

SEISOP: Space Environment Information System to support Satellites Operations

Federico Di Marco (VEGA Germany)



Overview

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- Safer Space Systems Operations
- Space Weather Service and Europe
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- Space Environment Information System to support Satellite Operations (SEISOP)
- Conclusions

Introduction

- Space and Ground Systems are exposed to hard space environment (Space Weather) conditions that influence their performance, reliability and lifetime
- The main concern of the satellite Flight Control Teams, Science Operation Teams, Launcher Teams and Ground Operators is to keep systems healthy and productive
- The main concern of Airline Operators and Space Manned missions operators is to keep humans healthy and safe
- It is hard to detect when environmental conditions are safe and when they are hazardous
- The identification of safer conditions is supported
 - Today by mission experiences and available data sources
 - **Tomorrow by complementary intelligent supporting tools**

Space Weather

What is Space Weather?

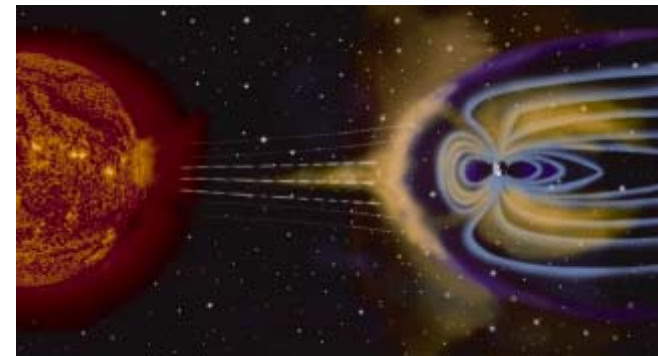
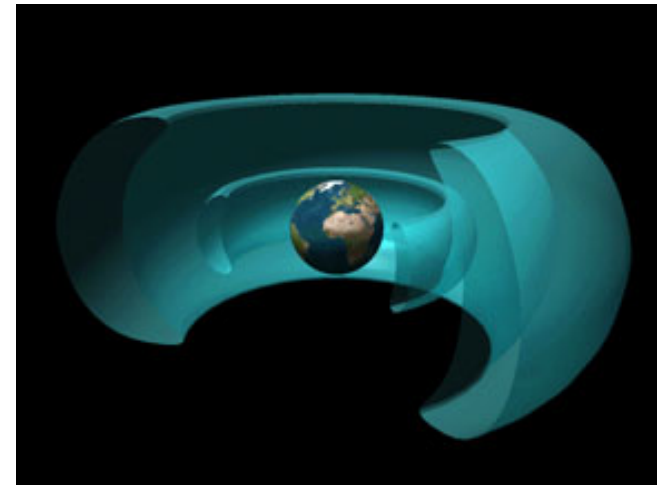
A definition is beneficial, the one most quoted is:

“Conditions on the sun and in the solar wind, magnetosphere, ionosphere and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life and health.”

