European Space Policy Institute

SPACE-BASED SERVICES IN EUROPE

ADDRESSING THE TRANSITION BETWEEN DEMONSTRATION AND OPERATION

Report 17, March 2009

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Addressing the transition between demonstration and operation

Executive Summary

Over the past decades, Europe has made considerable investments in the development of its space infrastructure which is now substantial. European institutions and citizens, however, are still far from being able to take full advantage of what this infrastructure could offer them. With the growing political dimension of Europe, closer relations between the European Space Agency (ESA) and the European Union, and the search for new sources of funding for space, European space activities have entered a new era and the investments made in the infrastructure could be further optimized. The focus is shifting from space systems to their applications and there is now strong political interest in the development of services, which could support European policies and further contribute to the European citizens' welfare.

Recent European initiatives to foster the development of new space-based services have nevertheless yielded limited results. Publicly funded programmes have led to the successful demonstration of new applications but most of these applications have not turned into operational services.

The objectives of the present report are to investigate the main challenges to the transition from demonstration to operation in Europe, to analyze the need for public action and to suggest to European decision-makers relevant measures that could ensure that European citizens fully benefit from a well-developed space infrastructure. It emphasizes the need for coordinated actions of all the stakeholders in Europe and for leadership in order to achieve a significant, large-scale development of space-based services in Europe, which could enable European decision-makers and citizens to reap the full benefits of their space infrastructure.

A prosperous service sector exploiting the full potential of European space infrastructure would be a major asset for Europe. Space-based services can actually contribute in a unique way to European policy objectives and their development will be a key driver of growth in the European space sector.

The Problematic Transition between Demonstration and Operational Services

Despite their importance and the initiatives already undertaken to support their development, operational services have been successfully established in only a few fields, mainly telecommunications and meteorology. In fact, the critical step in the establishment of sustainable services has not been properly addressed by European decision-makers. As presented in Figure A, there are four phases in the development of new services: a feasibility phase, a demonstration phase, a pre-operational phase and an operational phase.

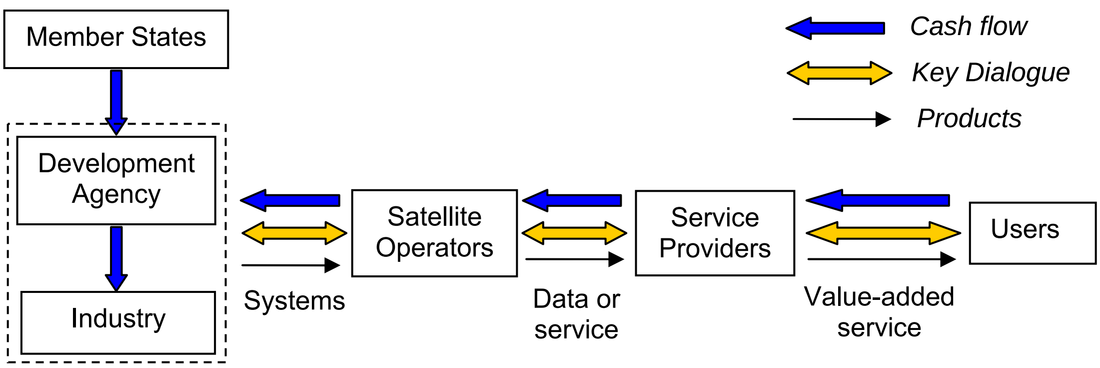

Figure A: The main steps in the development of operational services

The crucial step in this process is the transition between demonstration and operation. This involves not only technological developments to reach a pre-operational stage but more importantly it requires establishing the sustainability of the operational service. A sustainable service necessarily comprises many components that tend to be unique for each type of service:

- structured demand;
- reliable technology that is affordable, cost-effective and adapted to users needs; and
- proper structures that ensure appropriate funding allocation and generation and an adequate programmatic overview.

All these elements put together ensure the continuity, availability and sustainability of the services and of the infrastructure on which they are based, and represent the many challenges to a successful transition from demonstrated applications to operational services.

Several ESA and EC projects have funded the demonstration of new space-based applications and have promoted the use of space-based services. However, these programmes have not properly dealt with the transition between demonstration and operation and can therefore be improved. There are two key challenges to be addressed by European decision-makers:

- the fragmentation and lack of organization of the demand for services; and
- the sustainability of proposed space-based solutions.

Fostering and Structuring the Demand for Space-based Services in Europe

Users are central to the development of new operational services but many potential users do not know what space-based tools could do for them. On the other hand, the space sector still has limited knowledge and understanding of the demand for space-based services that, in addition, tend to be very fragmented in Europe. A systematic and large-scale approach is therefore needed to further promote the use of space and to identify, understand, federate and structure the demand for space-based services in Europe. In order to be successful, proper actions will have to be undertaken in a coordinated manner at different levels and scales by all stakeholders (policy-makers, space agencies/offices, industry etc.). Above all, this requires leadership from stake-holders, and organizations to take on and manage these efforts. Effectively promoting the use of space requires:

- access to new user communities;
- the ability to adapt to, communicate with and understand the needs of potential users; and
- the support of technical experts.

Possible actions range from outreach activities to demonstrations of pilot services and should be as targeted as much as possible towards a specific user community in order to maximise the impact and outcome. Once a new user community is identified, an initial dialogue should be established between the space community and these users. Workshops and joint working groups between users and providers could be organised. This requires the involvement of technical experts and "mediators", who would be the link between users and technical experts. A key element in the success of these initiatives is the choice of user communities to be initially targeted. Next, to give real impetus to the development of the service sector, the demand for services in Europe has to be federated. This consists of aggregating fragmented user communities e.g. aggregating local or national communities into a single European community, and leading this community to express common requirements.

Establishing Sustainable Services

Then, in order to provide users with sustainable solutions, two fundamental elements have to be established: access to space-delivered data and services should be secured and sustainable governance and funding of the services should be set up. Securing access to data and services consists mainly of ensuring the sustainability of the infrastructure and the availability and continuity of the data and services. Sustainable governance and funding require a structured and sustainable partnership with users, a proper programmatic overview and sustainable funding generation and allocation. All of these components form the overall value chain of operational space-based services presented in Figure B.

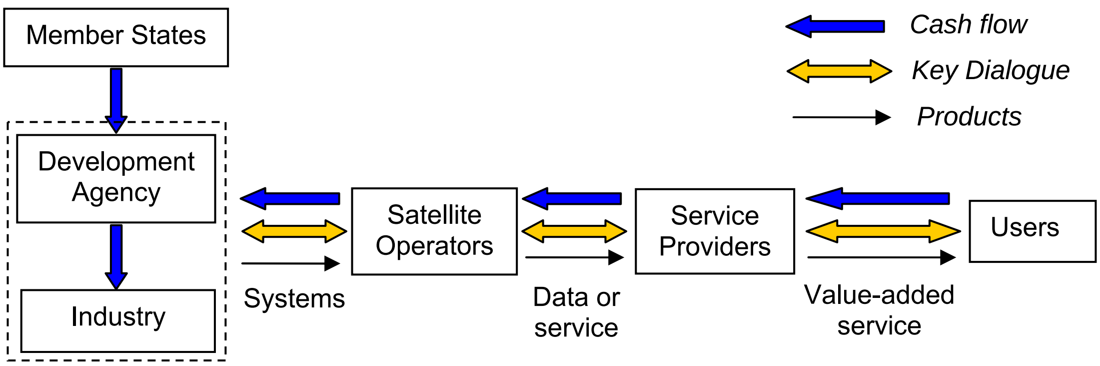

Figure B: The complete value chain of space-based services

From a Technology-push to a Demand-driven Paradigm

The last important issue to consider is the need for current organizations responsible for space activities in Europe (space agencies, industry, etc.) to adapt to the service paradigm and to evolve from the technology-push approach that corresponds to the development of space systems into a demand-driven approach required for the successful development of services. The space system and the service paradigms are presented in table A.

These organizations will also have to adapt their development programmes to the development of services. Moreover, to develop successful services, they will have to create programmes specific to each phase (feasibility, demonstration and transition), and especially to set up new programmes to support the transition from demonstration to operation, with innovative financial schemes to prepare the operational phase.

	Develop-ment Approach	**Techno-logies**	**Structure of Demand**	**Develop-ment Cycles**	**Develop-ment Costs**	**Develop-ment Risks**	**Structure of the Industry**
Space systems	Tech-nology - push	Space systems and their associated ground systems	A few large space agencies and operators	Long	High	High	Concentrated industrial structure with large organizations segmented per field
Space-based services	Demand-driven	Space tech. to be integrated with others	Multiplicity and diversity of users	Shorter	Lower	Lower	A number of small multi-disciplinary structures adapted to each user community + Direct competition with other technologies

Table A: The space system paradigm versus the space-based service paradigm

Space-based Services in Europe: Addressing the Transition between Demonstration and Operation

Introduction

Over the past half century, Europe has become a major player in space and has developed substantial space infrastructure. However, European space programmes have mainly addressed the needs of scientific communities and citizens have not fully benefited from these well-developed European space capabilities. Two major exceptions, the European meteorology and telecommunications programmes, have successfully evolved into services for much broader communities and have become part of everyday life. European citizens directly benefit from other space-based services but these services are based on systems that are not European in the communitarian sense. They are either part of non-European programmes such as the American GPS, or are part of national or multinational programmes that are managed by one or several European States, such as defence space programmes or the SPOT programme.

In view of the recent political development of Europe, closer relations between the European Space Agency (ESA) and the European Union, and the search for new funding for space programmes, European space activities have entered a new phase. The focus is shifting from space systems to space applications and there is now strong political will to further develop European downstream industry, thereby strengthening space industry overall. In the past decade new European application-oriented programmes have been set up. These include the two flagship programmes of the European Commission (EC), Galileo and GMES*, projects under the EC Framework Programmes and the ESA applications programmes including the Integrated Applications Promotion (IAP) programme that was approved at the last ESA Council at Ministerial level in November 2008.

However, the results of recent European initiatives to develop space-based services have been uneven. The use of existing space-generated data and space-delivered services could be extended to address some of the needs of European citizens in a number of additional areas. Many new applications integrating space-based tools have been demonstrated, mainly through publicly funded projects. However, only a limited number of these demonstrated applications have turned into actual operational services. Various challenges hindering the transition from demonstration to operation need to be addressed by European decision-makers in order to promote the development of space-based services and to fully use the potential of space systems to the benefit of citizens.

The objective of the present report is to analyse the main challenges to the transition between demonstrated space-based applications and operational services and to suggest relevant actions to European decision-makers, taking into account existing initiatives. This report first reviews the importance of space-based services for Europe and examines the current situation of the European service sector. It then describes the different phases of the development of space-based services and shows that the transition between demonstration and operation is the most critical step in the overall process. The two main challenges to this transition, i.e. the identification and aggregation of demand and the establishment of structures ensuring the sustainability of services, are successively analysed and specific actions to address each issue are suggested to decision-makers. The last part of the report examines a third, more general challenge to the transition, which is associated with the current structure of the space sector. The space sector, which has so far mainly focused on systems, needs to adapt to a service paradigm and to evolve from a technology-push approach to a demand-driven approach.

* Contrary to the other programmes mentioned, GMES is not a space programme and includes major ground infrastructure.

Definitions

To begin with, a definition of key words used in this report is necessary.

Space-based services are value-added, operational services delivered to a final user and enabled by space-based systems. In the generation of data and delivery of services, space-based systems can be complemented by ground-based and/or airborne systems. Space-based services range from simple signal transmission or raw data provision to more advanced, tailored and integrated services.

A *demonstration* aims to establish the technical feasibility of a service and to provide a first estimate of its cost. A service is considered as *operational* if it routinely and reliably delivers to users specific products that meet predefined requirements. A *pre-operational service* has the same technical characteristics as an operational service but its sustainability is not yet ensured by a proper organisational or institutional context and an appropriate funding mechanism. The *transition* is the process through which a demonstrated application becomes an operational service. The pre-operational service is the first intermediary step of this transition. A key condition for a service to be operational is its sustainability. The term *sustainable* refers to a service that can be provided to its users and maintained over the long term.

A distinction is made between four different types of programmes: *national, multilateral, European,* and *international* programmes. *Multilateral* programmes include programmes jointly undertaken by several European states (such as SPOT). The term *European* is used for the programmes of all organisations defined by European treaties, including the EC and ESA.

The term *European decision-makers* refers to the different persons who, through their function in a public organisation, shape the decisions that influence the development of space-based applications in Europe. These decision-makers:

- participate in the definition of the European space policy and applications programmes; and/or
- participate in the definition of the legal and regulatory framework for space-based services in Europe; and/or
- use space-based services in support of their actions/policies.
- In the present report, Europe's *public policies* refers to the policies adopted by any of these decision-makers rather than exclusively EC policies.

The distinction between *public* and *commercial* services is based on the source of funding for their operations, as sustainability of the services is ensured by this funding. The same distinction is used for space-based systems. These definitions do not refer to the source of funding for the development and implementation of the service or system. Moreover, public funding can come from two different sources: from a budget dedicated to space, usually a research budget; or from the operational budget of a ministry, a directorate general or any other public organisation using specific space-based services. The distinction between public and commercial is more complex when the public support is not direct. Even if the operations are privately funded, there are several ways in which the public sector can indirectly support a system or service:

- the initial development and implementation of the system or service can be publicly funded (e.g. SPOT); and/or
- a public organisation can commit to purchase a large amount of data or services before the system or service is developed, thereby ensuring a future level of activities and revenue sufficient to motivate the private sector to invest ("anchor tenancy" agreements, e.g. U.S. NIMA agreements with DigitalGlobe and Space Imaging). [1,2]

One can therefore distinguish three main categories of systems or services:

- purely commercial systems or services;
- purely public systems or services; and
- mixed systems or services.

In the last case, a combination of public and private sources of funding ensures the viability of the systems or services. For instance, additional commercial revenues can contribute to the sustainability of the operations of a system or service that is mainly publicly funded. In some cases these additional revenues are necessary for the public sector to maintain its funding.

1. Space-based Services in Europe

1.1. The importance of space-based services in Europe

Space-based tools have distinctive features that can make a unique contribution to addressing society's needs. They sometimes offer the sole technical solution to deliver information or services. Most importantly, they are not restricted by political borders and therefore contribute to European integration. The development of services based on these unique tools is crucial for Europe as well as for the European space sector.

