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IMPACT ASSESSMENT

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Proposal for a Decision of the European Parliament and of the Council establishing a space surveillance and tracking support programme

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IMPACT ASSESSMENT

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Proposal for a Decision of the European Parliament and of the Council establishing a space surveillance and tracking support programme

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1. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

1.1. Identification

Lead DG: DG Enterprise and Industry

Other involved DGs:

Agenda Planning/WP Reference: 2012/ENTR/021

1.2. Organisation and timing

This impact assessment builds on an earlier impact assessment on the future EU involvement in space which accompanied the Communication on "Elements for an EU strategy in space for the benefit of EU citizens" adopted by the College on 4 April 2011[1].

This second and more detailed impact assessment focuses exclusively on options concerning EU involvement in the setting up of a European service to avoid collisions between spacecraft and between spacecraft and debris and to monitor uncontrolled re-entry of spacecraft which forms the basis for the protection of critical European space infrastructure.

The Impact Assessment Steering Group (IASG) set up to accompany the preparation of this impact assessment met on 26 November 2010, 8 February 2011, 8 July 2011, 5 March 2012 and 15 March 2012. The following Commission services were invited to participate in the IASG: DG SANCO, DG RTD, DG MOVE, DG ENER, DG BUDG, DG ECFIN, DG RELEX, DG JRC, DG INFSO, DG ENV, DG ECHO, DG EMPL, DG EAC, DG HOME, the Secretariat-General as well as the European External Action Service (EEAS).

1.3. Consultation and expertise

Over the past years, DG Enterprise and Industry consulted different parties interested and involved in space affairs on various areas of potential future EU activities in space and notably on the development of a European Space Surveillance and Tracking (SST) service. The development of such service has also been the subject of political debate among EU Ministers responsible for space. The conclusions of those debates are reflected in several Council resolutions[2].

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1 COM (2011) 152 final

2 The Space Council is the concomitant meeting of the EU Council (competitiveness) and the ESA Ministerial Council. With the entry into force of the Lisbon Treaty the EU Council's (competitiveness) responsibilities were enlarged to address space policy matters in 2010. The Space Council or EU Council Resolutions or Conclusions referring to the need to set up an SSA capability at European level are: Council Resolution "Taking forward the European Space Policy" of 26 September 2008 (Council document 13569/08); Council Resolution on "The contribution of space to innovation and competitiveness in the context of the European Economic Recovery Plan, and further steps of 29 May 2009 (10500/09); Council Resolution "Global challenges: Taking full benefit of European space systems" of 25 November 2010 (16864/10); Council conclusions "Towards a space strategy for the EU that benefits its citizens" of 31 May 2011; and the Council conclusions "Orientations concerning the added value and benefits of space for the security of European citizens" of 6 December 2011 (18232/11).

The main conclusions of these consultations can be summarised as follows:

– There is a consensus amongst Member States, satellite operators and other stakeholders on the need to protect space infrastructure, and notably to protect it against the risk of collision;

– There is a political consensus among Member States that the setting up of a European SST service should be led by the EU, which has competence to coordinate the exploitation of space systems and has also the competence and the mechanisms in place to deal with the security dimension of such a service; Member States consider that ESA should support the EU in this endeavour (and is doing so through its SSA preparatory programme[3]) but, as an R&D organisation, does not have the competence and the mechanisms necessary to set up and run a European SST service on its own.

– There is a consensus among EU and ESA Member States and experts that a future European SST service should link and build on existing sensor capacity and develop it with new sensors; Member States possessing sensor capacity and those willing to develop it should play a key role in the setting up of the European SST service;

– There is a consensus that the development of a European SST service should be done in close cooperation with the United States of America;

– Public opinion is aware of and supports the need to protect space infrastructure.

These consultations are explained in detail below.

Consultations of national space agencies, ministries and industry representatives

In 2009, a series of bilateral meetings were held with national space agencies and ministries in charge of space matters in Member States more actively involved in space activities as well as with representatives of the European space industry. From these bilateral meetings the following conclusions could 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 European 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;

– Stakeholders agree that the most urgent priorities for the EU are the completion of the Galileo and Copernicus (new name for GMES) programmes (the latter including reinforced security and climate change dimensions), 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. Our economy and the well being of our citizens are increasingly dependent

[3] In the framework of its SSA preparatory programme launched in 2009 with a budget of around 55 M€, ESA conducts a number of technical studies to define SSA user requirements, system requirements as well as technical architecture options. This work provided useful indications concerning the assets needed in order to respond to civil user requirements. Furthermore, the programme included the development of 2 surveillance demonstrator radars.

on space-based applications and we need to acquire the capacity to protect them. Space Situational Awareness (SSA)[4] and notably SST is instrumental to ensuring such protection;

– There is also a consensus that the EU, ESA and their Member States need to work together on all of the above.

In addition, under the Spanish EU Presidency in 2009, a conference on space and security was held to contribute to defining the role of European institutions and centres in security programmes. In 2011, a conference on SSA under the Polish EU Presidency examined the current situation with regard to SSA in Europe and led to some first discussions on possible governance options.

Furthermore, the Communication "Towards a space strategy for the European Union that benefits the citizen"[5] aimed at triggering a debate amongst stakeholders on future EU action in space policy. The Council Conclusions adopted on 31 May 2011 in response to this Communication confirmed space and security as a priority for EU action after ensuring the implementation and sustainable exploitation of Galileo and Copernicus.

In 2010, relevant target stakeholders were interviewed by an external contractor[6], in the context of a study to support the preparation of the previous impact assessment accompanying the Communication the EU strategy for space adopted in April 2011. A further study was commissioned at the end of 2010 in support of the preparation of this current impact assessment[7]. It included a series of stakeholder interviews with ESA, national space agencies, national ministries responsible for space and industry representatives with the aim to get input on the potential implication of the EU in the setting up of a European SSA capability. The results of the study launched in 2010, in particular the risks related to space debris and the related estimated losses, have been presented to and discussed with Member States in late Spring 2011.

An ex-post evaluation of the European space policy is ongoing. However, its results will not have any impact on this impact assessment, as the EU did so far not take any action in the field of space surveillance and tracking apart from the prospective studies referred to below.

Finally, in general terms the policy options defined in chapter 5 of this impact assessment report have been discussed with Member States representatives on a number of occasions over the past two years. In these discussions, Member States expressed a clear preference for an approach to the setting up of European SST services along option 3 or an EU-led programme along options 4 or 5. Most recently, SST governance options have been discussed with Member States in the framework of the Enterprise and Industry DG led group of EU Member States space policy experts on 23 March 2012 where all Member States signalled readiness to support option 3. SSA data policy has been subject to discussion with the Council's space

4 Space Situational Awareness (SSA) refers to the protection of space infrastructure from collision with space objects (which would be a satellite or space debris) or asteroids or meteoroids (summarised as Near Earth Objects) and from solar radiation (the so called space weather). While these threats are often discussed together – and for this reason this report refers in some cases to SSA – the present impact assessment report concerns only the threats from space debris.

5 COM(2011) 152 final of 4.4.2011

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

7 Evaluation of options for an EU space programme 2014-2020, Booz & Company, Final report of 16 May 2011, contract no; 30-CE-036363/00-01

working party in autumn 2011 where Member States broadly agreed with the Commission's Staff Working Document setting out the key elements for the future SSA data policy[8].

Consultations of the broad public

As concerns the consultation of the broad public on space issues in general and SSA more specifically, two surveys have been carried out over the past three years:

- 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, and b) their perception of these activities. 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 Union[9]. Overall, 67% of the survey respondents consider it important to develop space based applications to improve citizens' security.

- A second public consultation was carried out via the Commission's Interactive Policy Making (IPM) tool from 3 January to 15 March 2011. The survey focused on the public's opinion on possible EU action in the domain of SSA and space exploration. In total, 608 contributions were received from 25 Member States. The majority of respondents (around 38 %) identified themselves as individuals. Around 14 % of the respondents were representatives of larger or smaller businesses or business associations. SME participation as well as the participation of public authorities (at European, national or regional level) amounted to around 8 % each. The consultation also prompted a number of separate position papers from industry provided in addition to questionnaire replies[10]. As concerns SSA, a **large majority of respondents (86%) were aware of and felt concerned by hazards caused by space debris**, space weather phenomena, or Near Earth Objects (NEOs) to a wide range of space-based and ground-based critical infrastructures and services. At the same time, 32% of the respondents indicated that they had no dealings with space or the space sector. **A large majority of respondents (83%) felt that the EU should have its own capacities to protect critical European satellites** either in order to complement third country capacities (57%) or to be autonomous from third country capacities (26%). 89% expressed the opinion that the EU should play a role in building a European SSA capability, which the EU should either set up alone or together with its Member States. Only 5% of the respondents expressed the opinion that the EU should not get involved in such capability building.

External expertise used

Two studies carried out by external contractors in 2010 (Ecorys) and end 2010/beginning of 2011 (Booz & Company) provided input alongside other sources to the preparation of this

[8] Commission Staff Working Paper "Discussion note on space situational awareness data policy", SEC(2011) 1246 final of 12 October 2011. This document is currently discussed within the Council Security Committee and will serve the basis for the Committee's concrete recommendations for SST data policy.

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

[10] http://ec.europa.eu/enterprise/newsroom/cf/itemdetail.cfm?item_id=5307&tpa=141&tk=&lang=en

impact assessment[11]. The Ecorys study underlined that EU action in space situational awareness should be given priority to any future EU action in space going beyond Galileo and Copernicus. The Booz & Company study provided valuable qualitative and quantitative input to refine the problem definition related to the protection of European space infrastructure and critical ground infrastructure, and helped defining policy options and their impacts.

Furthermore, the definition of the various policy options and their effect relies also heavily on ESA expertise. In the framework of its ongoing SSA preparatory programme, ESA conducted a number of technical studies to define SSA system requirements which led to useful preliminary indications concerning the assets needed in order to respond to civil user requirements defined in 2010 in collaboration with potential SSA user communities and ESA Member States[12].

1.4. Scrutiny by the Commission Impact Assessment Board

The Impact Assessment Board of the European Commission assessed a draft version of the present impact assessment and issued its opinion on 20/04/2012. The Impact Assessment Board made several recommendations and, in the light of the latter, the final impact assessment report:

- Describes in a clearer way the problems that need to be addressed, the nature and scope of the initiative proposed to address these problems, the current situation with regard to space surveillance and tracking activities in Europe (including an overview of existing SST relevant assets owned by EU Member States) and elsewhere, and explains what other long-term mitigation measures exist at international or multilateral level.

- Strengthens the baseline scenario by describing in more detail how the situation is expected to evolve in absence of any EU initiative in the SST domain, including cooperation amongst Member States, and why the baseline scenario would leave the problems unchanged. It also clarifies the value-added of EU action in SST.

- Describes more clearly and in a more structured way the policy options proposed, their differences in terms of governance, data policy, the difference in performance of the services provided, the new SST assets needed to achieve the targeted service performance level, and the related funding needs. A new chapter has been added to explain the position and views of stakeholders on the options set out in the report. Two tables have been added to facilitate the comparison between the options.

- Assesses in more detail the impacts of the options, in particular the expected economic and social impacts (by looking in particular into impacts on citizen's health and security).

The Impact Assessment Board issued a second opinion on the re-submitted impact assessment report on 20 June 2012 (written procedure). In response, the report was further amended to take into account the last remaining recommendations:

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

[12] ESA SSA Mission Requirements Document (SS-MRD) Revision 3; final version as presented to the ESA SSA Programme Board in its meeting on 2 May 2011.

- The impact analysis chapter describes in more detail how the proposed governance of the European SST service will address concerns related to the relationship between Member States involved in the SST service provision and those benefiting from the service.

- As concerns funding aspects, the report better explains that the performance of the planned SST service is incremental and that risks related to budgetary constraints at EU and Member States level could be offset by down-scaling the system, for example in terms of sensors to be included in the sensor function of the system, or in terms of new sensors to be developed by Member States. Financial contributions from both the public and private sector in form of service fees could be envisaged at a later stage.

- The analysis of the safety impacts of all options has been strengthened. Option 3 has been identified as the preferred option in terms of effectiveness, efficiency and coherence with Member States' political will and with other EU policies.

2. CONTEXT

The Commission's Communication "Towards a space strategy for the European Union that benefits its citizens" adopted in April 2011 defines priorities for the future involvement of the EU in space and sets out options for EU action. With relevance to this impact assessment it underlines that:

(1) Space infrastructure is critical infrastructure on which services that are essential to the smooth running of our societies and economies as well as our citizens's security depend. The protection of this infrastructure was underlined as a major issue for the EU going beyond the individual interests of individual satellite owners;

(2) In view of ensuring such protection, it underlines that the Union should define the organisation and governance of a European Space Situational Awareness (SSA) system taking into account its dual nature and the need to ensure its sustainable exploitation as highlighted in the Industrial Policy Communication adopted in October 2010.[13]

The need for European action in the domain of SSA has been supported by Member States in several 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, 6th, 7th and 8th Space Council meetings held in 2007, 2008 and 2009, 2010 and 2011as well in EU Council conclusions adopted on 31 May 2011. These views are also shared by the European Parliament in its report on the space strategy for the EU adopted on 30 November 2011[14].

If the policy choice leads to EU intervention, this impact issessment (IA) will accompany a proposal establishing a space surveillance and tracking support programme supporting the setting up and operation of a European service to prevent collisions in space and monitor un-controlled re-entry of spacecraft or parts thereof, which could come into force during the next

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13 Commission Communication "An integrated industrial policy for the globalisation era – putting competitiveness and sustainability at centre stage", COM(2010) 614 final of 27.10.2010

14 For references to the Space Council and EU Council (competitiveness) Resolutions and Conclusions see footnote 2. On 30 November 2011, the European Parliament adopted a report on the Commission's on a a space strategy for the European Union that benefits its citizens (2011/2148(INI)).

EU Multiannual Financial Framework from 2014-2020. This service will provide alerts to satellite operators and public authorities to avoid collision during launch, in-orbit operations, and will also inform relevant authorities of any potential danger for citizens and ground infrastructure derived from uncontrolled re-entries of inactive spacecraft or their debris into the Earth's atmosphere.

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

3. PROBLEM DEFINITION

3.1. The problems that require action

3.1.1. Security of critical European space infrastructure is not ensured

Space-based systems enable a wide spectrum of applications which play a fundamental role in our everyday reality (TV, Internet or GPS), are critical to key areas of the economy, and help ensuring our security[15].

Space infrastructures and derived services as well as space research have also become critical for the implementation of EU policies[16], such as transport, environment, climate change, maritime policies, development, agriculture, security related policies including the CFSP/CSDP, as well as the furthering of technical progress and industrial innovation and competitiveness.

With increasing dependance on space-based services, the ability to protect space assets and infrastructures has become essential to our society. Any shutdown of even a part of the space infrastructure could have significant consequences for citizens' safety and for the well-functioning of economic activities, and would impair the organisation of emergency services[17].

With Galileo and EGNOS, the EU itself has become owner of a growing fleet of satellites with related ground based infrastructure. Furthermore, the EU is responsible for the overall coordination of the ongoing GMES Initial Operations Programme including its satellite segment and can be expected to continue to have such role in the future. Thus, the EU will soon become one of the largest satellite operators in Europe.

However, space infrastructures are increasingly threatened by the risk of collision between sapcecraft and, more importantly, between spacecraft and space debris. Space debris has become the most serious threat to the sustainability of space activities.

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15 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

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

17 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 indispensible for today's crisis management.

In order to mitigate the risk of collision it is necessary to indentify and monitor satellites and space debris, cataloguing their positions, and tracking their movements (trajectory) when a potential risk of collision has been identified so that satellite operators can be alerted to move their satellites. This activity is known as space surveillance and tracking (SST).

A SST service comprises three basic functions:

– Sensor function, which through a network of instruments such as radars and telescopes allows to identify and track spacecraft and debris;

– Processing function, through which the relative orbit of spacecraft and debris can be catalogued and analysed to determine the probability of collision or to determine the re-entry path of space objects;

– Front desk function, which is responsible for the actual provision of the SST services (such as collision or re-entry alerts) to satellite operators and relevant authorities. At the same time, the front desk will be the entry point for user requests for SST information which it relays to the processing and sensor function.

It should be noted that SST is a dual-use activity which can serve both civil and military user communities. Both civil and military sensors can be used to provide SST services that respond to both civil and military user needs[18] - which are to a large degree identical.

Surveillance and tracking information is highly security-sensitive. Uncontrolled dissemination of SST information (revealing for example the existance and position of a sensitive military satellite) could jeopardise national security interests. Cooperation amongst actors within Europe (Member States, ESA and EU entities) requires a data policy and a governance that takes into account these national security concerns. It was for this reason, that Member States through the Space Council turned to the EU with the request to play an active role in the development of an SSA capability at European level, and to define its governance scheme and its data policy.

The fact is that Europe has today no SST service: existing sensors do not have adequate capacity to identify and track objects in space, they are not linked so that they can be used as a network, there is no adequate processing capacity in place and there is no front desk function.

3.1.1.1. Current situation in Europe

The **current situation in Europe** with regard to surveillance and tracking can be described as follows:

Sensor function

– The **French** space agency CNES and the French Army own radars and telescopes that can survey/observe space objects in the low earth orbit region up to 2000 km used for Earth Observation satellites such as the future Copernicus/GMES sentinels (GRAVES system) as

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18 Common civil and military SSA user requirements have been set out in the document "European Space Situational Awareness high-level civil-military user requirements" jointly prepared by the European Commission services and the European External Action Service (EEAS), SEC (2011) 1247 of 12.10.2011 and approved by the Council's Political and Security Committee (PSC) in its plenary meeting on 18 November 2011.

well as to survey higher orbits used mainly for navigation satellites such as Galileo or communication satellites (TAROT telescope). **UK**'s Chilbolton meteorological radar allows to survey space objects in low earth orbit; its Starbrook optical telescope is designed for surveying higher orbits. **Germany** owns radars that would allow to track and characterise specific space objects both in lower and higher orbits (TIRA and Effelsberg radiotelescope). **Spain's** optical observatory in La Sagra could support space surveillance activities. **Italy's** Croce del Nord radiotelescope and antenna could support tracking activities. In addition some R&D, design and pre-development activities have been carried out in the framework of the ESA "SSA preparatory programme"; these include the development of two demonstrator SST radars. **All of these existing sensors have significant shortcomings. Some were developed developed during the 1960s or 1970s for military purposes such as horizon monitoring in view of potential launches of ballistic missiles. Some were developped for research purposes. Most need substantial refurbishing and upgrading to become operational and others are too limited in operational availability despite potential high technical performance. None of them operate as a network and even if they would their combined capacity would not be sufficient to deliver a significant collision risk reduction.**

Processing function

– France and Germany have set up operational national centres for surveillance and tracking that allow for analysis of collision and re-entry risks. There is an early stage of European cooperation and sharing of data as exemplified by the Fanco-German cooperation in the operation of the French GRAVES surveillance radar and the German TIRA tracking radar, or the coordinated cooperation of the ESA optical surveillance telescope at Tenerife and the Swiss ZIMLAT telescope at Zimmerwald. These initiatives are the result of the discussion on future development of a European SST service. **However, no broader cooperation among Member States emerged from these bilateral cooperation arrangements. They also did not lead to the provision of operational SST services available to satellite operators in Europe**.

Front desk function

– There is no SST front desk function.

