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IMPACT ASSESSMENT

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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

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1. CONTEXT AND POLITICAL BACKGROUND

1.1. Context

This Impact Assessment (IA) will accompany a communication on the future involvement of the EU in space. It will look closely into the opportunities of the EU to play a future role in space policy and will set out different levels of ambition regarding thematic and financial scope for an EU Space Programme, which could come into force during the next financial perspectives from 2014-2020. The Communication does not amount to a formal proposal for the governance and funding of a European Space Programme. It will rather be the basis for a discussion that may lead to a proposal for a Regulation establishing an EU space programme to be presented alongside or including the GMES proposal Regulation referred to in the following paragraph. Any proposed Regulation would be accompanied by another impact assessment that would analyse the financial impact in a detailed manner.

This IA follows a pragmatic approach and has been drafted along the following lines:

- While Galileo must be seen as an integral part of the European Space Policy, given its complexity and the fact that it follows a decision making path of its own¹, the present impact assessment does not deal with Galileo;
- Similarly, GMES is also an integral part of the European Space Policy. However, it has been the subject of several impact assessments; the last of them was carried out prior to the adoption of the 28.10.2009 Commission Communication on the challenges and next steps for the space component² and is currently the subject of an IA in view of a proposal for a GMES Regulation 2014-2020. Therefore the present impact assessment does not cover GMES;
- The present IA contains some references to space research and innovation because they are intimately linked to the priority areas mentioned below. However, the impact assessment of space research and space and innovation will be dealt with as part of the preparatory work to be carried out for FP8 and for the possible successor of CIP³ respectively;
- Since Galileo and GMES have been clearly identified as the first priorities of the EU in space, the present IA focuses on the other priority areas identified by the 2008 Space Council Resolution⁴ on taking forward the European Space Policy, namely the space and security aspects not covered by GMES (protection of space infrastructure, otherwise referred to as Space Situational Awareness – SSA), and space exploration; like GMES, these actions will be based on the new Article 189 of the TFEU which provides the EU with a dedicated legal basis for action in the space domain.
- There is no programmatic or technical dependence between the actions proposed in this IA and GMES and Galileo. Any new EU activities in space will be additional to and have no

¹ Full reference documents available at

http://ec.europa.eu/enterprise/policies/space/documents/galileo/index_en.htm.

² Commission Communication “Global Monitoring for Environment and Security (GMES) – Challenges and next steps for the Space Component”, COM (2009)589 final.

³ CIP is the Competitiveness and Innovation Framework Programme.

⁴ 5th Space Council Resolution, “Taking forward the European Space Policy”, 26 September 2008.

financial impact on GMES and Galileo in so far as they should only be undertaken under the condition that adequate funding for both is ensured.

1.2. Political background

The political context of the initiative is framed by the new provision of the TFEU. With Article 189 that introduces a new and clear mandate for the EU to act in space matters, space has now become an EU policy in its own right which should be developed through appropriate measures.

The concerted political will of Member States is also reflected in the Council Resolutions and orientations on the European Space Policy (ESP) jointly adopted by the EU and the European Space Agency (ESA) at the 4th, 5th and 6th Space Council meetings held in 2007, 2008 and 2009⁵. These Resolutions put public policy objectives at the centre of the ESP and set priority areas for the future such as climate change, creating global market opportunities, contributing to the security of European citizens and the need for Europe to develop a common vision and a long-term strategic planning for space exploration.

The 2009 Resolution emphasised the contribution of space to innovation, competitiveness and economic recovery in Europe. It stressed that significant investments in space, and the technological progress it generates, must work for the whole of the European economic fabric.

In its 2008 Resolution, the European Parliament endorsed the European Space Policy and asked for concrete proposals in the four priority areas identified above⁶.

There are strong links between the objectives and priorities in these Council Resolutions and some of the central themes of President Barroso's political guidelines for his second mandate and with the EU2020 strategy⁷: growth and job creation, tackling climate change and the research and innovation revolution for a knowledge society.

In his guidelines, President Barroso also underlines that the EU must concentrate where it can bring the most added value. As the Council Resolutions acknowledge, there is a widely shared political view that EU involvement in space activities would offer great added value "to ESA and Member States, while respecting roles and responsibilities of each of them"⁸.

President Barroso in his intervention at the conference "The ambitions of Europe in Space", held in Brussels on 15th October 2009, stated that space is one of the areas that "should progress at EU level" in the future and outlined avenues for future EU involvement in space. He highlighted that space is an "enabling" tool that should help Europe to face fundamental challenges, such as "fighting the economic crisis, ensuring the well being of our citizens; tackling climate change; finding ways to unleash the full potential for innovation and job creation; bringing about a true knowledge society and reinforcing our position in the world scene".

⁵ 4th Space Council Resolution, "Resolution on the European Space Policy", 22 May 2007; 5th Space Council Resolution, "Taking forward the European Space Policy", 26 September 2008; 6th Space Council Resolution, "The contribution of Space to innovation and competitiveness in the context of the European Economic Recovery Plan and further steps", 29 May 2009.

⁶ European Parliament resolution on the European Space Policy, "How to bring space down to Earth", 20 November 2008.

⁷ http://ec.europa.eu/eu2020/index_en.htm.

⁸ 5th Space Council Resolution, "Taking forward the European Space Policy", 26 September 2008.

This initiative is related to the Commission Communication COM(2007)212 jointly developed by the European Commission and ESA and adopted in 2007, defining the strategic mission of a European Space Policy and covering all actors and key aspects of space activities in Europe.

This initiative builds on past achievements in space research under the R&D framework programmes. It is also closely linked to two other space flagship projects (Galileo and GMES) and will benefit other EU policies such as security and defence, environment or health.

2. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

2.1. Organisation and timing

IA Steering Group

DG Enterprise and Industry set up an Impact Assessment Steering Group (IASG) to which the following Services were invited: DG SANCO, DG RTD, DG TREN, DG BUDG, DG ECFIN, DG RELEX, DG JRC, DG INFSO, DG ENV, DG EMPL, DG EAC and the Secretariat-General. The IASG met in December 2009, May 2010 and June 2010 in order to accompany the preparation of the impact assessment.

IA Board opinion

The Impact Assessment Board of the European Commission assessed a draft version of the impact assessment and issued its opinion on 16.07.2010. The impact assessment board made several comments and, in the light of those suggestions, the final impact assessment report:

- Elaborates on the present situation as regards situational awareness and space exploration, including a new annex;
- Clarifies that the suggested action would not compete for funding with Galileo and GMES;
- Clarifies that the options are incremental and therefore their final configuration depends on available funding, once funding for Galileo and GMES has been secured;
- Explains what ESA is currently doing in the fields of space situational awareness and space exploration and analyses the limits for ESA further involvement;
- Further elaborates the impact on competitiveness of EU industry, the international cooperation aspects and provides examples of spin-offs in annex;
- Clarifies further consultation of stakeholders as per the IAB recommendations.

2.2. Stakeholder consultation

DG Enterprise consulted different parties interested and involved in space affairs.

Bilateral meetings were held in 2009 with National Space Agencies of the Member States more actively involved in space activities and with the representatives of the European space industry.

Relevant target stakeholders were interviewed by an external contractor⁹, in the context of a study to support the preparation of the present impact assessment.

The Space Advisory Group of the European Commission, that supports the European Commission services with strategic advice regarding the Space theme of the Framework Programme for Research, provided recommendations on Europe's role in global strategy for space exploration¹⁰.

A Eurobarometer survey on the space activities of the European Union was conducted by Gallup in July 2009 in order to examine EU citizens' opinions and to assess: a) their awareness of space activities of Europe and the European Union, b) their perception of these activities, and c) their general attitude toward space exploration. The majority of European Union citizens regard European space activities as important from the perspective of the EU's future global role: one in five citizens considered such activities *very* important (20%) and a further 43% felt that space activities are important in this respect. In total, almost two-thirds of Europeans share the view that space activities are important for the future international position of the European Union¹¹. Overall, 67% of the survey respondents consider it important to develop space based applications to improve citizens' security and 64% support greater EU involvement in space exploration. However out of the 64% supporting space exploration, 38% of the support was not unconditional (the reply was: yes, perhaps). This means that the EU has to demonstrate the added value of such undertaking.

In October 2009 the first EU-ESA conference on human space exploration marked the beginning of an intense consultation process enabling the EU, ESA and their respective Member States to define a common political vision and role in worldwide space exploration.

In the first semester of 2010 several conferences and workshops on space exploration were organised to stimulate a debate and gather feedback from space and scientific communities, from national governments, and from national and international organizations operating in the space sector. Themes ranged from scientific and educational aspects of space exploration, to the synergies between exploration, innovation, industrial competitiveness and technological progress, to future scenarios for space exploration.

In addition, under the Spanish Presidency, a conference on space and security was held to contribute to defining the role of European Institutions and centres in security programmes.

A second Presidency conference on governance of European Space Programmes involved the EU, ESA and their Member States in a reflection on future developments of the institutional framework for Space activities in Europe. This conference revealed that governance is an issue that has multiple dimensions; the discussion was therefore a step in a process that should gradually lead to each of these dimensions being addressed and eventually settled.

⁹ "Study on the EU Space Programme 2014-2020", Ecorys, Draft Final Report, 18 April 2010, contract n. SI2.541751.

¹⁰ For more information on the Space Advisory Group (SAG) <http://ec.europa.eu/research/fp7/pdf/advisorygroups/space-members.pdf#view=fit&pagemode=none>.

¹¹ http://ec.europa.eu/enterprise/newsroom/cf/itemlongdetail.cfm?lang=fr&item_id=3749.

A study was carried out by an external contractor (Ecorys) to examine possible space activities where the EU could be involved in the future¹². This study is an input alongside others in preparing this impact assessment. The study has been particularly helpful in identifying and confirming possible impacts of EU action in space.

The policy options presented in this IA have been built on the outcomes of these consultations. During the consultations it was made clear that Galileo and GMES are the utmost priorities in space policy. Therefore the suggested actions should not compete for funds with these flagship projects and could only be undertaken provided, inter alia, that additional funding for space is available. Stakeholders were also consulted on the order of priority of the options, i.e. on the fact that space situational awareness should be given priority over space exploration. There is a consensus in favour of this approach.

The action suggested under Option 2, i.e. Space Situational Awareness, has been discussed at length with Member States and there is widespread support for it.

As regards space exploration, Options 3 and 4 as such have not been presented to stakeholders. However, the building blocks of these options emerge from the extensive consultations referred to above.

It is important to underline that the purpose of the Communication on the future involvement of the EU in space is itself part of the wider consultation process. It aims at triggering a debate that may help the Commission in formulating concrete proposals for a possible EU space programme.