1.1.1. The contribution of space based services to European objectives

Space-based services can support Europe's public policies and contribute to the well-being of European citizens. They already do in some areas but their contribution can be significantly increased and expanded to new fields. Recognizing this, in the 2007 European Space Policy European decision-makers clearly affirmed the need *"to develop and exploit space applications serving Europe's public policy objectives and the needs of European enterprises and citizens"*.[3] They subsequently emphasised in the 2008 Council Resolution that *"space, as a high tech R&D domain and through the economic exploitation of its results, can contribute to reaching the Lisbon goals so as to fulfil the economic, educational, social and environmental ambitions of the EU and the expectations of its citizens, and so as to achieve the objectives for growth and employment by providing new business opportunities and innovative solutions for various services, throughout Europe, thus contributing to territorial cohesion."*[4] These statements underline some of the many political, societal, economic and strategic reasons for supporting the development of space-based services in Europe which can contribute in a unique way to a large spectrum of European policy objectives. In fact, there is a growing number of references in the European Union's documents to the role of space-based services in supporting a wide range of policies in the fields of agriculture[5], border surveillance[6], development[7], transport[8], maritime policy[9], etc. The development of space-based services can help Europe in bridging the digital divide[10], in achieving the Lisbon goals and in building a knowledge society. It can also support European integration, especially through the integration of service user communities throughout Europe. The development of regional services for groups of regions from different European countries with similar needs, e.g. the Alpine Region or all the Coastal Regions, could significantly contribute to the integration of the European Regions, as supported by the Network of European Regions Using Space technologies (NEREUS).[11] Furthermore, space-based services have the potential to generate significant economic growth and innovation and to create new business opportunities, especially for small and medium enterprises (SME). The overall market for space-based services was estimated in Europe at about 21 billion Euros in 2005 and is expected to grow until 2015 at an annual rate of 6%-10%.[12]
In addition, the development of space-based services is an essential and unique contribution to Europe's security, defence interests and sovereignty in terms of limiting dependence on other countries' capabilities. Finally, space-based services can support Europe's foreign policy, with initiatives such as "GMES for Africa".
However, if space-based services are expected to contribute significantly to all these European objectives they have to be operational and sustainable. Moreover, Europe has to continue investing in R&D and to adopt an appropriate industrial policy to ensure that its technologies and services remain competitive and at the leading edge.

1.1.2. The importance of space-based services for the European space sector

Further development of space-based services could also have significant economic and strategic impact on the European space sector. As stated in the 2007 European Space

Policy, *"the key to securing the maximum political, economic and social return from investment in space technologies lies in the development and exploitation of space applications."*
The European space manufacturing sector is currently experiencing limited growth. Long-term growth of space-related industrial activities in Europe will come mainly from two elements: the development of space-based operational services and the development of exports. However, the export performance of European industry will depend on its domestic base, and therefore on the successful development of operational services. The development of services can have a stabilising effect on the overall space industry as well as a positive impact on the level of funding for space activities, thereby increasing their sustainability. The use of new services could potentially create demand for new space infrastructure to the benefit of the manufacturing industry. The further development of services in Europe would enable the European space sector to be more present and competitive in the global services market. This is critical at a time when there are still many countries, such as Russia, where the demand for services is not properly addressed, while other rising space-faring nations, such as India, have built strong expertise in applications and have started to export it. Developing the service sector is also an opportunity for the space industry to work and become more integrated with other industries and to get closer to the end users of the technologies it develops.
The field of services also offers new opportunities for SMEs. As underlined in the 2008 Council Resolution, *"space applications [...] are expected to create substantial global market opportunities, especially for SMEs, through the development of value-added downstream services"*.[4] This field might also attract new and innovative companies from outside the space sector, especially ICT companies. Moreover, services offer new possibilities to integrate new EU Member States that are eager to participate in European space activities but have limited space capabilities and funding. Services also create new prospects for smaller countries with limited space budgets that could nonetheless become leaders in specific services instead of, or in addition to, being one of the many participants in a much larger infrastructure programme. Since the European space manufacturing industry is already somewhat oversized, Europe would benefit from having new Member States complementing the expertise already existing in system manufacturing and excelling in the field of services.

1.1.3. The current situation of the European service sector

The importance of space assets for Europe has justified large investments in space infrastructure that is now rather well-developed. Additional investments have been made to develop services ranging from R&D and demonstration initiatives to the promotion of space-based services. As a result, successful services have been operational for years and significant expertise has been gained in the field of services. However, the situation is very uneven from one domain of applications to another and there is still significant potential for growth. Thus, for example, the fields of meteorology and satellite telecommunications are already particularly well-developed with services that have reached maturity whereas in fields like Earth observation only a limited share of the many possible services has so far become operational. In addition, in domains such as defence, operational space-based services, such as the ones offered by Paradigm, have been successfully established and are used on a national or multinational basis. These various cases can be illustrated with more specific examples. First, Europe has successfully developed operational systems and associated services in the field of telecommunications, as is illustrated by the success of Direct-to-Home television broadcasting, and of meteorology where a range of meteorological services based on Eumetsat data is continuously provided by national meteorological offices. There are also examples of operational services in other fields such as land use and precision farming. Second, Europe has developed pre-operational services, such as emergency services, which are based on operational systems but are not yet sustained over the long-term. Third, a number of applications

Figure 1: Tele-medicine, an example of demonstrated space-based applications.[13]

based on operational systems have been demonstrated ranging from telemedicine or tele-education applications to resources management applications but most of these demonstrated applications have not yet developed into operational services. Last, there are even operational services based on systems that are not yet fully operational. For instance, Mercator Ocean offers operational services to describe and forecast the state of the ocean based on space systems that are not yet fully operational.[14]

Expertise exists in various fields of applications in Europe but remains divided into rather small and isolated groups of experts in different organisations. The lack of a critical mass of experts and the fragmentation of expertise in the service sector in Europe are additional factors limiting the development of the sector. Moreover, like the manufacturing industry, the downstream sector is highly dependent on public sources of funding for operations but most of these potential sources have not yet been fully identified.

2. The Problematic Transition between Demonstration and Operational Services

The main challenge to be addressed in the development of space-based services is the transition between demonstration and operation. There have been many successful demonstrations of space-based applications and of their utility to potential customers. However, the transition from demonstrated applications to operational services has been successful too rarely because of the gap existing between the demonstration and operational phases. Consequently, citizens do not derive the full potential benefits from current space infrastructure, investments made in R&D do not generate optimal outcomes, and there are missed opportunities to position European industry on the global market and space-based tools for the delivery of services with respect to other technologies (i.e. terrestrial or aerial technologies).

2.1. The different phases in the development of space-based services

There are five theoretical steps in the development of an operational service, as summarised in Figure 2.

During the feasibility phase, the technical feasibility of a concept is established. The feasibility phase is based on R&D inputs and may require specific R&D activities. In the demonstration phase a new application is developed based on the initial feasibility study. This new application concretely demonstrates the possibility of delivering a new service and the capabilities of this new tool. It also provides a first cost estimate of the service. The demonstrated application then transitions into an operational service in two steps: it first becomes a pre-operational service and then an operational service. The main difference between a pre-operational and an operational service is not technical. Rather, it lies in the existence of all the conditions necessary to guarantee the sustainability of the service. These two separate dimensions in the development of operational services - technology readiness and sustainability - are presented in Figure 3.[15] Not represented on the figure are the continuous technology upgrades that are necessary once the service is operational.

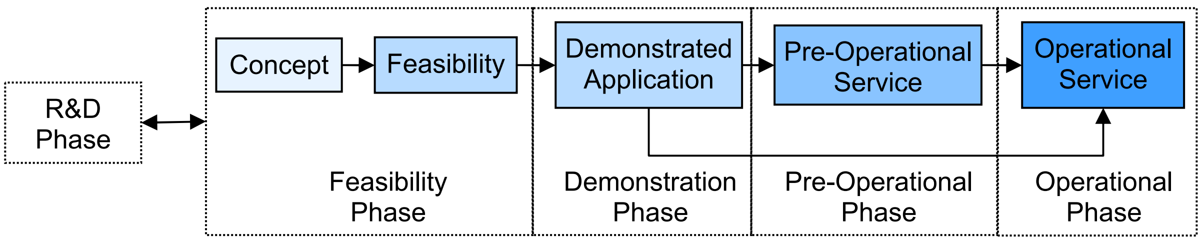

Figure 2: The main steps in the development of operational services

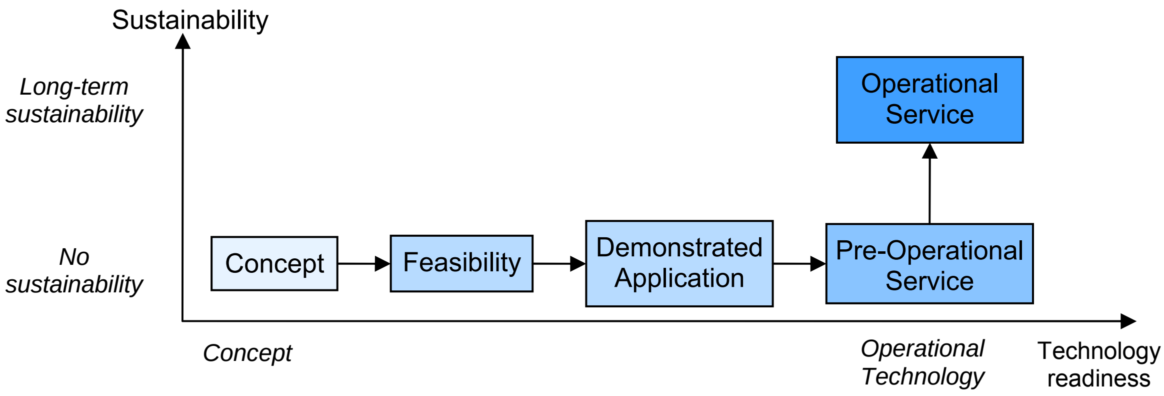

Figure 3: The two dimensions of the development of operational services

The end result of this process, an operational service, is a tool that routinely and reliably provides services and products meeting predefined requirements and makes them available to a variety of users.[16] A service can also evolve from demonstration to operation without any clear intermediary pre-operational phase. The development of space-based systems on which services are based follows a similar pattern.

The transition from demonstration to operation can be illustrated with two examples of space-based systems: the European meteorology satellites and the U.S.-European ocean altimetry satellites. Figure 4 presents a chronology of the European meteorology programmes to illustrate the transition from demonstration to

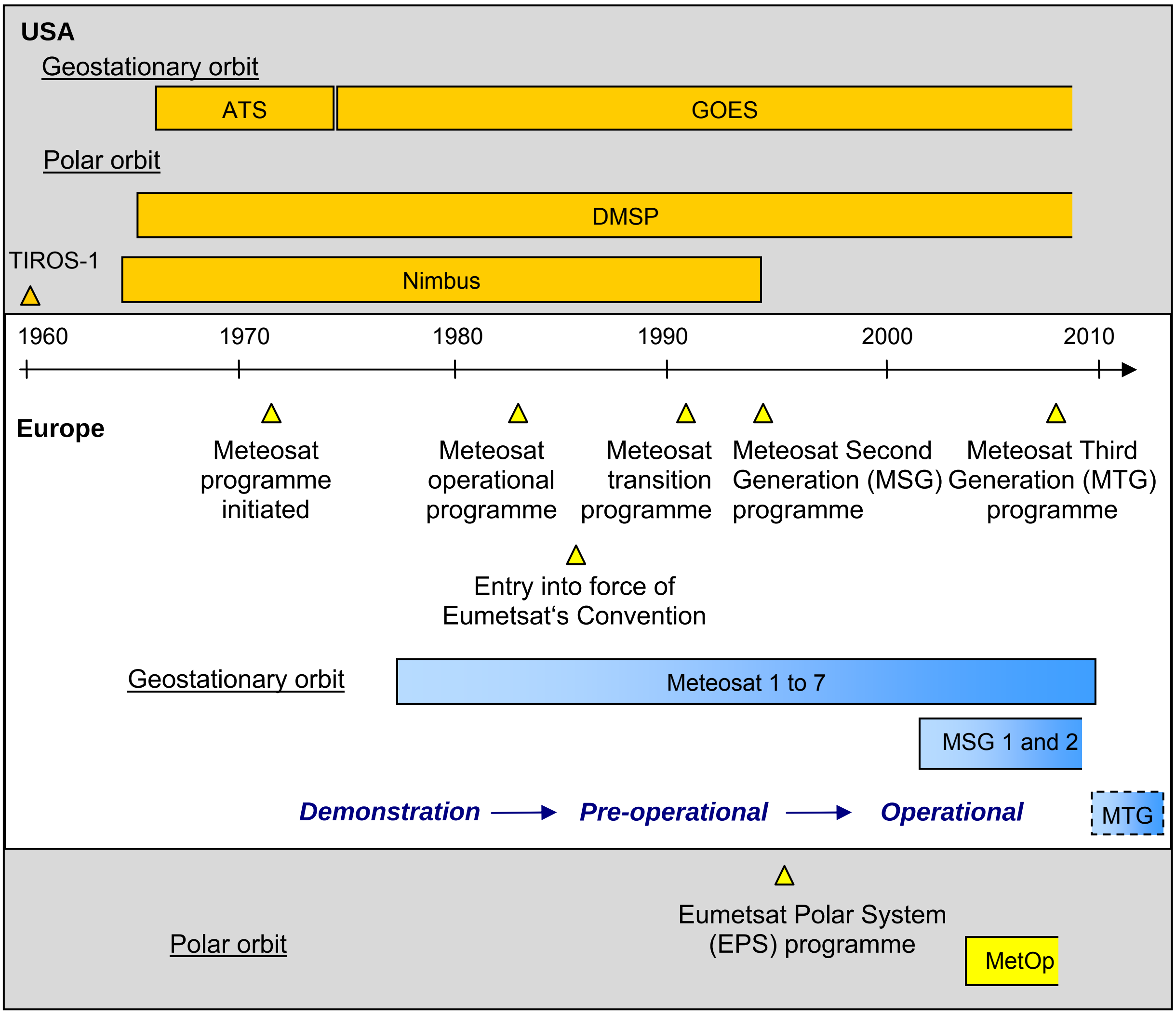

Figure 4: The transition from demonstration to operation of the European geostationary meteorology satellite[17,18]

operation of the European geostationary meteorology satellites. The development of the American meteorological systems is presented in parallel. The adoption of several successive development and operational programmes and the creation of Eumetsat, a dedicated satellite operator, made possible this transition from demonstration to operation.
Figure 5 shows the chronology of the American and European missions dedicated to ocean altimetry to illustrate the transition from demonstration to operation of the joint American/European ocean altimetry programme. The successive joint missions are based on a reference strategic document "The Future of Spaceborne Altimetry: Oceans and Climate Change - A Long-term Strategy" prepared by an international group of experts in 1992, often referred to as the "Purple Book".[19] These joint missions started as a CNES-NASA cooperation programme with Topex/Poseidon and Jason 1. NOAA and Eumetsat joined this collaboration for Jason 2. All partners have been involved in the development of the associated services.These two examples in the fields of meteorology and ocean altimetry illustrate the variety of approaches that can be taken to develop new operational systems. On the one hand, the ocean altimetry programme started with a research satellite, Topex/Poseidon, followed by the satellites Jason 1 and 2 which were built with the technical characteristics of operational systems even though the programme was not yet fully operational for non-technical reasons. On the other hand, the first Meteosat satellites were not research satellites and were already built with the technical characteristics of operational systems.

The example of ocean altimetry also clearly illustrates that the main difficulty in the development of space systems or space-based services lies in the transition from demonstration to a sustainable operational service, as illustrated in Figure 7. Consequently, a large number of successfully demonstrated applications never become operational services.
While there are several reasons why this transition occurs too rarely, of special importance is that it is a complex process that is not yet properly addressed by European decision-makers.

