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A European approach to Space Situational Awareness

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DEFINITIONS

“Space surveillance” can be defined as the routine, operational service of detection, correlation, characterization, and orbit determination of space **objects**.

(Task Force on Space Surveillance BNSC, CNES, DLR, ESA)

“Space Situational Awareness (SSA)” can be preliminarily defined as a comprehensive knowledge of the population of space **objects**, of existing **threats/risks**, and of the space **environment**.

(User Expert Group of ESA SSA requirement study)

An overlap exists, but SSA implies more in terms of data processing and use. A demand for SSA exists on European Level.

NEED FOR EUROPEAN SSA

- As we are well aware, space assets have become indispensable enablers for a wide spectrum of applications. The European independent utilisation of space for research or services depends on the capability to safely operate the European space infrastructures.
- Space based capabilities are indispensable to realise this commitment in an effective manner . The dependency on these space based assets will grow, as evident also outside Europe.
- But, this dependency raises concerns, because any shutdown of even a part of the space infrastructure would have major consequences for economic activities and would considerably impair the organisation of emergency services.
- Space Situational Awareness can be seen by Member States as a basis for any future measures (political, diplomatic, regulatory, technical) to guarantee access to space: indeed the driver for SSA is the consequence of interruption of space services; it is important to note that this disturbance is not exclusive related to space debris.

- Space Traffic Management, Confidence Building Measures, Rules of the Road in space are some of the most recent themes under discussion in the UN context (COPUOS and UN-DC) supported by an SSA capability.
- **SSA** is an essential element in the ESDP answers to an existing demand and builds on existing ESA's competences
- ***“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”***

(from the conclusions of the Workshop on security and arms control in space and the role of the EU – Berlin, June 2007).



ESA's initiative supporting the establishment of a European SSA

- Using funds from its General Budget, ESA has initiated in November 2006 three parallel industrial studies whose main objectives are:
 - To support the compilation of a SSA Users' Needs list (established by a selected group of Users Representatives)
 - To translate these needs into technical requirements
 - To design high level architectural options able to respond to those list
 - To identify potential technological issues
- At the end of 2006, the Agency set up an SSA Users Group representing the full spectrum of potential SSA user communities (civil, military, commercial operators, national space agencies, insurance companies, scientific community, defence intelligence, EC, EDA, etc.) and providing guidance on the definition of the needs and of the requirements.
- It should be noted that this first-of-its-kind European space civil-military platform/forum, under the chairmanship of ESA, is fully consistent and in line with the recommendations and the key implementing actions of the European Space Policy released this year.

SSA is the understanding and maintained awareness of

- (a) the Earth orbital population,**
- (b) the space environment, and**
- (c) possible threats.**

(a) Earth orbital population

- **Detection and/or tracking of man-made objects (e.g. US SSN Catalog, comprising spacecraft, rocket bodies, mission-related objects, and fragments)**
- **Identification and characterization of detected objects (e.g. launching nation, owner, operator, object status and function)**
- **Determination of orbit state and covariance information**
- **Identification of spacecraft manoeuvres**
- **Determination of spacecraft attitude**
- **Determination of antenna/instrument pointing**

(b) Space environment

- **Detection and/or tracking natural objects (e.g. near-Earth objects (NEO))**
- **Detect and understand man-made, induced environment**
- **Detect and understand interferences**
- **Forecast space weather and its effects**
- **Predict the natural particulate environment and its effects (meteoroids)**

