ESA/C(2008)142
12 Novembre 2008
(Original: English)

EUROPEAN SPACE AGENCY

COUNCIL

Space Situational Awareness Preparatory Programme Proposal

Summary

This document describes the scope, content, implementation approach and cost estimates for the initiation of the development of a European Space Situational Awareness (SSA) capability, as a proposal by the Director General. It is based on the preliminary elements and preparatory activities presented to Council meeting in December 2007[1], on the outcome of the March 2008 Council, and includes also the results of the discussions held with the members of the SSA Potential Participants Board during the time frame April – October 2008.

After an introduction of the SSA system objectives and its associated long term perspective, this document provides an overview of the proposed SSA services, as well as an outline of the SSA functionalities and the associated development projects required to achieve a European operational capability.

The conclusive programmatic section introduces the associated development logic and financial elements. The implementation of a full European SSA capability is to be prepared through the SSA Preparatory Programme, to be executed in three years (2009 – 2011) and including*:*

- Elaboration of a SSA governance model and related data policy
- Consolidation of SSA requirements and architectural study.
- Radar bread boarding and pilot Data Centres.
- Initiation of the delivery of agreed precursor services in the areas of Space Surveillance, Space Weather and NEOs..

The Preparatory Programme is proposed to be articulated in four elements. The first element (mandatory) will be dedicated to the governance, data security and data policy, SSA architecture and Space Surveillance aspects needed to ensure the coherency of the full SSA system. The second element will be dedicated to Space Weather activities covering also the NEOs. The third element will be dedicated to the bread boarding of essential surveillance radar subsystems based on available technology, and the fourth one to the prototyping of pilot Data Centres.

[1] ESA/C(2007)158

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1 SSA Objectives and long term perspectives

1.1 Why SSA in Europe?

"Space Situational Awareness (SSA)" is defined as a comprehensive knowledge, understanding and maintained awareness of the (i) population of space objects, of the (ii) space environment, and of the (iii) existing threats/risks.

The overall aim of the Space Situational Awareness (SSA) Preparatory Programme is to support the European independent utilisation of and access to space for research or services, through providing timely and quality data, information, services and knowledge regarding the environment, the threats and the sustainable exploitation of the outer space surrounding our planet Earth.

SSA serves the implementation of the strategic missions of the European Space Policy[2] based on the peaceful uses of outer space by all states, by supporting the autonomous capacity to securely and safely operate the critical European space infrastructures. SSA also serves the EU "Lisbon objectives"[3] by supporting the development of new applications, new jobs and new market opportunities in the space sector.

1.2 Socio-economic benefits for society

Space-based systems have become indispensable enablers for a wide spectrum of applications critical to key areas of the economy, including those related to security, and it can be anticipated that the dependency on space-based assets will grow rapidly in the short term.

These dependencies raise concerns[4], however, because any shutdown of even a part of the space infrastructure could have significant consequences for citizens' safety and for economic activities and would also considerably impair the organisation of emergency services.

Accurate, timely and complete space situational awareness is instrumental for the protection of critical European infrastructures in space and for the secure and safe operation of its space activities and services as well as for the protection of population

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[2] Released on 26 April 2007 as a proposal of ESA's General Director to the ESA Council and as a Communication of the European Commission, and welcomed and supported by ESA and EU Member States through the Resolution of the 4th Space Council.

[3] Conclusions of the EU Presidency, Lisbon European Council, 24/3/2000

[4] "...too much reliance on space-based assets, including in the economy sector, could induce new vulnerabilities in case these systems are defeated. This should be taken into account when considering European security and appropriate measures envisaged to identify, prevent, or at least to limit, these risks. Such measures could include space surveillance...", extract from "ESDP and Space", EU Council, 16 Nov. 2004.

in case of re-entry events or possible NEO impact threats: the capacity to assess the situation in space allows the assumptions of responsibility and liability.

The development of an autonomous SSA capability will also offer Europe the opportunity to play a fundamental role in support of the peaceful uses of Outer Space by providing the international community with independent options to verify the compliance to international Treaties and Codes of Conduct[5] for the disarmament and non-proliferation of weapons in space. Indeed space weaponisation could become a reality and the proliferation of space weapons (i.e. anti satellites) is today a concrete risk that could eventually lead to space becoming a more hostile environment than ever before.

The concerns about the fact that EU does not possess the capability to monitor space and its space assets and to identify potential man-made or natural threats to its security have been formally recorded in the conclusions of the Workshop on security and arms control in space and the role of the EU held on 21-22 June 2007 in Berlin[6].

1.3 Background activities

Numerous activities and studies related to space situational awareness areas (e.g. space debris, space weather, asteroids, etc.) have been carried out within ESA and its Member States over several years[7]. Though extremely relevant in terms of scientific and technological results, these activities were largely performed in mutual independence.

In order to address this issue through a structured and top-down approach, at the end of 2006, the Agency set up an SSA Users Group representing the potential user

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[5] Portugal, acting as the Presidency of the EU, proposed on 18 September 2007 a code of conduct on space objects and space activities. This initiative is the European contribution to two issues that have been greatly debated over the last years in the UN, and more specifically in the Conference on Disarmament (CD): International outer space transparency and confidence-building measures (TCBM) in the interest of maintaining international peace and security, and promoting international cooperation and the prevention of an arms race in outer space (PAROS). This initiative is the result of a process begun with UN General Assembly (UNGA) Resolution 60/66 of 8 December 2005, which then culminated in two UNGA Resolutions: (1.) Resolution *61/58* of 6 December 2006 calling for UN Member States to actively participate to the objective of the peaceful uses of outer space in order to reinforce and consolidate the legal regime applicable to outer space.;(2.) Resolution 61/75 of 6 December 2006 inviting all UN Members and especially space faring nations to issue concrete proposals for the attainment of the objective.

