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The Future of European Flagship Programmes in Space

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Executive Summary

For over sixty years the European integration project has been expanding and deepening immensely. From an original narrow – yet historic – cooperation in the production of coal and steel, EU policies and actions of today affect nearly all segments of the European social, economic and political landscape. At the moment, the European Union is in the middle of asserting a stronger role in space. It is doing so because its mandate and competences have now become so broad that space activities and policies are crucial elements in supporting and addressing them. An additional motivation is the fact that strategic assets like space capabilities, would benefit from validation at a high political level. Furthermore, space provides the EU with a tool to further the European integration project, increase its political weight vis-à-vis European Member States and assert its role as an *actor* on the international stage. It is thus likely that EU involvement in space will continue to expand both within and beyond its current undertakings.

The aim of this report is to assess how this expanding role in space could be enhanced from a policy and governance perspective and to support the reflection process for the European Commission and other European stakeholders in determining whether, in which area, and in what way the will to increase EC involvement in space activities could be channelled.

After demonstrating how the explicit choice for involvement in the fields of environmental monitoring and global satellite navigation has to be understood over time, the focus is first on the governance challenges and priorities for the operational phases in the current Copernicus and Galileo programmes. As Europe's new and autonomous all-round Earth Observation and global navigation satellite systems will achieve full operational status in the near future, it has to be assured that the data and services provided by the constellations can be reaped in an optimal fashion. Key elements in doing this for the first generation of systems turn out to be the different institutional support functions put in place and their structures. It is argued that although important steps have been taken for both programmes, this remains an ongoing effort for which many initiatives need to be evaluated and coordinated continuously and that in some cases the possibility to undertake further initiatives with regard to benefit optimisation should be considered. More specifically, it turns out to be the case especially in the Copernicus programme, which is characterised by a degree of uncompensated decentralisation in its various operational responsibilities.

As a second step, the report assesses how the two current flagship programmes can play a central role in spurring innovation ecosystems in their respective sectors. Here, it is advocated that four essential components should be addressed in terms of critical mass and innovation flows. More specifically, innovation should be pursued in both the up- and downstream segments and, both by institutional and private actors. In this respect it is demonstrated that Europe has already achieved a remarkable position in the growing markets of satellite navigation and Earth Observation. Nonetheless, a number of issues and sub-optimised flows remain. The report shows how addressing them could result in more performant, competitive and innovative sectors that would in turn spur future sustainable growth in Europe.

EU ambitions in space are not solely expressed by the current flagship programmes. Considerations are also made on how EU involvement can be taken further in the future. However, before elaborating on the possibility and opportunity for the EC to extend its involvement in space matters beyond Earth Observation and satellite navigation by means of a new flagship programme, another more fundamental question should be raised, namely whether *per se* the flagship model provides the most appropriate framework for the conduct of the EC's future space activities. After all, the financial and administrative difficulties encountered over the years by both the Galileo and Copernicus programmes have shed some doubt on the long-term suitability and sustainability of current schemes and could therefore induce the Commission to prefer an alternative approach to space, for instance, that of having a dedicated budget item for space to be allocated to a plethora of undertakings. It is, however, concluded that in the short-term it is more likely

that EU involvement in space will take the form of new flagship programmes.

In order to outline in which area and to which extent a new flagship programme by the EC could be channelled, the report set out general considerations on the criteria defining EU flagships and the underlying benefits expected from their implementation and operation. On the basis of this assessment, three different candidates are identified as potential candidates for future EU space efforts, namely: (1) space exploration, (2) access to space and, (3) space for security.

This particular selection is based on a number of considerations. For one thing, the three domains are among the most substantial elements in the programme of any spacefaring nation, and thus constitute elements towards the possible creation of an EU-led "European Space Programme", as explicitly contemplated by article 189 of the Lisbon Treaty. Second, in the first two cases, they were already indicated by European Union institutions as interesting areas for Europe in which to take a leading role. Finally, in all three cases there is – to a certain extent at least – room for added value generated by EU involvement that intergovernmental approaches could not bring. For each of the candidates the context and rationales are discussed and, at the end, an overall comparative assessment is provided based upon a set of benefit indicators and feasibility considerations. This resulted in the following findings:

- In space exploration the key rationale behind Commission involvement lies in the need to embed space exploration in a wider political perspective, thus complementing the science-driven and technology-focused approach so successfully pursued by ESA over the past 40 years. In addition to providing the political dimension that is required to fully capitalise on the political benefits stemming from exploration, the initiation of a flagship initiative in this domain is justified by a right mixture of scientific, technological and socioeconomic reasons. More specifically, this scenario would allow the EU to invest and create spill-over effects that create smart, sustainable and inclusive growth. In addition to this, the prestige and soft power associated with having an ambitious space exploration programme would enable the EU to reap a variety of strategic and political benefits. Although this candidate would score well in terms of political consensus as compared to the other scenarios, it is associated with high costs, a high degree of operational complexity and requires a prolonged political commitment spanning over multiple decades.
- In the launcher domain, an active EU involvement would be mainly justifiable because the EU could critically complement existing launcher capabilities in Europe. More precisely, it is argued that the EU would be in a good position to pursue more radical innovation in the launcher market segments, innovation that is currently not addressed or researched with anything close to sufficient funds. This option would therefore mainly be justifiable through a combination of commercial and geopolitical drivers. The associated socioeconomic benefits might be less pronounced compared to the exploration option. This mainly stems from the fact that ESA has already achieved an invaluable position in the sector. The EC involvement scenario for launchers does score significantly in that it would potentially give Europe a stronger, perhaps cutting-edge advantage in terms of long term competiveness and innovation. The latter is especially relevant considering the many game-changing technologies in this global and rapidly evolving field. In addition, EU involvement could allow Europe to leverage launchers in a more geopolitical fashion on the international stage thus providing a political profile to this highly strategic field. Autonomous access to space is a strategic good, and also, as such, well in line with the defined role of the EU. The level of financial commitment and operational complexity associated with the implementation of this flagship candidate would all-in-all be manageable, albeit with considerable risk of eventual failure – as with most investments in disruptive innovation.
- The space security option in this report refers to the utilisation of space-based systems to ensure security on Earth. The initiation of a flagship programme integrating Earth telecommunication, Earth Observation and navigation capabilities would respond to the need for pan-European space-based infrastructure in support of the ongoing capability requirements of the Common Foreign and Security policy of the Union. As an EU flagship programme, the socioeconomic benefits of the security option might perhaps have a lower degree of visibility. Nonetheless, a solid security architecture does, over the long term, generate demonstrable paybacks, especially considering that it would provide impetus to the European R&D communities and that

it would bring about stronger cross-fertilisation among the currently fairly stove-piped networks in the security domain. Moreover, from a strategic and political perspective a space security flagship programme would complement a whole range of existing EU policy domains and make the EU more competent in addressing its foreign policy actions. Although the political feasibility of this option is low, given member states' reluctance to integrate their defence policies and programmes, a space security flagship programme could pave the way towards the creation of a truly integrated pan-European security architecture, the flagship programme serving as a trailblazer. This in turn would be of paramount importance for consolidating the longstanding efforts of the European integration project. In other words, rather than being considering unfeasible, it might be regarded as an opportunity to provide a first step in this historically difficult field.

- While it is clear that each scenario has very particular characteristics that entail different pros and cons, selecting one candidate over another eventually comes down to the relative weight decision-makers will attribute to the different socioeconomic, strategic and political benefits as well as the challenges related to EC involvement for each scenario in terms of political, financial and operational feasibility. In this sense, the comparative assessment included in this report does not aspire to provide a conclusive answer regarding the best area for further EU involvement as any specific selection can only play out in actual political discourse.
- What is however recommendable is to define a coherent and transparent mechanism to support the selection process in an optimal manner. One possible path would be for the Space Advisory Group of the EC to establish a dedicated committee on future space flagship programmes. The specific feature of such 'flagship committee' would be to compare and contrast a number of scenarios and options rather than focusing on just one domain as it was done in the past with regard to space exploration. As there are many valid arguments underpinning the case for each candidate, doing so would allow decision makers to better weigh and familiarise themselves with the different socio-economic, strategic and political benefits involved in each option as well as the political, financial and operational effort required.
- It is also recommended that the work of such a flagships committee should be based on wide-scope hearings engaging representatives of ESA, EU Member States, the EU Parliament, the EEAS, and industry. One of the major advantages of an open approach is that it would identify how the relevant stakeholders assess each given option, as well as prepare the distribution of tasks and responsibilities of the different actors throughout the implementation process. Such a broad participatory approach could be also extended to engage the public as an active stakeholder. This would have the additional advantage of creating a strong link with society even before the conception of a programme, thereby increasing outreach, awareness and societal support

1. Introduction

Over the last decades the socioeconomic and strategic importance of space for society has increased considerably. The EU flagship programmes in space in the areas of Global Navigation Satellite Systems (GNSS) and Earth Observation (EO) – called Galileo and Copernicus, respectively – mark a major milestone in this evolution. In fact, they will significantly increase the strategic and socio-economic value of space for Europe once their operational capacities are up to speed – a feature that will materialise in the next few years. Although there have been some issues and delays during their establishment – which is not uncommon for projects of this order of magnitude – it is fair to say that overall capacity development is now proceeding at a steady pace.

Yet, large-scale programmes such as Galileo and Copernicus are complex in every phase of their life cycle, from their conception to operations, and every specific phase is associated with particular challenges. A first objective of this report is to assess, from a policy and governance perspective, the overall situation with regard to the two current flagship programmes.

In the second instance, the scope of the report will be opened up to the future. Since the growing importance of space for society can be expected to continue, and considering that the EU might eventually decide that a more extended role in space affairs is necessary to pursue its objectives, the question is whether and how future EU flagship programmes in space should be conceived.

To perform the analyses and assessments required to address the two main objectives identified above, this report will follow the structure of a typical lifecycle curve of large infrastructure projects such as Galileo and Copernicus. This is illustrated in figure 1 below, in which the green curve represents the efforts related to the implementation of the two programmes as a function of time. The different life cycle phases are separated by vertical dotted lines.

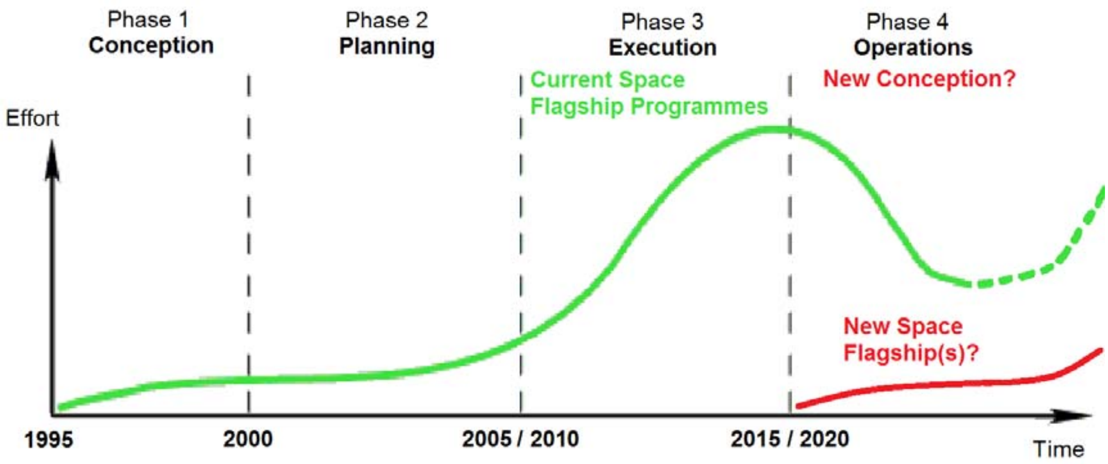

Figure 1: The Lifecycle Phases and Related Efforts of the Space Flagship Programmes as a Function of Time.[1]

[1] Authors' own visualisation based upon the typical development of large programmes.

Since both programmes have witnessed a very similar development in terms of timing, they can, for simplicity's sake, be represented by the same curve. The conception phase of Galileo and Copernicus occurred throughout the second half of the 1990s, when ideas for EU involvement in GNSS and operational EO were growing, were fine-tuned and started having a political dimension. Roughly at the turn of the millennium, the ideas for both flagship programmes turned into more concrete plans, in which the scope and missions of the constellations were defined, and assessments done of the associated budgets and expected socioeconomic benefits. Between 2005 and 2010, both programmes witnessed the beginning of their implementation, as the first instruments and satellites were built, integrated and tested. After 2010, the first satellites for both constellations were launched into orbit.

Following a general introduction on the role of the EU and its expanding mandate in outer space affairs, Chapter 2 describes the historic aspects of the current flagship programmes. Understanding their particular history is instrumental in understanding how the situation might, or not, be similar in the future when other scenarios are on the table. Moreover, the path-dependency in these two large programmes is important for understanding the challenges of the present and the future.

Regarding the future situation of EU space flagship programmes, Europe – and the EC in particular – is currently confronted with two main questions.

First, how can it be assured that the operational phases of the current flagship programmes are managed so that the objectives formulated at their inception will materialise to the fullest extent possible? This relates to the operational phases of Galileo and Copernicus and can be situated in the area corresponding to the dotted green line. This implies that socioeconomic benefits are maximised, but also that both programmes are governed in such a way that their strategic importance can be valorised sufficiently given the current institutional framework. An important element in this respect is the link to be made between the first generation of operational satellites and the definition of requirements for the second generations. These questions will be addressed in Chapter 3.

Second, given the increasing strategic and socioeconomic value of space for Europe and the fact that the EU's mandate is more comprehensive than ever, can future flagship programmes in space fulfil other needs – besides GNSS and operational wide-scope EO? In which cases would this be relevant and, how can potential candidates be evaluated? Given that establishing a flagship programme in space is a rather costly and lengthy process, especially if one takes into account the complexity of the European institutional landscape, it is important to stimulate the idea forming process in that direction in a timely manner. This is visualised by the new project lifecycle curve in red. The associated questions will be addressed in Chapter 4, where the potential for a new flagship programme will be discussed and three potential fields for EU involvement will be identified and assessed, namely in the fields of: (1) Space Exploration, (2) Launchers and, (3) Space Security.

Finally, Chapter 5 puts forward the main conclusions and recommendations of this report and proposes a way forward as to how the decision-makers could take the relevant steps in establishing a reflection process on future EU involvement in outer space through flagship programmes.

2. The EU and the Space Endeavour

This scene-setting chapter sets out considerations on the European Union's (EU) involvement in space activities. It first presents a concise overview of the EU integration process, which is used as a basis to discuss the progressive development of the European Commission (EC) competence in space matters. The legal and political framework for EU policy action in space is subsequently described and its main programmatic initiatives are discussed.

2.1 The European Union: An Emerging Global Actor

The establishment of the European Union, an economic and political entity currently composed of twenty-eight member states, is the latest successful result of a lengthy and complex project of integration initiated more than half a century ago with the creation of a European Coal and Steel Community (ECSC). Although its origins were modest, from its inception the European integration project has been of groundbreaking geopolitical intent. In the words of Jean Monnet in 1953, one of the founding fathers of the European project: "we can never sufficiently emphasise that the six Community countries are the forerunners of a broader Europe, whose bounds are set only by those who have not yet joined. Our Community is not a coal and steel producers' association; it is the beginning of Europe".[2]

While the immediate logic behind the enhancement of economic, political and social cooperation among European states was to create a *de facto* solidarity that would make war between France and Germany "materially impossible", the political evolution of Europe was also perceived as essential for Europeans to be able to act effectively in the international arena. The Cold War, after all, was making it clear that only continental structures like the U.S. and USSR had the ability to design the global order. Taken individually, France, Germany and the UK clearly lacked sufficient critical mass to deal on a peer-to-peer basis with the two juggernauts. But by coming together and pooling the valuable resources and intellectual capital already possessed by its constituent states, Europe could regain some of the power to shape global dynamics that it had exercised for much of modern history.[3]

Premised on this political vision, European countries decided to set up common institutions to which they gradually entrusted portions of their sovereignty and delegated the role to implement common policies in a number of areas. After more than 50 years of economic and political cooperation/integration, not only has the idea of an intra-European armed conflict has become virtually unthinkable, but Europe has – in spite of all its continuous difficulties and challenges – been emerging as a collective whole on the international scene.

2.1.1 What Kind of Actor?

Although the existence of a *European actorness* has been widely acknowledged, it is also clear that Europe is not a nation-state in a Westphalian sense, nor has a polity emerged from a single, authoritative source like in other countries.[4] It is a *unicum* on the international stage and, in a sense, "a renunciation of the Westphalian system […] that it had created, spread across the world and defended over the past three centuries".[5]

[2] *Cit*. Monnet, Jean. Memoirs. Doubleday & Company. New York. 1978: 378

[3] For a detailed analysis on this interpretation, see: Kupchan, Charles A. *The end of the American Era*. U.S. Foreign Policy and the Geopolitics of the Twenty-first Century. Vintage Book. New York. 2002: 65

[4] According to the definition of William Wallace, the EU can be regarded as a "partial, multi-layered polity", that is a "political entity which lacks, however, many of the features that one might expect to find in a traditional state". See: Wallace, William. "Post-Sovereign governance: the EU as a partial polity". In Horace Wallace et al. Policy Making in the European Union. Oxford University Press, Oxford: 483 -503

[5] *Cit*. Kissinger, Henry. *World Order.* Penguin Press. New York. 2014. As Kissinger notes, Europe represents in some sense a renunciation of Westphalia, or alternatively, its transformation into a new international system based on regional, not national, units. "The outcome has combined aspects of both national and regional approaches without, as yet, securing the full benefits of either. The EU diminishes its Member States 'sovereignty and traditional government functions, such as control of their currency and borders. On the other hand, European politics remains primarily national, and in many countries, objections to the EU policies have become the central domestic issue. The

Many debates and much analysis have been produced through the years in the attempt to understand what particular kind of actor the EU is. As correctly pointed out by Christopher Hill and Michael Smith:

> "Empirically the EU can be seen as one of the world's two economic 'superpowers', and an increasingly significant influence in the realms of international diplomacy, 'soft security', and broader world order. Analytically, the Union poses major challenges by virtue of its status as something more than an intergovernmental organisation but less than a fully-fledged European 'state'."[6]

The EU, indeed, is not a federal state with a strong central government, and it might never become one. But even if it remains an *institutional hybrid*, this fact should neither overshadow the complexities behind the realisation of such an unprecedented geopolitical engineering project, nor the invaluable achievements it has so far accomplished. After all, it was clear from the beginning that "Europe will not be made at once, or according to a single plan", as Robert Schuman stressed in the well-known declaration of 9 May 1950.[7] With modest origins, the EU has come a long way in terms of continuous reforms that have progressively europeanised traditional government functions, such as control of trade tariffs, borders and currency. As member states have accepted to delegate to the EU increasing portions of what was once part of their sovereign authority, the Union's governing bodies in Brussels, Strasbourg and Luxemburg have progressively seen their resources and authority increase.

In terms of resources, it suffices to note that back in 1958 the Community expenditure amounted to the equivalent of €81.3 million[8], while for the year 2014 the EU has an agreed budget of €134.3 billion and of €959.9 billion for the 2014-2020 period.[9] This amount still represents little more than the 1.0% of the EU's Gross National Income (GNI) for the considered period. Its growth, however, is a good indication of the Union's enhanced policy responsibilities as well as of its continuing process of enlargement from the original 6 founding states to the current 28 members.[10] In short, the EU's budget has gradually become a symbol of growing unity among an increasing number of countries wishing to create a union that would go far beyond the tasks of a traditional international organisation.[11]

It is thus interesting to see that in some areas EU member states have completely renounced any capacity to legislate, while still retaining all powers not explicitly handed to the Union. The former are areas in which the EU enjoys so-called *exclusive competence*. In other areas the EU and its member states continue to *share* the competence to enact legislation. While both can legislate in shared competence situations, normally member states can only legislate to the extent to which the EU has not. Finally, in yet other policy areas the EU can only co-ordinate, *support* and *supplement* Member-State actions but cannot enact legislation with the aim of harmonising national laws. The distribution of competences in various policy areas between member states and the Union is thus divided in the following three categories:

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result is a hybrid, constitutionally something between a state and a confederation, operating through ministerial meetings and a common bureaucracy… Yet, the EU struggles to resolve its internal tensions in the quest for the principles and goals by which it is guided. In the process, it pursues monetary union side by side with fiscal dispersion and bureaucracy at odds with democracy. In foreign policy it embraces universal ideals without the mean to enforce them, and a cosmopolitan identity in contention with national loyalties – with European unity accompanied by east-west and north-south divides and an ecumenical attitude toward autonomy movements (Catalan, Bavarian, Scot) challenging the integrity of States". In short, the EU can be seen as a hybrid of contending aspirations and contradictory trends. *Ibid*: 92-93

[6] *Cit*. Hill Christopher and Michael Smith. *International Relations and the European Union*. Oxford University Press: Oxford. 2005: 4.

[7] Declaration of 9th May 1950 delivered by Robert Schuman. Foundation Robert Schuman. Web. http://www.robert-schuman.eu/en/doc/questions-d-europe/qe-204-en.pdf

[8] See: Spence, James. "A high price to pay? Britain and the European budget". International Affairs 88. No 6. 2012: 1238

[9] For more information on the EU budget see: European Commission. 5 Feb. 2014 "The Multiannual Financial Framework explained". 20 Nov. 2014. Web. http://ec.europa.eu/budget/mff/introduction/index_en.cfm

[10] While in 1958 more than 85 per cent of the Community expenditure was on the Coal and Steel Community, in 2014 the EU budget is split in the management of policies and programmes in over 30 areas, ranging from Agriculture to Energy, to Human Rights, Transport and External Relations. Space research and applications are categorised as part of the Research and Innovation policy.

[11] See*:* Spence, James. "A high price to pay? Britain and the European budget". International Affairs 88. No 6. 2012: 1239

Exclusive Competence	Shared Competence			Supporting Competence
"The Union has exclusive competence to make directives and conclude international agreements when provided for in a Union legislative act."	*"Member States cannot exercise competence in areas where the Union has done so."*	*"Union exercise of competence shall not result in Member States being prevented from exercising theirs in …"*	*"The Union coordinates Member States policies or implements supplemental to theirs common policies, not covered elsewhere"*	*"The Union can carry out actions to support, coordinate or supplement Member States' actions in …"*
• Customs union • Establishing competition rules necessary for the functioning of the internal market • Monetary policy for Eurozone Member States • Conservation of marine biological resources under the common fisheries policy • Common commercial policy • Conclusion of certain international agreements	• The internal market • Social policy, for the aspects defined in this Treaty • Economic, social and territorial cohesion • Agriculture and fisheries, excluding the conservation of marine biological resources • Environment • Consumer protection • Transport • Trans-European networks • Energy • The area of freedom, security and justice • Common safety concerns in public health matters, for the aspects defined in the Treaty.	• **Research, technological development and outer space** • Development cooperation, humanitarian aid.	• Coordination of economic, employment and social policies • Common foreign, security and defence policies	• The protection and improvement of human health • Industry • Culture • Tourism • Education, youth, sport and vocational training • Civil protection (disaster protection) • Administrative cooperation

Table 1: EU Competences as Outlined in Title I of Part I of the Consolidated Treaty on the Functioning of the European Union (TFEU).[12]

2.1.2 From Coal to Space

In the progression from the European Coal and Steel Community, to the European Economic Community, to the European Union, the policy areas in which the European Commission (EC) – as the executive arm of the EU – has extended its mandate have broadened tremendously.[13] From an initial narrow concern with the removal of barriers for coal and steel production and trading, the Commission's policy responsibilities later expanded to manage the creation of a common market for the trade in goods among the six founding states. With the signing of the Euratom and Rome Treaties in 1957, the collaborative development of commercial nuclear

[12] Table based upon: Consolidated Version of the Treaty on the Functioning of the European Union, Official Journal of the European Union: OJ C 326. 26 October 2012: 47–390.

[13] Originating in 1951 as the High Authority in the European Coal and Steel Community, the Commission has undergone numerous changes in power and composition under various presidents, and involving three Communities.

power – which however never worked out – and the creation of a common market that would eliminate internal tariffs and establish a common external tariff were launched.

During the 1960s, European institutions worked to consolidate this common market by acquiring a broader range of economic competences and policy responsibilities. The newly introduced agricultural policy soon became a key focus of the Commission's activities, as demonstrated by the agriculture share of all Community expenditure, which rose from 8.5 percent in 1965 to 86.9 percent in 1970, in figures from €28 million to €3 billion.[14] The next step came in the early 1970s, with the inclusion of social and monetary policies within the spectrum of the Commission's competences. As early as 1972, an Exchange Rate Mechanism was introduced, paving the way for the successive establishment of the European Monetary System and for the eventual introduction of the Euro. Environment, energy, transport and external policy issues followed closely.

By the mid-1980s, Science and Technology (S&T) policy would also become subject to the Commission's competence. As noted by Nicolas Peter, although cooperation in the field of S&T "was part of the integration agenda from the very beginnings of the European project, […] research programmes were implemented on an ad hoc non-systematic basis",[15] and no explicit EC S&T policy was formulated for a long time. A legal basis for an explicit S&T policy at EC level was only sanctioned with the Single European Act (SEA) of 1987, which added a new "Research and Technological Development" title to the 1957 Rome Treaty, conferring the competence upon the EC to develop and implement its own set of S&T strategies. The Framework Programmes has since become the major instrument to support and foster Research and Technological Development (RTD) in Europe. Although the budget spent within the FP has grown significantly over the past 30 years, it should be noted that it is still is much smaller than the resources spent on R&D on member state level. The RTD competence of the EC was further strengthened with the Treaty of Maastricht of 1992, clearly stating in its provisions that EC competence now applied to "all the research activities deemed necessary by virtue of other chapters of this treaty".[16]

In acquiring the powers to take the lead in RTD policies to support other policy areas of the Commission's mandate, the way for EU involvement in space issues was eventually paved.

2.2 The EU in Space: The Institutional Framework

Although EU involvement in space affairs formally started as early as 1970 with its participation as an observer at the European Space Conference (ESC), it was not until the late 1980s that the EU fully realised the relevance of space technologies and applications to support its policy actions in a number of other areas determined at European level.

In its first "space communication" of July 1988, *The European Community and Space: A Coherent Approach*, the Commission recognised that space was an area with leverage potential in social, economic and political projects and EC involvement was deemed necessary.[17] At least initially, however, space was not considered a subject matter for a European policy in its own right, but recognised as a tool for reaching multiple policy objectives, in areas such as agriculture, environment, energy, foreign and security policy, information society, research and innovation, transport, etc.

The subsequent 1992 Communication, *The European Community and Space: Challenges, Opportunities and New Actions*, clearly urged the Union to develop a comprehensive space policy to better seize the precious opportunities offered by the development of space technologies and applications.[18] The release of this second space communication led the Commission to set up a Space Advisory Group (SAG) in 1992 to facilitate inter Directorate-General (DG) discussions and formulate a coherent space policy for the Commission.

In the EC's third space communication of 1996, *The European Union and Space: Fos-*

[14] The agricultural policy was set out at the Stresa Conference of 1958 and implemented in 1962, financed through the EC budget and confirmed by the Merger Treaty of 1965. See: Spence, James. "A high price to pay? Britain and the European budget". International Affairs 88. No 6. 2012: 1239

[15] *Cit*. Peter, Nicolas. "The EU's Emergent Space Diplomacy" Space Policy 23. Issue 2. May 2007: 98

[16] See: Treaty on European Union. Official Journal of the European Communities No. C 224, 1992, Item 1 – Document 1/4 (1992/C 224/01-1).

[17] European Commission. *The European Community and Space: A Coherent Approach*. July 1988.

[18] European Commission. *The European Union and Space: Fostering Applications, Markets and Industrial Competitiveness*. See Smith, Lesley Jane, and Kay-Uwe Hörl. "Constructing the European Space Policy: Past, Present and Future. Commerce in Space: Infrastructures, Technologies, and Applications. Phillip Olla. Hershey: Information Science Reference. 2008: 12.

tering Applications, Markets and Industrial Competitiveness, the willingness to become an active player in the space arena became even more marked. The document highlighted that the EU should use its competence "in terms of external trade, internal market and international cooperation to cover horizontal aspects such as ensuring a vigorous presence in space launch services, in the standardization of space components, and in establishing cooperative activities with foreign nations".[19] It should also be noted that with this third space communication, the awareness about the strategic significance of space activities for the construction of Europe and its cohesion became more apparent.