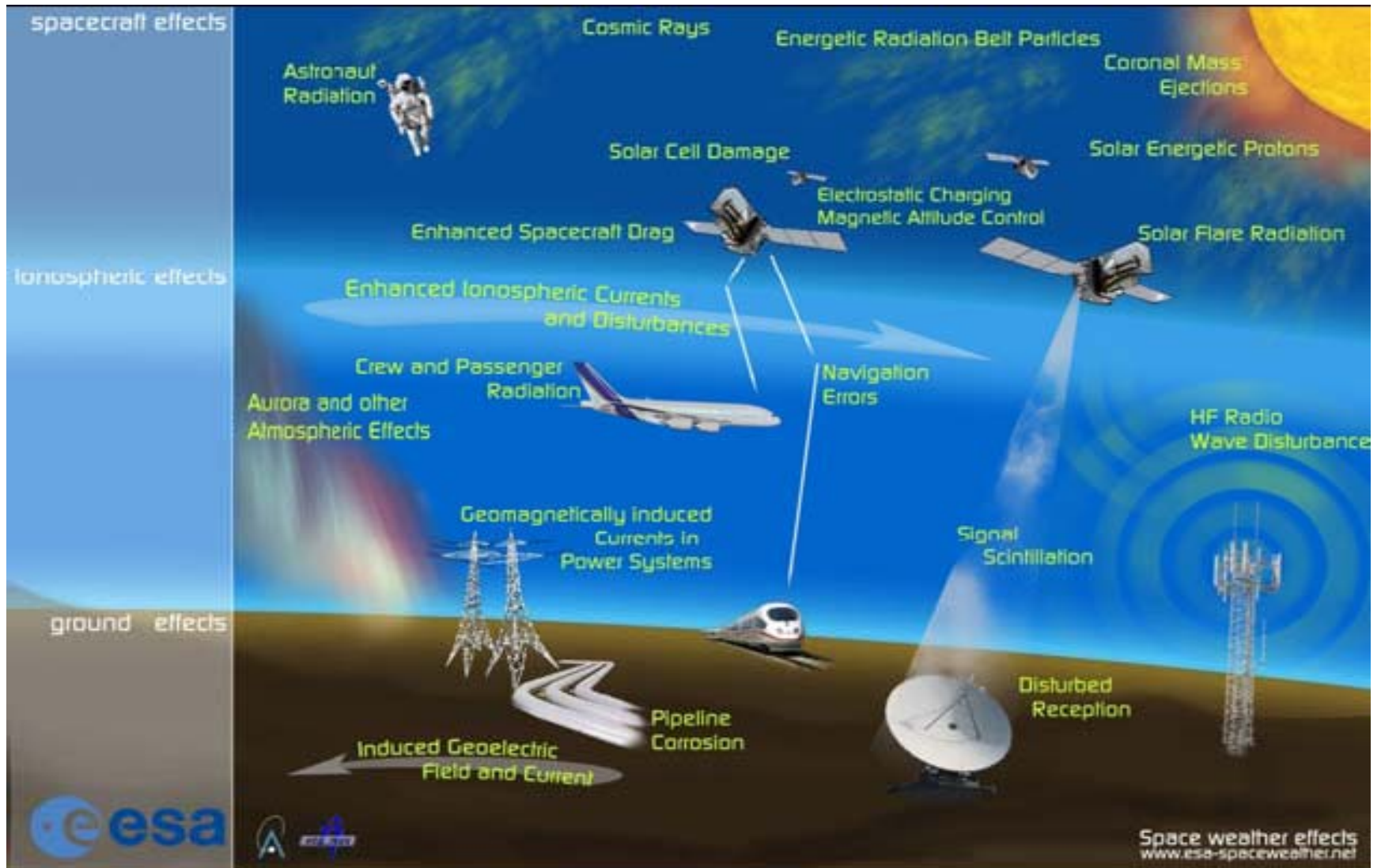
[US National Space Weather Program]

Space Weather in a nutshell

- Particles magnetically trapped in the near-Earth composed of
 - energetic protons
 - electrons
 - heavy ions
- Transient radiation: galactic cosmic ray particles (GCR) and particles from solar events (CMEs and flares)
 - GCR have low level fluxes with energies up to TeV
 - the solar eruptions produce energetic protons, alpha particles, heavy ions, and electrons
- Low energy plasma of electrons and protons
 - in the trapped particle regions