3.1.1.2. Situation at international level

The overall situation of SST services at international level is the following:

– While all major space faring nations have their own SSA systems to some extent, there is currently **no operational global system for space surveillance and tracking**. However, the USA has today the most extended sensor network, processing capacity and provides alerts (front desk). The US SST system is owned and operated by the US Air Force. **Most public and commercial satellite operators in Europe depend today on collision alerts provided by the US SST. However, these alerts often require verification and refinement through further analysis by the spacecraft operator to avoid risky or unnecessary mitigation measures** (collision avoidance manoeuvres). **US SST information is not accurate enough and it could not prevent a major catastrophe in**

terms of debris creation which was the collision between two satellites in 2009[19]. In view of this and given that not all Member States and satellite operators have the capacity to carry out the verification of US SST alerts, unnecessary anticollision maneuvers are often required as a precaution.

– The US system which has been operational since the 1960's is aging. Therefore, in its space policy issued in June 2010[20], the US recognised that its system requires updating and refurbishing to address the increasing need for SST information. As this requires substantial investments, **the US signalled openness to stengthen international cooperation in this domain with actors that can actively contribute to improve the quality of SST information**. **The setting up of a European SST capability would allow the EU to collaborate with and influence developments in the US as an equal partner with a view to mutually enhancing SST performance**.

– Russia, China, Japan and India have surveillance systems with limited geographical coverage and undisclosed performance capacity. Russia and China are known to work on strengthening their capacities. However, none of these systems are today open to cooperation with other space-faring nations[21].

3.1.1.3. Other actions to mitigate collision risks

In addition to avoidance manoeuvers there are other complementary measures that can be undertaken to mitigate the increasing risk of collision or the consequences of collisions:

– **Protecting satellites**: Satellites can be hardened or shielded against the impact of space debris. Research activities in this domain are ongoing. However, even the most state of the art hardening or shielding technologies cannot prevent satellites from being damaged from space debris;

– **Removal of space debris**: Research and development efforts also focus on technologies to remove space debris. However, work in this domain is at a very early stage, and it is generally accepted that debris removal can only be an effective solution in decades to come and cannot be expected to resolve the problem at hand;

– **Prevent the creation of space debris**: The international community widely recognises the proliferation of space debris as the current biggest threat to the sustainability of space activities. There are several initiatives seeking to ensure the commitment of space-faring nations to reducing the production of space debris when conducting space activities through international instruments (see annex IV). The International Space Code of Conduct proposed by the EU currently under negotiation has received so far wide international support. However, important as these instruments may be if their provisions are

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19 Since the 2009 Cosmos-Iridium, satellite collision which the US system did not detect in time, there has been an increased push in the U.S. to strengthen its capability for conjunction analysis — e.g. the ability to accurately predict high-speed collisions between two orbiting objects. A new Space Fence, currently under development, is expected to cost more than 1 billion US$ to design and procure. The system, with a target completion date of 2015, will likely include a series of S-band radars in at least three separate locations; Space Security 2011Report (complement reference)

20 United States of America, National Space Policy, 28 June 2010

21 This analysis relies on the study carried out by Booz & Company which provides a broad overview of SSA systems in space faring nations.

implemented, they will not eliminate the problem that existing and future debris pose, they will just reduce the exponential growth of space debris in the future[22].

Therefore the most viable way for spacecraft operators to mitigate collision risks is today to undertake collision avoidance manoeuvres.

3.1.2. Increased collision risks due to space debris

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 launch vehicle boosts a satellite into space, some debris is produced. Examples of space debris are: discarded rocket bodies, fuel tanks, satellite components, non-functional satellites and debris from collisions and explosions[23]. This material, orbiting the Earth at very high speed and in an uncontrolled manner, poses an ever increasing potential risk for the launch of spacecrafts and of their exploitation due to collision with other debris or other spacecrafts in orbit.

As a result of the current limitations of space surveillance systems, a large proportion of the overall population of the debris population is neither tracked or catalogued and is estimated by using mathematical models with different results. According to latest estimates, there are 16 000 objects orbiting Earth larger than 10 cm, which are catalogued and between 300 000 and 600 000 objects larger than 1 cm, not catalogued. According to ESA, the population of objects larger than 1 cm will continue to grow, and will reach a total of approximately 1 million debris in 2020. Furthermore, it is estimated that there are more than 300 million objects larger than 1 mm[24].

The vast majority of these space objects are not in deep space, but in the commercially most exploitable areas of the outer space region. These include the Geostationary Earth Orbit (GEO) at 36 000 km altitude which is mainly used for satellite telecommunications (and EGNOS), the Medium Earth Orbit (MEO) at around 20 000 km altitude where all satellite navigation constellations orbit including the Galileo satellites, and the Low Earth Orbit (LEO) (from around 600 to more than 2 000 km altitude) that is mostly used for Earth Observation satellites such as the future European Copernicus/GMES satellites.

At a speed of 10 km/s, space objects can cause serious harm to operational spacecraft, from total destruction (which would inevitably be the consequence of a collision with a space object larger than 10 cm) to permanent damage to sub-systems or instruments on-board spacecraft (which will be the minimum impact of a collision with a space object larger than 1 cm).

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22 According to UN and NASA research, space debris will continue to grow, even if all activities in space would be stopped. Source: Ecorys study which quotes NASA researcher Donald Kessler: "The future debris environment will be dominated by fragments resulting from random collisions between objects in orbit, and that environment will continue to increase, even if we do not launch any new objects into orbit."

23 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.

24 “Study on the EU Space Programme 2014-2020”, Ecorys, Draft Final Report, 18 April 2010, contract n. SI2.541751 and Study "evaluation of options for a space programme in 2014-2020", Booz & Company., Final report, 16 May 2011, contract n. ENTR/2009/050 lot 1.

The table below provides a synthesis of NASA, ESA and Booz & Company estimates on debris and possible damage to satellites.

Category	Definition	Estimated population	Potential risk to satellites
Traceable	Greater than 10 cm in diameter	16,000 catalogued; 20,000 in total	Complete destruction
Potentially Traceable	Greater than 1 cm in diameter	up to 600,000	Complete to partial destruction
Untraceable	Between 1 mm and 1 cm	More than 300 million	Degradation, loss of certain sensors or subsystems

Table 1 – NASA, ESA and Booz & Company estimates on debris and possible damage to satellites[25].

According to data analysed by Booz & Company, approximtely 950 active satellites were orbiting the Earth in January 2011 as well as a handful of additional spacecrafts such the International Space Station (ISS) or vehicles to ferry to and from the space station. More than 19 % of the active satellites are of European origin.

A particular and increasing source of concern is the LEO region where the satellites of the European Copernicus programme will be. For this region, NASA modelling estimates a risk of 8-9 collisions between catalogued objects over the next 40 years (that means one collision every 5 years). Approximately 50% of these collisions are predicted to lead to the complete distruction of the satellite[26]. This view is commonly accepted and shared by UK analyses as well as by experts of the French space agency CNES [27].

The collision risk with partially traceable space debris (between 1 cm and 10 cm), is estimated at 1 every 3 years[28]. Collision with space debris of this size is likely to lead to a complete or partial loss of the satellite.

In addition, taking into account debris smaller than 1 cm and under the same assumptions made above, the risk of collision with a satellite could rise drastically up to 500 every 3 years (i.e. around 170 per year). This kind of collisions may lead just to minor failures which, nonetheless, can have the effect of shortening the lifetime of a satellite[29].

Booz & Company, taking the lowest risk assumption of 1 collision every 3 years for partically catalogued debris globally in LEO as a basis, estimated Europe's economic risk in the LEO region at a minimum indicative of 2.5 M€ per year over the next decade[30]. This estimte takes

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

26 NASA Orbital Debris, Quarterly News, Vol. 14, issue of January 2010.

27 http://www.parliament.uk/documents/documents/upload/postpn355.pdf.

28 2011 Study of Booz & Co.

29 The satellite Jason 1 was hit twice by untracked small debris (2002 and 2005) leading to minor failures. CNES, Presentation "French Policy for Space Sustainability" at the ISU Symposium, 21st February 2012

30 The Booz & Company estimates are based on the following assumptions (see also annex V): Average satellite manufacturing costs are around 99 Million €; a launch to LEO costs indicatively 8 Million €

into account the satellite's destruction and the income shortfall generated by a 3 month service outage following the destruction.

Nonetheless, these estimates - already defined as conservative by their authors - do not take into account the consequences over the long term of collisions with debris smaller than 1 cm.

Geographical scope	Satellites in LEO	Satellite Loss probability (years)	Potential Satellite Losses (10 years)	Indicative economic damage (10 years in Mln Euro)		Annualized Economic damage (Mln Euro)
				Asset	Service Outage	
Global	470	~1 every 3 years	3 satellites	~ 150 to 180	~ 5 to 6	~ 15 Million Euro
Europe	68[31]	~1 every 20 years	0.5 satellite	~ 25	~ 1	~ 2.5 Million Euro

Table 2: European and global economic risk of debris in LEO; source: Booz & Company

3.1.3. Collision avoidance manoeuvres shorten the lifetime of satellites

As collision risks for potentially traceable or untraceable debris is difficult to predict, satellite operators tend to carry out avoidance manoeuvres on the basis of alerts of close approaches of space debris. Modelling work at global level 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 four times as many avoidance manoeuvres in 2059 as in 2019.

As stated above, space agencies in Europe as well as ESA rely on automated conjunction assessments and alerts from the US SST system. On this basis the French space agency CNES, for example, perfoms its own estimates and analysis, where necessary complemented by measures from its own surveillance and tracking system GRAVES, and performs a collision avoidance manoeuvre in case of elevated risks.

For the year 2010, CNES, operating a fleet of 17 satellites in LEO, reports almost 1 conjunction assessment risk per day, and 1 collision alert on average every 4 days. To mitigate collision risks it had to perform more than 1 collision avoidance manouvre per month.

Similar evidence is given by ESA sources and the German space agency DLR. In 2010, ESA had on average 16 conjunction risks per satellite[32] and performed on average 3 collision

per satellite; the satellite loss will occur in the middle of its lifetime; economic damage due to service outage has been calculated on the assumption that the replacement of the satellite could lead to 3 month service outage (rather conservative scenario) and data available concerning the global market for Earth observation data sales and mobile satellite services which can be considered to be the most common satellites in LEO.

31 68 European satellites out of a total of 470 globally in LEO. Being the number of European satellites one seventh of the total number, the probability of an impact for them is considered as seven times less than the total.

32 Using the ESA operated Envisat, ERS-1 and ERS-2 satellites as a reference

avoidance manoeuvres per satellite. DLR reports more than 2 conjuction asessment risks per satellite and performed 1 collision avoidance manoeuvre per satellite a year[33].

Combined data from CNES, the German space agency DLR and ESA suggest 1.5 collision avoidance manoeuvres per satellite per year in LEO. Considering that around 14% of the 470 satellites in LEO are European, this would imply around 100 collision avoidance manoeuvres per year in LEO perfomed by European satellite operators or EU Member States space agencies.

Collision risk avoidance manoeuvres are also a problem in the GEO region, not necessarily related to the need to avoid collision with debris, but due to the quantity of satellites in this very confined area of outer space. Stakeholder interviews carried out by Booz & Company revealed that an average GEO satellite operator with a fleet of 20 satellites performs up to 50 collision avoidance manoeuvres per year.

Each avoidance manoeuvre requires fuel, which shortens the active life of satellites, or requires additional fuel to be carried into orbit thus increasing the cost of launch[34]. Furthermore, due to the inaccuracy of data related to the position of the objects in question, it can be assumed that a good number of manoeuvres may not be indispensible but have to be made as a precaution generating extra costs.

The table below shows the estimated annualised costs of collision avoidance manoeuvres which result in the shortening of satellites' lifetime. The table also indicates the costs linked to the interruption of Earth observation data collection and distribution which occurs during avoidance maneouvers of Earth observation satellites in LEO[35] [36]:

Europe	Collision Avoidance (yearly)	Impact over time (10 years)	Indicative economic effect (10 years)	Annualized economic effect
Total 68 satellites in LEO	~ 90[37]	Life time shortening ~ 2900 weeks	~ 1.2 billion Euro	~ 120 Million Euro
32 satellites in LEO are Earth Observation satellite	~ 45	Days of EO loss of data ~ 450 days	~ 8 Million Euro	~ 0,8 Million Euro
~ 120 satellites in GEO	~ 25[38]	Life time shortening ~ 700-750 weeks	~ 150 – 200 million Euro	~ 15-20 Million Euro

Table 3 – Annualised costs of collision avoidance manoeuvres in LEO and GEO[39].

33 Using the DLR operated TerraSAR-X, TanDEM-X, GRACE 1 and GRACE 2 as a reference.

34 http://www.parliament.uk/documents/documents/upload/postpn355.pdf.

35 In general, there is no interruption of services during avoidance manoeuvres for satellites in GEO.

36 Detailed rationale and calculations can be found in the annex V "Calculation methodology" or at page 123 to 125 of the Booz & C. report

37 Not all (but 90 % of) avoidance manoeuvres in LEO lead to a significant consumption of propellant. Therefore, Booz & Company calculated the annualised economic effects of collision avoidance manoeuvres on the basis of 90 manoeuvres per year instead of 100.

38 Only 10 % of the avoidance manoeuvres in GEO lead to a significant consumption of propellant (e.g. only in case of large fly-bys). Therefore, Booz & Company calculated the annualised economic effects of collision avoidance manoeuvres on the basis of 25 manoeuvres per year instead of 250.

39 Source: Booz & Company

Accurate, timely and complete space surveillance and tracking information 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 events[40].

3.1.4. Re-entry of debris or uncontrolled spacecraft to Earth threaten the security of EU citizens

Re-entries of spacecraft and debris to Earth form an increasing hazard for the security of the Earth population. Whilst active spacecraft re-entries into the dense layers of the atmosphere are controlled (e.g. the US space shuttle, the Russian Soyuz, and the European Automated Transfer Vehicle), inactive satellites and debris regularly re-enter the atmosphere in an uncontrolled manner. These uncontrolled re-entries account for more than 90% of all re-entries[41].

According to the Aerospace Corporation Center for Orbital Debris studies, since the beginning of space activities in 1957, more than 20,000 catalogued objects re-entered the atmosphere, equivalent to more than one object per day on average[42]. However, most debris have hit the Earth far from inhabited areas due to the fact that 75% of the Earth surface is covered with water and only 25% of the Earth's land mass is inhabited.

Nevertheless, the ability to predit the trajectory of an object (which is highly dependant on the survey and tracking capability of a space surveillance system) is essential to mitigate risks related to re-entries. In controlled re-entry situations, this may include the evacuation of a certain area of the ocean by stopping air and sea traffic or boosting a spacecraft to remain on trajectory to a defined impact footprint. In uncontrolled re-entry situations, trajectory information is vital to alert local authorities of the impact assessment, or to take in extreme cases measures such as the US shooting of a missile in February 2008 to destroy their own military satellite.

According to Booz & Company a total of 27 space debris have been found on the ground and identified. Except for a few lightweight debris, the mass of these identified debris vary from 10 kg to a maximum of 270 kg. Debris are estimated to hit the ground at a speed of 30 km/h for lightweight debris and up to 300 km/h for the heaviest ones. Fortunately, in the last 20 years the damages to property caused by debris hitting the Earth have been marginal and no casualties have occurred.

However, uncontrolled re-entries can become a particularly serious hazard to citizens' security and health when they involve nuclear powered satellites. The most dangerous un-controlled re-entry in the history of space missions in terms of the actual damages caused on Earth occurred in January 1978, when the former USSR military nuclear powered satellite Cosmos 954 hit the Canadian territory. When impacting with the denser layers of the atmosphere the satellite broke up and a large number of radioactive debris crashed on the Canadian regions of Northwest Territories, Alberta and Saskatchewan. Almost all debris found of the ground were radioactive, some of it proved to be of lethal radioactivity. The Canadian authorities in charge of locating, recovering and cleaning-up the affected areas performed these activities in two phases over 8 months. The total cost of these activities incurred by various Canadian

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40 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.

41 Aerospace Corporation, Center for Orbital Debris Studies

42 US Stratcom Fact Sheet Re-entry Assessment, February 2008

departments and agencies was reported at $ 13.970.000 (at 1978 economic conditions). A few dozens of nuclear powered satellites of similar design remain in orbit.[43]

Examples of unctrolled re-entries over the past 15 years compiled by Booz & Company[44] illustrate the risks. Three of the cases shown concern debris from European origin:

Date	Debris and event characteristics	Source of debris	Country of origin
Jan 1997	A lightweight fragment of a debris (10 x 13 cm) grazed the shoulder of Mrs. L. Williams, whilst walking in Turley, Oklahoma, USA	Probably originating from a 2nd stage of a Delta II launcher	USA
April 2000	A 270 Kg debris was found 20 km from the nuclear power plant of Koeberg, South Africa	2nd stage of Delta II launcher	USA
Jan 2001	A 70 kg debris was found 1km from the motorway linking Riyadh to the city of Taef in Saudi Arabia	Rocket motor of Delta II launcher	USA
March 2002	A 49 kg debris landed in a house in Kasambya, Uganda	3rd stage of Ariane 3 launcher	Europe
August 2002	A 10 Kg debris landed near the village of Manzau, Angola	3rd stage of Ariane 4 launcher	Europe
March 2008	A 10 kg debris landed on a farm in Montividiu, Brazil	Probably from Atlas V launcher	USA
Sept 2011	The UARS (Upper Atmosphere Research Satellite) breaks apart and lands in the Pacific Ocean far off the U.S. coast. Twenty-six satellite components, weighing a total of about 1,200 pounds, could have survived the re-entry and reach the surface of Earth.	The US NASA owned UARS (about 12 by 5 meters) was among the largest spacecraft to re-enter Earth's atmosphere and make an uncontrolled descent.	USA
October 2011	Satellite weighing 1.7 tons re-enters the atmosphere over the Bay of Bengal; not clear whether space debris reached the Earth's surface and no damage to property has been reported.	German DLR owned X-Ray Observatory satellite ROSAT	Europe
December 2011	Re-entry with fireball observed above Belgium, the Netherlands, France and Germany; no damage reported;	Third stage of the Soyuz rocket that transported the Dutch astronaut André Kuipers to the ISS.	Russia
January 2012	The Russian Marsian probe Phobos-Grunt threatens to re-enter the Earth's atmosphere over Europe;	Satellite experiencing failure during the launch phase	Russia

Table 4: Examples of debris hitting land in dangerous circumstances; source: Booz & Company

With increasing population of satellites in orbit, the number of uncontrolled re-entry events can be assumed to increase over the coming years. Over the past 12 months, over fourty

[43] Booz and Company and HTTP://WWW.SPACE4PEACE.ORG/IANUS/NPSM3.HTM

[44] The non-comprehensive list of examples provided by Booz and Company were updated with recent re-entry examples; sources include: www.dlr.de; http://earthsky.org/space/where-will-nasas-uars-satellite-land; http://news.discovery.com/space/santa-soyuz-reentry-europe-sighting-111226.html

satellites and upper stages of launchers have re-entered the atmosphere[45] and in the last 6 months the US STRATCOM system issued three re-entry alerts: one for the US satellite UARS, another for the German ROSAT satellite and the third for the Russian Mars mission Phobos-Grunt. The three "threatening" probes eventually fell safely in the seas.

While there is no doubt about the serious risks posed by uncontrolled re-entries, it is not possible to estimate the annualised losses that they may cause. This is because, among other considerations, it is not possible to establish a statistic risk of uncontrolled re-entry and it is also not possible to predict whether the re-entry, if it happens, will cause or not damage on the ground.

3.1.5. Overview of estimated annualised losses due to hazards from space debris:

Section 3.1.2 estimates the annaulised economic impact for Europe resulting from collision risks due to space debris. Section 3.1.3 estimates the annalised economic impact of collision avoidance manoeuvres. The table below brings together these figures[46].