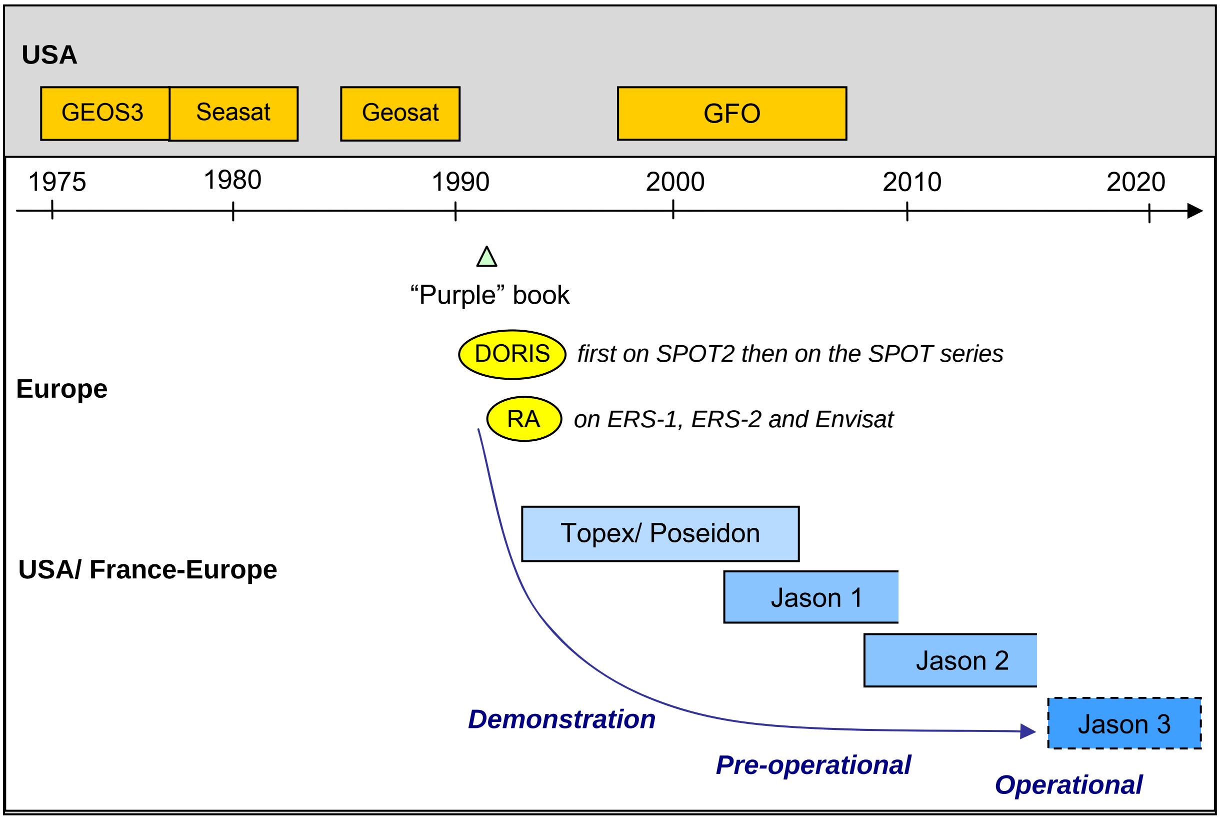

Figure 5: The transition from demonstration to operational ocean altimetry systems[20,21]

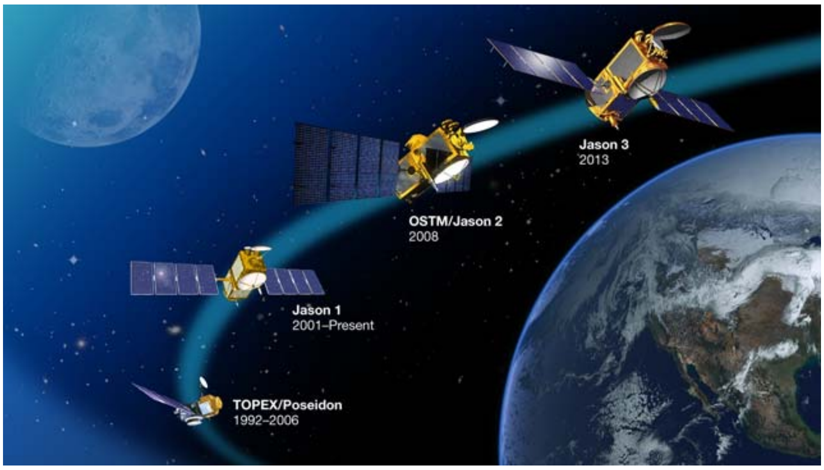

Figure 6: The joint ocean altimetry missions[22]

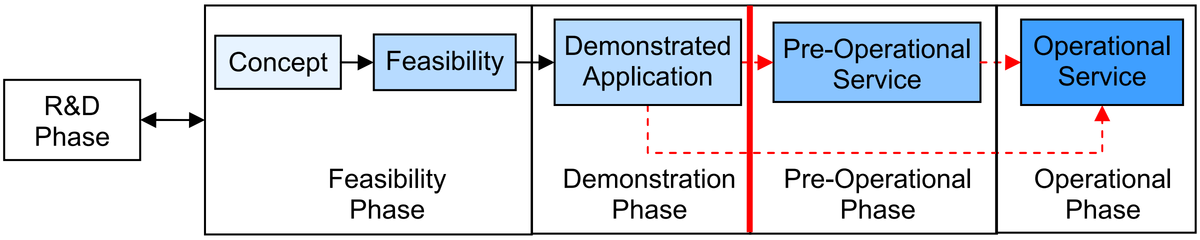

Figure 7: The critical step in the development of services: the transition between demonstration and operation

2.2. The complexity of the transition between demonstration and operation

2.2.1. From a demonstrated application to a sustainable, operational service

A demonstration establishes the technical feasibility and capabilities of a tool to address the requirements of representative potential users and gives a first estimate of the final cost of the service. As presented in Figure 8, an operational service requires many additional elements. First, the technology on which the operational service is based should be reliable. It should address all the operational requirements of users including technical, operational and organisational requirements, and it should be adapted to users. Next, the cost of the service should be determined. The service should be affordable for users and cost-effective, especially in comparison to similar services based on other technologies. Then, the demand for the service should be clearly identified, organised to the extent possible and a structured dialogue with user communities should be established to enable them to express their needs and gradually assimilate the space-based tool. Finally, the sustainability of the service should be ensured by the various elements of a value chain. This means in particular a structure that guarantees proper funding allocation and generation and programmatic overview of the service and its infrastructure. All the functions required in the overall service value chain (policy making, funding, programme management, implementation, operations and utilisation) need to be clearly defined and allocated to the different stakeholders.

All these elements put together ensure three necessary conditions for the service to be operational: 1) the sustainability of the infrastructure; 2) the continuity and availability of the infrastructure; and 3) the sustainability of the services. These conditions emphasise that operational and sustainable infrastructure is an essential prerequisite for any operational and sustainable service. However, in several cases space-based services have become almost operational before the space systems on which they are based have become operational. In such instances, the demand for services is a decisive incentive to making the systems operational. The development of operational services such as those offered by

Mercator Ocean has significantly contributed to the sustainability of the ocean altimetry missions and to the continuation of the Jason programme.[23]
A last but crucial element of the transition between demonstration and operation is the need for the European space sector to adapt to the service paradigm and to make the consequent necessary changes to its approach. The demonstration phase has so far usually been undertaken in a technology-push approach whereas the operational phase should be demand-driven. New programmes like the ESA IAP programme are in fact intended to adopt and apply a demand-driven approach as early as the feasibility and demonstration phases.

2.2.2. The components of a successful transition

To be successful the transition from a demonstrated application to an operational service requires many components. The first step of this transition, i.e. the establishment of a pre-operational service, primarily requires technological development, which includes all the developments that are necessary for the implementation of the operational service. Starting from what was already implemented for the demonstration, additional developments include further work on the ground infrastructure and, if needed, on the space infrastructure as well. This technical work should ensure the cost-effectiveness and affordability of the service.

The second step of this transition, i.e. between pre-operational and operational services, must be driven by the final users of the services and therefore first requires the identification and organisation of the demand. Next, the sustainability of the services should be guaranteed by setting up a proper structure, funding mechanisms and framework conditions, which will ensure the continuity, availability and upgrade of the service and of its infrastructure. The sustainability of the services will obviously also depend on the ability of the service providers to adapt to the users and to the evolution of their needs and on the assimilation of the space-based tools by the users.
The concept of sustainability of a service is rather straightforward for commercial services as it is associated with the existence of a market. For public services however, this notion is more complex. The sustainability of public services is usually ensured by a demand and associated budgets. This demand can be driven by:

- a strong constituency, based on the perceived benefits to the citizens;
- the critical dimension or strategic importance of the service; and/or
- normative elements, i.a. regulations, international agreements and conventions.

The associated sources of funding should be dedicated operational budgets.

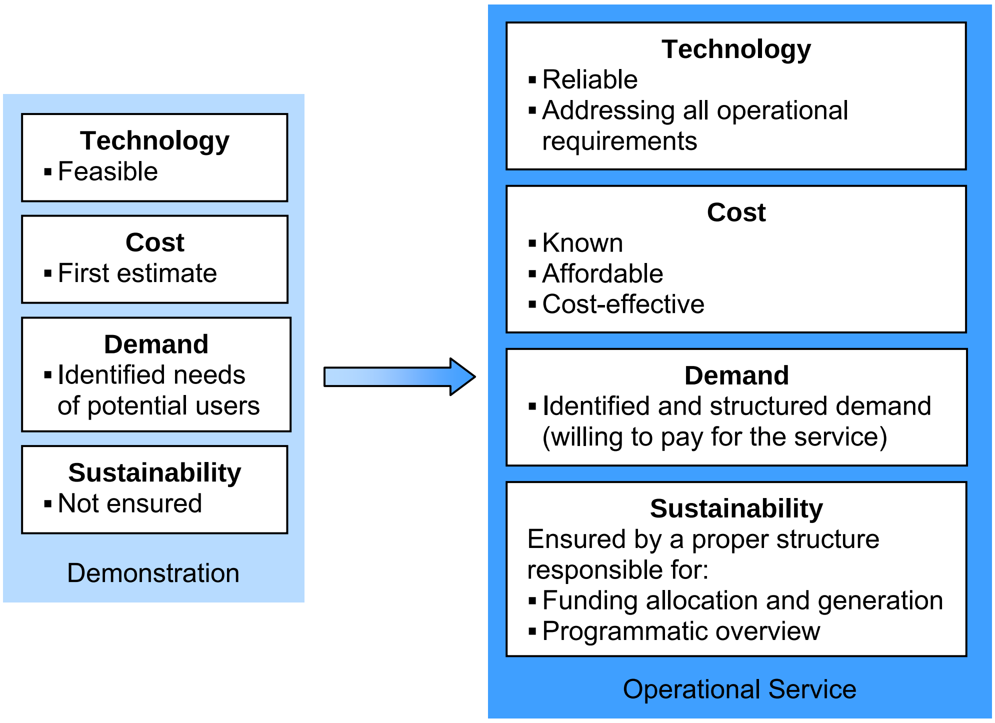

Figure 8: The different requirements for demonstration and operation

2.3. A transition not yet properly addressed by European public action

2.3.1. The role of the European public sector

The public sector plays a central role in shaping space-based services. It: funds a large share of space- and ground-based infrastructure; remains the main customer of the services; funds most of their development; and defines framework conditions that influence their development. In addition, public organisations operate many of the European space systems on which services are based and manage the European applications programmes.

2.3.2. The objectives of public action in the development of operational services

There are two main objectives of public action at the European level in the development of space-based services:

- establishing operational services that can support European policies; and
- contributing to the knowledge-based society and economic growth in the field, with benefits to the European space sector and to citizens.

The first objective addresses mainly public needs while the second deals also with the development of a successful commercial market.

2.3.3. Main initiatives at the European level

To address both objectives, EU Member States are funding key elements of space infrastructure (e.g. Galileo, the GMES Sentinels, or Meteosat) and the corresponding ground infrastructure as well as European R&D applications projects at community level as part of the EC Framework Programmes and ESA programmes.
To address the first objective, EU Member States are promoting the use of space-enabled tools to support European policies at all levels. For instance, TEN-T projects such as SESAR are intended to promote the use of Galileo-based services for transport policies.[24] These initiatives are based on a demand-driven approach.
To address the second objective, EU Member States are defining a proper framework and creating incentives to foster private sector interest in developing space-based services, including funding European demonstration projects. These initiatives have also been complemented by actions to promote the use of space-based services but the approach has so far been mainly technology-push. New programmes like the ESA IAP programme try to move to a more demand-driven approach.

2.3.4. The major challenges to the transition

All these initiatives, undertaken by different stakeholders with different sources of funding, can be improved and complemented by others to support more efficiently the development of space-based services in Europe. Various programmes produce successful feasibility studies and demonstrations but these turn too rarely into operational services. Moreover, initiatives to promote the use of space-based services propose solutions that are not always sustainable or adapted to users. Consequently, users are often not willing to pay for these solutions. Public action could be more effective and investments could be optimised if these initiatives were better coordinated and if various considerations, especially to make the transition easier and faster, were taken into account from the beginning of the projects.
The first issue to be addressed is the fragmentation and lack of organization of demand for space-based services in Europe. The second issue is the sustainability of the solutions proposed. The sustainability of services starts with the continuity, availability and sustainability of the infrastructure on which they are based. In this respect, European decision-makers have to provide user communities and service providers with long-term perspectives on the infrastructure so that the outcome of the R&D and demonstration programmes could be improved. Coordination between the various programmes could be increased, synergies developed and demonstration programmes could be designed in a way that better prepares the transition from demonstration to operation. The third issue to be addressed is the need for the current organisations of the space sector, i.e. the space agencies, industry, etc., to adapt to the service paradigm and to adjust their programmes accordingly. The service paradigm is drastically different from the system paradigm to which the sector is used and for which it is efficiently structured.
In addition to these three sets of issues, there remains in Europe, particularly among decision-makers, a limited understanding of the potential demand for space-based

services in Europe and an incomplete knowledge of the offer, i.e. the potential service providers. A few market surveys have been undertaken but these still give incomplete perspectives particularly with respect to fully understanding how real impetus can be given to the development of this sector.

In the next sections, the three sets of issues are addressed consecutively: the opportunities and challenges are investigated, the objectives to be reached are identified, and actions are suggested to European decision-makers.

3. Fostering and Structuring the Demand for Space-Based Services in Europe

Sustainable services first require users and, more precisely, structured user communities. The key element in the successful development of meteorological services in Europe was indeed their users, i.e. the European meteorological communities, which were well-structured, used to cooperate with one another and shared common requirements. They understood the benefits that their activities could derive from space-generated data and information and supported the establishment of the European Organisation for the Exploitation of Meteorological Satellites (Eumetsat). These users are particularly involved in Eumetsat's activities, especially through their representation in the organisation's Council and other bodies.

The users are indeed central to the development of sustainable services but today most potential users are not aware that space-based systems can address some of their needs. The demand for space-based services in Europe is neither well-identified nor well-understood and is often very fragmented. Proper actions are therefore needed to promote the use of space among broader communities and to identify and federate the demand at the European level.

