SEISOP, a System enabling Space Weather Services for the SSA

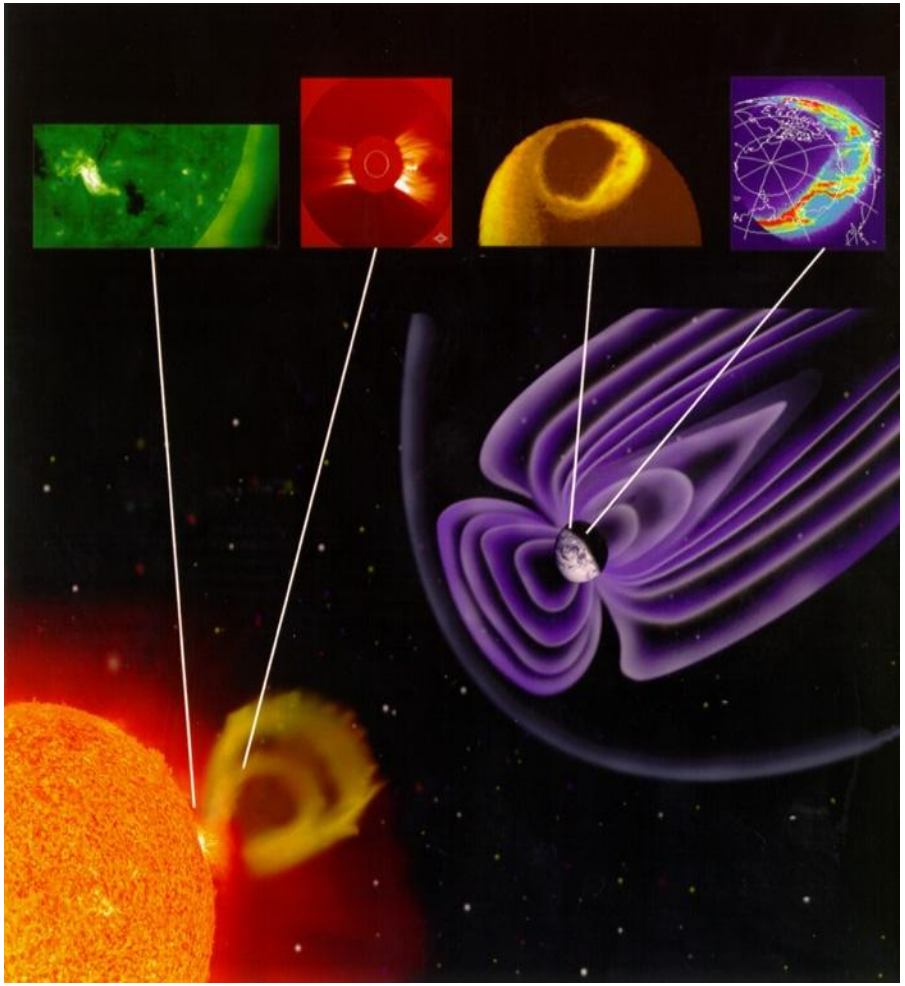
A. Rivera Campos; E. Parrilla Endrino; M. J. Enríquez; N. Sánchez Ortiz; S. Negrín

10th European Space Weather Week – November 18-22 2013, Antwerp, Belgium

SEISOP – Space Environment Support System for Operations

1. Overview
2. Architecture
3. Available Models
4. Available data and data sources
5. Summary

SEISOP - Overview



Developed by **Elecnor Deimos** and partners for the European Space Agency (ESA).

Its main objective is to supply information, to extract knowledge related to the Space Environment and to correlate effects on the affected systems.

The intended users are mission operators, project teams, spacecraft development engineers and scientists.

Precursors prototypes SEIS and SESS, with more than 8 years of researches.

SEISOP was selected as one of the six precursors services of the ESA Space Surveillance Awareness (SSA) Program and is successfully deployed since 2011 in the SSA infrastructure at ESAC and Redu premises.

SEISOP - Overview

SEISOP offers the users the following services and products:

- Data Acquisition
- Knowledge Extraction
- Knowledge and Data Reporting
- Short-term forecasting based on existing **Space Environment Models**
- Data Distribution & Export
- **Alarming service** based on user configurable rules
- Automatic generation of **reports**
- Fully customisable to import data from a variety of sources and providers, both in real-time and offline.
- Real-time **monitoring** of Space Weather parameters and Spacecraft housekeeping telemetries.

