The European SSA Preparatory Programme

5th meeting of the PECS committee

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What is Space Situational Awareness (SSA)?

The definition of the Space Situational Awareness (SSA) has been addressed in Europe by the SSA User Representatives Group (SSA-URG) during the time frame 2006 – 2008. The following was concluded:

Space Situational Awareness (SSA) comprises infrastructures and activities designed to provide knowledge, as well as timely and accurate data, information and services regarding:

(i) man-made objects in orbit,
(ii) the space environment and
(iii) natural objects near the Earth, as well as the associated threats and risks to European space activities and human life and property on the ground.

What are some of the threats that SSA seeks to identify?

There are three types of threats identified:

- First, any possible effects on Europe's space infrastructure, such as scientific, observation, telecommunication, navigation or weather satellites, due to in-orbit collisions or adversarial use of space.
- Second, any possible disruption or damage to space or ground infrastructure (satellites, power grids, networks, telecommunications, control systems) stemming from the space environment, such as radiation from solar storms.
- Third, the threat to human safety on the ground and in airspace posed by the growing population of space debris or by Near-Earth Objects (NEOs) upon atmospheric entry.

An increasingly crowded environment

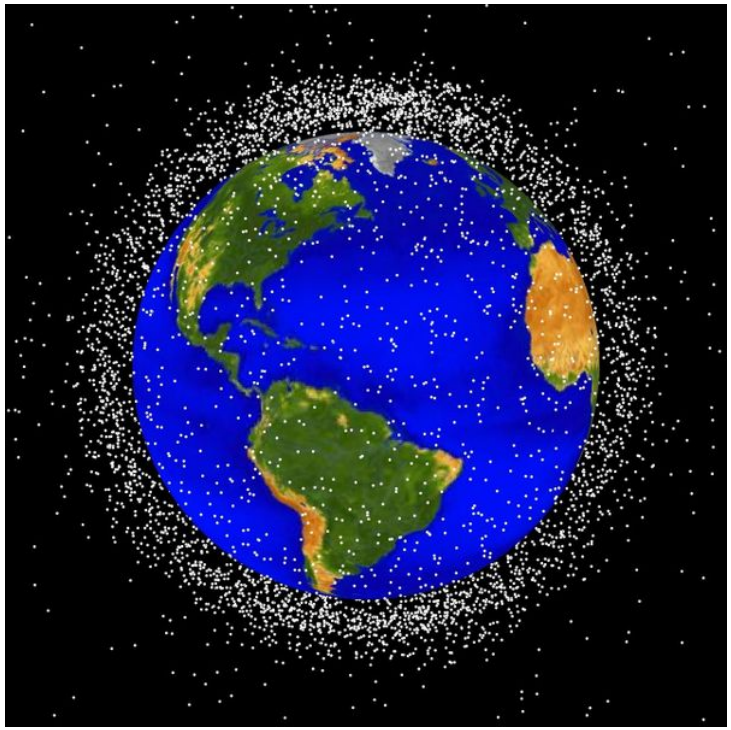
The estimated number of man-made objects in orbit, together with their main chracteristics (size, observability, distribution) has been summarized in a dedicated catalogue (ESA Master catalogue).