With the Treaty of Nice (2001), the EU's competence over space matters was finally introduced. Although the Treaty does not mention space policies and programmes, its provisions provide a first formal legal basis for space-based relevant technologies to be used in the implementation of existing EU policies. The following Constitutional Treaty (2004), for the first time, made an explicit reference to space. Article 1-14, in particular, confers on the EU the competence to define and implement space programmes, as long as the exercise of that competence does not result in member states being prevented from exercising theirs.

Notwithstanding the missing ratification of the Constitutional Treaty, the EU's increasing interest in space and progressive financial involvement in the implementation of two major space initiatives (see chapter 2.3) did not change. Indeed, to emphasise its growing space ambitions, the Commission decided to transfer control over EU space matters from the DG Research/Joint Research Centre (JRC) to the DG for Enterprise and Industry, clearly showing the strong industrial and strategic dimension assigned to space activities, as well as the EU's interest in emerging as a future leader of the European space landscape.[20]

2.2.1 A Complex Framework

When the EU formally decided to step into the space arena, pan-European collaborative schemes already had a consolidated tradition that had run in parallel to the processes of broader European political integration. Unlike other policy areas, the space sector had, in fact, already created a functioning institutional arrangement that satisfied the wide diversity of national policy interests and motivations. Since its creation in 1975 through the merger of ELDO and ESRO, the European Space Agency (ESA) had been entrusted with the role of coordinating and implementing European policies and programmes in the space sector. With the exception of autonomous human spaceflight, ESA has been successful in providing for the whole spectrum of space assets Europe needed.

Therefore, when the EU decided to develop its space activities, it did so as a new actor in the European space field, although the activities of the EU in the space field did not start from scratch – they were built upon existing technological and industrial capabilities. The governance of the space sector has nonetheless become more complex. In fact, while for a long time the institutional framework was essentially based on two pillars – a national pillar and ESA – since the EU's decision to position itself as an effective actor in European space activities, the space governance diarchy has turned into an "institutional triangle", simultaneously comprising national, intergovernmental and communitarian approaches.

Each player in this structure has its own competences and interests. While member states or national space agencies mainly coordinate space activities at national level without a European scope, and ESA is a research and development agency, the EU is a strong political player that has the legitimacy to take political leadership: the goal of such leadership being to ensure political coherence and proper policy coordination.

However, the interplay between national, intergovernmental and communitarian frameworks has created institutional misalignment, leading to cumbersome decision-making processes.[21] In particular, the relationship between the EU and ESA has been a rather complex one. Such complexity not only stems from the different nature of the institutions, but also from the fact that the two organisations have different ranges of competences and different member states.[22] In addition to that, it must be noted that ESA and the EU are two institutions that have constitutional provisions and principles that may conflict.

[19] *Cit*. European Commission. *The European Union and Space: fostering applications, markets and industrial competitiveness*. COM(96)617 final.

[20] See: Peter, Nicolas. "The EU's Emergent Space Diplomacy" Space Policy 23. Issue 2. May 2007: 102

[21] "Resolution on the European Space Policy. ESA Director-General's Proposal for the European Space Policy." June 2007. European Space Agency 29 Oct. 2013 <http://www.esa.int/esapub/br/br269/br269.pdf>.

[22] ESA membership (20 Member States) does not equate the EU membership (28 Member States). For a more detailed account on the issues accruing from the membership asymmetry, see: Klock, Erich and Marco Aliberti. "ESA Enlargement. What Interesting Countries Can Do to Prepare Themselves to Ultimate Accession – With a Special Focus on the CEE Region". ESPI Report 47. January 2014: 53-65.

The most important one concerns financing and industrial policy. While ESA's *modus operandi* is based on a geographical return principle, according to which ESA awards contributing member states with industrial contracts commensurate with their financial participation, the EU is based on pure best-value-for-money procurement. As discussed by many analysts, the simultaneous existence of EU's competition law and ESA's geographical return principle understandably creates some institutional and operational divergences that currently divide the two organisations.

However, in recent years the ties between the two institutions have been reinforced by a number of elements. Beyond the fact that they share a common basis of 20 members, there is the increasing role that space plays in supporting Europe's social, political and economic policies. Second, there is recognition that they are working towards a common objective: to strengthen European cohesion and economic growth to benefit its citizens. Third is the fact that each partner needs the other to fulfil public policy objectives to provide an appropriate political profile and a more coherent framework for space activities in Europe. In this regard, it should be recalled that some 23% of the funds managed by ESA now originate from the EU budget.[23] With a budget of €1030.5 million in 2015, the EU is the largest contributor to ESA, followed by Germany and France.

2.2.2 First Steps: From the Joint Task Force to the European Space Policy

The process of bringing ESA and the EU closer together has long-standing roots, with parallel EC Communications and ESA Council Resolutions as early as the 1990s, but it "officially" started with the creation, in January 2001, of a Joint Task Force (JTF) between the EC and ESA. Entrusted with the task of defining a suitable framework to enhance European capabilities and autonomy in space, the JTF produced its first report in November 2001, recommending closer collaboration between the two organisations. The JTF also played a role in the elaboration of the EC-issued *Green Paper on European Space Policy*, released on 21 January 2003.[24] The document, introduced in response to a July 2002 request from the European Parliament (EP), looked into Europe's assets and weaknesses in the space sector in order to launch a debate on Europe's space policy with all players including national and international organisations, the European space industry and its users, and Europe's scientific community and citizens.[25] Besides providing a set of recommendations for a more efficient organisation and framework for space activities in Europe, the Green Paper laid the foundation for the subsequent release of the White Paper in November 2003 and for the concomitant signature of an EU-ESA Framework Agreement.[26, 27]

The signature of the EC-ESA Framework Agreement in November 2003 conferred a legal basis to EU-ESA cooperation. The agreement, which entered into force in May 2004 and was subsequently renewed until 2016, attempts to deal with *all* aspects relevant for cooperation between the two institutions: "its provisions address the areas and overall objectives of cooperation, the rules governing the implementation of joint programmes, the establishment of common *ad hoc* structures for harmonising the European Space Governance, as well as the exchange of personnel, public relations", etc.[28] The Framework Agreement recognises that both parties have specific complementary and mutually reinforcing strengths, and commits them to working together for the implementation of space projects that are beneficial for both and to avoid duplication of efforts, in order to optimise available resources.[29] As also noted in a previous study by the European Space Policy Institute, the framework has two main objectives:[30]

[23] More precisely, for 2015 EU contributed to the ESA budget with 1030.5 Million Euro (or 23.2% of the total sum). European Space Agency. European Space Technology Master Plan 12th Edition. Noordwijk: ESA. 2015:35.

[24] Commission of the European Communities. Green Paper. European Space Policy. COM(2003) 17 final of 21 January 2003. Brussels: European Union.

[25] See: "European Milestones." 24 Jan. 2012. European Space Agency 29 October. 2013. Web <http://www.esa.int/About_Us/Welcome_to_ESA/European_milestones>.

[26] The White Paper, drafted together with ESA, includes proposals for joint ESA-EU space programmes and takes the Framework Agreement as its basis for implementation. See: Commission of the European Communities. White Paper. Space: a New European Frontier for an Expanding Union. An Action Plan for Implementing the European Space Policy. COM(2003) 673 final of 11 November 2003. Brussels: European Union.

[27] See: "European Milestones." 24 Jan. 2012. European Space Agency 29 October. 2013. Web <http://www.esa.int/About_Us/Welcome_to_ESA/European_milestones>.

[28] *Cit.*, *ibid*: 13.

[29] ESA will continue to address a variety of space R&D areas, e.g. launcher development, space science, earth observation, satellite communication and navigation, human space flight and exploration, while the European Commission will mainly concentrate on space applications to support its various policies and lead the overall coordination of the European Space Policy. *Ibid*.

[30] Klock, Erich and Marco Aliberti. "ESA Enlargement. What Interesting Countries Can Do to Prepare Themselves to Ultimate Accession – With a Special Focus on the CEE Region". ESPI Report 47 January 2014: 54.

- To establish a common basis and appropriate practical arrangements for efficient and mutually beneficial cooperation between ESA and EU;
- To progressively develop a European Space Policy (ESP) to link the demand for services and applications in support of EU policies with the supply, through ESA, of the space systems and infrastructure needed to meet that demand.

Institutional Arrangements

With respect to the first objective, the Framework Agreement foresees in its articles the establishment of a High-Level Space Policy Group (HSPG) and a Ministerial-level Space Council. The institutionalisation of both the Space Council and the HSPG is based on the provisions of Article 8 and replaces the previous *ad hoc* structures for coordination/cooperation (in particular the ESA-EC Joint Task Force).[31]

The HSPG is made up of high-level representatives of the EC, ESA and the responsible Ministries of the member states. Jointly chaired by the ESA Director-General and a high level representative of the Commission, the HSPG's main goal initially encompassed the elaboration of the different elements and strategic objectives to be contained in the ESP. Following the eventual release of the ESP in April 2007, its task has become that of reaching a shared understanding for its efficient implementation and for defining the future directions of the European space programme. The HSPG is also involved in preparing the meetings of the Space Council.[32]

The Space Council, a concomitant meeting of the Council of Ministers of the EU and the ESA Council at Ministerial Level, was set up for coordinating and facilitating cooperative activities between the EU and ESA.[33] The Space Council has become the common conference of the high-level representative boards of both organisations, allowing all ESA and EU member states, including cooperating states, to get together and discuss the development of a coherent overall European space programme. To this end, the Space Council issues orientations and resolutions. Lacking a concrete mandate, its orientations need to be approved by the two composing Councils in the joint meetings. Since its inception in 2004, eight Space Council meetings have taken place, all intended to further the effectiveness of the shared competence of the EU and ESA and the need for Europe to have a strong space policy and an "enlarged" programme.[34]

The European Space Policy

In the light of the increasing involvement of the EU in space activities, the need for a comprehensive space policy has turned out to be of crucial importance. The ESP could in fact provide support for a host of Europe's objectives, including Europe's continued construction and social cohesion, and generally enhance the benefits for the Union, its member states and citizens. It could also enable Europe to respond to competition from highly ambitious and capable emerging space powers and safeguard its interests in remaining an indispensable international partner by providing a more coherent and effective framework for its activities and, equally important, a stronger political profile in this field. The joint recognition of these factors by the EU, ESA and their member countries has fuelled the process eventually leading to the ESP. The ESP is the culmination of this decade-long process, characterised by a series of milestones such as the aforementioned adoption of the Green Paper and White Paper, as well as the orientations given by the Space Council, and the initiation of major flagship programmes to be delivered jointly by the EU and ESA (see chapter 2.3).

The drafting and implementation of a strong and coherent space policy is a complicated task in itself and in the case of Europe it is even more challenging. The multitude of actors involved (ESA, EC, and member states) makes the process of crafting a coherent framework a very complex task at best.[35] Despite its flexibility, the system lacks the stability, certainty and coherence needed for a strong European Space Policy. A coordinated and consolidated European Space Policy therefore also needs evolution of its governance. This would require that Europe realigns its relevant institutions and focuses its political and technical expertise.

Recognising the need for a stronger political profile in the space sector, the EU and ESA finally decided to adopt "the path of rapprochement and to combine their political, social, and technological expertise", in order to develop a comprehensive European Space

[31] See: Peter, Nicolas. "The EU's Emergent Space Diplomacy" Space Policy 23. Issue 2. May 2007: 102
[32] Rathgeber, Wolfgang. The European Architecture for Space and Security. ESPI Report 13. August 2008: 22.
[33] Ibid: 22
[34] *Cit.* http://ec.europa.eu/enterprise/policies/space/policy/institutional-relations/index_en.htm
[35] Smith, Lesley Jane, and Kay-Uwe Hörl. "Constructing the European Space Policy: Past, Present and Future. Commerce in Space: Infrastructures, Technologies, and Applications. Phillip Olla. Hershey: Information Science Reference. 2008: 12.

Policy.[36] In May 2007, twenty-nine European countries at the Fourth Space Council expressed their support for the implementation of a European Space Policy, unifying the approaches of ESA and the EU with those of their respective member states.[37, 38] Prepared jointly by the European Commission and ESA's Director-General and then adopted through a Resolution of the Space Council in May 2007, the European Space Policy sets out a basic vision and strategy for the space sector and addresses issues such as security and defence, and access to space and exploration. This was the first time that a common political framework for space activities was created in Europe. The significance of the European Space Policy lies in the fact that "it is the first wholly joint document addressing all dimensions of space activities, compiled and adopted after extensive consultations with member countries of the EU and ESA, as well as industry and other key stakeholders, and given an endorsement by those member countries."[39] Through this resolution, the EU, ESA and their member states have committed to increasing coordination of their activities and programmes and their respective roles relating to space.

In order to take advantage of ESA experience and its institutional setting, the ESP calls on the EC to draw on the management and technical expertise of ESA for managing the EC-funded R&D space infrastructure programmes, with ESA coordinating the relevant agencies and entities in Europe. This ESA role should include:[40]

- Supporting the European Commission as the technical expert in the elaboration of European Community initiatives involving space-related activities and relevant work programmes, and in the selection and monitoring of relevant work contractors,
- Management by ESA of European Community space-related activities in accordance with the rules of the European Community.

In addition to this, the Resolution invites member states – under the coordination of ESA – and in the case of significant European Community activities, in close cooperation with the European Commission:[41]

- To provide the best expertise for European space programmes (such as GMES-Space Component, exploration programmes and future launcher programmes), and
- To increase synergy between national, ESA and EC contributions to these programmes leading progressively to an integrated programmatic approach while respecting national sovereignty.

According to the resolution, closer ties and an increase in cooperation between ESA, the EU and the member states will bring substantial benefits to Europe by guaranteeing Europe's full and unrestricted access to services provided by space systems in support of its policies. Furthermore, it must be noted that the Resolution of the Space Council of May 2007 invited the European Commission and the ESA Executive to establish a process of regular monitoring and priority setting through an implementation plan for the ESP. Accordingly, consultations between the EU, ESA and member countries started immediately to define modalities and priorities of implementation. As far as the industrial policy is concerned, the Resolution recognises that ESA has a flexible and effective industrial policy based on cost-efficiency, competitiveness, fair distribution of activities and competitive bidding, which secures adequate industrial capacities, global competitiveness and a high degree of inner-European competition for efficient European cooperation on joint space projects, thus providing the basis for the successful development of space in Europe. It also invites the EC to develop adequate instruments and funding schemes for Community actions in the space domain, taking into account the specificities of the space sector, the need to strengthen its industry's competitiveness and the necessity of a balanced industrial structure. To conclude, with the release of the ESP, the way for more substantive policy action by the Commission was paved.

2.2.3 Toward a More Pro-Active EU Action: The Lisbon Treaty and the EC Communications.

The entry into force of the Lisbon Treaty reinforced further the case for space in Europe by finally creating a legal basis for the action of

[36] Commission of the European Communities. Communication from the Commission to the Council and the European Parliament: Establishing Appropriate Relations between the EU and the European Space Agency. COM(2012) 671 final of 14 November 2012. Brussels: European Union.

[37] *Ibid*: 13.

[38] Council of the European Union. Outcome of Proceedings of the Council (Competitiveness) on 21-22 May 2007. Resolution on the European Space Policy. 10037/07 of 25 May 2007. Brussels: European Union.

[39] *Cit*., "European Space Policy". 13 Aug. 2013. European Commission 10 Dec. 2013 <http://ec.europa.eu/enterprise/policies/space/policy/index_en.htm>

[40] Council of the European Union. Outcome of Proceedings of the Council (Competitiveness) on 21-22 May 2007. Resolution on the European Space Policy. 10037/07 of 25 May 2007. Brussels: European Union.

[41] *Ibid*.

the EU in this field, and by putting "space" at the highest level on the political agenda.[42] The Treaty contains two substantial articles that explicitly mention space: Article 4.3, and Article 189, the text of which is set out hereafter.[43]

> Article 4.3
> In the areas of research, technological development and space, the Union shall have competence to carry out activities, in particular to define and implement programmes; however, the exercise of that competence shall not result in Member States being prevented from exercising theirs.

> *Art. 189*, found under Title XIV of the Treaty headed "Research and technological development and Space"
> 1. To promote scientific and technical progress, industrial competitiveness and the implementation of its policies, the Union shall draw up a European space policy. To this end, it may promote joint initiatives, support research and technological development and coordinate the efforts needed for the exploration and exploitation of space.
> 2. To contribute to attaining the objectives referred to in paragraph 1, the European Parliament and the Council, acting in accordance with the ordinary legislative procedure, shall establish the necessary measures, which may take the form of a European space programme, excluding any harmonisation of the laws and regulations of the Member States.
> 3. The Union shall establish any appropriate relations with the European Space Agency.
> 4. This Article shall be without prejudice to the other provisions of this Title.

With the aim of resolving some of the previous uncertainties, the provisions of the Lisbon Treaty specify the EU's space competence as one that operates together with that of the EU member states. In this context, the provisions of Article 4.3 confirm the parallel and support competences of the EU in different fields in which space-based applications can serve as a tool "to help address the major challenges of the Union and which is at the service of citizens".[44] Beyond the traditional EU fields (i.e. agriculture, fisheries, transport, etc.), space can be an instrument at the service of the common foreign and security policy. Article 189 deals with the specific competence of the EU in the space domain, which entails mainly actions of support to R&D, coordination and promotion of joint space initiatives.

However, the Treaty does not provide guidance on the definition of appropriate instruments and mechanisms (for example the funding sources) for the future actions of the EU concerning space, and does not exactly specify what the "necessary measures" cited in the second paragraph could be, what instruments will be developed and what industrial policy will be followed.[45] Article 189.3 states that the EU should establish appropriate relations with ESA, but does not provide elements to qualify what "appropriate relations" with ESA entail.

Thanks to the provisions of the Treaty, not only ESA but also the EU has the competence to draw up "a European Space Policy and to implement a European Space Programme". As was noted in an Information Document by ESA "the utilisation of the indefinite article "a" in both the TFEU and ESA Convention" could imply the coexistence of more than one policy (an ESA policy and a separate EU policy with its member states, thus also including the non-members of ESA).[46] In practice, however, this did not occur because the EC and ESA jointly elaborated the ESP in 2007. Nevertheless, some issues remain to be resolved in terms of alignment. With the EU a political giant exists that has great legitimacy and indeed the possibility to enforce a space policy from a political and regulatory point of view, but does not have the technical capacity. ESA, on the other hand, has the technical competences and instruments to realise complex space projects. Bearing this in mind, the goal now must be to combine these strengths in order to optimally utilise the available resources and to promote economic growth. In general, there should be a balance of relative strength in the triangle between the EU, ESA and their respective member states.

If it is true that recent developments have reinforced ESA–EU governance, they have also deepened the complexity surrounding their respective roles over space affairs. Through a comparative reading of the ESP, the Lisbon Treaty and the resolutions of the Space Council, these different roles and competences ESA and the EU respectively have can be summarised as in the following table:

[42] The Treaty of Lisbon was signed on 13 December 2007 by the Heads of States and Government and entered into force on 1 December 2009, amending the Treaty on European Union (TEU), and the Treaty establishing the European Community (TEC), which is renamed the Treaty on the Functioning of the European Union (TFEU).
[43] Council of the European Union. Consolidated Version of the Treaty on the Functioning of the European Union. 6655/1/08 REV 1 of 30 April 2008. Brussels: European Union. Document available at: <http://www.consilium.europa.eu/uedocs/cmsUpload/st06655-re01.en08.pdf>.
[44] European Space Agency. European Space Technology Master Plan 2012. Paris: ESA. 2013: 66.
[45] ESA Council, "Information Document – Space in the 'Lisbon Treaty'". ESA/C(2008)19. March 2008.
[46] *Ibid*.:5

EU's Role Includes:	ESA's Role Includes:
• To carry out activities, in particular to define and implement programmes, in the different fields in which space-based applications can serve as a tool for addressing the EU's general policies; • To promote joint initiatives, support Research and Technology Development (RTD) and coordinate the efforts for the exploration and exploitation of space; • To ensure the availability and continuity of services supporting EU policies by funding relevant up-stream research activities; • To create an optimum regulatory environment and facilitate innovation; • To promote coordination of the European position in international cooperation; • To develop and implement the European Space Policy (ESP)	• To manage European Community space-related activities in accordance with the rules of the European Community; • To support the EC as technical expert in the elaboration of European space-related activities and in the selection and monitoring of work contractors; • To develop and implement space technologies, in particular access to space, science and exploration, and to support technical specifications of the space segment. • To lead the process of harmonising technology development programmes, since the EC recognises that the ESA system provides transparency on research across Europe and increases coordination;

Table 2: Distribution of EU-ESA Roles in EU-Funded Space Activities.[47]

By looking at this framework, what eventually becomes more evident is the increasing authority and influence the EU aims to exercise within the European space governance. In this respect the EU has made use of the momentum created by the Lisbon Treaty to further develop and implement the ESP by issuing a series of EC Communications.

One of the most relevant documents in this regard is the EC Communication entitled "Toward a space strategy for the European Union that benefits its citizens", released on 4 April 2011.[48] The Communication sets the basis for an EU space strategy. Despite the fact that it is a non-binding document, the Communication is a strong political statement that begins to address the real scope of EU space competence, as enabled by the Lisbon Treaty. It lays down, in fact, a whole set of policy rationales, priority actions as well as a governance and financial framework that prepare the basis for EU actions under its space competence.[49] After identifying the political imperatives for EU involvement in space, the document defines the EU space competences and the role of the EU in the European space-related decision making process.[50] It advances the EU position towards a coordinated European Space Strategy and explicitly asks ESA and the EU to establish a coordinated industrial policy and a coordinated governance scheme. In that respect, the Communication emphasises, in particular, "a reassessment of ESA–EU relations, with the view to a gradual adaptation of ESA in accordance with the increasing role of the EU" in the space domain.[51] To sum up, the Communication collects the results of the discussions that have taken place in recent years in the context of space, and contains a list of priority measures and instruments. It is not a strategy in itself; rather it is another step in the direction of defining the role of space in Europe as well as the role of the EU in the space field. Therefore, the Communication leaves open the questions of follow-through and necessary further steps to be taken. As the Communication and various other documents make clear, the EC sees space not as a goal in itself but rather as a tool to achieve economic, social and strategic goals through its support of other policy areas.

[47] Based upon: Klock, Erich and Marco Aliberti. "ESA Enlargement. What Interesting Countries Can Do to Prepare Themselves to Ultimate Accession – With a Special Focus on the CEE Region", ESPI Report 47. January 2014.
[48] European Commission. Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions. Towards a Space Strategy for the European Union that Benefits its Citizens. COM(2011) 152 final of 4 April 2011. Brussels: European Union. Document available at the European Commission website: <http://ec.europa.eu/enterprise/policies/space/files/policy/comm_pdf_com_2011_0152_f_communication_en.pdf>
[49] Sánchez Aranzamendi, Matxalen. "European Commission Communication "Towards a Space Strategy for the European Union that Benefits its Citizens" – Towards a Lisbon Generation Competence?" ESPI Perspectives 46. May 2011: 1.
[50] The EC document states that "space policy is an instrument serving the Union's internal and external policies and responds to three types of need: social, economic, and strategic".
[51] *Cit*., Sánchez Aranzamendi, Matxalen. "European Commission Communication "Towards a Space Strategy for the European Union that Benefits its Citizens" – Towards a Lisbon Generation Competence?" ESPI Perspectives 46. May 2011: 5.

This emphasis becomes even more visible in the Communication issued by the Commission to the Council and the European Parliament on 14 November 2012.[52] The document, entitled "Establishing appropriate relations between the EU and the European Space Agency", explicitly suggests that given the mismatch of financial rules, membership asymmetry, and security and defence-related asymmetry, "ESA could make the necessary structural adaptations [...] and make the necessary changes allowing unrestricted access to ESA's relevant statutory bodies...".[53] The document clearly states also that the EU can provide the political dimension (including at the international level) and legitimacy, as well as links with other policy areas. "The need for greater operational efficiency, symmetry in defence and security matters, political coordination and accountability can *only* be resolved, in the long term, through the rapprochement of ESA towards the European Union".[54]

It thus became manifest that the EU's intention was to gradually "morph" ESA to become part of the EU, as a kind of space agency of the EU similar, for instance, to the European Defence Agency (EDA). To date, ESA–EU relations are far from being determined but it goes without saying that an eventual transformation of ESA into an EU agency would also seriously alter the current governance of space activities with far-reaching consequences for the entire system.[55] This is most likely why the "Conclusions towards a shared EU-ESA vision for space fostering competitiveness" adopted by the Council of the European Union in May 2014 explicitly recognises that "transforming ESA into an agency of the EU would require political consensus which may be difficult to achieve in the foreseeable future".[56]

All in all, an eventual assimilation of ESA within EU bodies appears still far from taking place, but – as the same document subtly implies – it has to be acknowledged that the current and future EU-led space initiatives, in particular its flagship programmes, can be instruments to serve this ultimate purpose.

2.3 The Current Flagship Programmes in Space

The previous section focused on the legal milestones and political trends associated with the EU's mandate for space activities. The main objective of this report is, however, somewhat more practically orientated, namely, to assess the need and options regarding governance of the current flagship programmes and the identification and assessment of potential future flagship candidates. This section describes the nature of the current EU flagship programmes in space and throws light on the rationale behind their establishment as explicit EU flagship programmes in space.

Overall the European Commission has been expanding its involvement in aeronautics, telecommunication, Research and Development (R&D) related to satellite applications and Earth-oriented operational satellite systems. Most efforts in this respect, however, have gone to its two so-called space flagship projects: Copernicus and Galileo.

2.3.1 Galileo: Europe's Independent Global Navigation Satellite System

The ability to determine one's location and to navigate is something that has occupied hu-

[52] European Commission. Communication from the Commission to the Council and the European Parliament. Establishing Appropriate Relations between the EU and the European Space Agency. COM(2012) 671 final of 14 November 2012. Brussels: European Union. Document available at: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2012:0671:FIN:EN:PDF>.

[53] *Ibid*.

[54] More specifically, concerning the EU role, the document states that the EU could: 1) work through the Council of the EU, using as appropriate the open method of coordination to ensure coherence within the EU and consistency of EU Member States' positions in ESA with EU policies; 2) have systematic recourse to ESA for the design and development of EU space infrastructures, whereas exploitation activities will be carried out by other entities, such as the GSA.; 3) ensure a homogeneous approach in line with the EU Financial Regulation for delegating responsibilities over EU space programmes to ESA as a way to prepare ESA to work within the EU environment. Resource Document: *Ibid*.

[55] In a previous ESPI study it has been argued that such possible transformation could negatively affect the ESA enlargement process. Concretely, the implied approach of abiding by the EU rules, and in particular to the procurement principle of pure best-value-for-money (with the obvious abandonment of the geo-return principle), could raise fears and tangible problems for the aspiring members. The main ones would logically be that bigger industries, typically the ones of the historical members of the Agency will gain many advantages compared to the smaller industries of aspiring members. Without the geo-return principle, contributions to the ESA space programme could be easily perceived in the aspiring countries as "lost money", and their accession might be eventually postponed or even abandoned. See Klock, Erich and Marco Aliberti. "ESA Enlargement. What Interesting Countries Can Do to Prepare Themselves to Ultimate Accession – With a Special Focus on the CEE Region". ESPI Report 47. January 2014.