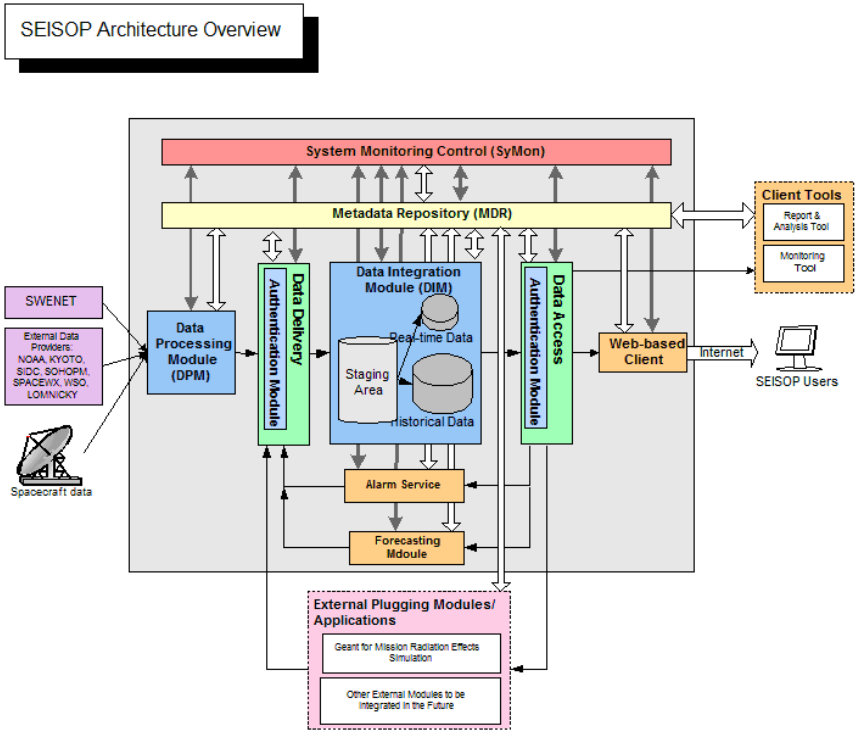
The benefits

- **Increase awareness** of Space Weather Events & Effects
- Improvement of the understanding of **Cause-Effect** Relationships
- Improve the **risk mitigation** and productivity of the space and ground system
- Facilitate the lessons learnt to **improve the manufacturing** of space weather sensitive components

SEISOP - Architecture

SEISOP has a modular approach:

- **Data Processing Module (DPM)** – this is a module that obtains data from different data sources. It then processes and formats the data to store it in the system.
- **Data Integration Module (DIM)** – this module is intended for system storage. It is a data warehouse with two different storages, one for real-time and the other for historical data.
- **Metadata Repository (MDR)** – this module is dedicated to the configuration of the system. SEISOP is based on the use of metadata so everything in the system is configurable due to this metadata repository.
- **Forecasting Module (FM)** – this module is composed by a suite of static Space Weather forecasting models.



On top of these components SEISOP offers a set of tools for accesing and handling the data:

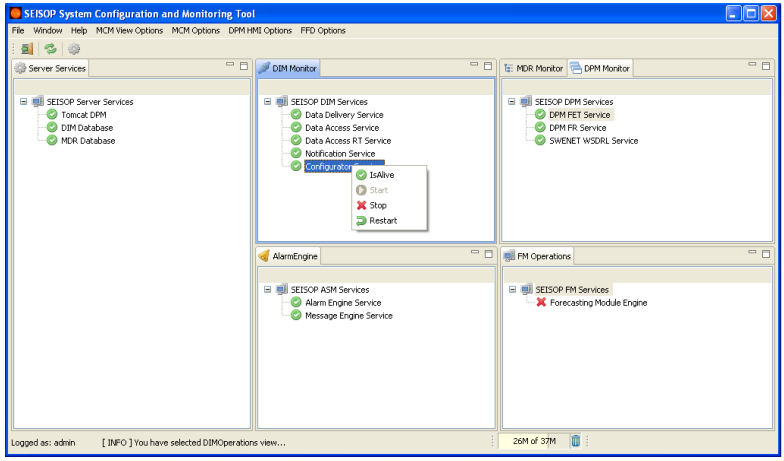
- **Centralized System Monitoring and Control tool (SYMON)** (standalone tool) – this tool provides the mechanisms needed to monitor and control the whole system.
- **Alarm Service** (standalone tool) – this is intended for the generation of alarms used to alert users about emergencies and to show the operational procedures that may be stored in the system.
- **Monitoring Tool** (web tool) – this allows for the monitoring of the real time data stored in the system.
- **Reporting and Analysis Tool** (standalone tool) – this tool provides the capability of automatically generate in offline mode ad-hoc complex reports