The table also includes an estimation of the possible annualised economic loss in light of the future evolution of satellite market growth. According to Euroconsult[47], the satellite industry launched an average of 76 satellites per year over the last ten years, ranging between 60 and 90 units per year. Since the market is expected to grow by 50% in the coming decade, with a total of 1,145 satellites to be built for launch over 2011-2020, the launch rate for satellites will increase approximately at the same level.

The table below gives only a non-exhaustive overview of quantifiable estimated losses[48]. As indicated above, it is not possible to estimate the annualised losses provoked by un-controlled re-entries.

Loss type	**Annualised loss**	
	Actual	**Actual + growth forecast (+50 %)**
Direct loss of satellite due to collision	~€ 2.5 Million	~€ 3,75 Million
Life-time shortening of satellites in LEO due to collision avoidance	~€ 120 Million	~€ 180 Million
Loss of Earth Observation data in LEO due to collision avoidance manouevres	~€ 0.8 Million	~€ 1,2 Million
Life time shortening in GEO due to collision avoidance manouevres	~€ 15-20 Million	~€ 22,5 -30 Million
Total minimum annualised loss	**~€ 140 Million**	**~€ 210 Million**

Table 5 – Estimated loss due to space debris.

45 Aerospace Corporation, Centre for Orbital Debris Studies, http://reentrynews.aero.org/past.html

46 The calculation is explained in detail in annex V and is based on the estimated annual revenue of Earth Observation Satellites and the risk of destruction of a European EO satellite.

47 Satellites to be Built & Launched by 2020

48 Detailed explanation in the annex "Calculation Methodology".

These costs are almost certainly just a small fraction of possible non-quantified costs and, to some extent, the non-quantifiable consequences that may result from the absence of a European space surveillance and tracking capability. For example the loss of a satellite may result in the loss of critical satellite communication capacity in an 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.

3.2. Underlying policy considerations regarding the problem and the design of the solutions

From discussions with stakeholders over the past years, it became clear that the setting up of operational European SST services will require the intervention of the EU.

3.2.1. SST development must be led by the EU

There is a consensus among EU and ESA Ministers responsible for space that the development of this service is to be led by the EU and not by the European Space Agency. This consensus is reflected in several Space Council Resolutions mentioned in the impact assessment. In particular, Member States asked the EU to define the governance and data policy for a European SST service, to play an active role in the setting up of the European service, and to make best use of sensors and expertise that already exists at national and European level. Member States were also very explicit as to how security concerns should be taken into account: SST sensors need to remain under national control. Confidentiality of SST information was defined as the key principle for the SST data policy (e.g. all information is to be classified, to be declassified on a case by case basis only).

The reason for such position is not formally recorded but emerged in numerous discussions: European SST service has a security dimension (it allows gathering intelligence on States' civil and military space infrastructure and operations) which the EU, unlike ESA, has competence and is equipped to deal with. The TFEU grants the EU competence to coordinate the exploitation of space activities and the TEU confers the EU competence over security issues such as those that arise in the context of SST. The EU has the necessary legislative capacity to put in place governance mechanisms and a data policy for SST.

ESA, on the other hand, is a world-class R&D agency designed to define and implement scientific, technology and space application development programmes. ESA is neither conceived to do the sort of complex policy and legislative work necessary to set up an SST system where assets are largely in the hands of the military, nor has it been designed to operate space-based services (a fact which ESA itself underlines in its policy documents).

Arguably, Member States could set up a new organisation to deal with SSA. Such organisation would have to have many of the features that the EU already has. Therefore such new organisation would generate duplications and inefficiency. In addition, some Member States have expressed concerns that any solution outside the EU framework may be dominated by those Member States that already possess today some sensor capacity preventing others from developping their own in the framework of a truly European service.

3.2.2. Future SST must build on exisitng assets and completed with new ones

There is a consensus among Member States and experts that any SST development should capitalise and build on existing assets which should be linked and operated as a network. There is also convergence regarding the fact that current assets are insufficient to ensure a minimum desirable level of performance. To reach this minimum desirable level of performance new assets need to be built and integrated in an SST system. These assets are primarily sensors such as tracking and surveillance radars and telescopes.

3.2.3. Governance: assets must remain under the control of Member States

Over the years-long discussion regarding the setting up of a European SST service, Member States possessing assets have insisted on one crucial governance aspect: due to security concerns the sensor and processing functions must, in any scenario, remain under the control of the national competent authories (i.e. military authorities). The majority of Member States possesing assets support the idea of that, for the purpose of setting up a European SST service could form a consortium to run, Member States possessing existing or new assets should form consortium to run, as a network, both sensor and processing functions.

Member States are of the view that the fornt desk funcion should be run either by the consortium itself or by another body with adequate security credentials, such as the European Union Satellite Center[49].

3.2.4. Data policy: SST information is classified

Under any scenario, SST data policy must upheld the principle that information is by definition classified and it should only be declassified on a case by case basis when the need arises.

3.2.5. Funding

Member States are willing to make their assets available for the setting up of the European SST service. They are of the view that, in return, the development of the SST should involve EU funding and should, as a minimum, cover operations directly linked to the setting up of the European SST service. In addition to making their assets available, Member States are open to contributing to it financially.

Although the overall benefits from the proposed initiative are estimated to exceed the costs, SST services are mainly of a public and precautionary nature which do not lend themselves to commercial activity. While the introduction of a fee for both public and private/commercial SST service users could be considered at a later stage to cover operational costs, SST is not likely to be an activity to be started of through private/commercial actors. Furthermore, those Member States owning assets, for reasons of national security, would not collaborate with a commercial actor in this sensitive domain.

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[49] The European Union Satellite Center (EUSC) is an agency of the EU Council that currently provides geospatial imagery information services and products with various levels of classification to a variety of users, both civil and military, at the EU Council, the Commission and in EU Member States. EUSC services are based on data stemming from existing national public satellite systems, private/commercial systems, or systems owned by third countries or international organisations.

3.3. Who is affected, in what ways and to what extent?

The most affected groups include:

– **The EU, and more precisely the European Commission**, which is about to become a significant European operator of space-based infrastructure;

– **Public/government entities and administrations** with legal and policy responsibilities related to the management of public space activities and those responsible for space security issues;

– **Public (national, European) and private/commercial satellite operators** having the legal responsibility and effective control over operational or experimental satellites;

– **Launch companies** share the same concerns as the satellite operators for the launch of satellites or other spacecraft;

– Space **insurance companies** will need space surveillance data to improve their risk analysis and propose better tailored products;

– Public authorities and private/commercial entities **responsible for the operations of ground based infrastructures with a satellite or space-based infrastructure component** (such as financial transaction networks, telecom networks or energy supply networks);

– Public/governmental entities and administrations with legal and policy responsibilities for **civil protection** early warning, mitigation and response actions for situations where the re-entry of space objects into the Earth's atmosphere threatens the property and life of citizens or the security of critical ground infrastructure.

While the primary concern in setting up a European SST service lies with the categories outlined above, the service may also help international partners that do not possess such service. It has already been mentioned earlier how the development of a European SST system can be carried out in collaboration with the US.

3.4. Foreseen evolution of the problem

As previously described (section 3.1.5), the number of active satellites in orbit is deemed to increase by 50% in the next ten years. This would imply a simple raise of 50% of satellites in orbit only if the current operational satellites that will have reached their end-of-life in that laps of time will be discarded (de-orbited or re-orbited following debris mitigation guidelines). Taking into account the fact that this assumption seems quite optimistic and that, for example, additional launcher upper stages may be left in orbit after the launch of a satellite, it is clear that the orbits' crowding will keep growing, raising further the level of risks assessed in the previous sections.

Moreover, the number of tracked and catalogued objects in orbit has increased by 100 % over the last 20 years (from 8,000 to 16,000 in 2012). As there is no visible sign for this trend to be reduced, with current capabilities, the number of tracked and catalogued objects can be estimated to be around 32,000 by 2032. The level of risk can be expected to increase accordingly. The 2011 space security report states that although there were no major fragmentations (events creating space debris) in 2010, the number of catalogued objects increased by 800, mostly due to continued discovery and cataloguing of debris from major fragmentation events in 2007 and 2009. A significant number of debris will not reenter the Earth's athmosphere and disintregrate in a relatively short period of time due to the athmospheric drag and will remain a threat for decades and even centuries to operational satellites and thus to the long-term sustainability of space activities.[50]

3.5. EU right to act

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 policy is defined as a shared competence between the EU and its Member States.

Under section 3.2 there is a detailed explanation of the reasons why the EU is asked to exercise its comptence in the specific domain of SST.

The EU does not seek to replace initiatives taken by Member States individually or in the framework of ESA. It seeks to complement actions taken at their level and reinforce coordination where such coordination is necessary to achieve common objectives.

The EU involvement would be necessary to aggregate the investment required to fund certain space projects, set in place governance arrangements, define a data policy and ensure that existing and future capacities are broguht to work in a coordianted and efficient manner ensuring a robust and interoperable system benefiting all relevant European stakeholders.

Furthermore, the proposed EU action does not seek to replace or duplicate existing mitigation measures at international or multi-lateral level, such as the UN guidelines for space debris mitigation or the EU proposal for an international Code of Conduct on outer space activities. These measures will not solve the problem at hand, but will reduce the growth of space debris in the long-term (see the detailed description of this measures in annex IV).

4. OBJECTIVES

4.1. General policy objectives

The general objective of the proposed initiative is to safeguard the long-term availability and security of European and national space infrastructures and services essential for the smooth running of Europe’s economies and societies and for European citizens’ security.

4.2. Specific policy objectives

More specifically, the initiative aims at increasing the EU’s capacity to:

– Reduce the risks related to the launch of European spacecrafts;

– Assess and reduce the risks to in-orbit operations of European spacecrafts in terms of collisions, and to enable spacecraft operators to more efficiently plan and carry out

[50] Space Security Report 2011

mitigation measures (e.g. more accurate collision avoidance manoeuvres; avoidance of unnecessary manoeuvres which are risky in itself and reduce a satellite's lifetime);

– Survey uncontrolled re-entries of spacecraft or their debris into the Earth's atmosphere and provide more accurate and efficient early warnings to national security and civil protection/disaster management administrations with the aim to reduce the potential risks to the security and health of European citizens and mitigate potential damage to critical terrestrial infrastructure.

4.3. Operational objectives

In order to realise the specific objectives, the continuous and sustainable provision of SST information to European and national public and private/commercial users needs to be ensured through:

– The setting up of an operational space surveillance and tracking capability at European level building on existing European and national assets and capable of intregrating future new assets as well as the implementation of an appropriate governance structure;

– The definition and implementation of data policy principles for the handling of SST information through the European SST capability;

– The definition and delivery of SST services open to all European and national public and private/commercial actors who need SST information; the services should respond to defined and agreed user requirements.

– Ensuring the necessary quality of SST services and their efficient and sustainable operational provision:

– Supervising the implementation and efficient functioning of the proposed operational SST capability and the operational SST services and by ensuring a sustainable EU funding contribution;

4.4. Consistency with other policies and objectives

The objectives are coherent with Member States political will expressed in Council conclusions as well as the objectives of the ongoing (and planned future) European GNSS programmes and the GMES initial operations programme which aim at ensuring the sustainable provision of European satellite navigation services or services for environment monitoring or in support of security related activities. They are also coherent with the objectives of space research activities carried under the current EU framework programme for research and development (FP7) as well as the planned Horizon 2020 programme. Furthermore, the proposed initiative's objectives are consistent with the objectives set in the EU's policy related to the protection of European critical infrastructure and the European Civil Protection Mechanism.

As concerns activities beyond the EU framework, the objectives of the proposed initiative are complementary with the ongoing ESA SSA preparatory programme as well as national SSA activities.

5. POLICY OPTIONS

This impact assessment identifies five options which - apart from the baseline scenario – seek to deliver the same output: establishing a European service to avoid collisions in space and monitor uncontrolled re-entries. However, they differ in terms of governance, funding and the degree of performance that the service can deliver.

The selection of the options is based on the following **considerations some of which have been outlined in previous sections and which can be summarised as follows**:

(1) European SST services should build on existing European and national assets and competences and would entail the development of additional ones;

(2) **SST capacity is incremental:** SST is an activity that can be developed in an incremental and modular way. New sensors or assets added to a European SST network can improve the system's overall performance and the quality of the data and information it provides**;**

(3) Without prejudice of on-going budgetary discussions**, funding for a European SST service would** come from redeployment of budget from existing programmes foreseen for the next MFF provided that such redeployment is compatible with the legal base of the proposed programmes[51];

(4) **No risk of cost-overruns:** SST performance is incremental and improvement of performance can be achieved with relatively (compared with other space programmes) modest investments. Any unlikely cost-overruns would be offset by down-scaling the system (for example with regard to number of sensors included in SST sensors function or new sensors to be developed by Member States), which can still guarantee enhanced performance compared with the current situation. In addition, to safeguard EU budget, EU funding provided under any of the options would take the form of fixed contributions;

(5) **Strengthened cooperation with US on SSA**: The US SST technology and architecture is old (with assets dating back to the 60ies) and needs modernising. As part of its space policy, the US has publicly stated its desire to collaborate internationally in this domain. Collaboration between the US and the EU could improve the accuracy and quality of SST overall and generate efficiency and savings. This two-way collaboration is obviously only possible in so far as the EU develops SST capacity of its own.

(6) The performance of the service allows reducing the risk of collision by a certain factor; the potential economic loss caused by collision will be reduced by the same

[51] The Commission's proposal for the future EU budget under the **next Multiannual Financial Framework (MFF) 2014-2020 does not foresee a specific budget support to the setting up of operational European SST services**. As the protection of space infrastructure during launch and in-orbit operations is to be considered an integral part of the operator's responsibilities, the Commission's proposal for a Regulation on the implementation and exploitation of European satellite navigation systems (COM(2011) 814 final of 30.11.2011) includes provisions for a limited funding contribution to the proposed activity. Redeployment of budget under other possible future EU financing instruments could be examined. Taking into account this constraint, the EU funding contribution to a European SST activity would have to be limited.

factor. As options 2, 3 and 4 are variations of the same option and based on expert advice, the performance of the service proposed in these options **suggests a risk reduction by a factor of 3 to 5. Option 5 which proposes a more performing service suggests a risk reduction by a factor of 10**.

(7) Any enhancement of SST capacity will result in improved ability to predict and monitor uncontrolled re-entries but we can not establish a target for this. Therefore, the options are designed considering only the target reduction of collision risk.

FROM PROBLEM DEFINITION TO OPTIONS			
1. PROBLEM DEFINITION	**2. SOLUTION**	**3. POLICY CONSIDERATIONS AFFECTING THE DESIGN OF THE SOLUTION**	**4. THE DESIGN Of THE SOLUTION: THE OPTIONS**
Increasing number of sapcecraft and debris generate an increasing risk of collision. Collision can destroy or damage satellites. There is direct economic loss due to destruction or damage. There is indirect loss of revenue. There is unquantified indirect damage due to disruption of satellite service. Incraesing risk of uncontrolled re-entries that may cause damage on the ground. In Europe there is at present no adequate capacity to survey and track space objects and to alert stellite operators of the risk of collision. The capacity that exists allows to survey and track limited number of objects. The alerts given are inaccurate and often demand unecessary avoidance maneouvres that shorten the life of satellite. There is also no adequate capacity to monitor uncontrolled re-entries.	The baseline scenario would not make the problem go away, on the contrary it can only get worse. The problem cannot be solved through debris mitigation measures which can only prevent the problem from becoming exponentially worse. The solution to the problem is to have the means to survey and track space objects to determine the risk of collision and provide alerts when such risk arises. These means will also serve to better predict and monitor the uncontrolled re-entry of space objects in order to alert if necessary public authorities of any potential danger that these re-entries may generate. These means is what the report refers to as Surveillance and Tracking Service which consists of three functions: – Sensor function, which through a network of instruments such as radars and telescopes allows to identify and track spacecraft and debris; – Processing function, through which the relative orbit of spacecraft and debris can be catalogued and analysed to determine the probability of collision or to determine the re-entry path of space objects; – Front desk function, which is responsible for the actual provision of the SST services (such as collision or re-entry alerts) to satellite operators and relevant authorities. At the same time, the front desk will be the entry point for user requests for SST information which it relays to the processing and sensor function.	Discussions on the potential development of SST have revealed that Member States have converging strong views on the fact that SST must be developed in the framework of the EU and on the following issues: **Architecture:** A SST service must be developed building on existing assets owned by Member States and by adding new assets. **Governance**: The European SST service has a highly sensitive security dimension as it allows gathering intelligence on States' civil and military space infrastructure and operations. Member States have made clear that due to security concerns the sensor and processing functions must, in any scenario, remain under the control of the national competent authories (i.e. military authorities). Given such security concerns, front desk function must be entrusted to an entity that has solid security credentials. **Data policy:** There is a consensus among Member States that SST information is by definition classified and can only be declassified on a case by case basis where the need arises. **Funding:** Member States are of the view that the development of the SST should involve the EU funding, but they are open to contributing to it financially.	There are basically two broad options: status quo and the developing of a European SST service. There are however possible variations on the latter. In column number 3, a number of policy considerations are idenitfied. In this light, any of the options will build on the combination of existing and new assets and will have identical governance and data policy. Against this backdrop, the design of the options is guided by the degree of performance that they seek, i.e. the quantifiable reduction of collistion risk, and the way the funding contributions necessary for the setting up and operations of the European SST service are shared between the EU and the Member States. Following expert advice, for the purpose of this report two targets have been identified: – a reduction by a factor of 3 to 5 (options 2, 3 and 4) and – a reduction of 10 (option 5). Achiving these targets requires the addition of new assets to the existing ones and a certain investment: 60 M€ to achieve the factor 3 to 5 target, and 120 M€ to achieve the factor 10 target. Options 2 and 3 propose EU funding as an incentive for Member States to invest in the new European SST service. Options 4 and 5 propose EU funding for all costs linked to the setting up and operation of the European SST service.

5.1. Option 1: Baseline scenario: No EU financial involvement in SST

Under the baseline scenario the EU would not engage in any action or provide any support (legal or financial) to the setting up and operational provision of European SST services.

The reasons underlying the need for EU intervention have been outlined under Section 3.2 of this impact assessment.

Without the preparation of an organisational framework setting out how the provision of operational SSA services would be organised and without an agreed data policy that would ensure the EU Member States that information related to sensitive satellites or their existing sensors is handled with the necessary level of confidentiality, there are no indications that EU Member States on their own initiative would come to a broader cooperation on SST outside the EU framework.

The fact that the need for setting up of European SSA services was highlighted in Space Council Resolutions since 2007, but no initiative was taken by EU Member States so far underpins the likelihood of this scenario.

Existing sensors and expertise at Member States level, such as radars and telescopes or SST data centres, that could form building blocks for a European SST system, will remain fragmented and not inter-connected. Bilateral cooperation as described in the problem definition may continue, but there are no indications today that this may lead to more formal cooperation arrangements apart from the cooperation between France and Germany which announced to interconnect their existing sensors and data centres (GRAVES, TIRA), but which is still not an operational reality.

Cooperation in the SSA domain between a number of EU Member States (in their capacity of ESA Member States) in the framework of ESA may continue. However, such cooperation emerged in the context of a several year-long policy discussion for the setting up of a European SST that is supposed to be led by the EU. If the EU does not take action, the continued cooperation on SST amongst EU Member States in the ESA framework is highly unlikely.

So far ESA has carried out a number of preparatory studies to define civil SSA user requirements, SSA system requirements, architecture options, and to develop two demonstrator radars. The proposal for actions in 2013-2015 currently under discussion indicates that the focus will be on space weather and NEO monitoring, which are typical R&D activities and have no significant security dimension. As concerns space surveillance and tracking, the current draft programme proposal suggests continuing the development, testing and validation of SST sensors (the already launched development of two demonstrator radars as well as three telescopes), the development of a secured network between existing sensors and the testing of pre-cursor SST services. These activities must be seen as technical support within the overall framework of an EU-led development of a European SST service to which assets developed through ESA will also contribute.