3.1. Promoting the use of space-based services

The first objective is to promote the use of space-based services among new potential user communities. Actions should aim to reach, inform and educate new user communities in order to increase their understanding of how space-based services can address some of their needs. These initiatives should consist of: identifying potential user communities and understanding how space tools can help them; creating opportunities, and even platforms, for dialogue; and demonstrating the concrete benefits of space to these potential users. In order to be successful, these actions require several components: access to new potential user communities; an ability to adapt to, communicate with and understand the needs of potential users; and technical support from experts. Moreover, promotion would probably be most effective if the promoters are as neutral as possible and if they focus on areas where space has a clear advantage over other technologies rather than trying to promote space-based applications to address all needs. Actions of all stakeholders, i.e. space agencies, industry, the European Commission, and other organisations closer to users, are therefore needed. To be effective, these actions should be undertaken at different levels and scales and be coordinated. There is also a key role for Eurisy in raising awareness of the possibilities offered by space-based applications and interacting with users.

Possible actions range from outreach activities to demonstrations of pilot services and should be targeted as much as possible towards a specific user community in order to maximise the impact and outcome.

The integration of services into mass market platforms such as cell phones is also a way to generate new demand for services. It can be achieved, for instance, by direct lobbying of telecommunications operators. Regulation is another very effective way to create demand for services. Lobbying public authorities in charge of making regulations can also lead to the creation of new demand. Providing free trial services is another method of promotion. However, a major difficulty in promoting space-based services is to attract new users who will then be willing to pay for the services. Providing services initially for free tends to limit the readiness of users to pay for them at a later stage. From the very beginning, the services should be presented in a cost-benefit perspective, even if the final cost of the service is not precisely known.

Initiatives to promote the use of space-based services should become more systematic and coordinated at the European level. These efforts should then start with services based on existing infrastructure and for which space has an obvious added value and comparative advantage over other technologies.

Figure 9: The integration of space-based navigation on mass market platforms

3.2. Identifying and understanding demand

Once new potential users are identified, the second objective is to set up an effective initial dialogue between the space community, services providers and users in order for them to understand one another. Service users need to clearly understand what space can or cannot do for them and service providers should understand user needs. The capacity of the space community to listen and to understand users will be decisive for the success of this dialogue. This dialogue requires the involvement of technical experts as well as mediators who would be the link between technical experts and users. The need for such trained mediators is not yet recognised even though their work is likely to be key to the success of future endeavours. They have a very specific role to play and should have very specific skills to contribute to the process.
In establishing a dialogue with users there is a role for space agencies/offices and industry as well as for the European Commission and some of the agencies of the EU such as the European Environment Agency (EEA), the European Defence Agency (EDA), or the European Agency for the Management of Operational Cooperation at the External Borders (FRONTEX). Targeted initiatives could be organised in defined thematic areas or for specific user communities. As part of these initiatives, workshops and/or joint working groups between users and providers could be organised. A key element in the success of these initiatives is the choice of user communities to be initially targeted. Depending on how well-structured a user community is, starting with a smaller user community and then scaling up the efforts might be easier than trying to address a larger community from the very beginning. The mediators should then ensure a proper understanding between users and providers. A first step in the establishment of such a function could be achieved by seconding experts. Space experts could indeed be seconded to a user organisation in order to understand user needs and the operational environment, or representatives of the user community could be seconded to a provider in order to support the development of relevant services.

3.3. Federating demand

The third objective is to address the fragmentation of demand in Europe, i.e. the segmentation of the market and the lack of common requirements. Federating demand at the European level could give a real impetus to the development of space-based services by significantly impacting on the cost of services. It could also help to attract the private sector which has demonstrated limited interest in developing services partly because of the limited size of currently available markets. Reaching a certain critical mass of demand would definitely make such markets much more attractive.
Federating demand consists of aggregating fragmented user communities (UC) and leading them to express common requirements, as illustrated in Figure 10.

It is a difficult task especially when the user communities are not homogeneous. However, a common service can be dual-use and thus meet the needs of both civil and military users such as, for example, some meteorological services. In such cases, a similar if not unique dialogue will have to be established with different kinds of users. Space agencies/offices and industry have the necessary expertise to support such a task and the EC has a particular role to play in structuring European demand for specific services. Where possible, space agencies or the EC supported by technical experts should work with an organisation representative of a user community with similar needs at the European level. This organisation could be a European agency, such as the agencies of the European Union, or a European professional association. Space agencies/offices or the EC should then help these users to express a common set of requirements and should support standardisation and interoperability efforts. Professional associations, such as the European Satellite Operators Association (ESOA), can also play an important role in the interaction with users. This cooperation could take place in joint working groups or

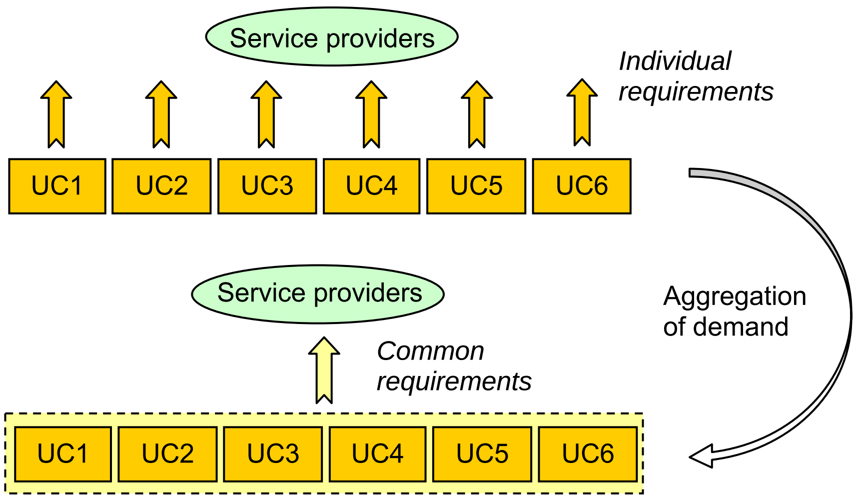

Figure 10: The aggregation of demand

forums with the support of a defined group of experts and could be facilitated by a framework agreement between the relevant organisations, as the one signed in March 2007 between ESA and the European Maritime Safety Agency (EMSA).

Figure 11: Signature of the agreement between ESA and EMSA in March 2007

If a potential user community is not properly represented by any organisation at the European level, demand could be aggregated by supporting the creation of virtual communities that can express common requirements. Space agencies/offices, the EC or even industry can initiate the creation of professional associations of users. Such associations can then take full advantage of the possibilities offered by the web: electronic forums, websites, mailing, etc. The examples of the European Association of Remote Sensing Laboratories (EARSeL)[25] that was founded in 1977 under the auspices of ESA, the European Commission and the Council of Europe, of the European Low Gravity Research Association (ELGRA)[26] that was founded in 1979 under the auspices of ESA and the Council of Europe, or of European Association of Remote Sensing Companies (EARSC) could be followed and applied to user communities.

Aggregating fragmented demand at the European level can also be done more directly by European decision-makers through regulation including the definition of European standards, the development of European procurement policies and through taking a more European approach to local needs (for instance, adopting a more holistic approach to the use of regional funds in Europe). A special case concerns defence applications where the further development of a common European Defence Policy will have a direct impact on the creation of a European, rather than national, demand for such services. Similarly, developing space-based services that can support defence objectives common to most European countries can contribute to the integration of fragmented demand for such services in Europe.

Federating demand can also include bringing closer not only end users but also service providers particularly when the service providers are public organisations. For example, national meteorology offices that are providing meteorological services based on Eumetsat's data also exchange additional processed information that increases the value of the services. Eumetsat's Satellite Applications Facilities (SAF) network thus enables national meteorology offices to benefit from the expertise and value-added information of other offices, as shown in Figure 12.

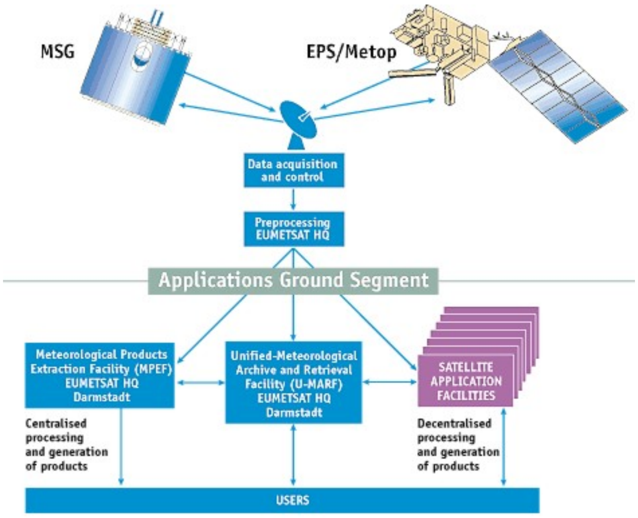

Figure 12: The Satellite Applications Facilities (SAF) in Eumetsat's architecture[27]

It should be emphasized that all the activities of promotion, identification and federation of demand require significant financial and human resources as well as technical expertise. They therefore need contributions from all stakeholders, i.e. the EC, space agencies/offices and industry, but this should be undertaken in a coordinated way. In addition, these activities require leadership and organisations to take on and to manage them.

Once the demand is identified, understood and federated, structures must be created to address it in a sustainable manner.

4. Establishing Sustainable Services

Space-based systems are usually developed and manufactured by industry for public development agencies in a technology-push approach. Once a demand for value-added services based on these systems is identified and organised, several elements of the services' value chain have to be put in place in order to deliver sustainable services to users, as represented by the dotted box in Figure 13.

Building this service value chain requires setting up sustainable architecture that ensures first a secure supply of space-delivered data and services and then the sustainability of the services.

4.1. Securing access to space-delivered data and services

A pre-requisite for the sustainability of a service is the guaranteed availability and continuity of space-delivered data or of the services on which it is based. Setting up new value-added services requires a long-term perspective on the availability and continuity of data or services to justify: the necessary adaptation of the institutional and technical infrastructure, the development of new tools, and the adaptation of users to these new tools. In addition, in some cases the value of the service lies in the guaranteed availability and continuity of the data over long periods of time. These requirements underline the particularly long lead time needed to develop services based on new systems.
The two features, i.e. availability and continuity, first require the sustainability of the infrastructure on which the service is based.

4.1.1. Ensuring the sustainability of infrastructure

The first objective in securing access to space data or space-delivered services is to ensure the sustainability of the infrastructure, especially the sustainability of the space-based infrastructure.

The sustainability of infrastructure should be guaranteed by an adequate operator and operational structure that:

a. Provides relevant data or services to service providers in an operational way;
b. Owns, manages and operates the infrastructure and ensures the programmatic overview of the development of new systems and their integration through its relations with development agencies and industry; and
c. Obtains funding from users.

As regards funding, in a demand-driven approach the financial sustainability of the infrastructure is ensured by cash flows through the value chain from the users to the operator. While the sources of funding may be private or public, the important factor is that the funding must come from operational budgets and not from research budgets.
The operator should be set up in such a way that it can evolve in accordance with the maturity of the systems, the scope of its activities and the needs of end users. It should be an operational structure which means that its objectives, organisation, operations, constraints and funding mechanisms should be of an operational nature and should differ from those of a development agency.

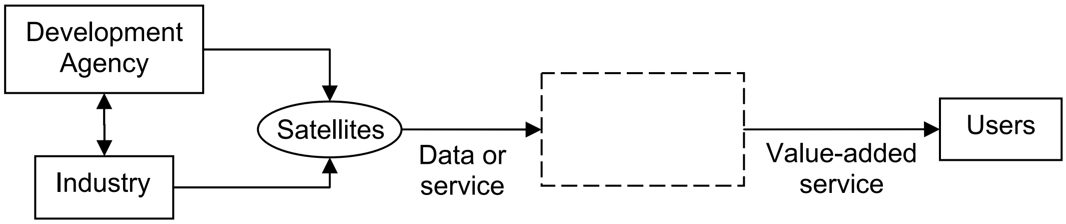

Figure 13: The elements of the value chain to be established to deliver sustainable services to users

A space system should be operated by a single operator but the data or services it delivers can be included in different value chains, addressing various user communities.

Several lessons can be learnt from successful European operators. There are already two main examples of sustainable European space-based infrastructure that is used to deliver operational services. The first example is European telecommunication satellites. As presented in Figure 14, Eutelsat and SES:

a. Provide relevant telecommunication services to telecommunication operators in an operational way;
b. Own, manage and operate telecommunication satellites and ensure the programmatic overview of the development of new systems and their integration through their relations with industry; and
c. Sell their services to telecommunication operators and re-invest in infrastructure.

television broadcasting. However, the involvement of development agencies and research funding remains necessary for new technological development.

In the second example of sustainable infrastructure, the European meteorological system, the infrastructure is publicly funded, but on operational budgets. As presented in Figure 17, Eumetsat:

a. Provides relevant meteorological data to national meteorology offices in an operational way;
b. Owns, manages and operates meteorology satellites and ground systems and ensures the programmatic overview of the development of new systems and their integration through its relation with ESA, industry and its Member States; and
c. Obtains its operational funding from the budgets of the ministries responsible for meteorology or from national meteorology offices and re-invests in infrastructure.

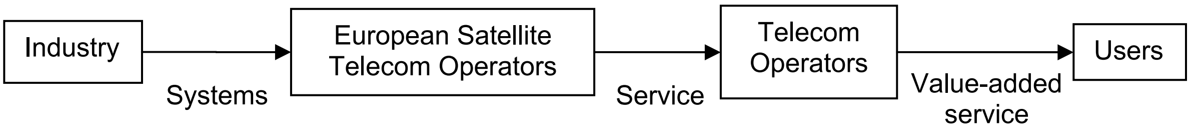

Figure 14: Eutelsat and SES in the value chain of space-based telecommunication services

The space-based telecommunications market is mature and large enough so that the share of private investment by telecommunications satellite operators, including Eutelsat, has become significant and today ensures the sustainability of the existing infrastructure. The SES and Eutelsat model has demonstrated its effectiveness for existing services such as Direct-To-Home (DTH)

The budgets are raised in each Member State by the national meteorology offices, i.e. the users of Eumetsat's data and the sustainability is ensured by the benefits to the citizens of these Member States. As represented in the figure, the decision-makers of the Member States of ESA and Eumetsat support and shape their respective industry.