(c) Possible threats

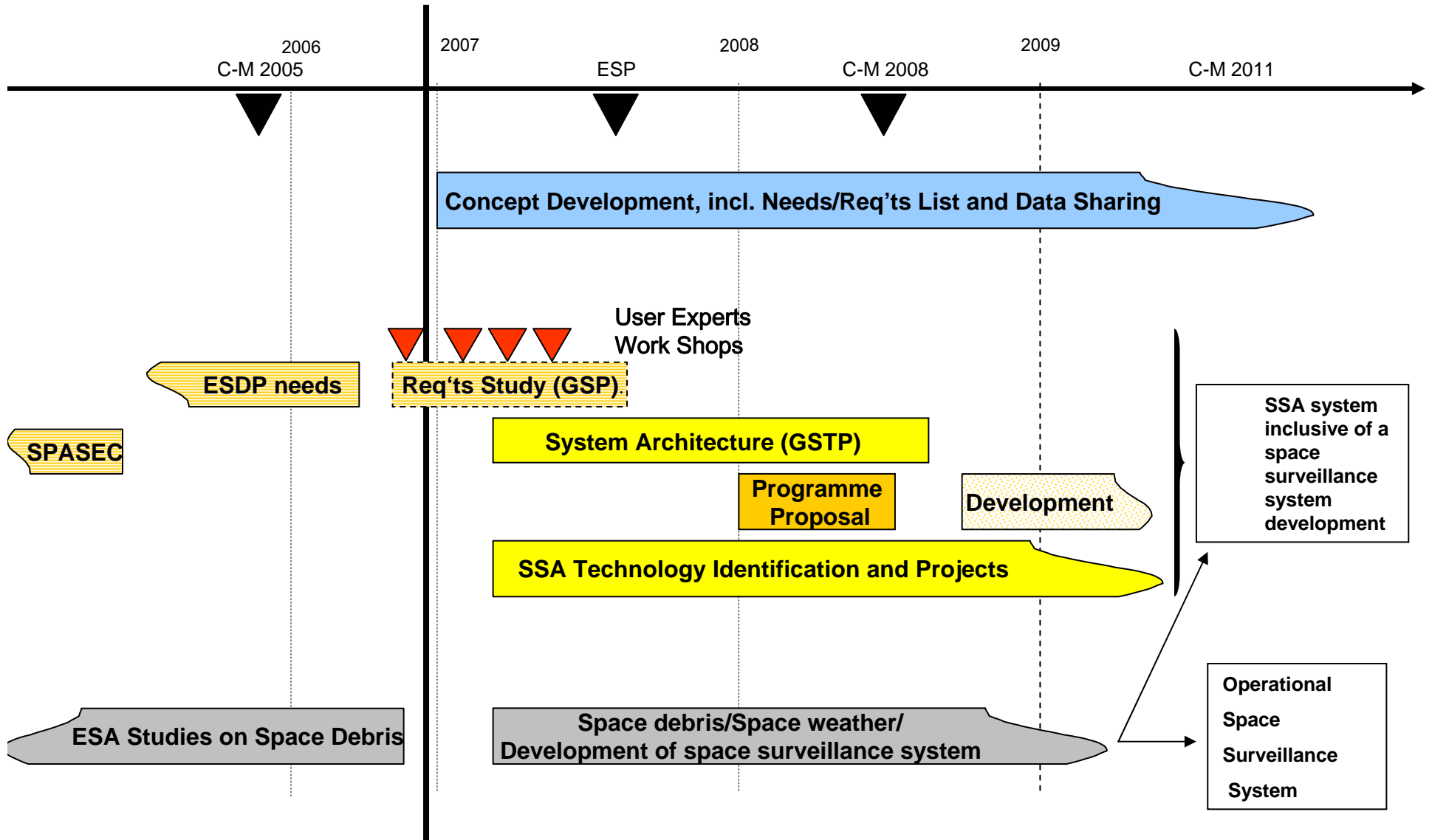
- **Predict and assess the risk to humans and property on ground and in air space due to re-entries**
- **Detect and assess adversary use or preparations for adversary use of or upon space systems (e.g. ground- or space-based)**
- **Detect on-orbit explosions and release events (accidental or intentional)**
- **Predict and/or detect on-orbit collisions (accidental or intentional)**
- **Predict and/or detect permanent or temporary disruption of mission and/or service capabilities**



ESA's initiative supporting the establishment of a European SSA

- ESA will soon initiate SSA detailed architecture and technological studies based on these requirements (GSTP framework): start of activities before end 2007.
- In parallel, ESA, supported by the users' group, (and also in cooperation with ESPI) needs to address issues as data policy, governance, international cooperation, business model, cost-benefit analysis, business models, etc.
- These two parallel elements will represent the components of a programme proposal for the next C-M 2008 encompassing SSA initial requirements within a Space Surveillance System.