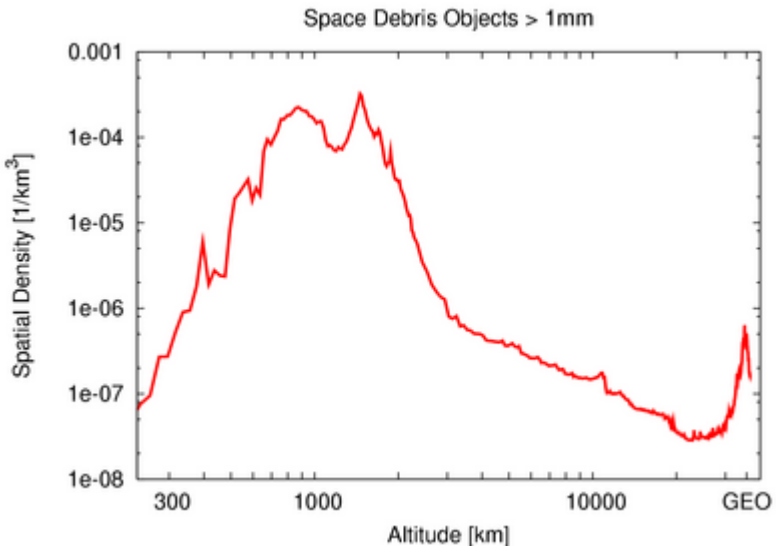
space objects larger than d [cm]		LEO		MEO-L	MEO-H	MEO-H & GEO	GEO
d [cm]	count	res.[%]	trans.[%]	res.[%]	res.[%]	trans.[%]	res.[%]
100	4,658	50.0	17.5	0.9	4.5	7.1	20.0
50	6,549	52.3	18.1	2.7	3.7	7.0	16.2
30	9,091	56.6	16.5	2.2	3.3	7.2	14.1
10	20,505	54.2	13.6	1.0	3.9	10.7	16.4
5	44,092	48.6	13.5	0.5	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		

Size, distribution and observability of space objects (MASTER 2005)

An increasingly crowded environment (cont.)

The analysis of the density distribution of space debris as a function of altitude shows that they are mostly concentrated at altitudes below 3000 Km with a local peak around GEO.





The need for greater situational awareness in space – who will use the SSA data and information?

SSA Services will ultimately be used by a wide range of customers, which could Include institutional and commercial entities:

- **European governments (EU, national, regional)**
- **European space agencies**
- **Spacecraft operators - commercial, academic and governmental**
- **Academic and research institutions**
- **Space insurance and space industry**
- **Energy industry, including surveying, electricity grid operators, electrical power suppliers**
- **Network operators, telecommunication operators, radar system operators, space weather service providers, etc.**
- **European and other air traffic control and navigation service providers**
- **European and international rescue and disaster-response authorities**
- **United Nations and other international bodies**
- **Defence sector/defence security**

An overview of ESA's SSA Proposal
Initials steps in establishing a European SSA System

- **Initial studies:** ESA has performed in 2006-2008 several industrial studies, the outcome of which was:
  - the compilation of a SSA Users' Needs list (established by a selected group of Users Representatives)
  - The translation of these needs into technical requirements
  - the identification of high level architectural options
  - the identification of potential technological gaps

- **SSA URG important role:** A Users' representatives group continuously supports ESA in this initiative. The Group is composed by representatives of EU Military Staff, EDA, EC, Ministries of Defence of ESA MSs, by National Space Agencies of I, F, UK, E, D, B, N, CH, by the UN-WMO, by commercial operators (e.g. Inmarsat, Eutelsat) and insurance companies. This User's Group will continue its advisory role during the execution of the SSA Programme.

An overview of ESA's SSA Proposal
Objectives and general context

- The objective of the Space Situational Awareness (SSA) initiative is to support the European independent utilisation of and access to space (SSA Programme Declaration). The first phase is the SSA Preparatory Programme and covers the period 2009 - 2011

  - 2009 - 2011 : Governance, Data Policy
    Requirements, architecture of the future European SSA system, delivery of precursor services
    radar bread boarding, pilot Data Centres

  - Phase 2 (2012 – 2019): Implementation of a fully operational European SSA system

- The first part of this Programme, the **SSA Preparatory Programme**, has been approved at the ESA Council at ministerial level (MC 2008), in November 2008.

- The second part of this Programme, the **SSA-Phase 2,** will be prepared during 2011, taking into account the results of the SSA Preparatory Programme, and is planned to be submitted to the approval of ESA Member States at the MC2011 (tbc). It will cover the timeframe 2012-2019.