[56] Council of the European Union. "Conclusions towards a shared EU-ESA vision for space fostering competitiveness". Competitiveness Council Meeting. Brussels. 26 May 2014. Web. http://www.consilium.europa.eu/uedocs/cms_Data/docs/pressdata/en/intm/142787.pdf

manity for millennia. The earliest efforts were, among other techniques, based upon the positions of the stars in the night sky and the angular measurements derived therefrom. During the Imperial Age new technologies, such as the maritime chronometer, were devised to improve navigation at sea for military and trading purposes. At the end of the 19th century another major revolution in this area followed after the discovery of radio signals and the establishment of the radar principle. Ironically, the latest and most accurate facility came full circle since it provides a solution again relying on outer space – the deployment of operational Global Navigation Satellite Systems (GNSS). These are systems comprising a constellation of satellites capable of providing global and autonomous geospatial positioning and timing.[57]

The U.S. military was the first actor to deploy a satellite navigation system in the mid-1960s, which was designed mainly with the objective of supporting its naval operations. This system, however, worked on a rather indirect basis by monitoring frequency shifts caused by the movement of the satellites in their orbit. This approach is based upon the Doppler Effect and not so precise by today's standards. Nevertheless the technology was successfully demonstrated and because of the need for even better accurate positioning capabilities in a Cold War era characterised by geopolitical tensions, investments in newer systems were made shortly after, both in the U.S. and the Soviet Union. By the late 1970s the Americans had started launching their first Global Positioning System (GPS) satellites, with the Soviets deploying their GLONASS system shortly after. Both systems were considered fully operational as of 1995.[58]

Although the European Space Agency, as well as some national space agencies such as CNES, started to realise the opportunity for a civil GNSS constellation already in the 1980s, the first concrete actions remained limited to the execution of technical studies and the deployment of a European Geostationary Navigation Overlay Service (EGNOS), which was initially known as GNSS-1. It was the EU in 1995 that oversaw the start of development and actual deployment of this service, which is a project in cooperation with the European Space Agency and the European Organisation for the Safety of Air Navigation (EUROCONTROL). By using multiple geostationary satellites and a network of ground stations throughout Europe, EGNOS transmits a signal giving information on the reliability and accuracy of positioning signals stemming from the GPS and GLONASS systems, thus augmenting the quality of satellite navigation coverage over the European continent. The EGNOS Open Service has been operational since 2009, the year in which ownership of the system was transferred to the EC.[59, 60]

At the same time as the start of the EGNOS project, the pendulum also began to swing in the direction of overall support for a fully-fledged independent GNSS system for Europe, then referred to as GNSS-2.[61] The factors driving this change were that satellite navigation signals had started to offer increased pay-offs, both in terms of socioeconomic benefits and geopolitical strategies. During that time GNSS signals, and GPS in particular, became increasingly used by non-military users worldwide for location tracking and traffic navigation, with ever more people, businesses and public services relying on their availability and quality. A major driving force prompting the worldwide access to the American GPS signals was related to the safety in airspace management following the disaster with Korean Air Lines Flight 007 during the Reagan Administration in 1983. Later, the trend of opening access continued when the U.S. government saw interesting commercial opportunities to further invest in the area of satellite navigation. In 1998 then U.S. Vice President Al Gore announced plans to further upgrade the American system, which gave rise to a GPS system with two new civilian signals for enhanced user accuracy and reliability.[62] In contrast, the Russian GLONASS started degrading around that time because of poor programme management and budget issues following the collapse of the Soviet Union. Later, however, it was decided with the impulse of Vladimir Putin's presidency in 2001 to revive the GLONASS system and make this a top government pri-

[57] Hofmann-Wellenhof, Berhard, Lichtenegger, Herbert and, Wasle, Elmar, eds. *GNSS Global Navigation Satellite Systems*. Vienna: SpringerWienNewYork. 2008.
[58] *Ibid*.

[59] "EGNOS Open Service" 18 Sep. 2014 European Space Agency 15 Oct. 2015 http://www.navipedia.net/index.php/EGNOS_Open_Service
[60] "About EGNOS" European GNSS Agency 15 Oct. 2015 http://www.egnos-portal.eu/discover-egnos/about-egnos
[61] An important milestone in this respect was the speech "European Strategy for GNSS" given by then Member of the European Commission responsible for Transport and Trans-European Networks, Neil Kinnock, at the GNSS 98 Symposium in Toulouse in 1998, which can be consulted at: http://europa.eu/rapid/press-release_SPEECH-98-210_en.htm
[62] The plan eventually translated into a formal decision in 2000 when the United States Congress authorised the effort, referring to it as GPS III.

ority. The system was restored and eventually became fully operational again in 2011.[63]

In order to fully understand the nature of the dynamic at the time it is necessary to consider what happened to a number of interconnected interests. Following the fall of the Iron Curtain, the structure of international relations was transformed from a bipolar model to a temporarily unipolar one; a regime order with only one remaining superpower at the centre of the global regime. In this phase, however, the seeds of a multipolar world order were already present and the most powerful states started acting upon this evolution shortly thereafter. In this new reality the position of Europe was changed in a way that entailed two major opportunities. First, from an internal perspective, the division that had separated Europe into two blocks since the end of the Second World War ceased to exist, which in turn offered the opportunity of a spatial continuation of the pan-European integration process – with a strong focus on eastern expansion. Second and related hereto, albeit from a more outward point of view, the collapse of the USSR indirectly altered the relative geopolitical weight of Europe on the global stage in the sense that it offered the EU the prospect of developing a stronger influence on the international agenda.[64]

To harvest opportunities and thus to increase its political weight, the EU had to develop the capacities that would ensure this – something it saw fit doing through the use of soft power. As opposed to hard power soft power relies on non-military tools such as the use of diplomatic influence and the establishment of international institutions, but it can also take the form of initiatives aimed at closing economic and technological gaps between second-tier players and the hegemon.[65] The development of a strong and autonomous space sector, supported by own capabilities such as GNSS, was at the time considered a strategic element in strengthening EU influence in international affairs. This was so because the EU planned to engage in space diplomacy, i.e. using space programmes as a tool to establish international cooperation and wider partnerships, but also because the capacities to be developed would benefit Europe in a number of tangible ways, namely in the areas of security and defence. The idea of a European GNSS had first gained impetus during the First Gulf War, when the realisation was made that Europe was lacking autonomy in certain areas of its military and defence set-up and that GNSS signals are a strategic and indispensable asset in carrying out air force operations. An autonomous GNSS constellation would make Europe less dependent on the U.S. in performing its own security-related operations.[66] In parallel to the security arguments, economic arguments also started to become significant around that time. The very outspoken ideological struggle characterising the playing field of international relations during the Cold War era had vanished and created a vacuum that was rapidly being filled by increased power projection through economic mechanisms. During the 1990s international trade witnessed an accelerated wave of globalisation and the neo-liberalism paradigm extended both in terms of reach and grip on a global scale. As a result the concepts of competitiveness and the ability to innovate in consumer products and services became more important. In this context it was felt that Europe’s space sector should not only excel in scientific research and technology development, but that it should also be competitive and innovative, thereby creating wealth and economic growth. The creation of this added value was envisaged through the development of commercial downstream applications and by fostering spillover effects and cross-fertilisations with regard to industrial sectors outside the field of space.[67] With these strategic objectives and socioeconomic benefits in mind for the long term, the European Commission called upon the European Council and the European Parliament to approve the development of a European GNSS in 1998.[68]

Hence ESA and the EU jointly decided to study the feasibility of a fully-fledged and independent European GNSS. The results showed that there were considerable economic pay-offs to be reaped from an autonomous European GNSS system and thus the programme was approved in 1999.[69] It was decided, as envisaged from the beginning, to develop Galileo as a civilian programme under civilian control – notwithstanding that it would serve dual use pur-

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[63] “GLONASS Future and Evolutions” 12 Apr. 2015 European Space Agency 15 Oct. 2015 http://www.navipedia.net/index.php/GLONASS_Future_and_Evolutions

[64] Johnson-Freese, Joan, and Erickson S. Andrew. “The emerging China–EU space partnership: A geotechnological balancer” Space Policy 22. 2006: 12-22.

[65] *Ibid*.

[66] *Ibid*.

[67] *Ibid*.

[68] Communication from the Commission to the Council and the European Parliament. Towards a Trans-European Positioning and Navigation Network including a European Strategy for Global Navigation Satellite Systems (GNSS). Brussels 21.01.1998 COM (1998) 29 final.

[69] Nicola Casarini. *Remaking Global Order: The Evolution of Europe-China Relations and its Implications for East Asia and the United States*. Oxford University Press. Oxford. 2009: 244 .

poses. In March 2002 the European Council of Transport Ministers approved a package of €450 million to initiate the development phase of the Galileo programme. Although the programme experienced a very turbulent set-up and implementation phase because it was wrongly conceived as a commercial and industrial venture initiated and sponsored by public funding, the so-called Galileo Joint Undertaking, it was brought back on the right track following a thorough reorientation when the programme's focal point became the GNSS Supervisory Authority. In this reorientation process towards Galileo as a strategic infrastructure for public service with commercial applications, the development of Galileo continued successfully, albeit with a delay. The entire constellation, which will consist of 30 satellites in Middle Earth Orbit (MEO) including three spares, is now expected to become fully operational around 2020.[70] The issues that occurred during the first phases of programme implementation demonstrate that projects of this scale are complex and that all aspects have to be considered and addressed properly in order for them to become successful.

2.3.2 Copernicus as an Operational Environmental Monitoring Programme

In the area of Earth Observation a number of evolutions, spanning over multiple decades, have contributed to the decision to establish what is now known as the Copernicus programme. As opposed to global satellite navigation, Europe, and ESA in particular, had been actively developing EO capabilities for quite a long time – in line with technology developments in this area on the other side of the Atlantic.

Initially, the first experimental remote sensing efforts in space were focused on weather monitoring only. The first country to invest heavily in space-based meteorological capacities was the United States with its Television Infrared Observation Satellite Program (TIROS), followed by the Soviet Union. After a number of promising technology demonstrations and successful proof-of-concept missions in the early 1960s, it became clear that remote sensing satellites for meteorology would translate into truly operational services. The path-breaking polar orbiting services were complemented by geostationary coverage about a decade later and both services quickly became a critical part of weather forecasting and therefore also subject to space programme development and mission planning in the United States. Relatively soon thereafter, in the mid-1970s, Europe also got involved in satellite meteorology when the Meteosat programme was initiated by CNES and ESA, with Meteosat later being brought under the auspices of the newly created European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT).[71]

The deployment of public remote sensing satellites with broader environmental monitoring applications for civil purposes started somewhat later, when it was realised that this field would also benefit from space based observations. The first milestones in this respect were the U.S. launches of the first civilian Earth Observation satellite Landsat in 1972, the first oceanography satellite Seasat in 1978 and, a number of satellites to measure atmospheric pollution (SAGE). In the following decades, environmental monitoring from space evolved, just as meteorology did, into a mature technological field. In this process the diversity of Earth Observation measurements increased as imaging, radar remote sensing, atmospheric composition monitoring, ocean altimetry and others were added to the list of capabilities. In Europe major progress was made during the 1990s and 2000s, with the launch of Topex-Poseidon, Envisat, the MetOp series, the specialised Earth Observation satellites in the ESA Living Planet programme, and a number of smaller national proof-of-concept missions. These developments vastly increased the socioeconomic and strategic benefits that could be derived from Earth Observation and gave Europe skills and expertise in developing state-of-the-art capabilities. Yet, wide-scope environmental monitoring from space was not directly translated into a truly operational service the same way that meteorology was during the second half of the 20th century. One of the reasons was that the users of environmental satellite data are more heterogeneous and have different operational requirements and priorities. Because of this, environmental monitoring has a smaller centralised demand compared to meteorology. Moreover environmental monitoring was for a long time considered as an issue of secondary priority. It was deemed not to offer considerable direct socioeconomic and strategic benefits, unlike meteorology, and there was less institutional demand because environmental issues were not at the top of the political agenda. The latter, however, had

[70] "Galileo Future and Evolutions" 7 July 2015 European Space Agency 21 July 2015 http://www.navipedia.net/index.php/Galileo_Future_and_Evolutions

[71] Lahcen, Arne "EUMETSAT-NOAA Collaboration in Meteorology from Space: Review of a Longstanding Trans-Atlantic Partnership" ESPI Report 46. September 2013: 12-15.

started to change by the end of the 20th century.

During the 1980s a number of global environmental problems started receiving attention in different parts of the world. Issues such as ozone depletion, acid rain, deforestation of tropical rainforests and climate change, started to reinforce ecological awareness in many industrialised countries. Supported by academic research the ecological movement – which had already grown considerably during the 1970s – was able to channel this awareness to become an impetus to move environmental monitoring and protection up the political agenda. In many parts of the world, high-level meetings, World Summits and scientific conferences continued to call on the international community to monitor the environment more carefully in order to increase understanding of its processes and facilitate mitigation measures.[72] As a consequence, the need to establish better Earth Observation capabilities became a political priority in Europe and beyond during the 1990s.

The first formal milestone in the establishment of what eventually would become the Copernicus programme was the creation of the "Baveno Manifesto". The Manifesto, signed in 1998, called on the European Commission and the European Space Agency to enter into a long term commitment to set up a global observation capacity to support agriculture, environmental monitoring and national security.[73] GMES became the programme acronym. At that time GMES stood for Global Monitoring of Environmental Security, as full awareness and acknowledgment of the security dimensions of the project only followed a year later. The document was adopted in the margins of a users' seminar organised by the Space Applications Institute (SAI), whose primary mission is to develop and promote the use of space-derived data in the service of EU policies, especially those relating to agriculture, fisheries, transport and anti-fraud. In this sense, in contrast with many other space programmes and initiatives, the initiative had strong ecological roots.

In February 2004, after a five year reflection and preparation period following the signing of the Baveno Manifesto, the European Commission released a Communication with a concrete Action Plan aimed at establishing a working GMES capability by 2008.[74] The system's data input would be provided by two main sources. In-situ observations would come from ground-based stations and airborne and seaborne measurements and would be managed by the European Environment Agency (EEA). The space component would consist of new infrastructure in the form of the Sentinel satellites, procured jointly by the EU and ESA, complemented by contributing missions. The overall Copernicus constellation would increase operational capacity until the 2020s. In addition to the data streams generated by the constellation, output would be provided in the form of thematic services in six predefined fields: (1) land monitoring, (2) marine monitoring, (3) atmosphere monitoring, (4) emergency management, (5) security and, (6) climate change.[75]

[72] "GEO History" 11 Aug. 2015 European Commission 18 Aug. 2015 http://ec.europa.eu/research/environment/index_en.cfm?section=geo&pg=history#1
[73] "Global Monitoring for Environmental Security: A Manifesto for a New European Course of Action", reaffirmed by ASI, BNSC, CNES, DLR, EARSC, ESA, EUMETSAT and the European Commission in Baveno, Italy on 19 May 1998.
[74] Commission of the European Communities. Global Monitoring for Environment and Security (GMES): Establishing a GMES capacity by 2008. COM(2004) 65 final of 3 Feb. 2004. Brussels: European Union.
[75] Allgeier, H., Eyres, H., Gibson, R., Hulsroj, P. and Lahcen, A. "Optimising Europe's Benefits from the Copernicus Programme: Addressing the Structural Gaps in Operational Earth Observation" ESPI Report 50. April 2015.

3. Copernicus and Galileo: Priorities for Operational Governance

The previous chapter already mentioned that several factors substantiated the decisions to establish the Galileo and Copernicus flagship programmes. A major element in this regard was the variety of expected socioeconomic and strategic benefits envisaged under the programmes. Now that both programmes are moving towards their operational phase it is necessary that their programme structures become conducive to the generation of these benefits in the most optimal fashion. Although this is desirable for any type of investment, it is even more important in this case considering that both constellations will be providing what is known in economic terms as 'public goods' (see table 3).

		Rivalry	
		rivalrous	non-rivalrous
Access	excludable	**Private Goods**	**Club Goods**
	non-excludable	**Common Resources**	**Public Goods**

Table 3: Classification of Goods.[76]

As opposed to many other areas of space utilisation – such as, for example, human spaceflight, telecommunication and launchers – the Copernicus data and Galileo signals will be both 'non-rivalrous' and 'non-excludable' types of provisions. Non-rivalrous means that use by one does not reduce availability to others, regardless of the number of simultaneous users. This is the case because GNSS signals do not decrease in strength as a function of the number of users and because it is digital information, Earth Observation data can be copied and distributed at virtually no cost once downloaded. Both are also non-excludable because of the explicit choice to establish systems for civil use, with open access to as many users as possible – at least for most of the applications and only with certain reservations under national law and security restrictions. Open access was not self-evident, since there was also the option of commercialising these services, making them 'club-goods' – provisions available on a non-rivalrous yet excludable basis, like satellite television for instance.[77]

The commercialisation of Copernicus and Galileo did not materialise because of the context and time in which the programmes came about. The civil access to GNSS signals was initiated in the mid-1990s by the United States. Although initially in Europe the idea was to finance Galileo through a public-private partnership, difficulties in negotiating the concession contracts, as described above, called for a larger role of the public sector in establishing an independent GNSS system. Hence the door was open for a decision in favour of open access.[78] Furthermore, in the field of remote sensing, full and open data access became a political trend, in line with the data sharing principles formulated by the intergovernmental Group on Earth Observations (GEO).[79] The idea behind the open approach in Earth Observation is to support evidence-based policy and have the greatest possible use of the data. Landsat experience shows that data is used much more, both in terms of numbers of users and applications, when made available at no cost compared to when imposing significant charges. This is because only liberal data access will encourage academic, government and, commercial scientists to start using the data, thereby elevating the number of users to the level

[76] Authors' visualisation.
[77] For an analysis on the qualification of GNSS signals as a public good see: Plattard, Serge. "Can GNSS Signals Qualify to Become a World Public Good?". IAC-14-E3.3.12. Toronto, Canada. 2014.
[78] For more info, see: "Galileo public-private partnership crashes to earth" 5 Sept. 2007 Politico 5 Feb. 2015 http://www.politico.eu/article/galileo-public-private-partnership-crashes-to-earth-2/
[79] "GEO Data Sharing Principles Implementation" Group on Earth Observations 5 Feb. 2015 https://www.earthobservations.org/geoss_dsp.shtml

required for the maturing of analytic tools, which is in turn to the benefit of all parties.[80] Thus, free and open access fosters the development of a value adding industry, as the intense use of free services is more prone to stimulate the development of downstream applications and services because of the higher ultimate demand and smaller financial risk of brokers.[81] All of these elements also have a positive impact on the innovation dynamics of the GNSS and EO markets.

One important feature of public goods is that commercial mechanisms cannot properly guarantee their provision and thus governmental involvement is required for longer periods of time. Since the capabilities are established with taxpayers' money, it is key that European citizens, enterprises and governmental players get a proper return on their investment. In the case of the flagship programmes in space, it is the EU in particular which must ensure that mechanisms are in place assuring that benefits can be maximised and that the governance structures for both flagship programmes are adapted to accommodate this accordingly. This chapter will focus on the major elements in this respect.

3.1 Optimising the Benefits of the Current Generations

The first question regarding the optimisation of potential benefits of Copernicus and Galileo is a near term one. Namely, how can it be assured that under the programmes' first generation of satellites, once sufficiently operational, European actors will be in a position to reap the maximum amount of strategic and socioeconomic benefits from the overall system? To shed light on this question, the current mechanisms for the generation and propagation of benefits foreseen in these programmes will be considered first. Doing so reveals which elements in the value chain have been addressed adequately and which issues merit further attention.

3.1.1 Copernicus

Maximising the benefits from Copernicus' data is currently pursued through two channels. The decision to adopt a full, free and open data access policy for users was an important first pillar in allowing the data to be used widely. The preference for a data policy that would give away much of the generated information for free was already stressed in the early policy documents of the European Commission, such as the Action Plan of 2004, which referred to the Aarhus Convention.[82] Following the findings of a socioeconomic benefit study and a Downstream Services Market Study, the European Commission adopted the full and open access to data policy via a Delegated Regulation in December 2013.[83] By doing so the EC wanted to strengthen the commercial market for downstream Earth Observation applications while at the same time offering support to the European research, technology and innovation communities. In turn this particular business model is expected to create the highest growth and job creation compared to other data policy scenarios. For most end-users, however, unprocessed data is of little use and therefore the six thematic services were created in addition to the specific data policy. As illustrated in the table below, the implementation and operation of the services are managed by different institutions in Europe.

[80] National Research Council of the National Academies, ed. Earth Observations from Space – The First 50 Years of Scientific Achievements. Washington DC: The National Academy Press. 2008.
[81] EARSC Position Paper "Industry Access to Copernicus Sentinel Data - The practical aspects of Copernicus Data Policy" – February 2013
http://earsc.org/file_download/143/EARSC+Position+Paper+on+Industry+access+to+GMES+_+Copernicus+Data+final.pdf
[82] Commission of the European Communities. Communication from the Commission to the European Parliament and the Council Global Monitoring for Environment and Security (GMES): Establishing a GMES capacity by 2008 - (Action Plan (2004-2008)). COM (2004) 0065 final of 16 Apr. 2004. Brussels: European Union. Document available at: http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52004DC0065&from=EN
[83] Regulation (EU) No 377/2014 of the European Parliament and of the Council of 3 April 2014 establishing the Copernicus Programme and repealing Regulation (EU) No 911/2010, Document available at: http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32014R0377&from=EN

Service	Status	Components and / or Projects
Land Monitoring	Operational	Global Component (coordinated by the JRC) Pan-European Component (implemented by the EEA) Local Component (implemented by the EEA)
Emergency Management	Operational	Copernicus Emergency Management Service (GIO EMS) European Flood Awareness System (EFAS) (implemented by the JRC)
Atmosphere Monitoring	Pre-Operational	Monitoring Atmospheric Composition and Climate – Interim Implementation (MAC-II)
Marine Monitoring	Pre-Operational	MyOcean2
Security	Under Development	Border Surveillance: G-MOSAIC Maritime Surveillance: • Development of Pre-operational Services for Highly Innovative Maritime Surveillance Capabilities (DOLPHIN) • New Service Capabilities for Integrated and Advanced Maritime Surveillance (NEREIDS) • Simulator for Moving Target Indicator System (SIMTISYS) Support to EU External Action: G-MOSAIC
Climate Change	Under Development	Development is supported by a series of FP7 projects

Table 4: The Six Copernicus Services, their Status and Components and/or Projects.[84]

The Land Monitoring and Emergency Management services are already operational. The land monitoring service consists of three components with different geographical focus.[85] The global component produces data across a wide range of global biophysical variables describing the state of vegetation, the energy budget and the water cycle. The pan-European component produces five high resolution data sets describing the main land cover types: artificial surfaces, forest areas, agricultural areas, wetlands, and small water bodies. The local component provides detailed information on land cover and land use for European hot spots such as cities. The emergency management service aims to pro-

[84] Allgeier, H., Eyres, H., Gibson, R., Hulsroj, P. and Lahcen, A. "Optimising Europe's Benefits from the Copernicus Programme: Addressing the Structural Gaps in Operational Earth Observation" ESPI Report 50. April 2015.

[85] The preparations for the Land Monitoring service were made in projects Geoland and Geoland2. Based upon the experience acquired by the European remote sensing consortia, the EC and the EEA agreed to redistribute the responsibility for implementation of the different components. In 2011, the EEA took over the implementation of the pan-European and the local components. As of 2013, the JRC is responsible for the coordination of the global component. This gradual transition assured that the service portfolios previously developed were to a large extent taken up on the GMES Initial Operations (GIO), bridging the gap between research and operations.

vide timely and accurate geo-spatial information to all actors involved in the management of natural disasters, man-made emergency situations, and humanitarian crises. It consists of two components: a mapping service (EMS) and a European Flood Awareness System (EFAS), both of which have been developed by the EC's Joint Research Centre (JRC) since 2002. Both components have been operational since 2012.[86]

The Atmosphere Monitoring and Marine Monitoring services are currently in a pre-operational mode. The first element is provided by the Monitoring Atmospheric Composition and Climate - Interim Implementation (MACC-II). By combining state-of-the-art atmospheric modelling with observation capabilities, MACC-II provides data on atmospheric composition for recent years, data for monitoring present conditions, and forecasts of the distribution of key constituents up to a few days ahead. The Marine Monitoring service provides regular and systematic reference information on the state of the physical oceans and regional seas around the world. Currently the MyOcean2 project, the successor to MyOcean and Mersea, is responsible for the development of the pre-operational functions.[87, 88]

All Copernicus services for security applications and climate change are still under development. The security applications will support the EU in three major policy areas: border surveillance, maritime surveillance and support to EU External Action. Border surveillance and support to EU External Action are being developed by the services for Management of Operations, Situation Awareness and Intelligence for regional Crises project (G-MOSAIC). The Maritime Surveillance service has the objective of ensuring the safe use of the sea and securing Europe's maritime borders. The Climate Change service is supported by a various European projects that focus on different aspects and variables that affect the evolution and modelling of the climate. As climate is a complex interplay of terrestrial, marine and atmospheric components, the service is supported by a wide range of data sources and other services. Ultimately, the service will help to support climate adaptation and mitigation.[89]

From an analytical perspective, the road taken with regard to benefit optimisation as described in the above is heading in the right direction. Major progress has been made in the development of the six services, especially for those currently in operational or pre-operational mode. Still, in the overall scheme of things, there seems to be room left for further optimisation. This is true for the actions that are being implemented at the moment, but also regarding the need for future initiatives that should go beyond what is currently being addressed.

The approach of channelling demand around six centralised thematic services is expected to strongly support institutional demand for environmental monitoring, security and scientific research. The six services themselves will not be sufficient alone to stimulate the uptake of Copernicus data among all potential users in the European setting, however. European public awareness of the EO flagship programme remains low and it lacks sufficient exposure among its targeted end-users – even among institutional users within EU structures. Before its termination, the GMES Bureau, which had the task of promoting user uptake, made efforts to improve this situation by creating awareness across EC services and by launching a number of relevant joint initiatives with several DGs of the EC. In spite of its success in increasing institutional awareness, a consultancy report of 2009 stated that the GMES Bureau was less successful in actually engaging those institutional users and creating direct links with industrial users.[90] At the same time the study noted that this shortfall should not be attributed to the Bureau itself, considering its limited scope and mandate. As a recommendation it stated that the creation of awareness on a pan-European scale would require the involvement of intermediate levels such as the member states. After all, once informed, they are in a better position to identify and connect to the variety of potential users within their territory and to federate the needs of their domestic users.

In order to validate the full market potential, it would be beneficial to set up additional user uptake schemes aimed at informing market players of the economic potential of the data stream and services that are / will be generated by Copernicus. Providing the

[86] "Copernicus Products and Services" FDC 5 Feb. 2015 http://www.copernicus.eu/main/services
[87] In terms of substance this includes the elaboration of a governance model for the Marine Service and the preparation of a long term roadmap for the Marine Service for the future. Until recently, most European Member States had built their own operational oceanography capacities and so an important task of MyOcean2 is to build a system of systems and avoid duplication of efforts. To this effect the project has established intense cooperation with major European centres in oceanography, and has involved users since its inception.
[88] "Copernicus Products and Services" FDC 5 Feb. 2015 http://www.copernicus.eu/main/services
[89] *Ibid*.
[90] Clark, J., Pitsaros, E. and, Simmonds, P., Evaluation of the Activities of the European Commission's GMES Bureau, Final Report, Technopolis Group. February 2009.

data in an accessible way is the first major step in spurring the development of downstream applications, but bringing (potential) entrepreneurs and users to engage and process the data to create profit or benefits is a second key component that merits additional action. In some instances certain initiatives have been put in place to achieve this, but they remain rather fragmented and lack the critical mass required for efficient and effective functioning. Consideration should therefore be given to further integrating the promotion and use of Copernicus capabilities into the wider scope of policy support related activities of the EU, such as, for example: common fisheries policy, conclusion of international agreements, commercial policy, economic, social and territorial cohesion, environment, transport, tourism, energy, trans-European networks. But, importantly, Copernicus data should also be promoted much more for purely commercial and private purposes in fields such as agriculture, tourism, and energy.

In addition to the reinforcement of current user uptake practices, the Copernicus constellation will be in a position to reap certain less self-evident – or at least less tangible – benefits. These issues have been reflected upon by ESPI in a previously published report dealing with the question of European benefit optimisation from the Copernicus Programme.[91] One of the assertions in that analysis is that Copernicus will be in an excellent position to gauge unaddressed societal needs related to EO data beyond the core purposes of environmental monitoring and security. The examples of the U.S. Geological Survey (USGS) and the U.S. National Geospatial-Intelligence Agency (NGA) illustrate that there are strong arguments for more holistic approaches to data management to broaden benefits and stimulate their propagation through society. For instance, such a centralisation could ensure better that data analysis expertise is pooled with other fields of expertise such as software development, environmental sciences and various voices from societal fields that could benefit from more accurate data and information on the environment and security. In addition, a central agency would be better positioned to ensure the development of private downstream business and service providers. The NGA, for instance, has been instrumental in the development of software tools such as Google Earth and it cooperates with Microsoft to advance the design and delivery of geospatial information applications to customers.[92] This demonstrates that in order for private industry to grow and develop a mature set of products and services, government funding and demand are often crucial. Besides that, the NGA also provides services for disaster management relief and the planning of large ad-hoc events such as the Olympics. Of course the European situation is distinct from the American one, because of the differences in military and security uses and the differences in markets and governmental set-ups. The question, however, is whether Europe could learn from this approach to establish other, European-strength based applications and services. These would be based upon Copernicus and data from other European assets, beyond the strict thematic distribution that forms the basis for current Copernicus services. Interestingly, it was also argued in the same ESPI report that this would also offer the opportunity of leveraging what can be learned from EO for the benefit of society as a whole. In the current political debate on the health of the Earth, there is a serious lack of distinction between scientific fact and political assessment. There is a need to clearly communicate this important distinction. One of the issues of most concern today is that the political debate on the environment and climate is a debate that allows the best scientific assumptions to be replaced by political convenience arguments. There is an urgent need to communicate Earth Observation science results in such a fashion that incontrovertible boundaries are set for political discussion. For this to happen the body politic must progressively get a better understanding of the results provided by Earth Observation. It is important to note that this is not a problem unique to Copernicus and therefore it should not necessarily be expected to resolve this issue in isolation.