PREPARATION OF SSA



HIGH-LEVEL SSA OBJECTIVES

Provide to the users verifiable, dependable, accurate and timely information in order to:

- Identify non-compliance with relevant international treaties and recommendations
- Enable the assumption of responsibility (e.g. as launching state, owner, or operator), and support confidence building measures
- Support safe and secured operation of space assets and related services
- Support risk management (on orbit and during re-entry) and liability assessment
- Assess the functional status and capabilities of space systems

Information must be provided with integrity, with an architecture enabling the implementation of a data policy, based on an autonomous European SSA system.

For what concerns the objectives of a European SSA, according to the agreed definition and scope, the following areas of activities contributing to the goal of achieving a complete Space Situational Awareness were identified:

- **Survey and Tracking,**
- **Imaging,**
- **Space weather**

SSA industrial studies preliminary results

- The assessment of the **high-level architectural options** presented by the three industrial consortia on 16 and 17 July 2007 (more than 45 participants from all over Europe) in the framework of the GSP study on SSA capability gaps is currently on-going; nevertheless some general considerations can be already tabled.
- The SSA capability gaps were evaluated as the results of functional and performances gaps. The full list of identified technological gaps represents an input for the follow up GSTP study.
- The main SSA candidate architectures and possible sensors for each option, function and orbit, are synthesized by 3 main architectural options:
 - mainly ground based,
 - mainly space based and
 - a mixed scheme.

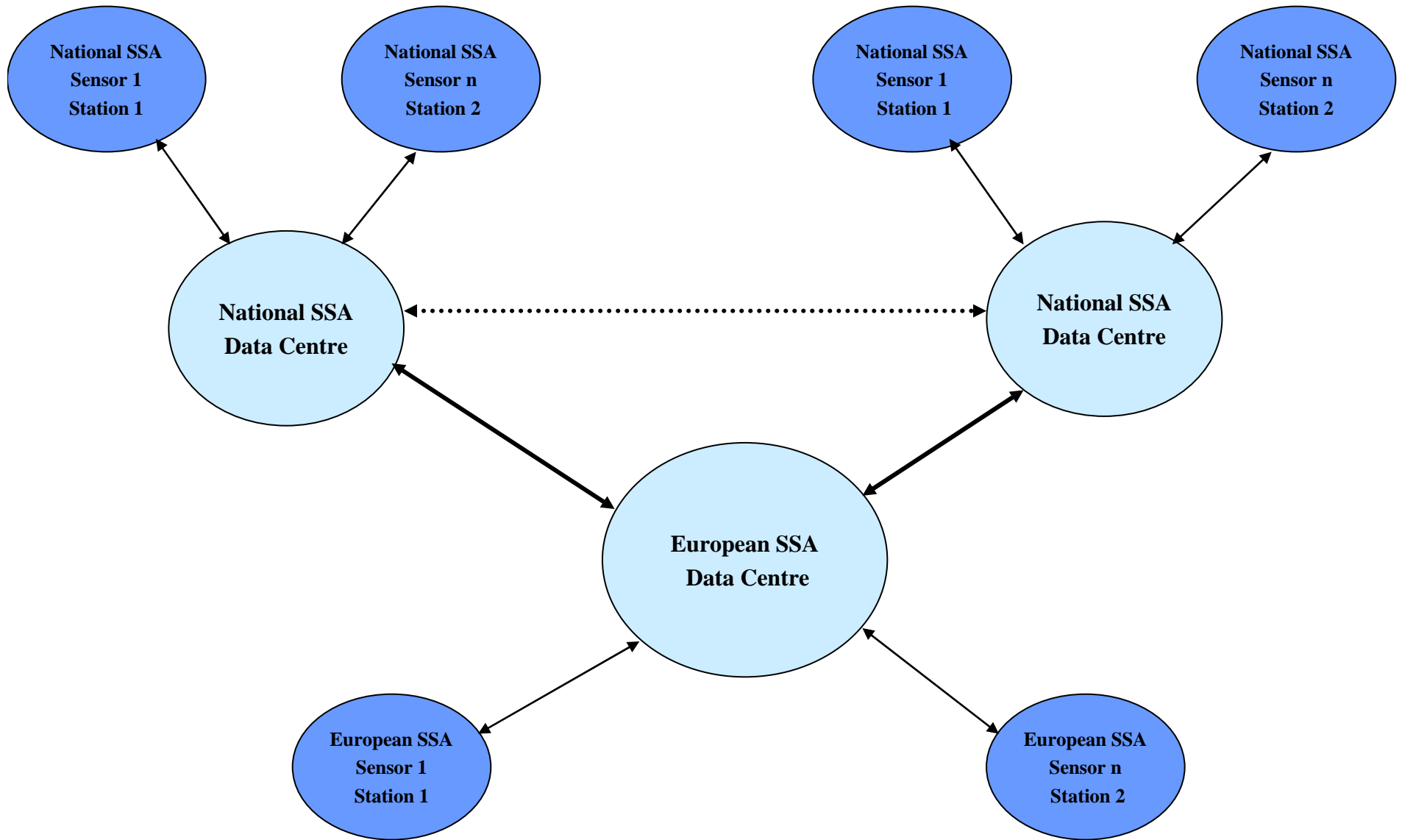
Examples of potential architectural options