2.3. Key issues emerging from stakeholder consultations

From the bilateral meetings held with national space agencies, with Ministries in charge of space matters and with the industry association, the following considerations can be drawn:

- The European Union has a very important role to play in space matters. Together with Member States and ESA, the EU is one of the three main players in the space field, each of them having a specific and distinct role. The EU has a political role and a political responsibility and must aggregate and represent the interest of all, when deciding its involvement in space;
- The EU needs a vision for its future involvement in space, in order to elicit public and political support;
- Stakeholders agree that the most urgent priorities for the EU are the completion of the Galileo and GMES (including reinforced security and climate change dimensions) programmes, in order to start benefiting from the services they provide;
- The next priority for stakeholders, notably Member States, is the protection of our space infrastructure (as described in option 2). Our economy and the well being of our citizens is increasingly dependent on space-based applications and we need to acquire the capacity to protect it;

¹² “Study on the EU Space Programme 2014-2020”, Ecorys, Draft Final Report, 18 April 2010, contract n. SI2.541751.

- As regards space exploration (covered in options 3 and 4), Member States believe it is important to define a long-term strategy that may include both robotic and human space exploration, that considers the issue of access to space and is backed up by a programme to develop the necessary enabling technologies for short, medium and long term space exploration. Space exploration is seen as a field that offers great potential for industrial development but it does not have to be developed at the detriment of other priorities. Support for the International Space Station is to be considered as part of a wider space exploration strategy and not as an end in itself;
- Stakeholders also underline the importance of public/EU funding for the space industry (delivered mainly through public procurement); the industry association emphasises the need to stimulate competitiveness of European space industry at international level and favours the introduction of accompanying measures to ensure the involvement of new Member States' industry in public funded space procurement;
- There is also a consensus that the EU, ESA and their Member States need to work together on all of the above.

Overall there is a clear consensus among Member States in support of the development of an EU Space Situational Awareness capacity. Member States have expressed their political will and support for a stronger EU involvement in SSA in several Space Council Resolutions, particularly the one of September 2008 which asks the EU “to take an active role to set up progressively this capability and an appropriate governance structure”. There is also a positive and receptive attitude towards EU further involvement and expenditure in space exploration, as a complement to ESA's and Member States' activities. However, Member States final position will depend on many factors including the concrete proposals for action that the Commission will table and the funding mechanisms for such actions.

3. WHAT ARE THE PROBLEMS?

3.1. Problem definition

3.1.1. Introduction: Member States involvement in space

It is widely acknowledged that space-based applications and services have become part of our everyday reality. Our society increasingly depends on space-based technologies. Space applications and space spin-offs play a fundamental role in improving our everyday life.¹³

Space infrastructure and services as well as space research have become critical to EU policies¹⁴, including the furthering of technical progress and industrial innovation and competitiveness. Still the EU and the European space sector as it stands today face a number of challenges which could hinder the fulfilment of overall EU policy objectives.

¹³ As regards space applications: GPS, Internet services routed by satellite, TV broadcast by satellite. For examples of spin-offs from Space R&D activities to applications used in everyday life, consult http://www.esa.int/esaCP/GGGIPLH3KCC_Improving_0.html
<http://www.sti.nasa.gov/tto/Spinoff2009/pdf/spinoff2009.pdf>

¹⁴ Applications from Earth observation, navigation and telecommunication satellites are important for issues such as transport, agriculture, fishery, science, environment, health and security.

Space infrastructure and activities in Europe have sprung out of individual nations' or ESA initiatives over which the EU has had limited influence up to now (with the exception of Galileo and GMES).

The space sector is heavily dependent on public funding which accounts for nearly 60% of the European space industry's turnover and 80% in the US.

The degree and nature of involvement of EU Member States in space activities, including space situational awareness and space exploration, varies considerably. Only 18 Member States have developed space activities. Of those, seven Member States represent 91.5% of the civil space activity. This varying degree of involvement among Member States is the result of policy choices made on the basis of national strategic and economic considerations. Among Member States there is a clear difference between those that joined the EU after 2004 (EU 12) and the others. Member States not active in space belong to the first group. However, over the last decade national budgets devoted to space have grown considerably (including among some EU12 Member States) demonstrating that overall the interest in space activities remains steadily on the raise.

Much of this national investment in space has been channelled through ESA. The public budget for the civilian space sector is estimated at €5.7 billion in Europe¹⁵. Of this, ESA accounted for about €3.6 billion in 2009. The national programmes accounted for €2.1 billion¹⁶, while the EU civil public expenditure amounted to €750 million. Military space budgets are rather small (around € 1 billion per year in total)¹⁷.

Despite notorious European successes in space, the different degree of involvement of Member States in space and the fact that space activities respond primarily to national interests (even when conducted through ESA¹⁸) have resulted in fragmentation as regards space activities in general, including space situational awareness and space exploration which is described in detail in the following sections.

3.1.2. Security of critical European space infrastructures is not ensured

3.1.2.1. Description of the security threat due to space debris, space weather and Near-Earth Objects (NEOs)

The ability to protect space assets has become essential to our society. Space-based systems enable a wide spectrum of applications critical to key areas of the economy, including those related to security. This dependence is expected to grow further in the future. It also raises serious concerns because any shutdown of even a part of the space infrastructure could have

¹⁵ Compared to the US space budget the gap is 1:6 for civilian programmes and even worse for military space outlays (1:20). Overall government spending on space programmes (civilian and defence combined) is rising worldwide with expenditures going up 12% in 2009.

¹⁶ European Space Directory, 25th Edition.

¹⁷ Profiles of Government Space Programmes: Analysis of 60 Countries and Agencies, Euroconsult, 2010

¹⁸ Most projects developed through ESA are optional, namely funded through national subscriptions and therefore responding primarily to national interests.

significant consequences for citizens' safety and for economic activities and would impair the organisation of emergency services¹⁹.

During the past half century objects have been launched into space regularly, reaching a peak of 140 items per year during the Cold War. Every time a vehicle boosts a satellite into space, some debris is produced. Examples of space debris are: discarded fuel tanks, satellite components and debris from collisions²⁰. This material, orbiting the Earth at very high speed and in an uncontrolled manner, poses an ever increasing potential risk of collision for spacecraft in orbit.

There are different estimates as to the debris population. According to some estimates, there are between 12 600 objects orbiting Earth larger than 10 cm, which are catalogued and 300 000 objects larger than 1 cm, not catalogued. Furthermore, there are more than 300 million objects larger than 1 mm²¹.

In terms of collisions with debris the average time for a collision between debris and an active satellite has been estimated by some sources at 3-4 years²². At a speed of 10km/s, any of these objects can cause harm to operational spacecraft, from total destruction to permanent damage to sub-systems on-board spacecraft.

According to ESA sources, there is currently 1 collision alert per month. Without any mitigation measures, other sources estimate the probability of effective collisions at 1 every 5 years²³.

The table below provided by ESA summarises ESA's own estimates on debris and possible damage to satellites.

Category	Definition	Estimated population	Potential risk to satellites
Traceable	Greater than 10 cm in diameter	20,000	Complete destruction
Potentially Traceable	Greater than 1 cm in diameter	600,000	Complete to partial destruction
Untraceable	Between 1 mm and 1 cm	More than 300 million	Degradation, loss of certain sensors or subsystems

Tab 1 – ESA's estimates on debris and possible damage to satellites²⁴.

¹⁹ For example, communication systems, electrical power grids, and financial networks all rely on satellite timing for synchronisation. The provision of satellite-based rapid mapping services is indispensable for today's crisis management.

²⁰ On February 11 2009 about 800 pieces of debris were generated by a collision between a US and a defunct Russian satellite. A similar number of debris was generated by a Chinese anti-satellite test in 2007. Such 'accidents' can generate a chain reaction that would destroy most satellites in a given orbit, knowing that the speed of a satellite and debris is 10 km/second.

²¹ "Study on the EU Space Programme 2014-2020", Ecorys, Draft Final Report, 18 April 2010, contract n. S12.541751.

²² "Study on the EU Space Programme 2014-2020", Ecorys, Draft Final Report, 18 April 2010, contract n. S12.541751.

²³ <http://www.parliament.uk/documents/documents/upload/postpn355.pdf>.

Modelling work has suggested that close approaches will rise from 13,000 a week in 2009 to 20,000 by 2019 and more than 50,000 by 2059, meaning satellite operators will have to make five times as many avoidance manoeuvres in 2059 as in 2019. Since each manoeuvre requires fuel, this shortens the active life of satellites, or requires additional fuel to be carried into orbit thus increasing the cost of launch²⁵. The problem is that information available on the position of the objects in question is not accurate and therefore a good number of manoeuvres may not be indispensable but have to be made as a precaution generating extra costs.

On 1st April 2010, 183 out of 928 satellites in orbit had EU contractors/owners (19.71%)²⁶. According to Euroconsult, the average satellite price over the next decade will be \$99 million and the satellite launch price is predicted to remain flat, at \$51 million²⁷ (not taking into account the effect of increased collision risk as described above). Assuming that the direct costs of losing a satellite would be the full cost of the launch and around 50% the cost of an average new satellite assuming that the satellite is destroyed when it reaches its mid-life, the loss would amount to some \$100 million on average per satellite including launches. Ecorys has estimated that the prevention of collisions would amount to a direct cost reduction of €84 million on average per satellite²⁸.

The revenue produced downstream by satellite-driven services²⁹ is estimated to exceed \$60 billion US. European industry has managed to retain a market share of about 40% of the space segment³⁰. While there are not sufficient elements to estimate precisely the potential loss of revenue derived from the destruction of a satellite, the available figures suggest that this amount would be within the range of a hundred million Euros per satellite³¹.

Accurate, timely and complete space situational awareness (SSA) is instrumental for the protection of critical European infrastructures in space and for the secure and safe operation of space-based services, as well as for the protection of the population in case of re-entry events³².

Another threat to the security and functioning of spacecraft/satellites and related ground infrastructure stems from the effects of solar activity, known as 'space weather'. The EU does not currently possess appropriate knowledge of these phenomena. The Sun goes through cycles of high and low activity that repeats approximately every 11 years. The number of dark spots on the Sun (sunspots) marks this variation; as the number of sunspots increases, so does solar activity. Sunspots are sources of flares, the most violent events in the solar system. In a matter of minutes, a large flare releases a million times more energy than the largest earthquake. Episodic solar activity has a number of effects that are of interest to us. A

²⁴ http://www.esa.int/esaMI/Space_Debris/SEM2D7WX3RF_0.html.

²⁵ <http://www.parliament.uk/documents/documents/upload/postpn355.pdf>.