The creation of these less tangible benefits is, however, complicated by the institutional set-up in the current Copernicus programme architecture. As can be noted from table 4, there is a high degree of decentralisation present in the provision of the services, for instance. They are compartmentalised into six and for many of them actual operations are split into subservices with different operators. This was chosen explicitly because the EC wanted to make best use of existing strengths, as there is a lot of valuable expertise present in the European institutional landscape. The challenge in terms of benefit maximisation here is thus not the high de-

[91] Allgeier, H., Eyres, H., Gibson, R., Hulsroj, P. and Lahcen, A. "Optimising Europe's Benefits from the Copernicus Programme: Addressing the Structural Gaps in Operational Earth Observation" ESPI Report 50. April 2015.

[92] Shorrock, Tim. Ed. Spies for Hire: the Secret World of Intelligence Outsourcing. New York: Simon and Schuster. 2008: 247 – 250.

gree of decentralisation of the services. Rather, it is the fact that, for the time being, no mechanism is in place to tackle the attendant management and optimisation challenges that follow from decentralisation. Thus, there is no operational function or mechanism in existence that coordinates the six services and involves all the relevant stakeholders, notably those with the most direct link to the users. If the European Commission wants to ensure that all strategic benefits materialise in the long term, this issue must be addressed in a way that is supported by all other institutional stakeholders in the Copernicus programme: ESA, EUMETSAT, EEA and the member states.

3.1.2 Galileo

For Galileo, the mechanisms developed to encourage user uptake and benefit optimisation were also conceived in the form of different services. Whereas the services in Copernicus are segmented thematically, those for Galileo will be tailored to the requirements and demands of users. This has resulted in the definition of four different services as summarised in table 5 below. The Galileo Open Service (OS) will be the most used service of the four as it will offer excellent positioning and timing performance to all users worldwide free of charge. For critical transport applications such as aviation and maritime navigation, the Galileo Safety of Life (SoL) Service was devised. It will deliver, on a guaranteed basis, enhanced performance over the OS through its key integrity function that will warn users when it fails to meet certain accuracy margins.[93] This allows users to correctly estimate the accuracy and thus reliability of their exact location fix. The Galileo Commercial Service (CS) will enable the creation of value added services through its higher performance. To achieve this, the service uses a combination of two encrypted signals for a higher data transmission rate and higher accuracy authenticated data. The service will be available for a fee.[94] Finally, the Galileo Public Regulated Service (PRS) will make use of interference mitigation technologies in order to provide a higher level of protection against threats to Galileo signals such as those coming from jamming or spoofing. This will make PRS signals more robust during crisis times and is intended to safeguard the strategic value of Galileo in the interest of member states.[95] The PRS will have controlled access.

Service	Description
Galileo Open Service (OS)	Free of charge for all users, featuring excellent positioning and timing performance.
Galileo Safety of Life (SoL) Service	Will deliver guaranteed enhanced performance, including a key integrity function, i.e. a warning of system failure alarming users when certain accuracy levels cannot be met.
Galileo Commercial Service (CS)	Access to two additional encrypted and guaranteed signals, delivering a higher data throughput rate and increased accuracy.
Galileo Public Regulated Service (PRS)	Will provide position and timing to specific users requiring a high continuity of service, with controlled access.
Search and Rescue Service (SAR)	Will help to forward distress signals to a rescue coordination centre by detecting emergency signals.

Table 5: Overview of the Different Galileo Services.[96]

Although the implementation of the Galileo programme witnessed some delays in its early planning phase, the deployment phase is now steadily progressing and full operational capacity is expected around 2020. Since the overall capacity is highly dependent upon the integrity of the constellation, Galileo's implementation is following a phased approach. During the In-Orbit Validation (IOV) phase the satellite's Middle Earth Orbit (MEO) was characterised and the performance of the critical payloads' capacities was tested in outer space for the first time. At the end of the IOV phase, in March 2013, ESA managed to get a first position fix using four satellites. The transition from IOV to Initial

[93] "Galileo Safety of Life" 2011. European Space Agency 11 March 2015. http://www.navipedia.net/index.php/Galileo_Safety_of_Life_(SoL)

[94] "Galileo Commercial Service" 2011. European Space Agency 11 March 2015. http://www.navipedia.net/index.php/Galileo_Commercial_Service_(CS)

[95] "Galileo Public Regulated Service" 2011. European Space Agency 11 March 2015. http://www.navipedia.net/index.php/Galileo_Public_Regulated_Service_(PRS)

[96] Authors' visualisation.

Operational Capability (IOC) is now taking place. Once the IOC phase is reached, the Open Service, Search and Rescue and Public Regulated Service will become available with initial performances.[97] As the constellation is expanded in the following years, the services will be further validated and made available until Full Operational Capability (FOC) is reached.

The development of four services with different performance characteristics was a very sensible decision from the perspective of benefit optimisation. Not only does it respond to the differentiated needs of various user categories, it also enables Europe to generate direct revenues on a commercial basis whilst offering a free public GNSS service. In order to link Galileo signals with the needs of users and to stimulate user uptake, the European GNSS Agency (GSA) was established by the European Council in 2004. The GSA runs a number of initiatives to achieve this purpose. First, it stimulates user uptake by increasing awareness of European GNSS Programmes and applications in User Forums and beyond and it develops tools (i.e. best practices, roadmaps, harmonised user cases, user requirements etc.) to be used in advisory services and education to improve awareness among users about how GNSS technology can contribute to their business. Second, it is responsible for the design and the enabling of services corresponding to the needs of European users. In addition to this, it also takes on the role of an intermediate body. It provides, for instance, grants to support the development of applications in certain areas and it oversees the procurement of certain services related to Galileo operations such as security, ICT support and quality management services. This is closely related to the development of a sustainable and commercially viable downstream industry that benefits from support in the development of new applications and value added services. The latter is key in the generation of pan-European socioeconomic benefits. Now that the constellation is being deployed in orbit, the GSA is steadily increasing its operational capabilities and acquiring expertise in the fields relevant for these operational tasks. Interestingly, some further organisations were also established with the objective of stimulating downstream technologies and business development, such as the non-profit organisation Galileo Services.[98]

Because of the actions taken by the European Council, the GSA seems now to be in an excellent position to perform its assigned tasks under the EU mandate. The question of governance in the European context is, however, wider than taking care of operational tasks and outreach. Similar to the situation in the case of Copernicus, the governance of Galileo with respect to benefit optimisation is also very much linked to the involvement of players at international level as well as the governance support for Galileo coming from within the EU itself – in particular the policy designed by the European Commission.

In terms of the latter, it is key that the EU develops a strategic roadmap to build on its Galileo programme that goes beyond merely stimulating user uptake through the development of certain services and business development support as currently offered by the GSA itself. The EU, for example, could, in various economic fields, ensure that ambitious binding targets are defined at EU and Member State level thus requiring new terrestrial technologies to be developed and integrated into European society and the economy. To this effect, adequate R&D and implementation funds should be made available. This is especially necessary for certain areas of investment where private markets will not easily go because of the high investment cost and uncertain return on investment. Examples in this category include automated farming (which is becoming increasingly relevant due to the declining workforce in the agricultural sector) and integrated safety systems for air, road, rail and maritime transport. These kinds of R&D areas will require considerable institutional demand-pull to materialise, even in the long term.

For the proper functioning of Galileo the international governance aspect is essential. In fact, a key element in the expected accuracy for end users is the fact that Galileo signals will be compatible with existing GPS and GLONASS signals.[99] The range of radio frequencies to be used by different GNSS constellations was defined by the International Telecommunications Union's (ITU) Bureau for Radio Communications. International consul-

[97] "What is Galileo" 2015. European Space Agency 27 Aug. 2015 http://www.esa.int/Our_Activities/Navigation/The_future_-_Galileo/What_is_Galileo

[98] "What is GS?" 2015. Galileo Services 11 March 2015. http://www.galileo-services.org/what_is_gs/what_is_gs.html

[99] "The Results are In: Galileo Increases the Accuracy of Location Based Services" 27 May 2014 GSA 11 Mar. 2015 http://www.gsa.europa.eu/news/results-are-galileo-increases-accuracy-location-based-services

tations between representatives of GNSS providers, however, take place in the context of the International Committee on GNSS (ICG). This informal body was established by the GNSS Action Team within the COPUOS framework following the recommendations of the UNISPACE III Conference held in 1999.

So far decisions within the ICG have been taking place through consultations based upon a 'best practices' approach. This implies that the different GNSS providers coordinate their systems on a voluntary basis, bearing in mind that all systems have to coexist with each other. A first priority of the ICG will be the phase of operations in which all GNSS systems currently under deployment will be working in conjunction. It will need to be assured that all systems are compatible with each other on an interoperable basis, free of interferences. In the long run, in the post 2020 time frame, it seems advisable that the different GNSS providers around the world reflect on the possibility of pooling expertise to increase global GNSS performance – on a voluntary basis. Currently, GNSS capabilities are considered a strong strategic advantage and thus related security constraints exist. As multiple players deploy trusted GNSS constellations, however, the dynamic for consultation and coordination changes for the better. Currently, the various players are building up experience, know-how and, not insignificantly, the comparative advantage of one partner having a specific strategic capability decreases, which in turn affects the security dynamic underlying systems that have dual use applications. In this sense, it can be hoped that in the long term certain systems will at least be coordinated to improve performance. In the much longer term, certain systems might even be integrated in one way or another, in order to save costs of what by then will be continuous global operational services.

Looking at the architecture of the ICG it is striking that there is no clear methodology for interfacing with users yet, which is surprising given the widespread commercial and private use of navigation services. The ICG would be well advised to introduce mechanisms allowing user communities to be consulted in the decision-making process to make sure that important voices are heard, such as the ones of end-users. In this respect, it is very positive that the GSA is actively involved in engaging users in the identification of user requirements through its Strengthening User Networks for Requirement Investigation and Supporting Entrepreneurship (SUNRISE) initiative.[100] This raises the question as to whether and how Europe could use this capacity in the long run by leveraging it into an ICG context so that European users and other users worldwide can be involved in the formulation of requirements for the global coordination of GNSS constellations.

3.1.3 Validating Benefits at the Policy Level

In parallel to the optimisation of socioeconomic benefits downstream for citizens, enterprises and governments at national and local level, it is also crucial that the European Union reaps the full potential of Galileo and Copernicus services for its more strategic policy objectives. Such benefits generally rely on more hybrid forms of GNSS and EO capabilities and they are more centralised within the European institutions.

Since the EU consists of different institutional actors, the roles the operational programmes can fulfil play out differently in each case. For the European Commission the relevance is mainly in the areas of policy monitoring and reinforcement and the identification of needs for new actions to achieve EU objectives. For the European Parliament, as for the EC, the operational flagships in space could also be helpful in identifying needs and proposing related policies based upon state-of-the-art and updated information in a whole range of fields such as, for instance, security, environment, energy, resources and mobility. For the European Council and the Council of the European Union, the constellations will be relevant for the evolution of EU mandates over time, for instance in the areas of foreign affairs and the common defence and security policy.

For this to materialise in an optimal fashion, the operational programmes must be able to feed information back to the political level. More specifically, the question to be asked is how the possibilities opened up by both systems, both individually and jointly, can be communicated clearly to the political level, including: the President of the European Council, the High Representative of the Union for Foreign Affairs and Security Policy, the relevant EU Commissioners, the Members of the European Parliament, National Ministers of the European Council and the Heads of Government/State of member states). Up to today, the programmes have witnessed a development that has been mainly politically driven since they were conceived and approved by politicians based upon the general

[100] "About SUNRISE" SUNRISE 16 Dec. 2014. Web. http://www.sunrise-project.eu/index.php/about-sunrise

needs they had identified as described in the previous chapter. As the programmes are becoming operational, it would be beneficial to bring more clarity to politicians on the following technical and practical specificities: (1) which policy related support functions are currently being served by use of the data from the flagship programmes (2) which policy related support functions have become possible by using the data and services provided by the flagship programmes in space (but are not yet in place), (3) which policy related support functions are not possible due to the architecture of the current constellations, (4) what might become technically possible in future generations and, (5) what cannot ever be provided by space-based infrastructure in the fields of GNSS and EO. Doing so would ensure that policy actions enabled by the operational Galileo and Copernicus constellations will find their way more easily to the political level where decisions are made, and that more opportunities are identified overall, which in turn increases the benefits derived from the systems.

3.2 Creating an Innovative Ecosystem for Operational Services

From an overall perspective, Galileo and Copernicus will be able to cover the fields of GNSS and Earth Observation with state-of-the-art capabilities. Therefore, no dedicated new programmes will be necessary for either domain. But there will be questions as to how best to ensure programme evolution, especially because both will be operational constellations with a long term outlook and thus follow-up generations of infrastructure.

As opposed to the channels for benefit optimisation discussed in the previous section (which are concerned with the current potential of the flagship programmes), the innovation dynamic underlying the constellations focuses on the long term. From a sustainability perspective, it should be ensured that both flagship programmes are able to evolve and increase in performance over time and that they become an engine in spurring strong, diverse and competitive GNSS and EO sectors in Europe. Without proper avenues for moving in this direction, the constellations risk becoming obsolete and Europe would no longer be in a position to reap the full socio-economic and political benefits of Copernicus and Galileo. Clearly, the partners involved in the establishment of both programmes are highly aware of the importance of innovation and are using their expertise to keep Europe at the forefront of technological development in these fields. The point is, however, that for programmes of this order of magnitude the innovation strategy should be developed in a holistic fashion in which the different components – which are managed by different actors – are properly attuned. The latter implies that each component within the innovation ecosystem disposes of a critical mass and that the right channels for interaction with other components are established.

3.2.1 The Components in an Innovation Ecosystem

To see how this plays out in operational public programmes of this size and with such a potential impact, one should distinguish the four components in an innovation ecosystem based upon the actor pursuing innovation (top-down versus bottom-up) and the segment in the value chain (upstream or downstream). This gives rise to a matrix that is displayed in table 6 below.

	Top-Down Approach	**Bottom-Up Approach**
Upstream Segment	Innovation for new infrastructure, hardware or system configurations planned and managed by the system's (co-) proprietors.	Innovation performed by the private sector and users on the constellation's infrastructure, hardware and components or additional hardware using its output.
Downstream Segment	Innovation for new services and applications planned and managed by the system's (co-) proprietors.	Innovation performed by SMEs and users on services and applications based on the constellation's output.

Table 6: Innovation Matrix Based upon the Type of Actor and Segment in the Value Chain.[101]

Top-Down Innovation in the Upstream Segment

The upper left box in the table refers to the kind of innovation concerned with the upstream segment of the value chain that is pursued on a top-down basis. It is top-down in the sense that its planning and execution processes are decided and managed by the

[101] Authors' own visualisation.

actors responsible for the provision of the flagship programmes and therefore it is situated in the institutional sphere. In the case of GNSS and EO, this type of innovation is taken care of mainly by ESA. More specifically, the Agency runs an optional Earth Observation Envelope Programme through which it takes care of the development and launch of new types of EO spacecraft that meet the needs of the scientific community and by which it takes care of all general preparatory activities for future EO missions.[102] This programme is not specifically focused on innovation for Copernicus per se, but the innovation in terms of remote sensing technologies to which it gives rise might eventually, over the very long term, be included directly or indirectly in the programme's constellation. ESA's European GNSS Evolution Programme undertakes R&D intended to sustain, evolve and broaden GNSS-related technological know-how in Europe and prepares the replenishment, evolution and upgrades of the European EGNOS and Galileo constellations to meet future needs, as identified in coordination with the EC and other stakeholders.[103] This type of centralised and planned innovation is essential for the programmes' long-term evolution for two reasons. First, ESA has the level of expertise to develop technology demonstrator missions and test them well before they eventually translate into components of the operational constellations. Second, the Agency's scope enables it to continuously evaluate the systems' overall architecture and to define, steer and implement structural changes over the course of multiple generations of satellites.

Top-Down Innovation in the Downstream Segment

The lower left quadrant in the matrix regards innovation in services and applications taken care of by the institutions that manage the flagship programmes. In the case of Galileo this task is mainly fulfilled by the GSA, which – as indicated in the previous section – oversees the provision of the four predefined Galileo services and manages and outsources R&D activities related to new applications and services. For Copernicus the situation is different. In terms of the operational governance tasks provided under the auspices of the EC, some major steps have been taken including the distribution of operational tasks among different service providers. Still, there seems to be an understanding within the European EO community that more action is required to ensure strong innovation potential in the evolution of the Copernicus services. One of the main reasons for this concern goes back to the high degree of decentralisation, as discussed in the previous section on the maximisation of socioeconomic and political benefits. Since there is no central operational authority that can pull the threads together, much of the tacit knowledge related to operational activities and the daily interaction with users would not be captured in a holistic fashion. In turn, this complicates continuous evaluation of the services on a fully informed basis, and might result in the opportunities for new or hybrid services in the future being left unidentified or designed with an incomplete scope.

Bottom-Up Innovation in the Upstream Segment

The upper right quadrant in the table, which refers to the bottom-up innovation in the upstream segment, deals with technological innovation created by parties other than systems' proprietors. This type of innovation is not necessarily only directly related to the technical innovation in the flagships constellations. In fact, it is mainly relevant for creating an overall environment for innovative EO and GNSS sectors in Europe. In terms of actors the most direct example in this category is private sector involvement but, to a certain extent, some academic research is also working through this bottom-up approach. From an overall perspective, Europe has a fair number of innovative space hardware manufacturers performing R&D activities on GNSS and EO satellites and components. As these are relatively new sectors and thus are still maturing, however, some elements are still of concern, as described below.

In Earth Observation the trend towards commercialisation in the manufacturing industry in Europe – which is essential in creating an innovative ecosystem – started taking hold in the 1980s, after operational activities in the field of imaging were leveraged to the (semi-) private sector. The growing commercial and institutional demand for EO in turn instigated market reforms as a result of which many companies became subsidiaries, merged or became part of consortia. Consequently, Europe's three major System Integrators (Airbus Group, Thales Alenia Space and OHB) now manage diverse portfolios, all of which include intense R&D activities in the area of remote sensing technologies. In fact they are strongly involved in the Copernicus constellation, either by manufacturing and integrating components, or by providing Copernicus-qualified contributions to the system from other sources. In spite of the strong

[102] European Space Agency, European Space Technology Master Plan 12th Edition. Noordwijk: ESA Communication Production Office. 2014.
[103] *Ibid*.

European involvement in EO hardware innovation, a remaining issue is that Small and Medium-sized Enterprises (SMEs) remain fairly underrepresented and far from reaching their full potential. This is due to a number of entry barriers. Entry barriers are a general issue in the space industry. A couple of years ago, it was estimated that of the 700,000 SMEs in Europe that are developing high technology, only about 1600 are registered with ESA as potential suppliers.[104] Although it is very hard to assess the overall situation accurately because of the complexity in the added-value chain with its mix of contractors, subcontractors and suppliers, it demonstrates a recognised need for increased SME involvement in space. For remote sensing a reinforcing element is that most EO hardware consists of space qualified components and therefore is less conducive for mass production – as opposed to GNSS receivers or satellite telecom and broadcast devices. Still, the market dynamic for SME involvement is changing for the better. First, the market for Earth Observation services and applications is growing at a steady pace and this trend is expected to persist for the foreseeable future. Second, the miniaturisation trend in remote sensing technologies will bring the manufacturing process of EO satellites within reach of more SMEs, both in terms of the scope of engineering and cost. At the same time, these Nano-, Pico- and Femto-satellites will often fly in constellations with a higher number of satellites, which reduces the necessity of large system integrator involvement, and makes it possible for multiple SMEs to manufacture small satellites in parallel. From an innovation point of view, this development is highly desirable and should therefore be fostered. As new types of EO infrastructure and capabilities complement the current middle and large scale R&D missions and operational systems, technological diversity within the remote sensing sector will increase and more cross-fertilisation between systems and their output will arise. Also the increasing importance of smaller missions (in terms of satellite price, mass and size) will impact how innovation is done, since it means that production cycles will become shorter. This makes it possible to narrow the gap between terrestrial and space-based technology innovation, make it possible for needs to be addressed faster and, it might increase the number of innovation iterations over a given time. Finally, the number of players within the market for EO manufacturing will increase as a result of the overall increase of innovation. For these reasons the upstream segment will require a stronger SME involvement in the European EO sector.

In the field of GNSS the upstream market segment too is mainly taken care of by the large system integrators. The innovation dynamics in this area of satellite navigation, however, play out differently compared to EO. The space segment of Galileo, being an integrated constellation of similar satellites, is much more characterised by monolithic systems and thus less modular in structure than the Copernicus constellation – in which additional or new components can be changed, updated or added. Therefore SME involvement in space hardware manufacturing will remain more relevant for subcontracting, and less for the creation of fast-paced innovation in additional independent space systems. The European Commission is aware of the limited room for manoeuvre in terms of innovation and is trying to address it in a more indirect fashion. In January 2010 the EC awarded the contract for the first 14 Galileo satellites within the frame of initial operational capability. The EC stated that the procurement of the Galileo satellite series would be done in tranches and that the winner of each tranche would be selected based on which company provides the best value for money. At the same time, however, the EC also added that it would follow a strategy of double sourcing so as to lower risks in terms of delivery timing and, at the same time, increase flexibility. By doing so, the EC is pursuing a procurement strategy that favours industrial diversification as part of its industrial policy of competitive dialogue. The latter assures that over time multiple large system integrators will remain involved in the development of GNSS technologies and therefore Europe will draw on diverse innovation channels. This centralised innovation of GNSS upstream technologies is in strong contrast to the decentralised innovation dynamics further downstream.

Bottom-Up Innovation in the Downstream Segment

The downstream bottom-up approach is part of the lower right quadrant, which refers to innovation created by the private sector in applications and services. The increasing demand and use of satellite navigation signals has spurred development in the manufacturing of GNSS chipsets, devices and services and content in Europe. As a result this sector is maturing at a very fast pace and competition and product innovation have increased significantly over the last decade. According to a GSA study on the GNSS market, this trend is expected to continue and a

[104] "Improving SME Participation in Europe's Space Business" 4 Apr. 2007 European Space Agency. 11 April 2015. http://www.esa.int/About_Us/Industry/Improving_SME_participation_in_Europe_s_space_business/%28print%29

result, Galileo will be able to offer added value in the growing GNSS market segments of location-based services, road, aviation, rail, maritime, agriculture, and surveying.[105] The commercial potential of GNSS services and applications and the related hardware have strongly spurred the downstream private sector in Europe. A database compiled by the GSA reveals strong pan-European SME involvement and capabilities within component manufacturing, value added services and system integration, ensuring that GNSS signals can be used in daily activities and for a whole range of socioeconomic activities.[106]

In Earth Observation, the markets for products and services are perhaps more segmented and structured around more differentiated types of use. The largest players in this field are mainly private and active in imagery. This trend of commercialisation in remote sensing, which took off when the French space agency CNES founded SPOT Image in 1982, has now resulted in a number of operators with constellations that can offer high resolution imagery from orbit to institutional and private players in Europe and beyond. Most notable providers in this respect include Airbus Defence and Space (which now operates the SPOT satellites and is the exclusive distributor of data from the very-high resolution dual use Pleiades satellites), the German company BlackBridge AG, a geospatial information company using its SSTL-built satellite constellation to deliver rapid scanning services, and DMC International Imaging, an SSTL-owned company managing the Disaster Monitoring Constellation serving the International Charter for Space and Major Disasters. Thanks to digitalisation in remote sensing technology and society in general, more companies are now integrating and processing data from different sources to offer added value geo-information services and consulting. Although a number of European companies are active in this area and have interesting growth perspectives, in Europe as a whole has there is still room for further improving the exploitation of investments in this area in terms of mass market penetration and turnover – especially when compared to the EO services and applications industry in the United States. Although according to a 2015 EARSC paper European companies and actors should not necessarily try to copy the business models of American players in this respect, it suggested that Europe should leverage Copernicus more and improve the public-private interface, optimise the existing approach of research and development in EO and, increase awareness and understanding of the potential of EO data and services so as to restructure the market and stimulate further user uptake.[107]

3.2.2 The Flows in an Innovation Ecosystem

In addition to having both critical mass and capabilities in each segment as described above, it is also necessary to ensure that technological innovation and the information required hereto can flow easily between different actors and segments. This gives rises to hybrid forms of innovation that are more open, less stove-piped and thus combine the best of many worlds. To this effect proper mechanisms to make the borders between the quadrants permeable need to be present.

In many respects communication between the different types of actors works very well. The biggest challenge is to make communication between industrial and scientific actors and the system proprietors more effective. This requires draw-in mechanisms, i.e. how well can the institutional players involve, or take into account, the private players and end-users in their top-down innovation planning processes. Thus a crucial issue in terms of the flagship programmes is how operational user experiences and user requirements can be formulated, gathered and communicated to the (co-) proprietors of Galileo and Copernicus in a transparent and efficient way. Time is both an essential driver and constraint in this respect.

Galileo will start offering its first services from 2016 and full completion of the system in its 30-satellite configuration (24 operational and 6 active spares) is expected by 2020. With an expected individual satellite lifetime of over 12 years and the first satellites of full operational capability having been launched in 2014, a new generation of satellites should be placed in MEO around the mid-2020s. Because of the considerable lead-time, the European Commission has therefore now started the process of reflection on the requirements for Galileo Second Generation. More precisely, the Research and Technology Development phase is currently taking place, consisting both of mission and system evolution. By the end of 2015 or early in 2016, a decision regarding the second generation is

[105] GSA, GNSS Market Report, Issue 4 – March 2015.
[106] For a complete overview, see: GSA Database Public with Descriptions, online: http://www.gsa.europa.eu/sites/default/files/GSA_Extract_database_public_with_descriptions.xlsx
[107] "European Geospatial services: Developing the Private Sector Capability" April 2015 European Association of Remote Sensing Companies. 4 May 2015 http://earsc.org/file_download/238/EARSC+views+on+downsteam+development+final.pdf

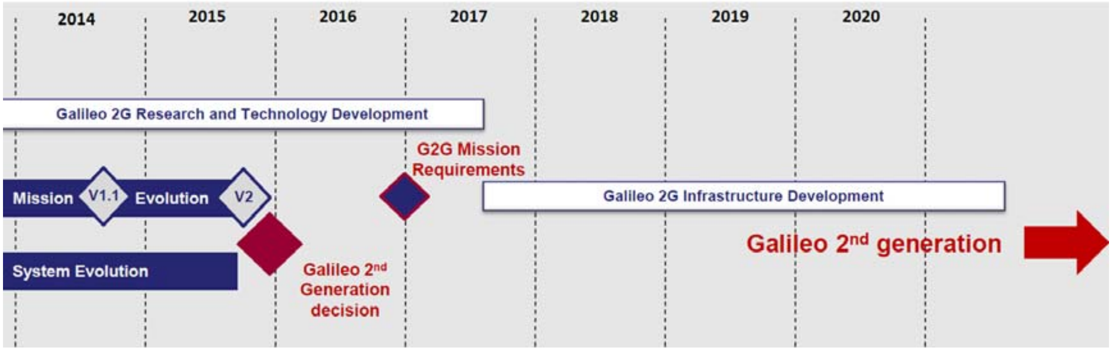

Figure 2: European GNSS Evolution.[108]

expected, which should then be translated into concrete mission requirements by 2017, paving the way for the infrastructure development phase afterwards.