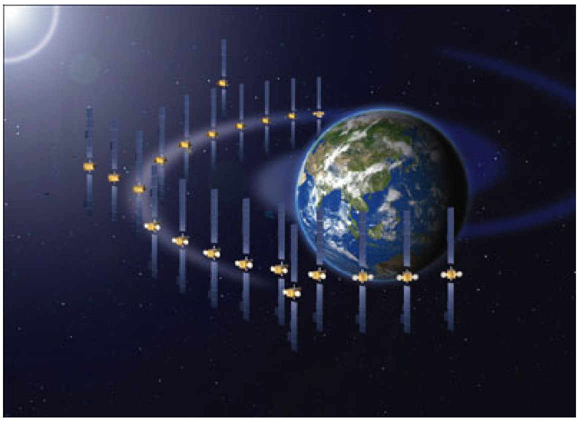

Figure 15: Eutelsat's satellite fleet[28]

Figure 16: Eumetsat controls its satellites from its centre in Darmstadt[29]

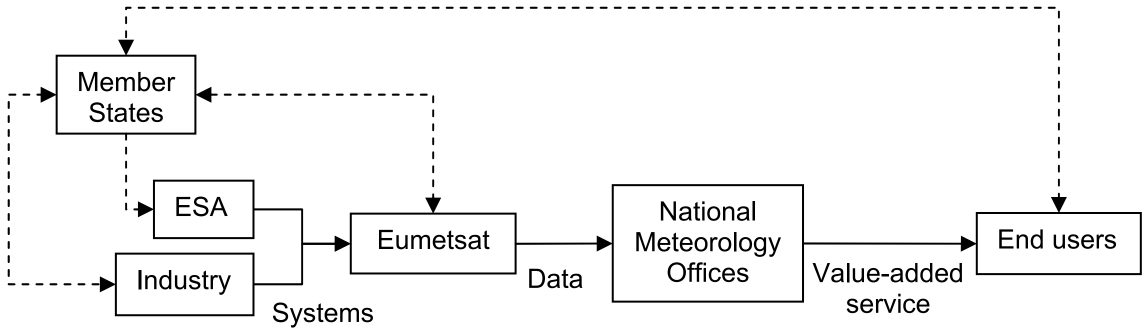

Figure 17: Eumetsat in the value chain of meteorological services

Eumetsat is a mature organization with good working relations with its users and with ESA which is in charge of the procurement of satellites. The national meteorological offices play a major role in the administration of the operator through their representation on its Council and other bodies. Eumetsat is currently producing operational services from two ongoing operational programmes and is preparing two new programmes. In addition, its mandate was extended to operate new satellites and broaden the scope of its activities to new fields. Moreover, the demand for Eumetsat services is growing as more states join the organisation.
The three operators Eutelsat, SES and Eumetsat have been very successful in delivering data and services to service providers in a sustainable manner. The development of a new generation of systems or new technologies still remains a critical issue for these organisations, as this usually requires additional public funding and the involvement of development agencies.

Both Eumetsat and Eutelsat were initially established as Inter-Governmental Agencies (IGO) in the 1970s. Eutelsat was later privatised, when the market was mature enough. But other models of infrastructure operations can also be used. SES was set up as a private operator form the very beginning. With the exception of the telecommunications sector, the market for space-based services is too small and the payback time is too long for private companies to make the required investments and carry the associated risks of investing in the development and operations of their own infrastructure. As a result, infrastructure development and operations are mostly entirely or partially publicly funded, directly or indirectly, and a variety of models of private/public cooperation are used. The two main types of model are the anchor tenancy[†] and the public-private partnership (PPP)[‡].
In the anchor tenancy model, the infrastructure is indirectly funded by public end users, whose commitment to buy a certain amount of services enables the private sector to make significant investments in the development of the infrastructure and to privately operate the infrastructure.

In the PPP model, the partnership between the public and the private sector can take different forms and the organisation of infrastructure operations is associated with corresponding business models. Examples of PPPs in the space sector include the Paradigm concession model, the TerraSAR co-ownership model and the Spot Image government-owned and company-operated (GOCO) model. These entities can be subsidiaries of development agencies (e.g. Spot Image was initially a subsidiary of CNES) or of companies (e.g. Paradigm is a

† "The government becomes an "anchor tenant" when it becomes a major customer for products and/or services offered by a commercial organization. The government's motivation is to create or stimulate a market that will provide sufficient revenue to encourage further private-sector investment to expand the offering of those products and/or services to a broader range of customers. Anchor tenancy also reduces market uncertainty and perceived financial risk. There are instances in which a private-sector customer is the anchor tenant, but these cases are unusual." AIAA Public Policy Committee. AIAA Position Paper on Space Commercialization. January 1996.
‡ "A PPP represents a means whereby public and private sectors - government and private industry - work together on the implementation of projects requiring significant capital instruments. In a narrower sense [it can] be defined as a legal entity consisting of one or more public organisations and one or more private organisations together pursuing direct or indirect commercial (private) goals as well as social (public) goals, by means of constructing a facility and/or producing services, with pro-rata sharing of equity requirements, liabilities, profits and control and contributing know-how." ESPI/Euroconsult/Milbank. The Future of Public-Private Partnerships in Satellite Communications. March 2009.

subsidiary of EADS Astrium). The most suitable operational and business models for a given infrastructure depend on various factors such as the size of investment required, the volume of the business, the maturity of the market and the nature of the users. These models however, do not by themselves ensure the sustainability of the infrastructure which, whatever the model, comes from the cash flow from the downstream to the upstream part of the value chain i.e. from the users to the operator.[30]

Apart from telecommunications and meteorology, the issue of sustainability remains critical for most other European space-based infrastructures, as is currently illustrated with programmes such as Jason and SPOT or the Sentinel satellites of GMES. In a sustainable model, users should eventually pay for the infrastructure, i.e. for the systems and their operations. They may be private users or public users who are paying services from a dedicated operational budgetary line. In the sustainable model the technological developments necessary to upgrade the infrastructure, particularly space infrastructure (e.g. for new generations of satellites) are still, however, funded by public R&D budgets and are carried out by development agencies. Given the high costs and levels of risk, the funding of new major developments for space infrastructure is unlikely to come only from the end users. This last element will therefore remain a major weakness in the sustainability of most space-based services as at least part of the budget for necessary major technological developments will have to be raised from R&D budgets. The demand for services is crucial in such instances. The stronger the demand, the easier it is to raise R&D funding. The need for such funding can nevertheless be anticipated and planned for rather than being discussed on an ad hoc basis. In the case of public services, long-term perspectives can be ensured to a certain extent by the development of relations between operators and users that go beyond pure “buyer-seller” relations. Rather than paying only for data or services, users can commit to invest in the upgrade of the infrastructure, which would contribute to its sustainability.

As mentioned above, in a demand-driven approach the financial sustainability of the infrastructure is ensured by a cash flow from the users to the operator. There is a major exception to this model with the Galileo system which is not expected to be financially sustainable on the basis of direct revenues generated by its services. There will neither be any cash flow from the users to the operators to pay for the infrastructure nor any connection between the public investments made in the infrastructure and the revenues of the associated services. The only assurance of the sustainability of this space infrastructure is the political commitment of European governments to fund it, as they consider this system to be strategic for Europe.

In this section, the desirable end-state architecture has been investigated. But the problem of the operator for a new system also needs to be addressed. For the establishment of a value chain that integrates a new system, existing structures should be taken into account and should be used whenever appropriate. Either the mandate of an existing structure can be extended to include the operations of the new system or a new structure can be created to operate the system. The responsibility for a new system initially developed, owned and managed mainly by a development agency can then be transferred to the operating structure.

The example of the GMES Sentinels illustrates this process. ESA is taking on the role of interim operator of the Sentinel-1, -2 and -3 (land part) before transferring responsibility to another organisation (still to be defined). An existing operator, Eumetsat, has been chosen to operate Sentinel -3 (marine part), -4 and -5.[31] In fact, Eumetsat’s mandate was extended in the 1990s to include not only meteorology but more generally climate monitoring. These amendments to its Convention paved the way for the organisation’s new responsibilities.[32]

In any event, the operator should have an evolutionary structure. If it is newly created, it will probably have to evolve with the growing maturity of the systems and services. The operator might also need to evolve if its mandate and the scope of its activities are extended to operate new systems.

Clearly, the operator of a European infrastructure should be European, which adds complexity and constraints to the definition of operators for new systems. To operate new systems, either existing European structures can be used whenever relevant and possible or new European structures have to be created as an IGO or an agency of the European Union (particularly if it supports EU policies). When private European operators are delivering services considered strategic, the European decision-makers also need to consider the potential risks associated with the evolution of these operators’ shareholding structure, especially with non-European investors.

The main steps in setting up a sustainable infrastructure can be summarised as follows:

- Development of a new system by a development agency;
- Identification or establishment of an operator;
- Transfer of responsibilities for the pre-operational system from the development agency to the operator;
- Integration of the space system with other systems; and
- Transition of the system from pre-operational to operational.

When it becomes responsible for the infrastructure, the operator then has the responsibility to guarantee the availability and continuity of the data and services it delivers.

4.1.2. Securing access to data

The first objective for the operator in order to secure the supply of data is to ensure the data's availability i.e. to secure the access to data with proper data policies and distribution schemes. Data policies include the definition of:

- Who can access the data (categories of users or of use);
- How data are distributed (direct licensing to end-users or distributors);
- Who holds the ownership and intellectual property rights (IPR) over the data and derived products; and
- What is the price of data for the different categories of users/use.

Access, distribution, IPR and pricing policies have important consequences on the flow and use of space-delivered data and therefore on the development of the downstream sector and indirectly on the sustainability of the infrastructure. These policies create clear incentives and disincentives for services providers to use space-delivered data and to prefer one source of data to another. In Europe, the use of data delivered by European systems should obviously be promoted through appropriate policies.
In general, open access and low prices contribute significantly to the development of services.
In particular, open and free access to European data for scientific use, with conditions on the publication of the results, should be promoted. Access to data to be used for scientific purposes should be as open as possible as the research work done on this data is a strong incentive for its use. While this seems evident when space infrastructure is entirely publicly funded, it should also be considered when the infrastructure is partly privately funded as it remains a clear incentive to wide use of the data delivered by this infrastructure. Besides, differences in access and pricing policies can also influence the development of supply and demand for space-based services and can indeed even distort the market. Moreover, access and pricing policies usually differ between raw data and processed, tailored information. Adequate policies for specific kinds of data depend on factors such as the maturity of the market and the amount of revenue expected from the sale of data. In all cases, these policies should be stable and should ensure revenues from the data sales that are sufficient to ensure the sustainability of the infrastructure in accordance with the business model chosen.
Similar to private companies, many public agencies and international organisations have developed their own data policies and licensing conditions which, despite common overarching principles, tend to be specific to each mission,.
With regard to data distribution, ESA has defined two categories of use for the data of the Earth Observation satellites it operates i.e. Envisat, ERS and the Earth Explorer missions. ESA distinguishes research and applications development use from all other uses. It directly distributes data to users worldwide for research and applications development use, free of charge or at a cost limited to the reproduction costs. The use of data is authorised for the purpose of a specific project. For delivering data and services to all other users, ESA has appointed distributing entities that set data and product prices.[33,34] In the field of meteorology, the national meteorological offices are exclusive licensing agents of Eumetsat data over their national territories and are responsible for commercial data distribution and marketing.[35]
With regard to IPR, the situation in Europe appears more restrictive than in other parts of the world as public organisations can claim copyright over their data and products.[36] ESA retains ownership of all primary data and any derived product[33] and Eumetsat holds the full ownership and IPR to the data and products of its satellites.[35] CNES also retains full ownership of the SPOT data, while Spot Image, which was given an exclusive license for the exploitation, distribution and sales of SPOT data, retains property with regard to licensed value-added products.

With regard to the use of European data for scientific purpose, CNES, which unlike ESA does not directly distribute the SPOT data has a dedicated programme (ISIS) for the promotion of the scientific use of SPOT satellite imagery,. For selected scientific projects CNES pays a large share of the data costs to Spot Image.[37]

In some instances, data policies and licensing conditions are considered as too restrictive and as hindering the use of space-based data and the development of the downstream sector in Europe in particular. A first issue is the limitation introduced by the single-purpose use of licensed data. Data, such as all the ESA data provided for research and applications development use, has to be used only for a specific project. Multi-purpose licences with proper restrictions could be considered for scientific use in order to foster data use and exchange among scientific communities. Second, data that is not commercialised can be difficult to locate and to access, which is particularly critical in Europe where there is no obligation to make publicly funded data widely available.[36] In addition, as mentioned above, IPR on publicly funded data are used in a more stringent way in Europe than in other regions. An important step towards open access to data in Europe is the data policy component of the INSPIRE Directive,[§,38] even though access, prices and intellectual property are left to the discretion of the EU Member States.[39] This Directive is restricted to environmental data, but the model could also be used in other fields of public interest.[40] The INSPIRE Directive also address the important issue of interoperability. As already achieved in the field of meteorology, specific efforts have indeed to be undertaken to support the harmonisation of data policies, the standardisation of data and inter-operability as these are major incentives or disincentives for service providers if a service is based on data from different sources.

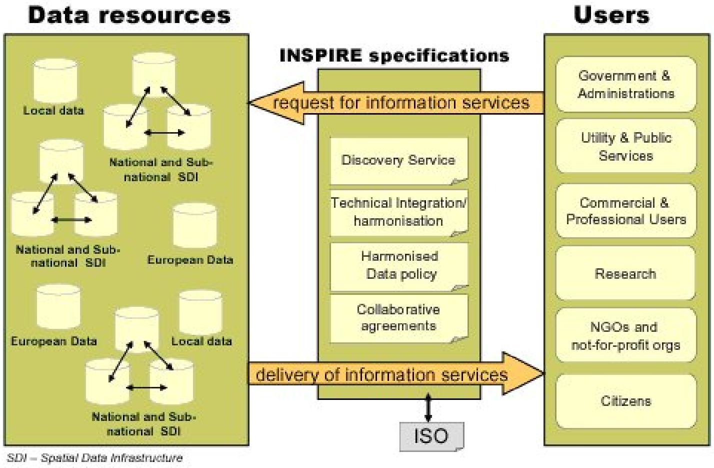

Figure 18: INSPIRE information flow[41]

4.1.3. Securing the supply of space-delivered data and services

The second objective for the operator is to ensure the continuity of space-delivered data or services in all instances, which means anticipating a possible failure of the infrastructure and defining back-up strategies. A disruption of services can be particularly critical in many cases, such as for safety-of-life services or defence-related services. The most serious event would be a failure of the space infrastructure. The first way to secure a continuous supply of space-delivered data or services is redundancy, which is used mainly for satellite constellations such as navigation constellations with spare satellites already in orbit. The second way is to establish agreements with other satellite service providers or data suppliers (such as the Formosat/Spot agreement). Although the number of applications satellites in the world is expected to increase in the future, it is questionable whether a number of similar agreements will materialise in view of growing competition in the international market. A third way is bilateral ad hoc arrangements between public satellite operators in case of failure. Such arrangements were made for instance between ESA/Eumetsat and the U.S. National Oceanic and Atmospheric Administration (NOAA) when these agencies experienced the failure of one of their meteorological satellites. In 1985, after the failure of the Data Collection Platform (DCP) payload on Meteosat-2 and the end of life of Meteosat-1, NOAA agreed to reposition its GOES-4 satellite over the Atlantic to take over the DCP mission until mid-1988. In turn, after

§ For the purposes of EC environmental policies, the Infrastructure for Spatial Information in the European Community programme (INSPIRE) aims to address the weaknesses of spatial information in Europe, i.e. fragmentation of data sets and sources, gaps in availability, lack of harmonisation between data sets at different geographical scales and duplication of information collection. The objective of the EC is to establish a European spatial information infrastructure that delivers integrated spatial information services to users. The EU member States are to enact national regulations to implement the INSPIRE Directive before 15 May 2009.

the failure of GOES-6 in January 1989, Meteosat-3 was repositioned over the Atlantic in 1991, and again in 1993, to monitor tropical storms and hurricanes reaching the East Coast of the U.S..[42,43] On 20 August 1993, NOAA and Eumetsat actually signed a long-term agreement for mutual backup of their geostationary weather satellites, which became effective in late 1995. If a satellite failure occurs, NOAA has agreed to reposition an operable GOES satellite eastward to ensure European coverage while Eumetsat has agreed to reposition an operable Meteosat satellite westward to ensure U.S. coverage.[44] Following this NOAA/Eumetsat agreement, a similar agreement was signed between NOAA and the Japanese Meteorological Agency (JMA) in February 2005. These operators are in fact part of the international informal Coordination Group for Meteorological Satellites (CGMS), founded in 1992. One of the objectives of the CGMS is to encourage complementarity, compatibility and possible mutual backup in the event of system failure. This objective is embodied in the Global Contingency Plan recently adopted by all CGMS members. Further examples of ad hoc bilateral arrangements and details on the CGMS and its Global Contingency Plan can be found in Appendix A.