| | Survey sensor | | Tracking sensor | | Imaging sensor | | Telemetry sensor | | Space environment survey | | |
|-------------------|--|--|-----------------|--|----------------|---|--|------------|--|---------|--|
| Function | MF1 | | MF1 & 3 | | MF1 & 3 | | MF1 & 3 | | MF2 & 3 | | |
| Orbits | LEO | Non LEO | LEO | Non LEO | LEO | Non LEO | LEO | Non LEO | LEO | Non LEO | |
| Option 1 | UHF radar | 4 sites + telescopes | L band radar | 4 sites + telescopes | Ku band radar | Satellites + slice telescope | RF antenna | RF antenna | Detectors on SSO, MEO, GEO, (GTO or HEO) | | |
| Option 2 | UHF radar | 1 to 8 satellites 2 to 4 sites+telescopes | L band radar | 1 to 8 satellites 2 to 4 sites+telescopes | Ku band radar | Satellites + slice telescope | RF antenna | RF antenna | Detectors on SSO, MEO, GEO, (GTO or HEO) | | |
| Option 3 | UHF radar | 1 to x satellites | L band radar | 1 to x satellites | Ku band radar | Satellites + slice telescope | RF antenna | | Detectors on SSO, MEO, GEO, (GTO or HEO) | | |
| Non-sensor issues | Unified data processing for autonomous cataloguing space objects | | | | | | | | | | |
| | | | | | | Unified data processing for autonomous characterizing space objects | | | | | |
| | | Unified data processing for autonomous cataloguing space objects | | | | | Unified data processing for related space environment services | | | | |