The task of organising user communities and interacting with them on a structural basis was assigned to the GSA, which undertakes a number of activities with this objective. Supported by FP7 funds, the GSA is building user communities in a number of ways, including:[109]

- By uniting key stakeholders in specific user groups represented through user forums;
- By encouraging these stakeholders to cooperate in order to collect, consolidate and share views and formulate requirements;
- By encouraging users to issue advice and recommendations to the GSA and the European Commission on technical issues, business development, regulation and standardisation;
- By creating a European network of GNSS based innovation initiatives in certain application areas such as agriculture.
- By supporting the development of a Galileo "applications store", which can be found at: http://galileo-apps.sunrise-project.eu/

This integrated approach with regard to community building among users and user groups has a number of particular benefits in terms of innovation. First, it makes the users more connected and better networked, which is essential in creating an innovation ecosystem that is characterised by intense interaction and exchange of information. Second, it makes the users' voices more heard while at the same time stimulating a process of convergence within the community. The latter makes it easier for the EC (and ESA) to incorporate user requirements into the design of later generations of constellations and in the development of new applications and services.

For Copernicus, drawing-in downstream requirements to plan for innovation and later generations of Sentinels is slightly more complex because of the involvement of a number of proprietor institutions and organisations and the greater diversity of the space component. The consultation of Copernicus' data users and user communities for the purpose of involving them in the requirement gathering processes is also funded through several FP7 programmes. Still, the situation is quite different from the approach taken in GNSS. Because of the high degree of decentralisation among the operators of different Sentinel satellites and the services provided, the mechanisms for user involvement are also diffuse. For the programmes dedicated to atmosphere, climate and marine monitoring, efforts that are currently managed through FP7 initiatives will be merged into the Partnership for User Requirements Evaluation (PURE), a programme managed by EUMETSAT for the EC. For imagery and radar the EC has decided to outsource the user requirements guiding processes to industry through ITTs rather than leaving it with ESA, leaving the ESA role somewhat undefined and putting industry in a potentially compromised position.

Issues arise as a result of such a decentralised gathering of user requirements. Since the systemic integrity of the system must be guaranteed when reconciling new and existing continuity requirements, a decentralised method of gathering them risks thwarting the definition of overall system priorities and the constellation's composition in the long term. The structural segmentation also creates a barrier for the many users that have transversal requirements. The presence of a cen-

[108] Zegers Tanja, "EGNSS Evolution, infrastructure related R&D activities" Presentation. Horizon 2020 Space Info Day. Vilnius, Lithuania. 12 December 2013
[109] *Ibid*.

tral operational authority would be able to address the management challenges that result from this high degree of decentralisation, but, as was indicated earlier, a cohesive central authority is not yet present in the Copernicus programme architecture. This absence impedes a proper flow of information from the users to the institutions that take care of the technical, managerial and operational components in Copernicus. Moreover, a cohesive operational function would help a great deal in managing and supporting the commercialisation of applications and the general creation of benefits – acting as a centralised node in the entire EO ecosystem.

Setting the stage for the next generation of Copernicus infrastructure in the right way, making sure that users and those closest to the users are involved in the decision-making process in the best possible manner, is urgent. The benefits of Copernicus are for today and for tomorrow. To optimise both requires fresh thinking and new structural approaches. How this can be done is the purpose of the ESPI Report "Optimising Europe's Benefits from the Copernicus Programme", published in April 2015 - its recommendations remain valid.[110]

A second essential flow for innovation optimisation is determined by the amount of demand pull; the different market support mechanisms for R&D in applications and services set up by the institutions that own and operate the Galileo and Copernicus constellations. For GNSS the dynamics of commercial markets are more conducive for strong innovation. In contrast, the market for EO applications and services is still young and thus fragile, and therefore governmental initiatives have a role to play in ensuring private sector growth. Over time this stimulation should result in a mature EO sector which should be in a better position to link to the GNSS (and other) sectors, ensuring that both have enough critical mass to become self-sustaining entities within their respective ecosystems. In this regard several initiatives have been established in Europe. ESA has taken an important step by means of its ARTES 20 initiative: the Integrated Applications Promotion (IAP) programme. IAP fosters the use of multiple space assets in order to create new solutions and as such is exactly aiming at the creation of space related services and applications in many areas, including GNSS and EO. In addition to this, the EC has established a number of initiatives. In satellite navigation, the Horizon 2020 programme uses simplified rules, managed by the GSA, to provide opportunities for the development of applications for use with EGNOS and Galileo.

For the Geo-Information service industry some issues remain of concern. As indicated in the table on the Copernicus Services at the beginning of this chapter, the EC has delegated the authority of procurement for the different services to various "entrusted entities" in the European institutional landscape. This approach was intended to make the development and implementation processes efficient by making best use of the technical knowledge and competences in Europe. From an effectiveness point of view, however, it is questionable whether the road taken so far will result in strong stimulation of the downstream EO sector. In a position paper published in September 2014, the European Association of Remote Sensing Companies (EARSC) expressed its concerns in this respect.[111] It stated that without clear guidance and imposed rules, strong private sector involvement, and especially by SMEs, will become unlikely in current circumstances. It recommended that the procurement of Copernicus Services should be able to benefit from all European strengths: public, private and academic and that to this effect specific measures needed to be introduced in terms of harmonisation and stimulation of bidding by more actors. By this approach the EC should be able to create hybrid services in which different actors can leverage their strengths and expertise to produce more innovative services that benefit both the public and private sector, and the European public.[112]

[110] Allgeier, H., Eyres, H., Gibson, R., Hulsroj, P. and Lahcen, A. "Optimising Europe's Benefits from the Copernicus Programme: Addressing the Structural Gaps in Operational Earth Observation" ESPI Report 50. April 2015.

[111] EARSC Position Paper "EARSC Views on the Procurement of the Copernicus Services" – September 2014, http://earsc.org/file_download/211/Copernicus+service+procurement+final.pdf

[112] *Ibid*.

4. Towards a New EU Flagship Programme in Space?

With Copernicus and Galileo slated to become fully operational in the near term, institutional room will arise to contemplate new EU flagship programmes in space. Considering the long lead time from conception to operations and the EU desire to get involved more strongly in outer space, it is advisable to initiate reflection and discussion on the possible options soon. This chapter elaborates on the possibility and opportunity for the European Commission to extend its involvement in outer space beyond Earth Observation and global satellite navigation by means of a new flagship programme. First, it debates the case for and against the initiation of a new programme. In doing so, it also explains the generic characteristics of EU flagship programmes. Subsequently three different candidates for flagship projects are defined, discussed, and assessed.

4.1 Debating a New Flagship Programme

Before addressing the different options for a new EU involvement in space, the question should be raised whether the EU should go down the road of a new flagship programme at all. After all, the financial and administrative difficulties that have surrounded the execution of the Copernicus and Galileo programmes have cast serious doubts on the viability of the flagship model. Indeed, flagship programmes are complex undertakings that require prolonged political support and financial commitment at the highest levels, both at Member State and at EU level. This implies that new EC initiatives in space should provide demonstrable net benefits for Europe and that those benefits would be difficult, if not impossible, to achieve in a more effective way with other actors. In other words, more EC involvement in outer space is not necessarily a given and will have to be justified substantively. That said, it should be noted that the EC is an actor that is able to leverage political clout and critical mass and that therefore it is very well positioned to take up a leading role in certain scenarios. In order to see whether this would be true for new scenarios of involvement in outer space, the specificities and context of new flagship candidates have to be explored in more detail.

For Galileo and Copernicus the benefits of EU involvement in the establishment of operational services were fairly clear and straightforward in nature. As illustrated in the previous chapter, investments in the fields of GNSS and operational EO suit the socioeconomic needs associated with EC's many policy domains. An additional element that supported those specific choices is that their development would in turn spur the development of industrial capabilities, expertise and non-dependence in these areas. Until the initiation of Galileo, Europe had not developed much technical expertise in the area of satellite navigation systems. In the case of Copernicus there was a lot of expertise present in the European institutional landscape and the private sector, but the introduction of broad-based operational EO monitoring services would increase demand – further spurring what was already becoming a growing sector with a lot of innovation potential. Another important fact was that both programmes are operational in nature and as such they would fall outside ESA's normal mandate of research and development. All these elements pointed to EC involvement in terms of mandate and expected socioeconomic, strategic and political benefits.

The surrounding context and driving forces for possible new flagship programmes will be different from those in the current ones, however. Before one can see how this would play out, a more general question should be addressed. Namely, which elements specifically constitute an EU flagship programme? In answering this question the focus should be on the generic features that would apply to any flagship programme within an EU context. Although the term "flagship" is an adjective used in EU documents and programmes of diverse kinds, the concept has never been explicitly defined in an EU policy context. In fact, the use of the term flagship in the EU context is not limited to projects and programmes only. The European Commission also defines a number of "flagship initiatives", the thematic focus areas on the broader level around which its programmes are structured.

In terms of funding, like many other significant programmes, space is categorised as part of the Research and Innovation Policy. The space budget is placed in the commitment appropriation "Competitiveness for Growth and Jobs", which is in turn part of the "Smart and Inclusive Growth" section of the Multiannual Financial Framework, in which space has acquired a growing importance over time. Currently, budgets for space activities are provided under Framework Programme 8, also known as Horizon 2020.

In a generic sense, flagship programmes address grand scientific and societal challenges, which require a common European research effort and sustained support for a development period of at least ten years. They represent science-driven, large-scale, multidisciplinary research initiatives oriented towards a unifying goal, which is expected to have a transformational impact on science and technology and substantial benefits for European competitiveness and society. The goals of such initiatives are visionary and highly ambitious in terms of scientific challenges, resources required and coordination of efforts. In terms of implementation and operations, they require cooperation between a range of disciplines, communities and programmes, including national and European initiatives. In this respect they are typically established through partnerships that enable effective coordination of joint efforts feeding the whole value-chain and boosting European innovation.[113]

There is a considerable difference between non-space and space related flagship projects. Whereas in general R&D projects in the EU can receive flagship status if they match a number of strategic criteria,[114] the flagship projects in space – together with some other wide-scope initiatives – have grown much more from a top-down perspective. There are multiple reasons for this centralised approach. First, flagship programmes in space are not only objectives, they are – in the first instance – means to support the EU in the creation, monitoring, evaluation and enforcement of many of its policy domains. Second, space programmes– in contrast to some other flagship programmes – have a special status in that they generate capabilities that serve strategic purposes that also have security implications and thus in turn help the EU in strengthening its role as a global political actor. Therefore, involvement and capacity development in this field is something to be considered carefully and in a sensitive way.

4.1.1 Flagship Constituencies

In the following, parameters that should ideally be served through the establishment and/or operations of a new flagship programme are described. These parameters will later be used as benchmarks to assess and compare the relevance of potential flagship candidates. All parameters are captured in Table 7, which makes a distinction between economic and social benefits on the one hand and, strategic and political benefits on the other. The first category comprises the parameters that relate to the generation of more tangible benefits and how citizens, commercial companies and governmental actors throughout Europe would enjoy them. The second category contains indicators that are less tangible in terms of monetary value but are crucial in that they capture degree to which the benefits would propagate through the web of EU policies and interests. In this sense they are benefits that would mainly – or even entirely – arise as a result of explicit EU involvement and thus they are important in assessing whether further EU involvement in space through flagship programmes would be a sensible decision. It should be noted that the distinction between the two categories is not absolute as certain parameters of one category also have features of the other. This, however, is not necessarily problematic for the assessment because the benefits are not added-up, merged or calculated. Rather, they are illustrated and assessed in a comparative and narrative fashion.

Based on the above, the following sections will discuss whether and to what degree future candidates for EU flagship programmes in space can be identified. For the practical purpose of this study three potential candidates were selected: (1) Space Exploration, (2) Access to Space and, (3) Space for Security. This selection is based on a number of interrelated considerations. First, all three candidates– together with the current flagship capabilities – are part of every comprehensive space programme as pursued by major geopolitical actors worldwide. Therefore they would reinforce the political objectives the EU has set for its space ambitions, namely the creation of a "European space programme". Second, in all three cases– to a certain extent at least – there is room for added value generated by EU involvement that could not be fully brought by an inter-

[113] European Commission. "Future Emerging Technology – FET Flagships". European Commission Directorate General for Communications Networks, Content and Technology. Brussels. 2013.

[114] For an overview of the requirements, funding conditions, and procedures for the submission of flagship projects see FFG "Technical Guidelines for Flagship Projects". May 2013. https://www.ffg.at/sites/default/files/dok/guidelines_flagship_projects_v20.pdf

governmental approach. Third, exploration and access to space were already identified by European Union institutions as areas in which Europe could be interested in taking on a leading role or at least expanding its current role. Finally, the rationale for an EU involvement is different in each of these domains. For all three candidates the following sections will describe their current status, as well as the possible rationale for EU involvement by means of a new flagship programme.

Economic and Social Benefits
Bring benefits to a large number of users in society and the economy.
Support diverse segments and regions of European society and the economy.
Become a tool in spurring economic growth in the long run.
Contribute to making the European scientific research and engineering communities more productive and efficient, and establishing new networks.
Strategic and Political Benefits
Give Europe a strong or leading role in the domain and offer a cutting-edge advantage.
Serve geopolitical objectives: autonomy, non-dependence and strengthen EU international presence.
Advance Europe's diplomatic goals and support the foreign policy action of the EU.
Enable the EU to become more competent in addressing a range of policy needs.
Drive advances and innovation in science, technology, engineering and programme management.
Stimulate European integration.
Create a strong European brand that could stimulate a European sense of identity and citizenship.

Table 7: Parameters for Flagship Constituencies.[115]

4.2 Identifying Potential Candidates: Space Exploration

With the EC already actively involved in several aspects of the policy planning process, space exploration appears on paper to be the most favoured candidate for a new flagship programme.[116] The commitment of the Union to playing a more active and visible role in international space exploration initiatives is rooted in a number of EU-ESA Council Resolutions and EC Communications, all of which consider space exploration as one of the main priorities for the European Space Policy. The case for the inclusion of space exploration within the space mandate of the Commission has been reinforced by the EC's Space Advisory Group (SAG), which in 2010 issued a policy proposal strongly recommending the introduction of Space Exploration as a new European Flagship programme for the 2014-2020 period.[117]

4.2.1 Status of Europe's Space Exploration Programme

Europe has a rich and longstanding tradition of space exploration, be it with robotic or manned missions. Over the past 40 years, European activities in this field have been mainly led by the efforts of ESA, in addition to those of several national space agencies. ESA has embarked on several successful programmes on its own or in partnership with other space agencies (SMART-1, Mars Express, Venus-Express, Cassini-Huygens, Rosetta, etc.), gaining key competences and demonstrating that it is a trustworthy partner in large space exploration endeavours. In the manned spaceflight field the significant contributions provided by Europe to the ISS programme such as the Automated Transfer Vehicles (ATVs), the Columbus Orbital Laboratory and other ISS infrastructures elements like the Node 2, the Node 3,[118] the Cupola – and the European astronaut corps – should be mentioned. Importantly, all these activities have created an excellent "heritage" permitting serious consideration of future European involvement in human missions beyond LEO. An additional and complementary asset for Europe is the wide and robust

[115] See, among the others, European Commission. "Future Emerging Technology –FET Flagships". European Commission Directorate General for Communications Networks, Content and Technology. Brussels. 2013. Space Advisory Group of the European Commission. "Space Exploration, a new European flagship Programme. European Commission Framework Programme 7 – Space Theme. 10 October 2010.

[116] Within this report, the term "space exploration" is used to indicate both robotic and human activities for the discovery of extra-terrestrial environments.

[117] Space Advisory Group of the European Commission. "Space Exploration, a new European flagship Programme. European Commission Framework Programme 7 – Space Theme. 10 October 2010.

[118] The Node 3, also known as Tranquillity, although not a European module, was built for NASA by ASI.

network of cooperative relations ESA has built through the years with all other space actors worldwide, which has put Europe in a strong position to promote and harmonise broader international initiatives in space exploration.

As noted by several analysts, European successes and reliability as a partner can to some extent be explained by the different nature of the objectives it has pursued in its space programmes: unlike other leading space nations that have made space exploration a national priority to suit political and strategic agendas, European space programmes have been traditionally science-based and technologically-focused with little political concern. This pragmatic approach has in turn typically protected public funds and space projects from the political volatility experienced in other countries.[119] However the programmatic stability typically ensured by this approach has not allowed Europe to take the next step and pursue even more ground-breaking initiatives, such as an autonomous human spaceflight programme.

That Europe aspired to become the third space power, after the USSR and the US, to have an independent human spaceflight capability is evident from the plans for the development of the Hermes space-plane adopted by the ESA Council in November 1987. In 1992, however, the programme was terminated due to the lack of solid financial and political backing: no Hermes shuttle was ever developed and the ambition to possess independent human space transportation capabilities was put on hold indefinitely.[120] As a result, Europe depended on NASA's Space Shuttle and Roscosmos' Soyuz to launch its astronaut corps. ESA utilisation of the ISS currently comprises a number of experiment series in medical, biomedical and physiological sciences that are also intended as preparatory activities to pave the way for future human spaceflight beyond LEO. In this regard, ESA is making progress in the study and development of the EXPErimental Reentry Testbed (EXPERT) and of the Micro-Ecological Life Support System Alternative (MELiSSA).

Ambitious new plans for a European space exploration programme re-emerged in 2001, with the presentation of the Aurora programme at the ESA ministerial Council in Edinburgh. The objective of the Aurora programme was to formulate and then implement a European long-term plan for the robotic and human exploration of the solar system. The programme was intended as the European building block in a broader international effort for the robotic and human exploration of Mars, with the Moon as an important stepping-stone.[121]

The long-term vision embedded within the Aurora programme was to be derived from the human spaceflight experience on the ISS and the development of robotic planetary exploration. While the former was to be continued and enhanced so that human spaceflight could be extended beyond LEO, the latter was to be pursued throughout the Aurora Programme with the aim of extending capabilities towards larger spacecraft, suitable for exploration of the solar system. According to ESA, the intertwined development of capabilities in the two strands would have eventually resulted in Europe being able to play a key role in a future international human mission to Mars.[122] The proposed roadmap was rather ambitious and contemplated a number of robotic missions as well as a human mission to the Moon to demonstrate key life support and habitation technologies, as well as aspects of crew performance and adaptation, and *in situ* resources utilisation technologies.

Of this ambitious plan, however, only the *ExoMars* mission – an exobiology mission to send a rover to Mars to search for traces of life and characterise the nature of the surface environment – was formally approved at the ESA Ministerial Council of December 2005. This mission has subsequently been much delayed (also due to NASA´s withdrawal), redefined as two missions, and is currently being implemented in collaboration with Roscosmos and slated to launch in 2016 and 2018.[123] As for the human part of the pro-

[119] Thépaut, Jean-Baptiste. "Analysis of Cooperation Opportunities for Europe in Future Space Exploration Programmes (COFSEP)". IAC-12-A3.1.3. Naples.2012.

[120] Hermes was to have been part of a manned space flight programme and would have been launched using an Ariane 5 launcher. The project, as approved in November 1987, had an initial pre-development phase from 1988 to 1990, with a green light for full-rate development depending on the outcome of the phase. The project suffered numerous delays and funding issues. It was cancelled in 1992 since neither cost nor performance goals could be achieved.

[121] Messina, Piero; *et al*. "The Aurora Programme: Europe's Framework for Space Exploration". ESA Bulletin No. 126 May 2006.

[122] European Space Agency. "Aurora Roadmap to Mars". 19 December 2003. Web. http://www.esa.int/Our_Activities/Human_Spaceflight/Exploration/Aurora_s_roadmap_to_Mars

[123] The 2016 mission will carry the ESA-provided Trace Gas Orbiter (TGO) and the Entry descent and Landing Demonstrator Module (EDM), and will be launched by a Russian Proton launcher. The 2018 mission will consist of an ESA-provided Carrier Module, bringing the Russian Descent Module and Surface Platform and the ESA Rover to Mars. The Rover will investigate the Mars surface searching for past and present signs of life. The scientific

gramme, this was not sufficiently backed with high-level political commitment (and financial support) and did not move beyond the study phase of the Crew Space Transportation System (CSTS).[124]

With the Aurora programme placed on the back burner, ESA's efforts have been directed to RTD activities intended to prepare the European participation in future exploration missions. Three different programmes – subscribed by Member States on an optional basis – in particular constituted ESA's core focus: the European Life and Physical Science Programme (ELIPS), the European Transportation and Human Exploration Preparatory Activities (ETHEP), the Exploration Technology Programme (ETP).[125]

While awaiting a new political commitment for the implementation of more ambitious programmes, the Agency has promoted exploration through a paradigm of "interdependence and partnership". In addition to the two *ExoMars* missions, this approach is also evident in the agreement with NASA to develop and supply the Orion Multi-Purpose Crew Vehicle (MPCV) with the ATV-derived Service Module, which will provide the spacecraft with propulsion, power and thermal control.

A new political impetus towards the elaboration of a long-term vision for space exploration has been gradually emerging thanks to the increased involvement of the EU. Starting with the adoption of the European Space Policy in 2007, the EU has increasingly acknowledged the political dimension of space exploration and thus the necessity to become more actively involved in this domain in order to ensure a higher degree of political visibility of space in Europe and of Europe in the global arena.

Although the Union in 2007 identified satellite systems and applications – specifically Galileo and Copernicus – as its policy priority areas, the expansion of its mandate over space matters sanctioned by the Lisbon Treaty has eventually influenced the Commission to consider a possible contribution to space exploration and to provide political backing for its development. In May 2009 the Space Advisory Group (SAG) of the EC formed a Subcommittee on space exploration (SAG-SP) with the aim of providing expert advice to the Commission on Europe's future role in a global space exploration strategy. The group recommended that the EU should take a central role in order to ensure the success of future European space exploration.[126]

A first important step in this direction was taken with the organisation of the first EU-ESA Conference on Human Space Exploration, which was held in Prague in October 2009. On that occasion, Ministers expressed their support for a major financial investment in space exploration and agreed on the need for active EU involvement in this domain to ensure an appropriate political profile and financial framework.

A second ESA-EU Conference was held in Brussels in October 2010, co-organised by the EC, the Belgian Presidency of the EU, Italy (as the Chair of the ESA Ministerial Council) and ESA. Among its major conclusions, the conference identified the need for policy discussion at international level and thus called for the organisation of a first meeting of an international, high-level space exploration platform, in which future directions and cooperation schemes could be discussed.[127]

Accordingly, the third Space Exploration Conference transformed the proceedings into a high-level global discussion involving 28 countries. To highlight this evolution, the conference was renamed the First High-Level International Exploration Platform. The first meeting took place in Lucca in November 2011, while a second conference was held in Washington in January 2014. The next round of discussions is scheduled to take place in Japan in 2016 or 2017.

In the meantime, building on the recommendations of the SAG and the conclusions of the different conferences, the EC issued a working document entitled, "A Role for Europe within a Global Space Exploration Endeavour". The document, released on 20 August 2013, emphasises the importance of an integrated approach (both at European and in-

instruments of the two missions will be provided by both partners.

[124] The CSTS was specifically intended for use in human exploration missions to the Moon (both in orbit and on the surface) via LEO assembly, in addition to supporting missions to the ISS. The decision to develop the CSTS can be seen as the European answer to the NASA-led Orion Crew Vehicle, which was initially not intended for international cooperation. Aware that not being involved in the next generation transportation systems would have meant to remain forever a second-class partner, ESA has eventually succeeded in participating to the development of Orion, after the cancellation on the CSTS programme.

[125] See: European Space Agency. "European Space Technology Master Plan". 11th Edition. ESA-ESTEC: 58.

[126] Space Advisory Group of the European Commission. "Space Exploration, a new European flagship Programme. European Commission Framework Programme 7 – Space Theme. 10 October 2010. See also: Horneck, Gerda *et al.* "Towards a European vision for space exploration: Recommendations of the Space Advisory Group of the European Commission". Space Policy No. 26. 2010: 109-112.

[127] Ehrenfreund, Pascale; *et al.* "Toward a global space exploration program: A stepping stone approach". Advances in Space Research No. 49. September 2011.

ternational level) in the field of space exploration and proposes to build the current European long-term vision, consistent with international plans, in a three-step sequence:[128]

- 1st step, 2015-2020 (now 2024): utilisation of the ISS, robotic missions (including *ExoMars*), R&D for preparing the next step, and demonstration of human transportation capabilities;
- 2nd step, 2020-2030: continued robotic missions including Mars Sample Return, human missions beyond low Earth orbit, R&D for preparing the next step;
- 3rd step, >2030: sophisticated robotic missions in the Solar System, continued human exploration missions, including possibly human missions to Mars.

In the light of these developments, it appears clear that for European countries any ambitious space exploration scenario can only be achieved through both the involvement of the EC and the establishment of international partnerships. While the latter issue is addressed in international fora such as the International Space Exploration Coordination Group (ISECG) and the aforementioned Space Conference, the former might be conceived in the form of a new European Flagship programme.

4.2.2 Is there Added Value in EU Involvement?

The need for more active involvement of the EU in space exploration is rooted in a number of Space Council Resolutions and EC Communications, which all consider space exploration as a political priority for the effective implementation of the ESP and the pursuit of the Union's objectives across a broad spectrum.[129] According to the aforementioned policy proposal of the SAG, space exploration has all the ingredients (goal, impact, ambition, inter-disciplinary research, resources needed, plausibility and sustainability) necessary to constitute a European flagship, and setting up such a European flagship is thus instrumental for Europe to realise its ambitions and harvest a number of valuable benefits.[130]

The myriads of benefits stemming from space exploration have been widely acknowledged and documented in several publications and policy analysis documents.[131] Space exploration endeavours are, *inter alia*, a catalyst for the emergence of new technologies and scientific results with a potentially huge impact in terms of innovation, economic growth and job creation. In addition to delivering value across a number of areas and enlarging the sphere of economic activity, space exploration also possesses an inherent cultural value and provides inspiration and motivation for the younger generations and European citizens in general.[132]

Given these demonstrated paybacks, space exploration is an area of great interest for the EU and for Europe as a whole. Importantly, the benefits stemming from space exploration match well the objectives and goals set by the Commission as priority policy actions for the Union. As also stressed by the SAG, substantial EU support to exploration would in particular contribute to reach the general EU target for R&D intensity and contribute to the concept of the Innovation Union, where ideas can be turned into products and services that create growth and jobs, as the Europe 2020 strategy states. It would lead to smart, sustainable and inclusive growth.

Although the combination of scientific, technological, economic, and inspirational drivers would in themselves fully justify the initiation of a new flagship programme, the discussion needs to be more properly centred on the unique values that a flagship initiative could bring in complementing ESA's long-standing efforts in a more synergistic fashion.

Over the past 40 years, as mentioned above, ESA's science-based and technologically-focused approach to exploration activities has enabled Europe to acquire a state-of-the-art technological level and a solid set of critical capabilities, which often contribute to make it a so-called "partner of choice" for international cooperation. While this pragmatic ap-

[128] European Commission. A Role for Europe within a Global Space Exploration Endeavour. Commission Staff Working Document. SWD (2013) 301 final. Brussels 20 August 2013. http://www.parlament.gv.at/PAKT/EU/XXIV/EU/12/33/EU_123382/imfname_10413860.pdf

[129] See in particular the Resolutions of the Sixth, Seventh and Eight Space Councils as well as the EC's 2011 Communication Towards a Space Strategy for the European Union that Benefits its Citizens.

[130] Space Advisory Group of the European Commission. "Space Exploration, a new European flagship Programme. European Commission Framework Programme 7 – Space Theme. 10 October 2010.

[131] Among the various publications and analyses, see in particular: Benefits Stemming from Space Exploration". International Space Exploration Coordination Group. August 2013.

[132] European Commission. A Role for Europe within a Global Space Exploration Endeavour. Commission Staff Working Document. SWD (2013) 301 final. Brussels 20 August 2013. http://www.parlament.gv.at/PAKT/EU/XXIV/EU/12/33/EU_123382/imfname_10413860.pdf

proach has typically served as a source of strength for Europe, it has also brought a downside, namely the lack of a strong political dimension within the current governance of space exploration activities. This political dimension is however an indispensable element for defining a long-term vision in space exploration and becoming involved in new major undertakings, which will inevitably entail a large degree of cooperation with non-European countries. It is no coincidence that the most ambitious European programmes such as Hermes and Aurora have ultimately failed. Nor it is a coincidence that, in spite of the considerable efforts put in through the years by ESA, a comprehensive and long-term vision for space exploration and human spaceflight in the post-ISS period is still lacking. Indeed, it could be argued that Europe's inability to define its long-term priorities and to develop a clear vision of its future role in exploration mainly stems from the dearth of a strong coupling between the space community and policy makers as well as the lack of a political grand vision in support of exploration activities.