²⁶ http://www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/technical_issues/ucs-satellite-database.html.

²⁷ "Satellites to be Built & Launched by 2018, World Market Survey", Euroconsult, <http://www.euroconsult-ec.com/research-reports/space-industry-reports/satellites-to-be-built-launched-by-2018-38-29.html>.

²⁸ "Study on the EU Space Programme 2014-2020", Ecorys, Draft Final Report, 18 April 2010, contract n. SI2.541751.

²⁹ Example of downstream services are telecommunications or TV broadcasting.

³⁰ <http://telecom.esa.int/telecom/www/object/index.cfm?fobjectid=456>.

³¹ This amount results from calculating the EU share of revenue divided by the number of "EU" satellites.

³² There could be significant negative economic, environmental and social impact generated if debris from spacecraft fall on the surface of the Earth, notably if the spacecraft are powered by nuclear fuel, as is the case with a small number of them today.

radiation dose from energetic particles is an occasional hazard for astronauts and for electronics on satellites. Geomagnetic field disturbances may damage power systems, disrupt communications and degrade satellite-based navigation systems on the ground³³.

The following table reflects the world direct satellite losses due to space weather:

Loss type	Frequency of event	Annualised loss
Complete satellite failure	Rare (<3 per solar cycle)	~€30 to 60 million
Service outage	Frequent (up to 60 anomalies per annum)	~ €30 million
Shortened satellite lifetime	Rare (<10 per solar cycle)	~€5-10 million

Tab 2 – Assessment of financial impacts on satellites due to space weather³⁴.

Complete satellite failure due to space weather has been reported in 11 cases in 25 years. Taking into account the number of EU satellites (183 in 2010), the cost of a satellite and the revenue from commercial satellites, the annualised costs of complete satellite failure would amount to more than €9 million. If we add to this the likely cost for the EU of service outage and shortened satellite lifetime, the total annualised loss for the EU would be greater than €16 million.

Geomagnetic storms³⁵ occur with a frequency of 1 every 30 to 100 years. None occurred during the 25 year period referred to above.

Lacking information on space weather, European operators, including ESA and MS, have no reliable advice on when to shut down spacecraft operations in orbit and to identify the source of potential failures.

Space weather can have negative social impacts due, for example, to the disruption of electricity and telecommunication activities which may in turn disrupt daily life, possibly creating hazardous situations³⁶.

³³ <http://www.swpc.noaa.gov/info/SolarEffects.html>.

³⁴ http://www.esa-spaceweather.net/spweather/esa_initiatives/spweatherstudies/ALC/WP1200MarketAnalysisfinalreport.pdf.

³⁵ Geomagnetic storms are temporary disturbance of the Earth's magnetosphere caused by a disturbance in space weather, http://en.wikipedia.org/wiki/Geomagnetic_storm.

³⁶ One example of space weather impact on satellites is the Canadian communication service provider Telesat's experience in 1994. On 20 January 1994, one of Telesat's satellites was disabled for about 7 hours as a result of space weather-induced damage to its control electronics. During this period, the Canadian press was unable to deliver news to 100 newspapers and 450 radio stations. In addition, telephone service to 40 communities was interrupted.

Finally, Near-Earth Objects (NEOs)³⁷, comets and asteroids whose orbits bring them close to the Earth, are a rare but dramatic danger for Earth and the population in case of impact threats. Predicting and preventing possible impact is paramount but Europe does not currently play a significant role in this international concern³⁸. Scientists divide NEOs in several categories including Potentially Hazardous Asteroids (PHAs). PHAs are currently defined based on parameters that measure the asteroid's potential to make threateningly close approaches to the Earth³⁹. There are currently 1137 known PHAs. Europe needs a capacity to monitor NEOs and in particular these PHAs, updating their orbits as new observations become available so that we are in a position to better predict the close-approach statistics and thus their Earth-impact threat.

The consequences of a NEO impact on the surface of the Earth are difficult to estimate precisely, but they could be catastrophic on the economy and society, including potential loss of life and serious disruption of the economy. Environmental damage can also occur. For example, the 1908 Tunguska Event⁴⁰ is thought to have destroyed 2 000 square kilometres of Siberian forest.

Because satellites and other space-borne assets have become instrumental to many areas of economic activity (e.g. telecommunications, satellite TV, banking, weather forecasting, to name a few), the issue of space infrastructure protection is relevant to all EU Member States and not only major owners or operators of space assets.

3.1.2.2. The current situation regarding space situational awareness

The EU does not at present have full and accurate information on satellites and debris orbiting the Earth.

EU Member States possess valuable assets with potential for SSA. These include radar sensors, optical sensors (telescopes), secure data communication networks, storage and computation as well as human expertise. There is already today a certain degree of European cooperation and sharing of resources and data as exemplified by the Franco-German cooperation on the operation of the French GRAVES surveillance radar and the German TIRA tracking radar and the coordinated operation of the ESA optical space debris telescope at Tenerife and the Swiss ZIMLAT telescope at Zimmerwald. However these systems have significant shortcomings. Many sensors need to be upgraded to become operational; others are too limited in operational availability despite a high technical performance (e.g. French ARMOR radar on the naval vessel Monge).

³⁷ A near-Earth object (NEO) is a Solar System object whose orbit brings it into close proximity with the Earth. They include a few thousand near-Earth asteroids (NEAs), near-Earth comets, a number of solar-orbiting spacecraft, and meteoroids large enough to be tracked in space before striking the Earth. According to some estimates, the Earth is indeed hit on average annually by an object with 5 kilotonnes equivalent energy. The atomic bomb dropped on Hiroshima (which caused between 65,000 to 200,000 deaths and more than 70,000 injured) had approximately 15 kilotonnes of TNT. See <http://www.nature.com/nature/journal/v420/n6913/full/nature01238.html>.

³⁸ It is estimated that a 300m-wide asteroid colliding with the Earth would wipe out a medium-size country.

³⁹ <http://neo.jpl.nasa.gov/neo/groups.html>.

⁴⁰ The Tunguska Event, or Tunguska explosion, was a powerful explosion which occurred close to the Podkamennaya Tunguska River in Russia. It is commonly believed that the cause of the explosion was the air burst of a large meteoroid or comet fragment.

Studies by ESA have shown that existing European resources (ground and space-based) are insufficient.

SSA is a dual-use activity by its nature. However, at present many of the existing national assets relevant for the tracking of space objects and related imagery available are under military control⁴¹. Inefficiencies and duplication result also from the fact that at present civil and military SSA requirements are not integrated and responded to by a single SSA system building on both civil and military assets and expertise.

Since the 1980s a series of non-binding international agreements and guidelines have been agreed⁴². The EU itself is currently working on a draft international Code of Conduct that could have a positive effect in this area.

Despite existing national capabilities and existing international arrangements, Europe is to a large extent dependent on third parties capabilities and goodwill to receive essential information on objects orbiting the Earth.

Not all data are publicly shared because they could be used to interfere with national security. Currently only the US has well established capabilities for a rather effective monitoring of these elements and provides advice to European operators on actions to take, without revealing the basis for that advice. However, these capabilities date back to the Cold War era and, it is generally acknowledged in circles where SSA is discussed that these capabilities do not perform to the standards required by present needs. The available data has not allowed avoiding satellite collisions such as the Iridium 33 and Kosmos 2251 in 2009⁴³.

Recently satellites owned by ESA and the French Space Agency CNES were threatened by potential collisions with debris from other satellites. Collision was avoided thanks to information made available by a non-European space power. Should it have been decided not to share this information with the EU, European assets would have been endangered.

Europe is already active in the area of space weather and capable of producing, to some extent, space weather products. There is also longstanding international cooperation in this field notably with the US National Oceanic and Atmospheric Administration (NOAA) Space Weather Prediction Center. However there is widespread recognition that a new, coordinated

⁴¹ A synthesis of existing space tracking and surveillance assets in Europe prepared by ONERA in 2007 on behalf of ESA reveals that more than 65 % of existing sensors for the Low Earth Orbit (LEO) area are partially or fully operated by Ministries of Defence. Study on capability gaps concerning Space Situational Awareness, ONERA, 2007.

⁴² <http://www.parliament.uk/documents/documents/upload/postpn355.pdf>: "Debris mitigation principles were first put into practice by the US, starting in the 1980s. Since then, a series of voluntary, non-binding international agreements and guidelines have been agreed. The Inter-Agency Space Debris Co-ordination Committee (IADC) was founded in 1993, comprising 11 national space agencies including NASA, ESA and the British National Space Centre (BNSC). In 2002, the IADC adopted a set of recommendations for debris mitigation covering the points in the main text, which has achieved wide international recognition. The UN Committee on the Peaceful Uses of Outer Space developed these recommendations into a set of guidelines which were adopted by the UN in 2008. Several European space agencies developed a European Code of Conduct consistent with the IADC recommendations. ISO (the International Organization for Standardization) is currently transforming the recommendations into a set of International Standards, the first of which should be published in April/May 2010. BNSC chairs the ISO group responsible for developing these standards, which aim to assist the space industry in complying technically with the IADC guidelines."

⁴³ See footnote n. 20.

approach to developing space weather applications tailored to European user needs together with the supporting research and infrastructure is necessary and would increase our capabilities in this area⁴⁴.

The European Space Agency is currently implementing a Space Situational Awareness Preparatory Programme (SSA-PP) launched on 1 January 2009 which will run until 2011. The SSA Preparatory Programme (SSA-PP) is being implemented as an Optional Programme with financial participation by 13 Member States and focuses on issues such as governance and data policy definition and designing the overall architecture of the future European SSA system.

However EU and ESA Member States, as expressed in the 2008 Council Resolution on “Taking forward the European Space Policy”, consider that, taking into account the international and political nature of this capability, the European Union will take, liaising with ESA and their respective Member States, an active role to set up progressively this capability and an appropriate governance structure.

3.1.2.3. Estimated annualised losses due to collision and space weather

On the basis of available data, the table below gives only a non-exhaustive impression of quantifiable estimated loss due to collision and space weather⁴⁵

Loss type	Annualised loss
Direct loss of satellite due to collision	~€4 million
Indirect cost (loss of revenue) due to collision	~€32 million
Satellite failure due to space weather	~€9 million
Service outage and shortened satellite life due to space weather	~€7 million
Indirect cost (loss of revenue) due to complete satellite failure	~€57 million
Geomagnetic storms impact on satellites	~€223 million
Total minimum annualised loss	~€332million

3.1.3. *Tab 3 – Estimated loss due to collisions and space weather effects.*

These costs are almost certainly a small fraction of possible non-quantified consequences and costs that may result from the absence of a European Space Situational Awareness System. For example the loss of a satellite may result in the loss of critical satellite communication capacity in emergency situation resulting in loss of life. Destruction or complete failure of a satellite can result in serious disruption of economic activity (banking relies increasingly on satellite communications) and could have an impact on client business through loss of service. The loss of Earth observation capacity could also have serious consequences in emergency and non-emergency situations. The costs related to disruption of the electricity grid due to

⁴⁴ http://www.esa.int/esaMI/SSA/SEMYTICKP6G_0.html

⁴⁵ Detailed explanation in annex

solar storms (which could occur once every solar cycle, i.e. 11 years) for all EU Member States could amount to \$2160 million per year⁴⁶. At present there are no reliable figures for estimating the value of such losses. Similarly, it is impossible to quantify the consequences of Near Earth Objects impacting on the Earth.