SYMON – Centralized System Monitoring and Control tool

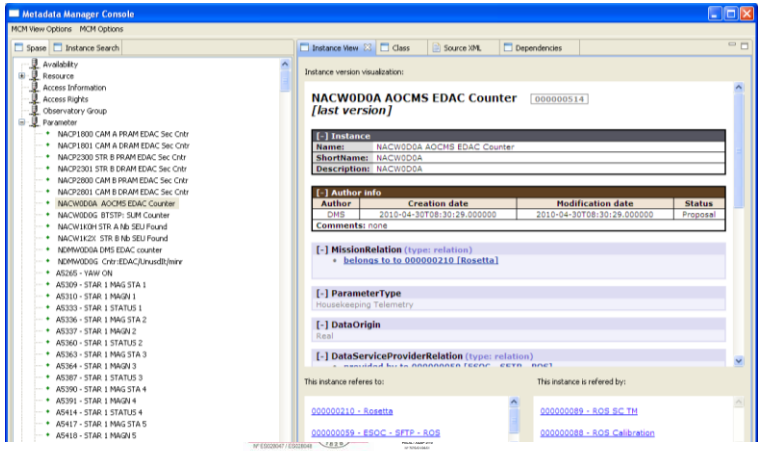
It is in charge of the configuration and maintenance of the whole system (administrator view)

It is composed of several perspectives for covering the various aspects needed for the system to run. Some perspectives of interest from this tool are:

- The **Monitoring and Control** perspective shows the status of all the system modules (WebServices, databases, daemons, processes, etc.)
- The **Data Processing Module** along with a File Format Definition tool, are also integrated into SYMON for creating, browsing and editing the Data Service Providers and files stored in the metadata repository

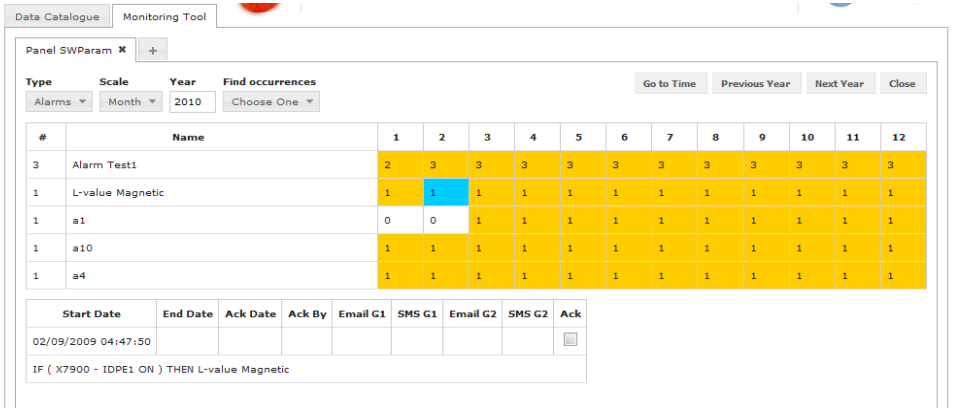


- The **Metadata Manager Console** perspective allows the user to access the configuration files of the modules installed in the system.



Web Client Tool

This tool allows the user to monitor predefined variables, events and alarms. The set of data to monitor is configurable by the user so only the data of interest will be shown.