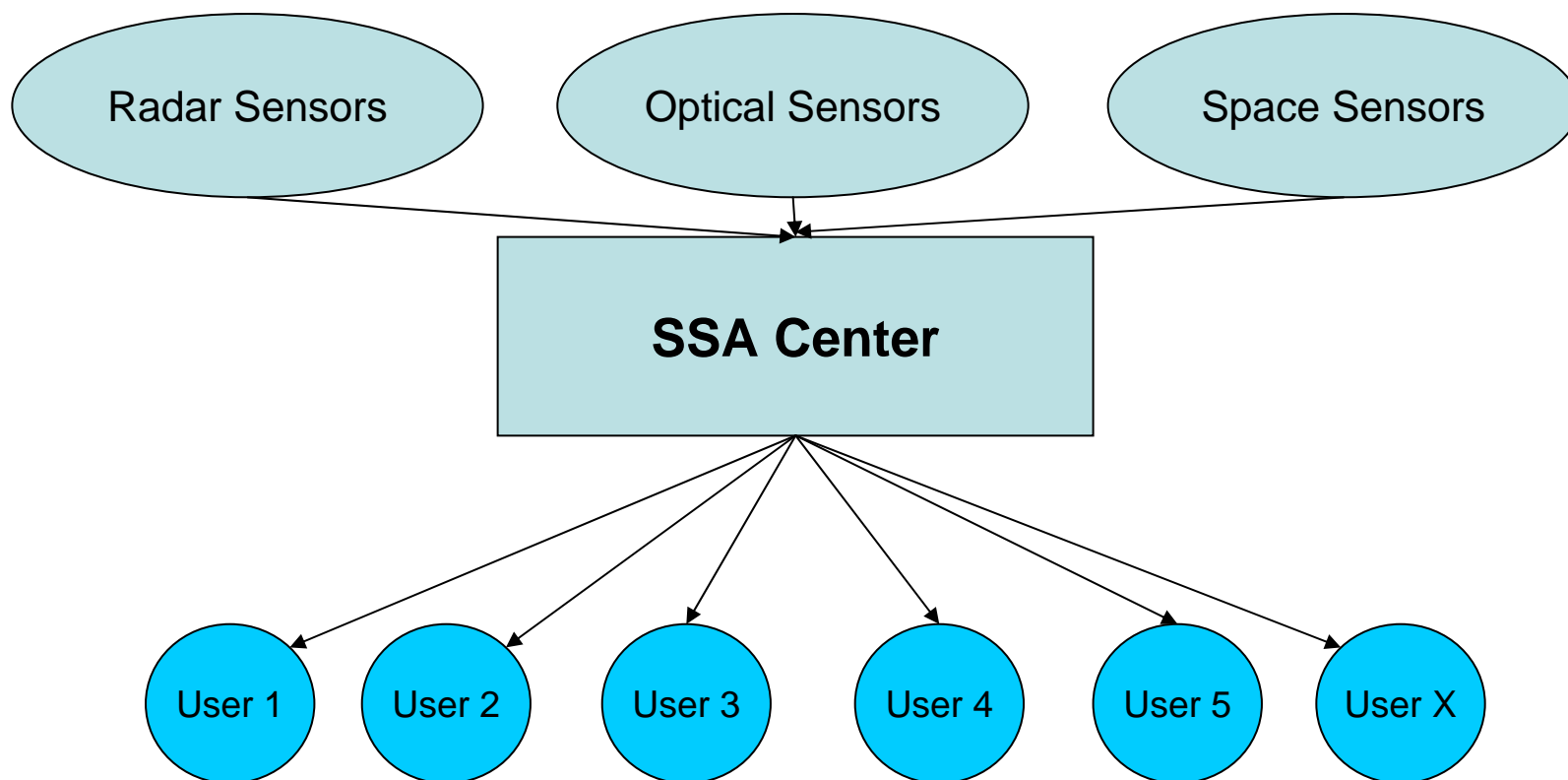
 Space-based solution

 Ground-based solution

European SSA Cooperation scheme



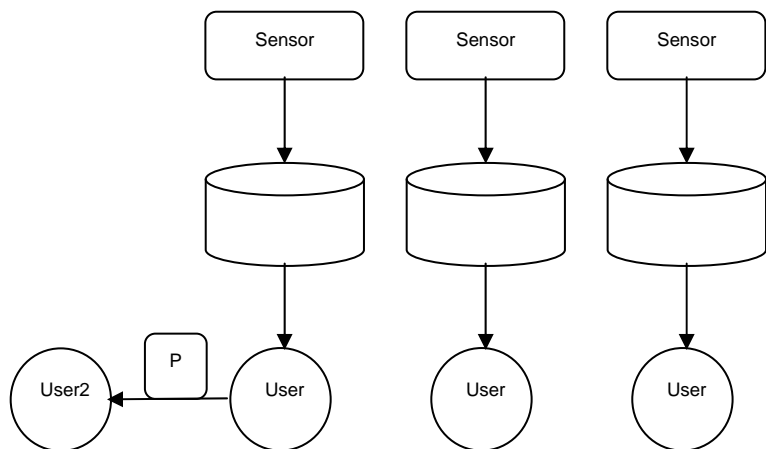