3.1.4. Europe lacks a long-term strategy and critical mass for space exploration

Space exploration is a highly political endeavour which gives nations that are involved in it a high political profile in the international arena. It is also a driver for technological innovation whose spin-offs have enhanced citizens' every day life to a scale that is not often realised by the general public.

Europe through individual Member States and ESA have already made significant contributions to spaceflight and space exploration. Prominent European achievements include the Columbus laboratory of the International Space Station, the Automated Transfer Vehicle (ATV) - the largest ever automatic cargo space vehicle, and some other essential ISS elements. European scientists have contributed to the exploration of several planets in the solar system: Venus (Venus Express), Mars (Mars Express) and the Moon (Smart-1, European instruments on Chandrayaan-1). The successful Huygens mission on Titan has marked the farthest landing in the solar system so far. These European achievements are recognised internationally.

However, the prevailing perception among stakeholders is that space exploration requires a political thrust, a vision and a strategy to carry it through that Europe lacks today. This is the overarching problem. There is a growing consensus that the current lack of a more consistent and strategic approach to space exploration is detrimental to Europe from an international standpoint and also has negative economic consequences.

Up to now, ESA and its Member States have provided the main interface with international partners. ESA communicates with partners at agency level, while major partners address the exploration, and especially human exploration issues at the highest political level (usually heads of state and government). EU Member States in isolation are not as well placed to influence strategic international exploration developments as they would be if they acted in a concerted manner.

The dispersion is reflected, for example, in the European involvement in the international forum for space exploration coordination (the International Space Exploration Coordination Group): for example, four Member States and ESA are individual members of this group, other Member States are represented through ESA and the EU is altogether absent from this international forum.

At present there are not enough streamlining or synergies between EU, national and ESA exploration initiatives. Europe has neither a high visibility nor a critical mass required for the participation in international exploration programmes at a significant level. For example, ESA

⁴⁶

http://www.esa-spaceweather.net/spweather/esa_initiatives/spweatherstudies/ALC/wp1100_Benefits_v3.1.pdf
Since a Hydro-Quebec incident may occur once every solar cycle (11 years), the annualised loss (mostly due to unsupplied energy) is about \$450 M/year for the UK alone, according to the UK National Grid estimations. This figure should be multiplied by 1.5 for France, 1.5 for Germany, 0.5 for Spain and 0.3 for Portugal. Total amount for these member states would be \$2160 M/year.

was not able to maintain its leadership in the search for life programme within the ExoMars⁴⁷ project in 2013; ESA has now become dependent on US launches to place its rover on Mars in 2018.

In addition, only very few MS can afford to have a say or can be directly involved in space exploration activities. For example, only France and Germany could so far afford a significant role in non ESA-led exploration missions (e.g. DE instruments on the NASA Mars Pathfinder mission). Other Member States have also ambitions but cannot participate in non-ESA missions because they cannot financially afford to participate at a significant level. This is detrimental to European integration and international visibility. Without a high-level political commitment and a coordinated approach Europe will be unable to play any significant role at international level.

The life of the International Space Station (ISS) will be extended until 2020 and beyond. The absence of appropriate coordination mechanisms between the EU, ESA and Member States is likely to result in an inadequate representation of European interests in ISS and exploitation of the ISS as a platform for space exploration. Current arrangements prevent a good number of EU Member States from having access to the station, as only those that contribute financially individually or through ESA (8 Member States) have access to it.

At present there is no autonomous or independent transportation system to the low Earth orbit that the EU, ESA and Member States can fully rely on. Europe has not acquired the capacity to conduct autonomous manned space flight either using existing third party transportation systems or its own.

Yet, Europe has with Ariane 5 the launcher capacity to develop such transportation system. Ariane 5 was developed as a launcher for an autonomous European crew transportation system (Hermes) which was abandoned because of lack of firm European leadership to carry the project through. Today, Europe does not fully exploit the potential capacity of Ariane 5. The failure of Hermes illustrates the inadequacies of the current situation regarding space exploration.

The Automated Transfer Vehicle (ATV) which services ISS represents an extraordinary European technological achievement. Today ATV is not retrievable and burns up on re-entry. The ATV has the potential to be transformed into a retrievable vehicle and to be the basis for a future crew transportation system. The fact that such potential is not exploited is detrimental to technological progress in this field.

There is an added value in terms of innovation and competitiveness for the European economy that space exploration could bring about beyond the space sector itself and which does not fully materialise given the fragmentation of space exploration activities and their isolation from non-space sectors.

The EU can help unleash the innovative potential of the European space sector towards other, non-space areas by promoting cross-sectoral fertilisation and synergies and in this way providing a strong multiplier for the investments made.

Space exploration touches on many key space technologies of interest to other space sub-sectors such as launchers, propulsion, remote sensing, telecommunication or navigation

⁴⁷ http://www.esa.int/esaMI/ExoMars/SEMGB7MJ74G_0.html.

systems. If EU does not participate in space exploration, the European industry will fail to maintain and further expand its capabilities in developing technologies that are essential to space and partly also to non-space sectors. Not taking part in large global exploration programmes will impair the competitive positions of the European space industry in the world⁴⁸.

As recognised in recent consultations⁴⁹ the absence of a long term vision and of a strategy for securing a European role in space exploration at international level could have negative repercussions on:

- the scientific community: the potential for research that exploration could offer is not fully exploited; furthermore, there could be a significant “brain drain” of European scientists working abroad and contributing to foreign successes⁵⁰;
- industrial competitiveness: European space industry will be confronted with less critical and less innovative tasks, while at the same time becoming more dependent on commercial markets, relative to international competitors; the competitiveness of European industry would decrease compared to other space-faring nations who engage in the challenges of space exploration;
- trans-sectoral innovation: exploration needs and non-space related needs that space exploration could bring together are disconnected and therefore opportunities for trans-sectoral innovations are lost;
- education and inspiration: the absence of significant exploration challenges deprives the EU of a powerful tool that can be used to stimulate a whole new generation to embrace science and engineering careers, thus contributing to alleviate the current negative trends of students swaying away from science⁵¹;
- European integration: EU participation in international exploration programmes could have a strong impact on a common European identity and the appreciation of EU citizens of what it means to be European.

⁴⁸ ASD-Eurospace (2009) Space exploration position paper, 12 October 2009.

⁴⁹ Conclusions of the workshops “Space exploration and innovation, industrial competitiveness and technology advance” and “Science and education within space exploration”, http://ec.europa.eu/enterprise/policies/space/esp/conferences_space_en.htm.

⁵⁰ The problem of brain-drain notably towards the US is well documented. This article gives interesting US perspective of the problem: http://www.time.com/time/europe/html/040119/brain/story_4.html; The need to enhance the attractiveness of European higher education and research is behind a number of EC initiatives such as the European Institute of Technology (COM(2006) 77 final of 22 February 2006). On brain-drain of European researchers towards the US: <ftp://repec.iza.org/RePEc/Discussionpaper/dp1310.pdf>. US space programmes have attracted scientists from other countries, including those which cancelled their own programmes: <http://www.thespacereview.com/article/1543/1>.

⁵¹ A review on students’ attitudes towards science can be found here: <http://eprints.ioe.ac.uk/652/1/Osborneeta2003attitudes1049.pdf>.

3.1.5. *Space policies and investments are decided at national/intergovernmental level*

The space sector is largely driven by national public funding spent either directly (often in bilateral programmes) or via a contribution to ESA⁵². As a consequence:

- Space initiatives are primarily a function of national interests and national priorities and only indirectly respond to broader European policy objectives, or to the interests of EU citizens; as an example the utilisation of the International Space Station as a research infrastructure only benefits 8 EU MS via ESA programmes and space exploration is done either at MS level or via ESA, not at EU level;
- National space policies are often aimed at the benefit of national industries. Within ESA, MS contribute to the budget in proportion to the anticipated share of contracts to be awarded to their national companies. This policy has been successful in building up a strong space industry in Europe. However, if such an approach remains the sole form of funding of European industry, in the long term it will not encourage national companies to be more competitive in the public procurement market. It would be beneficial to industry competitiveness to complement this approach, at EU level, with a public procurement approach based on best value for money. Such an approach would still recognise the specificities of the space sector but would allow at the same time for increased competition and more efficient use of European industrial competences (including SMEs and industries from Member States which are not ESA members). The absence of an EU approach could become detrimental to the competitive development of the European space industry and to its competitiveness outside Europe;
- There is a risk of overlaps, fragmentation and discontinuity of the activities in the European space sector. For example, if research efforts remain fragmented between EU, ESA and MS this may cause duplication and ineffectiveness, as investments cannot benefit from economy of scale advantages. A good example of this can be found in the field of Space Situational Awareness: there are seven radar sensors in Member States that may serve surveillance and tracking purposes; however these capacities, which have been designed to suit national needs, overlap to some extent, leave significant coverage gaps and are not connected in a way that can fully exploit their potential.

3.1.6. *National investments for dedicated space programmes cannot sufficiently address the needs of EU policies and interventions*

A limited number of individual MS cannot be expected to fund systems to meet the needs of Europe as a whole. Investment through ESA is primarily designed to focus on R&D, not to provide for maintenance and operations of space infrastructure and the delivery of services. Where the main markets are public sector and particularly where these are spread across many different users, the market mechanism alone does not support such costs.

The Member States' willingness to invest through ESA relies heavily on the assurance that the original investment is returned to national industries. Projects that cannot guarantee such return to national industry may result in a decreased motivation of Member States to invest in

⁵² The big European space powers (FR, DE, IT) contribute about half of their national space budgets to ESA, most other countries consider ESA as their space agency and contribute most or all the national space budget to ESA. The overall ESA budget is over €3,5 billion; MS cumulative individual space budget is also roughly €3 billion. NASA annual budget is in the range of \$18 billion.

space. At the same time, there is wide recognition that future space developments in certain areas such as security or space exploration, the exploitation of space infrastructure and space-based applications require a coordinated funding approach.