The implementation of space exploration needs the backing of a motivated and fully-fledged political player. EU involvement could arguably bring to exploration the political dimension that is currently lacking in Europe, in addition to more solid financial support for the implementation of a major undertaking in this domain. It is in fact clear that that the big financial investments required for European participation in large-scale space exploration programmes makes the EU contribution and political support indispensable.

The role of the EU, however, should not only be seen as important for providing the necessary political backing for Europe's way forward as well as for mobilising the significant investment needed, but also for embedding space exploration in a wider political perspective and to better seize the full spectrum of benefits stemming from space exploration.

Space exploration and human spaceflight are not simply scientific and technological undertakings but also political endeavours bearing a marked geopolitical value. As such, space exploration can (and should) also be in the service of advancing broader political objectives. To echo the EC's Space Advisory Group, space exploration is a field where Europe can assert itself globally and where European institutions can bolster their image and status in the eyes of their citizens and of the world.[133] It is a political driver for projecting European geopolitical skills and values on the international stage and a precious instrument for both reinforcing Europe's foreign policy actions and making Europe a centre of gravity in global S&T affairs. Space exploration can be leveraged by Europe to both reinforce existing external relations and to establish new strategic partnerships. It can contribute to building bridges among countries and ultimately improve international relations. Cooperation in this field is thus not simply a matter of scientific and technological collaboration aimed at avoiding duplication of efforts and optimising the utilisation of resources, but more accurately an enabler for valuable political objectives.

The skilful crafting of a major cooperative space endeavour in exploration could thus be instrumental for Europe to realise a number of "high politics" goals. Space exploration is inherently linked to the concept of national power and accordingly should be seen as an indispensable element for a region with global ambitions.[134]

As emphasised by the abovementioned Communication *Toward a space strategy for the European Union that benefits its citizens*, Europe "is not making the most of its potential because its actions are too piecemeal and because of the lack of linkage between space exploration and the political, economic and social challenges it faces".[135] The message implied in the Communication is that only through the more active involvement of the EC, which would complement ESA's technical expertise, can Europe build up a more coherent framework for space exploration activities and be able to fully reap the political benefits. It is undeniable that the EU, as a strong political player, is better equipped to embed space exploration in a wider political dimension. Another fact is that, unlike ESA, which, understandably, can only be reactive to the overall geopolitical context, the EU can be more proactive on the international scene,

[133] Horneck, Gerda *et al.* "Towards a European vision for space exploration: Recommendations of the Space Advisory Group of the European Commission". Space Policy No. 26. 2010: 109-112.

[134] Peter, Nicolas. *Space Exploration 2025: Global Perspectives and Options for Europe*. ESPI Report 14. August 2008: 64.

[135] European Commission. Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions. Towards a Space Strategy for the European Union that Benefits its Citizens. COM(2011) 152 final of 4 April 2011. Brussels: European Union. Document available at the European Commission website: <http://ec.europa.eu/enterprise/policies/space/files/policy/comm_pdf_com_2011_0152_f_communication_en.pdf>

and it is able to cooperate at different levels with different actors.[136]

Besides advancing Europe's diplomatic goals and supporting Europe's foreign policy actions in a more coherent fashion, an important added value that the political dimension offered by the Commission could bring, lies in the possibility of producing a stronger impact on Europe's long-standing efforts to promote a "meta-national" European perspective and reinforce the sense of European identity.

It is well known that the space exploration programmes of all the major spacefaring nations have traditionally served as a unifying cause, strengthening national cohesiveness and providing a source of pride for citizens and governments. There is however little evidence that this has also been the case for Europe. Quite to the contrary, ESA-led space efforts have arguably proved incapable of profoundly reaching and impacting the imagination of Europeans beyond the confines of their home states, and thus to ultimately act as a catalyst for further European integration.[137] The success of Rosetta (demonstrating the power of exploration) might have slightly altered this situation, yet the basic conclusion remains. It is important to note that such inability does not stem from a fallible outreach strategy, but more simply from the inherent difficulty of the public identifying ESA efforts as European efforts. The reason is that nationalism is still the overwhelming perspective: it is no coincidence that even the most visible achievements in this field such as the flight of an ESA astronaut to the ISS have been mostly celebrated through national – not European – lenses.[138]

This is not to say that an involvement of the Commission would automatically alter this perspective. It would, however, provide the EU with another element that would respond consistently to the overarching EU objectives with regard to European identity. In other words, undertaking space exploration within the frame of a European flagship programme could provide the EU with an element of the European construction as well as a building block to further the sense of European identity. To echo the well-known statement of Robert Schuman, "Europe will not be all made at once but through concrete achievements that will create an increasing solidarity among European countries and citizens". It can be argued that a major undertaking in exploration could be one of these achievements. It could help promote the awareness of a common European identity among citizens and demonstrate increased political confidence.[139] More than Copernicus and Galileo, the setting up of an ambitious European flagship programme in exploration could thus have a dramatic impact on the long-standing efforts of the EU to promote a "meta-national" European perspective.

Finally, the case for setting up an EU flagship programme in the field of exploration is made more compelling by looking at the undesirable rifts and drawbacks that the lack of involvement by the Commission would generate. Opting not to invest in costly and demanding domains like space exploration would of course save precious resources. However, as also openly warned by the SAG, any delay in "the launching of a space exploration programme (could) lead to a loss of the present technical competences, difficulties to exploit European facilities and the difficulty to retain the European talent in our private and public entities".[140] Furthermore, there is the risk that European strategic partners in space will not wait for Europe and that this will in turn bring a loss of leadership in future space activities, thus compromising European future ability to shape the priorities and timing of international endeavours and to attract the best partners and reap the benefits.

Europe currently enjoys a strong position within the international space pecking order, but its future status appears now at a critical juncture as other space powers are developing ambitious space exploration programmes. In the end, the question should be raised whether Europe is willing to take the risk of excluding itself *a priori* from the revitalisation of human spaceflight ambitions beyond LEO, especially considering its longstanding efforts to develop many of the critical technologies required. Failing to exercise a more proactive and assertive role in this field would inevitably make Europe just a follower of the major players and, perhaps more dramatic, help condemn Europe to political and cultural decline on the international stage.

[136] Peter, Nicolas. *Space Exploration 2025: Global Perspectives and Options for Europe*. ESPI Report 14. August 2008: 64.

[137] Venet, Christophe, and Blandina Baranes (eds.). *European Identity through Space. Space Activities and Programmes as a Tool to Reinvigorate the European identity*. Springer. Wien. 2012.

[138] For a detailed analysis on the impact of nationalism on the emergence of a pan-European identity, see: Woolf, Stuart. "Europe and its Historians" Contemporary European History: 12, 3 (2003): 323–337.

[139] Peter, Nicolas. *Space Exploration 2025: Global Perspectives and Options for Europe*. ESPI Report 14. August 2008: 64.

[140] Space Advisory Group of the European Commission. "Space Exploration, a new European flagship Programme. European Commission Framework Programme 7 – Space Theme. 10 October 2010.

Setting up an ambitious EU flagship programme in the field of space exploration/human spaceflight can thus be key to avoid such a gloomy outcome and enable Europe to promote itself as a centre of gravity in the post-ISS exploration context. In this respect, the idea of a Moon Village recently launched by ESA Director General J.-D. Wörner can provide an ambitious framework for the implementation of such a flagship programme.[141]

While identifying the specific implementation approach and technical capabilities to be develop by means of a new flagship falls outside the scope of this report, it is clear that a dedicated programme must be based on a strengthening of the cooperation between the EU and ESA and that the EU part has to be devoted to the development of new, complementary technical capabilities that have not been fully mastered through national and ESA programmes, but that are instrumental to reaching the goal. The Commission has already started to fund advanced space robotics within the Horizon 2020 framework,[142] and could for instance contemplate to dedicate funding to the development and exploitation of additive manufacturing capabilities (3-D printing in space) as part of this new programme. Ideally, it could also address the issues related to the transportation system, which are key to future space exploration and especially human exploration. ESA is currently developing the ATV-derived service module for the MPCV and the successor of the Ariane 5 launch vehicle (see next section), but the development of autonomous launch capabilities to send astronauts into space ostensibly remain outside its plans and – equally important – financial possibilities. An EU space exploration flagship programme could address this aspect, mobilise the significant resources required for the development of a human-rated launch vehicle,[143] and eventually link space exploration to another potential flagship candidate: access to space.

[141] Hollingham, Richard. "Should we build a Village on the Moon?" BBC. 13 July 2015. Web. http://www.bbc.com/future/story/20150712-should-we-build-a-village-on-the-moon

[142] See European Commission. Guidelines for Strategic Research Cluster on Space Robotics Technologies Horizon 2020 Space Call 2016. Brussels. 2015.

[143] It is estimated that a budget in the order of several billion euros would be required.

4.3 Identifying Potential Candidates: The Launcher Option.

Autonomy in space is a catchphrase systematically highlighted in the policies of the major spacefaring nations, including Europe. Developing and maintaining independent access to space is the first enabling element towards the achievement of such autonomy and the full utilisation of space assets. As also reiterated by the EC in a number of policy documents, Europe needs to maintain an efficient autonomous fleet of launchers and the infrastructure to access space. Without these, it would be impossible to pursue a truly European space policy.

European accomplishments in this field are noteworthy and the decisions endorsed at the ESA Council at Ministerial level of December 2014 bode well for the future. The question to be addressed is whether the multi-layered, intergovernmental approach so far pursued to secure this strategic need will prove effective and beneficial also in the future and whether possible involvement by the Commission might not be the best way forward. Accordingly, after assessing the status of Europe's launcher programmes, these considerations will be laid out.

4.3.1 European Launchers: Past, Present and Future.

The development of launchers was one of the very first drivers behind the initiation of pan-European cooperative schemes in space. Cooperation in this field predates the establishment of ESA. It began as early as 1962 with the creation of the first intergovernmental entity devoted to space activities in Europe, the European Launcher Development Organisation (ELDO), which eventually merged in 1975 with the European Space Research Organisation (ESRO) to form ESA.[144] Although at that time European countries already had significantly different views and priorities with regard to space activities, the development of an indigenous European launcher was not a point of contention. All the pioneering European space countries agreed that Europe needed to have autonomous access to space. Such necessity was made even clearer by the well-known disagreement with the U.S. over

[144] See European Space Agency. "Launcher strategy". Web http://www.esa.int/Our_Activities/Launchers/Launcher_strategy

the launch of the French-German *Symphonie* satellites.[145]

After the unsuccessful initiative of the Europa rocket, efforts were revitalised by France, which in 1972 proposed to bring its *Launceur a Trois Etages de Substitution* (L3S) programme into a common European framework.[146] Work on this launcher programme – eventually renamed the Ariane Launcher Programme – began as early as 1974 and the inaugural launch of Ariane-1 took place in December 1979. Building on this success, in 1980, Arianespace – the world's first commercial satellite launch company – was established to manage and commercialise operations of Ariane. For more than three decades, Ariane launchers have served a variety of institutional and commercial missions, becoming symbols of Europe's autonomy and achievements in space. The five different generations that have succeeded one another in the Ariane family have won a considerable share of the global market, currently launching half of the world's commercial satellites and enabling Europe to construct a robust satellite launch industry and infrastructure.

The Ariane-5 rocket, the most recent and major evolution for the Ariane family, has now emerged as a global point of reference for commercial launches and a cornerstone of European institutional launches. Operational since 1999, Ariane-5 is a heavy-lift launcher, capable of providing either double launches (i.e. two satellites launched simultaneously) or single launches with heavier loads.[147] At present, there are two operational configurations: Ariane-5 ECA, which mainly delivers communication satellites to Geostationary Transfer Orbit (GTO), with a launch capacity of 10 tonnes, and Ariane-5 ES, which is used for various missions to the Low Earth Orbit (LEO) with a launch capacity of 20 tonnes. The latter configuration was also used for the launches of the five ATVs to the ISS. Ariane-5 is launched six to seven times a year, the majority of which are for private customers. As at June 2015, the Ariane-5 launch log stands at a total of 79 launches.

In addition, in the late 1990s ESA initiated the diversification of its launchers through the adaptation of the medium-lift launcher Soyuz and the development of the light-weight Vega.

[145] For a detailed assessment and historical analysis of the Ariane launcher, see Al-Ekabi, Cenan and Panos Mastorakis. "The Evolution of Europe´s Launcher and Flagship Space Initiatives". In: Al-Ekabi, Cenan (ed.). European Autonomy in Space. Springer, Vienna. 2015: 2-14.
[146] *Ibid*: 10-12.
[147] See European Space Agency. "Ariane 5". Web http://www.esa.int/Our_Activities/Launchers/Launch_vehicles/Ariane_5

The European version of the Russian-manufactured Soyuz was introduced to consolidate Europe's access to space for medium-size missions, in particular to launch satellites up to 3.2 tonnes into GTO, and constellations of two or more satellites into LEO and MEO. Named Soyuz-ST, it joined the family of European launchers in 2005, following the signature of a cooperation agreement between ESA and Roscosmos, which enabled Soyuz to use Europe's spaceport in Kourou. The decision to develop a dedicated launch infrastructure at the Guiana Space Centre was of interest to both Europe and Russia, as it enabled the former to complement the performance of ESA launchers Ariane and Vega, and the latter to benefit from improved access to commercial markets and improved performance of the Soyuz launcher when being launched much closer to Equator.[148] At that time, it was also in the interest of both Europe and Russia to boost their relationship, and cooperation in the launcher sector was seen as a tool for pursuing this objective. Soyuz-ST was launched from Kourou for the first time in October 2011 and is designed to be used for medium-weight communication satellites as well as navigation and earth observation missions. The fact that the GSC can operate Soyuz has made it easier to use it for dual-use missions, as happened with the launch of France´s Pleiades constellation and ELISA satellites.[149] Since the very beginning, however, it has been in question whether Europe should rely on Soyuz for missions having a higher political-strategic value (e.g. Galileo satellites), considering that Soyuz is not a truly European launcher.

The small launcher VEGA (Vettore Europeo di Generazione Avanzata – European Advanced Generation Vehicle) was developed as a result of an Italian initiative through an ESA optional programme that began in 1998. Vega is a four-stage launcher comprising three solid motor powered stages (the P80, Zefiro-23 and Zefiro-9) and a liquid-fuelled fourth stage called AVUM, which is produced by Yuzhnoye in Ukraine.[150] As a light-weight launcher, Vega is designed to seize the institutional small satellite market (300-2000kg) as well as to respond to the growing demand

[148] The agreement was preceded by the European-Russian company Starsem, which was established in 1996 to commercialise launches with Soyuz. Starsem's shareholders are EADS-Astrium (35%), Roscosmos (25%), Samara Space Centre (25%) and Arianespace (15%).
[149] Veclani, Anna Clementina, Jean-Pierre Darnis. "European Space Launch Capabilities and Prospects". In: Schrogl, Kai-Uwe, *et al*. Handbook of Space Security. Policies, Applications and Programs. Volume 2. Springer. 2014: 783-800.
[150] See European Launch Vehicle. "Vega Launcher composition". Web. http://www.elv.it/en/launcher-vega/composizione-lanciatore/

for micro-satellites. Vega is capable of placing 300-2500 kg into LEOs and, thanks to the re-ignitable upper stage, can simultaneously launch multiple payloads into orbit. Vega´s inaugural flight took place in February 2012 from Europe's spaceport in French Guiana. Its exploitation has been supported by the Vega Research and Technology Accompaniment (VERTA) programme, which *inter alia* foresaw the procurement of five demonstration flights, including ESA's Intermediate eXperimental Vehicle (IXV), Proba-V, Aeolus, LISA Pathfinder, and Copernicus Sentinels. By June 2015, all the five demonstration launches had been performed successfully.

With the successful introduction of Soyuz-ST and Vega, the European family of launchers has expanded to ensure performance and flexibility, two features that are increasingly required in the launch market. The payload segment covered by the three different launcher categories now allows the entire range of launch requirements to be covered (see Figure 3).

Figure 3:Europe's Launcher Family (source: ESA)

Ariane, Soyuz and Vega development programmes are managed by ESA on the basis of optional programmes, with a varying number of ESA Member States for each of the programmes in question. The major contributing countries are France, Germany, Italy, Belgium and Sweden. The overall budget for launcher-related activities has traditionally accounted for a substantial share of the ESA budget: in 2014 the programmes received 15.1 % of ESA's budget – or Euro 617.4 million.[151]

The prime contractors and suppliers are selected on the basis of ESA's geo-return policy, which reflects national financial participation in the project. The European space launcher industry is concentrated in a relatively small number of industrial firms, with a high degree of vertical integration.[152] There is a handful of large industrial actors and approximately 40 suppliers involved in the design, development and manufacturing processes, the majority of which are highly dependent on Ariane business.[153] The working system assigns the responsibility for the whole process to a single industrial prime contractor for each launcher type. The prime contractor of Ariane-5 is Airbus Space and Defence, with Safran playing the leading role for the propulsion systems. Soyuz´ prime contractor is the Russian federal space agency, Roscosmos, while the European Launch Vehicle (ELV), a joint venture between Avio (70%) and ASI (30%), manages the Vega rocket.

Once the launch systems are qualified, responsibility is handed over to Arianespace, which is in charge of executing the operational launcher exploitation phase, including procurement from the launcher system prime contractor, and the commercialisation and launch of the rockets. Prime contractors, however, take part, with Arianespace's staff, in the integration of components at Europe's Spaceport in Kourou. While designed to avoid duplication of efforts, this framework presents a high degree of complexity, also considering that both ELV and Airbus are at the same time suppliers and shareholders of Arianespace.[154]

Like other spacefaring nations, Europe has been almost constantly facing the challenge of improving and modernising its launchers to ensure the availability and sustainability of autonomous access to space over the long-term. Not surprisingly, the successor of Ariane 5 has been under debate since shortly after it entered into service in 1999. A dedicated programme, called Future Launchers Preparatory Programme (FLPP), was launched by ESA as early as 2003. The programme was subscribed on an optional basis by 14 ESA Member States and structured in a series of partially overlapping stages covering the 2004-2018 period.

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151 European Space Agency. "ESA Funding". Web. http://www.esa.int/About_Us/Welcome_to_ESA/Funding

152 Hayward, Keith. "The Structure and Dynamics of the European Space Industry Base". ESPI Perspectives 55. Vienna: European Space Policy Institute. December 2011: 3.

153 *Ibid*: 3.

154 Arianespace´s capital is owned by 21 shareholders from 10 different countries (France, Germany, Italy, Belgium, Denmark, Norway, Netherlands, Spain, Sweden, and Switzerland). In terms of shareholders, the largest has historically been CNES, followed by Airbus. The corporate governance of Arianespace is, however, currently undergoing a strong revision, following the creation of a Joint Venture between Airbus and Safran (see below). The Joint Venture, operational since 2015, has already expressed the intention to purchase CNES´ shares of Arianespace.

Besides fostering the development of new technologies capable of delivering improved performance and reliability as well as reducing operational costs, a major field of activity of the FLPP was the development of various launch vehicle concepts and the identification of the technologies required to make them possible. This activity was intended to form the basis of the key decision to be made on the characteristics and design of the Next Generation Launcher (NGL).[155] The objective of the FLPP was thus not the development of a new launcher itself, but the selection and maturation of technologies – the targeted Technology Readiness Level (TRL) was 5 – to pave the way for the development of a new launch system. A key issue was whether to develop another heavy-lift launcher for double launches or a medium-lift launcher for single launches, which could in the long term also become a replacement of the Europeanised Soyuz-ST.[156] Such technical and operational considerations were to a large extent driven by the need to better cope with the increasing difficulties encountered by Arianespace during the exploitation of Ariane 5.[157]

Already in 2003, ESA Member States had approved the European Guaranteed Access to Space (EGAS) to cover fixed production costs of Ariane 5 and provide around €250 million annually to Arianespace for 6 years (2004-2010).[158] While the programme came to an end in December 2010, the persistence of financial hurdles started to call for a profound revision of the European launch model, and in particular for a reorganisation and a progressive streamlining of the whole industrial process.[159] At the same time, the necessity to develop a new launcher capable of sustaining itself on the market without requiring public support became even more pressing.

As a medium-term solution, at the end of 2010 it was decided to begin work on the development of the Ariane-5 Midlife Evolution (ME) and start preliminary design work on Ariane 6. Ariane-5 ME was designed to feature a new, re-ignitable upper stage that would increase the payload-carrying capacity by 20% and thus enable the launch of an extra two tonnes to GTO, a crucial market for Ariane´s business. Ariane-5 ME was intended "to replace Ariane-5 ECA and Ariane-5 ES to become Europe's new workhorse launcher until the arrival of Ariane 6".[160]

Although at the ESA Council at Ministerial level held in Naples in 2012 Ministers postponed a clear decision, initial funding was secured for both the activities on Ariane-5 ME and for a detailed definition study of the new Ariane-6, "with the goal of maximising commonalities and avoiding delays in commercial exploitation of the two launchers while minimising costs for Ariane-6".[161]

However, in the climate of budgetary constraints imposed by the financial crisis, consensus among the major players quickly vanished and the two launcher concepts started to compete against each other. While France started to strongly advocate a steady commitment to the development of Ariane 6, Germany showed a clear preference for Ariane 5 ME, *inter alia* because of higher German industrial involvement.[162] In an attempt to remedy this difficult situation in October 2014, the ESA Director-General sent ESA Member States a policy proposal on the parallel development of Ariane-5 ME and Ariane 6, both considered as complementary – not competing – projects.[163] The disagreement was resolved on the eve of the Ministerial Council Meeting in 2014, with Germany and France eventually agreeing to skip the planned upgrade of Ariane 5 and proceed directly to the development of a substantially reconceived Ariane 6.

By the same time, Airbus Space & Defence and Safran had proposed to create a joint venture to lead the development and produc-

[155] See European Space Agency. "European Space Technology Master Plan". 11th Edition. ESA-ESTEC: 323.
[156] See Al-Ekabi, Cenan. "European Access to Space: Factors of Autonomy". In: Al-Ekabi, Cenan (ed.). *European Autonomy in Space*. Springer. 2015: 137-155.
[157] Such difficulties were the direct result of two main problems: on the one hand, the fact that launch prices on the commercial market were lower than launch and production costs (a situation that was primarily driven by the need to cope with the sharp downturn in commercial launch demand of the early 2000s); and on the other, the limited number of institutional launches performed by Ariane 5, which has been preventing the creation of scale economies for spreading fixed operational costs over a higher number of launches.
[158] See: Al-Ekabi, Cenan. "European Access to Space: Factors of Autonomy". In: Al-Ekabi, Cenan (ed.). European Autonomy in Space. Springer. Vienna. 2015: 145
[159] Various solutions and initiatives were advanced over the last few years to reduce costs. See for instance the rationalization of the propulsion sector advanced by Astrium; the establishment of a direct link between Astrium and ESA, without Arianespace as intermediary proposed by the Academie de l´Air et de l´Espace; and the introduction of a tax on satellite operators to finance the European launch sector.
[160] *Cit*. European Space Agency. "Adapted Ariane 5 ME". 14 October 2014. Web. http://www.esa.int/Our_Activities/Launchers/Launch_vehicles/Adapted_Ariane_5_ME
[161] *Ibid*.
[162] De Selding, Peter. "DLR's Woerner Remains Unconvinced Just-unveiled Ariane design Is Right Way to Go". Space News. 12 July 2013.
[163] See Dordain, Jean-Jacques. "Answer to Questions of Germany". Paris. 29 October 2014: pp. 17-18. The concepts developed for Ariane 5 ME were intended to be applicable to Ariane 6 as well, thereby reducing costs and risks associated with Ariane 6.

tion of Ariane 6 to streamline industrial organisation, overcome the inefficiencies of the industrial cycle and thus reduce the costs to be borne by Member States.[164] In response to this proposal, major stakeholders from ESA Member States and industry worked together to outline a joint ESA–industry scheme for the development of Ariane 6, “based on a balanced responsibility, cost and risk sharing between the Agency and the industrial Joint Venture”.[165]

The Ministerial 2014

The official sanctioning of the new industrial scheme and the final decision regarding the complete development of Ariane 6 was taken at the ESA Ministerial Council on 2 December 2014, in the context of the overall launcher strategy for the next 10 years. The *Resolution on Europe´s Access to Space* acknowledges the difficulties faced by the European launch sector (*inter alia*, the economy of Ariane 5 on the commercial market; the dependence of a significant part of the European institutional launches on the Soyuz launcher; the deficit of commonalities between Ariane 5, Soyuz and Vega, which limit the synergies in their exploitation; the increasing competition in the worldwide commercial market) and calls for the “availability as soon as possible of new European launch services which are not only competitive without requiring public support during exploitation, but also flexible and modular enough for responding to a wide range of needs, from institutional to commercial requirements, as well as to the uncertainties on the evolution of the commercial requirements”. [166]

Figure 4: Artist’s view of Ariane-6 (source: ESA)

Ariane 6 is conceived as a modular three-stage (solid–cryogenic–cryogenic) launcher with two different variants using either two boosters (A62) or four boosters (Ariane 64).[167] The payload capacity of the Ariane 62 configuration is of 5 tons to GTO, while that of Ariane 64 is 11 tons to GTO (single payload) or 10 tons with dual payload.

The general architecture of Ariane 6 will allow it to cover a wide range of missions in GTO, LEO, MEO and Polar orbits and to respond to different market needs in a cost-effective way thanks to the possibility to vary the number of boosters in the configuration. This double configuration is indeed a key element in the context of the new launcher strategy and responds to precise goals with respect to both the commercial and the institutional dimensions of Europe´s future access to space.

Two points deserve particular attention. First, the decision has allowed the overcoming of the apparent trade-off between developing another heavy-lift launcher for double launches or a medium-lift launcher for single launches. While the double launch-capability will be retained by Ariane 64, Ariane 62 will ensure flexibility in availability since it will not require efforts in terms of pairing satellites and scheduling of launches. Together, Ariane 62 and 64 will provide the modularity required to adapt to the uncertainties of the future commercial market.[168]

In addition to that, because Ariane 62 and Ariane 64 are two configurations of the same launcher that are intended to be exploited together, this will allow the enhancement of the cadence of the production rate and thus contribute to cost reduction of Ariane 64. All in all, “Ariane 64 will make the overall exploitation of Ariane profitable thanks to the revenues of double launches and provide the margins for a more competitive pricing policy of Ariane 62”.[169]

In parallel to the commercial logic, the decision to proceed with a double configuration for Ariane 6 responds to political considerations as well, particularly the perceived need to overcome the current dependence of European institutional launches on the availability and prices of Soyuz. As a medium-lift launcher, Ariane 62 will cover the same payload segment as Soyuz and will thus offer the possibility of replacing the Russian-manufactured rocket with a truly European launcher.[170] Indeed, although not officially

[164] *Cit*. European Space Agency. “Ariane 6”. Web. http://www.esa.int/Our_Activities/Launchers/Launch_vehicles/Ariane_6
[165] *Cit*. ESA Council at Ministerial Level. “Resolution on Europe’s Access to Space”. ESA/C-M/CCXLVII/Res. 1 (Final). 2 December 2014.
[166] *Cit*. ESA Council at Ministerial Level. “Resolution on Europe’s Access to Space”. ESA/C-M/CCXLVII/Res. 1 (Final). 2 December 2014.
[167] European Space Agency. “Ariane 6”. Web. http://www.esa.int/Our_Activities/Launchers/Launch_vehicles/Ariane_6
[168] Dordain, Jean-Jacques. “Answer to Questions of Germany”. Paris. 29 October 2014: 6
[169] *Ibid*: 7
[170] Besides ensuring autonomy in a strategic payload segment, a key driver here is to help sustaining industrial activities and research capabilities in ESA Member States rather than in Russia. As stated by many, this is an essen-

formalised, ESA´s commitment to its development makes clear that "Soyuz in Guiana" will ultimately remain only a transition solution in Europe's strategy for access to space.[171]

With regard to the scheduling aspect, the upper stage and the P120 boosters will be ready in 2018. The maiden flight of Ariane 62 is expected in 2020 with entry into the commercial market (provision of services) around 2022.

