme
Spain	- Helios – 2,5% quota - MUSIS

France, as the major European actor in space activities, has developed several forms of cooperation with other European countries:

- Germany and France have agreed to exchange services provided by Helios (optical EO) and SAR-Lupe (radar EO) in order to obtain information independently of weather conditions on a 7/24 basis.
- Spain, Belgium, Italy and Greece participate directly to Helios program with 2,5% quota each.
- Italy and France have signed an agreement to exchange observation information. Pléiades (radar EO) and Cosmo sky-med (optical EO) form together the Optical and Radar Federated Earth Observation (ORFEO, agreement signed in 2001, called “accordo di Torino”).
- In addition to NATO, the German Defence Ministry has leased the equivalent of two SHF transponders on Syracuse 3A for five years while waiting for its two Satcom Bw military telecommunications satellites to become operational. The Belgian Defence Ministry also has leased a small amount of capacity, leaving French forces with just 45% of Syracuse 3A for their own use.
- France is engaged on Multinational Space based imaging System (MUSIS) program with Helios’ partners (Italy, Spain, Greece, Belgium, Germany) aimed to provide initial architecture studies for a multinational observation system for security and defence purposes.

THE NETHERLANDS – PARADIGME CONTRACT

Paradigme Secure Communications has signed an export contract of two phases with the Netherlands Ministry of Defence (MoD) to deliver military satellites communications services. A first phase gives to the Netherlands MoD access to services from Skynet 4 satellite on a as-and-when required basis until December 2006. From January 2007 the second phase provides

the Netherlands MoD with a full service provision provided by both Skynet 4 and Skynet 5 satellites.

SWEDISH EO SVEA PROGRAM

In order to meet the interest of a national Swedish surveillance satellite system, Swedish Space Corporation is developing SVEA, a low cost EO program based on the re-use of recent and ongoing programs, such as SMART-1 and PRISMA.
SVEA is a basic flexible observation system that also targets the need of other potential public or commercial customers.
There is not yet a decision by Swedish authorities to build the system, but since it has a low cost and a low development risk, SVEA can be realized in a relatively short time, and the first satellite could be launched in 2010.

MULTINATIONAL SATELLITE PROGRAMS

EUROPEAN	**GALILEO**
Objective	positioning
Year of launch	4 satellites: 2008-2009 26 satellites: 2010-2011
Budget (M€)	3000 (probably to increase)
Partners	CE ESA
Weight	700kg
Industries	Consortium Galileo Industries (GmbH, Alcatel Space, Astrium Otd, Alenia Spazio)
Performance	
Orbit	
Altitude	24000 km
Image resolution	< 1 m
Launcher	

EUROPEAN GMES

GMES (Global Monitoring for Environment and Security) is a European (EC and ESA) initiative of Earth Observation (EO) for the implementation of information services dealing with security and environment.
GMES will support decision-making by both institutional and private actors (national and European authorities, civil protection organisations, etc..) and could concern security measures in case of a natural or man–made catastrophes.
An action plan has been published in February 2004, followed by its implementation phase (2004-2008). The objective is to gradually develop and validate a number of pilot operational services, based on selected R&D projects. In accordance with this objective, 3 "fast-track" services have been already selected, dealing respectively with emergency response, land monitoring and marine services. They should become operational as of 2008.
The two main management structures guiding this program are the GMES Advisory Council (GAC) and the GMES Bureau. The first brings together the EU Member States, the Commission, ESA, and relevant other Agencies active in earth observation. Its main role is to strengthen the political ownership of GMES.
The GMES Bureau is a specialised core team, whose main task is to develop a federated and structured demand for earth observation and to deal with medium-term issues such as governance structure and financial sustainability.

NATO SATCOM POST 2000

Under the Satcom Post 2000 program the British, French and Italian governments are providing NATO, through the so called "Capability Provision", with advanced satellite communication capabilities for 15 years as of January 2005 at a price within the NATO funding ceiling of Euro 457 million.

The benefits of the program, which gives the Alliance improved satellite communication capabilities, include increased bandwidth, coverage and expanded capacity for communications and data, including with ships at sea, air assets, and troops deployed across the globe.
The program provides NATO with access to the military segment of three national satellite communications systems: the French Syracuse, Italian SICRAL, and British Skynet 4/5.
This new system replaces the two existing NATO IV communications satellites, which were launched in 1991 and 1993, respectively, and were designed to last 10 years.
NATO can access to two components: super high frequency (SHF) for ground stations with larger radar dishes and ultra high frequency (UHF) communications, used for tactical communications.