An overview of ESA's SSA Proposal
The three domains of the European SSA system

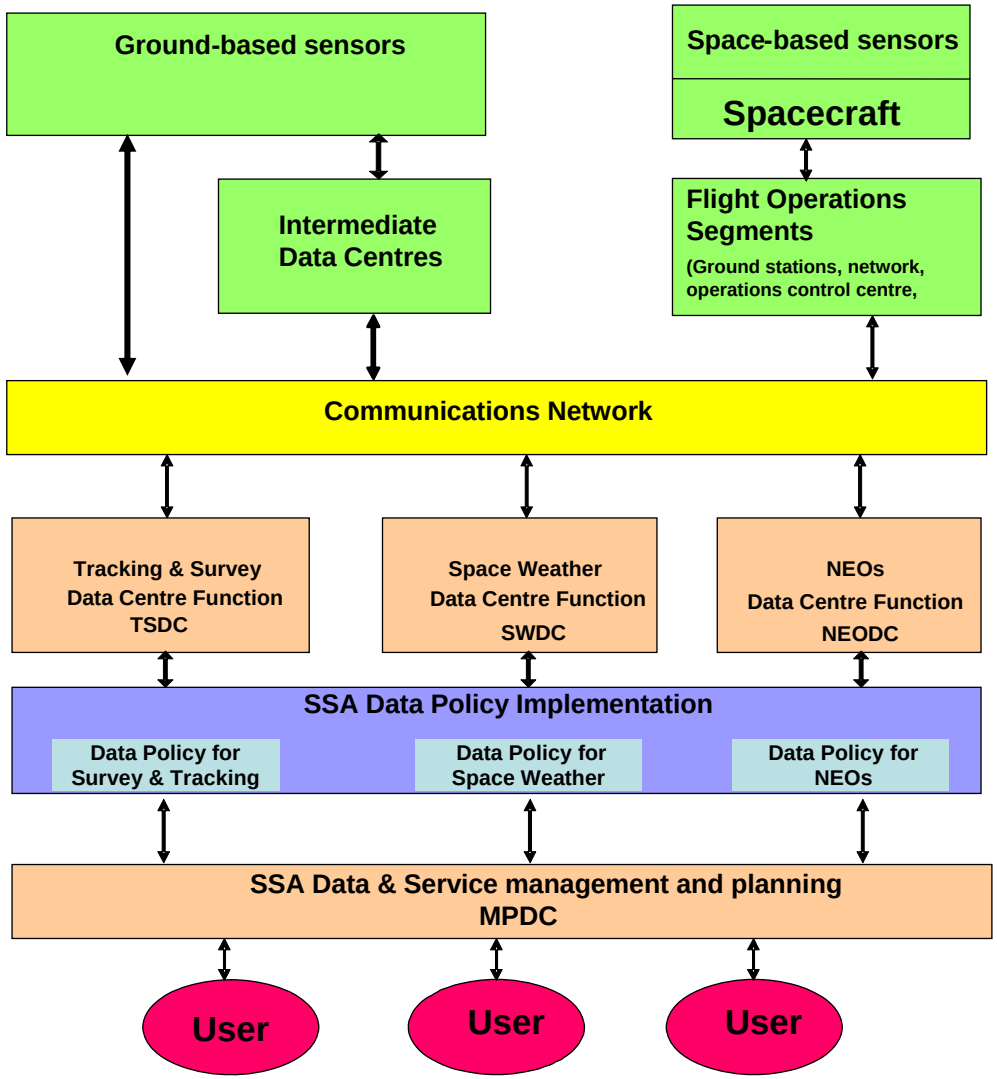
The European SSA System can be broken down in three distinct domains:

a) **Space surveillance** of man-made objects in Earth-bound orbits
b) **Space Weather effects** (e.g. solar radiation)
c) **Near Earth Objects (NEOs):** hazardeous asteroids and comets