 - in the outer regions of the magnetosphere the plasma is associated with the solar wind



Space Weather Effects



Known Space Weather Effects to Space Missions

■ Direct Impact

- Service outages,
- Mission degradation,
- Mission failure,
- Data loss,
- Sensor degradation,
- Subsystem failure,
- Launch delays.

■ Offline Impact

- Redesign & testing,
- Anomaly analyses.

Example of Space Weather Effects to Space Systems

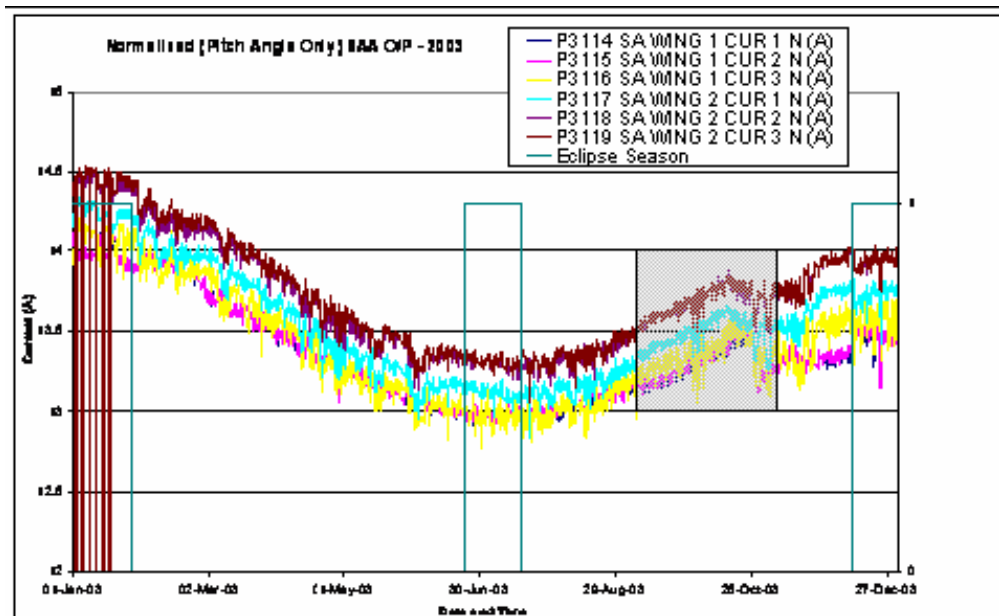
- Solar Storm on November 2003 affecting several spacecrafts from NASA and ESA fleet