Existing European Systems providing the NATO Satcom post-2000 SHF service

Systems	Skynet 4 A,B,C	Skynet 4 D,E,F	Skynet 5	SICRAL	Syracuse 3 A,B
Lead Contractor	ASTRIUM	ASTRIUM	ASTRIUM	SITAB Consortium	ALCATEL
Date	1988-1990	1998-2001	2006-2008	2001	2005-2006
Total life costs	800 million EUR	3700 million EUR	5 000 million EUR (all service by Paradigm included[49])	450 million EUR (103 million EUR for the recurrent Model with an additional 73 million EUR for non recurrent costs)	2300 million EUR
Life duration	7 years	7 Years	15 Years	10 Years	12 Years
Coverage	Global	Global, Spot	Global, Spot	Spots	Global, Spots
Bands	SHF	SHF	SHF-UHF-EHF	SHF-UHF-EHF	SHF-EHF

Procurement of Space Systems

NAME	# SAT	OPERATING YEARS	COST (Million EUR)
Telecommunications			
Skynet 5	3	2007-2022	5000 (service included)
Sicral	1	2005-2015	500
Syracuse 3	2	2005-2017	2300
Satcom Bw	1	2009-2024	340
Spainsat	1	2006-2021	415
Earth Observation			

[49] Paradigm also formally manages the Skynet 4 services.

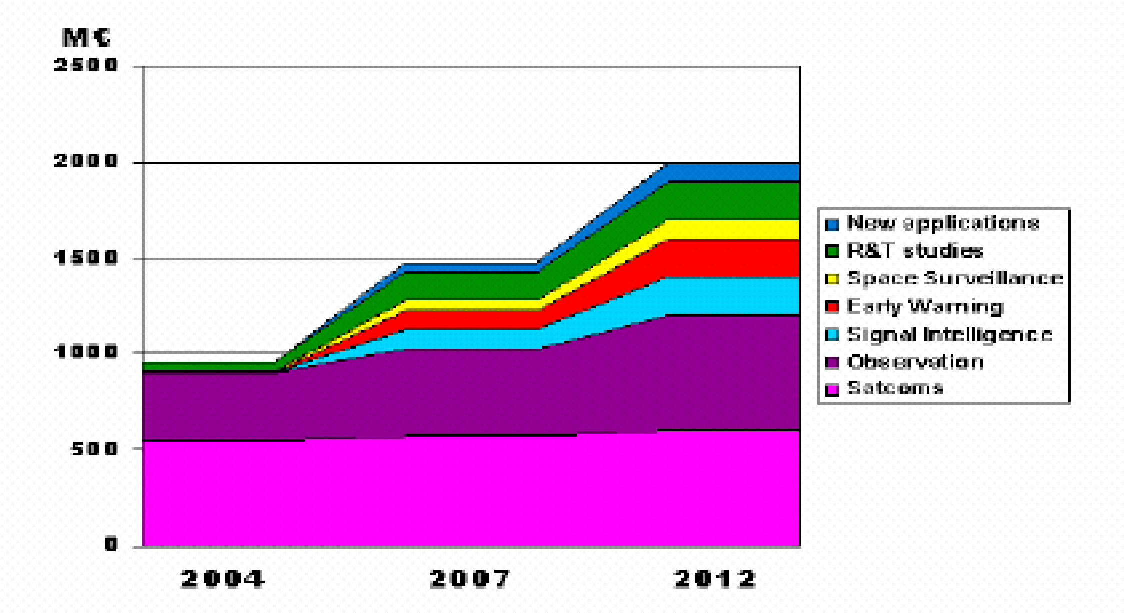
Helios 2	2	2004- /2008-	1800
Pléiades	2	2009-2014/2010-2014	400
Cosmo Sky-Med	4	2006-2011	900
TopSat	1	2005-2006	21
Sar-Lupe	5	2006-2016/2008-2018	300
Spainsat	1	2006-2021	415

Past estimates of ESDP space needs

First estimate (2001) of the cost of a European military space capability

Programme	Programme cost	Programme duration	Annual cost	French Participation (29,1 %)
Telecom	3 100 M€	15 Y	207 M€	62,1 M€
Observation	2 300 M€	10 Y	230 M€	69 M€
Galileo*	150 M€	8 Y	19 M€	5,7 M€
ELINT	1 220 M€	10 Y	122 M€	36,6 M€
Space Surv.	760 M€	10 Y	76 M€	22,8 M€
Early Warning	760 M€	10 Y	76 M€	22,8 M€
Total	8 290 M€		730 M€	219 M€