Due to the fragmentation of national decision making channels, space governance frameworks and lack of coordination of funding mechanisms, investment in certain essential space activities such as SSA or space exploration does not always acquire the necessary critical mass. The large number of, and limited coordination between the European and national public stakeholders involved in space activities (i.e. EU, ESA, EDA, Eumetsat, national space agencies, national ministries of defence, etc.) further adds to the complexity of the decision-making process and makes the design and financing of space systems more difficult.

This fragmentation affects negatively also the connection with other EU policies. Possible synergies are not always sought in a structured manner. For example, the potential of space exploration for innovation is disconnected from the EU 2020 growth strategy as space exploration is seen primarily as a scientific undertaking with not sufficient regard to economic and societal needs.

3.2. EU right to act: subsidiarity and proportionality

Article 189 TFEU introduces a right for the EU to act in drawing up a European Space Policy, while building on past achievements at the level of ESA and Member States, and gives the European Commission a clear mandate to exercise its right of initiative. Space becomes a shared competence between the EU and its Member States.

At European level, space must be addressed as a common endeavour due to the problems described above, including the lack of coordination. The EU does not seek to replace initiatives taken by Member States individually or in the framework of ESA. It seeks to complement action taken at their level and reinforce coordination where such coordination is necessary to achieve common objectives.

The EU involvement would not only be necessary to aggregate the investment required to fund certain space projects. Above all it would be necessary to aggregate demand for operational systems and space applications that meets public sector needs and ensure the long-term availability of these applications at EU level. An EU involvement would help materialise the full benefits that Space Situational Awareness and space exploration can bring about as a tool contributing to other EU policies (such as innovation and competitiveness, health or environment), in a way that Member States or ESA alone cannot achieve. The EU involvement would be necessary to federate interests and demand of users in different Member States, including where appropriate, to represent them in negotiations at international level.

A potential EU intervention would take fully into account what has already been achieved at the level of Member States and ESA and build on these achievements. The EU would fund the development of systems that do not yet exist or that complement those existing in Member States, in this way avoiding unnecessary duplication.

A stronger EU role in either SSA or space exploration would bring substantial added value because it would help design projects that are truly European as opposed to simple prolongations of national initiatives. The EU will also be in a position to speak on behalf of

all Member States and ensure that Europe is represented with one voice at the highest political level in international space cooperation fora.

In SSA the EU would be able to pool its existing capabilities (civilian and military) and reinforce them with the missing links and appropriate governance framework that ensures a robust and interoperable system benefiting all relevant European stakeholders.

The EU should refrain from action if the funding available is not sufficient to ensure its successful completion.

4. OBJECTIVES

Considering the nature of this Communication, general and specific objectives will be defined. Operational objectives will be treated in the impact assessment for a possible proposal defining a future Space Programme.

4.1. General objectives

The general objectives of this initiative are the following:

- (1) to promote scientific and technical progress;
- (2) to promote innovation and industrial competitiveness;
- (3) to ensure citizens' well being derived from space-based applications
- (4) to enhance the EU profile in space at world level.

A set of more specific objectives is defined on this general basis to address the problems identified in the previous section.

4.2. Specific objectives

The specific objectives would be as follows:

- (1) Ensure the long-term availability and security of European space infrastructures and services;
- (2) Ensure that the EU is in a position to fulfil the coordination role in exploration that Article 189 of the Treaty calls for and to capitalise on the space exploration potential to contribute to the objectives of the EU 2020 strategy;
- (3) Ensure the conditions necessary to guarantee European access to space and on-orbit infrastructures;
- (4) Ensure convergence of national and EU policies and investment in the field of SSA and space exploration as well as convergence between action in these two areas and other EU policies;
- (5) Ensure a leading and strategic role for the EU in space at global level and in particular in international negotiations related to SSA and space exploration.

5. POLICY OPTIONS

This IA identifies four incremental policy scenarios based on different levels of EU intervention which will depend on (i) the role and level of ambition which the EU would like to assume in the space domain and (ii) the amount of available funding.

5.1. Option 1: Baseline scenario

Under the baseline scenario the EU would not invest in security of critical European space infrastructures and would not engage in any space exploration efforts.

This would not affect the implementation of the other EU flagships in space, Galileo and GMES, but their long-term security and sustainable exploitation could be affected.

The baseline scenario would mean that the situation described under the problem definition would be likely to remain.

Activities by ESA and Member States would continue. For example, some SSA activities are likely to continue at national level (e.g. France, Germany) and within ESA; collaboration with the US would be arranged but there would be no guarantee that such arrangements would result in a fully operational system and respond to global EU interests. The risk of likely losses identified under problem definition would be likely to remain. Europe would continue to depend on third parties for information and advice in a critical area of space activities.

Similarly, space exploration activities would continue without EU involvement. However, these activities would be limited in scope and the European position on the international scene is likely to remain weak. European involvement in exploration would remain largely in the realm of scientific cooperation and potential benefits of spill-over for innovative technologies and business opportunities that would result from an ambitious EU engagement in space exploration would be foregone.

In the absence of EU involvement, could ESA undertake the actions that are described under options 2 to 4?

The answer is: theoretically yes, but facts prove the contrary. The nature of the decision making process and funding mechanisms described under problem definition means that ESA is not well placed to guarantee that a fully operational European SSA system responding to global EU user needs be put in place. In particular, without EU involvement it is possible (and even likely) that due to diverging industrial interests of Member States, the capability gaps identified for a complete SSA system may not be filled because the programmes necessary to acquire such capabilities are not subscribed (i.e. funded) by any or sufficient number of Member States. Similarly, without the EU it is likely that diverging interests on security matters among Member States and, by extension, within ESA, prevent the setting up of adequate coordination mechanisms and operating structures necessary for SSA.

Similarly, while involvement of Member States, individually and through ESA, in space exploration is likely to continue, the fragmented approach is also likely to persist depriving the EU of the full benefits of space exploration.

The impacts of adopting the baseline scenario are described in detail under section 6.1.

5.2. Option 2: Security in space dimension

This scenario addresses the issue of security in space and focuses on the protection of critical European space infrastructures from natural and man-made objects and phenomena such as spacecraft, space debris, near-earth objects (NEOs), space weather and sun activities. Currently only the US has such a service in place. Under this scenario, Europe would develop a capability of its own. The proposed European Space Situational Awareness system (ESSAS) would build on, and complement existing national capacities in Member States and on possible international cooperation. The purpose of the system would be not only to give the EU a level of autonomy in this area but also to fill existing gaps and bring added value through additional developments.

ESA is currently implementing a preparatory SSA programme with a budget of €55 million for the first phase (2009-2011), which envisages a series of studies on the overall system architecture and design, aggregation of user requirements, governance and data policy, as well as a limited infrastructure component and demonstration (pre-cursor) services. Assuming that development, deployment and initial operations costs until 2014 would be financed through the ESA Programme, the first indicative estimates for a fully deployed European Space Situational Awareness System as from 2014 are assessed at around €130 million per year (in 2009 prices). This envelope covers:

- the acquisition of the main components necessary to complete the European SSA system; this includes surveillance and tracking radars, telescopes; space weather and NEO instruments; data and service centres, communication networks, security layer and satellites for space weather and space surveillance; subject to a more detailed needs analysis, according to ESA estimates this would amount to some € 600 million from 2014 to 2020;
- the maintenance and operation of SSA ground systems (including radars, telescopes, space weather sensors, data centres, communications); and SSA space systems (including dedicated space weather satellites and instruments deployed on hosting platforms); according to ESA's estimates this represents € 270 million for the above period.

The implementation of this option would require that existing mechanisms for space and security cooperation, notably the so-called “Structured Dialogue on Space and Security” between the Commission, the Council Secretariat-General, the European Defence Agency and the European Space Agency be reinforced. Such mechanism is necessary given the (former) interpillar dimension of cooperation in space and security matters and the necessity to bring in the military dimension through EDA and technical expertise through ESA.

As regards implementation, while ESA would be responsible for the development of the required additional components, the operation of the ESSAS would require an adequate operational entity to be identified. Such an entity should be able to integrate and coordinate existing and new national and European assets and ensure the provision of SSA services to both civil and military users.

International cooperation would be an important element in the implementation of this option since SSA is a global issue and activities should also be shared internationally. Dialogue and cooperation particularly with the US but also with other partners would be essential to secure international data sharing and complementarity between the systems, and allow the possibility for sharing the burden (technical, financial) between the systems. By having its autonomous

capacity Europe would be able to negotiate on an equal footing with other space actors and ensure that fruitful cooperation could be sustained in the long run.

5.3. Option 3: Option 2 plus limited involvement in space exploration

The main difference to Option 2 is the addition of a space exploration dimension. Under this option the EU would extend the space exploration activities and coordination in Europe, jointly with the Member States and ESA.

Space exploration should be seen as a comprehensive global endeavour. The scientific, technical and international relations aspects of this have been addressed in detail during a series of EU-ESA workshops conducted in March–May 2010⁵³. The basic scenario for the next decade identifies the International Space Station (ISS) as a cornerstone and enabler for science and technology validation to prepare the way for future exploration steps, including access to space with cargo and crew.

Option 3 foresees a role for the EU in federating space exploration objectives and coordinating the European exploration programmes (undertaken by the EU, ESA and Members States).

This scenario has two main components:

- access to on-orbit infrastructures through extended participation and utilisation of the ISS to be used as a platform for exploration, including a human spaceflight programme; and
- contributing to independent access to space (for human spaceflight, payloads to the ISS and for European robotic missions) by supporting the maintenance and upgrading of the European launch infrastructures at the Guiana Space Centre (GSC) in Kourou.

5.3.1. Participation in the ISS

Participation in the ISS as considered here goes beyond support for R&D and focuses on enhanced EU human presence in the ISS through a programme to prepare for sustainable human presence in deep space.

The programme would allow enhanced EU presence in the ISS through an EU astronaut corps and increased possibilities for missions which would be placed gradually under direct European control using existing transportation systems (as opposed to the situation today, where Europeans can only fly into space as passengers of US or Russian led missions) and, ultimately, a European crew transportation system in the longer term.

This option includes testing for sustainable human presence in space beyond low Earth orbit (LEO), including protection against radiation and life support systems (e.g. water, waste recycling, health and well-being, etc.).

This programme could be run as an autonomous module fully integrated in an ESA wider space exploration programme (including integration of both ESA's and EU astronaut corps). It could also be easily integrated into a larger international space exploration endeavour to be negotiated in tandem by the EU and ESA with international partners.

⁵³ See workshops' conclusions in annexes.