Taking into account the fact that Member States do not see the development of a European SST service as a mission to be entrusted to ESA as explained in section 3.2, the setting up of operational SST services at European level under the baseline scenario cannot be expected.

Cooperation between EU Member States and third countries is expected to remain at the current status: The US are expected to remain the only space-faring nation that shares SST information with public and private/commercial European satellite operators on an individual basis. However, as set out in the problem definition chapter of this report, the information provided by the US is not accurate enough to efficiently plan and carry out collision avoidance manoeuvres. Operators that do not have the means to refine such information, or cannot get help in time from Member States that do possess such means, are forced to carry out sometimes unnecessary avoidance manoeuvres as a precaution.

The EU in its role as owner and operator of the EGNOS and Galileo would have to rely on the US SST and make arrangements with those Member States that have SST assets to ensure refined assessments of collision risks and to accompany collision avoidance manoeuvres.

Even in the absence of EU intervention, the US is likely to improve its SST capacity. However, it is not possible to predict whether, on what basis and with which degree of accuracy the US will continue to provide SST information to third parties. It is certain that the US will take such decision as a function, first and foremost, of US own national interests.

As concerns other mitigation measures to reduce collision risks for satellites, a number of actions may be taken including action at international level with the objective to limit the growth of space debris as illustrated under chapter 3.1.1.3.

These international mitigation measures seek to prevent the exponential growth of debris and may only be effective in the long-term, if indeed they are implemented. However, these actions cannot replace short-term mitigation measures such as collision avoidance manoeuvres.

5.2. Option 2: Partnership approach – EU funding for the European SST front desk function

This option would seek a reduction of the collition risk by a factor of 3 to 5 and therefore a reduction of economic loss due to satellite failure or destructions by the same factor. There is convergence among experts that in order to achieve such reduction the sensor function must be developped linking and operating as a netwok existing assets and adding to this network 1 tracking radar, 1 surveillance radar and 8 telescopes. These assets should be linked by secured lines. The processing function must be set up including in particular a robust data center. A front desk must also be set up.

This would require an overall investement, coming from EU and Member States, of some 60 M€ per annum (for details see annex V on the calculation method). According to the most conservative estimate the current anualised estimated loss of 140 M€ would be reduced to between 28 to 46 M€.

In this option, operational European SST services would be set up in partnership with EU Member States owning relevant assets. The EU would define the legal framework for the setting up and operations of European SST services on the basis of existing sensors and capacities as well as those Member States may decide to develop (for instance in the follow-up programme to the ongoing ESA SSA preparatory programme to be decided at the ESA Ministerial Council in November 2012).

This option is based on the so-called small option in the study carried out by Booz & Company. Further discussions and verifications with experts from ESA and national space agencies led to converging views on the new infrastructure elements needed to reach the targeted performance levels of the European SST service indicated above and the cost estimates.

5.2.1. Governance

The EU, through an appropriate legal instrument, would define the roles and responsibilities of each actor in the implementation and operation of the proposed European SST capability which comprises of three functions:

– the **sensor function** (consisting of a network of existing and new SST sensors connected amongst each other and with the SST data processing centres),

– the **processing function** (consisting of a combination of existing SST data centres and analytical expertise to process the data captured by the SST sensors, merge it with US SST data, build a European catalogue of space objects, analyse collision risks and re-entry risks etc), and

– a **front desk function** (handles the dissemination of SST information, e. g.collision risk alerts during launch and in-orbit operations and re-entry early warning alerts, to European users through defined SST services).

The governance framework would also define the services to be provided in accordance with defined user requirements, set out data policy principles, and define coordination and monitoring mechanisms to ensure the overall functioning of the European SST service, the implementation of the services and the agreed data policy, as well as the contacts with service users.

As explained under section 3.2, Member States have made clear that the sensor and processing function must remain under the control of competent national authorities (i.e. military authorities). Therefore, **a consortium set up by competent authorities of Member States would be responsible for the sensor and the processing functions** of the European SST capability. The consortium should be open to all EU Member States and European actors that are ready to contribute SST sensors or other relevant capacities or expertise. The consortium members will retain the full control over their assets, and will be responsible for their operation, maintenance and upgrading/further development. The consortium will also be responsible for the implementation and the operation of the secured network interconnecting sensors and the processing function. The processing function will consist of centres at Member States level (both France and Germany have set up such "precursor" national centres) and a central data center. In line with the role of the processing function explained above, the consortium would build and operate a European catalogue of space objects and provide analytical support to the front desk function. The interior organisation of the consortium would be the responsibility of the Member States constituting it on the basis of broad terms of reference to be provided by the European Commission. France and Germany declared readiness to form the nucleus for such a consortium on the basis of their existing assets.

The **front desk function** would be entrusted to an existing operational entity/agency with suitable security credentials and a proven capacity to handle SST information in a secured environment (for example the EU Satellite Centre provided that it will be given an appropriate mandate by its Member States[52]). The front desk ensures the provision of SST services open to all European and national public and private/commercial users.

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[52] Recent discussions within EUSC Board reveal openness to go in this direction.

The **European Commission** would not engage in any day to day operational activity, but would ensure the **overall coordination of the SST functional elements**. To this end, it would set up and chair a board consisting of the members of the Consortium and the European SST front desk.

5.2.2. Service provision

The services to be provided would be defined by the European Commission based on the civil-military SSA user requirements approved by Member States in October 2011(see footnote 18):

SST service groups	Users
Collision avoidance: Services related to the risk assessment of a collision between spacecraft or between spacecraft and space debris and the generation of collision avoidance alerts;	• Operators of public/governmental, scientific and commercial spacecraft within the EU and third countries; • Military spacecraft operators; • Launch service providers; • Government services that have legal and policy responsibilities related to the management of public space activities; • Space insurance companies and banks that provide financing for space actors; • ESA, EU
Detection and characterisation of on-orbit fragmentations: Services to detect and assess the risks of on-orbit fragmentation events (explosions or break-ups that lead to the creation of space debris) or collisions, and to issue alerts where required;	• Public (civil or military) and commercial spacecraft operators and launch service providers; • Government services that have legal and policy responsibilities related to the management of public space activities; • Space insurance companies and banks that provide financing for space actors; • International scientific community interested in orbital debris population; • Defence/governmental community in case such collisions could have an intentional nature (such as so called anti-satellite (ASAT) tests which aim at intentionally destroy a satellite); • ESA, EU
Re-entry predictions for hazardous space objects: Services to assess risky re-entries of space objects into the Earth's atmosphere, predict the time and location of impact, and initiate alert procedures to predefined points of contact	• Public (civil or military) and commercial spacecraft operators and launch service providers; • Government services that have legal and policy responsibilities related to the management of public space activities; • Space insurance companies and banks that provide financing for space actors; • Governmental civil protection services • ESA, EU

5.2.3. Data policy

The Commission in cooperation with EEAS and Member States is already working on principles for the SST data security policy. The SST data security policy will define the framework for the acquisition, handling, processing and distribution of SST data derived from the observation of space objects, information related to the SSA systems and its various components (functioning, availability, precision etc) as well as information related to the users.

The most stringent requirements on confidentiality of SST information are imposed by the defence community[53] in order to protect sensitive governmental space assets of Member States and allies. Uncontrolled disclosure of information related to these assets (including information concerning their existence, orbital parameters, space manoeuvres in view of military or intelligence operations), as well as information revealing interest expressed for specific assets or systems or information related to the characteristics of military SST sensors, could jeopardise national security.

In accordance with these needs, SST related information concerning objects detected through the SST sensors will be considered classified by default. Information about an object may only be declassified if it is cleary identified as a non-sensitive object. At any time, when there is a risk of collision or a hazardous re-entry involving a classified object, an ad-hoc decision shall be taken on the risk of declassification. The processing function of the proposed European SST system will be reponsible for taking such decisions based on the agreed data policy. No declassification decision will be taken without involving the actor responsible for the object.

5.2.4. Funding

The overall costs of the setting up and operation of the European SST capability would be co-funded **by the Member States constituting the consortium and the EU in the manner describe below**.

The **Member States participating in the consortium** would provide funding for:

– all capital investments related to the setting up of the sensor function including the development of new assets and its full operation;

– the capital investment for the setting up of the processing function;

– the secured network to inter-connect sensors and the processing function

– The maintenance and operational costs of the sensors and processing functions necessary for the Europan SST service;

The costs for the acquisition of new assets (1 surveillance radar, 1 tracking radar and 8 telescopes, the required equipment to network existing assets and the processing function and a data center) necessary to guarantee the targeted collision risk reduction factor of 3 to 5 is estimated at 50 M€ per annum. Costs for the operations of sensors and processing functions can be estimated at 8 M€ per annum[54].

The total contribution of Member States participating in the consortium would be around 58 M€.

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53 See footnote 18 on the common civil-military SSA user requirements approved by Member States in 2011.

54 See details in annex V.

The **EU** would provide funding for:

– the setting up and operation of the front desk function, namely the staff required to run such service (estimated at 6 FTE) the acquisition of the necessary hardware and software, the maintenance of such equipement and overheads[55].

Funding of the SST front desk function can be estimated at an average of 2 M€ per year. Therefore, the total contribution of the EU would be 2 M€.

As explained on page 24, the provision of SSA services is not likely to be an activity to be started through private or commercial actors. Member States owning relevant SST assets are not willing to collaborate with a commercial actor in this sensitive domain as commercial actors do not meet the security requirements identified to protect national security interests. However, similar to ongoing US STRATCOM reflections, the generation of revenues through the introduction of service fees for both public SST service users (who are not part of the consortium) and private/commercial users could be envisaged in the longer run – once the planned European SST services have reached a stable operational stage and the necessary quality level. The introduction of service fees could be examined in the context of the evaluation of the initative's implemementation.

5.3. Option 3: Partnership approach – EU funding for networking and operation of sensor, processing and front desk functions

This option is identical to option 2 in all respects except as regards the distribution of funding provided by the consortium of Member States and the EU.

Under this option **Member States** participating in the consortium would fund:

– the capital investments related to the setting up of the sensor function including the development of new assets and its full operation;

– the capital investment for the setting up of the processing function;

– The capital investments for the secured network to inter-connect sensors and the processing function;

As in option 2, the acquisition of new assets (1 surveillance radar, 1 tracking radar and 8 telescopes, the required equipment to network existing assets and a data centre) necessary to guarantee the targeted collision risk reduction factor of 3 to 5 is estimated at 50 M€ per annum.

The total contribution from Member States in the consortium would be some 50 M€ per annuum(see also annex V on the calculation method).

The **EU** would fund:

– The operational costs of the sensors and processing functions necessary for the Europan SST service;

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55 Operational costs the EU front desk function have been estimated on the basis of current EUSC man/hour costs for Earth Observation imagery analysts and the assumption that 6 analysists would be required to man the front desk. .

– the setting up and operation of the front desk function, namely the staff required to run such service (estimated at 6 FTE), the acquisition of the necessary hardware and software, the maintenance of such equipement and overheads.

The EU funding contribution would amount to 10 M€ per annum (8 M€ for maintenance and operation of the sensor and processing function and 2 M€ for the front desk function).

As in option 2, the introduction of service fees could be examined in the context of the evaluation of the initative's implementation.

5.4. Option 4: EU-led SST development and funding (risk reduction factor of 3 to 5)

As in option 2 and 3, this options assumes the development of 1 surveillance radar, 1 tracking radar, 8 telescopes for both surveillance and tracking and a data centre. The risk reduction factor would be identical to that under options 2 and 3, but there would be differences in terms of governance and funding because the EU would be the system owner and would fund the totality of the costs directly linked to the European SST service.

The EU defines the related legal framework (including data policy), and takes the full responsibility for the development of the structures needed to federate existing national and European sensors and capacities and to ensure the provision of SST services.

The Commission would engage in public procurement processes and would become owner of SST infrastructure elements where necessary.

5.4.1. Governance

The sensor function would be a shared responsibility of Member States and the EU as it would comprise existing assets remaining under the control and responsibility of Member States and European assets developed and owned by the EU. For the same reasons, the processing function would be largely the responsibility of Member States, but it would have to involve the EU to a larger extent than options 2 and 3.

Following the same logic as in previous options, e. g. to entrust the sensor function and the processing function to a consortium of Member States to meet Member States' security concers, the management of the new EU-funded assets would be entrusted to the consortium, and the front desk function to an entity with adequate security credentials such as the EU Satellite Centre (EUSC).

The European Union would be the owner of any new assets procured for the setting up of the European SST service, would be responsible for the overall political supervision and would oversee the execution of the programme. Given that the EU would be the main architect and source of funding for the European SST service, it would have greater responsibility than under options 2 and 3.

5.4.2. Data policy

Data security policy would be identical as in the options 2 and 3.

5.4.3. Service provision

Service provision would be identical as in options 2 and 3.

5.4.4. Funding

Under this option the EU would fund:

- the capital investments related to the setting up of the sensor function including the development of new assets;
- the capital investment for the setting up of the processing function;
- The secured network to inter-connect sensors and the processing function;
- The operational costs of the sensors and processing functions necessary for the Europan SST service;
- the setting up and operation of the front desk function, namely the staff required to run such service (estimated at 6 FTE) the acquisition of the necessary hardware and software, the maintenance of such equipement and overheads.

As in option 2 and 3, the acquisition of new assets (1 surveillance radar, 1 tracking radar and 8 telescopes, the required equipment to network existing assets and a data centre) necessary to guarantee the target collision risk reduction factor of 3 to 5 is estimated at 50 M€ per annum.

The EU funding contribution towards maintenance and operation costs of sensors and processing funcion would amount to 8 M€ for maintenance and operation of the sensor and processing function; the EU funding of the front desk function would amount to 2 M€.

Total contribution from the EU would amount to some 60 M€ per annum (see also annex V on calculation method).

5.5. Option 5: EU-led SST development and exploitation (risk reduction factor of10)

Option 5 follows the same logic as option 4, but seeks to reduce the risk of collision by a factor of 10 and consequently of the estimated losses above a factor of 10. This option requires the acquisition of 2 surveillance radars, 2 tracking radars and 14 telescopes.

The development of new sensors to complement existing national sensors would increase the system's capacity to detect space objects in terms of geographic coverage and size of objects. As a consequence, this option would improve the quality and accuracy of the SST services provided.

This option is based in the medium option in the study carried out by Booz & Company. As all the previuos options, option 5 would also leverage on existing sensors in Europe.

5.5.1. Funding

Funding would follow the same logic as in option 4 but with double the number of new assets (2 surveillance radars, 2 tracking radars and 14 telescopes) which also implies enhanced processing capacity as well as a higher performing service.

EU funding can be estimated at some 120 M€ per year for the period 2014-2020 (see also annex V on the calculation method).

5.6. Summary of the options

Option 1: Baseline	Option 2	Option 3	Option 4	Option 5
5.6.1. Governance				
Non existent	EU provides the legal framework Consortium of Member States own and operate sensor and processing function EU entity entrusted with front desk function EU ensures overall running of the system in partnership with Member States		EU provides the legal framework EU funds and owns new assets Consortium of Member States own exisiting assets Consortium operates sensor and processing fucntion, including those owned by EU EU entity entrusted with front desk function EU has a much stronger grip of the development of SST than in options 2 & 3 EU ensures overall running of the system in partnership with Member States. It has greater responsibility than in options 2 and 3	
5.6.2. Data policy				
Non existent	Developed as part of the EU framework			
5.6.3. Service provision				
Non existent	24/7 service -Risk collision reduction by factor 3 to 5			24/7 service – Collision risk reduction by factor 10
5.6.4. Funding				
Undetermined	Consortium funds sensor and processing funcions and new assets – 58 M€/year EU funds front desk – 2 M€/year	Consortium funds new assets – 50 M€/year EU funds operations of sensor, precessing and front desk functions – 10 M€/year	EU funds new assets and operations of sensor, processing and front desk function – 60 M€/year	EU funds new assets and operations of sensor, processing and front desk function – 120 M€/year

5.7. Summary of stakeholder views on the options

There are two broad categories of stakeholders: public authorities and industry.

The idea of developing a European SST service has been under discussion for a number of years. The building blocks of the options presented have all been discussed with stakeholders either bilaterally or multilaterally on numerous occasions.

Industry could be roughly grouped in two categories: manufacturing industry and commercial satellite operators. Both groups are strongly in favour of the setting up of a European SST capacity. Manufacturing industry is clearly in favour of the option that guarantees the highest investment and therefore the highest industrial return. Satellite operators are concerned with the performance of the system and favour the highest possible performance. They are however concerned that high performance would not result in any additional costs imposed on them.

Industry has not expressed particular views on governance, which is understood to be a political issue, or data policy. As regards, service provision, satellite operators underline the need for accurate and timely information, which is the objective under any of the suggested options.

As far as Member States are concerned, some of them have far clearer and stronger position on these matters than others.

All Member states agree on the need to set up a European SST service. They all agree that such service should build on existing assets and this is foreseen in options 2 to 5. All Member States are in agreement with the governance suggested in the options: e. g. a consortium of Member States being entrusted with the operation of the sensor and processing functions. One Member State has indicated on a number of occasions that it would prefer that a European entity be set up to to handle these functions but accepts the governance arrangements proposed in the suggested options provided that the consortium is not reserved to Member States that currently possess relevant assets and that it guarantees the involvement of all Member States willing to contribute to these functions, which will indeed be the case.

All Member States agree on the proposed data policy, which is identical for all the options and, in brief, foresees that data on space objects is by definition classified information and it is only disclosed on a case by case basis when required. A data policy based on this guiding principle and involvement of Member States owning existing SST sensors in the governance of the planned European SST service, would in particular meet the security concerns of those Member States where existing assets are under military control. No further trade-offs would be needed to ensure military participation in a European SST service open to both public (civil and military) and private/commercial operators and authorities.

As far as service provision is concerned, all Member States are open to the idea that a front desk function be strongly linked but differentiated from the sensor and processing function and entrusted to an organisation with a record as service provided and suitable credentials in the security domain, such as the European Union Satellite Centre. One particular Member State is strongly in favour of such idea.

As regards the target performance of the system, this issue was put to Member States during the presentation of the study carried out by Booz & Company. It is clear from the discussions that were held in that context and elsewhere that they are rather in favour on building on existing assets and adding the minimum necessary to guarantee an improvement in relation with the current situation. This is confirmed by the developments being suggested in the context of ESA's SSA preparatory programme. Member States are therefore in favour of an improved performance of the order suggested in options 2 to 4.

Ideally, all Member States would like the EU to fund the totality of a European SST service. However, for some Member States, the interest in developing an SST capability is closely linked with the desire to support national industry active in this domain. The EU can not guarantee geo-return and therefore, from some Member States' perspective, there would be a drawback in the options suggesting the EU fully funding European SST service.

Notwithstanding the above, Member States understand budgetary constraints and are aware of the possible difficulties in redeploying the budget necessary to secure full EU funding of the European SST service. In this context, Member States have made clear that, as a minimum, the EU should cover the operations of the sensor, processing and front desk functions necessary to establish a European SST service, and have shown willingness to fund the development additional capacities that could contribute to it.

As concerns other space faring nations, in particular the US signalled openness to strengthened cooperation with other space-faring nations provided that the international partner has the appropriate credentials to ensure the confidentiality of the SST data received.

Taken all of the above into account, while Member States would potentially be open to any the options proposed, their most favoured options are 3 and 4.