Cost Estimates of European Space System for ESDP

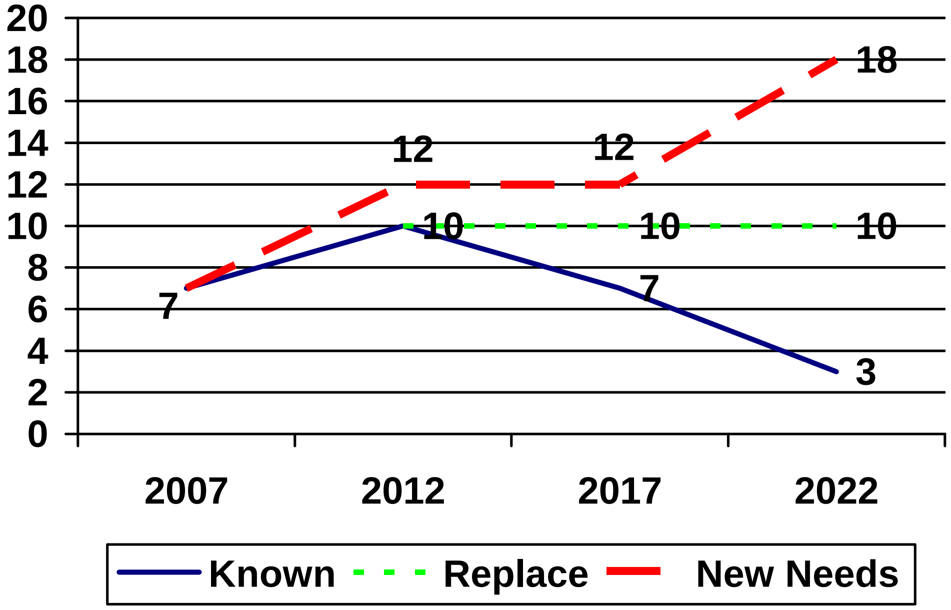


Source: Spasec Report, Appendix C, European Commission, March 2005, p.52.