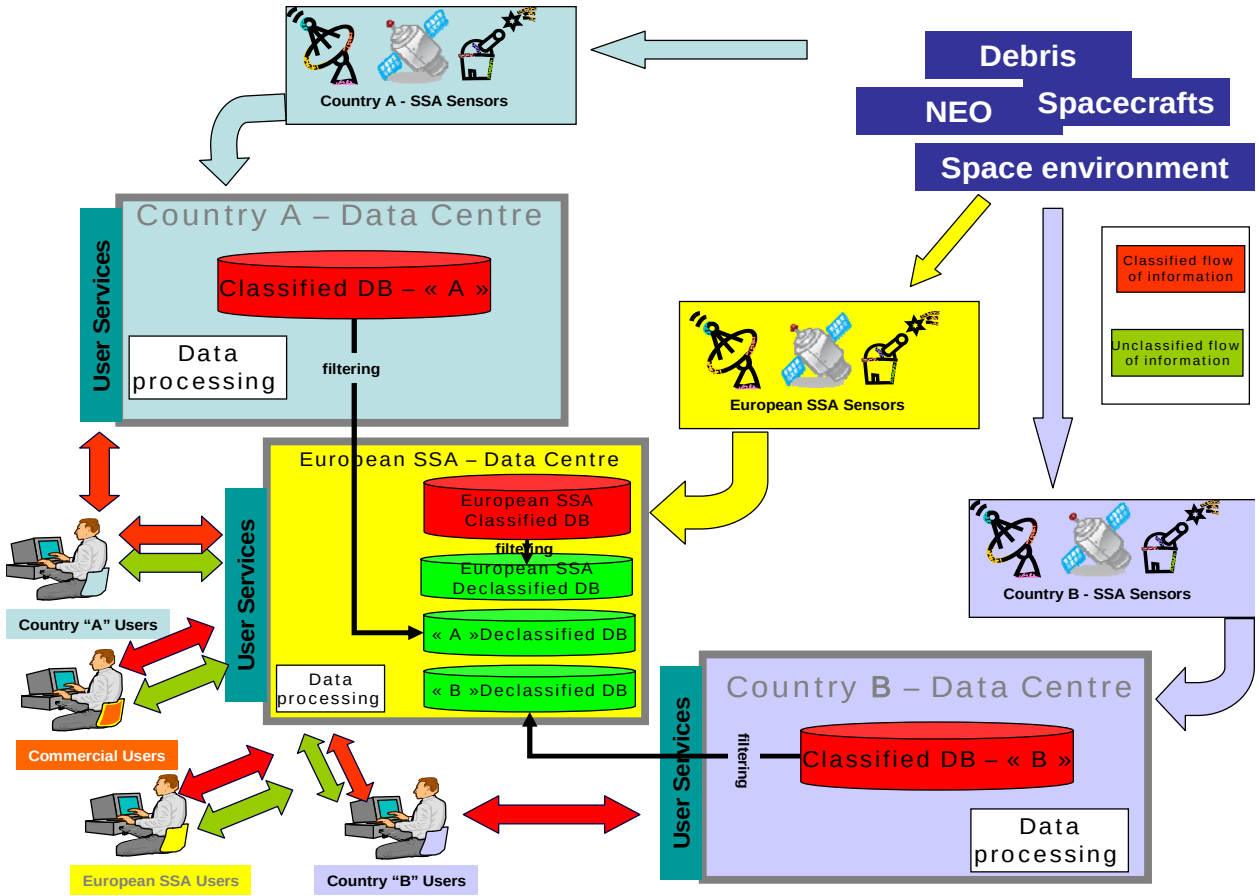
During the preparatory Programme (2009 – 2011), the overall architecture of the Surveillance, Space Weather and NEOs domains will be addressed taking into account the required data policy and data security requirements.

The implementation of the European SSA system will be executed taking into account the existence and availability of National SSA assets (federation of assets) as well as the selected governance model.