[6] Excerpts from the conclusion of the Workshop on security and arms control in space and the role of the EU, 21-22 June 2007, Berlin. *[…] As the EU at this juncture does not possess the capability to monitor space and its space assets and to identify potential man-made or natural threats to their security, the establishment of an independent space situational awareness system is a key requirement (cf. tasks of monitoring space and satellites, assessing main capabilities and providing information to decision makers). A space situational awareness system is a strategic key asset (which can be developed making use of existing capabilities, in particular at the level of individual EU member states). While an independent surveillance capability is needed, it should not be established in isolation from our partners. Dialogue and coordination, in particular with USA, remains important […]*.

[7] For a complete and detailed descriptions of these projects, ESA/C(2007)181, Annexes 2 and 3

communities (civil, military, commercial operators, insurance companies, scientific community, and other European and international institutions) and providing guidance on the definition of SSA capability and of the related needs and requirements. The SSA User Group features today the participation of the national space Agencies and Ministries of Defence of several ESA's Member States[8] as well as representatives of the EU Council, EC, EDA[9], EUSC[10], UN-WMO[11], UN-COPUOS[12], ESWWT[13], commercial operators[14] and insurance brokers[15].

The first result achieved by the SSA Users Representatives Group (SSA-URG), was to obtain a common understanding concerning the definition and scope of a European Space Situational Awareness system (see paragraph 1.4). In parallel, the SSA-URG supported ESA in the steering of three parallel industrial studies[16]. The outcome of these studies led to the translation of the high-level users' needs into services and technical requirements, and to the identification of high level system architectural options able to respond to such list. Potential policy and technological issues[17] were also identified through these studies.

The preliminary indications and results stemming from these studies are currently being further developed and refined in the framework of two parallel GSTP contracts[18]. These activities, building on the results of the above mentioned studies and the recommendations of the SSA-URG will support the definition of relevant space elements and the related technology developments.

Additional dedicated studies on the specific issue of governance and data policy have been recently completed by European think-tanks and law firms[19]. These studies will contribute to support the reflection of the SSA stakeholders[20] concerning the selection and the responsibilities of an operational entity (or cooperating entities) for the purpose of the system exploitation.

Finally, a study aiming at the elaboration of the SSA ground-based radar main system parameters and trade-offs has also been initiated under the GSTP-V Programme.

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[8] Belgium, Germany, France, Italy, United Kingdom, Spain, Norway and Swiss
[9] European Defence Agency
[10] EU Satellite Centre (Torrejon, Spain)
[11] United Nations' World Meteorological Organisation
[12] United Nations' Committee for Peaceful Use of Outer Space
[13] European Space Weather Working Team
[14] Inmarsat, Eutelsat, Hispasat, SES Astra, Telespazio
[15] AON and MARSH
[16] GSP contracts 20118/06/FR/VS, 20373/06/FR/VS, 20374/06/FR/VS "Study on the Capability Gaps Concerning European Space Situational Awareness"
[17] For a synthesis of the outcome of the three studies, ESA/C(2007)181
[18] Proof of Concept for Enabling Technologies for Space Surveillance , Ref. Gstp Np30-01sy
[19] Study on suitable governance and Data Policy models for a European Space Situational Awareness (SSA) System – ESA GSP Contract n° 21443/08/F/MOS
[20] The first High-level SSA Governance workshop took place in ESRIN on 14th February 2008.

1.4 Definition and Scope of SSA in Europe

As mentioned in the first paragraph, the definition of Space Situational Awareness [21] as agreed by the SSA-URG is:

"Space Situational Awareness (SSA)" is defined as a comprehensive knowledge, understanding and maintained awareness of the (i) population of space objects, of the (ii) space environment, and of the (iii) existing threats/risks.

In this context:

- The *Earth orbital population* part refers to detection and/or tracking of man-made objects, the identification (and characterization) of detected objects, as well as the determination and prediction of orbit state, covariance information, spacecraft manoeuvres, spacecraft attitude, and antenna/instrument pointing.

- The *space environment* part refers to the detection and/or tracking of natural objects, the detection and understanding of interferences and man-made, induced environments, the detection and forecasting of space weather and its effects, as well as the understanding and prediction of the natural meteoroid environment and its effects.

- The *possible threat* part refers to predicting and assessing the risk to humans and property on ground and in air space due to re-entries, detecting and assessing adversary use or preparations for adversary use of or upon space systems, detecting on-orbit explosions and release events, predicting and/or detecting on-orbit collisions, as well as permanent or temporary disruption of mission and/or service capabilities, and prediction and detection the potential impact of a Near-Earth Object.

In benchmarking the US SSA capabilities, it is useful to recall that the US SSA network performs approximately 80.000 observations per day (ground-based and space-based). The distribution of this information to the European countries is limited by the "National Defense Authorization Act"[22] implying an access to a public catalogue of about 9500 objects. The orbital elements of European classified military satellites are publicly distributed in this catalogue.