At the Ministerial Council, investments were also secured for the development of an upgraded version of the Vega launch system, the Vega-Consolidated (Vega-C), with an inaugural flight scheduled for 2018. The major feature of Vega-C will be the utilization of the P120 as a first stage replacing the P80.[172] The P120 will also serve as a strap-on booster for the first stage of Ariane 6. This common element is considered a key factor for the successful commercialisation of Europe´s future launchers, as it will enable significantly enhanced production rates and thus decrease the costs for both Vega and Ariane. To this effect, the Ministerial Resolution underlined the mutual benefit in preparing the exploitation of Ariane 6 and Vega-C together, so as to ensure that the overall competitiveness of the future launchers will be enhanced.[173]

In addition to the numerous synergies between Ariane 62, 64 and Vega-C, the successful exploitation of the new European launchers on the commercial market will also be supported by important changes in governance, particularly in the relations between industry and governments. With the new arrangements, the Member States and ESA will have responsibility for guaranteeing five institutional launches per year for Ariane 6,[174] while the newly-established Airbus-Safran Launchers (ASL) Joint Venture will bear all commercial market risks during exploitation, since Member States will no longer provide public support payments as was done to Arianespace in the past.

The new industrial organisation still needs to be consolidated and it thus remains to be seen whether it will be capable of enhancing the efficiency of the industrial cycle and ensuring sufficient margins for the competitiveness of Ariane. Accordingly, the decisions endorsed at the Ministerial 2014 will be subject to final review in June 2016.[175]

4.3.2 Is There Added Value in EU Involvement?

The ESA-based, intergovernmental approach so far pursued by European countries to implement the launcher strategy has been successful by any measure. The Ariane family of launchers figures as one of the major technological achievements for Europe, and has provided independent access to space for the last 35 years. More than 400 satellites have been successfully launched from Europe's spaceport in Kourou and more than half of the commercial satellites in service today were launched with Ariane.[176] Thanks to this impressive launch performance and an order book of more than 80 satellites to be launched within the next four years,[177] Arianespace has emerged as the world's leading launch provider with sales of almost $1 billion per year ($930 million in 2014, approximately 40% of the global launch revenues).[178]

European launchers thus have many achievements to look back on and, thanks to the decisions endorsed at the 2014 ESA Ministerial, the way to a promising future has been paved. Against this pleasing backdrop, the potential involvement of the EC could

tial element to ensure the sustainability of future access to space, which indeed requires constant R&D efforts and support to technological and industrial competitiveness.

[171] It is however likely that Arianespace will continue to commercialise Soyuz from the Baikonur launch site, as evidenced by the signature in June 2015 of a commercial launch contract with OneWeb (a contract to launch roughly 700 LEO satellites aboard the Russian Soyuz from the cosmodrome of Baikonur). See De Selding, Peter "Launch Options were key to Arianespace´s One-Web Win". Space News 25 June 2015.

[172] In addition, the second stage Zefiro 23 will be replaced by Zefiro 40 (which will have roughly +17 tons propellant loading and an increased diameter). The fourth stage will also see slight modifications (mainly larger propellant tanks) and will be called AVUM+.

[173] See ESA Council at Ministerial Level. "Resolution on Europe's Access to Space". ESA/C-M/CCXLVII/Res. 1 (Final). 2 December 2014.

[174] As stressed in an interview with former ESA Director of Launcher Antonio Fabrizi "The joint venture will rely, de facto, on an ESA-guaranteed market of five institutional launches, but this is not ESA-owned market. ESA can decide its own satellites, but not for the others (there are national, Eumetsat, EU that have not committed to the application of a European preference clause). The Commission can provide comfort through a certain degree of preference, but not a guarantee they will use Ariane 6. See: De Selding, Peter. "Profile: Antonio Fabrizi". Space News. 27 January 2015.

[175] De Selding, Peter. "Desire for Competitive Ariane 6 Nudges ESA towards Compromise". Space News. 3 April 2015.

[176] European Commission. "Access to space". Web. http://ec.europa.eu/enterprise/policies/space/policy/space-on-earth/access-to-space/index_en.htm

177 Arianespace. "World Satellite Business Week 2015: Arianespace headed for business and operational records in 2015". Press Release. 14 September 2015. Web http://www.arianespace.com/news-press-release/2015/9-14-2015-Euroconsult.asp

[178] Federal Aviation Administration (FAA). *Commercial Space Transportation: 2014 Year In Review*, Washington, FAA: February 2015.

thus be questioned, as it would appear unnecessary, or even lead to a higher degree of complexity. Yet, there are several considerations that could make involvement by the Commission both plausible and praiseworthy.

To begin with, thanks to the Copernicus and Galileo programmes, the EU is progressively emerging as the biggest institutional customer for launch services in Europe, as well as one of Arianespace's most important customer in general. In addition, given the importance of the EU's space policy for the effectiveness of the Union's internal and external action, autonomous, cost-effective and sustainable access to space is a fundamental and strategic asset for the Union. Launcher policies, in effect, mirror all the major features of the ESP, as they deal with political, industrial, economic, strategic, and symbolic issues.[179]

Activities in this field, in particular, respond to two overarching and closely interrelated elements that explicitly fall within the concern of the EC: market competition and geopolitics. The strong and visible *policy nexus* between these two elements creates both opportunities and challenges Europe must necessarily deal with.

In terms of commercial logic, the launch market is a segment in which Europe is increasingly bound to compete with other countries and private undertakings. Albeit small compared to the downstream sector (and in particular satellite communications), the launching business is extremely competitive, because global demand remains modest compared to the availability of supply.[180] Launch suppliers compete to ensure the most cost-effective services mainly to institutional customers, whose demand today accounts for the largest part of the global market.[181] The strongest demand comes from the governments of Russia, the United States and China (see Table 8), but not all launches are commercially accessible to foreign launch providers. This is because access to space is a highly strategic sector publicly sustained not only by significant government funding, but also by regulations limiting foreign competition and orders placed with national space industries.[182]

Country / Region	Commercial Launches	Non-Commercial launches	Total Launches
United States	11	12	23
Russia	4	28	32
Europe	6	5	11
China	0	16	16
Japan	0	4	4
India	1	3	4
Israel	0	1	1
Multinational	1	0	1
Total	**23**	**69**	**92**

Table 8: Worldwide Orbital Launch Events in 2014 (source: FAA)

While over the past two decades Ariane launch services have commanded a de-facto duopoly with the Russian Proton launcher, the situation is changing rapidly. New competitors have entered or are on the verge of entering the market, as demonstrated by the abrupt advent of Space X – which in 2014 replaced the International Launch Service as Arianespace's main competitor for the GTO – and more broadly by the many launcher development efforts currently underway in a significant number of spacefaring nations. Also launch service providers that have been mostly inactive, such as the United Launch Alliance (ULA) and Japan´s Mitsubishi Heavy Industries (MHI), are revitalising efforts to capture commercial payloads on the global market.

With new generations of modular launch vehicles (Angara 5, GSLV Mk III, Falcon Heavy, Long March 5/6/7, Vulcan and H-III) progressing towards operational readiness and offering increased flexibility and reduced costs, competitive pressures are expected to further increase and to challenge the position

[179] See: Al-Ekabi, Cenan. "European Access to Space: Factors of Autonomy". In: Al-Ekabi, Cenan (ed.). European Autonomy in Space. Springer, Vienna. 2015: 137-155.

[180] See: Federal Aviation Administration (FAA), *Commercial Space Transportation: 2014 Year In Review*, Washington, FAA: February 2015. Logsdon, John. "Commercial Launch Industry". Encyclopaedia Britannica online. http://www.britannica.com/EBchecked/topic/332323/launch-vehicle/272750/Commercial-launch-industry>.

[181] Around 75%. See: Federal Aviation Administration (FAA). "Commercial Space Transportation: 2014 Year In Review." Washington D.C. February 2015

[182] See Berteau, David and Gregory Kiley (project directors). "National Security and the Commercial Space Sector. An Analysis and Evaluation of Options for Improving Commercial Access to Space". Center for Strategic and International Studies, Washington D.C. July 2010. Web. http://csis.org/publication/national-security-andcommercial-space-sector.

of established actors. At the same time, this growing competition is taking place in a market where overall demand is projected to remain stable over the medium term, bar a substantial decrease in launch prices.[183] Additional supply could thus potentially lead to a situation of overcapacity, consequently forcing launch service providers to adopt more aggressive stances or withdraw completely from the accessible market.

All in all, access to space, albeit far from becoming "just another commodity", seems to be becoming even more responsive to price pressures, with increased competition expected to lead to a further intensification of cost reduction efforts, and to the eventual materialisation of new approaches and disruptive innovative solutions for access to space.

Against this background, the success of future European launchers on the commercial market will thus primarily depend on the ability of Ariane to outcompete established and emerging players in terms of launch prices and versatility.[184] In this respect, the 2014 Ministerial meeting adopted a multi-pronged strategy aimed at increasing flexibility and reducing costs through a number of levers, including the utilisation of heritage hardware, the streamlining of the industrial organisation with a substantial reduction in the number of interfaces, the maximisation of common expendable elements and the creation of synergies between different market segments. All these levers – together with the guarantee of five institutional launches per year – are essentially designed to increase the production rates so as to generate economies of scale that will ensure competitive pricing for Ariane 6 and Vega-C without the need for public support payments during exploitation.[185]

While all these measures will presumably prove cost-effective, it is nonetheless undeniable that the projected way forward remains to a large extent – and perhaps inevitably so – conservative. For one thing, the new launcher strategy fundamentally aims to achieve cost reductions through efficiency-driven processes, rather than through the development of innovative launch service solutions.[186] More importantly, it projects the current policy reality over a 15-year period in the belief that the current strong market situation of duopoly will last. In doing so, it may not sufficiently appreciate certain key factors such as the determination and focus of the emerging powers and the eventual success of new entrepreneurial efforts in establishing and commercialising game-changing launch technologies and approaches.

Indeed, the introduction of disruptive innovation technologies currently pursued by several launch providers, (most notably the reusability concepts pursued by Space X and envisaged by the ULA),[187] combined with innovative approaches in the manufacturing sector,[188] could dramatically affect Ariane 6's future prospects and blunt its forecasted competitive edge by the time it enters into service or soon thereafter.

The great dynamism of the international launch industry and the stiffening of international competition thus pose challenges that Europe must necessarily continue to confront. Such challenges dictate to Europe a steady and constant investment in launch capabilities that goes beyond Ariane 6, and a strong commitment to disruptive innovation and to the leapfrogging of new launch technologies in such a way as to reduce the cost of access to space and outcompete the established and emerging players in the launch sector. However, as lamented by many, only a modest research effort was approved to advance new core technologies for cheaper access to

[183] Al-Ekabi, Cenan. "European Access to Space: Factors of Autonomy". In: Al-Ekabi, Cenan (ed.). European Autonomy in Space. Springer. Vienna. 2015: 137-155.

[184] Launcher competitiveness is not only determined by price considerations, but by multiple factors: launch price is the primary consideration, but performance, reliability, availability and security of the service are likewise important, given that the key rationale behind the selection of a launch provider is to ensure the success of the mission. Needless to say, the possibility of easily integrating the payload with the launcher is also an indispensable element.

[185] As noted by former ESA Director of Launcher, Antonio Fabrizi the core objective – not to say the only objective – of Ariane 6 and Vega- C is to eliminate the need of annual support payments during exploitation, while continuing to guarantee a competitive pricing policy. See de Selding, Peter. "Profile –Antonio Fabrizi". Space News. 27 January 2015.

[186] As also stressed by the ESA Director General in the policy proposal for Ariane 6 released in October 2014, the new Ariane relies upon a substantial heritage which has no equivalent compared to any previous launcher programme. As a matter of fact, the architecture (and in particular the staging) is the same as for Ariane 5. The main stage, which will burning liquid oxygen and hydrogen, is based on the Vulcan engine of Ariane 5 ECA, while the cryogenic upper stage will be powered by a Vinci engine, which relies on work made for the Ariane 5ME upper stage. As for the P120 solid rocket booster, this is directly derived from the first stage of the Vega rocket, the P80, and will be also utilised as the first stage for the upcoming Vega-C.

[187] Technical feasibility and commercial viability of reusable systems still have to be proven, but if introduced, this evolution would allow the cost of launches to decline significantly. This would in turn be channelled towards a substantial decrease in launch prices, or alternatively – though less likely – a mere increase in profitability.

[188] As an example, see the adaptation of the automobile industry's mass production techniques to selected space systems, which could assist the realisation of the currently envisaged mega-constellations.

space, and in particular to refine the technology needed to recover, refurbish and reuse an entire Ariane launcher stage.[189]

Arguably, this is a domain where not only ESA but also the EU may wish to take action. There are two main reasons supporting complementary efforts between the EC and ESA. First, the EC might be generally better positioned to initiate institutional programmes that pursue disruptive innovation. As opposed to sustaining innovation, the outcome of disruptive innovation is not guaranteed and thus it entails stronger risk and uncertainty in terms of pay-offs. When successful, however, disruptive innovation efforts can deliver cutting-edge advantages and open up roads to establish and dominate new markets. In this sense this type of innovation requires strong political commitment and support – something that can more easily be provided by the EC, rather than within the traditionally risk-averse ESA framework. Second, the EU as an actor has an interrelated number of *interests* and *tools* to do so in terms of industrial policy, promotion of European industrial and technological competitiveness and, research and innovation schemes, since "its infrastructure is already set-up to meet a competitive market".[190]

Possible EU efforts towards ensuring the competitiveness and sustainability of European launch capabilities over the long term should thus be seen as complementary – not alternative – to those of ESA. The EU could for instance launch a dedicated programme to refine the required technology to reuse the first stage of an Ariane rocket, or even finance the development of a completely new reusable launch system, thus complementing the too modest research efforts currently undertaken by ESA and industry.[191] Alternatively, a possible EU launcher programme could be directed to test other potentially disruptive technologies such as non-vertical launch systems, or even ground-breaking space transportation concepts like mass drivers, among the others.[192]

[189] See De Selding, Peter. "With Eye on Space X. CNES Begins Work on Reusable Rocket Stage". Space News. 5 January 2015.

[190] *Cit*. Clemens, Rumpf."Op-ed. Increased Competition will Challenge ESA´s Space Authority". Space News. 16 February 2015.

[191] See for instance the Advanced Expendable Launcher with Innovative engine Economy (ADELINE), an Airbus project to develop a partially reusable launcher. See de Selding, Peter. "Meet Adeline, Airbus'sAnswer To Space X Reusability". Space News. 5 June 2015.

[192] Mass driver is a possible non-rocket launch method, which would use an electromagnetic accelerator to accelerate payloads to orbital velocity. See Logsdon, John. "Commercial Launch Industry". Encyclopaedia Britannica online. http://www.britannica.com/ EBchecked/topic/332323/launch-vehicle/272750/Commercial-launch-industry>.

This approach and type of activities would ostensibly be *sui generis* if compared to the Galileo and Copernicus programmes or other potential flagship candidates like space exploration, and would also be – at least in the short term – less demanding in terms of allocation of financial resources. This, however, would not be a reason to abstain from investing in the development of critical capabilities that will ultimately guarantee a gateway to space for Europe and the conduct of its future civil, military and commercial space endeavours. Indeed, an EU/ESA double-track approach could in the long run result in new types of launch services being offered and in a more robust and diversified launcher industry in Europe, which could count on increased support and would be better positioned to face competition in the global market.

Now, proactive involvement of the EU in launcher technology development will not in the short term make the EU 'the owner' of the European launch capability – it will not make the EU the most significant actor. But it would signal political recognition of the importance of launcher capability for Europe's technological goals and as an enabler of Europe's geopolitical aspirations. This could then have the consequence that the EU would embrace the potentialities of space as a policy instrument more firmly, and that more consideration would be given to how European launchers can be instrumentalised as a tool for international alliance building and S&T based diplomacy. In this sense a flagship project of the EU on disruptive launcher technology would fit the 'flagship' criteria very well. Indeed, a flagship project on disruptive launcher technology could be a first step towards entirely 'communitising' European launch capability, something that would be appropriate in the long term considering the strategic and political significance of what in the final analysis is a key European infrastructure.

4.4 Identifying Potential Candidates: Space Security

Space security is another domain where an EU flagship initiative might be considered. The term needs clarification, however, as it simultaneously comprises two distinct, yet interconnected, concepts: security *of* space and security *from* space. While the former generally indicates "the secure and sustainable access to, and use of, space and freedom from space-based threats", the latter refers to the utilisation of space-based assets and systems to ensure security on Earth.[193] Security in the latter context is generally taken in a wider sense and covers not only military operations, but also the environment, energy and food security, early warning, crisis prevention and management, peacekeeping, civil protection and other areas.

Although both concepts should be acknowledged as an integral part of a comprehensive European space policy, it is the concept of security *from* space that is hereby taken into account as a potential candidate for a new EU flagship programme. As will be explained in the following section, it is this domain that could comprise sufficient ingredients in terms of goal, impact, novelty and ambition to constitute a flagship programme.

4.4.1 Status of Europe's Space Security Efforts

National and Multi-National Programmes

If looked at from a pan-European perspective, the utilisation of space assets for security-related purposes is a relatively new domain in Europe. Indeed, although Europe has made great strides in developing European space systems, there has been reluctance on the part of individual Member States to pool, or share, their individual military space capabilities under a common framework (be it under the ESA or the EU umbrella), as the limitations of doing so have been perceived to exceed the benefits.[194]

Consequently, most of Europe's security-related space programmes have been conducted on a national level or through government-to-government collaboration. This has inevitably brought a high level of duplication and fragmentation of efforts. Similarly, European national preferences continue to influence contract selection and to directly or indirectly define European space technology priorities.[195] Noteworthy also is the high degree of concentration in terms of capabilities and expenditures. Five European countries alone constitute over 96% of military space expenditures in Europe (see Table 9).

	Expenditure 2014 in M€	**Percentage**
France	440	47.8
Italy	186	20.2
United Kingdom	181	19.6
Germany	49	5.3
Spain	29	3.1
Other	35	3.8
Total	920	100.0

Table 9: Government Expenditures on Defence Space Programmes (source: Euroconsult 2015)

In terms of the development of military space systems, France is the most advanced European country, particularly with regard to optical earth observation satellites (Helios-2 and Pleiades) and electronic intelligence satellites. It is also planning to launch a space-borne ballistic missile early warning system by 2020. Both Germany and Italy are leaders in Synthetic Aperture Radar (SAR) satellites, respectively with the SAR-Lupe and COSMO Sky-Med constellations. Germany also launched five medium-resolution electro-optical satellites in 2008 (the Rapid-Eye constellation) and is currently developing a replacement for the SAR-Lupe (the SARah constellation), while in 2015 Italy approved the development of the Cosmo Sky-Med second generation.[196] France, the UK, Italy and Spain operate GEO satellites for military communications. As an indication of the abovementioned duplication of efforts, the most relevant national activities for dual-use purposes are listed in Table 10.

[193] Definition of the Space Security Index. See Jaramillo, Cesar (ed). *Space Security Index 2013*. Waterloo, Canada. October 2013: 5. Web. http://swfound.org/media/121668/ssi_full_report_2013.pdf

[194] Robinson, Jana. "Europe's Key Foreign Policy Objectives Via Space". ESPI Report 30. Vienna: European Space Policy Institute. February 2011: 26-27.

[195] Hayward, Keith. "The Structure and Dynamics of the European Space Industry Base". ESPI Perspective 55. Vienna: European Space Policy Institute. December 2011.

[196] Other German missions are Terra-Sar X and Tandem X, which are civil/commercial missions but with a strong potential for security applications. See: Hellman, Martin, and Wolfgang Rathgeber. "European Member States Satellite Programs". In: Schrogl, Kai-Uwe, et al (eds). *Handbook of Space Security. Policies, Applications and Programs*. Volume 2. Springer. 2014: 831-841.

Earth Observation	Communication	Intelligence / Early Warning
COSMO Sky-Med (Italy)	Athena-Fidus (France-Italy)	Clementine (France)
SAR-Lupe (Germany)	Immarsat-4 (UK)	Essaim (France)
Helios (France-led)	SatcomBw 2 (Germany)	ELISA (France)
Pleiades (France)	Sicral 1/2 (Italy-France)	Spirale (France)
Rapid-Eye (Germany)	Skynet 4 (UK)	
SEOSAT (Spain)	Spainsat (Spain)	
SVEA (Sweden)	Syracuse II/III (France)	
TopSat (UK)	XTAR-EUR (Spain)	

Table 10: European Dual-Use Satellite System

In addition to individual national programmes, a limited number of bilateral and multilateral cooperative arrangements have been concluded among several European countries, with France acting as the hub of major initiatives. The Athena-Fidus communication satellite, for instance, is the result of cooperation between France and Italy and was launched on 6 February 2014. Among the major initiatives in the field of Earth Observation is the ORFEO (Optical and Radar Federated Earth Observation) system. It is the result of a Franco-Italian agreement signed in 2001, which was intended to combine the radar observation capabilities of the four COSMO Sky-Med satellites with the optical capabilities of the two Pleiades satellites.[197] Germany and France signed another bilateral agreement in the field of EO in 2002 for the sharing of the radar and electro-optical capacities of SAR-Lupe and Helios-2. For both the ORFEO and the SAR-Lupe–Helios-2 cooperation schemes, the exchange of operational image data started only in 2010. New arrangements between France and Germany are in the process of being finalised for the deployment of France's next generation optical reconnaissance satellites (*Composante Spatiale Optique* – CSO).[198]

In terms of multilateral initiatives, in 2001 six European countries (France, Germany, Italy, Spain, Belgium and Greece) concluded a joint agreement on common operational requirements (BOC, from the French Besoins Operationnels Communs). The purpose of the BOC was to develop a common set of requirements for a European global satellite observation system for security and defence purposes. As documented in previous ESPI studies, the conflicts in Bosnia, Kosovo, Afghanistan and Iraq contributed to altering Europe's approach to military space and greater efforts emerged to coordinate European military space assets, particularly satellite communications and remote sensing.[199] Consequently, in 2006 the six BOC signatory countries initiated studies for a Multinational Space-Based Imaging System for Surveillance, Reconnaissance and Observation (MUSIS) with the goal of harmonising future optical and radar observation systems.[200] To a large extent the project was ground breaking in nature. Based on a federation of systems, it was intended to enable participating countries (the six BOC signatories plus Poland and Sweden) to exchange military intelligence images and provide access to space-based components in a transparent and coherent manner through a common ground user segment.[201] Although in 2008 the implementation phase was officially launched and in 2009 the European Defence Agency (EDA) also became involved in its development, the future of the project is bleak, as the countries have struggled to agree on issues such as financial contributions, technical characteristics of the User Ground Segment, and capacity exchange rules.[202]

[197] Austria, Belgium, Spain and Sweden have signed bilateral agreements with France through which they have been participating to the costs of the two Pleiades satellites (launched in December 2011 and 2012) in exchange for access to data.
[198] De Selding, Peter. "Germany to Invest in French Recon Satellite for Access to Full Constellation". Space News. 9 February 2015.

[199] Robinson, Jana. "Europe's Key Foreign Policy Objectives Via Space". ESPI Report 30. Vienna: European Space Policy Institute. February 2011: 26-27.
[200] See European Defence Agency. "Multinational Space-Based Imaging System for Surveillance, Reconnaissance and Observation". Web. https://www.eda.europa.eu/our-work/projects-search/multinational-space-based-imaging-system
[201] For a more detailed description of the MUSIS project Kolovos, Alexander, and Kostas Pilaftis. "European Multinational Satellite Programs". In: Schrogl, Kai-Uwe, et al (eds). *Handbook of Space Security. Policies, Applications and Programs*. Volume 2. Springer. 2014: 843-866.
[202] See: French Senate. "Projet de loi de finances pour 2015: Défense: équipement des forces". Web.

European Actors, Programmes and Policies

In parallel to these national developments, over the past decade European-level institutions have also become increasingly involved in the field of security from space, although none of the programmes in question were intended to be purely military space programmes. The European Commission has become the engine of space security initiatives, as demonstrated by its intention that the services provided by its two flagship programmes should serve security and defence policies as well as by the growing number of policy initiatives it has undertaken.

Both Copernicus and Galileo are intended as civil programmes under civil control. However they both possess an obvious security component and, among other tasks, are intended to enhance the management of security-related challenges. One of the functions of the Copernicus programme is to provide dedicated security services in the areas of border surveillance, maritime surveillance and support to EU external action (e.g. support to the planning and conduct of both military and civilian operations of crisis management and peacekeeping operations by specifically assessing the situation on the ground).[203] The Copernicus programme will, however, also provide security services in the broader sense, for instance by assisting the EU in the prevention of disasters such as flooding, forest fires and oil spills that require timely and precise information. As for the security-related services of Galileo, once operational, the system is intended to provide the armed forces of the Member States, EU Battle groups and the CSDP with Positioning, Navigation and Timing (PNT) services. Galileo will also offer support to humanitarian search and rescue activities and will provide public authorities with encrypted signals as well as warnings if the signal's integrity is at risk.[204]

In terms of policy initiatives, since the release of its White Paper on Space in 2003, the EU has endorsed the need to consider space as a whole, thus also the possibility of using space technology in the practical implementation of the European Security and Defence Policy (ESPD), now a component of the CFSP. The EC established a Space and Security Panel of Experts (SPASEC) that was convened in June 2004 and was followed by a SPASEC Report in March 2005, which identified capabilities and capability gaps as well as the operational needs of Europe.[205]

The topic of space security has increasingly gained momentum through such developments as the Resolutions of the EU-ESA Space Council and the Lisbon Treaty of 2009.

The Resolution on the ESP adopted by the Space Council in May 2007 introduced a dedicated chapter on security and space. The chapter clearly linked space activities with the European Security and Defence Policy and outlined how the security of Europe and its citizens is increasingly relying upon space-based capabilities. It also called for a "structured dialogue on space and security" involving the European Council, the EC, and ESA, and proposed moving toward more interoperable, coordinated space capabilities among the relevant entities.

In 2008, the ESP Progress Report emphasised that European space capacities had become critical information tools in addressing a diversity of environmental, economic and security challenges on a global and regional scale. Autonomous access to information derived from space is thus a strategic EU asset. The EU will need to further strengthen its ability to respond to these challenges, including in the security and defence domains, through both improved coordination and the development of indigenous capacities.[206]

The Lisbon Treaty not only created a legal basis for the stronger action of the EU in space but also provided the Union with the mandate to strengthen its international engagement in security and defence matters. In this respect, the Treaty established a European External Action Service (EEAS) and created the post of High Representative of the Union for Foreign Affairs and Security Policy, which has accordingly assumed a number of specific tasks with regard to space security. Assisted by the EEAS, the High Representative supervises two fundamental institutions for space security: the European Union Satellite Centre (EU SatCen) and the European Defence Agency (EDA).

The EU SatCen, located near Madrid, was founded in 1992 and incorporated as an agency into the EU in January 2002. Its stated mission is to "support the decision–

[203] Marta, Lucia. "European Institutional Satellite Programs". In: Schrogl, Kai-Uwe, et al (eds). Handbook of Space Security. Policies, Applications and Programs. Volume 2. Springer. 2014: 802-827.

[204] *Ibid*: 821-822.

[205] Report of the Panel of Expert on Space and Security. March 2005. Available on ESPI website.

206 Commission of the European Communities. "Commission Working Document – European Space Policy Progress Report". Report COM(2008)561 final of 11 Sep. 2008. Brussels: European Union. 15 December 2012. <http://eurlex. eu-ropa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0561:FIN:en:PDF>: 6.

making of the European Union in the field of the Common Foreign and Security Policy (CFSP), in particular of the Common Security and Defence Policy (CSDP), including European Union crisis management operations, by providing, as appropriate, products resulting from the analysis of satellite imagery and collateral data, including aerial imagery, and related services".[207] The Centre is one of the key institutions for European Union's Security and Defence policy, and the only one specifically dedicated to space.

The European Defence Agency (EDA) was established by a Joint Action of the Council of the EU in July 2004 and completely restructured in 2013. The mission of the Agency is to "support the Council and the Member States in their effort to improve the EU's defence capabilities in the field of crisis management and to sustain the CSDP as it stands now and it develops in the future".[208] Among its various tasks, the Agency is involved in the space security domain.[209] Its primary objective in this respect is to identify defence requirements that could be met by space-based solutions and to promote measures to satisfy those requirements. Following the Resolution of the Space Council of 25 November 2010 – which called for the establishment of appropriate mechanisms to effectively exploit space systems to support the capability of the CSDP – space has also been included in EDA's Defence Capability Development Plan as a core enabler for defence-related capabilities.[210] In concrete terms, EDA has been entrusted with the management of a Governmental Satellite Telecommunication (GOVSATCOM) initiative, with the objective of providing Member States with several options for a future collaborative programme and to pave the way for the next generation of telecommunication capabilities in the 2025 timeframe.[211] In addition, EDA has been involved in the "Structured Dialogue on Space and Security", gathering the EC, the EEAS, the Council Secretariat General, EDA and ESA for regular exchanges of views and coordination of relative space-related activities.