The cost estimate for this activity is in the order of €300 million per year. This amount is an average over a seven year period. It is based on ESA estimates and would cover the astronaut programme, mission control requirements, up to a maximum of 3 launches in the second half of the financial perspectives as well as an EU human presence in ISS during that period.

5.3.2. *Launch infrastructures*

Access to space is a basic requirement for activities in space exploration. Today Europe has the Ariane-5 launcher as its heavy lift capability capable of launching 20 tons into Low Earth Orbit. (This mass is reduced by a factor of 10 for exploration missions which by definition need to escape from the Earth.) Such heavy lift capability is essential for deep space exploration. It is expected that the next generation of Ariane launchers may well be smaller⁵⁴ than Ariane-5 to fit the commercial satellite market needs. Should a future European launch system replace the Ariane-5 launcher on the commercial market around 2025, the justification to maintain the Ariane-5 beyond that date will be mainly to serve automatic deep space exploration missions and potential successors to the Automated Transfer Vehicle (ATV)⁵⁵ to the ISS orbit. As a consequence, the existing Ariane-5 launch infrastructure, as well as the industrial production capacity must be maintained and further upgraded at least until 2025 and possibly beyond.

Option 3 thus foresees a possibility for the EU to contribute towards the adaptation of the current launch infrastructure to accommodate the evolution of the Ariane-5 launcher (e.g. Ariane-5 mid-life evolution and human rating) and the annual costs of maintaining in operational conditions related ESA-owned launch infrastructures at the Guyana Space Centre (GSC), which would amount to €3.5 billion over 6 years⁵⁶. The adaptation of the GSC to human spaceflight alone has been estimated at €1.5 billion for the period 2015 to 2019. Considering that funding should be shared by ESA, Member States and the EU, a reasonable assumption is that a minimum EU contribution for the corresponding launch infrastructure adaptation and operational maintenance would amount to an average of €100 million per year. This amount represents a third of the total cost of the adaptation of the GSC for 2015 to 2019. The rest would have to be covered through ESA and its Member States. The precise components to be covered by EU funding will have to be negotiated with ESA.

5.3.3. *Coordination and implementation*

ESA would continue acting as the technical implementing agency of exploration endeavours. This option would bring the EU into the space exploration arena beyond R&D. This would require stepping up coordination at European level. The EU together with ESA and in consultation with Member States would define a common European vision and strategy for space exploration, accompanied by a detailed roadmap and implementation plan, as foreseen in the conclusions of the first EU/ESA high-level conference on space exploration⁵⁷.

⁵⁴ Report on future launchers (Ariane-6) issued by the French Prime Minister, available at <http://www.gouvernement.fr/premier-ministre/un-nouveau-lanceur-spatial-europeen-a-l-horizon-20202025>.

⁵⁵ <http://www.esa.int/esaMI/ATV/index.html>.

⁵⁶ Data from the European Space Agency provided during a presentation to the Commission on 25 May 2010.

⁵⁷ First EU-ESA High Level Political Conference on Human Space Exploration, 22-23 October 2009, Prague, Czech Republic.

International cooperation would be a central element to this strategy. Space exploration has become an activity of interest to a growing number of countries around the world. New actors are developing capabilities leading to the internationalisation and globalisation of the space exploration context. The European strategy would have to be firmly embedded in this evolving international context. The EU and ESA in tandem would lead the dialogue with the international partner community to ensure that the European strategy is compatible with the scenarios and priorities of other major exploration partners. The complementarity between the technical and scientific expertise of ESA and the EU's political influence would ensure that Europe could better negotiate the terms of its engagement in global exploration programmes to better suit its objectives.

5.3.4. Cost

Compared with option 2, the additional cost of this option would be € 400 million per year as explained below. Added to the €130 million of option 1, the total overall cost of option would be €530 million per year

5.4. Option 4: Option 3 plus substantial investment in space exploration

Under this scenario, the EU would be the driver of future European endeavours in space exploration and would play a leading role in defining the exploration strategy for future decades. ESA would continue playing a fundamental role in technical implementation. The EU, together with ESA, would lead robotic explorations to Mars, paving the way for future involvement in human exploration beyond LEO. A human space transportation system will be developed. As in Option 3, the EU would continue to be involved in supporting and exploiting the ISS, and supporting the launch infrastructure at GSC.

5.4.1. Fully autonomous human access to space

Under this option the European cargo transfer vehicle (ATV) would be improved to be able not only to send cargo but also return payloads safely back to Earth (i.e. Advanced Re-entry Vehicle, ARV) for better utilisation of the ISS and providing a bartering capacity⁵⁸. In a second step the ARV would be improved and upgraded to transport crew to and back from LEO (ARV-Crew).

The development costs up to the first mission have been estimated at €9.5 billion between 2011 and 2019⁵⁹. These costs would be broken down as follows:

Item	Cost in billions of euros	Schedule
ARV cargo	1.5	2011-2017
ARV Crew version (including Crew Escape System)	4.5	2014-2020
Ariane 5 adaptation to human rating	2	2014-2019
CSG adaptation for human spaceflight	1.5	2015-2019

⁵⁸ The ISS partnership is based on a non-exchange of funds, therefore any contribution to the ISS is in kind providing exchange possibilities for flight opportunities, hardware and services.

⁵⁹ ESA Council document ESAC (2010)48 Exploration scenarios.

Tab 4 – ESA’s estimation of development costs up to the first mission⁶⁰.

This approach builds on existing European strengths, namely the fact that Ariane 5 was initially designed for crew transportation (the original project was abandoned and Ariane 5 was subsequently modified for satellite and cargo launches so it needs “re-adaptation” for human spaceflight) and the successful experience with ATV.

Europe has so far failed to acquire autonomous crew transportation capacity. The financial intervention of the EU could guarantee that the EU does develop its own crew transportation system. The EU contribution for the adaptation of CSG for human spaceflight has been considered under option 3. The additional EU contribution has been estimated at around €800 million per year in the timeframe 2014-2020. The EU would therefore be the main contributor.

5.4.2. Mars sample return mission

A first Mars sample return mission could be launched by the middle of the next decade. Such a mission would be a technological and scientific challenge for Europe and would validate key technologies for future human missions to Mars. International cooperation would be an essential condition for such a mission in order to complement some technology gaps and share the overall costs. The total cost⁶¹ is estimated in the order of €5 billion spread over 10 years. It can be assumed that 50% of these costs would be borne by international partners. The EU Member States and ESA would contribute significantly to the European costs. The remaining expenses would only occur in the 2021-2027 timeframe (amounting to about € 200 million per year, of which about half could come from ESA). It is estimated an average EU contribution of about €100 million per year would be needed in the period 2014-2020. This funding could cover the purpose-built technical facility (referred to as “curation” facility in space jargon) to which the samples would be brought back and which gives the hosting partner a highly visible and leading role in the project.

5.4.3. Coordination and implementation

The mechanisms for coordination will be similar to those established under option 3, though the degree of EU involvement will require more intense coordination with ESA, Member States and international partners. ESA would be delegated the implementation of EU space exploration activities.

As in option 3 and for similar reasons, international cooperation is an essential dimension of this option.

5.4.4. Cost

Option 4 includes the cost of option 3 (€530 million per year) plus an additional €900 million per year. The total of Option 4 would therefore be €1.43 billion per year.

⁶⁰ Data from the European Space Agency provided during a presentation to the Commission on 25 May 2010.

⁶¹ ESA Council document ESAC (2010)48 Exploration scenarios.

5.5. Cost overrun considerations for options 2 to 4

A risk management mechanism would be built in with the objective to minimise the probability of programme cost increases. Mitigation mechanisms would be based on better cost estimation, learning from previous experience (e.g. Galileo, GMES, others) and the implementation of an incremental/modular approach to system implementation.

Options 2, 3 and 4 could be built progressively. Should cost overruns occur due to external factors outside programme management control, they could result in certain components of the options being dropped or their deployment delayed. Yet, the incremental modular approach would guarantee that action taken would still be relevant and bring added value in comparison with the present situation.

Notwithstanding the above, option 4 does represent higher risk of programme cost increases because the modular approach cannot be applied to the ARVC development, which would be the bulk of the expense under this option. Should this option be adopted, a specific cost increase mitigation approach needs to be defined beforehand, including scenarios for project cancellation.

6. ANALYSIS OF IMPACTS OF OPTIONS

6.1. Option 1: Baseline scenario

6.1.1. Economic impact

Under this option the EU would not fund either a European Space Situational Awareness System or space exploration.

Funding would be available for other initiatives but the problems connected to the absence of SSA and lack of a concerted European approach in space exploration will remain.

Without EU involvement which could guarantee an appropriate European SSA system, the risk of likely losses due to collision and space weather identified under problem definition would remain. This risk could increase exponentially if further collisions occur. Such risk could also increase if the necessary upgrades on existing capabilities are not implemented in a coordinated manner or at all. The EU would increasingly depend on third parties for information and advice in a critical area of space activities.

The problems identified in connection with the absence of the EU from space exploration will also remain. It can be argued that if funding is invested elsewhere perhaps some of the problems can be mitigated (for example in the field of innovation). However the potential of these actions to contribute to this strategy has to be weighed against the potential of space exploration to enhance the profile of the EU internationally while guaranteeing the economic impact described under the following sections.

Space exploration depends almost exclusively on public funding. The absence of EU engagement in space exploration would have a negative impact on the competitiveness of the European space manufacturing industry. Space exploration encompasses all space sub-sectors. Without the EU thrust to space exploration, all such sub-sectors would experience a negative impact. The activities proposed under space exploration have been chosen on the basis of extensive discussions with ESA, national space agencies and industries taking into

consideration their potential to enhance industrial competitiveness (see for instance the recommendations of the *EU-ESA Workshop on Exploration and Innovation, Industrial Competitiveness and Technological Advance*. By not supporting them, industry would lose the possibility of developing key space technologies, which would have a spill-over effect into other space sub-sectors such as launchers⁶², propulsion, remote sensing, telecommunications and navigation systems. This would have a negative impact on European industry's competitive position on the global market and hinder its capacity to fulfil its strategic mission.

It is a well documented fact that space exploration generates innovation⁶³. In particular, human exploration is one of the most technologically complex activities and requires innovative solutions to the challenges it poses. Space exploration requires the development of new technologies and products that stimulate industrial innovation; the complexity of space exploration requires pooling of resources and capacities, which in turn generate new forms of economic cooperation and activities that create new jobs. The innovation generated by space exploration activities can be used to address societal challenges and result in spin offs in fields such as intelligent energy, waste and water recycling, health prevention and monitoring, and environmental control.

All of this is of critical importance during these times of economic crisis. By not engaging in space exploration, the EU will deprive itself of an important tool to stimulate short term economic recovery and to build a more robust industrial development in the long term. The EU will forgo a key instrument to improve Europe's global economic competitive position.