An overview of ESA's SSA Proposal
Functional view



An overview of ESA's SSA Proposal multi-access to sensitive SSA data



An overview of ESA's SSA Proposal
Breakdown of the SSA Preparatory Programme

The MS Delegations requested the SSA preparatory Programme to cover 3 years (2009 – 2011), and be split in four elements:

a) **Core element** (Governance, Data Policy, Data Security, SSA general architecture, Space Surveillance precursor services)

b) **Space Weather element** (including some NEOs activities)

c) **Radar element** (bread boarding of essential radar sub-systems), in close coordination with ESA's technology Programmes such as the TRP and GSTP – Enabler of the core element

d) **Pilot Data Centres element** (prototyping of the required Data Centres). This is an enabler of the core and Space Weather elements.

An overview of ESA's SSA Proposal
Financial breakdown per element

The following subscription level has been reached at the MC 2008:

- Core element:	20.2 MEUR
- Space Weather element:	11.4 MEUR
- Radar element:	8.2 MEUR
- Pilot Data Centers element:	10.1 MEUR
TOTAL:	49.9 MEUR (@2008 e.c)

11 ESA Member States are participating to the SSA Preparatory Programme:

Austria, Belgium, France, Germany, Greece, Italy, Norway, Portugal, Spain, Switzerland, UK

An overview of ESA's SSA Proposal
Space surveillance services

The following services are foreseen to be delivered in the area of Space Surveillance once the system becomes operational:

- Detection and Tracking of objects in Earth-bound orbits (LEO, MEO, GEO, HEO)
- Identification and correlation of tracked objects
- Establishment of a catalogue
- Tasking of radar and optical sensors for follow-up observations
- During the development / prototyping phase, distribution of optical and radar tracking data, according to an agreed Data Policy
- Identification of high-risk conjunctions between tracked objects, issue of alerts and recommendations for avoidance manoeuvres
- Prediction of high-risk re-entry events and initiation of alert procedures
- Detection of on-orbit explosions or collisions and issue of alerts
- Study of possible mitigation actions

An overview of ESA's SSA Proposal
Sensors that could be used in the SSA system

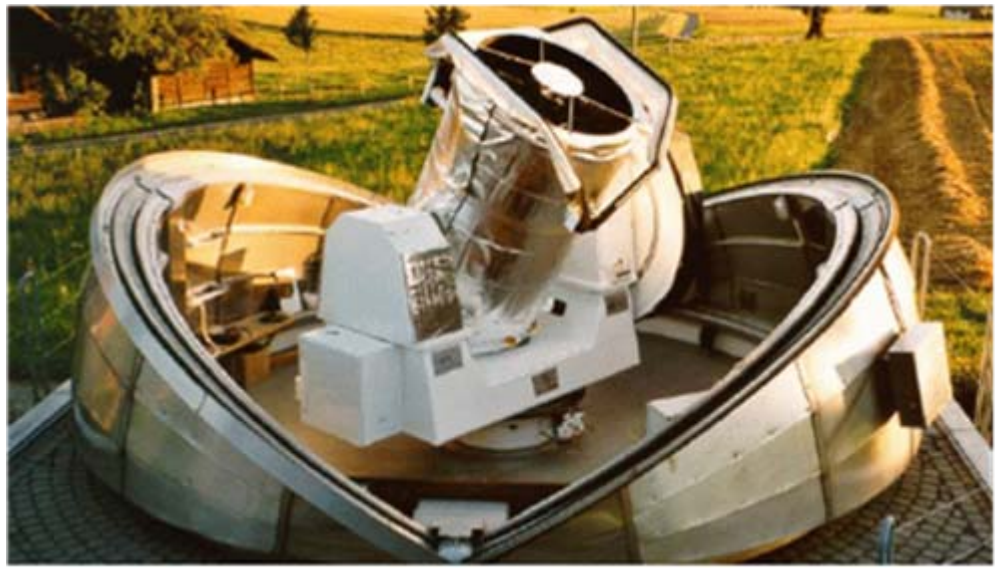
Sensors for surveillance and tracking:

Graves (France) – Bi-static surveillance radar

An overview of ESA's SSA Proposal
Sensors that could be used in the SSA system

Sensors for surveillance and tracking (cont.):