The European approach to SSA needs to take these facts into account and to address the strategic issue of allowing Europe to have unrestricted access to vital information needed to safely operate European space infrastructure while contributing to the assessment of the situation in space, through autonomous control of major relevant

[21] see doc. ESA/C(2007)181, Annex 1 for the complete list of SSA functions, updated as of 21st November 2007
[22] National Defense Authorization Act for Fiscal Year 2004, 117 Stat. 1565 Public Law 108-136-24, November 2003

data and parameter. The set up of such a capability shall build, capitalise and complement the already existing and available European infrastructures.

1.5 Resulting actions from the March 2008 Council

As a starting act, ESA Council adopted on 12 March 2008 the Enabling Resolution (ESA/C/CXCIX/Res.5) by which, on the basis of the programme proposal ref. ESA/C(2008)30, Council accepted the SSA programme to be carried out in ESA over a ten year framework.

The Executive was requested to proceed with the SSA Programme preparation activities on the basis of a reduced initial period of three years (2009 – 2011) for a budget of 100 M€.

Council established a meeting of potential participants to elaborate a Programme Declaration for the forthcoming Council at Ministerial level, and invited the DG to study the possible models for the overall infrastructure, governance and data policy of the SSA Programme and to report the results of this study to Council by the end of 2010.

The SSA Potential Participants (SSA-PP) finalised the SSA Programme Declaration and draft Implementing Rules for the MC 2008 as stated in the par. 5 of the Enabling Resolution (ESA/C/CXCIX/Res.5).

The main objectives of the SSA Preparatory Programme activities starting after the MC 2008 will be the consolidation of the SSA requirements, the study of an overall SSA architecture, the completion of required technological studies through the GSP, GSTP and TRP Programmes, the formulation of appropriate Data Policy and Governance models, and delivery of an initial set of precursor services.

In addition, radar system bread boarding and pilot Data Centres activities will be undertaken in the time frame 2009 – 2011.

1.6 Resulting actions from the Potential Participants meetings (April – October 2008)

During September 2008, the Potential Participating States requested the Executive to reduce the envelope of the Programme to an estimated amount of 55 ME, and to rename the first Period of the Programme (2009 – 2011) “SSA Preparatory Programme”.

As a result of the discussions carried out during the Potential Participants meetings, the SSA Preparatory Programme has been constructed around four main elements:

a) Core element
b) Space Weather element including NEOs
c) Radar element
d) Pilot Data Centres

The programmatic content of each of these elements and its place in the SSA system architecture will be addressed in the Chapters 4 and 5 of this Proposal.

2 Policy framework: governance, data policy and data security

2.1 Governance background

During the preparatory phase of the SSA initiative carried out throughout 2008, it emerged clearly that the most challenging issue to be addressed in the development of a European SSA capability concerns the set up of a suitable governance model and its associated data policy and data security. The responsibility for the identification of such governance model, data policy and data security rests solely with the stakeholders participating in the development of the European SSA system.

With regard to the governance model, the SSA stakeholders shall agree about the most *appropriate institutional, technical and financial framework able to support decision-making, the rules for decision-making and, in addition, the mechanisms to ensure conformance with the data policy rules and procedures*. A high priority must therefore be given to the identification of a suitable operational model and to the implementation of the associated governance scheme. Concerning the data policy and data security, the stakeholders will have to agree on *the rules and procedures for accessing, handling, storing and distributing on the one hand raw data gained by sensors and on the other hand processed data processed at subsequent system stages.*

In-depth discussions dedicated to these issues, in particular with representatives of the interested Member States and prospective stakeholders, are on-going, thus complementing the debate on the SSA System in view of the decisions to be taken at the next MC 2008. In particular, the debate with Participating States and institutions will notably provide indications on the main principles and guidelines to be adopted for the effective operation and exploitation of the SSA system, including for the dissemination of the resulting data to users, and for the process to identify the entities in charge of operations. This approach will prepare the decision on a suitable operational governance model, needed to achieve an initial operational capability of the future SSA system.

In order to support the stakeholders' debate on the identification of such a governance model, ESA has completed several studies, awarding contracts to ESPI[23] and other

[23] European Space Policy Institute (Wien)

major European think-tanks, consultancy and law firms[24]. The studies aim at providing an in-depth overview and analysis of currently existing governance and data policy models as applicable for existing dual-use space application programmes. The studies shall further outline possible options for the future SSA system in terms of governance and data policy..
The support action led by the Executive also includes the organisation of SSA High-Level Forum meetings[25] (for European space agencies and MoDs).

Taking into account that the SSA-related information in domains such as space surveillance, space weather and NEOs is to a large extent made available to Europe by US organisations (US Air Force, NASA, NOAA, etc.), a good cooperation with the US authorities and a mutual trust are instrumental for a successful implementation of an SSA capability in Europe.

2.2 Governance, data policy and data security approaches

While ESA can be responsible for the development and validation of the European SSA system, its exploitation is expected to be assigned to a separate operational entity, which will operate it in line with the agreed governance, data policy and data security principles (see Fig.1 below). Thus, once pre-operational qualification is achieved the SSA system will be handed over to this operations entity.