6.1.2. Environmental Impact

Under this scenario the environmental threats from satellite debris and NEOs referred to in the problem definition remain.

6.1.3. Social impact

Under this option the threats with social impact referred to in the problem definition remain.

6.2. Option 2

6.2.1. Economic Impact

The implementation of option 2 will have limited direct impact on the space manufacturing industry as it will mainly lead to the procurement of non-space items (including tracking radars, telescope, data and service centres, communication networks and other ground-based capabilities).

However, the results from the intervention will significantly reduce (by 90%, according to ESA estimates) the risk of economic loss due to damage (including total destruction) of spacecraft due to collision between satellites, debris and space weather and lead to improved space security. This in turn leads to prevention of future damage and the prevention of a

⁶² Ariane 5 was initially developed as a launcher for European manned spacecraft (Hermes). Although the project was cancelled, Ariane 5 was transformed into a heavy lift launcher which has given Europe the competitive lead in this sector.

⁶³ See annex on space exploration spin-offs.

domino effect: since debris cannot be removed yet, any collision will increase exponentially the risks of further collisions and will render the operations in LEO increasingly difficult and launches of satellites very risky. Space debris can also endanger human crew in space (as was the case in March 2009 when space debris threatened the ISS) and citizens on Earth. Furthermore, the intervention regarding space weather could lead to benefits in other sectors, such as e.g. the aviation and electricity sectors.

Due to the fact that space systems are essential to the availability and functioning of many economic activities (e.g. banking, telecommunication, satellite TV, etc.) protecting space infrastructure will have positive repercussions on all Member States and not exclusively those that own or operate satellite infrastructure.

Significant economic impact can also be derived from supporting space weather information services. In addition to the reduction of the losses identified in the problem definition, an ESA commissioned study on the costs and benefits of these services suggests a potential market of €1 billion over 15 years for services to mitigate threats arising from STP⁶⁴ phenomena in the ionosphere, e.g. effects on GPS and radio communications and induced currents in power grids. The analysis also identifies a smaller market for spacecraft protection – around €100 million over 15 years⁶⁵.

Another study⁶⁶ on mitigating measures to reduce the risks of space weather has identified additional benefits in terms of reduction in the cost of rerouting (polar) flights due to better prediction of radiation risks for passengers and crew or savings realised from minimising the loss of power failures caused by geomagnetic storms. Ecorys⁶⁷ has identified annual benefits derived from better space weather in the range of € 25 million.

	Annual benefit
Prevention re-routing polar flights (7 major EU airlines)	€ 10 million
Cost savings Arianespace	€ 2 million
Loss reduction power failure	€ 13 million
	€ 25 million

Tab 5 – Annual benefits derived from better knowledge of space weather⁶⁸.

Finally, activities in the area of SSA and securing space infrastructures from threats can also impact the competitiveness of the European space industry. In addition, increased security in space is to be seen as an important condition for any robotic or human exploration missions in the future.

⁶⁴ Solar-terrestrial physics (STP) is the study of the physical processes through which the Sun affects the Earth and the general space environment in the solar system. The relevant solar emissions include electromagnetic radiation (especially at UV, EUV and X-ray wavelengths).

⁶⁵ Solar-Terrestrial Physics in the UK. An input to the Physics Review by the UK Magnetosphere, Ionosphere and Solar-terrestrial community Mike Hapgood (2008) http://www.mist.ac.uk/stp_wakeham.pdf.

⁶⁶ WMO, The Potential Role of WMO in Space Weather, April 2008.

⁶⁷ “Study on the EU Space Programme 2014-2020”, Ecorys, Draft Final Report, 18 April 2010, contract n. SI2.541751.

⁶⁸ Ibidem.

6.2.2. *Environmental impact*

Some environmental impact may arise from the intervention. In particular, better information on space weather may result in better knowledge of climate change and Earth weather.

6.2.3. *Social impact*

Protecting space assets ensures that important societal services, communications, search and rescue operations, emergency, etc. will keep functioning even under conditions of major disruption to terrestrial systems. This benefits equally all EU MS. In this respect, a reinforced effort in space infrastructure security would have significant political and strategic impact for Europe as a whole.

The development of technologies to detect space debris, and increased surveillance and research on space weather conditions will result in skills development in these technologies. Increased coordination and collaboration will also result in wider knowledge dissemination and building up of skills.

6.3. **Option 3**

6.3.1. *Economic impact*

The activities foreseen under option 3 will involve expenditure on a wide range of areas, including technology demonstration and hardware or processes development, such as the ISS utilisation for scientific and technical purposes related to exploration preparation (e.g. inflatable habitats technologies, life support systems, remote medical assistance), launch pads operational maintenance, ground based infrastructures, communication systems, etc. These products and services are delivered by a wide range of public and private institutions and manufacturers, which will be affected by a future space exploration effort (or the by the lack of it).

The EU expenditure on space exploration can be expected to translate directly into turnover for the space industry, as the funds will be used for contracting out innovative technology development activities. Since the value-added shares in turnover are relatively high in the space industry, it is expected that an increase in final demand for the services of the space industry would result in an increase in added value in this industry. (For example, UK data suggest a value added share of 60 percent for upstream space industries, implying that an increase in final demand of €100 million would result in an increase in value added of €60 million in the industry.)

In terms of indirect turnover impacts, Ecorys suggests a production multiplier of 2.3, implying that spending on space exploration of €100 million will result in €230 million in supplying industries and in new products. Other sources provide different estimates. For example, a study on Norway⁶⁹ found a multiplier of 4.4 resulting from space-related spending in Norway by ESA. Similar results were found for Denmark⁷⁰, i.e. Danish spending on ESA programmes

⁶⁹ Norwegian Space Centre (2005) Annual Report, as seen at The Space Economy at a glance (OECD, 2007), <http://browse.oecdbookshop.org/oecd/pdfs/browseit/0307021E.PDF>.

⁷⁰ <http://en.fi.dk/publications/publications-2008/evaluation-of-danish-industrial-activities-in-the-european-space-agency-esa-2013-assessment-of-the-economic-impacts-of-the-danish-esa-membership/Evaluation%20of%20Danish%20Industrial%20Activities%20in%20ESA-pdf.pdf>.

resulted in a multiplier of 4.5. In terms of sub-programmes related to space exploration, expenditures on micro-gravity resulted in a multiplier of 1.4 and expenditure on the ISS had a multiplier of 2.3.

Recent cost-benefit studies have been done for a number of potential spin-off technologies of space exploration which showed high net present values⁷¹.

The most significant spill-over impact on non-space sectors is expected in the field of life support, health and wellbeing⁷². An example in the field of health/biotechnology is provided by the bioMerieux Inds. bacteriological detection system VITEC. The original patent was acquired from the US space industry (for the NASA Skylab programme) and used for the development of a commercial diagnostics device. The total sales of the device from 1972 to 1997 amounted to \$ 500 million⁷³ and from 1997 to 2009 to \$ 455 million⁷⁴.

Technopolis⁷⁵ demonstrates that classical spin-offs from exploration programmes give rise to valuable benefits. This study shows that targeted expenditure in space exploration (which is different from a bottom-up approach in R&D) can be a trigger for major innovations in sectors such as health, secure access to energy and renewable energy, and access to clean water. In these fields only the estimated benefits are in the order of several hundred million over the next 5 years and a few billion euros over the long term.

The world market for water and wastewater amounts to \$ 350 billion in 2008⁷⁶. Every year around \$ 150 billion is spent worldwide on wastewater treatment, and this figure is expected to exceed \$ 240 billion by 2016⁷⁷. The human space exploration can trigger innovation and a technology leap in this sector⁷⁸.

Overall, space exploration will contribute to the competitiveness of the European industry and to the development of the knowledge-based society in Europe, since all activities in space exploration support increasing knowledge through science and technology demonstration missions.

6.3.2. *Environmental impact*

Space exploration will enhance the understanding of our own environment, which in turn will result in better definition of environmental policies. In a number of areas support of mainly human space exploration will have positive environmental effects. A few examples include:

⁷¹ “Economic Analysis to support a Study on the Options for UK Involvement in Space Exploration”, London Economics, 19 March 2009, <http://www.ukspaceagency.bis.gov.uk/assets/pdf/FREER.pdf>.

⁷² “Space exploration and innovation, industrial competitiveness and technology advance”, Workshop, 29-30 April 2010, Harwell (UK)
http://ec.europa.eu/enterprise/policies/space/esp/conferences_space_en.htm.

⁷³ Measuring the returns to NASA life sciences research and development, H. Hertzfeld, Space Policy Institute, George Washington University, 1998.

⁷⁴ “The Contribution of Space exploration to Innovation”, Technopolis, Draft Final Report, 11 June 2010, contract n. ENTR/2008/006.

⁷⁵ Ibidem.

⁷⁶ <http://www.hkc22.com/watermarketsworldwide.html>.

⁷⁷ “Water: a market of the future”, SAM study, 2007, http://www.sam-group.com/downloads/studies/waterstudy_e.pdf.

⁷⁸ <http://ecls.esa.int/ecls/>.

- Air quality management and regeneration; in a manned spacecraft the air must be revitalised constantly but, unlike planes, spacecraft cannot take air from the outside. Therefore advanced technologies must be developed to monitor air quality including various contaminants, regenerated (e.g. CO₂ regeneration into O₂) and purified. Those technologies have numerous applications.
- Energy production, storage and distribution technologies, resulting in more efficient and durable solar cells, batteries, fuel cells or fission reactors. Manned spacecrafts need an amount of energy comparable to that required by a household. Embarking chemical energy is costly and risky and the only external source is solar energy. Therefore, significant progress must be made on optimising energy production and management. Innovations in this area are essential to make the transition from a fossil-fuel based economy to one based on renewable energy and so limit the effects of climate change;
- Water must be recycled up to 100% during human spaceflight. Water for cleaning, washing and food and drinking cannot be brought for several months because of exorbitant costs for the launch (several tons would be needed). Therefore, significant progress must be made to achieve full water autonomy during future space travel by advanced recycling and quality monitoring technologies (including detection of trace contaminants). Innovations in this area offer significant potential to improve the management of Europe's water throughout the water cycle and improve the quality and quantity of drinking water in a future where water resources may be under increased pressure from population growth, urbanisation and climate change. Grey and black water recycling processes increase the potential to manage water at a local level in large-scale commercial, domestic and public buildings (offices, hospitals, schools etc.) making organisations, communities and individuals more responsible for their own water use.

6.3.3. *Social impact*

An EU intervention in space exploration is expected to lead to social impact in terms of employment, labour market structure and education, and health.