6. ANALYSIS OF IMPACTS

The methodology applied for assessing the impacts of the options set out in chapter 5 is based on the following:

- Space activities undertaken by space faring nations are often driven by strategic and security considerations. These considerations are particularly relevant for space surveillance and tracking activities. Furthermore, governance and funding issues can have a strategic impact. Therefore, options will also be assessed in view of their strategic and governance impacts. The strategic impacts section will focus on whether the option provides strategic independence and knowledge, whether it provides significant political "currency" for Europe to be seen as a credible partner which can contribute to international cooperation, whether the options contribute to overcoming fragmentation of efforts.

- The economic impacts section will focus on the industrial return of the options, and to which level the option contributes to reducing risks that have an economic impact.

- As concerns social impacts two aspects will be considered: the creation of jobs and the impact of the threats that can be monitored via an SSA system on citizens' security and health.

- Finally, the assessment of environmental impacts will focus on the proliferation of space debris.

- The problem definition section of this impact assessment report underlined the lack and fragmentation of available information, (case) studies or statistics which made it in many cases difficult to quantify the risks and potential losses linked to the problems identified. It is possible to quantify the minimum economic losses linked the risk of collision which can be estimated on the basis of object that can be tracked today. However it is not possible to quantify risks related to uncontrolled re-entries, which can only be illustrated through anecdotal evidence. Consequently, the assessment of the impacts of the various options will be a mix of qualitative and quantitative impacts.

6.1. Impacts of option 1: baseline scenario

6.1.1. Strategic and governance impact

Under the baseline scenario, the EU would take no action to promote the setting up of operational SST services at European level. This would have no impact on the implementation of the EU flagship programmes Galileo and Copernicus, but their long-term security and sustainable exploitation could be affected.

SST activities in Europe would remain limited and fragmented – apart from some bilateral cooperation (e.g. between France and Germany) which, incidentally, has emerged in the context of the discussion of an EU-led development of a European SST service. In absence of any incentive or European framework, it is quite unlikely that any broader cooperation between Member States with a view to the setting up of a European SST capability would develop. Without EU involvement, there are no grounds to believe that Member States will take the necessary steps to set up of adequate coordination mechanisms and operating structures necessary for SST services.

However, should some form of cooperation emerge including assets owned by Member States other than France and Germany, there is a consensus among SST experts that this will not reduce the current level of collision risk.

European cooperation with the US would remain at current bilateral level. A substantial number of European spacecraft operators as well as civil protection authorities at EU and Member States level may remain dependant solely on the, for now, freely available (but not accurate enough) US SST information in a critical area of their space activities.

6.1.2. Economic impact

The problems identified in section 3 would not be addressed and are likely to aggravate over the coming years. With increasing space activity and increasing space debris, economic losses due to launch failures, satellite loss or damage, and service outages are expected to increase.

Industrial activity in SST in Europe would stay at current limited level. In absence of EU involvement, and in the light of years of political discussion on the development of a European SST service, there is no ground to believe that ESA could undertake the actions that are described under options 2 to 4 and spur some industrial activity in this domain. For the reasons spelled out throughout this impact assessment, this appears rather unlikely to happen.

6.1.3. Social impact

In absence of EU action and the fact that Member States do not seem to be ready to engage in major SST development activities in the framework of ESA, the impact on job creation of this option is negligible.

As operational European SST services (including re-entry warning services) do not exist today and are not likely to be set up without any EU support, Europe would not increase its capacity to survey controlled or uncontrolled re-entries of space debris into the Earth's atmosphere. Re-entry warnings and alerts would continue to be provided in a sporadic and uncoordinated manner. Security threats from uncontrolled re-entries of space debris into the Earth's atmosphere as explained in the problem definition section would not be addressed or mitigated. With increasing space activity, the risks to the security and health of European citizens or the security of critical ground-based infrastructure risks to increase.

6.1.4. Environmental impact

The main environmental benefit of building a European SST capability is related to the outer space environment and the ability to monitor the evolution of debris and debris clouds. As described in more detail in the problem definition, a large proportion of the space debris population (around 95% overall) is currently not catalogued. The population of 'potentially traceable' debris (e.g. 1 cm to 10 in diameter) is estimated using different mathematical models which lead to large differences in results with estimates varying by a factor of 2 to 3. However, all estimates agree on the constant and significant growth of the debris population in the future (in fact each collision between space objects leads to an exponential growth of the debris population[56]) and the need for action to preserve the space environment.

Recent theories concerning the generation of space debris clouds resulting from in-orbit collisions which significantly contribute to the growth of the debris population and which may, in the long-term prevent the scientific and commercial exploitation of "crowded" orbits such as LEO have to some extent been confirmed by the Iridium 33 collision. This collision produced a debris cloud of 1875 catalogued debris, and an undefined number of un-catalogued debris which is likely to be in the order of some thousand.

Recent UN and NASA studies underlined the risk of growth of debris in LEO which would continue to grow even if all launch activities (and thus the further use of space) would stop. Space debris presents particular characteristics in the GEO region which are not yet fully understood (why, for example, there is a tendency of debris concentration close to positions occupied by satellites). These phenomena can be better understood through SST. It is worth noting that the members of the International Telecommunication Union recently agreed to consider GEO as a unique natural resource with an economic value of approximately 70 Billion US$ per year.

International mitigation measures have been approved at UN level. In addition, in 2009 the EU presented a proposal for an international Code of Conduct proposing a set of transparency and confidence-building measures with the aim of preventing the creation of space debris. These measures will have a long-term effect by influencing spacecraft operators' behaviour. However, improved capacity to monitor the debris population is considered the most effective short-term effort to mitigate the risk of space debris creation and thus contribute to preserve space as a natural resource. While under the baseline scenario, the EU would continue to act on long-term measures through its proposal for an international Code of Conduct, it would not make any efforts with a short-term effect to preserve the usability of certain orbits such as LEO. Ultimately this could jeopardise the sustainable provision of public services based on Earth observation satellites which are relevant for the implementation of European and national policies in various policy domains including environment or climate change policies.

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[56] ESA estimates the number of 'potentially traceable' debris to grow to almost 1 million by 2020.

Another aspect to consider is linked to the problem of un-controlled re-entries of space debris which has been analysed in the problem definition. Incidences involving space debris from nuclear powered satellites or satellites with dangerous substances on board (such as hydrazine) can become seriously harmful events for the environment as well as for the health of citizens. An example may illustrate the scale of the problem: In 1978, the nuclear powered Cosmos 954 satellite hit the Canadian soil. Radioactive debris was found over a large territory throughout several Canadian provinces. Cleaning-up operations lasted 8 months at reported costs of around 14 Million US$ at the time (equivalent to 40-50 Million US$ today). While SST systems cannot prevent such incidences, they are the basis for taking mitigating measures based on state of the art early warning services and responding as efficiently as possible to potential (catastrophic) events on the ground.

6.2. Impacts of options 2, 3 and 4

Options 2, 3 and 4 all seek a target reduction of risk collision of a factor of 3 to 5 (as explained in chapter 6.2.2) through a similar architecture, and data policy. They all envisage the same level of funding for the establishment of a European SST service. The difference lies in the split between EU and Member States contributions which implies differences in the governance for option 4 (see summary table 5.6.4).

As impacts are a direct consequence of the performance of the system (i.e. reduction of the risk of collision) and the investment which are the same for the three options, the three options would in principle deliver the same impacts.

However, the options may not be equally likely to materialise. The strengths and weaknesses of the options is analysed under section 7.1.

6.2.1. Strategic impact

Data security policy principles would be identical to all options. A key principle of the data policy applied for the handling of SST data in the proposed organisational framework is to consider all space objects confidential from the outset. Information about space objects detected will only be declassified on a case by case basis and distributed only when it has been identified as a non-sensitive object.

The proposed governance scheme will allow Member States to actively contribute and safeguard their national security interests. Furthermore, Member States would under any of these options be responsible for operating the sensor and processing functions, including the establishment and maintenance of a European catalogue of space objects which will allow them to control the classification/declassification process.

The involvement of the EU in the governance of the European SST service (through an EU entity acting as an SST service front desk), and the fact that the consortium will be open to Member States owning relevant assets and capacities should disperse concerns expressed by those Member States that have no such capacities today (see also pages 23 and 40).

These options would build on existing international cooperation with the US. The US system requires updating and refurbishing to address the increasing need for SST information. As this requires substantial investments, the US signalled openness to stengthen international cooperation in this domain with actors that can actively contribute to improve the quality of SST information. The setting up of a European SST capability would allow the EU to collaborate with the US as an equal partner with a view to mutually enhancing SST performance.

Furthermore, these options would strengthen Europe's independent access to space (an objective of the European space policy and highlighted by Member States in several Council Resolutions) and its capacity to make independent decisions concerning the safety of spacecraft operations. Europe currently strongly relies on information from the US to obtain clearance to launch and gain access to space (e.g. Arianespace confirmed that it is dependant on information from the US to obtain to determine the viability of its launch path with regard to risks of collisions with satellites or space debris[57]).

The EU's financial contribution foreseen in options 2 and 3 would provide a different level of incentive for the Member States consortium to engage in the necessary capital investments related to the setting up of the European SST capability (e.g. investments necessary to create a secured sensor network, to refurbish and modernise existing sensors and develop new ones).

The assumption that Member States are willing to develop such assets is based on bilateral discussions and on the current proposals for the second phase of the ESA SSA preparatory programme 2013-2015, which makes proposals in this direction.

Option 4 suggests that the EU would fund all the costs linked to the European SST service. This would still require the participation of Member States with existing assets, though they would not incur in any of the extra cost of a European SST service.

Any of these options would ensure a truly European SST service which would respond to defined and agreed European SST user requirements and needs and be available to all European public and private/commercial users. However the different options have different strengths and weaknesses and present different risks in terms of effectiveness and efficiency which are compared under sections 7.1 and 7.2 respectively.

6.2.2. Economic impact

The proposed initiative would improve the European SST service's ability to detect hazardous situations and provide more accurate SST information (conjunction assessments and trajectory data) for the launch and in-orbit operation of satellites. It would imply a reduction of the risk of satellite losses and the number of collision avoidance manoeuvres leading to a reduction of economic losses (see problem definition section).

According to ESA expertise one can assume a linear correlation between the increase in tracking capacity and the reduction of risks and potential quantified annual losses (as identified in chapter 3 and summarised in chapter 3.1.5.). The SST capability under these options would target a reduction of collision risk by a factor of 3 to 5 and would therefore lead to a reduction of losses due to collisions by a factor 3 to 5 by 2020[58] implying a possible reduction of the estimated annual losses of 93-112 M€.

As pointed out in the problem definition section, European operators of spacecraft in LEO face around 13 conjunction assessment risks per satellite a year. Leading space agencies in Europe, such as CNES, DLR and ESA, rely on initial data from the US surveillance system to estimate conjunction assessment risks for their own satellites which needs to be complemented with measurements based on their own surveillance assets as the information the US is ready to share without jeopardizing national and military security interests. While the SST capability proposed in the options 2, 3 and 4 would not preclude continued cooperation with the US, which can result in even higher performance through the pooling of

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57 Booz & Company, stakeholder interviews;

58 See also Booz & Company based on stakeholder interviews.

resources, they would significantly improve the ability and quality of European operators to carry out their own complementary risk assessments.

These options would build on existing SST sensors and human expertise and foresee the development of new SST sensors. Using as reference the defence sector from which ground based technology used for SST (e.g. radars) originates, Booz & Company suggests that the development of new sensors foreseen in these options is likely to have a multiplier effect in terms of industrial activity of 2.3. Considering only that the investment in new assets would amount to roughly 50 M€ per annum (which do not take into account ICT for processing and front desk functions), i.e. 350 M€ over the seven year period 2014-2020, the total industrial return can be estimated at 805 M€ which is a rather conservative estimate. Would we apply the multiplier effect usually applied for investments in space programmes (4.8), the industrial return could be estimated at 1680 M€[59]. SMEs in the sector are expected to benefit from this industrial activity as the development of SST sensors often requires niche technologies often produced by SMEs. SME participation does not require specific measures and is not expected to imply specific burdens.

6.2.3. Social impact

Using the Booz & Company study as a reference, the estimated number of permanent staff generated by options 2, 3 or 4 would be around 50. On the basis of their own experience, national and ESA experts consider this a very conservative estimate, but will nevertheless be used here due to the lack of a more precise estimate.

The proposed action will lead to an improvement of Europe's ability to predict and survey re-entries of space debris into the Earth’s atmosphere, and thus help reducing the risks to the security and health of European citizens and the security of terrestrial critical infrastructures. The problem definition section of this report highlighted that on average 1 debris per day hits the Earth (and the trend is rising). While these incidences have so far not led to casualties, debris from inactive satellites or rockets varying between 10 kg to 270 kg can cause severe material damage and should be considered a security and health hazard. Due to lack of any quantitative data and studies on material damage caused by un-controlled re-entries it is unfortunately not possible at this point of time to quantify this positive impact.

6.2.4. Environmental impact

These options would increase Europe's capacity to monitor uncontrolled re-entries of space debris and to put in place a coherent and clear procedure to issue meaningful and timely warnings to national security authorities.

A recent re-entry event may illustrate the improvements that could be achieved through a more coordinated approach to re-entry warnings at European level: In mid-January 2012, the Russian Marsian probe Phobos-Grunt, which encountered a failure during the launch phase, re-entered the Earth's atmosphere in an un-controlled way. For the first time, the US State Department provided the EU with Tracking and Impact Prediction (TIP) Alert Messages. The Crisis Management and Planning Department (CMPD) within the European External Action

[59] 2.3 corresponds to the multiplier effect usually applied to investments made in the defence sector; 4.8 corresponds to the multiplier effect usually applied to investments made in the space sector for programmes with scientific content; the see Booz & Company, page 247 on the basis of Oxford economics, the economic case for investing in the UK defence industry, September 2009 and Danish agency for science and innovation, Evaluation of Danish Industrial Activities in the European Space Agency, March 2008.

Service (EEAS) acting as contact point relayed the information to other EU actors and to Member States' national security authorities via the Council's Political and Security Committee (PSC). The US also alerted ESA. In parallel, the Russian authorities alerted some EU Member States space agencies including the German space agency DLR which relayed the information to other national space agencies. None of the actors involved was informed about others being contacted. As a result, national authorities received partly diverging warnings from different sources through different channels.

6.3. Impacts of option 5: EU-led SST development and exploitation

6.3.1. Strategic impact

In addition to the strategic impacts outlined for the previous options, option 5 could clearly increase the EU's strategic potential to strengthen and intensify cooperation in SST with other space-faring nations (notably the US) through established political channels.

In this option, the EU would have the full control over the setting up of the European SST capability, and that the initiative is open to all EU Member States that wish to participate. It would also ensure that the operational SST services to be set up would correspond to agreed European user requirements and that they are open to all European users.

6.3.2. Economic impact

The EU SST programme proposed in this option implies the development/procurement of new SST assets for the amount of 810 M€. Booz & Company suggests that investments made in the development of ground-based infrastructure as suggested in this option is likely to have a multiplier effect in terms of industrial activity of 2.3. This would result in a direct and indirect industrial turnover between 1.9 billion € and 3.9 M€ depending on the multiplier used (see chapter 6.2.2.).

Applying the same approach to estimate the reduction of economic losses likely to be brought about by option 3, it could be estimated that option 5 could reduce the risks identified in the problem definition by a factor of 10 or above. This would imply a possible reduction of estimated annual losses due to collisions of 126 M€.

6.3.3. Social impact

The EU SST programme foresees the development of a number of new SST assets and the setting up of a new or the extension of existing SST data centres which will require permanent staffing to ensure operations on a 24/7 basis. Based on estimates from Booz & Company, the potential for the creation of permanent jobs in the engineering and data analyst domain would be around 100 new jobs across Europe.

As option 2, 3 and 4, this option would lead to an improvement of Europe's ability to predict re-entries of space debris into the Earth’s atmosphere. Option 5 provides a potential to reduce risks to the security of European citizens and critical terrestrial infrastructure even further.

6.3.4. Environmental impact

As in options 2, 3 and 4, this option would strengthen Europe's capacity to monitor the debris population, avoid collisions, and thus to mitigate the risk of further space debris creation.

According to Booz & Company option 5 would allow the detection of debris up to 3 to 5 cm which are today not catalogued. This would significantly increase Europe's capacity the risk of debris clouds and their long-term proliferation in Low Earth Orbit.

6.3.5. *Overview of impacts*

	Strategic impacts	Economic impacts	Social impacts	Environmental impacts
Option 1: Baseline	SST activities in Europe remain fragmented apart from some bilateral cooperation; no European SST service to emerge in absence of EU action. Cooperation with US remains at current bilateral level; continued high dependency of European operators on US SST information.	Risks related to collisions and uncontrolled re-entries will not be addressed and are likely to increase as space activities increase; increase of economic losses due to launch failures, satellite loss or damage, and service outages expected. Industrial activity in SST in Europe expected to stay at current limited level.	Impact on job creation is negligible. Services for survey of re-entries are not likely to emerge in absence of EU action; alerts and warnings are likely to continue to be issued in a sporadic + uncoordinated manner; risks to security and health of citizens from un-controlled re-entries are expected to increase with increasing space activity;	Europe's capacity to monitor the evolution of space debris and debris clouds would not improve; also its capacity to avoid the creation of new space debris would not increase. Risk related to re-entries that may have serious impacts on environment are likely to increase.
Options 2, 3 and 4	Proposed governance and data policy allows MS to actively contribute in the European SST service and safeguard national security interests. Option 2 and 3 provide incentives for MS to invest in setting up of European SST service and develop new assets. Option 4 also builds on MS contributions, but funding for new assets is ensured by the EU. Setting up of European SST service allows to collaborate with EU as an equal partner with a view to mutually enhance SST performance. Europe's independent access to space would be strengthened (e.g. proper and more accurate information to clear launches).	SST capability under these options targets a collision risk reduction by a factor 3 to 5 by 2020. This suggests a reduction of the losses by the same factor, meaning a reduction of the estimated annual economic losses of 93 to 112 M€. Industrial activity due to development of new assets (350 M€ in 2014-2020) is expected to have a multiplier effect of at least 2.3 leading to a total industrial turnover of 805 M€.	Creation of around 50 jobs in Europe estimated; Europe's ability to predict and survey re-entries would be improved and reduce the risks to the security and health of citizens and the security of critical terrestrial infrastructure (increase and positive impact not quantifiable).	Options increase Europe's capacity to detect debris not catalogued today, monitor the evolution of space debris and predict un-controlled re-entries. Setting up of European SST service allows putting in place a coherent procedure for re-entry warnings and alerts for public authorities, thus increasing the effectiveness of re-entry warning and alert services.
Option 5	Governance: EU has full control over the setting up of the European SST service. Option 5 would further strengthen Europe's potential to strengthen cooperation with other space-faring nations on SST (notably US).	SST capability under this option targets a collision risk reduction by a factor 10. This implies a reduction of estimated economic annual losses of 126 M€. Industrial activity of 810 M€ during 2014-2020 can be expected to lead to total industrial turnover of at least 1900 M€.	Creation of around 100 new jobs in Europe expected. Europe's ability to predict and survey re-entries would be improved further than in options 2, 3 and 4 and further reduce the risk to the security and health of citizens and the security of critical terrestrial infrastructure (increase and positive impact not quantifiable).	As in option 2, 3 and 4, this option would further increase Europe's capacity to monitor the evolution of space debris and predict un-controlled re-entries. SST service would allow detecting debris up to 3-5 cm (today not catalogued).

