ESA Space Situational Awareness services related to spacecraft charging

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• Needs
• Today’s approach
• Future: ESA Space Situational Awareness programme
Charged particle interactions with space systems

- **Instrumental:**
  - Detection of particles and fields
  - Remote sensing
  - Propulsion

- **Detrimental:**
  - Contamination and interferences
  - Electrostatic discharges
  - Radiation effects
How to address them

• Orbit optimisation
• Protection
• Space weather monitoring and feed-back of information into operational processes
## Needs

<table>
<thead>
<tr>
<th>Service needs</th>
<th>End users</th>
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<tbody>
<tr>
<td>Statistical specification of the space plasma environment or of effects</td>
<td>Development, Operation planning</td>
</tr>
<tr>
<td>Real-time information on environment or on effects</td>
<td>Operators</td>
</tr>
<tr>
<td>Reconstruction of the state of the plasma environment for event analysis</td>
<td>Development, Operators</td>
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<tr>
<td>Forecast of the plasma environment</td>
<td>Operators</td>
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Today’s approach

• Seek data from various sources e.g. (science programme)
• Use adhoc monitors in support to missions.
• Develop and operate models that are often r&d prototypes.
Data from solar-terrestrial missions

- Ulysses: out of the ecliptic solar observation
- SOHO: solar monitoring
- Cluster: magnetospheric dynamics
- Double star: magnetospheric dynamics
- To come: SWARM: low altitude magnetosphere; Solar orbiter; etc…
Examples of SWE available Resources

- ESA/NASA SOHO
- NASA ACE
- NOAA GOES
- ESA-EU Giove
- Ionospheric monitoring (GPS TEC)
- Ground Based Magnetometers
- GNSS Scintillation Network (CLS)
- ESA/NASA SEM
- NASA POLAR
- Aurora
- NOAA/SEM
TR&D programme on space weather effects - 1

- Models of environments and effects for specifications and analysis
- Space environment monitors to support operations
- Effects experiments
- Technology sat
TR&D programme on space weather effects - 2

- Models of environments and effects for specifications and analysis
- Space environment monitors to support mission operations
- Effects experiments
NOAA Space Weather Prediction Centre

• Full operational capability 24h/24h 7Day/7Day
• Continuity of space elements (GOES/SEM, POES, SEM)
• Testing new space elements: ACE solar wind monitoring
• Modelling programme
ESA application programmes: space weather programme

• 1998: review of assets and capabilities

• 2000: review of requirements for a programme: customer requirements, system requirements, architecture study

• 2002: cost benefit analysis of a federative approach to space weather service provision

• 2008: adoption of a Space Situational Awareness (SSA) programme with a space weather element besides a survey and tracking element and a NEO element.
SSA programme

• Objective: to set-up an independent European SSA system in a 10 year-time scale and transfer it to an operator.

• Application domains:
  – Survey and tracking
  – (Imaging)
  – Space weather
  – Near Earth objects

• Phases:
  – Preparatory programme + TR&D: 2009-2011
  – Development phase: 2012-2019

• Participating countries:
  Austria, Belgium, Finland, France, Germany, Greece, Italy, Luxembourg, Norway, Portugal, Spain, Switzerland, UK.
SSA Programme Tasks

2009 – 2011: Preparatory Programme

- Requirements analysis
  - User requirements
  - Governance Definition
  - Data Policy
- Architecture
- Precursor Services
- Federation
- Pilot Data Centres
- Radar Breadboard
- Other TR&D from ESA relevant R&D
SSA SPACE WEATHER SEGMENT ACTIVITIES

User Domains and Services

1. Spacecraft designers
   • Environment specification and post event analysis

2. Spacecraft operators
   • In orbit environment and effects monitoring/forecasting, post event analysis, mission analysis

3. Human space flights
   • In flight and cumulative crew radiation exposure, increased crew radiation exposure risk

4. Launch operators
   • In flight monitoring, estimates and forecasts of radiation effects in electronics, atmospheric density forecasts

5. Transionospheric radio link users
   • Near real-time and forecast TEC maps, scintillation maps, ionospheric disturbances monitoring

6. Survey and tracking
   • Atmospheric estimates, geomagnetic and solar indices archives and forecast for drag calculation

7. Data services
   • Space weather data archive, event based alarms, integrated space weather model platform,

8. Non Space Systems Operators
   • Power systems and pipeline operators, airlines, resource exploitation system operators, auroral tourism sector
SSA SPACE WEATHER SEGMENT ACTIVITIES

Precursor Services

• More than 30 services identified.
• SN-1 contract: preliminary service segment work – to begin soon.
  • Review of existing applications and assessment of maturity:
    • Cat-1: existing quasi-operational application
    • Cat-2: all building block exist in non-operational environment
    • Cat-3: critical building block is missing
• A subset of existing applications and services to be re-deployed in Redu (B) in 2010.
• ESA owned applications to be part of these precursor services:
  ▪ Space Environment Data System (SEDAT)
  ▪ European Impact Detector Database (EDID)
  ▪ Space Environment Information System (SPENVIS)
  ▪ Standard Radiation Environment Monitors (SREM)
  ▪ Space Weather European Service Network (SWENET) portal
  ▪ Space Environment System for Operations (SEISOP)
  ▪ Ionospheric Monitoring Facility (IONMON)
• Service assessment based on re-deployed or federated applications, prototypes or mock-up’s.
• More precursor services to be developed under future contracts (SN-4)
SSA SPACE WEATHER SEGMENT ACTIVITIES

Measurement Infrastructure

System requirement and architecture study to be performed under Co-1 contract – started.

Re-use of existing (ground based and space based) Member States assets will be considered in priority – start soon.

Meanwhile preparatory work for piggy-backing on planned platforms is to be performed under SN-2 contract – started.

Platforms include ESA, MS and other (international, commercial, …).

Baseline list of SWE Instrument types to be addressed in SN-2:

- X/EUV imager
- X-ray flux monitor
- UV flux monitor
- Wide Angle Coronagraph
- 3D Magnetometer
- Solar wind plasma monitor
- Plasma spectrometer and
- (Langmuir) density probe.

- Medium energy particle detector
- Compact Radiation Monitor
- High energy particle spectrometer
- GNSS dual frequency receiver in radio-occultation mode
- Micro-particle detector
Conclusions

• SSA PP is preparing for a full blown operational European space weather application system.

• As a first step SSA PP is transitioning relevant assets (including research models and instruments concepts based on science mission heritage) into operational elements.

• Many aspects need to be defined and an appropriate architecture found:
  – query handling
  – data system
  – measurement infrastructure
  – service provision