In Europe, another question associated with the need for continuity needs to be addressed by European decision-makers. Decisions will have to be made on the redundancy of space systems and analysis performed on the relative long-term benefits of national systems versus, or in addition to, European systems.

4.2. Establishing sustainable governance and funding of services

In the previous section the focus was on the upstream part of the value chain and the relation between operators, industry and development agencies. This section focuses on the downstream part of the value chain and on the relations between operator, service providers and users, as represented in Figure 19.

Once demand is identified and structured and the supply of space-delivered data and services is secured, the sustainability of the services requires establishing three main elements: a structured and sustainable partnership with users, sustainable funding generation and allocation, and a programmatic overview of the infrastructure and services.

4.2.1. Ensuring a structured and sustainable partnership with users

A key element in the sustainability of services is the partnership between operators, service providers and end-users, as illustrated in Figure 20. The operator can be a separate organisation, as is represented in the next figure, but the function can also be endorsed by a development agency on a temporary or permanent basis.

As the development of services should be demand-driven, a structured dialogue should primarily enable operators and service providers to understand the needs of users and their constraints not only in technical terms but also in organisational and operational terms. It would enable service providers to adapt the tools to user requirements and operators to deliver relevant data and services to providers in standardised formats and in a timely manner. Effective communication between these different actors requires operators to adapt so as to understand users and even to “speak their language”. Such a dialogue can take place in joint working groups meeting regularly.
Partnership between the various actors of the value chain is a necessary end-result. However, when a new system is developed and a new service is to be created, the initiation of a fruitful dialogue is essential to the establishment of a sustainable value chain.

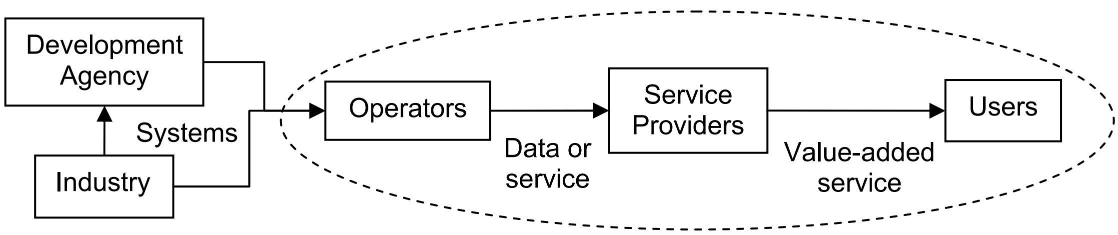

Figure 19: The downstream part of the service value chain

Figure 20: The need for a structured dialogue between operators, service providers and users

When the system is initially under the responsibility of a development agency and an operator has not yet been created or identified, the dialogue can only be initiated between the development agency or industry and the potential end-users as there is no other available intermediary. This is presented in Figure 21.

Industry has a role to play in setting up this dialogue even though there is some reluctance on the part of public organisation users to deal directly with industry. A development agency is usually in a better position to establish the partnership. Industry can work directly with private users, as it already does, but in the near future this work is likely to remain limited to a few targeted user communities. Besides, when industry provide services to users in countries in which the public authorities have a central role in space activities, the involvement of public development agencies is necessary to support the industry.

However, both development agencies and the space industry are not optimally structured for this task and have inadequate expertise and limited resources to invest in it. The main difficulty stems from the structure of the user communities: all user communities are different from each other and have specific needs. Furthermore, building a long-term relationship and reaching a common understanding takes time. The relationship can be initiated by creating temporary links and seconding trained experts over sufficient periods of time, either from the development agency to a user organisation or, vice versa, from a user organisation to the development agency.

When the development agency that manages a space-based system initiates a dialogue with potential users of the system, it would make sense for the agency to become involved in pre-operations and operations, at least initially on a transitory basis. For instance, given its status, CNES has the possibility to create subsidiaries to support the development of operational activities and/or to commercialise the products from the systems it develops. These subsidiaries can be of different legal natures, depending on the objectives. CNES can have shares in these subsidiaries, which benefit from both their independence from the R&D environment and the presence of other partners.[45] CNES thus created and had shares in Spot Image, which commercialises Spot data and associated services, and co-founded CLS or Mercator Ocean, both of which provide services based on space systems developed by CNES. However, in this respect CNES is an exception as the development of these subsidiaries has been part of this agency's policy and strategy, as reflected by its status.

At the European level, ESA's mandate does not prevent it from becoming involved in operational activities but its involvement in operational activities has been foreseen as temporary until another organisation can take over the responsibility for the operational systems. The text of the ESA Convention, approved by the Conference of Plenipotentiaries on 30 May 1975, included a section on operational activities - Article V.2:

"2. In the area of space applications the Agency may, should the occasion arise, carry out operational activities under conditions to be defined by the Council by a majority of all Member States. When so doing the Agency shall

a. place at the disposal of the operating agencies concerned such of its own facilities as may be useful to them;

b. ensure as required, on behalf of the operating agencies concerned, the

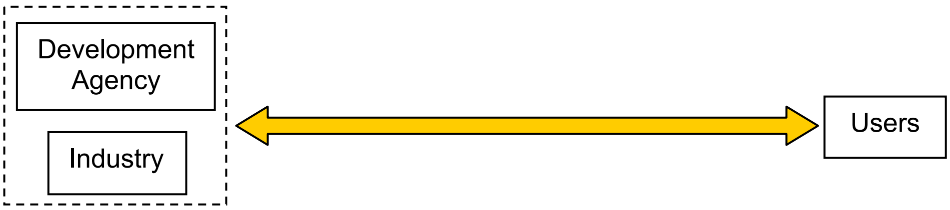

Figure 21: The initial dialogue has to be established between system developers and end-users

launching, placing in orbit and control of operational application satellites;

c. carry out any other activity requested by users and approved by the Council.

The cost of such operational activities shall be borne by the users concerned."[46]

The question of ESA's role in operational programmes has in fact been discussed since the early days of the agency, as questions on its possible role in the operations of Meteosat had arisen as early as 1972. In February 1977, the first ESA Council at ministerial level adopted a resolution on "The Agency and the Operational Systems", presented in the Appendix B. The "Operations Resolution" complemented Article V.2 of the Convention and defined more clearly ESA's possible role as regards pre-operational and operational systems:

1. *"As regards the pre-operational systems which the Member States entrust to it for execution, the Agency will have full responsibility for design, development and exploitation. It will exercise this responsibility in consultation with potential users, particularly in cases where the development of prototypes is considered to be the best way of advancing the associated technology and facile-tating the transition to the operational phase.*
2. *As regards operational systems:*
   a. *In the fields where organized users do not exist, the Agency will encourage the potential users of operational systems to take over the management of these systems and to organize their exploitation. In accordance with the Council's instructions, it will furnish them with all the technical and institutional assistance they may request to this end, including the making available of facilities.*
   b. *In the fields where organized users exist, the Agency will not undertake tasks unless so requested by them."*[47]

Figure 22: ESA Director General Roy Gibson and Mario Pedini, Chair of the Council meeting at Ministerial level in Paris in 1977[48]

According to the ESA Convention and the 1977 Resolution, ESA may carry out operational activities, but only if requested by users to do so. Moreover, operational activities were clearly distinguished from mandatory and optional programmes, which were to remain the first priority of the Agency. The responsibility of ESA for operational systems was mainly intended to avoid the situation in which there is no operator for the systems it develops. It was to be no more than provisional on behalf of users and was expected to be temporary before a transfer of responsibility to external organisations.[49] A key issue in the involvement of development agencies in operational activities was and remains the source of funding which should be different for R&D and operational activities. This issue is raised by the last sentence of Article V.2, quoted above.

The organisation to which ESA might transfer the responsibility for the systems has to be defined on a case-by-case basis.[50] The "Operations Resolution" refers to "the users themselves" or "a body designated by them".[45,47] The only condition in making the divestment is that: "Member States that have contributed to the development of a space programme [are] to be equitably associated with the follow-up operational activities resulting from the programme in question, taking due account of any commercial constraints."[47]

For public services, the partnership between operators and service providers can be formalised by providers having a role in the administration of the operator. In this way the operator and service provider have a real capability to shape and effectively meet user demand. For example, national meteorology offices are represented in Eumetsat's bodies. The more intertwined the partners, the more sustainable is the value chain and therefore the service.

4.2.2. Ensuring programmatic overview

The operator also bears the responsibility for the programmatic overview of all space- and ground-based systems and their integration. This responsibility includes upgrade of the systems based on the evolution of user needs. This underlines the importance of continuous interaction and dialogue with users.

The operator's main difficulty is to strike a balance between operational needs and budgets on the one hand, and the technology-push tendency of system developers on the other hand. Users require a high-level of reliability of services at an acceptable cost, while system developers tend to promote the use of the most advanced technologies. Addressing this challenge requires a balanced relationship with system developers on the one hand and system users in the other hand, which underlines the necessity of a separate entity to arbitrate between differing interests.

If the operator is not procuring its own satellites, it has to make an agreement with a development agency for this purpose. Eutelsat and SES procure their satellites directly from industry whereas Eumetsat's satellites are procured by ESA on the operator's behalf. In either case, an agreement has to be made between the operator and a development agency for the development of new generations of satellites and of new technologies. For example, the first model of each new generation of Eumetsat's satellites is developed as an ESA programme with R&D funds complemented by a fixed financial contribution from the operator. For instance, for the first satellite of Meteosat Second Generation, MSG-1, ESA contributed two thirds and Eumetsat one third of the satellite development cost.

Figure 23: Cooperation between ESA and Eumetsat for Meteosat Third Generation formalised at the 63rd Eumetsat Council meeting

4.2.3. Ensuring sustainable funding generation and allocation

The operator also has a central role in the cash flow along the value chain, as presented in Figure 24. Member States provide funding for the development of new systems according to the benefits to their citizens.

The operator should obtain its funding from its users through service providers and both funding generation and allocation should be operational thus serving the prime objective of delivering sustainable, cost-effective services to end users. As an illustration, Eumetsat's contributions are based on its Member States' GDP and its contracts are awarded on a purely competitive basis in order to reduce costs.

Rules on how the data or services are paid for by the service providers and on how the operator finances the operations of its infrastructure and new developments have to be defined. Some rules can improve the relative sustainability of the systems and services. A regular payment to the operator for data or services as a fixed contribution is for instance more sustainable than an ad hoc payment for each acquisition.

At European level, funding has to be raised from users at national, regional or even local levels, which tends to be facilitated if service providers are represented at the corresponding level. Eutelsat is supported by telecommunications operators which are nationally represented; Eumetsat by national meteorology offices. These national representations create a constituency that strengthens the overall value chain at the European level.

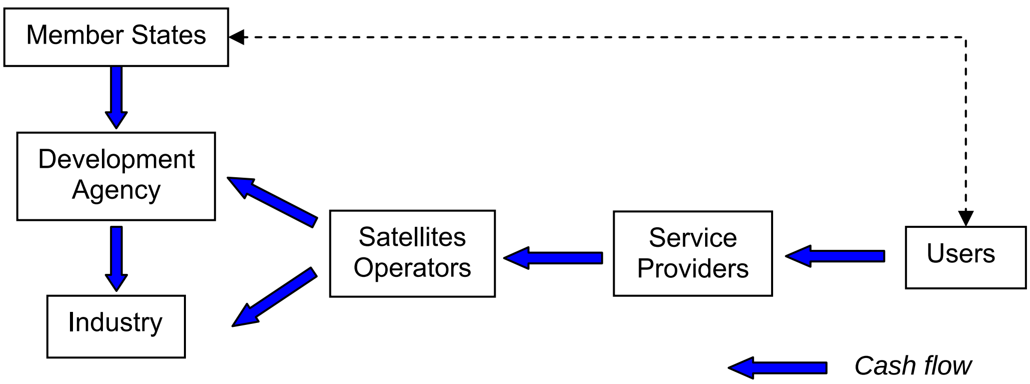

Figure 24: The initial dialogue has to be established between system developers and end-users

4.3. The complete value chain of space-based services

Theoretically, the complete value chain of space-based services should have all the elements presented in Figure 25. The feedback from users to their decision-makers and the influence of these decision-makers on the use of services (normative regulations or incentives) are also represented. The transition between a demonstrated application and a sustainable service requires putting together all these elements. In some cases, many of the elements of a given value chain already exist but still need to be properly connected.

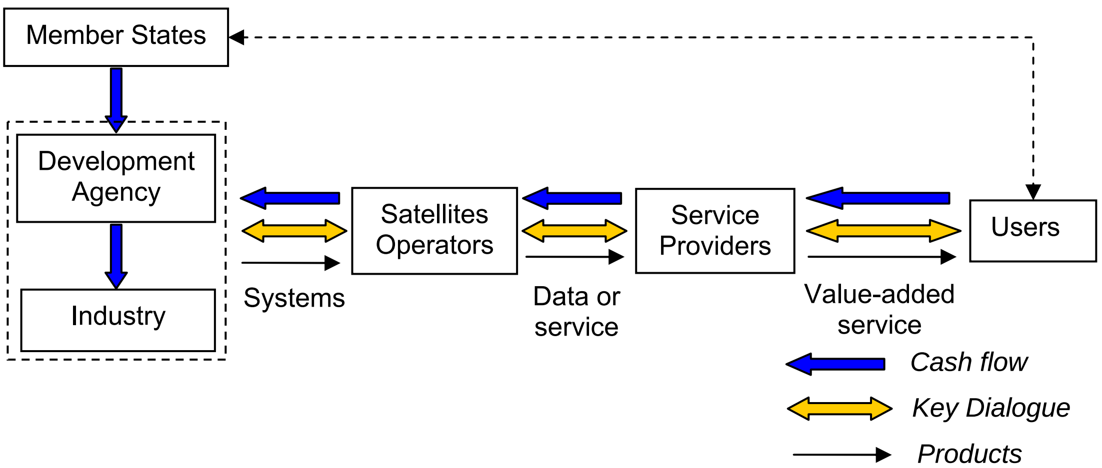

Figure 25: The complete value chain of space-based services

5. From a Technology-push to a Demand-driven Paradigm

The previous sections investigated the two main challenges to the development of specific services. In addition to these issues there is a more general challenge to the long-term development of space-based services in Europe. The transition from a technology-push to a demand-driven paradigm that is necessary for the successful development of space-based services in Europe requires adaptation of the current organisations of the space sector and of their programmes.