Mission	Change in operational status	SEU	Noisy HK	Solar array degradation	unrecoverable loss of instrument data
AQUA	none	X			
CHANDRA	instrument safed				X
CHIPS	control loss	X			X
CLUSTER	none			X	
GENESIS	auto safed	X			X
GOES-9&10	none		X		
ICESAT	none	X			
LANDSAT-7	instrument safed				X
MER-A & B	auto safed		X		X
RHESSI	ATS stannard	X			X

Credit: NASA/ESA

Example of Space Weather Effects to Space Systems

- Solar Array degradation information indicated an accelerated loss of array power



Credit: ESA/ INTEGRAL FCT

Safer Space Systems Operations: General Recommendations

- Assess **mission/system susceptibility** before operations phase begins
- Assess **mission/system risk** based on mission susceptibility
- Identify **means** to find out if a space weather event is occurring
- Set **susceptibility metrics** at which the spacecraft will be sent in safer mode
- Set **science** and **engineering Teams** points of contact in the alert mechanism
- Automate **environmental monitoring** to increase ops reliability
- Increase the monitor of **spacecraft and space weather** to support Spacecraft predictive/preventive operations maintenance (e.g. switch payload sensor into safe state)

Safer Space Systems Operations

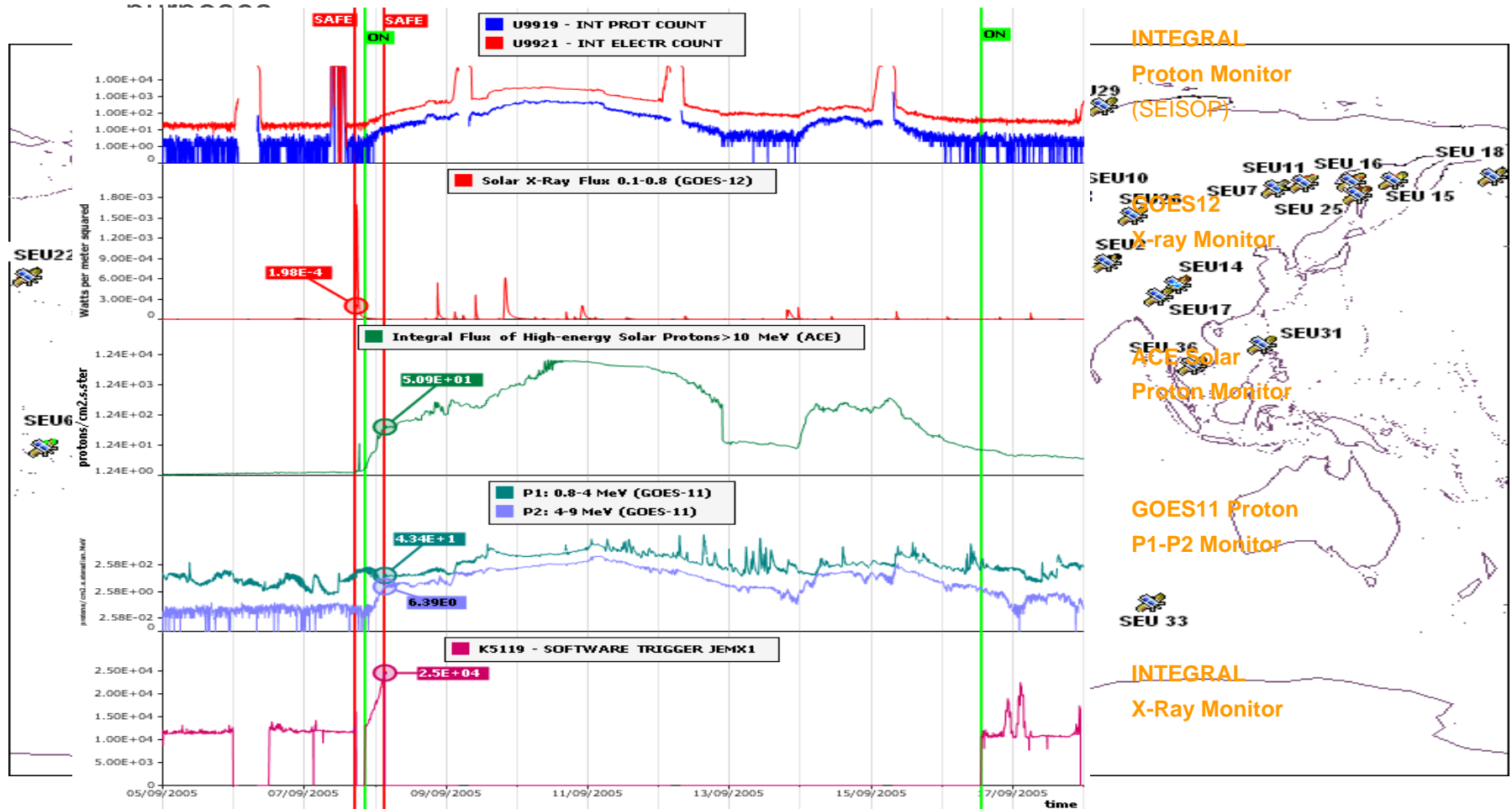
- **Goal:**
 - **Increase the monitor of spacecraft and space weather to support Spacecraft predictive/preventive operations maintenance**
- **Requirements for Space Weather Service for Operations:**
 - **Availability / acquisition of data (space weather, spacecraft telemetry, ...)**
 - **Real time information display**
 - **Space Environment models validation**
 - **Knowledge extraction**
 - **Forecasting**