7. COMPARING THE OPTIONS AND CONCLUSIONS

7.1. Summary of strengths and weaknesses of the options

	Strengths	Weakness
Option 1: Baseline	A limited service is provided by the US at no cost. Public funds may be diverted to other priorities.	The risk of collision remains and will get worse. EU unable to protect critical space infrastructure. Negative strategic, economic, social and environmental impacts. It does not meet either Member States or industry expectations.
Option 2	A collision risk reduction of 3 to 5 is targeted. Positive strategic, economic, social and environmental impacts. Several Member States have given indications of their willingness to develop additional SST assets in the framework of an EU-led SST initiative. This option comforts Member States' perception that developing their own assets guarantees that their investment benefits national industry.	This option requires significant funding from both the EU and from Member States willing to develop new assets. Although there is evidence that some Member States are indeed supportive of this idea and willing to develop new assets, the EU does not have full control over the funding required to set up a European SST service. The EU investment does not cover an important part of the costs directly linked with the setting up of a European SST; i.e. the operations of the sensor and processing function. It does not meet Member States' expectations that as a minimum the EU would cover the operational costs of the European SST service and therefore may not provide sufficient incentive for Member States to invest.
Option 3	As in option 2, a collision risk reduction of 3 to 5 is targeted. Positive strategic, economic, social and environmental impacts. Several Member States have given indications of their willingness to develop additional SST assets in the framework of an EU-led SST initiative. This option comforts Member States' perception that developing their own assets guarantees that their investment benefits national industry. This option meets Member States expectations that as a minimum the EU would cover the operational costs of the European SST service.	As in option 2, this option requires significant funding from both the EU and from Member States willing to develop new assets. Although there is evidence that some Member States are indeed supportive of this idea and willing to develop new assets, the EU does not have full control over the funding required to set up a European SST service.

Option 4	A collision risk reduction of 3 to 5 is targeted. Positive strategic, economic, social and environmental impacts. It gives the EU practically full control over the funding required to set up a European SST service. Some Member States would welcome higher funding from the EU as this guarantees the setting up of an EU SST service and would give tem the choice of either invest further in SST or in other space projects.	As sole contributor, the EU has a higher responsibility for the overall system and in particular it has to supervise the acquisition of new assets. As the EU funding for SST is to be redeployed from other sources, the amount required under this option would impose a non-negligible burden on those sources.
Option 5	A collision risk reduction of 10 is targeted. This option provides the most positive strategic, economic, social and environmental impacts. It gives the EU practically full control over the funding required to set up a European SST service. Some Member States would welcome higher funding from the EU as this guarantees the setting up of an EU SST service and would give tem the choice of either invest further in SST or in other space projects.	As sole contributor, the EU has a higher responsibility for the overall system and in particular it has to supervise the acquisition of new assets. As the EU funding for SST is to be redeployed from other sources, the amount required under this option can only be made available through very significant cuts in other programmes and would require very difficult trade offs.

7.2. Comparison in terms of effectiveness, efficiency and coherence with agreed policies

The table below provides an overview of the various options in terms of their effectiveness, their efficiency and their coherence with agreed policy objectives expresses in Council conclusions or other policy documents:

Options	Effectiveness	Efficiency	Coherence
Option 1	Baseline scenario: would not achieve specific objectives of this action.	No resources needed; no improvement of the current problem situation;	This option is not consistent with Member States political will expressed in several Council conclusions which ask the EU to take an active role in the setting up of an operational SSA capability at European level. It is also not consistent with the objectives of the European space policy.
Option 2	This option could achieve the specific objectives. It would allow diminishing risks related to the loss of satellites as well as domino effects due to spacecraft destruction. The option would bring about important strategic, economic,	Option 2 involves minimum EU expenditure of 2 M€ and Member States would contribute 50 M€. From a purely EU budgetary perspective could be the most efficient. Member States expectations is	This option would meet the objectives set in past Council conclusions and the European space policy. It is also coherent with the EU2020 strategy. SSA does represent certain potential for

	social and environmental benefits resulting from reducing the risk of disruption of satellite based services, and better control of spacecraft re-entries. However it may not provide a sufficient incentive for Member States to invest in additional assets and the target collision risk reduction may not be achieved.	that, as a minimum, EU funding covers all the operation costs linked of the European SST service, which is not the case under this option. This may discourage Member States to invest in new assets. Discussions over this issue may result in inefficiencies and in the European SST not being implemented. The EU would not be involved in the development of SST infrastructure, it would not be responsible or own SST assets, and would not be involved in operational activities.	innovation and growth. Its main purpose is the protection of space infrastructure that represents the basis for downstream services that may generate innovation and growth as well as to reduce risks to the security of European citizens and critical terrestrial infrastructure to the extent possible.
Option 3	This option could achieve the specific objectives in the manner described in option 2. Unlike option 2 it does provides a solid incentive for Member States to invest in additional assets necessary to reach the target collision risk reduction.	Option 3 entails an estimated expenditure of 10 M€ per year on average for a system whose total cost would be 50 M€. From an EU budgetary perspective is an efficient option. This option meets Member States expectations that, as a minimum, EU funding covers all the operation costs linked of the European SST service. It offers a strong incentive for the European SST service to be set up. As in option 2, the EU would not be involved in the development of SST infrastructure, it would not be responsible or own SST assets and would not be involved in operational activities.	Same as option 2.
Option 4	European SST would be fully funded by the EU and does not depend on MS funding. The EU would, in principle, guarantee that the specific objectives – as described in option 2 - are achieved. As SST is to be funded through redeployment of existing funding instruments, finding 60 M€ represents a much higher burden than the amounts under options 2 or 3. This is a significant risk for the effectiveness of this option.	Option 4 entails annual EU funding of 60 M€. From an EU budgetary perspective is less efficient than either options 2 or 3. However, under this option success does not depend on MS contribution. Under this option new assets would be fully funded by the EU, which implies that the EU would be the owner of such assets. In addition, as the sole contributor and even if most of the tasks are externalised, the EU would bear a higher responsibility for the system than in options 2 and 3, where the responsibility would be largely shared with MS. This imposes a burden on the EU which renders this option less efficient than options 2 and 3.	Same as option 2.

Option 5	This option guarantees, in principle achieving all the objectives. In addition it would allow the setting up of a European SST service whose performance would be better than that under options 2, 3 and 4 leading to higher risk reduction, and more significant economic and social impacts. However the problem related to redeployment would be aggravated under this option as the amount required would be 120 M€. This would be a risk for the effectiveness of this option.	Option 5 entails annual EU funding of 120 M€. From an EU budgetary perspective is less efficient than any of the other options. However, as in option 4, under this option success does not depend on MS contribution. The same issues related to ownership of assets and higher responsibility identified under option 4 arise under option 5 and would be aggravated by the larger investment required. However, under option 4 this drawback would be compensated by the gains in terms of reduction of economic loss as well as positive economic and social impacts.	The coherence with European Space Policy and the Europe 2020 agenda is guaranteed as in the previous options. Under option 5 the impacts in terms of industrial return and job creations are higher than in the other options given the higher investment involved.

While option 2 would be the most efficient in view of the EU financial involvement required, there is a risk that it may not lead to the envisaged performance of the European SST service and, as a result, to a reduced effectiveness of the proposed initiative. A relatively modest increase of EU financial involvement (compared to other EU space programmes) as suggested in option 3 would provide a far better basis to achieve the objectives set and reach the targeted collision risk reduction. Option 5 would be the most effective one in terms of the reduction of collision risks. However, it lacks efficiency as it would not make use of existing Member States assets and capacities, and may be difficult to implement in the short-term. Therefore, option 3 has been identified as the preferred option in terms of effectiveness, efficiency and coherence with Member States political will and other EU policies.

8. MONITORING AND EVALUATION

8.1. Evaluation

The proposed action to be taken by the EU will have to be defined through a legal proposal. In accordance with provisions made therein, ongoing evaluation of the implementation of the proposed initiatives and the achievement of objectives set will be undertaken by:

– A Board which will oversee and advise on the implementation and operation of the functional elements of the European SST capability to be set up. The Board shall be composed of the Member States constituting the consortium to operate the sensor and processing segments of the SST capability, the Commission and other EU actors concerned, the entity representing the EU front desk responsible for the SST service segment.

– The Commission through regular meetings with the SST user communities;

A mid-term and ex-post evaluation will be carried out on the basis of the above indicators

– The impact of the proposed initiative could be measured on the basis of the widespread use of the SST services through European and national users; the actual reduction of loss of satellites and unnecessary collision avoidance manoeuvres, the increased efficiency of collision avoidance manoeuvres or re-entry early warnings. The evaluation of these impacts would mainly be based on feedback provided by the SST user communities.

8.2. Monitoring

The Commission will ensure that grant agreements or contracts under the framework of the proposed initiative provide for supervision and financial control by the Commission, if necessary by means of on-the-spot checks, sample checks, and audits by the Court of Auditors On the basis of the results of the on-the-spot checks, the Commission will ensure that, if necessary, the scale or the conditions for allocation of the funding contribution originally approved as well as the timetable for payments are adjusted.

In addition to the financial supervision, the Commission will put in place mechanisms to ensure the continuous quality of the SST services provided. This will be realised by measuring users' satisfaction on one side and by technical audits on the other side. Finally, as stated above, the Commission will organise regular meetings with user communities to ensure that services respond to user needs.

Indicators to monitor the achievement of the objectives could be:

Objectives	**Indicators**
General objective:	
Safeguard the long-term availability and security of European and national space infrastructures and services essential for the smooth running of Europe's economies and societies and for European citizens' security	• Absence of collision • No disruption of satellite or launch operations due to difficulties in risk analysis
Specific objectives:	
• Reduce the risks related to the launch of European spacecrafts; • Assess and reduce the risks to in-orbit operations of European spacecrafts in terms of collisions, and to enable spacecraft operators to more efficiently plan and carry out mitigation measures (e.g. more accurate collision avoidance manoeuvres; avoidance of unnecessary manoeuvres which are risky in itself and reduce a satellite's lifetime); • Survey uncontrolled re-entries of spacecraft or their debris into the Earth's atmosphere and provide more accurate and efficient early warnings to national security and civil protection/disaster management administrations with the aim to reduce the potential risks to the security of European citizens and mitigate potential damage to critical terrestrial infrastructure.	• No disruption of launches due to uncertainty of collision risk. • Existence of necessary and properly operational sensor and processing capacity to asses and reduce collision risks. • Positive feedback from operators regarding mitigation measures collected through regular surveys. • Established and properly operating sensor and processing capacity to monitor re-entries. • Existence of a fully operational service and establishment of an agreed procedure to provide early warnings to civil protection and disaster management authorities.
Operational objectives:	
• The setting up of an operational space surveillance and tracking capability at European level building	• All relevant existing national assets and future assets are effectively integrated within the

on existing European and national assets and capable of integrating future new assets as well as the implementation of an appropriate governance structure; • The definition and implementation of data policy principles for the handling of SST information through the European SST capability; • The definition and delivery of SST services open to all European and national public and private/commercial actors who need SST information; the services should respond to defined and agreed user requirements. • Ensuring the necessary quality of SST services and their efficient and sustainable operational provision: • Supervising the implementation and efficient functioning of the proposed operational SST capability and the operational SST services and by ensuring a sustainable EU funding contribution.	governance structure. • Data policy is actually defined and effectively implemented within the three functions of the European SST service. • All services are formally defined. The SST front desk function is set up, manned and operational according to defined requirements. • Definition of quality standards. Mechanisms are established to collect feedback from operators on the quality of the SST service. Positive feedback received from operators. • Effective supervision mechanisms are in place with clear tasks, timetables and milestones

8.3. Anti-fraud measures

The setting up of the operational SST capability and SST services will take place through the Commission's partners: The consortium of Member States owning relevant SST assets which will be responsible for setting up and operating the SST sensor network and the SST information processing segment as well as the EU entity that will act as the EU front desk and be responsible for the provision of the SST services (possibly the EU satellite centre provided that it is given a mandate by the EU Member States).

EU funding is proposed to be provided through grant agreements which will allow for appropriate financial control through the Commission. The proposed EU initiative to set up and operate European SST services, stipulates that the Commission will ensure that, when actions financed under this initiative are implemented, financial interests are protected by the application of preventive measures against fraud, corruption and any other illegal activities, by means of effective checks and by the recovery of amounts unduly paid and, if irregularities are detected, by effective, proportional and dissuasive penalties.

ANNEX I: GLOSSARY

CNES, Centre National d'Etudes Spatiales:

The French Space Agency

ESA, European Space Agency

Inter-governmental organisation established in 1975 to provide for and to promote, for exclusively peaceful purposes, co-operation among European States in space research and technology and their space applications. Today, 18 European Countries are ESA Member States: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

GMES, Global Monitoring for Environment and Security (now called Copernicus)

European initiative for the implementation of information services dealing with environment and security. Copernicus is based on observation data received from Earth Observation satellites and ground based information. These data are coordinated, analysed and prepared for end-users. It develops a set of services for European citizens helping to improve their quality of life regarding environment and security. Copernicus plays a strategic role in supporting major EU policies by its services.

Launchers

Rocket-based systems that deliver payloads (satellites, manned vehicles, etc.) into space. They can be heavy, medium and small, according to the relative weight of payloads that a particular launcher can carry into space.

LEO, Low Earth Orbit

Generally considered to be an orbit at an altitude of 400 to 1000 km.

Meteor

Brief streak of light seen in the night sky when a speck of dust burns up as it enters the upper atmosphere. Also known as a shooting star or falling star.

Meteorite

A fragment of rock that survives its fall to Earth from space. Usually named after the place where it fell.

Meteoroid

A piece of rock or dust in space with the potential to enter Earth's atmosphere and become a meteor or meteorite.

NEO, Near Earth Objects

Asteroids or comets whose orbit brings them into close proximity with the Earth (less than 1.3 astronomical unit a unit defined by the Earth – Sun distance).

Payload

Equipment carried by a spacecraft. A product becomes a payload once it is intended to fly on board a spacecraft.

Satellite

A man-made object (such as a spacecraft) placed in orbit around the Earth, another planet or the Sun.

Soyuz Launcher

A launcher system developed by the Soviet Union, also used as a medium-lift launcher for Europe.

Spacecraft

Artificial satellite. Term often used before a satellite is placed in orbit around the Earth, when it is transporting something or when it is being sent into deep space.

Space weather

The changing conditions in interplanetary space caused by fluctuations in the solar wind.

SSA, Space Situational Awareness

Comprehensive knowledge, understanding and maintained awareness of the population of space objects (spacecraft such as satellites or space debris), of the space environment, and of the existing threats/risks to space operations. SSA systems rely on ground or space based tracking and monitoring sensors.

The Space Situational Awareness (SSA) Preparatory Programme is a new initiative of ESA, accepted at the November 2008 Ministerial Conference in The Hague. SSA includes activities in three main domains: space surveillance, space weather and Near Earth Objects (NEOs).

ANNEX II: STAKEHOLDER CONSULTATIONS AND RESULTS

(1) List of stakeholders consultations

(a) Bilateral meetings held in 2009 by DG ENTR with MS actively involved in the space sector: Germany, France, UK, Spain, Italy; industry association;

(b) Interviews of relevant stakeholders, conducted by Ecorys in the context of the "Study on the EU Space Programme 2014-2020" (December 2009-January 2010);

(c) Eurobarometer survey on the space activities of the European Union conducted by Gallup in July 2009;

(d) Contributions and speeches of the conference "Space policy: a powerful ambition for the EU", Brussels, 15-16 October 2009;

(e) Stakeholder consultation in the framework of the "Study on the EU Space Programme 2014-2020" carried out by Ecorys in cooperation with TNO on behalf of the European Commission; final report of 4 July 2010;

(f) Events under Spanish EU Presidency:

(g) Workshop on Space and Security, 10-11 March 2010, Madrid, Spain;

(h) Conference on governance of European Space programmes, 3-4 May 2010 Segovia, Spain;

(i) ESA contribution to the definition of future EU space activities;

(j) Public consultation via the Commission's Interactive Policy Making (IPM) tool from 3 January to 15 March 2011;

(k) Stakeholder consultation in the framework of the study on "Evaluation of options for a space programme in 2014-2020" carried out by Booz & Company on behalf of the European Commission; final report of 16 May 2011;

(l) Seminar on Space Situational Awareness (SSA) under the Polish EU Presidency on 29 September 2011 in Warsaw;

(2) Conclusions Conference on Space and Security, Madrid 10-11 March 2011

The Workshop emphasised the relevance of space to security users as a tool with the potential to address specific needs, in particular that of timely response. Being one tool of many, space can provide the most added-value when seamlessly integrated with others. To achieve this, effective integration of space technologies such as Earth observation (and especially GMES), satellite communication and navigation (Galileo with its PRS) will be required. In parallel, the way the space systems interact and network with ground based and airborne platforms needs to be further looked into.

Services of the EU Council and the European Commission, the European Defence Agency (EDA) and the European Space Agency (ESA) have been working together on the identification of security related user requirements under the umbrella of the Structured Dialogue on Space and Security. The new Crisis Management and Planning Directorate of the Council offers the potential for genuine synergies between civilian and military effort, and will continue to contribute to the ongoing developments in space and security. The expertise of the EUSC in analyzing EO data and disseminating geospatial products for security applications should be taken in due account in the implementation of GMES security services.

Concerning the security dimension of GMES, workshop participants recognised the progress made to date. Recommendations have been made on how GMES should support EU border surveillance (in particular EUROSUR), while work on the identification of user requirements for GMES to support EU External Action has begun. GMES security services to be developed on the basis of these requirements will complement the support provided by GMES to Emergency Response.

The complexity of integrating both civil and military requirements has been illustrated by the cooperation on Space Situational Awareness (SSA), which is the first European space initiative to consider dual use dimensions from the outset. ESA, in the framework of its SSA preparatory programme, has been mandated to gather civilian SSA user requirements and design the technical architecture of what could become a European capacity. The European Defence Agency is currently drafting military requirements for SSA. The EU Council and European Commission, together with potential SSA contributors, will have to define the governance model and the related data policy for an operational European SSA system. The EUSC data model could be considered in this context.

Discussions on effective synergies and the governance of GMES and SSA highlighted the importance of national assets as essential components of any European Space system responding to security objectives. These national assets could be complemented by European capabilities when needed, while avoiding unnecessary duplication. As an example, Spain presented its National Earth Observation Satellite Programme consisting of an optical and a radar satellite (PAZ) that will be operated together and have been designed to serve the needs of security and non-security users both at national and international level in the context of GMES and other cooperation programmes.

The European Space Policy highlights the need for the European Union, ESA and their Member States to increase synergies between their security and defence space activities and programmes. The Structured Dialogue has started this process. The Workshop highlighted the need to increase and expand this coordination. It also suggested the setting up of an appropriate coordination platform with Member States owning relevant assets.

These issues should be further explored during a dedicated follow-up seminar planned for summer 2010 with a view to provide input for a discussion at ministerial level in an appropriate setting.

(3) Conclusions Conference on Governance of European Space Programmes, Segovia, Spain, 3-4 May 2010

Europe needs space. It needs strategic space capabilities and efficient space-based services to ensure the wellbeing of our citizens and as a tool to support public policies. It needs to exploit these capabilities and services to their maximum potential.

Europe needs a range of activities and organisations to meet its wide range of objectives for space. How these interact in the short- and longer-term will be the key determinant of Europe's continuing success in space.

The Conference has recognised that the entry into force of the Lisbon Treaty presents an opportunity to further develop the institutional framework for Space activities in Europe. The Treaty on the Functioning of the European Union (TFEU) provides a legal basis and an explicit competence in Space for the EU. This competence, which is shared with the Member States, calls upon the EU "to coordinate the effort needed for the exploitation and exploration of space" and to "establish any appropriate relations with the European Space Agency". It then consolidates the triangle of European space actors i.e. the EU, ESA and their respective Member States.

Governance arrangements are a tool to deliver objectives. Clarity of vision and objectives must come first.