EUROPEAN SSA – A SYSTEM OF SYSTEMS



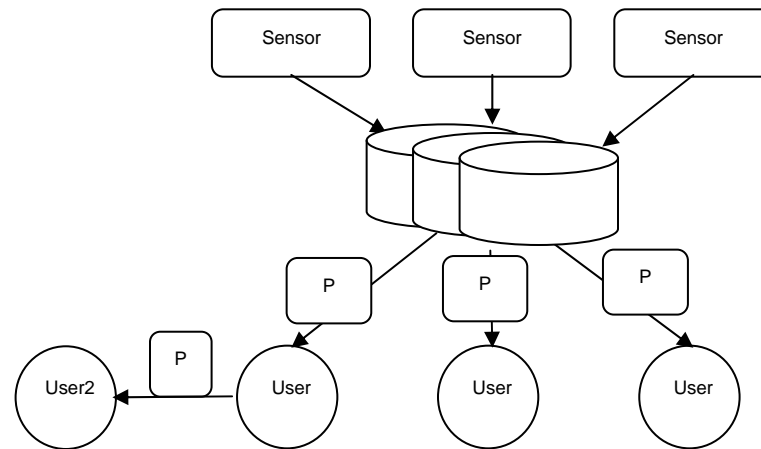
Key for the success of SSA realisation is a concept based on agreed European needs/requirements and data sharing policy.