[24] Study on suitable governance and Data Policy models for a European Space Situational Awareness (SSA) System – ESA GSP Contract n° 21443/08/F/MOS
[25] The first of these meetings took place on 14th Feb. 2008 in ESRIN

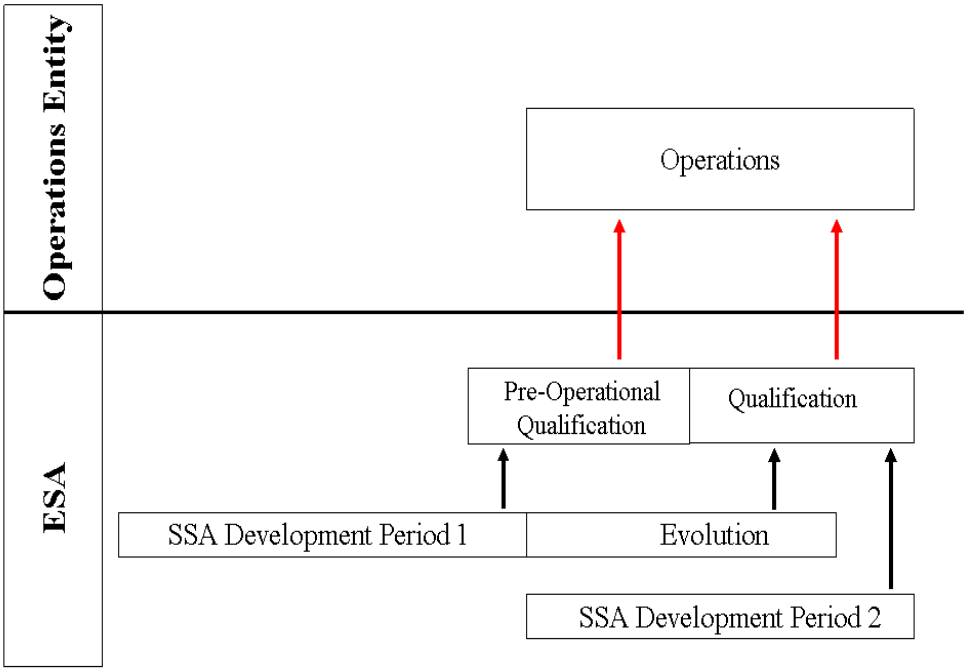

Figure 1: SSA system development and exploitation phases

In parallel, it is proposed that ESA would remain in charge of further evolution of the SSA system adopting a modular or spiral development/procurement type of approach. In fact, it is expected that requirements will arise for adaptation and evolution of the SSA system during initial system operations. ESA will thus remain responsible for carrying out such system evolutions, qualifying them and then handing them over to the operations entity. These evolutions could include new instruments, enhancements of the ground and space infrastructure, new data products and services, as well as adaptation of the system to new technologies.

The governance, data policy and data security model that will be put in place for the exploitation of the elements of the European SSA system shall:

- respect data classification requirements security/confidentiality, classified/proprietary as concerns access and distribution of the data;
- consider legal and other aspects linked to international cooperation beyond the European framework with either partner countries or international organisations;
- allow for multilateral cooperation between national and European data centres;
- take into account the requirements of commercial service providers.
- allow for the mixed use of assets and data fusion, i.e. combining space-based and ground-based assets as well as survey sensors, tracking sensors (tasked), imaging sensors (tasked), space environment survey;

- allow the future evolution of the system.

The reflection about an adequate governance of the SSA system will include also the links in particular with the EU Council (e.g. EDA, EUMS, EUSC)[26], and other EU bodies as applicable, in order to take into account their requirements on the SSA system.

2.3 Business models

Though the future European SSA system will have primarily a strategic value for its stakeholders, the system will be designed to offer the potential for future business opportunities. A preliminary analysis of the potential business models shows that typical candidate customers for purchase of SSA data/products include spacecraft operators, Launch and Early Orbit Phase (LEOP) service providers, insurance companies, space application (telecommunication, satellite navigation) service providers, etc.

Space weather data can additionally be of interest to terrestrial users such as, airlines, electricity suppliers and surveying companies. In the context of potential commercial exploitation, associated issues and technical boundary conditions have to be considered. In any case, it will be crucial for the future European SSA to offer added value data/information compared to freely available products.

It is important to stress that the functionality of the SSA system is largely independent on the funding and operations/ownership routes.

3 SSA budgetary and programmatic aspects

3.1 Scope of the SSA Preparatory Programme

The development of a European SSA System is a long term activity that will be regularly submitted to the scrutiny of the participating Member States through an SSA Programme Board to be established, as well as to the ESA Councils.

The SSA Preparatory Programme covers SSA activities during the years 2009 to 2011 in line with the discussions held with the Participating States throughout 2008.

The SSA Preparatory Programme is an ESA optional Programme. The approach broken down in distinct elements as presented in Chapter 1.6 creates the conditions for the leaderships and experiences matured so far by the different European SSA actors to be maintained in the current set-up, by adding the benefits of an overall coordination layer.

[26] In line with the principles of the European Space Policy

The management of the SSA Preparatory Programme within ESA will be implemented through the set up of a dedicated Project Team with a possibility to have detached representatives from the national or European security-related administrations aimed at supporting the ESA staff.

3.2 Elements of the SSA Preparatory Programme (2009 – 2011)

The discussions within the SSA Potential Participants led during 2008 in preparation for the MC08, were concluded with the definition of the elements that will constitute the SSA Preparatory Programme. Activities related to imaging will be deferred to the Period 2.

The SSA activities will be broken down in four distinct elements:

a) core element
b) Space Weather element including NEOs
c) Radar element
d) Pilot Data Centres element

The core element activities will pursue the objective of supporting the definition of the Governance, of developing an appropriate Data Policy and Data Security, and of specifying the Data Centres that need to be established within the SSA system. It will also include the specification and architectural design of a space surveillance system that will monitor man-made objects in Earth-bound orbits including Space Debris.