The current institutional set-up for the European Space Policy – the EC/ESA Framework Agreement which entered into force in 2004 – has provided a solid foundation for coordinating and aligning the space activities of the EU and ESA. This arrangement works well but may have to evolve at the end of the current analysis, in view of Art. 189 TFEU and in order to expand the opportunities for Space in Europe.

The Conference recognised that the existing institutional asymmetries between the two organisations (supranational v. intergovernmental) pose a number of challenges which will have to be addressed. Along with the growing EU role in space, Member States also value intergovernmental ways of working within ESA as a research and development agency. Efficient collaboration will require adaptation, including possibly through continued institutional convergence between the EU and ESA. ESA, its Member States and the EU have to explore the different scenarios for the evolution of this collaboration.

Industrial policy and technology policy are inextricably linked. The Conference recognised the importance of a coherent framework for Space Industrial policy in Europe. The peculiarities of the space sector call for a combination of measures at EU, ESA and Member States level in order to create the right environment that will nurture a competitive industry and ensure a fair and balanced participation of all industrial actors, including in particular SMEs. These measures must and will continue to evolve.

The Conference identified procurement as the major but not the only instrument driving industrial policy. Other instruments should continue to be promoted. At the EU level, examples include instruments such as FP7, CIP and structural funds, as well as EIB loans and EIF guarantees. While taking full advantage of the existing EU, ESA and Member States industrial policy instruments, other instruments could be designed as incentives for the European space industry to maintain and improve its competitiveness and develop technologies, applications and services which are innovative, sustainable, reliable, cost-effective and efficiently respond to growing societal needs in Europe.

The Conference widely recognized the technical expertise of ESA in designing and procuring European Space Programmes. Despite difficulties, the first EU flagship projects in Space, GMES and Galileo, are moving closer to fruition. Future industrial policy should allow for the development of mechanisms to enable EU-ESA cooperation in Space. Past experiences, in these programmes and also in ESA-EUMETSAT programmes, provide valuable lessons in the governance of future endeavours.

In future programmes, governance arrangements will have to be put in place from the beginning, which should guarantee the efficiency of public investments in Space, the long-term sustainability of the programmes and their optimum utilisation as well as ensuring motivation of Member States to continue their volunteer investments in space. Continuity between the research and development and exploitation phases will have to be ensured. While it will be impossible to find 'one-size-fit-all' solution for all the programmes that could be conceived in the future, a degree of coherence will be necessary.

The EU identity in security and defence matters has been reinforced. Security and defence policy is in an evolutionary period. The EU has a competence in foreign and security policy, including the progressive framing of a common defence policy, in conformity with the TEU. Space actions may serve foreign and security (including defence) policy goals.

Governance of space activities related to security and defence needs will have to reflect that evolution.

(4) Polish EU Presidency seminar on Space Situational Awareness Warsaw 29 September 2011 – Summary of Presidency conclusions presented at the meeting

- Seminar participants reiterated the need to ensure the protection of European space infrastructure against hazards from space debris and space weather phenomena. They also underlined the need for Europe to develop proper capabilities to ensure such protection, notably the development of an SSA capability at European level to provide more reliable information to European satellite operators.

- Recognising the dual-use nature of SSA and taking into account its particular security dimension, Member States reiterated that a future SSA capability at European level should make the widest possible use of existing national and European assets, capacities and expertise, and ensure a balanced involvement and development of SSA competences and capacities in Europe (important point for PO Presidency).

- Member States underlined that the definition of an SSA data policy scheme as well as an SSA governance scheme are a pre-condition for their willingness to engage in the development of an SSA capability at European level, in particular for those Member States owning national assets which could form part of a European SSA capability.

- In that context, Member States welcomed the work done so far by the European Commission and the EU External Action Service (EEAS) in collaboration with ESA, EDA, and Member States to define aggregated civil-military SSA user requirements to be endorsed by Member States through the EU Council's Political and Security Committee (PSC) as the basis for future discussions on SSA governance.

- They welcomed the intention to involve the national security agencies – assembled in the EU Council's Security Committee (CSC) – in the definition of the SSA data policy scheme, in particular by seeking their advice on data security aspects. Data security aspects need to be taken into account in all stages of the development of a European SSA capability, as well as in all preparatory activities such as the data policy schemes to be developed for the exploitation of the breadboard radars and pre-operational SSA services to be developed in the framework of the ESA SSA preparatory programme.

- With regard to the forthcoming ESA Ministerial Council, Member States called on the EU and ESA to exploit synergies and ensure complementarity in the planning and implementation of current and future SSA related activities.

- Member States urged the European Commission and the EEAS to swiftly advance with the work on defining an SSA governance scheme and an SSA data policy scheme with the aim to come forward with first concrete proposals in view of a decision to be made on an ESA SSA follow-on programme at the ESA Ministerial scheduled for end of 2012.

- International cooperation in SSA is essential to ensure the reliability and improve the completeness/quality of SSA information available to satellite and space system operators, and ultimately to strengthen the protection of space infrastructure. Member States welcomed discussions launched with the US - by ESA at technical level and by the EEAS and the European Commission at political level - to explore areas for cooperation in SSA including the sharing of SSA service products, the sharing of SSA observation data in medium term, as well as the potential inter-operability of systems and the sharing of real-time data and products as a potential long-term objective. These discussions should be reinforced and extended to address issues related to data protection and security needs as compatibility in these domains will be essential for future cooperation.

ANNEX III: OVERVIEW OF EXISTING SSA/SST CAPABILITIES

(5) European assets

Activities in the area of Space Situational Awareness (SSA) are being conducted both at European and national level. A number of Member States have developed SSA capabilities, many of which – in particularly tracking and satellite imaging facilities – are owned and operated by national defence agencies. In Europe, such facilities are available in France, Germany, Norway and the UK, the latter two being part of the US anti missile defence network. Some facilities are also operated by space agencies, e.g. optical telescopes for surveying the Geostationary orbit (GEO). An overview of existing space surveillance assets in Europe prepared by ONERA[60] in 2007 on behalf of ESA[61] found that more than 65 % of existing sensors for the Low-Earth orbit (LEO) area are partially or fully operated by ministries of defence-related institutions.

Existing radar capabilities such as the GRAVES system or the Armor radar in France (see description below) are owned and operated by the Air Force. Operational since December 2005, the GRAVES radar produces surveillance and tracking data used for cataloguing space objects in the framework of a dominant military interest. More specific radars such as Armor (under the responsibility of the French Navy) have direct military uses and may contribute to the surveillance, tracking and characterisation of space objects. In Germany, the main radar equipment FGAN-TIRA is run by research teams from the High Frequency Physics and radar Techniques (FHR)[62], with a special partnership with the German Ministry of Defence, a dominant user of the radar capability for space imagery. The list attached at the end provides an overview of the main European space surveillance and tracking resources.

Since January 1, 2009 ESA has been implementing a preparatory SSA Programme as an optional programme with 13 participating Member States at present (Austria, Belgium, Finland, France, Germany, Greece, Italy, Luxembourg, Norway, Portugal, Spain, Switzerland, the UK). The programme, which is running since 2008 and for which the next phase should be approved in November 2012, should lay the groundwork of a future European SSA system. Its primary focus has been mainly on the definition of user requirements, a series of studies to design system requirements and architecture options, the development of demonstrator sensors (notably 2 demonstrator tracking radars), and preparatory work towards pre-cursor services in the domains of surveillance and tracking, space weather and NEO monitoring.

(6) The US Space Surveillance Network

The US Department of Defence established a space surveillance network as early as 1957. The system was built up progressively by networking different observation capabilities, some of which were initially developed for ballistic missile detection. Access to this database has subsequently been made available to any (registered) user. Today, the US Space Surveillance Network (SSN) represents the reference for all space surveillance information across the world. ESA, EU and ESA Member States authorities and space agencies acting as operators of space systems as well as European commercial operators today rely to a large extent on the US SSN.

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60 Office national d'études et recherches aérospatiales.
61 Study on capability gaps concerning Space Situational Awareness, ONERA, 2007.
62 Under the auspices of the Research Establishment for Applied Science – FGAN.

However, the US system has some aging capabilities and faces new challenges with the increasing orbital population. The US, while planning investments for the modernization of its capabilities, recognises today the need to widen international cooperation and in the different fields covered by SSA, and looks at earmarking potential domains for increased trans-Atlantic cooperation on SSA, in support of common civil, commercial and military requirements. The new US national space policy adopted on 28.06.2010 makes specific reference to the need for international measures to promote safe and responsible operations in space through improved information collection and sharing for space object collision avoidance.

(7) Other space surveillance activities

The Russian federation, via the Russian military space forces, operates space surveillance capabilities independent of its ballistic missile early warning (BMEW) assets. These systems have performed various military and civil roles, including the analysis of the surface impact point of the Mir Space Station and identification of space debris[63]. Russian companies are in a position to offer or sell space surveillance data to external entities.

China, since joining the Inter-Agency Debris Committee (IADC) in 1995, also maintains its own catalogue of space objects. Space surveillance is an area of growth for China with reported investments in phased-array radar technology and optical telescopes for debris monitoring since 2003. In 2005, the Chinese Academy of Sciences established a Space Object and Debris Monitoring and Research Center at Purple Mountain Observatory that employs researchers to develop a debris warning system for China's space assets.

(8) International cooperation

For SSA international cooperation plays a very important role. Today international cooperation efforts in the area of space surveillance for debris monitoring and awareness are largely dominated by the existence of the US space surveillance network. This system makes non-sensitive information freely available over the internet (a subset of the US space surveillance catalogue of orbiting objects.) There is also bilateral cooperation between the US and some European states, between US agencies (NASA, NOAA) and ESA, as well as *ad hoc* cooperation with commercial and national satellite operators in case the US system detects a collision threat.

There is today a growing awareness of the desirability of enhanced cooperation between the US system and a future autonomous European SSA system. Both sides have expressed willingness to take the existing cooperation further during recent high-level meetings, including, for instance, a EU-US space dialogue held in April 2010 in Washington, DC.

To facilitate such cooperation, the EU is already making funding available through the FP7 Space Theme: e.g. a number of projects have been selected in 2010 which include US partners (as well as partners from the Ukraine, South Africa and India). These projects address, among others, space surveillance and anti-collision issues.

At the level of space agencies, cooperation takes place in the context of the Inter-Agency Space Debris Co-ordination Committee established in 1993. IADC comprises 12 national major space agencies including NASA, Roscosmos, Jaxa, ESA and some of the European

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[63] http://geimint.blogspot.com/2008/06/soviet-russian-space-surveillance.html

space agencies (CNES, UK Space Agency, ASI, and DLR). Its primary purposes are to exchange information on space debris research activities between member space agencies, to facilitate opportunities for cooperation in space debris research, to review the progress of ongoing cooperative activities, and to identify debris mitigation options. In 2002, the IADC adopted a set of recommendations for debris mitigation, which has achieved wide international recognition (*Space Debris Mitigation Guidelines, IADC, 2002*). The UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS) developed these recommendations into a set of guidelines, which were adopted by the UN in 2008. These guidelines for good conduct in space are voluntary and non-binding. At technical and commercial level, the recommendations are translated into international engineering standards, such as International Organisation for Standardisation (ISO) or European Cooperation for Space Standardisation (ESS).

(9) Examples of existing European capabilities for space surveillance and tracking

Optical sensors[64]:

Tenerife: ESA operates a space debris telescope on Tenerife that covers a sector of 120° of the GEO ring. From single observations, initial orbits can be derived which are generally adequate for re-acquisition of the object within the same night, and which can then be successively improved. The Optical Ground Station (OGS), installed in the Teide observatory 2400 m above the sea level, was built as part of ESA long-term efforts for research in the field of inter-satellite optical communications. The original purpose of the station, equipped with a telescope (1m aperture), is to perform the in-orbit test of laser telecommunications terminals on board of satellites in Low Earth Orbit and Geostationary Orbit. Since 2001, the ESA survey of Space Debris in the Geostationary Orbit and the Geostationary Transfer Orbit is also being carried out with a devoted wide field camera to determine the orbital parameters of debris objects. The Optical Ground Station was inaugurated in 1995. The Instituto de Astrofísica de Canarias participated in the integration of the station instruments and has since then been in charge of the station operation. This is the contribution of ESA to the worldwide common efforts on this task with NASA and NASDA (National Aerospace and Defence Agency of Japan).

TAROT: CNES uses observation time of the TAROT telescope (Télescope à Action Rapide pour les Objets Transitoires) in France to survey the GEO ring. TAROT's primary mission is to detect the optical afterglow of gamma-ray bursts. A companion telescope, TAROT-S has been deployed in Chile. Since 2004, CNES observes satellites in the geostationary orbit with this network of robotic ground based fully automated telescopes. The system makes real time processing and its wide field of view is useful for detection, systematic survey and tracking both catalogued and uncatalogued objects.

Starbrook: The then British National Space Centre (now UK Space Agency) has sponsored the Starbrook wide-field telescope as an experimental survey sensor since 2006. The telescope is located at Troodos/Cyprus, It can detect GEO objects down to 1.5 m sizes (visual magnitude of +14).

64 Optical telescopes suitable for observation of the Geostationary (GEO) ring at 36000 km altitude and (Medium Earth Orbit) MEO at 23000 km where Galileo satellites will be placed.

ZIMLAT/ZimSMART: The Astronomical Institute of the University of Bern (AIUB) operates a ZIMLAT telescope. From its location in Zimmerwald/Switzerland, the telescope covers a sector of 100° of the GEO ring. The primary applications of ZIMLAT are astrometry and laser ranging. However, up to 40% of its night-time observations are used for follow-ups of GEO objects discovered by the ESA telescope at Tenerife. ZIMLAT was complemented in 2006 by the 20 cm ZimSMART telescope (Zimmerwald Small Aperture Robotic Telescope).

SPOC and ROSACE: SPOC (Système Probatoire d'Observation du Ciel) is part of the French DGA network of target tracking systems. The ROSACE and TAROT telescopes are used by CNES for observation of GEO objects > 50 cm. TAROT detects the objects, ROSACE determines their orbit.

PIMS: The PIMS telescope (Passive Imaging Metric Sensor) is owned by the UK Ministry of Defence. They monitor objects in GEO > 1m. They are stationed in Gibraltar, Cyprus and Herstmonceux (East Sussex, UK).

Radar sensors[65]:

Fylingdales: A most powerful space surveillance sensor located in Fylingdales (UK) and operated by the British/US armed forces. Most of the activities are geared to the US Space Surveillance Network (SSN) early warning and space surveillance mission.

Globus II: A second facility associated with the US SSN is the Norwegian Globus II radar. It is located in Vardø, at the northernmost tip of Norway. Due to special bilateral agreements between the US SSN and the operators of Fylingdales and Globus II, data from these sites have so far not been available for unclassified use within Europe.

GRAVES: The French GRAVES system (Grand Réseau Adapté à la Veille Spatiale) is presently the only European installation outside the US SSN that can perform space surveillance in the classical sense. GRAVES is owned by the French Ministry of Defence and operated by the French air force. GRAVES started operational tests in 2001. Routine operations started in 2005. The system produces a 'self-starting' catalogue which can be autonomously built up and maintained. It is limited to objects of typically 1 m size and larger in low Earth orbits (LEO) up to an altitude of 1000 km. The object catalogue contains currently about 2500 objects. Object data of GRAVES are used for target allocation of other radars.

TIRA: The German FGAN Radar belongs to the Research Establishment for Applied Science at Wachtberg (organisational arrangements are currently changed to create a legal position, to be able to use the radar operationally for SSA and not only for research). In its tracking mode, the TIRA system determines orbits from direction angles, range, and Doppler for single targets. The modes include target tracking and imaging (for identification). The detection size threshold is about 2 cm at 1000 km range, 40 cm in GEO orbit. For statistical observations this sensitivity can be enhanced to about 1 cm, when operating TIRA and the nearby Effelsberg 100 m radio telescope in a bistatic beam-park mode with TIRA as transmitter and Effelsberg as receiver.

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[65] Radar stations suited for observation of the Low Earth Orbit (LEO) region up to 2000 km.

FS Monge: DGA/DCE, the Systems Evaluation and Test Directorate of the French Ministry of Defence, is operating several radar and optical sensors throughout France. The most powerful of these systems, Armor, is located on the tracking ship Monge. The two radars are dedicated to tracking tasks, based on high resolution angular and range data. Other less powerful radars are the Atlas, the Bearn and the Savoie.

Chilbolton: The Chilbolton radar is located in Winchester, UK, operated by the Radio Communications Research Unit (RCRU) of the Rutherford Appleton Laboratory (RAL). It is mainly used for atmospheric and ionospheric research. With a planned upgrade the radar will be able to track LEO objects down to 10 cm sizes at 600 km altitude.

In-situ sensors[66]:

SODAD (Orbital System for the Active Detection Of. Debris) are French space debris detectors currently in orbit (1 on ISS and 3 on satellite SAC-D) measuring the flux of micrometeriods (natural) and microorbital debris (manmade).

[66] Sensors that measure flow of small objects such as micrometeriods and microdebris. Such sensors are mounted on space craft (ISS, Space shuttle, satellites)

ANNEX IV: INTERNATIONAL INITIATIVES ON DEBRIS MITIGATION

This Annex provides details on initiatives related to the mitigation of space debris which have been developed at international level. The impact assessment report refers to these initiatives in pages 23 and 40 of the main report as well as in pages 59 and 60 of Annex III.

(10) Initiative of general scope

Name of the initiative: *International Space Code of Conduct on outer space activities*

Forum: International negotiations led by the European Union. The Council Working Group on Global Disarmament and Arms Control (CODUN) is in charge of the discussions at EU institutional level.

Objective: The objective of this initiative is to design a comprehensive international code which is revised and negotiated following discussions between the EU with third countries, with a view to it being ratified by as many countries as possible. The initiative was proposed UN Resolution 61/75 of 6 December 2006 on transparency and confidence-building measures in outer space activities.

Content: The draft code covers the full range of space objects and activities, whether civilian or military and contains commitments based on transparency and confidence-building measures (such as a general commitment to advance adherence to international law instruments on space activities), measures on space debris control and mitigation as well as cooperation mechanisms in the domain of space activities. As regards debris mitigation, negotiations have show fluctuations as to the extent of the mention of space debris control and mitigation measures. The last version of 2011, following the comments of the US, merely includes a one sentence commitment "to take appropriate measures to limit the generation of long-lived debris", whereas the 2010 version also included a mention of the non-binding UN General Assembly Resolution 62/217 adopting the Space Debris Mitigation Guidelines of the UNCOPUOS (see below).

Developments and expected evolution: A first draft was published in December 2008 and led to a first round of international consultations in 2009, its revision in 2010, and in September 2010 the Council invited the High Representative to pursue consultations with third countries on the basis of this revised draft, which are still ongoing. Upon finalization, all States will be invited to adhere on a voluntary basis. The current perspective, confirmed at Council level, is the possibility of opening the Code for signature at an ad hoc diplomatic conference to take place possibly mid-2013. In order to get to this diplomatic conference, there will be a series of multilateral experts meetings, open to the participation of all States, the fist one of which is foreseen to take place in Vienna on 5 June 2012.

(11) Initiatives exclusively related to debris mitigation measures

Name of the initiative: *The IADC and the Space Debris Mitigation Guidelines*, 2002

Forum*:* Inter-Agency Space Debris Co-ordination Committee (IADC) The IADC is an international agency level forum for the worldwide coordination of activities related to the issues of man-made and natural debris in space. It is worth highlighting the fact that the IADC is internationally recognised as a space debris centre of competence. It includes member agencies from Italy, France, China, Canada, Germany, ESA, India, Japan, the US, Ukraine, Russia and the UK. The IADC meetings take place in different Member States.