Space Weather Service and Europe

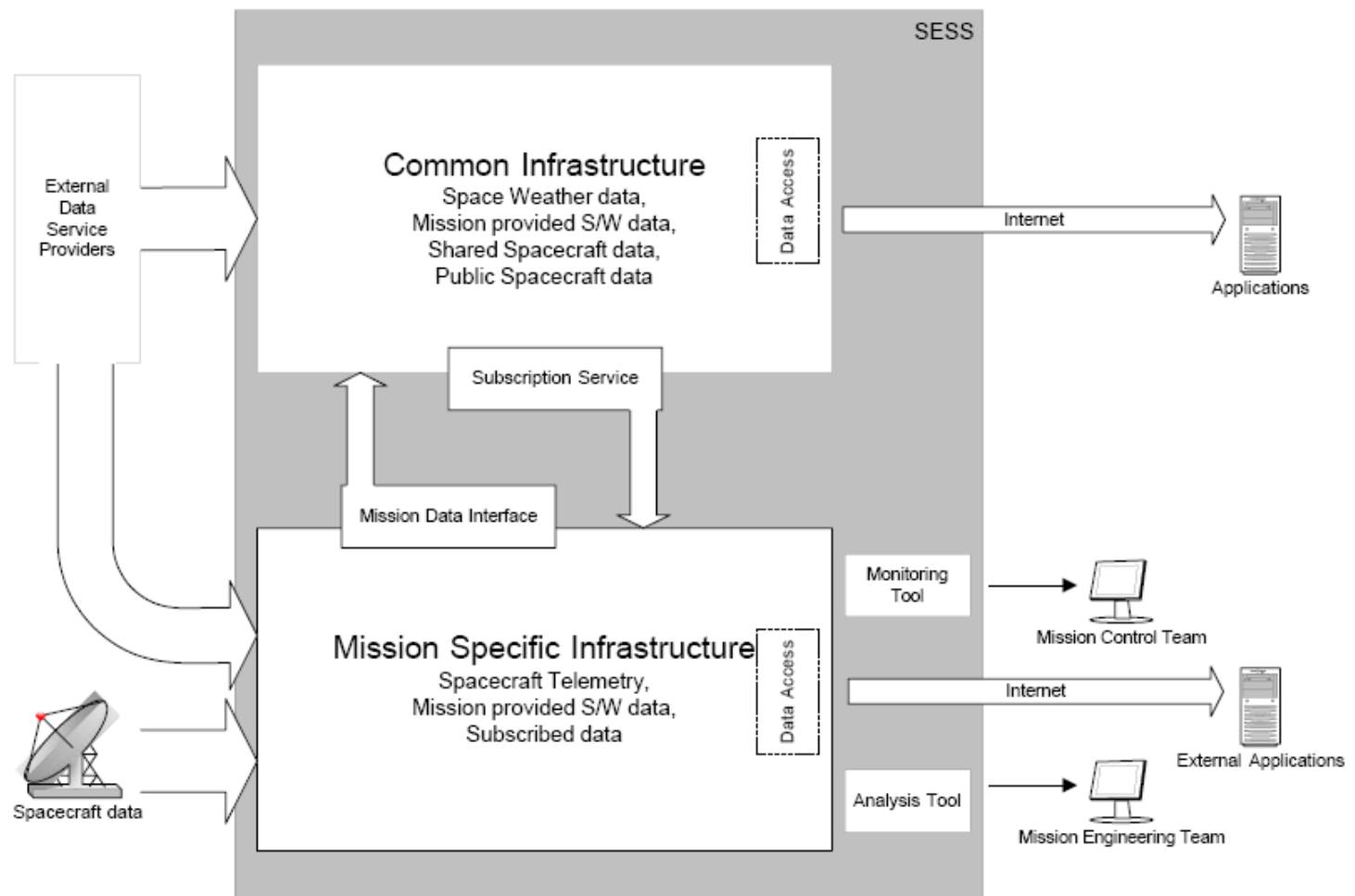
- ESA strong interest in a European Space Weather Services
 - as a user
 - as sponsor of technology research and service development
 - in establishing networks of Competences in Space Environments and Effects
- Space Weather Pilot Project SWPP (2003) to assess applications and benefits
 - successful initiative
 - maturity of the European market
 - development of pilot services (Service Development Activity)
- SEIS pilot project, used at European Space Operations Centre since 2005
 - combinations of data-provider of space weather services
 - Demonstrating the quantitative benefits of space weather services
- **Ultimately Space Weather is part of a new ESA initiative Space Situation Awareness!**

Service Demonstration: SEIS

Built on users requirements, SEIS is a decision support system for mission control