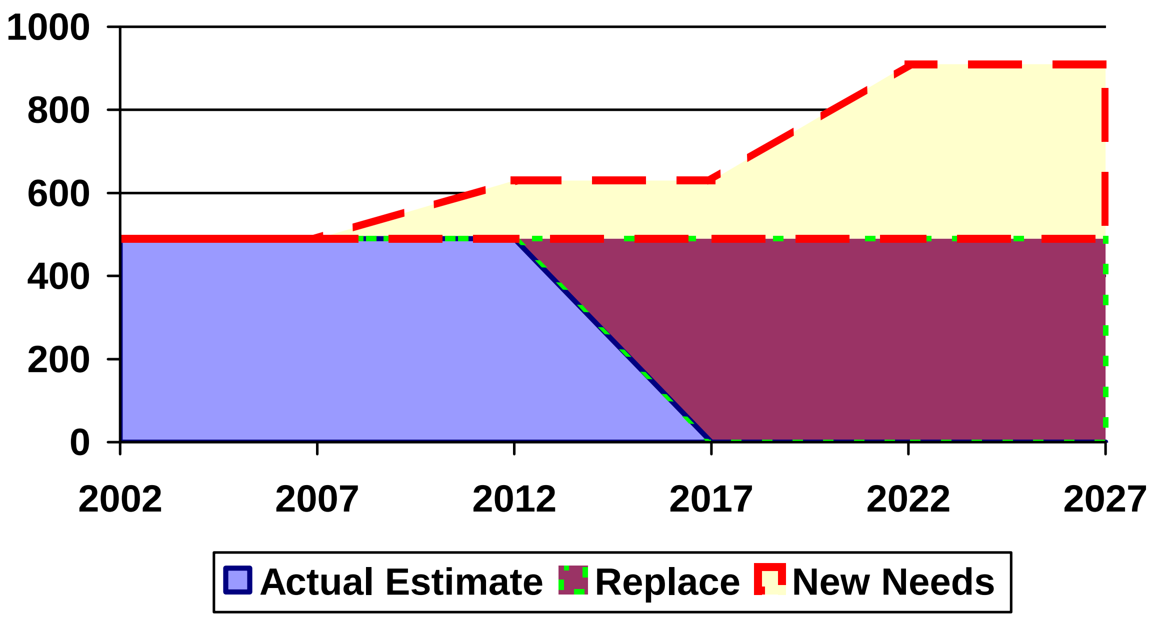
Table
Cost Impact – an estimate

	Planned Spending	**Proposed Spending**	**Additional spending (average per year)**
SATCOM			
(estimate, 2007 M€)	**7.500** (2005-2024)	**13.500** (2007-2022)	**+ 400** (over 15 years)
Data Gathering			
(estimate, 2007 M€)	**4.000** (2004-2018)	**8.000** (2012-2022)	**+ 400** (over 10 years)

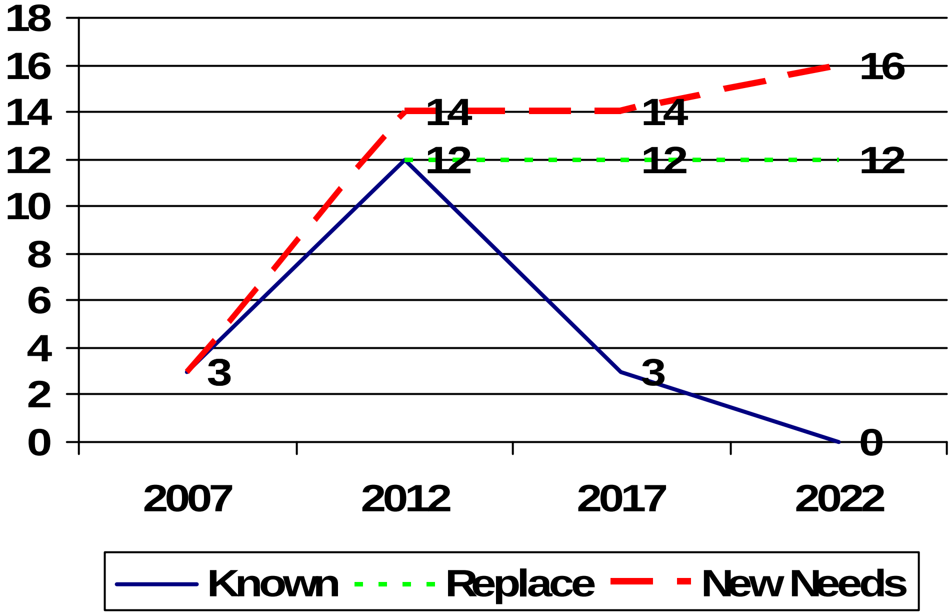
Number of Dedicated Military Communication Satellites



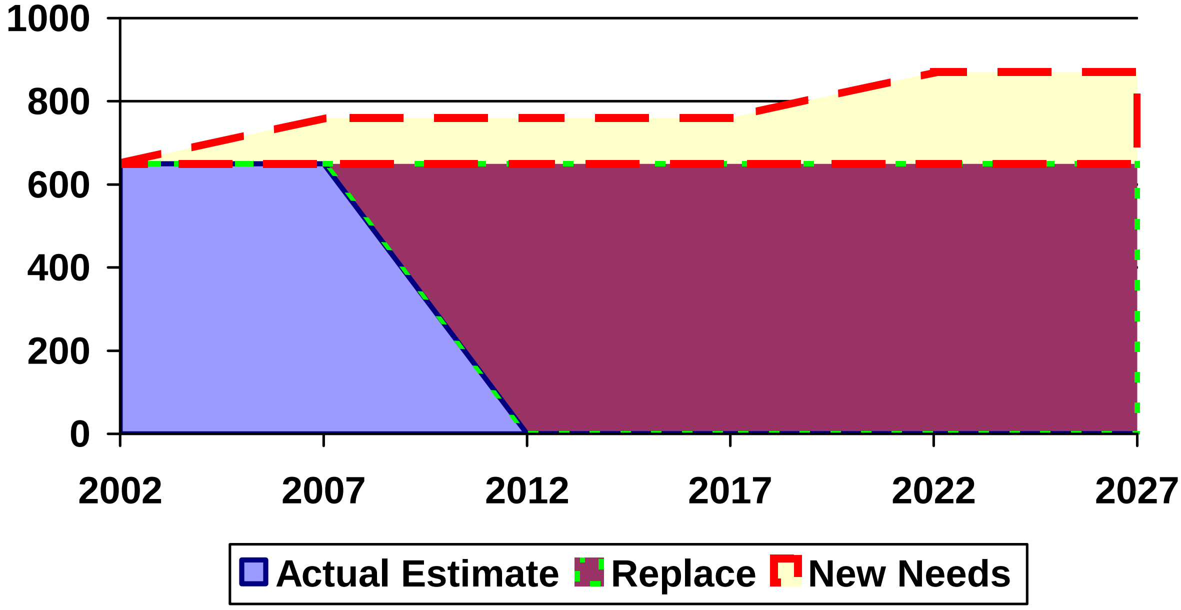
Dedicated Military Communication Satellites
Estimated Average Yearly Procurement Budget, (2007 M€) (including launch)