Objective: The main purpose of the IADC itself is to exchange information on space debris research activities between member space agencies, to facilitate opportunities for cooperation in space debris research, to review the progress of ongoing cooperative activities, and to identify debris mitigation options. In this context, it feeds the work of the UNCOPUOS with its presentations and findings. The IADC has developed the Space Debris Mitigation Guidelines in 2002 upon invitation of the Scientific and Technical Subcommittee of the UNCOPUOS. These guidelines are not mandatory for States or manufacturers, although in many cases they have become a commonly accepted practice in the space manufactory industry.

Content: The IADC Debris Mitigation Guidelines are a comprehensive document that describes best existing practices for limiting of space debris, includes the proposals on debris mitigation and contains technical information to help establish mission requirements for planned and existing space systems. As an example, the IADC guidelines include, among others, guidelines on limiting debris released during normal operations or on minimising the potential for on-orbit break-ups.

Developments and expected evolution: the IADC guidelines have been complemented by Support Documentation in 2004 and amended in 2007. The guidelines are translated into international engineering standards at technical and commercial level, such as International Organisation for Standardisation (ISO) or European Cooperation for Space Standardisation (ESS). Moreover, as explained below, the UNCOPUOS has developed its own version on the basis of the IADC Guidelines that was later adopted by the UN General Assembly.

Name of the initiative: *UN Space Debris Mitigation Guidelines*

Forum: United Nations – General Assembly - UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS). This committee was set up by the UN General Assembly in 1959 to review the scope of international cooperation in peaceful uses of outer space, to devise programmes in this field to be undertaken under UN auspices, to encourage continued research on legal and scientific problems linked to space exploration and exploitation.

Objective: similar to the IADC guidelines, which have served as inspiration to the UNCOPUOS, the UN guidelines intend to curtail the generation of potentially harmful space debris and prevent further pollution of the space environment.

Content: The Scientific and Technical Subcommittee of the UNCOPUOS developed the IADC Guidelines into its own set of guidelines. The IADC Guidelines are the basis for the UNCOPUOS guidelines and therefore the content is similar.

Developments and expected evolution: The guidelines were approved in 2007 by the 63 Member nations of the UNCOPUOS as voluntary high-level mitigation measures and then were endorsed by the UN General Assembly in 2008 in its Resolution 62/217 on the international cooperation in the peaceful uses of outer space. Further to this endorsement there has been no major development in this forum in the following years. The fact that the UN guidelines have been adopted by the General Assembly could be interpreted as an attempt to raise awareness of the importance of the issue at international level, although resolutions of the UN General Assembly are not binding to UN Member States.

Name of the initiative: *European Code of Conduct*

Forum: National space agencies in Europe including ESA. This initiative is another has been developed by space agencies in Europe since the mid-1990s and referred to as the "European Code of Conduct." The Code has been signed by ASI (Italian Space Agency), BNSC (British National Space Centre), CNES (French Space Agency), DLR (German Space Agency) and ESA in 2006.

Objective: In line with the other initiatives listed in this section, the objective these guidelines is to help to technically manage the space debris hazard, namely in the design and operation of space systems that will avoid or minimise the generation of space debris.

Content: The European Code of Conduct is another set of guidelines that has been developed to be used by projects to assist in the early consideration of measures to reduce space debris while also giving an insight into necessary future practices. The core elements of this Code of Conduct are in line with the IADC Guidelines and UN COPUOS guidelines seen above. Nonetheless, the Code of Conduct provides greater detail and rationale.

Developments and expected evolution: Besides the signature of the Code by the above national space agencies, ESA has developed their own "Requirements on Space Debris Mitigation for Agency Projects" in order to tailor the Code of Conduct to the specific needs of ESA projects. These instructions came into force in 2008 and are applicable to procurements of space systems (launchers, satellites and inhabited objects) by ESA. Compliance with its provisions is voluntary, although recommended.

Other conferences and fora active in the research of debris mitigation: other instances deal with the issue of debris mitigation and foster discussion from a more theoretical perspective. Research initiatives and studies are presented at the quadrennial series of the ESA-organised European Conferences on Space Debris and at dedicated sessions of IAC (International Astronautical Congress) and COSPAR (Committee on Space Research) congresses.

ANNEX V: CALCULATION METHODOLOGY

The impact assessment provides quantitative estimates of the impact of proposed SSA/SST activities on the basis of available data. This annex explains the methodology followed.

The parameters taken into consideration are the following:

- On January 2011, there were approximately 950 satellites in orbit around the Earth (GEO, LEO, MEO and elliptical orbits). 68 out of 470 satellites in LEO (14.46%) and ~120 out of 390 satellites in GEO (30.76%) had EU contractors/owners[67];

- According to Euroconsult, the average satellite price over the next decade will be $99 million and the satellite launch average price is predicted to remain flat, at $51 million[68]; for launches in LEO, the average price is estimated at $8 million[69].

- The average number of catastrophic collisions with catalogued objects in LEO during the next 40 years is one every 5 years[70]; for partially traceable debris the average number of collisions raises up to 1 every 3 years[71].

- The average number of catastrophic collisions at GEO is 1 every 155 years[72], therefore negligible for the purpose of our calculations; the risk in Medium Earth Orbits is also considered negligible;

- For the purpose of calculation we assume that collisions take place at satellite's mid life and its cost at this stage would be 50% of its average cost ($99 million), namely $49,5 million;

- For the purpose of this calculation $1 = € 1;

Calculation of annual direct loss due to collision (satellite's loss) in LEO:

Number of collisions concerning the total satellite population over 10 years in LEO (at one collision every 3 years) ~= 3.3 collisions;

Number of EU satellites affected by collisions in the next 10 years [3.3 collisions x 14.46% of EU satellites over the total satellite population] ~= 0.5;

Annualised cost of satellite loss over a 10 year period in LEO [0.5 x (satellite cost at midlife, i.e. $49.5 million + cost of launch, i.e. $8 million)/10 years] = ~$2.9 million. However, in its

67 Booz & C. figures based on: Satellite database of the Union of Concerned Scientists available at HTTP://WWW.UCSUSA.ORG/NUCLEAR_WEAPONS_AND_GLOBAL_SECURITY/SPACE_WEAPONS/TECHNICAL_ISSUES/UCS-SATELLITE-DATABASE.HTML.
These figures have negligibly evolved in one year's time: 1st January 2012, 67 out of 471 for LEO and 123 out of 420 for GEO. Nonetheless, the 2011 figures are used for consistency with the rest of the information collected in the timeframe taken into consideration by the study of Booz & C.

68 "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

69 Euroconsult and Futron data, Booz & Co analysis

70 http://www.parliament.uk/documents/documents/upload/postpn355.pdf Page 2 Chart 2

71 Booz & C. report

72 http://www.mcgill.ca/files/iasl/Session_5_William_Ailor.pdf

study Booz and Company retains an approximated figure of ~$2.5 million in order to take into account the most conservative estimates at each intermediate stage of the calculation.

Calculation of annual indirect loss due to collision (service outage) in LEO:

– Annual average value of satellite services/year for an EO satellite ~= 6M€[73]

– Annual average value of satellite services/year for a Mobile Satellite services satellite ~= 8M€[74]

– The minimum service outage considered is 3 months. This leads to a yearly loss between (6M€/12 months)*3 months~=1,5 M€ et (8 M€/12 months)*3 months~=2 M€/year

The economic loss for LEO satellites over 10 years is then approximately between 5 M€ [1,2 M€/year x (3.3 probability of collision over 10 years)] and more than 6 M€ [2M€/year x (3.3 probability of collision over 10 years)].

For Europe, only 68 satellites out of 470 have to be considered in the calculation: 14,46% of the amount between 5 and 6 M€ that the Booz report approximated to 1M€ over 10 years.

Calculation of annual indirect loss (shortening of satellites' lifetime) due to avoidance manoeuvres in LEO[75]:

– For a satellite in general, the average lifetime shortening of a collision avoidance manoeuvre is 3 weeks;

– 1.5 avoidance collision manoeuvres per satellite/year are considered;

– 90% of avoidance manoeuvres in LEO lead to significant consumption of propellant.

– Average lifetime for a LEO satellite is 3 to 5 years

Lifetime shortening over 10 years for European satellites [(68 European satellites x 1.5 avoidance collision manoeuvres per satellite/year x 3 weeks of lifetimes shortening per manoeuvre) x 10 years x 0.9] ~= ~2700/2900 weeks in order to take into account the most conservative estimates at each intermediate stage of the calculation.

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73 Report of Booz & Company: "It has been also considered that the most common satellites in LEO (i.e. the 'typical victim' of a collision) are either Earth Observation (EO) or Mobile Satellite Service (MSS) satellites**.** Since the global market of EO data sales/year is approximately 830 Mln Euro, and the global market of MSS services/year is approximately 1800 Mln Euro*; a conservative estimate (assuming the ratio of market value of satellite services per satellite will not change in the coming years**) would suggest that the value of the service outage/disruption of the 'typical victim' is an hypothetical average service value of a LEO satellite over a year (i.e. indicatively 7 to 8 M€ in service revenues, averaging between a EO and an MSS considering number of satellites) and scaled that value down to the assumed 3 months service outage period (i.e. indicatively 1.5 to 2 Million Euro per satellite loss)." *Satellite Industry Association, State of the Satellite Industry Report, June 2010; **The Booz & Company analysis based on current market data shows an indicative ~ 6 Million Euro as an average value of satellite services per satellite a year for an EO satellite, and ~ 8 Million Euro as an average value of satellite services for an MSS satellite.

74 Report of Booz & Company; see footnote 73.

75 Report of Booz & Company, pages 123 to 125.

Equivalent in additional satellites needed to compensate the lifetime shortening over 10 years [(2700/2900 weeks / 52 weeks per year)/ 5 years lifetime of a LEO satellite] ~=10 to 11 satellites

Indicative economic impact over 10 years [(99 M€ cost of a satellite + 8 M€ cost for the launch) x 10 to 11 satellites] ~=1.2 B€ or 120 M€ per year

Calculation of annual indirect loss due to Earth observation loss of data due to avoidance manoeuvres in LEO[76]:

– 32 out of 68 European satellites are Earth Observation satellites

– 24 hours are necessary after each avoidance manoeuvre to recalibrate the optical devices and instruments;

Lack of data acquisition over 10 years [(32 satellites x 1.5 avoidance collision manoeuvres per satellite/year x 1 day x 10 years] ~= 450 days (=1.23 years)

– 6 M€ is the estimated value in terms of sales over a year for Earth Observation's data for 1 satellite

Economic impact of lack of data acquisition over 10 years [6 M€ x 1.23 years] ~= 8 M€ or 0.8 M€ per year

Calculation of annual indirect loss due to avoidance manoeuvres in GEO[77]:

– For a fleet of 20 satellites in GEO, a European satellite operator performs 3 to 5 large manoeuvres per year (large fly-by), i.e. 0.21 manoeuvres per satellite per year.

Lifetime shortening over 10 years for European satellites [(120 European satellites in GEO x 0.21 avoidance collision manoeuvres per satellite/year x 3 weeks of lifetimes shortening per manoeuvre) x 10 years] ~= 700-750 weeks

Equivalent in additional satellites needed to compensate the lifetime shortening over 10 years [(700/750 weeks / 52 weeks per year)/ 10 to 15 years lifetime of a GEO satellite] ~=1 satellite

Indicative economic impact over 10 years is then of 150 to 200 M€ (average cost of a GEO telecom satellite launch included) or 15-20 M€ per year.

Costing of the European SST service

The costing is based on combined information from several sources, notably the European Space Agency and information gathered by Booz & Company and contained in the Space Situational awareness section of its study "Evaluation of options for a space programme in 2014". Information was also received from experts in space national agencies and other entities on a confidential basis which have helped in elaborating the estimates below.
On this basis, for options 2, 3 and 4 the following assumptions have been made regarding new assets would be as follows:

- A new surveillance radar would cost between 150 and 200 M€; for the purpose of calculation we use 175 M€;
- A new tracking radar would cost 40 M€;
- A telescope for surveillance and tracking would cost 10 M€
- A data centre for surveillance and tracking would cost 50 M€

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76 Ibid.
77 Ibid.

Experts estimate that in order to achieve a target reduction of risk collision by a factor of 3 to 5, it would be necessary to acquire 1 new tracking radar and 1 new surveillance radar, 8 new telescopes for surveillance and tracking and one data centre. This represents a total of 345 M€ and an annualised cost of some 49 M€.

As the costs figures are estimates and include a certain margin for error, for simplicity sake the total figure for new assets has been rounded to 50 M€ in the impact assessment.

The secured networking, operations and maintenance of existing and new assets for the sole purpose of European SST service can be estimated at annual cost of 8 M€. This amount has been estimated including information provided on a confidential basis and takes into account the shared use of assets for the European SST service and for Member States own purposes.

The setting up (ICT equipment), operation (6 FTE) and maintenance of a front desk function has been estimated at an average annual cost of 2 M€.

The total cost in options 2, 3 and 4 would amount to an estimated annual amount of 60 M€.

Option 5 corresponds broadly to the "Medium option" of Booz & Company which estimates de annual cost at 124 M€. Again, for the sake of simplicity we have rounded this figure to 120 M€ in the impact assessment.

ANNEX VI: REFERENCE STUDIES AND DOCUMENTS

External studies performed by contractors:

(8) Study on the EU Space Programme 2014-2020, Ecorys Nederland BV for the European Commission, final report of 4 July 2010; contract no. SI2.541751

(9) Study "Evaluation of options for a European space programme in 2014-2020; Booz & Company, final report of May 2011; contract no. 30-CE-036363/00-01

(10) Commission Staff Working Paper "European Space Situational Awareness high-level civil-military user requirements, SEC (2011) 1247 of 12.10.2011. The document was jointly prepared by the European Commission services and the European External Action Service and approved by the Council's Political and Security Committee (PSC) on 18 November 2011.

(11) Commission Staff Working Paper "Discussion note on space situational awareness data policy, SEC(2011) 1246 final of 12.10.2011

References to the EU policy documents:

(12) 4th Space Council Resolution, "Resolution on the European Space Policy", 22 May 2007; HTTP://REGISTER.CONSILIUM.EUROPA.EU/PDF/EN/07/ST10/ST10037.EN07.PDF

(13) 5th Space Council Resolution, "Taking forward the European Space Policy", 26 September 2008; HTTP://WWW.CONSILIUM.EUROPA.EU/UEDOCS/CMS_DATA/DOCS/PRESSDATA/EN/INTM/103050.PDF

(14) 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; HTTP://EC.EUROPA.EU/ENTERPRISE/POLICIES/SPACE/FILES/POLICY/6TH_SPACE_COUNCIL_EN.PDF

(15) 7th Space Council Resolution, " Global challenges: taking full benefit of European space systems", 25 November 2010; HTTP://REGISTER.CONSILIUM.EUROPA.EU/PDF/EN/10/ST16/ST16864.EN10.PDF

(16) Council Resolution "Orientations concerning added value and benefits of space for the security of European citizens" of 6 December 2011; Council document 18232/11; HTTP://REGISTER.CONSILIUM.EUROPA.EU/PDF/EN/11/ST17/ST17828-RE01.EN11.PDF

(17) "Towards a space strategy for the European Union that benefits its citizens" Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions (Sec(2011) 381 final);

HTTP://EC.EUROPA.EU/ENTERPRISE/POLICIES/SPACE/FILES/POLICY/COMM_NATIVE_COM_2011_0152_6_COMMUNICATION_EN.PDF

Surveys and consultations conducted/commissioned by the EU:

(18) Eurobarometer survey on the space activities of the European Union, 272, Gallup in July 2009; HTTP://EC.EUROPA.EU/ENTERPRISE/NEWSROOM/CF/_GETDOCUMENT.CFM?DOC_ID=5333

(19) Public consultation carried out via the Commission's Interactive Policy Making (IPM) tool, 2011; HTTP://EC.EUROPA.EU/ENTERPRISE/NEWSROOM/CF/ITEMDETAIL.CFM?ITEM_ID=5307&TPA=141&TK=&LANG=EN

Other sources:

(20) AGI - Center for Space Standards and Innovation, Iridium collision report; HTTP://CELESTRAK.COM/EVENTS/COLLISION/

(21) Characterizing the Space Debris Environment with a variety of SSA sensors, presentation NASA Orbital debris program office, G. Stansbery July 2010

(22) International Academy of Astronautics, Position Paper on orbital debris, 2001 HTTP://WWW.ESA.INT/ESAPUB/SP/SP1301/SP1301.PDF

(23) NASA Orbital Debris Quarterly News, volume 14 & 15 of January 2010 and January 2011, NASA Orbital Debris Program Office HTTP://WWW.ORBITALDEBRIS.JSC.NASA.GOV/INDEX.HTML

(24) NASA Space Science Data Center Master Catalogue, HTTP://NSSDC.GSFC.NASA.GOV/NMC/SPACECRAFTDISPLAY.DO?ID=1995-033B"

(25) NASA Wide-field Infrared Survey Explorer – WISE- fact sheet, September 2009; HTTP://WWW.NASA.GOV/MISSION_PAGES/WISE/MAIN/INDEX.HTML

(26) Presentation "French Policy for Space Sustainability" at the ISU Symposium, 21st February 2012, CNES

(27) Recovered debris list, Aerospace, Centre for Orbital and Re-entry Debris Studies HTTP://REENTRYNEWS.AERO.ORG/RECOVERED.HTML

(28) Requirements for Candidate Assets and SSA Gap Analysis of 2007, EADS; HTTP://WWW.ESA.INT/ESAPUB/SP/SP1301/SP1301.PDF

(29) Satellites to be Built & Launched by 2020, Report, Euroconsult 2011

(30) Space debris- ESA, 2009; HTTP://WWW.ESA.INT/ESAMI/SPACE_DEBRIS/SEM2D7WX3RF_0.HTML .

(31) Space debris, Parliamentary Office of Science and Technology (UK); HTTP://WWW.PARLIAMENT.UK/DOCUMENTS/DOCUMENTS/UPLOAD/POSTPN355.PDF.

(32) Space Security Report 2010, Space Security Organisation; HTTP://WWW.SPACESECURITY.ORG/SPACE.SECURITY.2010.REDUCED.PDF

(33) Space debris and the cost of Space Operations, in Proceedings of Fourth IAASS Conference "Making Safety Matter", Huntsville, Alabama, USA, Aerospace Corporation 19-21 May 2010

(34) US Stratcom Fact Sheet Re-entry Assessment, February 2008; HTTP://REENTRYNEWS.AERO.ORG/PAST.HTML

(35) USC Satellite database; HTTP://WWW.UCSUSA.ORG/NUCLEAR_WEAPONS_AND_GLOBAL_SECURITY/SPACE_WEAPONS/TECHNICAL_ISSUES/UCSSATELLITE-DATABASE.HTML.

(36) Description of the ESA "Space Situational Awareness Preparatory Programme (SSA-PP)", ESA; HTTP://WWW.ESA.INT/ESAMI/SSA/SEMYTICKP6G_0.HTML

(37) The impact of space environment on space systems, 6th Spacecraft Technology Conference, Aerospace Corporation, 2000

(38) Active debris removal - An essential Mechanism for ensuring the safety and sustainability of outer space; report of the international interdisciplinary congress on space debris remediation and on-orbit satellite servicing; UN Committee on the Peaceful Uses of Outer Space; Vienna, 6-17 February 2012;

(39) Space debris - on collision course for insurers? The implications of debris colliding with operational satellites from a technical, legal and insurance perspective; study prepared by Swiss Reinsurance Company Ltd., 2011; HTTP://MEDIA.SWISSRE.COM/DOCUMENTS/PUBL11_SPACE+DEBRIS.PDF