In order to deal with the governance matter, ESA together with European institutions and participating States will support the following activities:

- Interactions with the institutional stakeholders through dedicated workshops aimed at collecting the indications of participating States and at discussing the governance options identified as more promising.
- Consultations with the users' community, through the Users' Representative Group meetings aimed at collecting and identifying the operational concerns related to the data policy.
- The appropriate European and/or national authorities in international workshops to exchange information and to support cooperation with other partners, such as International Organizations, USA, etc on issues like data policy, data security and governance.
- Studies and analysis, with the support of think-tanks, academia and legal advisors to provide an overview and detailed analysis about relevant existing governance and data policy models in the space domain and beyond. These studies will also consider the legal and financial implications linked to the potential exploitation of the overall system by multiple public and private entities from both the civilian and military sector.

The European defence community will also express operational needs related to the European SSA capability development. Though this process could take place within already existing intergovernmental structures (e.g. EDA), the traceability of the consequences of taking into account the defence requirements should be kept all through the SSA Preparatory Programme.

The Space Weather element will be targeted at the preparatory activities in this area, covering the consolidation of the requirements and architectural design of the Space Weather and NEOs systems. Federation of existing and available assets as well as enhancement of already existing services for subsequent delivery of precursor services will be also part of this element.

The radar element will be dedicated to the pre-development and bread boarding of essential surveillance radar components such as phased arrays, transmitters, receivers, processing chains and to the start of a pilot surveillance radar project. This activity will be undertaken in close coordination with the on-going radar studies performed under GSTP.

The pilot Data Centres element will be executed after the completion of the SSA architectural design phase in the core element. It will cover prototyping of pilot Data Centres, taking into account the result of the SSA Data Policy discussions.

3.3 Budget Framework

The SSA activities of the Preparatory Programme will be broken down in four distinct elements, each of them receiving an independent budgetary allocation:

e) A core element that includes the definition of the Governance, Data Policy and Data Security; as well as the specification and architectural design of a space surveillance system and a delivery of a set of precursor services.

f) A Space Weather element that includes the consolidation of the requirements and architectural design of the Space Weather and NEOs systems, the federation of existing and available assets as well as enhancement of already existing services for subsequent delivery of precursor services

g) A Radar element dedicated to the pre-development and bread boarding of essential surveillance radar components and to the start of a pilot surveillance radar project

h) Pilot Data Centres element that includes the prototyping of pilot Data Centres

The financial envelope for the total of the SSA Preparatory Programme amounts to 55M€ at 2008 economic conditions. It consists of the core element with a fixed envelope of 20 M€, and three additional elements estimated at the financial sub-envelopes set out in the Table 1 below:

Financial sub-envelopes	**M€** (2008 e.c.)
Core element	20
Space weather element	11
Radar element	11
Pilot Data Centres element	13
TOTAL	**55**

Table 1 – Financial estimates for each element of SSA

The profile of expenditure is indicated in the Table 2 below:

PA (M€) at 2008 e.c.	**2009**	**2010**	**2011**	**2012**
Core element	4	6	6	4
Space Weather element	3	3	3	2
Radar element	3	3	3	2
Pilot Data Centres element			8	5
TOTAL	**10**	**12**	**20**	**13**

Table 2: Profile of expenditure during SSA Preparatory Programme

3.4 Phasing of activities

A tentative schedule of the activities that will be performed during the Preparatory programme is shown on Fig.2 below.

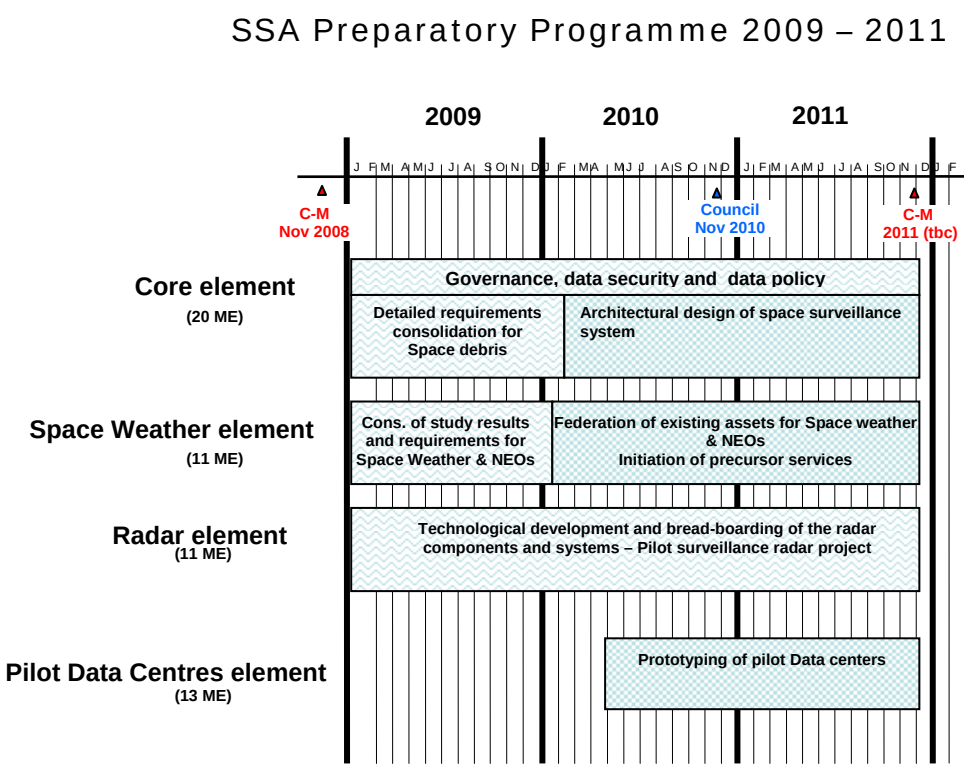

Fig.2: Phasing of activities during SSA Preparatory Programme

4 SSA System services and functionalities

The information needed by the future users of an SSA system is specific to each user community (survey and tracking, imaging, space weather, NEOs).