With regard to ESA, this Agency has for a long time been playing a role in supporting synergies between space and security through its activities (e.g. launcher development) which are inherently dual-use in nature, even if the corresponding programmes have always been designed without any specific security requirements.[212] Indeed, the Agency has traditionally avoided any direct involvement in security-related activities. For many, this was because the ESA Convention states that the Agency should operate for "exclusively peaceful purposes".[213] However, as explained by ESA in a 2003 position paper, this reference cannot be interpreted as restricting ESA's capacity to conduct activities of a dual use or military nature.[214] In fact, in recent years ESA has become increasingly involved in the area of space security.

In terms of security from space, ESA's involvement is visible through its participation in the Copernicus and Galileo flagship programmes, as well as through the European Data Relay Satellite System (EDRS), a system of two GEO payloads (to be launched in 2015 and 2016) that will relay information between satellites, spacecraft, UAVs and ground stations, also for security purposes.[215] In addition, following the Resolution of the 7th EU-ESA Space Council, on 20 June 2011, an administrative agreement with the European Defence Agency (EDA) was concluded with the aim of exploring the specific contributions space assets can bring to the development of

[207] European Union Satellite Centre. "Mission". 15 December 2014. Web. http://www.satcen.europa.eu/index.php?option=com_content&task=view&id=3&Itemid=11

[208] European Defence Agency. "Mission". Web. http://www.eda.europa.eu/Aboutus/Whatwedo

[209] As major tasks, the Agency identifies operational requirements and promotes measures to satisfy those requirements needed to strengthen the industrial and technological base of the industrial sector. It also participates in defining a European capabilities and armaments policy; it promotes harmonisation of operational needs and the adoption of effective, compatible procurement methods; it proposes multilateral projects to fulfil objectives in terms of military capabilities; it supports defence and technology research and coordinates joint research activities.

[210] European Defence Agency. "Governmental Satellite Communications". Web. http://www.eda.europa.eu/Aboutus/Whatwedo/capability-programmes/governmental-satellite-communications

[211] The GOVSATCOM programme is envisioned with a "sequential approach, consisting of a first step dedicated to addressing user needs and to identifying the technical, system and mission requirements. EDA, together with all involved parties, will landscape and assess the ability of various solutions to fulfil these requirements and finally develop the appropriate framework [of a future collaborative programme] including governance issues, concept of operations and cooperation framework". European Defence Agency. "Governmental Satellite Communications". 16 June 2016. Web. http://www.eda.europa.eu/what-we-do/activities/activities-search/governmental-satellite-communications-(govsatcom)

[212] European Space Agency Council. "Status of Security-related Activities in ESA". ESA/C(2007)111. Paris, 25 September 2007.

[213] The Convention refers to the organisation's promotion of space for exclusively peaceful purposes in both the Preamble and Article II

[214] European Space Agency Council. "Position paper on ESA and the Defence sector" ESA/C(2003)153. Paris, 1 December 2003.

[215] The first EDRS payload will be placed on board the Eutelsat 9B communication satellite, while the second EDRS will be launched on a dedicated satellite. See European Data Relay Satellite System webpage: http://www.edrs-spacedatahighway.com/

European capabilities in the area of crisis management and the CSDP.[216]

The Administrative Arrangement foresees the possibility of launching Implementing Arrangements for specific joint projects in accordance with the respective rules and procedures of ESA and EDA. A first implementing arrangement was signed in December 2011 with regard to a joint demonstration mission in the area of Unmanned Aerial Systems Command and Control over Satellites. Additional identified activities of common interest include intelligence, surveillance, reconnaissance, civil-military synergies, Earth Observation, satellite communications, Space Situational Awareness and critical space technology for European non-dependence.[217] Several joint demonstration projects in those areas are currently in the phase of being implemented.

All in all, the socio-economic dimension on which European space undertakings have so far focused has started to be increasingly accompanied by a security dimension. It remains however to be seen whether more integrated and ambitious approaches will follow to fulfil Europe´s growing space security needs.

4.4.2 Is there Added Value in EU Involvement?

Since the very beginning of the European project it was clear that economic integration alone would not be sufficient to realise Europe's ultimate goal of creating a unified and strong entity capable of projecting geopolitical skills and values on the world stage. In order to ensure this goal, by necessity, the EU has to become a more coherent, credible and capable actor also in terms of foreign and security policy. Without a stronger profile in this domain, Europe would perhaps loom large on an economic map of the world but remain a geopolitical blip, reliant on NATO and ultimately on the U.S. to safeguard its interests and security. [218, 219] Defence needs to move beyond the transatlantic paradigm, because Europe cannot be a *normative power* without *real power*.

The creation of the EEAS and of the post of the High Representative as well as the adoption of a CSDP and the introduction of the notion of Permanent Structure Cooperation (PESCO) initiatives have certainly marked important steps forward, but much work remains to be done on the institutional, military and technological front in order to *materially* improve the security- and defence-related capabilities of the Union.

Improving such capabilities is vital to ensuring an effective CSDP, and space assets constitute an essential segment of the military means needed. Space-based systems are an integral part of the defence capabilities of any nation aiming to have a strategic presence in the world and can be "a force multiplier, which at the very least makes the implementation of security policies more effective".[220]

When looking at the key objectives set by the EU for security, there appears to be much room for space assets to strengthen these objectives. The objectives as well as the contribution brought by space to their fulfilment are well known and have been assessed in a number of policy analysis documents; it thus suffices to mention them only briefly.[221] Space imagery can, *inter alia*, provide valuable support in terms of environmental, energy and food security. In addition, it can assist in the planning and conduct of both military and civilian aspects of crisis management and peacekeeping operations by specifically assessing the situation on the ground. Secure and reliable satellite communications are essential for exercising political control and strategic direction over any civil or military operation. They are particularly valuable in external theatres, especially where local infrastructure is deficient, and

[216] More specifically, the EDA-ESA Administrative Arrangement states that cooperation between the two agencies will seek to: a) Identify those capabilities gaps that could be filled by space assets for the sustainable and effective implementation of the EU policies; b) Investigate whether identified capabilities requirements can be shared and thus supported by both ESA and EDA; c) Coordinate research, technology and demonstration activities, including access to study results as appropriate and subject to their respective rules.; d) Investigate synergies between existing dedicated EDA and ESA programmes and their future evolution.; e) Explore synergies and coordinate activities in support of industrial competitiveness and European non-dependency issues

[217] European Space Agency. "European Space Technology Master Plan." 11th Edition. ESA/ESTEC. October 2014.

[218] Kupchan, Charles A. *The end of the American Era. U.S. Foreign Policy and the Geopolitics of the Twenty-first Century*. Vintage Book. New York. 2002: 60-70

[219] The conflict in Kosovo, Bosnia-Herzegovina and more recently Libya have been unfortunate precedents in this regard and have made once again clear the inadequate level of Europe's defence capabilities and level of integration.

[220] *Cit*. Smith, Lesley Jane, and Kay-Uwe Hörl. "Constructing the European Space Policy: Past, Present and Future. Commerce in Space: Infrastructures, Technologies, and Applications. Phillip Olla. Hershey: Information Science Reference. 2008: 12.

[221] See for instance: Johnson-Freese, Joan. *Space as a Strategic Asset. Columbia University Press*. New York: 2007. Academie Nationale de l'Air et de l`Espace. *Space for defence. A European Vision*. April 2005. (Available on ESPI website). Robinson, Jana. "Enabling Europe's Foreign Policy Objectives via Space". ESPI Report 30. February 2011.

communication capabilities thus exclusively dependent upon space-based assets. Also, Navigation, Positioning and Timing (PNT) are important to military forces and civilian units involved in crisis management and peace-keeping operations.

An *integrated* and *autonomous* access to information and services provided by space is thus a strategic asset for the EU and the implementation of its policies. While this necessity *per se* could justify the initiation of a dedicated flagship programme in the field of space security - particularly in the area of satellite telecommunications - it is also true that much of the required technology and infrastructure (including telecommunications, optical reconnaissance and radar observation satellites) is already in the possession of European countries and ideally could be made available to the EU. Additionally, valuable services will be offered by adequate exploitation of the Copernicus and Galileo programmes. More importantly, *all* European actors (namely, the EC, the EU Council, EDA, ESA and Member States) have, since the elaboration of the ESP, agreed to systematically explore common ways to support current and future capabilities needs of the CFSP/CSDP through cost-effective access to space assets and services (integrating global satellite communications, earth observation, positioning and timing and taking full advantage of dual-use synergies).

The rhetoric of official policy documents notwithstanding, engaging defence decision-makers in pan-European space is no easy task as there appear to be both objective difficulties in pooling and sharing strategic assets and an underlying hesitancy by European Member States to surrender a key part of their autonomy. In fact, it is no coincidence that dedicated security space programmes have not been initiated at European level, but have firmly remained based either on national or government-to-government collaboration. As mentioned, this has led to unprofitable duplication and fragmentation, which appears indefensible, particularly considering the period of prolonged austerity faced by most European countries. The recent cuts in EU Member States' defence budgets have made it clear that it is no longer possible to maintain adequate military capabilities (including in terms of space assets) at national level, meaning that a form of pan-European initiative will be necessary.[222]

What is also clear is that leaving European military space systems to national agencies and agreements outside a common framework is in contradiction to the policy of consolidation of European space efforts, and more broadly with the project of European integration (also on matters of collective defence) pursued over the last decades. Defence, to be sure, is an intergovernmental task and cannot be handed over to the Commission as such.[223] Military capabilities will likely continue to remain within the remit of Member States also in the future, as they are understandably still not comfortable enough to completely merge their defence policies and programmes.

Be this as it may, functional steps can nonetheless be taken to achieve greater European integration on security and defence matters, and a space flagship initiative could be a good place to start. Besides accruing *material* payoffs on the operational, technological and industrial level, a flagship programme in the field of space *for* security can also be of paramount importance to inducing changes on the institutional and political level. Put simply, it might act as a trailblazer, giving impetus to bolder initiatives within the CSDP and Permanent Structured Cooperation, and creating a *positive spillover effect* to further the process of political integration in the security domain. After all, Jean Monnet's functionalism remains a guiding principle of the European integration project also in the field of security.[224] Thus, the underlying idea is that space may again become a domain setting broader political trends, rather than a reflection of current ones. As such, the value of initiating a flagship programme for space security is that it would enable the EU to provide both the pan-European space efforts with their currently missing dimension, and to start delivering success in the broader area of security, thus fulfilling its mandate and reaffirming a leading role in both fields. Put simply, should security become the next EU flagship for space, the reverse might also prove to be true: space would become a flagship programme for European security.

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[222] Identified steps forward include: the implementation of the pooling and sharing approach on the military level; the establishment of the permanent structure of cooperation on the institutional level; the definition of a European roadmap for dual-use technologies on the technological level; and the launch of European procurement programmes co-financed by the EU at the industrial level. *Cit.* Marrone, Alessandro and Michele Nones. "More Europe on defence or no Europe". Istituto Affari Internazionali. June 2013.

[223] Smith, Lesley Jane, and Kay-Uwe Hörl. "Constructing the European Space Policy: Past, Present and Future. Commerce in Space: Infrastructures, Technologies, and Applications. Phillip Olla. Hershey: Information Science Reference. 2008: 12.

[224] According to functionalism, the integration between states in one specific sector will create stronger incentives for integration in further sectors, in order to fully capture the peaks of integration in the sector in which it started.

Ideally, such a flagship programme could be primarily devoted to the development of pan-European capabilities in the field of satellite telecommunications, since it at present remains an area covered only by the GOVSATCOM feasibility study of EDA. The programme could, however, be designed to progressively integrate those capabilities with the EO and PNT services covered by the current flagships in a more structured fashion and to develop a dedicated, centralised infrastructure for the management of all security-related space services.

The opportunity for the EU to take a more pro-active stance in the security domain offered by a space flagship programme could also act as a double identity-forming element for Europe, i.e. for both the security and the space dimensions.[225] Clearly such a programme would provide just some building blocks in the bigger frame of a European identity, but – as previously stressed– flagship programmes are ultimately instruments designed to further stimulate European cohesiveness and spur a meta-national European integration and identity. Like exploration, a flagship initiative in the field of space *for* security could noticeably push forward the European integration project, the difference being that such a programme would specifically impact the governmental and political level rather than the level of citizens.

An additional key rationale behind the possible initiation of a Space Security Flagship emerges by putting it into the appropriate perspective. By definition, a flagship involves a long-term programme with a first development period of at least 10-15 years and, as such, it can tackle operational needs in the long-term only. Whereas in the current context the ideal pathway to ensuring Europe's space-related security needs is through the concrete pooling of national capabilities (and in the near future by effective integration of those capabilities with the services provided by Copernicus and Galileo), the continuity and upgrading of the required assets and services can be fully met only in the long term perspective of an optimised programme.

The key advantage in embedding space security within the frame of a long-term flagship is thus that it would provide Member States time to calibrate their national space efforts in the security domain, while at the same time overcoming the prospect of a restrained space security programme maintained by a handful of military capable Member States only. In other words, through the implementation of a flagship programme, national actors could sensibly reduce their long term investment in security-related space assets in favour of a growing pan-European approach, "able to pull together, in a coherent and consistent way, the weight of all Member States and of all the European institutions".[226] Great political benefits and material payoffs would be the result.

4.5 Assessment of the Future Flagship Options

The discussion above has revealed that all three candidates possess specific characteristics that could potentially point to added value resulting from EU involvement. In this final section they will be compared side by side from an overall perspective against the benchmark indicators identified in section 4.1. These indicators, however, cannot be interpreted in isolation from feasibility considerations in terms of political commitment, financial resources and operational complexity. Political feasibility is a measure of how well the considered flagship candidate would generate convergence of interests and broad consensus among European stakeholders. A feasible candidate is thus one that has a high probability of receiving sufficient political push and support to be implemented. Operational feasibility refers to the concrete management challenges the programme would entail. Finally, financial feasibility refers to the amount of European budget to be mobilised over a period of at least ten years. In this respect, specific estimates fall outside the scope of this report. However, the order of magnitude is provided to feed political discussion among stakeholders, particularly within the Commission.

It is important to note that the comparative assessment offered below (see Table 11) is based on a relative approach in two respects. First, it is relative in that scenarios for the three candidates are compared against each other for every criterion individually. Second, for each parameter the candidates are rated according to how well EC involvement would score as compared to the *status quo*, taking into account current initiatives and activities. A blank field in Table 11 signals no or negligible additional benefits compared to the *status*

[225] On the role of space and security as forming element for European identity see: Remuss, Nina-Louisa. "Space and Security as an identity forming element – meeting Europe´s external and internal security through space applications". In: Venet, Christophe, and Blandina Baranes (eds.). *European Identity through Space. Space Activities and Programmes as a Tool to Reinvigorate the European identity*. Springer. Wien. 2012.

[226] *Cit*. Vasconcelos, Alvaro. "What ambitions for European Defence in 2020?". European Union Institute for Security Studies. July 2009.

quo, one dot represents a moderate potential and, two dots implies a significant potential for added value through EC involvement. In the feasibility heading, the number of dots corresponds to the degree of feasibility.

Criterion	**Exploration**	**Launcher**	**Security**
Economic and Social Benefits:			
Bring benefits to a large number of users in society and the economy.	•		•
Support diverse segments and regions of the European society and economy.	••	•	•
Become a tool in spurring structural economic growth.	•	•	•
Make European scientific research and engineering communities more productive and efficient, and establish new networks.	••	••	••
Strategic and Political Benefits:			
Give Europe a strong or leading role in the domain and offer a cutting-edge advantage.	•	••	•
Serve geopolitical objectives: autonomy, non-dependence and strengthen EU international presence.	•	••	••
Advance Europe's diplomatic goals and support the foreign policy action of the EU.	••	•	••
Enable the EU to become more competent in addressing diverse policy needs.			••
Drive advances and innovation in science, technology, engineering and programme management.	••	••	•
Stimulate European integration and identity at political EU level.	•	•	••
Create a strong European brand that could stimulate European sense of identity and citizenship.	••		
Feasibility			
Political	••	•	
Financial		•	••
Operational		••	•

Table 11: Assessment of the Future Flagship Programme Options.

Generally speaking, involvement of the Commission in the field of space exploration is expected to yield a wide range of benefits in a number of areas. One of the main reasons for this is the huge diversity in technological capabilities required in space exploration and human spaceflight in particular. More specifically, this would allow the EU to invest and create spillover effects that generate smart growth, sustainable growth, and inclusive growth. In addition to this, the prestige and soft power associated with having an ambitious space exploration programme would enable the EU to reap a variety of strategic and political benefits. Although this option would score well in terms of political consensus as compared to the other scenarios, it is associated with high costs, a high level of operational complexity and, a prolonged political commitment, at the highest levels, spanning over multiple decades.

In the launcher option the socioeconomic benefits might be less pronounced compared to the exploration option. This is mainly because ESA has already achieved a strong position in the sector. Where EC involvement in launchers does score significantly is in how it would enable Europe to gain an even stronger cutting-edge advantage in terms of innovation and long term competeiveness – especially with regard to game-changing technologies in this ever more rapidly evolving field. It would thus support and foster European industrial capabilities and assist Europe in maintaining a leading position in the commercial market. In addition, EU involvement could encourage Europe to leverage launchers as a policy tool on the international stage, thus providing a stronger political profile to this highly strategic field. The level of financial commitment required for the implementation of this flagship candidate might be relatively high, but the operational complexity would be all-in-all conceivably manageable, albeit with considerable risk of eventual failure – as with most investments in disruptive innovation.

As an EU flagship programme, the socioeconomic benefits of the security option might perhaps have a lower degree of visibility. Nonetheless, over the long term a solid security architecture would generate demonstrable paybacks, especially considering that it would provide impetus to the European R&D communities and that it would bring about stronger cross-fertilisation among the currently fairly stove-piped networks in the security domain. Moreover, from a strategic and political perspective, a space security flagship programme would complement a wide range of existing EU policy domains and make security operations more effective and efficient. Although the political feasibility of this option is low given the Member States' reluctance to merge their defence policies and programmes, a space security flagship programme would prove a milestone towards further and broader steps in the creation of a truly European Common Security and Defence Policy, besides providing European space efforts with their missing dimension. This in turn would be of paramount importance in consolidating the longstanding efforts of the European integration project.

While it is clear that each scenario has very particular characteristics, selecting one candidate over another eventually comes down to the relative weight decision-makers will attribute to the different socioeconomic, strategic and political benefits as well as the challenges related to EC involvement for each scenario in terms of political, financial and operational feasibility. Although this report does not aspire to bring any conclusive answer regarding the way to go, it is hoped that it will be an element supporting the reflection process for the European Commission and other European stakeholders in determining whether, in which area, to which extent, and in what way the will to increase EC involvement in space activities will be channelled.

5. Conclusions

For more than sixty years the European integration project has been expanding and deepening immensely. From the original narrow – yet historic – cooperation in the production of coal and steel, EU policies and actions today affect nearly all segments of European social, economic and political life. The European Union is currently in the process of asserting a stronger role in space. It is doing so because its mandate and competences have now become so broad that space activities and policies are becoming a crucial element in supporting and addressing them. Another motivation is that strategic assets such as space capabilities could benefit from validation at a high political level. Furthermore, space provides the EU with a tool to further the European integration project, increase its political weight vis-à-vis European Member States and assert its role as an *actor* on the international stage. It is thus likely that EU involvement in space will continue to expand both within and beyond its current undertakings.

The first aim of this report was to assess how this expanding role in space could be enhanced from a policy and governance perspective. As Europe's new and autonomous all-round Earth Observation programmes and Global Satellite Navigation System will achieve full operational status in the near future, priority should be given to the operational governance of Copernicus and Galileo. To this effect, this report investigated how to ensure that the data and services provided by the current constellations can be reaped in an optimal fashion. It was demonstrated that many important steps have been taken. Some crucial links and elements remain, however, to be established. For Copernicus, exposure among potential users within Europe remains relatively weak. Furthermore, there is still a structural mismatch between the current organisational structure of the services, which is highly decentralised, and the need to also pursue more holistic approaches to data management. The report suggests that the current approach of thematic services is sensible, but that alone it cannot guarantee full passage of socioeconomic and scientific benefits from the scientific community to the public and society as a whole. For Galileo, the creation of different services corresponding to various needs was a very sensible decision. However, there are no or few defined binding targets to integrate location based services and navigation throughout the European economy – although reflection on how the public sector might complement the private sector in this respect is certainly worthwhile. It is recommended that European diplomacy be used to explore the option of pooling expertise worldwide to achieve interoperability with the aim of increasing worldwide GNSS performance, and seeking to establish better user interfacing mechanisms at the global level. In terms of validating the benefits of both flagship programmes at political level, there is a strong need for information to flow back to the political system.

As a second step, it must be ensured that the two current flagship programmes will play a central role in spurring innovation ecosystems in their respective sectors. In this respect, it is recommendable that innovation be pursued in both the up- and downstream segments, and by both institutional and private actors. Upon closer scrutiny, it seems that the current set up is not entirely conducive for the creation of a balanced ecosystem. SMEs in particular remain fairly underrepresented and far from reaching their potential, although they will become ever more involved in the EO and GNSS sectors, and therefore will also be a key driver in technological innovation.

Another concern is that Europe faces further difficulties in cross-fertilisation between the dot-com sector and EO and GNSS applications because the former is not as strongly developed as, for instance, in the United States.

Finally, the decentralised method of gathering new and existing continuity requirements in Copernicus endangers the coherent definition of overall system priorities and the constellation's composition over the long term, as well as creating an unnecessary barrier for accommodating users with transversal requirements.

The second main objective of this report was to investigate the possibility and opportunity for the EC to extend its involvement over space matters by means of a new flagship programme. The report set out general considerations on the criteria defining EU flagships programmes and identified three candidates that have the necessary appeal and ingredients to constitute a new flagship programme. These are: space exploration, access to space, and space security.

However, consideration should be given as to whether the flagship model provides *per se* the most appropriate framework for the conduct of the EC's future space activities. The financial and administrative difficulties encountered over the years by both the Galileo and Copernicus programmes shed some doubt on the long-term suitability and sustainability of current schemes and could therefore induce the Commission to prefer an alternative approach to space, for instance, that of having a dedicated budget item for space to be allocated to a plethora of undertakings. That being said, it appears quite clear that if a different approach were to be pursued, this would be closely connected to major changes within the overall governance of space activities in Europe (including the future evolution of ESA vis-à-vis the EU). Therefore, for the time being it is more likely that EU involvement will continue to evolve by the means of flagship programmes.

Consideration of the actual implementation aspects of a new flagship programme will vary according to the candidate the EC selects. The comparative assessment included in this report does not aspire to provide a conclusive answer regarding the best area for further EU involvement. Each of the candidate flagships possesses unique characteristics, and a specific selection would thus entail pros and cons that can only play out in actual political discourse. What is however recommendable is to define a coherent and transparent mechanism to support the selection process in an optimal manner.

One possible path would be for the Space Advisory Group of the EC to establish a dedicated committee on future space flagship programmes. Whereas the practice is not new, as a SAG sub-committee was already formed in 2009 to provide the Commission advice on its potential contribution to space exploration, the specific feature of 'flagship committee' would be that of comparing and contrasting a number of scenarios and options rather than focusing on just one domain. As there are many valid arguments underpinning the case for each candidate, doing so would allow decision makers to better weigh the different socio-economic, strategic and political benefits involved in each option as well as the political, financial and operational effort required.

It is also recommended that the work of such a flagships committee should be based on wide-scope hearings involving all major stakeholders. Ideally, these hearings should be set up to engage representatives of EU Member States, the EU Parliament, ESA, and industry, but also actors - such as the European External Action Service - that have so far been less directly involved in the planning and conduct of space activities but that can nonetheless play a crucial role. One of the major advantages of an open approach is that it would identify how the relevant stakeholders assess each given option, as well as prepare the distribution of tasks and responsibilities of the different actors throughout the implementation process. Such a broad participatory approach could be also extended to engage the public as an active stakeholder. This would have the additional advantage of creating a strong link with society even before the conception of a programme, thereby increasing outreach, and awareness and societal support.

List of Acronyms

Acronym	Explanation
A	
ASI	Agenzia Spaziale Italiana (Italian Space Agency)
ASL	Airbus-Safran Launchers
ATV	Automated Transfer Vehicle
B	
BOC	Besoins Operationnels Communs (common operational requirements)
C	
CFSP	Common Foreign and Security Policy
CNES	Centre National D'Etudes Spatiales (French Space Agency)
CS	Commercial Service (Galileo)
CSDP	Common Security and Defence Policy
D	
DG	Directorate-General
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Space Agency)
DOLPHIN	Development of Pre-operational Services for Highly Innovative Maritime Surveillance Capabilities
E	
EARSC	European Association of Remote Sensing Companies
EC	European Commission
ECSC	European Coal and Steel Community
EDA	European Defence Agency
EDRS	European Data Relay System
EEAS	European Union External Action Service
EFAS	European Flood Awareness System
EGAS	European Guaranteed Access to Space
EGNOS	European Geostationary Navigation Overlay Service
ELDO	European Launcher Development Organisation
ELV	European Launch Vehicle
EMS	Emergency Management Service (Galileo)
EO	Earth Observation
EP	European Parliament
ESA	European Space Agency
ESC	European Space Conference
ESP	European Space Policy

Acronym	Explanation
ESPI	European Space Policy Institute
ESRO	European Space Research Organisation
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EUSatCen	European Union Satellite Centre
F	
FLPP	Future Launchers Preparatory Programme
FOC	Full Operational Capability
FP	Framework Programme
G	
GEO	Group on Earth Observations
GMES	Global Monitoring for Environment and Security
GNI	Gross National Income
GNSS	Global Navigation Satellite System
GOVSATCOM	Governmental Satellite Communications Programme (EDA)
GPS	Global Positioning System
GSA	European GNSS Agency
H	
H2020	Horizon 2020
HSPG	High-Level Space Policy Group
I	
ICG	International Committee on GNSS
ICT	Information and Communications Technology
IOC	Initial Operational Capability
IOV	In-Orbit Validation
ISECG	International Space Exploration Coordination Group
ISEF	International Space Exploration Forum
ISS	International Space Station
ITU	International Telecommunication Union
IXV	Intermediate Experimental Vehicle
J	
JRC	Joint Research Centre
JTF	Joint Task Force (ESA-EU)
M	
MAC-II	Monitoring Atmospheric Composition and Climate – Interim Implementation
MEO	Medium Earth Orbit
MFF	Multiannual Financial Framework
MOSAIC	Management of Operations, Situation Awareness and Intelligence for regional Crises
MPCV	Multi-Purpose Crew Vehicle (Orion)

Acronym	Explanation
MS	Member State
MUSIS	Multinational Space-Based Imaging System
N	
NEREIDS	New Service Capabilities for Integrated and Advanced Maritime Surveillance
NGA	National Geospatial-Intelligence Agency
NGL	Next Generation Launcher
O	
OS	Open Service (Galileo)
P	
PESCO	Permanent Structure of Cooperation
PRS	Public Regulated Service (Galileo)
PURE	Partnership for User Requirements Evaluation
R	
R&D	Research and Development
RTD	Research and Technological Development
S	
S&T	Science and Technology
SAG	Space Advisory Group (EC)
SAGE	Stratospheric Aerosol and Gas Experiment
SAI	Space Applications Institute
SAR	Synthetic Aperture Radar
SAR	Search and Rescue Service (Galileo)
SCG	Space Coordination Group
SIMTISYS	Simulator for Moving Target Indicator System
SME	Small and Medium-sized Enterprises
SoL	Safety of Life (Galileo)
SSA	Space Situational Awareness
SUNRISE	Strengthening User Networks for Requirement Investigation and Supporting Entrepreneurship
T	
TFEU	Treaty on the Functioning of the European Union
TRL	Technology Readiness Level
U	
U.S.	United States
UK	United Kingdom
USGS	United States Geological Survey
USSR	Union of Soviet Socialist Republics

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