5.1. Challenges for existing organisations

The space sector is currently efficiently structured to develop and manufacture space systems in a technology-push approach, as long as the current sources of funding are maintained. However, for the successful development of services, a transition from technology-push to a demand-driven approach is necessary.

The structure of the space sector is adapted to the characteristics of its main product. Satellites are usually unique and customised systems and their development is associated with long cycles, high costs and high levels of financial and technical risk. These characteristics have resulted in a few large space agencies in Europe and a concentrated and stable industrial structure.

Up to now, the space industry has mainly focused on infrastructure and has developed satellites used mainly by scientific communities, with the major exception of the telecommunications sector. As a result, both development agencies and industry are today efficiently structured to develop satellites for communities which they know quite well. Their activities and structures are thus segmented according to the field, i.e. telecommunications, navigation or Earth observation, and the type of systems, i.e. space versus ground infrastructure.

As products, space-based services have characteristics very different from those of space systems: the development and implementation cycles are much shorter and the costs and level of risks are much lower. Moreover, the field of services is much broader and has a wider variety of user communities which are structured very differently than the communities usually addressed by the space sector. Last but not least, services require the space sector to interact with other sectors which, until now, it has not much done. These challenges are reflected in the development of the GMES programme, which goes well beyond other traditional space programmes and require both vertical and horizontal integrations of the activities. Services by their nature require the combination and integration of a variety of ground-based and space-based tools. All these elements require an adaptation of the space sector to a new “service paradigm” on a much larger scale than today. Addressing users in the most-efficient way requires the establishment of multidisciplinary teams. In addition, each community of users requires a specific team composition on a case-by-case basis. For space agencies, adaptation means the ability to create multidisciplinary teams, supported by specialised teams, within an application programme. These multidisciplinary teams should include experts in downstream services that are aware of competing solutions based on terrestrial technologies as well as experts able to assess the potential sustainability of new applications. This expertise should be acquired and maintained by space agencies/offices and industry.

The differences between the “space system paradigm” and the “space-based service paradigm” are summarised in Table 1.

	Development Approach	Technologies	Structure of Demand	Development Cycles	Development Costs	Development Risks	Structure of the Industry
Space systems	Technology-push	Space systems and their associated ground systems	A few large space agencies and operators	Long	High	High	Concentrated industrial structure with large organizations segmented per field
Space-based services	Demand-driven	Space technologies to be integrated with others	Multiplicity and diversity of users	Shorter	Lower	Lower	A number of small multi-disciplinary structures adapted to each user community + Direct competition with other technologies

Table 1: The space system paradigm versus the space-based service paradigm

Today, the space manufacturing industry has to position itself in the downstream part of the value chain. The industry, which has evolved towards large, integrated structures, is not structured to properly address the current service market in which service providers should be smaller entities that are particularly responsive to the market in view of the shorter cycles and competition with solutions based on other technologies. To ensure vertical integration, large manufacturers can either team up with existing service providers (e.g.. the Space Alliance between Telespazio and Thales Alenia Space) or create or acquire a number of specialised subsidiaries that can address specific needs at different levels (local, regional, national or European levels). Through vertical integration, large manufacturers can also secure the supply of data (e.g. EADS Astrium and Spot Image).

Large space manufacturers have an opportunity to structure market supply and demand for space-based services but they are still reluctant to invest significantly and to adapt to this new paradigm because of limited short-term prospects (due to the fragmentation of the market, the lack of structured dialogue with potential users, etc.) and a lack of relevant non-technical expertise. As a result, “outsiders” have had a significant impact in shaping the field and the demand for space-based services. The most striking example is the impact of “virtual globes” like Google Earth.

5.2. Challenges for existing programmes

The development of space-based services is supported by several programmes in Europe. However, these programmes are not optimally designed to ensure the development of sustainable services. The programmes that support the development of space-based services are mainly R&D programmes with demonstration as their main objective. When participating in such programmes, industry and research institutes obtain funding for the demonstration of a new tool addressing the technical requirements of potential users. However, the development of new applications tends to stop at this demonstration phase without further investment in the transition towards an operational service. With such programmes, new expertise is developed and demonstrations are successfully achieved but only a limited number of operational services are established.

A first objective when considering existing programmes and designing new ones is to adapt programmes to the characteristics of applications rather than to space systems. A second objective is to connect demonstration activities and operations which are not currently linked. A third objective is to prepare the transition between demonstration and operations to make it as effective and as fast as possible and to design demonstration programmes accordingly.

While solutions to effectively develop space-based services are strongly dependent on the nature of the services and on demand, common objectives and considerations can be defined.

5.2.1. The need for different programmes specific to space-based applications

As detailed in the previous section, as products, space-based applications and space systems have very different characteristics.

As a consequence, programmes supporting the development of new space systems should be significantly longer and more expensive than programmes supporting the development of new space-based applications. Moreover, the criteria used to assess the success of these two kinds of programmes should be very different. Programmes supporting the development of applications should therefore be separate from, and designed differently than, those supporting the development of space-based applications.

Next, as presented in section 2., there are different phases in the development of a space-based service and different types of programme should support each of these phases, as illustrated in Figure 26. Consecutively, there should be R&D programmes, feasibility programmes, demonstration programmes and finally, transition programmes.

5.2.2. Connecting demonstration programmes and operation

The second objective is to connect demonstration and operation by creating relevant transition programmes. These programmes are particularly important as they address the most critical step in the development of new services and do not yet exist. End users should directly or indirectly manage such programmes with the possible technical and financial support of public organisations.

The transition programmes should connect demonstration programmes and operations. This is particularly critical as demonstration and operations are likely to be managed by different stakeholders and funded from different sources.

The need for such programmes can be illustrated with the example of services supporting European regions. Local and

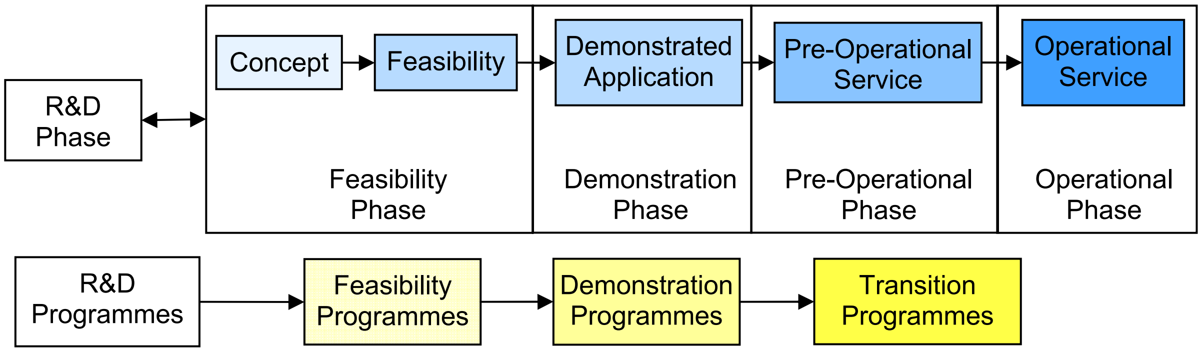

Figure 26: Specific programmes to support the development of space-based services

Each of these programmes could be managed by different stakeholders. The progressive divestment of development agencies and investment of users should be foreseen. For instance a development agency could manage the early phases (i.e. the R&D, feasibility and demonstration programmes) and then an organisation representing the users could manage the transition programme. Each of these programmes should also have features that are most suited to the corresponding phase: they could have different durations, funding rules, sources of funding, criteria of success, etc. As a result, not only would R&D funding be used to develop space-based services in Europe but also users would get involved earlier in the process. Last, the successive R&D, feasibility, demonstration and transition programmes should be coordinated and connected to ensure timely development of new services and the continuity of financial support.

regional authorities can benefit from space-based services financially supported by the European Commission in two different ways. First, they can benefit from free services during the services demonstration phase. This demonstration can be part of an FP project funded by the EC and the projects' partners. It would then come at no, or limited, cost for the local and regional authorities. Second, local and regional authorities can benefit from operational space-based services co-financed by EC structural funds. However, there is no coordination between the two public sources of funding, i.e. the FP of the Directorate General for Research and the structural funds of the Directorate General for Regional Policy. This prevents the transition from demonstration to operation.[51,52] Many similar examples of services potentially funded by other EC Directorate Generals or other public organisations can be given. The need for transition programmes is represented in Figure 27.

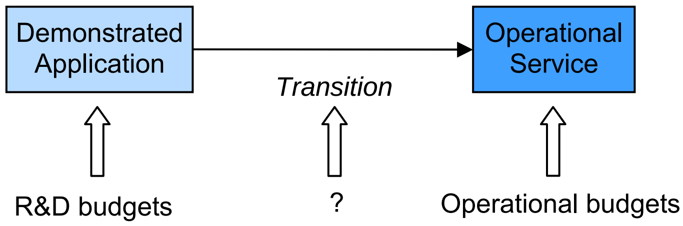

Figure 27: The need for transition programmes

A key issue is the source of funding for such transition programmes as it should not be R&D budgets. Moreover, users are often initially not willing to pay for the transition. For public users, innovative financing schemes including loans from public organisations and mechanisms like the Risk Sharing Finance Facility (RSFF)[**,53] can be used. In any event, efforts should be undertaken by public authorities to attract private investments to support the transition phase.

5.2.3. Preparing the transition

The third objective is to properly anticipate the transition in the design of the demonstration programmes. First, users should be involved from the very beginning of new projects. Next, the difficulties of the transition detailed above should be anticipated. The objective of the demonstration programmes should go beyond demonstration only. Solution providers should be required to consider the non-technical, operational requirements of users in addition to their technical requirements. Interoperability with other technologies and integration with existing tools should be also prepared as part of the solution provided. A sound business case, based on a realistic cost analysis and considering competing solutions based on other technologies should also be required. Finally, a plan for the transition should also be prepared. The criteria of success of demonstration programmes should evolve in consequence to include an assessment of the readiness and chances of success of the transition from demonstration to operation. There is, however, another element in the design of the demonstration programmes that can hinder the transition. The formation of a European consortium that is required by programmes like the EC FP programmes might hinder the development of a service as the consortium created for the demonstration might not be optimal to deliver sustainable, cost-effective services in the future.

The development of the future GMES services and the new ESA IAP programme should indeed address several of the existing programmes' shortcomings. For instance the ESA IAP programme aims: to adopt a demand-driven approach focused on user needs by fostering and organising the demand for space-based services; and to provide users with integrated solutions that combine existing space and non-space systems. This objective is summarised as “connecting expert communities and combining systems”. The programme consists in four consecutive steps, with specific support for each of them: awareness activities, feasibility studies, demonstration projects and pre-operational activities. Furthermore, the results of these activities will be assessed based on technical and economic criteria as well as on the potential sustainability of the final service.

** RSFF is a new instrument jointly developed by the European Commission and the European Investment Bank (EIB) in support of higher risk financing for Research, Technological Development, Demonstration and Innovation investments (RDI projects).

Conclusions

The further development and use of space-based services in Europe is of great economic, social and strategic importance. Despite a number of successes and several ongoing initiatives, Europe is still far from taking full advantage of its substantial space infrastructure and of the space-based solutions that could address its citizens' needs in a unique way. Proper actions at European level are therefore needed.

Developing operational space-based services is, however, a complex endeavour because of the number and variety of challenges to be tackled. The European dimension creates some additional complexity. Significant progress on a large scale will thus be achieved only with both strong political support and coordinated and adequate actions involving all the European stakeholders, i.e. space agencies, industry, users, policy-makers, etc. These efforts should build on each of these stakeholders' strengths and expertise, taking into account their constraints and limited resources, and should aim at maximizing synergies.

The most complex issue is to identify and structure the demand for space-based services in Europe. Next, the sustainability of the solutions proposed has to be ensured with the establishment of proper structures and complete value chains. Last but not least, the European space sector has to understand and adapt to the service paradigm.

Successful development of space-based services would enable Europe to optimally benefit from its large investments and the European space sector to develop new expertise and strengthen its position on international markets. Europe has indeed developed unique know-how and capabilities in space systems and can become an equally successful and acknowledged player in the field of services, beyond its past achievements. This evolution would significantly contribute to the overall sustainability and growth of the European space sector.

Europe must seize the current opportunities offered in the field of services. To start with, it should add new success stories in operational services to its long list of space achievements and should use them to promote space applications among broader communities.

Appendices

Appendix A
The Coordination Group for Meteorological Satellites and its Global Contingency Plan

The Coordination Group for Meteorological Satellites

The Coordination Group for Meteorological Satellites (CGMS) is an informal international group, founded in 1972 by ESRO, JMA and NOAA, meeting once a year and functioning on a best efforts basis.

Membership[54]

Its 15 members are: China Meteorological Agency (CMA), Centre National d'Etudes Spatiales (CNES), China National Space Administration (CNSA), European Space Agency (ESA), European Organisation for the Exploitation of Meteorological Satellites (Eumetsat), India Meteorological Department (IMD), Intergovernmental Oceanographic Commission (IOC/UNESCO), Japan Aerospace Exploration Agency (JAXA), Japan Meteorological Agency (JMA), Korea Meteorological Administration (KMA), National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), Russian Federal Space Agency (Roscosmos), Russian Federal Service for Hydrometeorology and Environment Monitoring (Roshydromet) and World Meteorological Organization (WMO).

Objectives[55]

As defined in its charter, the CGMS objectives are:

- to provide a forum for the exchange of technical information on geostationary and polar-orbiting meteorological satellite systems and R&D missions
- to harmonise meteorological satellite mission parameters
- to encourage complementarity, compatibility and possible mutual back-up in the event of system failure

The CGMS Global Contingency Plan

The CGMS established a Global Contigency Plan that "aims to serve as a reference for CGMS satellite operators in the planning and implementation of satellite missions, and in particular to facilitate the definition and implementation of joint undertakings in the framework of CGMS to prevent or mitigate contingency situations and secure the continuity of essential meteorological and climate observation missions."[44]

The Global Contingency Plan refers to previous bilateral arrangements and bilateral mutual backup agreements.

Past cases of bilateral arrangements between public operators[44,56]

Through ad hoc bilateral arrangements, public satellite operators have already provided emergency cover to other operators:

- GOES-1 was moved over the Indian Ocean in support of the First Global GARP Experiment (FGGE) in 1978 and 1979
- GOES-4 supported the Meteosat Data Collection Platforms (DCP) mission between 1985 and 1988 after the failure of the DCP payload on Meteosat-2
- Meteosat-3 provided Atlantic Data Coverage (ADC) in 1991-1992 after the failure of GOES-6
- Meteosat-3 provided an extended ADC (XADC) from 1992
- Japan supported the GOES Data Collection System with its GMS in 1992
- Meteosat-5 was repositioned when the Soviet GOMS –Electro N1 failed in May 1989
- GOES-9 was repositioned to replace GMS-5 when the latter failed in 2003 and until MTSAT-1R was launched in 2005

Bilateral mutual back-up agreements between public operators[44]

On 20 August 1993, NOAA and Eumetsat "signed a long-term agreement for mutual backup of their geostationary weather satellites", which "became effective when both parties had baseline systems in place, which occurred by late 1995. If a satellite failure occurs, NOAA has agreed to reposition an operable GOES eastward to ensure European coverage while Eumetsat has agreed to reposition an operable Meteosat westward to ensure U.S. coverage."