System architecture options

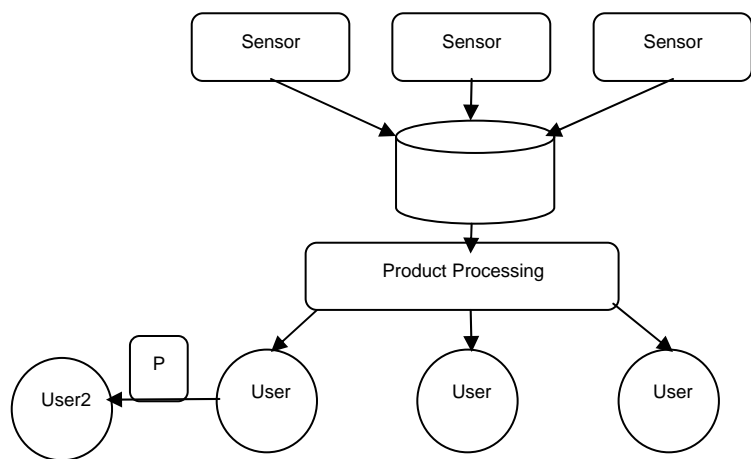
Current Situation



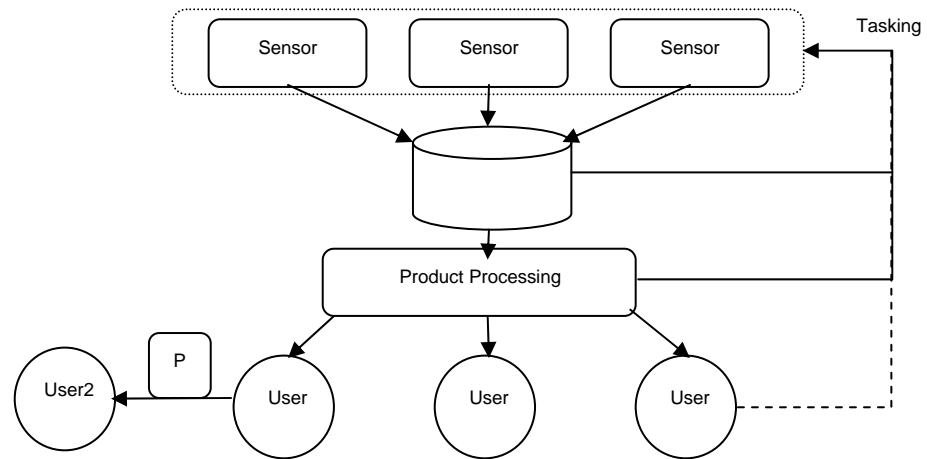
Shared Data Environment



Product Suite



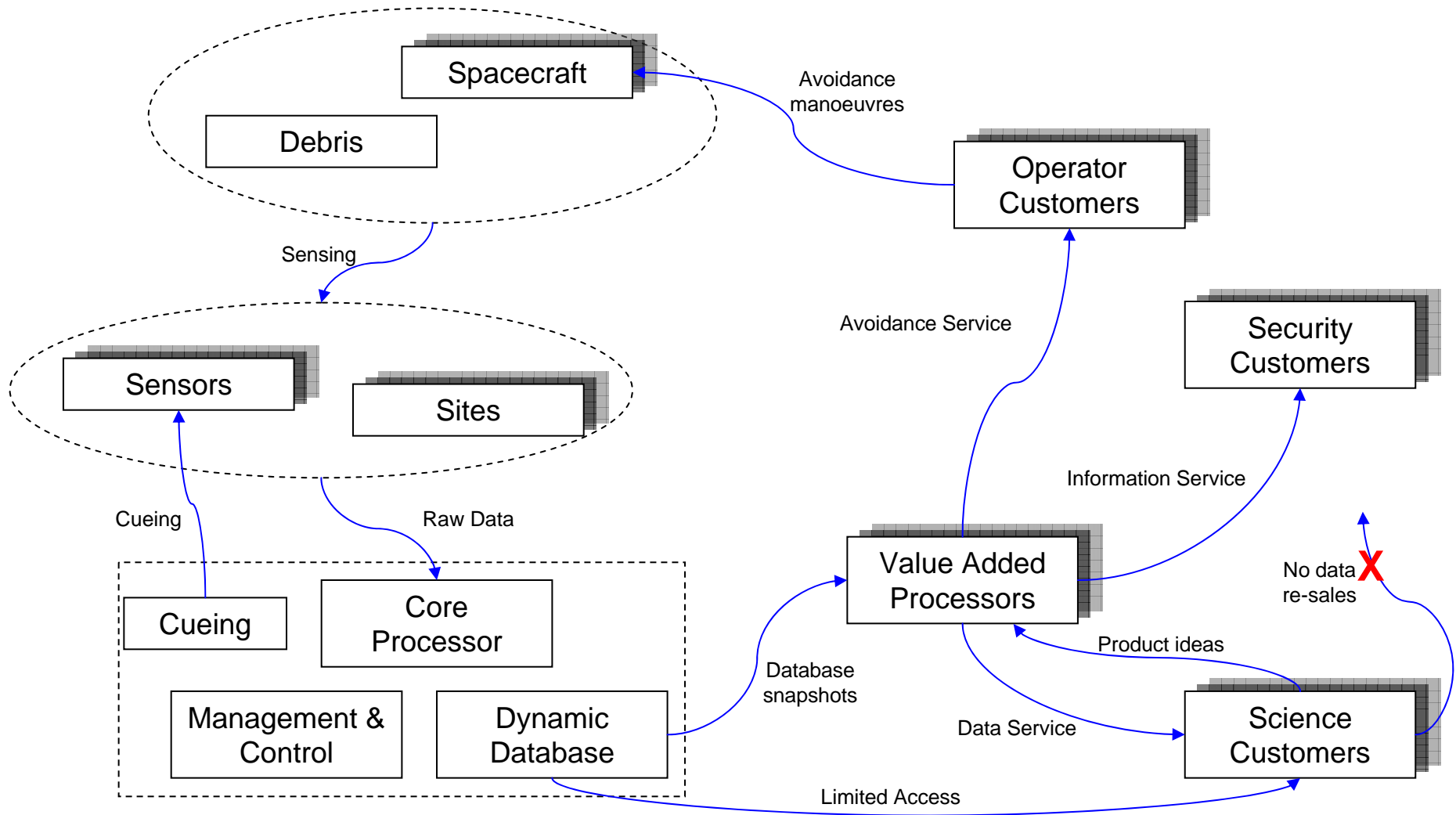
Integrated System



Data policy issues

- The models foresees (selective) data exchange both in raw and in processed format. A crucial role will be played by system interoperability, requiring among others standardized interfaces. The decision what data is released for exchange (put alternately, what data is retained) is taken by the sensor operator, following common rules laid down beforehand.
- The handling/processing stage comprises all institutions concerned with processing, calibration, refinement, archiving, etc., and a variety of actors like military, agencies, public institutions or even private companies will be involved. Beyond this stage, data format / product standardization is more difficult to achieve than at the raw data stage.
- In more detail, specific complementary functions (CFs) related to the data policy have been preliminarily identified:
 - CF1 : Comply with Data Policy Rules.
 - CF1.1 : Maintain non classified data of orbital parameters information
 - CF1.2 : Maintain non classified data of space environment information
 - CF1.3 : Manage prioritized data acquisition
 - CF2 : Comply with Resources Sharing Principles.
 - CF2.1 : Manage data format exchange between the system and the contributing sensors or the contributing sources of information.

Sensors, Investors and Customers – Overview example



Possible way forward

- The proposal for the initial phase that could be submitted to the next ESA MC 2008, is represented by the development of a basic kernel of activities aimed at providing Europe with an initial and credible capability in each of the three domains of SSA (survey/tracking, imaging, space weather).
- Being a detailed technical assessment still on-going and specific discussion with Member States not yet started, the possible configuration described today is susceptible to be updated accordingly in the next months. Nevertheless at this stage a possible set of ESA activities could include:
 - the development of precursor services in order to catalyse the users interests (via the federation of the available European ground assets and the cooperation of available space segments),
 - the deployment of ground infrastructures for achieving initial European autonomous SSA capabilities,
 - the definition of space assets and the development of enabling technologies under NewPro
 - the in-orbit demonstration, via dedicated or opportunity missions,
 - the later deployment of operational space-based sensors for high-definition imagery/characterisation of space assets and space weather prediction
- Such initial kernel might already offer Europe a substantially increased capability compared to the current available service supplied free-of-charge by the US.

Possible way forward

- Once the feasibility and benefits of this initial capability are assessed, phases following thereafter are proposed to install and refine/improve the European SSA by adding additional modules with increased performances and capabilities.
- A reflection on the role of ESA in this context must also take into consideration the handover of responsibilities to an operational entity or to cooperating entities for the purpose of its exploitation, the definition of which in terms of governance and funding (pre-operational and, above all, operational), i.e. business model, should occur shortly enough to provide solid ground for the corresponding investment from Member States in infrastructures.
- In this deployment strategy, the Agency could adopt a modular or spiral development/procurement type of approach, where the SSA architecture is delivered in its *Initial Operational Capabilities* status, while further development activities run in parallel. A reflection on the role of ESA in this context must also take into consideration the handover of responsibilities to an operational entity or to cooperating entities for the purpose of its exploitation.