Number of Military and Dual Intelligence (Observation and SIGINT) Gathering Satellites – (Not including Early Warning and Space Observation systems)



Military and Dual Intelligence (Observation and SIGINT) Gathering Satellites
Estimated Average Yearly Procurement Budget, (2007 M€) (including launch)



RADIO FREQUENCY SPECTRUM

Band name	Abbr	ITU band	Frequency Wavelength	Example uses
Extremely low frequency	ELF	1	3–30 Hz 100,000 km – 10,000 km	Communication with submarines
Super low frequency	SLF	2	30–300 Hz 10,000 km – 1000 km	Communication with submarines
Ultra low frequency	ULF	3	300–3000 Hz 1000 km – 100 km	Communication within mines
Very low frequency	VLF	4	3–30 kHz 100 km – 10 km	Submarine communication, avalanche beacons, wireless heart rate monitors, geophysics
Low frequency	LF	5	30–300 kHz 10 km – 1 km	Navigation, time signals, AM longwave broadcasting
Medium frequency	MF	6	300–3000 kHz 1 km – 100 m	AM (Medium-wave) broadcasts
High frequency	HF	7	3–30 MHz 100 m – 10 m	Shortwave broadcasts, amateur radio and over-the-horizon aviation communications
Very high frequency	VHF	8	30–300 MHz 10 m – 1 m	FM, television broadcasts and line-of-sight ground-to-aircraft and aircraft-to-aircraft communications
Ultra high frequency	UHF	9	300–3000 MHz 1 m – 100 mm	television broadcasts, microwave ovens, mobile phones, wireless LAN, Bluetooth, and Two-Way Radios such as FRS and GMRS Radios
Super high frequency	SHF	10	3–30 GHz 100 mm – 10 mm	microwave devices, wireless LAN, most modern Radars

Extremely high frequency	EHF	11	30–300 GHz 10 mm – 1 mm	Radio astronomy, high-speed microwave radio relay

<u>**MAIN INDUSTRIAL SPACE ACTORS**</u>

EADS ASTRIUM

<u>PRODUCTS:</u>

Equipment & Subsystems: Avionic & Electronic Systems, Mechanical Equipment and subsystems, Payloads equipment. Earth Observation & Navigation: Satellite Platforms, Instruments/Payloads, Ground Systems. Services, software products, instrument accessories, other components

<u>TURNOVER</u>: 2,7 BILLION EUR in 2005

<u>SHAREHOLDING STRUCTURE</u>: Contractual partnership : 57,90% (Legardèere and French State 29,95%, SEPI (Spain) 5, 48%, Dymler Chrysler (Germany) 22, 47%)
Free float: 42,10%

<u>EMPLOYES:</u> 11.000

<u>R&D BUDGET EADS</u> : 2,1 BILLION EUR in 2005

<u>MAIN LOCATIONS:</u>

FRANCE : Paris (Headquarters) ; Toulouse ; Vélizy ; Les Mureaux ; Aquitaine ; Kourou (French Guiana)

UK : Stevenage ; Portsmouth ; Poynton

GERMANY: Ottobrunn ; Bremen ; Lampoldshausen ; Friedrichshafen

SPAIN: Barajas (Madrid) ; Tres Cantos (Madrid) ;

THE NETHERLANDS: Leiden

USA: Houston (Astrium North America)

THALES AEROSPACE

<u>PRODUCTS:</u> Guidance and navigation equipment, launchers (Ariane), receivers and electronics (EGNOS), Galileo