In the US one study reported that the Apollo budget had an employment spin-off effect of 10 (industry and university workers) to 1 NASA worker⁷⁹. An investigation by The Space Division of Rockwell International on the relationship between NASA's Space Shuttle program and employment in the state of California estimated that the Space Shuttle program generated an employment multiplier of 2.8; that is, direct Shuttle employment of 95,300 man-years in California produced an increase of 266,000 man-years in total employment.

The space industry employs a highly qualified workforce. In the European space industry 75 percent of the employees have university level of education (53 percent 4 years and more and 22 percent up to three years) and 21 percent have vocational education. Consequently, additional spending on space exploration will have a positive impact on the demand for highly qualified workers. An inspiring endeavour like space exploration may stimulate young people's interest in science, technology, engineering and mathematics (STEM) and motivate

⁷⁹ Jerome Schnee, The Economic Impact of the US Space Programme, Rutgers University, <http://er.jsc.nasa.gov/seh/economics.html>.

students to engage in science and technology careers⁸⁰. For example, it has been found that space is the second most popular factor motivating choice of physics as a degree⁸¹.

The space environment offers also possibilities to study health problems related to various diseases, ageing or immobility, since the provision of equipment and services to manage and maintain crew health on long distance spaceflights has similar requirements. Point-of-care delivery of healthcare by intelligent and autonomous systems is essential as inter-planetary travel duration will be in the order of years and as unplanned and premature return to Earth is not an option. Furthermore, spaceflight (even short duration) creates physiological effects that are akin to accelerated ageing (reduced bone density, cardiovascular de-conditioning). Therefore improved understanding of cardiovascular and musculoskeletal systems and development of countermeasures (e.g. by specific nutrition and exercise regimens) is essential to ensure that crew remain healthy throughout a long duration mission.

Improved understanding of the conditions of ageing (osteoporosis, cardiovascular problems etc.) along with the miniaturisation of medical technologies and their integration with communications technologies will enable better and ‘smarter’ diagnosis and treatment to be delivered at the point-of-care, i.e. at home or in a local clinic, thereby reducing the cost of provision, enhancing healthcare delivery and ensuring ongoing quality of life (Technopolis).

EU investment in human exploration under option 3 will therefore generate direct benefits for citizens derived from areas related to human survivability in space. Other societal benefits will be derived in the fields of energy, health, biotechnology, environment or security.

Type of impact	Comments
Space industry	Spending will translate in contracts with universities, R&D institutions, hardware producers. Spending of €100m will generate €60m of value added.
Indirect effects	A multiplier of 2.3 is suggested as a conservative figure, implying that spending on space exploration of €100m will result in €230m in supplying industries and in new products.
R&D effects	Long-term effects of spending €100m will result in €70m of European GDP per year with serendipitous spin-offs and at least an order of magnitude more if new policies are put into place to promote synergetic R&D between space and non-space sectors.
Labour market	Increase in spending will result in increased employment. Most employment will be in terms of highly qualified jobs.
Health	Space exploration will have important effects on the prevention and monitoring of a range of public health problems.
Environment	The direct adverse impacts of space exploration are considered to

⁸⁰ "Science and education within space exploration", Workshop, 29-30 March 2010, Strasbourg (FR), http://ec.europa.eu/enterprise/policies/space/esp/conferences_space_en.htm.

⁸¹ "Bringing space into school science", Barstow, M., Report commissioned by BNSC, 2005, <http://www.stfc.ac.uk/Resources/PDF/barstow.pdf>.

	be limited. Positive effects are related to comparative climatology, developments in the field of power generation and storage and water or waste recycling.
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Table 6: Benefits of EU spending on space exploration⁸².

6.4. Option 4

Option 4 steps up considerably the investment in space exploration and places the EU at the same level as other main international players. This investment brings in substantial economic impact and will enhance the perception of the EU as a global player both within and outside the space domain.

Option 4 will give the EU a leading role in international cooperation efforts in space exploration. The EU would join the small club of nations with human space flight capability of their own. This will be a major boost to EU visibility as well as economic and political influence.

6.4.1. Economic impact

Option 4 represents an investment in the order of €1.43 billion per year. The rationale for economic impact described under option 3 applies to option 4. The potential economic impacts will therefore be commensurate to the increased funding.

The European launcher annual development and production costs are €1300 million⁸³. Today the European launcher sector has a 50% share in the international private market. As shown from the past (Ariane 5 launcher was foreseen for human spaceflight upfront⁸⁴), space exploration programmes are an essential element in order to maintain the competitiveness of current and next generation European launchers. Without the technical challenges posed by exploration (e.g. heavy lift capability, increasing reliability of launchers, supporting institutional flights) the current leading position of Europe would fade away.

Investment in space exploration at this scale will have significant impact on technological progress and industrial competitiveness and spill-overs to other sectors. For example, the London Economics study demonstrates that investment in advanced (reusable) launch systems could lead to profitable private businesses (e.g. space tourism), as well as to reducing the costs for satellite launches.

As regards robotic exploration, the same study⁸⁵ further shows that technologies developed for exploration, such as automated deep drilling or in-situ resources utilisation (e.g. extraction technologies applied on Earth), can have a significant positive benefit/cost ratio for the oil and mining industries respectively.

Due to the various technologies needed (sample analysis, its protection, protection of personnel, of the environment and the population) a large number of high tech applications in

⁸² Jerome Schnee, The Economic Impact of the US Space Programme, Rutgers University, <http://er.jsc.nasa.gov/seh/economics.html>.

⁸³ ASD-Eurospace, European space industry facts & figures, 2009.

⁸⁴ <http://www.astronautix.com/gallery/chermes.htm>.

⁸⁵ "Economic Analysis to support a Study on the Options for UK Involvement in Space Exploration", London Economics, 19 March 2009, <http://www.ukspaceagency.bis.gov.uk/assets/pdf/FRER.pdf>.

the biotechnology and pharmaceutical industry are foreseen, e.g. bio-containment, tele-operations including remote micro-robotics, automated handling and storage systems and micro-analytical systems⁸⁶.

In addition, the profile of the EU at global level will be significantly enhanced. The EU's capacity to influence negotiations in the space domain will be reinforced. From another angle, the capacity to undertake space exploration goes hand in hand with stronger international recognition; by being fully involved in space exploration and especially human exploration, the EU will benefit from greater political influence, which in turn may yield indirect economic gains.

6.4.2. *Social impact*

As space exploration is closely linked to space science, it will also contribute to developing global scientific leadership for Europe. The activities in preparation studies for human exploration, as well as the research onboard the ISS will support life and physical sciences and will also promote collaborative research programmes. Space exploration activities will foster the public interest in space science and technology, and will contribute further to attracting young people into science, technology, engineering and maths (STEM).

There will be a substantial positive impact on creating new, qualified jobs. ESA⁸⁷ estimates that an investment of the magnitude proposed under option 4 will lead to the creation of 3000 highly qualified direct jobs. Ecorys as well assesses the employment impact of an ambitious EU space exploration initiative in excess of 3000 direct new jobs⁸⁸. A study referred to under the previous option⁸⁹ identified an employment factor of 2.8, which means that overall employment generated by this option could accrue to more than 8000 jobs.

6.4.3. *Environmental impact*

By boosting topics such as comparative planetary climatology or Earth observation from the ISS, research related to space exploration would help understand climate change on Earth.

⁸⁶ “Space exploration and innovation, industrial competitiveness and technology advance”, Workshop, 29-30 April 2010, Harwell (UK), http://ec.europa.eu/enterprise/policies/space/esp/conferences_space_en.htm.

⁸⁷ Data provided by the European Space Agency.

⁸⁸ “Study on the EU Space Programme 2014-2020”, Ecorys, Draft Final Report, 18 April 2010, contract n. SI2.541751.

⁸⁹ Jerome Schnee, The Economic Impact of the US Space Programme, Rutgers University, <http://er.jsc.nasa.gov/seh/economics.html>.

7. COMPARISON OF THE OPTIONS

Options	Effectiveness	Efficiency	Coherence
Option 1	Option 1 will not achieve the specific objectives of this action. The funding would be available for other initiatives.	Not applicable	This option is not consistent with the EU2020 growth strategy, which emphasises the key importance of innovation and the industrial competitiveness and refers to the development of space policy as instruments to achieve the goals of such strategy.
Option 2	This option achieves specific objectives (1) regarding long term availability and security of European space infrastructures and services and partly objective (4) regarding the convergence of national and EU policies and investments on SSA and the connection of these and other EU policies.	Option 2 entails an expenditure of € 130 million per year . SSA An SSA system could save as a minimum over €300 million per year, although non quantified costs could be exponentially higher. This option also diminishes the risk of domino effect due to spacecraft destruction. This option has important social benefits resulting from avoiding the disruption of satellite based services, better prevention of electricity grid failure as well as the impacts of NEOs. Positive impact on environment notably by learning more from space weather.	This option is partly but not fully coherent with the EU2020 strategy growth. While SSA does represent certain potential for innovation and growth, its main purpose is the protection of space infrastructure. There is an enormous potential for innovation in space exploration, which is not addressed in this option.
Option 3	This option achieves objectives (1), (2) and (4), but only in part objective (3) and (5). It does not fully guarantee independent access to on-orbit infrastructures. Option 3 will give EU a higher profile in space matters but not the leading and strategic role that objective 5 refers to.	Option 3 entails an additional expenditure of some € 400 million per year. The total for this option to €530 million per year . Conservative estimates put the rate of return for investment in space exploration at 2.3 and employment factor at 2.8. Other significant impacts on Europe's visibility and innovation potential, the creation of qualified high-skilled jobs and beneficial spin-off effects.	Option 3 is fully consistent with the EU2020 strategy; it will contribute to innovation and will derive spill-over benefits in many areas and EU policies including health and environment.
Option 4	This option will achieve the five objectives identified.	The rationale described for option 3 applies to option 4. This option adds €900 million per year, the total being €1.43 billion per year . Option 4 represents an enormous technological challenge which will accelerate the pace of technological progress and multiply the spill-off and spill-over benefits for our economy and citizens.	From the coherence standpoint, this option is similar to option 3.

8. MONITORING AND EVALUATION

The present impact assessment will accompany a Communication on the future involvement of the EU in space and does not amount to a formal proposal for funding. The Communication could pave the way for a possible Regulation on a future European Space Programme. That Regulation will be accompanied by a follow-up Impact Assessment. Detailed provision for monitoring and evaluation will be discussed in that Impact Assessment.

As regards an evaluation, the Commission will assess the extent to which EU activities in space reach the policy objectives and the problems identified in the Communication are being tackled. The EU programme will be evaluated according to the parameters of relevance, effectiveness, efficiency, utility and sustainability.