The User needs have been expressed during the SSA User's Group meetings held during 2007 and 2008, and have constituted the starting basis for the discussions held with the Potential Participating States during the meetings in the April 2008 – October 2008 time frame.

These needs have been translated in services, which in turn have triggered the main assumptions for the future functionalities of the SSA system. These aspects will be addressed in detail during the requirements consolidation and architectural design phases of the SSA Preparatory Programme.

4.1 Main SSA services

The long term objective is the development of a SSA system that will deliver services in the areas of Space Surveillance, Space Weather, NEOs, and subject to the outcome of future discussions also in the area of Imaging.

For the Space Surveillance area, they are covering the detection and tracking of objects above a given size threshold and their cataloguing, the issuing of collision warning alerts, the recommendation of avoidance manoeuvres, as well as detection of on-orbit explosions. The services will also cover the prediction of high-risk re-entry events and initiation of related alert procedures.

Space Weather affects many systems in space and on the ground through effects that include radiation and spacecraft charging hazards, spacecraft drag, ionospheric perturbations, aircraft radiation hazards, geomagnetic disturbances and current induced in large conductive networks such as power lines and pipelines. The Space Weather services are related to the monitoring of the Sun, the solar wind, the radiation belts, the magnetosphere and ionosphere. They will include as well the provision of all required predicted local spacecraft and launcher radiation, plasma and electromagnetic environment data.

The NEOs activities are related to the detection of natural objects other than the large planets ranging from dust in the micro- to mm-size range, to asteroids and comets with size in the order of several 10 km. The largest asteroids are several 100 km in diameter. Some of them represent a collision threat to the Earth, due to their orbits crossing the Earth's orbit. The NEOs services will be related to the detection of these objects, as well as their monitoring and cataloguing. Studies regarding possible mitigation measures will also be undertaken.

Table 3 below maps the Users' Needs to the type of information actually needed by the users and identifies the proposed service elements of the SSA programme that shall delivery such information.

High Level User's Needs	Information need	Services
Assess the functional status and capabilities of space systems	- Provide information about the state (attitude, agility) of a satellite - Provide information about the state (deployment state, pointing etc…) of satellite appendices - Identification and characterization of natural space objects	- Survey and Tracking - Imaging
Support risk management and liability assessment	- Awareness of collision and re-entry risks - Provide information about the state (deployment state, pointing etc…) of satellite appendices - NEO-related risks - Environmental effects	- Survey and Tracking - Imaging - Space weather - NEO
Support safe and secured operation of space assets and related services	- Identification, correlation and characterization - Current and future positions - Awareness of resulting collision and re-entry risks - Verifiable, dependable, timely data with integrity and known accuracy - Environmental effects	- Survey and Tracking - Space weather
Enable the assumption of responsibility and support confidence building measures	- Current and future positions - Provide information about the state (deployment state, pointing etc…) of satellite appendices - Provide information about the state (attitude, agility) of a satellite - Identification and basic characterization of natural space objects - Discrimination of natural and man-made effects	- Survey and Tracking - Imaging - Space weather
Detect non-compliance with relevant international treaties and recommendations	- Identification, correlation and characterization - Current and future positions - Provide information about the state (attitude, agility) of a satellite - Identification and characterization of natural space objects - Identification of human impact on the space environment and interferences.	- Survey and Tracking - Imaging - Space weather

Table 3 – SSA: users' needs vs information needs and services

4.2 SSA main functionalities

This paragraph introduces the high-level SSA functionalities that will allow the definition of an SSA infrastructure able to provide the services identified by the prospective users and outlined above. It identifies also the activities that will be performed in each area during the SSA Preparatory Programme.

4.2.1 Survey and tracking function

The "survey and tracking" function will be a core element of a European space surveillance capability, which in itself will form the backbone of a more comprehensive European SSA system. A first set of such requirements has been compiled by the SSA User Representative Group.

The system requirements will be largely driven by the requested detection threshold for different orbit regimes. This is illustrated in Table 4 where all objects of the ESA space debris environment model (MASTER-2005) are classified into different orbit classes (selected to match observability constraints), with specific size thresholds.

space objects larger than d [cm]		LEO		MEO-L	MEO-H	MEO-H & GEO	GEO
d [cm]	count	res.[%]	trans.[%]	res.[%]	res.[%]	trans.[%]	res.[%]
100	4,658	50.0	17.5	0.9	4.5	7.1	20.0
50	6,549	52.3	18.1	2.7	3.7	7.0	16.2
30	9,091	56.6	16.5	2.2	3.3	7.2	14.1
10	20,505	54.2	13.6	1.0	3.9	10.7	16.4
5	44,092	48.6	13.5	0.5	4.5	14.3	18.4
3	90,541	44.8	15.1	0.2	4.8	15.9	19.0
1	606,474	32.1	23.3	0.2	5.6	24.8	13.8
altitudes [km] ⇨		120 to 2,000 km			15,000 to 38,000 km		
observability ⇨		radar		difficult	Optical		

min. required performance expected performance

Table 4: Distribution and observability of space objects (MASTER 2005)

All information that will be collected on the terrestrial space object population by a European surveillance network shall be acquired through ground-based sensors (radars, telescopes), augmented by space-based sensors in the optical spectrum. The initial definition of such a system will be performance-wise in line with the detection and tracking capabilities of the US Space Surveillance Network (SSN), with detection size thresholds of about 5 to 10 cm in the low Earth orbit regime, and about 0.3 to 1 m near the geostationary orbit.