<u>CONSOLIDATED REVENUES</u>: 2.4 BILLION EUR in 2005

<u>SHAREHOLDING STRUCTURE:</u> Public: France 50,7%; Public, bound by shareholders agreement: 26,7%, Alcatel-Lucent: 21%, Thales: 1,6%

<u>EMPLOYES</u> 13.000
<u>R&D BUDGET</u> 408 MILLION EUR

<u>MAIN LOCATIONS:</u>

USA: Edison, Nj; Seattle, Wa; Irvine, Ca; Phoenix, Az

GERMANY: Frankfurt; Überlingen

ITALY: Vergiate, Varese

FRANCE: Neuilly Sur Seine Cedex; Meudon-La-Foret; Le Haillan; Valence; Chatellerault; Chatellerault; Toulouse; Chatou; Meru; Conflans-Ste-Honorine; Elancourt , Brest ;
UK **:** West Sussex; London; Leicester; Edinburgh

THALES ALENIA SPACE

PRODUCTS: complete space systems, satellite for telecommunications and multimedia services, remote sensing, meteorology and scientific applications, manned and unmanned in-orbit infrastructures, launch, transport, re-entry systems, space software.

CONSOLIDATED REVENUES: 1,8 BILLION EUR in 2004

SHAREHOLDING STRUCTURE In April 2006 Alcatel handed in his space activities to Thales. Space activities are identified in two joint-ventures with Finmeccanica: Alcatel Alenia Space (now Thales Alenia Space, satellite manufacturing, 67% Thales-33% Finmeccanica) and Telespazio (satellite services, 67% Finmeccanica-33% Thales).

EMPLOYES 7200 in 2004

R&D BUDGET 7,5 MILLION EUR

MAIN LOCATIONS

BELGIUM : Mont-Sur-Marchienne
ITALIA: Rome, Turin, Milan, L'Acquila, Florence
FRANCE
SPAIN

SELECTED CIVIL COMMUNICATIONS

Name	Characteristics	Note
INMARSAT *International Maritime Satellite Organization*	8 satellites Global coverage	100% free float
IRIDUM	66 satellites low-earth orbiting	Built by Motorola - Failed and then bought by USA DoD
GLOBALSTAR	48 satellites	
ARTEMIS	1 satellite multirole, radio-optic frequency – first satellite to satellite laser system	

TYPICAL SATELLITE SYSTEMS LIFECYCLE

Phase	R&D	Procurement	Launch	Service
Time estimate	3-5 years	1-3 years	6-12 months	5-7 years (Observation) 10-15 years (Communication)

EUROPEAN CIVIL/MILITARY SPACE SPENDING

Million EUR, when not differently indicated	2005	
	civil	military
ESA budget (1)	2.556	
European military space spending (2)		700
ITALY budget ASI (3)	952	
ITALY MoD (4)		55,2
FRANCE MoD (5)		433
France research budget (6)	1366	
UK British National Space Centre budget (7)	266	
USA NASA budget (8)	15,2 Billion USD	
USA DoD in 2006 (9)		1,5 Billion USD

(1): Total of the national contributions' sum in 2005.
In detail:

	Country	Contributions, M EURO	%
1	France	740,91	28,99
2	Germany	571,08	22,34
3	Italy	362,89	14,20
4	UK	216,47	8,47
5	Belgium	159,59	6,24
6	Spain	136,66	5,35
7	Switzerland	87,98	3,44
8	The Netherlands	72,92	3,13
9	Sweden	56,38	2,21
10	Norway	30,94	1,21
11	Austria	30,75	1,20
12	Denmark	25,95	1,02
13	Finland	17,53	0,69
14	Canada	16,02	0,63
15	Portugal	10,98	0,43
16	Ireland	9,21	0,36
17	Greece	1,70	0,07

18	Luxemburg	1,07	0,04
	TOTAL	**2.556,03**	**100**

Source: ASI , Piano AeroSpaziale Nazionale 2006-08

(2): Data estimated. Source: Defence News, 20/11/06
(3): Source: ASI
(4): Data elaborated from official Italian MoD document (Nota Aggiuntiva del Ministero della Difesa 2004)
(5) Average data estimated per year in the six-year spending blueprint covering the period 2003 to 2008. Source: Financial Times 5/03/07 p. 26
(6): Source: eu.spaceref.com ; http://eu.spaceref.com/news/viewsr.html?pid=16161
(7): Source: Space Security 2006, p. 74
(8): Source: NASA website
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