FGAN (Germany) – tracking radar



Zimmerwald (Switzerland)
Tracking telescope

An overview of ESA's SSA Proposal
Sensors that could be used in the SSA system

Sensors for surveillance and tracking (cont.):

ESA – Optical Ground Station (OGS) – Tenerife, Spain

An overview of ESA's SSA Proposal
Space weather services

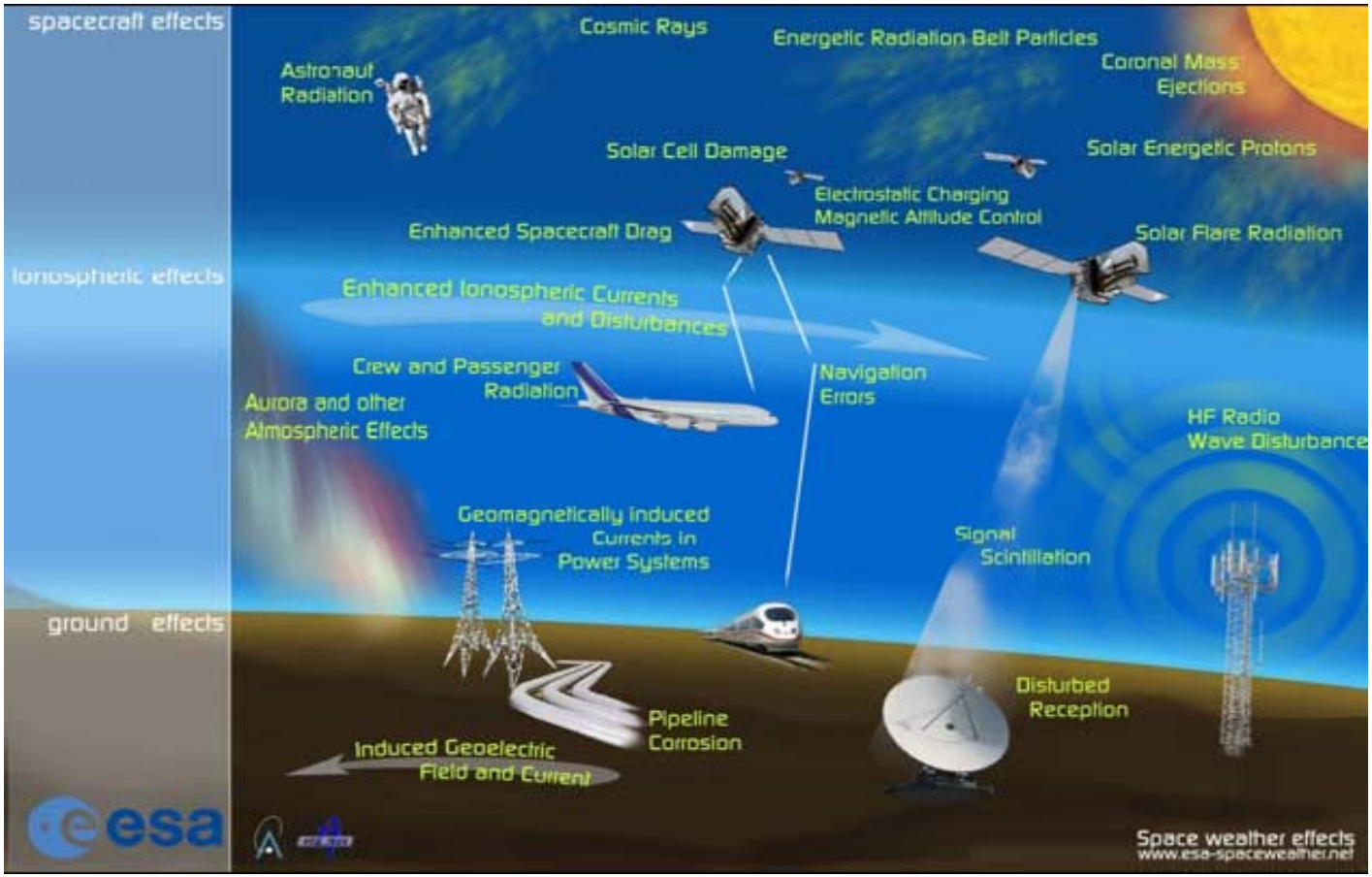
What is Space Weather about? Effects of the sun, of the solar wind, solar flares, status of magnetosphere, ionosphere and thermosphere, cosmic radiation. Effects on the space and ground infrastructures.