"On 23 February 2005, NOAA and JMA signed a long-term agreement for mutual backup of their geostationary meteorological satellite systems to ensure continuous geostationary coverage of East Asia and the Western Pacific for the U.S. and Japan. NOAA and JMA agreed to provide geostationary [mutual] backup coverage in an emergency, to monitor severe weather threatening both nations, and in the case of satellite failure, to provide coverage for up to one year at no cost. The arrangement will enter into force when JMA has two operable meteorological satellites, assuming JMA and NOAA are maintaining their baseline satellite systems." JMA should have two operational meteorological satellites in 2010.[57]

Appendix B
Resolution on the Agency and its Operational Systems (adopted on 15 February 1977)

The Council, meeting at ministerial level,

CONSIDERING that, in addition to its task of developing space technology, the European Space Agency also has the mission, under the Convention for the establishment of a European Space Agency, of giving support for the development and management of European operational space systems,

RECOGNISING that the execution of operational activities will enable the Agency to exploit its capabilities and capital investments to the full and to achieve a better regulation of the workloads of the Agency and of industry, as well as to arrive at a better definition of its subsequent programmes in the light of the requirements of space-systems users,

CONSIDERING the importance, in the overall European economic context, of avoiding multiplication of space-related capabilities and capital investments,

JUDGING IT DESIRABLE, in consequence, to adopt a positive attitude in relation to the management of operational systems,

AGREES that the Agency's activities in the operational field must conform to the following principles:

1. "As regards the pre-operational systems which the Member States entrust to it for execution, the Agency will have full responsibility for design, development and exploitation. It will exercise this responsibility in consultation with potential users, particularly in cases where the development of prototypes is considered to be the best way of advancing the associated technology and facilitating the transition to the operational phase.

2. As regards operational systems:
   a. In the fields where organized users do not exist, the Agency will encourage the potential users of operational systems to take over the management of these systems and to organize their exploitation. In accordance with the Council's instructions, it will furnish them with all the technical and institutional assistance they may request to this end, including the making available of facilities.
   b. In the fields where organized users exist, the Agency will not undertake tasks unless so requested by them

3. Subject to any other activity requested by users and approved by the Council, the Agency will limit its operational activities to the launching, placing in orbit, and orbital control of satellites or space transport systems, and to the provision of technical assistance, in the design and exploitation of systems, either to the users themselves or to a body designated by them.
4. The Agency will undertake operational activities only if it can do so without interfering with the effective discharge of the principal tasks for which it has been established.

5. The Agency will abstain from encroaching upon the acknowledged attributions of the user organisations. The principles set out in Article VII of the ESA Convention will be equally applicable to operational activities entrusted to the Agency.

6. The interfaces between the Agency and the users will be defined precisely and will be the subject of appropriate arrangements.

7. The Agency's internal costs incurred through the execution of its operational activities will be limited as far as possible. To this end a charging policy relating to these costs will be defined.

8. The Agency's expenditure in connection with these activities will be charged to the users in accordance with terms to be determined in the arrangements referred to above. The Council will determine those cases in which the Agency may continue during a limited period to bear certain expenditure, notably in order to promote the constitution and starting up of user groups; in doing so the Agency will make every effort to reduce the amount of such expenditure.
9. No financial involvement shall arise for any Member State from operational activities without the specific approval of that Member State.

10. The Agency will set up a suitable internal management and accounting structure to permit clear identification and correct charging of activities in the operational sector.

11. The Agency will take care to remain within the framework of the privileges and immunities granted to it by the Member States in accordance with the provisions of Article 7.2 of Annex I of the ESA Convention.

12. The Agency will define and carry out a policy enabling the Member States that have contributed to the development of a space programme to be equitably associated with the follow-up operational activities resulting from the programme in question, taking due account of any commercial constraints.

13. The Agency will recommend to Member States all measures which allow harmonisation of the policies of user administrations or entities in their countries with the Agency's policy defined in the preceding paragraph.

14. The Council will take the necessary steps for the implementation of the above principles, which it will review from time to time in the light of experience gained.

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Acronyms

ADC	Atlantic Data Coverage
ATS	Applications Technology Satellite
CGMS	Coordination Group for Meteorological Satellites
CLS	Collecte Localisation Satellites
CMA	China Meteorological Agency
CNES	Centre National d'Etudes Spatiales
CNSA	China National Space Administration
DCP	Data Collection Platforms
DMSP	Defense Meteorological Satellites Program
DORIS	Détermination d'Orbite et Radiopositionnement Intégrés par Satellite
DTH	Direct-to-Home
EARSC	European Association of Remote Sensing Companies
EARSeL	European Association of Remote Sensing Laboratories
EC	European Commission
EDA	European Defence Agency
EEA	European Environment Agency
ELGRA	European Low Gravity Research Association
EMSA	European Maritime Safety Agency
EPS	Eumetsat Polar System
ERS	European Remote Sensing Satellite
ESA	European Space Agency
ESOA	European Satellite Operators Association
ESRO	European Space Research Organization
EU	European Union
Eumetsat	European Organisation for the Exploitation of Meteorological Satellites
Eutelsat	European Telecommunication Satellite Organization
FGGE	First Global GARP Experiment
FP	Framework Programme
FRONTEX	European Agency for the Management of Operational Cooperation at the External Borders
GARP	Global Atmospheric Research Program
GDP	Gross Domestic Product
GEOS	Geodetic and Earth Orbiting Satellite
Geosat	Geodetic Satellite
GFO	Geosat Follow-On
GMES	Global Monitoring for Environment and Security
GMS	Geostationary Meteorological Satellite
GOCO	Government-Owned Company-Operated
GOES	Geostationary Operational Environmental Satellite
GOMS	Geostationary Operational Meteorological Satellite
GPS	Global Positioning System
IAP	Integrated Applications Promotion
ICT	Information and Communication Technologies
IGO	Intergovernmental organization
IMD	India Meteorological Department
INSPIRE	Infrastructure for Spatial Information in the European Community
IOC	Intergovernmental Oceanographic Commission
IPR	Intellectual Property Rights
ISIS	Incitation à l'utilisation Scientifique des Images SPOT
JAXA	Japan Aerospace Exploration Agency
JMA	Japan Meteorological Agency
KMA	Korea Meteorological Administration
MetOp	Meteorological Operational satellite
MSG	Meteosat Second Generation
MTG	Meteosat Third Generation
MTSAT	Multi-functional Transport Satellite
NASA	National Aeronautics and Space Administration
NEREUS	Network of European Regions Using Space technologies

NIMA	National Imagery and Mapping Agency
NOAA	National Oceanic and Atmospheric Administration
PPP	Public-Private Partnership
RA	Radar Altimeter
R&D	Research and Development
Roshydromet	Russian Federal Service for Hydrometeorology and Environment Monitoring
Roscosmos	Russian Federal Space Agency
RSFF	Risk Sharing Finance Facility
SAF	Satellite Applications Facilities
SESAR	Single European Sky ATM Research
SME	Small and Medium Entreprise
SPOT	Satellite Pour l'Observation de la Terre
TEN-T	Trans-European Transport Network
TIROS	Television Infrared Observation Satellite
UC	User Community
UNESCO	United Nations Educational, Scientific and Cultural Organization
WMO	World Meteorological Organization
XADC	Extended Atlantic Data Coverage

References

[1] U.S. National Imagery and Mapping Agency. "NIMA Reinforces Its Commitment to Remote-Sensing Industry." Press Release. 30 Sept. 2003.
[2] Bates, Jason. "Military Helps Stabilize Satellite Imagery Market." Space News 2 Sept. 2003.
[3] European Commission. European Space Policy. Communication COM(2007) 212. 26 April 2007.
[4] Council of the European Union. Taking Forward the European Space Policy. Council Resolution 13569/08. 29 September 2008
[5] See for instance: Council Regulation on the measures to be undertaken by the Commission in 2008-2013 making use of the remote-sensing applications developed within the framework of the common agricultural policy. 78/2008. 21 Jan. 2008.
[6] See for instance: European Commission. "Examining the Creation of a European Border Surveillance System (EUROSUR)". Communication COM(2008) 68. 13 Feb. 2008
[7] See for instance: European Commission. EU Report on Policy Coherence for Development. Working Paper COM(2007) 545. 20 Sept. 2007.
[8] See for instance: European Commission. "Towards a new culture for urban mobility." Green Paper COM(2007) 551. 25 Sept. 2007.
[9] See for instance: European Commission. "Towards a future Maritime Policy for the Union: a European vision for the oceans and seas." Green Paper COM(2006) 275. 7 Jun. 2006.
[10] "Wir können alle weiβen Flecken in Deutschland schlieβen" Die Welt 9 Mar. 2009.
[11] NEREUS website <www.nereus-regions.eu>.
[12] Euroconsult. "Assessment of the Downstream Value-Adding Sectors of Space-based Applications." 11 April 2007.
[13] Image : ESA
[14] Mercator Ocean. Mercator History <www.mercator-ocean.fr/html/mercator/histoire/index_en.html>.
[15] World Meteorological Organization. "Transition from Relevant R&D Instruments to Operational Missions." WMO(CM-8)/Doc.8. 15-16 Jan. 2008.
[16] National Research Council. Committee on NASA-NOAA Transition from Research to Operations. Satellite Observations of the Earth's Environment: Accelerating the Transition of Research to Operations.Washington: The National Academies Press, 2003.
[17] Eumetsat. L'Histoire d'Eumetsat. Darmstadt: Eumetsat. 2001.
[18] NOAA Office of Satellite Operations. NOAA's Environmental Satellites: A History. NOAA website. <www.oso.noaa.gov/history>.
[19] The Future Altimetry Working Group. "The Future of Spaceborne Altimetry, Oceans and Climate Change." Koblinski, Chester J., Gaspar, P. and Gary Lagerloef, editors. Washington: Joint Oceanographic Institutions Inc., 1992.
[20] AVISO. Altimetry History <www.aviso.oceanobs.com/en/altimetry/history>.
[21] CNES. "Jason et notre Planète Océan. " Dossier d'information CNES/NASA. Nov. 2001.
[22] Copyright NASA.
[23] Mercator Ocean. Mercator History <www.mercator-ocean.fr/html/mercator/histoire/index_en.html>.
[24] SESAR Joint Undertaking website <www.sesarju.eu>.
[25] EARSeL website <www.earsel.org>.
[26] ELGRA website <www.elgra.org>.
[27] Copyright Eumetsat.
[28] Copyright Eutelsat.
[29] Copyright Eumetsat.
[30] Grimard, Max. "Interaction between Industry, Government, and Private Investors: It is a Question of Position in the Value Chain." IAC-08-E6.3.4. 59th International Astronautical Congress (IAC). Glasgow, 29 Sept. – 3 Oct. 2008.
[31] European Commission. "GMES: We care for a Safer Planet". Communication COM(2008)748 12 Nov. 2008.
[32] Eumetsat. "Amending Protocol Convention - Amendments to the Convention for the Establishment of a European Organisation for the Exploitation of Meteorological Satellites ("EUMETSAT") of 24 May 1983." Adopted by the Eumetsat Council on 4-5 Jun. 1991. Entered into Force on 19 Nov. 2000.
[33] ESA. "Envisat Data Policy." MMO-POL-003-EOAD: ENVISAT Data Policy. 23 Aug. 2000.
[34] ESA. "Extract of the Earth Explorer Data Policy." EEXP-MMAN-EOPG-PD-03-001.18 Dec. 2003.
[35] Eumetsat. "Eumetsat Principles on Data Policy." Eumetsat Data Policy based on the EUMETSAT Principles on Data Policy laid down in Council Resolution EUM/C/98/Res.IV and amended in Council Resolution EUM/C/57/05/Res. III.
[36] Smith, Lesley J and Catherine Doldirina. "Remote Sensing: A Case for Moving Space Data towards the Public Good." Space Policy 24(2008): 22-32.
[37] ISIS website < www.isis-cnes.fr>.
[38] INSPIRE website <inspire.jrc.ec.europa.eu>.

[39] Doldirina, Catherine. "INSPIRE: A Real Step Forward in Building an Interoperable and Unified Spatial Information Infrastructure fro Europe?" ESPI Perspectives 20. Vienna: ESPI (2009).
[40] European Parliament and European Council. "Directive establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)." 2007/2/EC. 14 Mar. 2007.
[41] Copyright Eurogeographics.
[42] Eumetsat. "Resolution on Atlantic Data Coverage." Council Resolution EUM/C/Res. XV. Adopted on 19-20 Jun. 1989.
[43] ESA. "Meteosat Remains in Good Hands." Press Release 51-1995. 20 Nov. 1995.
[44] CGMS. "CGMS Global Contigency Plan." WMO Space Programme Department. Version 2. 7 May 2007.
[45] Madders, Kevin. A New Force at a New Frontier. Cambridge: Cambridge University Press, 2007: 488-489.
[46] ESA. "Convention for the Establishment of a European Space Agency." Approved by the Conference of Plenipotentiaries. Paris, 30 May 1975.
[47] ESA. "Resolution on the Agency and the Operational Systems." Adopted by the Ministerial Council meeting on 15 February 1977. ESA/C-M(February 77), Res.3.
[48] Copyright ESA.
[49] Lafferanderie, Gabriel. "La Notion d'Activités Opérationnelles dans la Convention de l'Agence." ESA Bulletin 37 (February 1984): 68-71.
[50] Krige, John, Russo, Arturo, and Lorenza Sebesta. A History of the European Space Agency 1958-1987 Vol. II The story of ESA, 1973 to 1987. Paris: ESA Publications (2000): 675.
[51] Eurisy. "Regional Policy: Benefits from Satellite Information and Services." Conference Report. 11 Sept. 2008.
[52] Thomas Andersson "For a facilitated access for Local and Regional Authorities to the benefits of Satellite Information and Services". Eurisy Conference on Regional Policy: Benefits from Satellite Information and Services. Brussels, 11 Sept. 2008.
[53] EIB webpage on RSFF <http://www.eib.org/products/loans/special/rsff/index.htm>. European Commission DG RTD B.4 RSFF Sector Team. Risk-Sharing Finance Facility (RSFF): A new financing instrument supported by FP 7 for more investment in R&D and Innovation. Brussels, 15 September 2008 <http://ec.europa.eu/enterprise/security/doc/2nd_call_infoday_presentations/Commission/6_RSFF.pdf>.
[54] CGMS website <www.wmo.ch/pages/prog/sat/CGMS/CGMS_home.html>.
[55] CGMS. "Charter for the Coordination Group for Meteorological Satellites (CGMS)."
[56] Mohr T. International Cooperation of Meteorological/Earth Observing Satellites. 88th Annual Meeting of the American Meteorological Society. 20-24 Jan. 2008.
[57] JMA website <http://www.jma.go.jp/jma/jma-eng/satellite/index.html>.

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