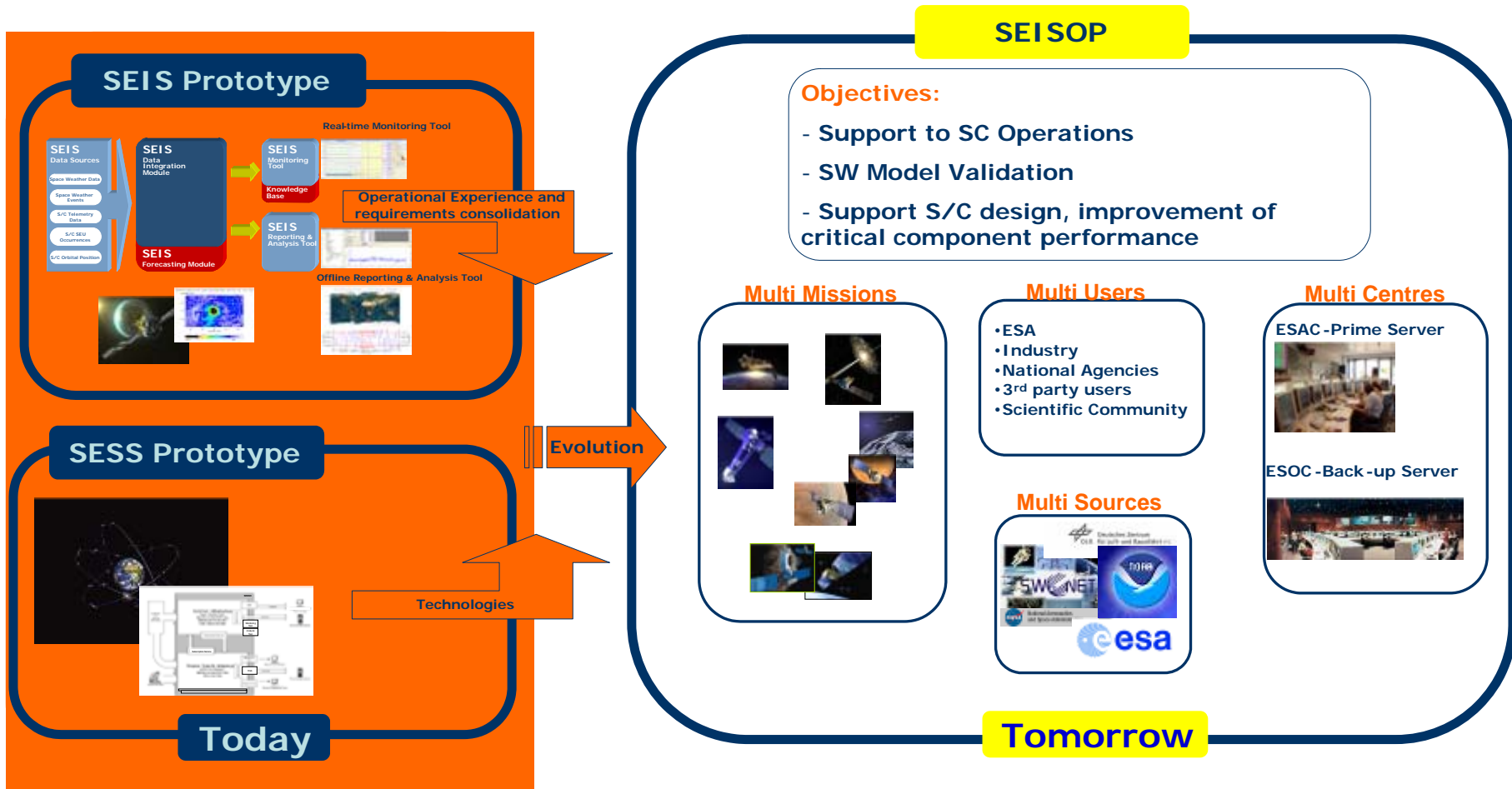
Service Demonstration: SESS



Space Environment Information System to support Satellite Operations (SEISOP)

- **SEISOP** represents the next step, towards a mature operational tool:
 - Access for external components, such as **data mining** technology and new forecasting modules
 - **Consolidating the architecture** and the underlined **functionalities**
 - Access to data from **multiple missions** and other sources

Space Environment Information System to support Satellite Operations (SEISOP)



Space Environment Information System to support Satellite Operations (SEISOP)

Design drivers:

- Main/redundant concept (ESOC/ESAC)
- Data access fully configurable
- Multiple missions
 - Observatory, Space Exploration, Earth Observation, Navigation and Telecom
- Support several different users
 - Flight Control Teams, Launcher Team, Scientists and Spacecraft Designers
- Client/server applications, client applications interface web based
- Platform to run existing models related to the space environment
- Platform to validate new models and compare their output to real data

Space Environment Information System to support Satellite Operations (SEISOP)

The main functionalities include

- Data Acquisition
- Knowledge Extraction
- Knowledge and Data Reporting
- Data Forecasting
- Data Distribution & Export
- Alarming service based on user configurable rules
- Automatic generation of reports, e.g. multi spacecraft anomaly report

Data imported from a variety of sources and providers

- ESA mission's data
- ESA mission's auxiliary data,
- Data available from other space sources located worldwide
 - e.g. NASA, SEC, SIDC, SWENET
- Data from ground-based measurements e.g. Thule,
- Data from relevant physical and/or numerical models
 - e.g. AP8/AE8, CRESPO, CRESELE, EQUIPOT, SOLARC...

Conclusions

The prototyping phase paved the way to implement SEISOP, a mature space weather service:

- Added value of forecasting and diagnosis
- Multi-mission environment, multi centres, multi-users
- Modular and expandable
- Consolidate functionalities already verified in the prototyping phase
- Services through client applications and web services.
- available to the general public by using a web browser
- plug-in external modules

Conclusions

SEISOP will contribute to:

- Improve the **risk mitigation** and **productivity** of the space and ground system
- Facilitate the lessons learnt loop to improve the **manufacturing** of space weather sensitive components
- Provide a set of space radiation and effects data to the scientific community in order to speed up the **development** of future space weather models

Co-Authors

- A. Donati

ESA/ESOC, Germany

- D. Ponz

ESA/ESAC, Spain

- M. Pantoquilha

SOLENIX Deutschland GmbH, Germany

Thanks for the attention!

DEMO REPORTING