Space Weather services

- Spacecraft and payload operations' radiation protection.
- Thermosphere modelling for spacecraft drag calculation
- Launcher radiation protection for operations
- Space environment modelling for spacecraft design
- Human space flight radiation protection
- Ionospheric interference for navigation satellite signals
- Space environment modelling for SSA survey and tracking

An overview of ESA's SSA Proposal
Space weather services

Space and ground infrastructures affected by Space Weather:



An overview of ESA's SSA Proposal
NEOs services

What are the NEOs ? These are asteroids and comets that represent a risk of collision with the Earth. (Earth's orbit crossing at a distance < 45 Millions KM)

What is the number of NEOs ? Approximately 6000 are known, for a total estimated at more than 66,000.

Services in the domain of Near Earth Objects (NEOs)

- Detection and tracking of all NEOs above a given size or risk threshold
- Determination of the orbit state
- Identification and ranking of NEO collision risks with the Earth
- Production of warnings about potential NEO impacts
- Provision of liaison between observers, data analyzers and government services.
- Study of possible mitigation measures

An overview of ESA's SSA Proposal
Effect of a NEO impact with the Earth

- The impact of an asteroid on the Earth at a speed between 15 and 30 Km/s has a devastating effect due to the release of an enormous kinetic energy: blast waves, tsunamis, atmospheric and electromagnetic changes

- The amount of energy released can be significantly higher than generated by the most powerful nuclear bombs, and will depend on the size of the asteroid colliding with the Earth.

NEO diameter	MT*	Average interval
75 m	10 to 100	1,000 years
350 m	1,000 to 10,000	16,000 years
3 Km	1,000,000 to 10,000,000	1,000,000 years

- *** MT: Explosive power of 1 Mega Tonne of TNT**
- **The Hiroshima bomb had an explosive power of 15 KT**

An overview of ESA's SSA Proposal
Tunguska event in Siberia (1908)

- The 1908 explosion in Siberia was most likely caused by the air burst of a large meteoroid or comet fragment at an altitude of 5 – 10 Km above the Earth.
- The size of the object has been estimated at 50 – 80 m
- Estimates of the energy of the blast are in the order of 10 – 15 MT, which is 1000 times the energy released by the Hiroshima nuclear bomb !
- An area of ca. 2000 sq. Km has been destroyed by this explosion.

Managing international cooperation in SSA

- During the first year of activities (2009), the cooperation continues with the US (State Department, US-AF, NOAA, NASA) due to historical links and existing cooperation in many areas. Workshops and conferences are planned to take place on a regular basis involving also other European institutions (EC, EU-Council, EDA).
- It is also of strategic importance to also extend SSA cooperation to other Space Powers as discussed during a recent EC – ESA Workshop on SSA.
- Consequently, as the European SSA System grows, international cooperation in the SSA domain is planned to be developed with other Space Powers (e.g. Russia, China, India, Japan).

Adhesion to the SSA Programme by an ESA MS

- The rules for the adhesion to the SSA Programme are set in the Article 11 of the SSA Programme Implementing Rules

- Any ESA MS that has not subscribed to the SSA Programme Declaration may become a participating State on the approval of the other participating States

- For this purpose, it has to subscribe to the terms of the Programme Declaration and accept the Implementing Rules

- The government concerned shall notify its intention to become a participating State to the ESA DG, who shall propose it for decision to the participating States