On January 1, 2007, the corresponding US Space Surveillance Network catalogue consisted of about 10,000 objects, with about 7% (700) thereof operational satellites.

The European Space Situational Awareness System will concentrate its tracking priorities on those orbital regions that are densely populated and/or which are of a high commercial, scientific, or technological value. This is the case for the LEO region (~67% of the SSN catalogue), the GEO region (~10% of the catalogue), and the medium altitude orbits (MEO) of navigation satellites (~4% of the catalogue). Of second priority, due to the increased investment versus detection probability, would be highly elliptical orbits (HEO), including the GEO transfer orbits (GTO), which together account for ~11% of the catalogue, and orbits beyond the GEO ring (~8%).

The following activities will be undertaken during the SSA Preparatory Programme (2009 – 2011) in the area of Space Surveillance:

- Consolidation of the requirements for ground-based radar(s), covering surveillance and tracking functionalities
- Architectural design of the ground-based radar system, including the definition of the most efficient implementation trade-off of the surveillance and tracking functionalities
- Consolidation of requirements and architectural design for ground-based telescopes for surveillance and tracking
- Consolidation of requirements for spacecraft payloads and platforms related to surveillance and tracking, as well as cost efficiency analysis.
- Consolidation of requirements for the establishment of catalogues for Space Surveillance data based on existing models
- Development of algorithms, methods and analysis software
- Analysis and evaluation of existing assets and competencies in the area of surveillance and tracking
- Preparatory activities for the subsequent delivery of precursor services based on the results of the studies on governance and data policy and on available European and International assets and data (e.g. GRAVES, TIRA, MONGE, ZIMLAT, ZIMSMART, etc)

4.2.2 Imaging function

This part will not be addressed during the SSA Preparatory Programme

4.2.3 Space weather function

The main Space Weather functions are indicated in the Table 5 below, together with their relevance to the services in that domain.

Relevance scale in each category: XXX: Critical for all services XX : Critical for some services X : Important but not critical - : Not relevant		Space weather service category				
		local spacecraft environment post-event re-construction, nowcast or forecast	prediction of thermospheric density	ionospheric scintillation nowcast or forecast	ionospheric density profile nowcast or forecast	ground-level magnetic field variations monitoring or forecast
Space Weather functionalities	Space based in-situ radiation monitoring	XXX	-	-	-	-
	Space based in-situ magnetospheric plasma monitoring	XX	X	X	X	X
	in-situ monitoring of the solar wind plasma and magnetic field	XX	XX	XX	XX	XX
	Ground geomagnetic field monitoring	XX	XX	XX	XX	XXX
	Ionospheric remote sensing (ground based and space-based monitoring)	XX	-	XXX	XX	X
	Solar surface and low corona real-time imaging	XX	XX	XX	XX	XX

Table 5: functionalities versus service requirements

The Space Weather SSA component shall acquire process and distribute all relevant data to provide reliable, continuous and non-dependent services to the European users.

The following activities will be undertaken during the SSA Preparatory Programme (2009 – 2011) in the area of Space Weather:

- Consolidation of the requirements related to the Space Weather activities in Europe.
- Establishment of agreements and designs for implementation of Space Weather auxiliary payloads on already planned ESA/European partner spacecraft.
- Analysis and evaluation of existing assets and competencies in the area of Space Weather
- Definition and enhancement of the services provided using the existing prototype European Space Weather Networks.
- Architectural design of the required ground components, as well as spacecraft payloads and platforms (e.g. through the Concurrent Design Facility at ESTEC)

4.2.4 NEO function

The NEO function of the European SSA System will have eventually the capability to contribute significantly to the international effort of monitoring the NEOs population representing a threat to the Earth, while keeping a strategic coherence and non dependence at European level.

The orbital state and perturbation parameters of all objects with new observations shall be updated at least once per day.

Predicted data for known NEOs in state or ephemeris format shall be made available "in real time", i.e. on request by the user, e.g. via a web interface. A similar approach will be taken for the available orbit data and physical characteristics.

For newly discovered objects, where the physical characteristics are not known, the determination of these characteristics is dependent on the possible observation conditions. It shall be guaranteed that after the next possible observing window (i.e. when the object is bright enough and in the right solar elongation to be observable) the physical characteristics for objects brighter than magnitude 20 can be determined.

The identification and ranking of collision risks of NEOs with the Earth shall be determined and updated at least once per day.

Possible mitigation studies will be undertaken, taking into account the results of previous activities (e.g. Don Quichotes Project).

The following activities will be undertaken during the SSA Preparatory Programme (2009 – 2011) in the area of NEOs

- Analysis and evaluation of existing assets for NEOs
- Definition of precursor services to be delivered in the area of NEOs
- Study of possible mitigation measures
- Architectural design of the required ground components
- Preparation for the inclusion of NEOs data acquired through planned missions (e.g. GAIA)

5 SSA System enabling activities

During the SSA Preparatory Programme, important activities in addition to those described in the Chapter 4 will be undertaken. They will enable the future SSA system to deliver the planned services in an appropriate political and technical frame.

The first set of activities will be part of the core element. They are related to the governance, data policy, data security and overall architecture of the SSA system.

The second set of activities will consist of bread boarding the essential components of the future radar system and is part of the radar element of the Preparatory Programme. This, together with complementary studies carried out through the GSTP and TRP Programmes will enable the future development of the radar system required for the Survey and Tracking function described in the Chapter 4.2.1 above.

Finally, prototyping activities of the future data centres will also be undertaken during the Preparatory Programme. This will allow precursor services to be already delivered after the initial three years of activities.

5.1 Governance, Data Security, Data Policy and SSA architecture

Under this topic, three types of activities will be undertaken:

a) Collaboration with participating States and the European Union relevant institutions in support of the definition of an appropriate Governance model for the future European SSA System

b) Development of data security requirements and data policy for the distribution of SSA data, taking into account the confidentiality requirements and international political considerations.

c) Architectural design of the complete SSA System, as well as specification and architectural design of new Data Centres, taking into account the developed data policy for the distribution of the SSA data. These Data Centres will be in charge of acquisition, processing, dissemination and possibly fusion of data, together with the associated delivery of services.

During the Preparatory Programme, the following specific activities will be undertaken:

- Consultations with relevant EU institutions and European Member States to support the development of an appropriate Governance model for the future European SSA System

- Development of a SSA Data Security and Data Policy including associated agreements with data providers in the areas of Surveillance & Tracking, Space Weather and NEOs
- Study and design of the overall European SSA System architecture taking into account international cooperation
- Consolidation of the requirements related to the Data Centres, including the functional requirements for the pilot Data Centres
- Establishment of a consolidated list of SSA services
- Architectural design of all the Data Centres
- Establishment of a consolidated list of standards for all the services related to the SSA System
- Coordination and foster cooperation with international partners.
- Establishment of Service Level Agreements for the procurement of services from the selected national and/or international assets
- Evaluation of a possible transfer of national assets to the European SSA system in the form of in kind contribution.

5.2 Radar system bread boarding

The development of the surveillance radar, foreseen to take place during the next phase after completion of the initial requirements consolidation and architectural design is a complex activity, relying on the availability of proven sub-systems.

The purpose of the Radar element is to initiate the activities related to essential radar subsystems, such as the antennas, the transmitters, the receivers and the signal processing chains. This will allow ensuring their future availability at the end of the SSA Preparatory Programme, in close collaboration with the GSTP and TRP study Programmes.

An important objective will be to achieve sufficient non dependency of these essential subsystems from non European industries. In addition, a pilot project aimed at the validation of the overall concept will be initiated.

In summary, the following two activities will be undertaken under the Radar element during the SSA Preparatory Programme:

- Development and bread boarding of the core components of the surveillance radar system.
- Validation of the correct functioning of these core elements through a pilot Project.

5.3 Prototyping of pilot data centres

The prototyping of the Data Centres resulting from the architectural design and functional requirements carried out in the core element of the SSA Preparatory Programme will be initiated in the pilot data centres element through a pilot project.

It will take into account the results of the Governance and Data Policy activities carried out in the core element.

The purpose of this activity will be aimed at the availability of pilot Data Centres at the end of the SSA Preparatory Programme, to enable the provision of precursor services defined in the Core and Space Weather elements.

Based on the outcome of the architectural design of the SSA Data Centres carried out in the core element, development of prototype software applications, as well as their test and validation in an operational environment will be undertaken

The following activities will be performed in the time frame 2009 - 2011:

- Prototyping of the Data Centre for Space Surveillance
- Prototyping of the Data Centres for the Space Weather element
- Development of prototype software applications
- Test and validation in a realistic operational environment

6 Conclusion

The Executive trusts that its Member States, as well as the relevant European institutions share the importance of establishing SSA as a priority action for Europe. In order to prepare for the full implementation of a European SSA capability, the current programme proposal covers the preparation of an initial operational capability able to deliver precursor services, while building up for a joint decision by the relevant European stakeholders regarding the full implementation of SSA beyond 2011, including its associated Data Policy, Data Security, Governance and business models.

The Council at Ministerial level in November 2008 will be a decisive event to assure that SSA starts to move forward. A well funded and strongly implemented SSA can serve the ambitious goals of Europe to become one of the most dynamic knowledge based societies in the world thus providing a favourable platform for Europe’s institutions, organisations, industry and scientists to maintain a leading edge in preserving the sustainable and peaceful exploitation of outer space while reinforcing global safety and security.

7 List of acronyms

DB	Data base
EC	European Commission
EDA	European Defence Agency
ESP	European Space Policy
ESPI	European Space Policy Institute
EU	European Union
EUMS	EU Military Staff
EUSC	European Union Satellite Centre (Torrejon, Spain)
GEO	Geostationary Orbit
GNSS	Global Navigations Satellite System
GSP	General Studies Programme (of ESA)
LEO	Low Earth Orbit
MEO-L	Low Medium Earth Orbit
MEO-H	High Medium Earth Orbit
MoD	Ministry of Defence
NASA	National Aeronautics and Space Administration
NEO	Near-Earth Object
NOAA	National Oceanographic and Atmospheric Administration
SSA	Space Situational Awareness
TAROT	Télescope à Action Rapide pour les Objets Transitoires
TIRA	Tracking and Imaging Radar
ZimLAT	Zimmerwald Laser Tracking
ZimSMART	Zimmerwald Small Aperture Robotic Telescope