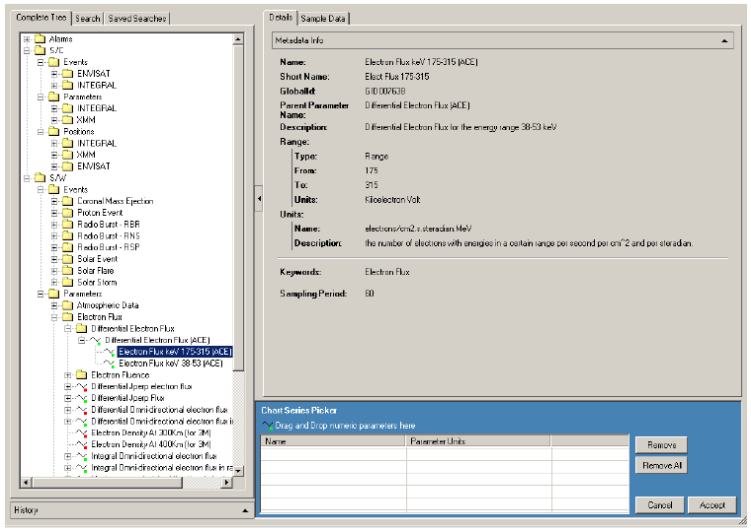


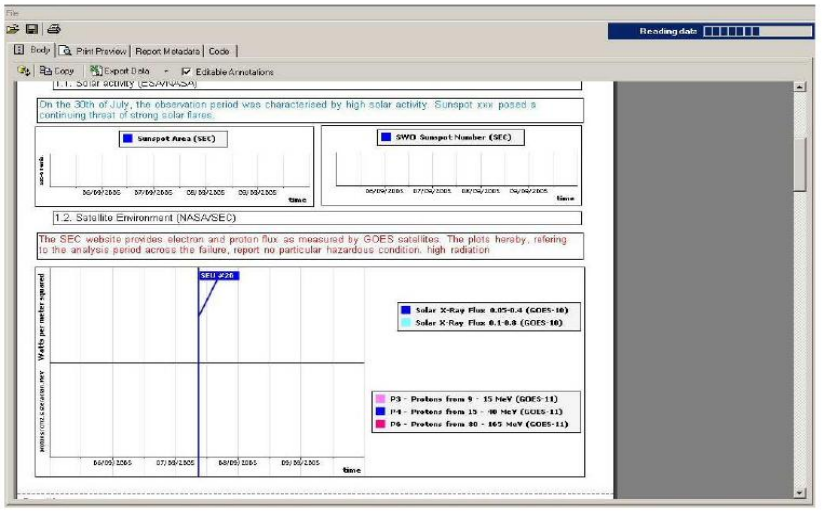
Report Designer Tool

The production of automated reports must be done by using the Report Designer tool, this tool allows the user to access the data catalogue available in SEISOP.

Through the data catalogue the user is able to select the *parameters*, *alarms*, using interpolation for certain data, establish *time frames* or *data aggregation* to be showed in the report.

Large degree of freedom in the definition of the reports





SEISOP – Available Models

A key part of the SEISOP system is the models implemented and the data stored and made available for forecasting and reports generation.

As such, models that cover a variety of domains have been implemented inside the system covering, among others, Trapped Particle models, GCR, Solar Particles, Geomagnetic Field, etc.

SEISOP – Available Models

Domain	Related Models	Applicability
Trapped Particles	AP-8	All Earth orbits except for those the ECSS recommends the use of other models.
	AE-8	All Earth orbits except for those the ECSS recommends the use of other models.
	IGE-2006	Geostationary Orbit $\pm$ 500 km
	MEOv2	Navigation orbit: 20000 $\pm$ 500 km and 55º inclination
	FLUMIC	Outer Radiation Belt L > 2.5 Re Inner Radiation Belt L < 2.5 Re
Cosmic Rays and Solar Energetic Particles	CREME-96	All Earth orbits
	Nymmik (MSU-Model or ISO-15390)	All Earth orbits

SEISOP – Available Models

Domain	Related Models	Applicability
Plasmasphere	GCPM	For Plasma parameters of the plasmasphere
Ionosphere	IRI-2007	For Ionospheric environmnet estimation
Outer magnetosphere	ECSS Analytical Outer Magnetosphere data	Engineering assessment of surface charging in the outer magnetosphere
Solar Flux	ECSS Solar Irradiance Flux ECSS Solar Energy Flux	All Earth orbits
Solar Wind	ECSS Analytical Solar Wind	Engineering assessment of Solar Wind Effects

SEISOP – Available Models

Domain	Related Models	Applicability
Geomagnetical Field	IGRF	Internal Field
	Olson-Pfizer Dynamic	Non Standard model for External field
	Olson-Pfizer quiet	Non Standard model for External field
	Tsyganenko 96	External field
Atmosphere	NRLMSIS-E-00	Calculation of atmosphere composition and temperature Total atmospheric density below 120 km
	JB-2006	Calculation of total atmospheric density above 120 km

SEISOP – Available data and data sources

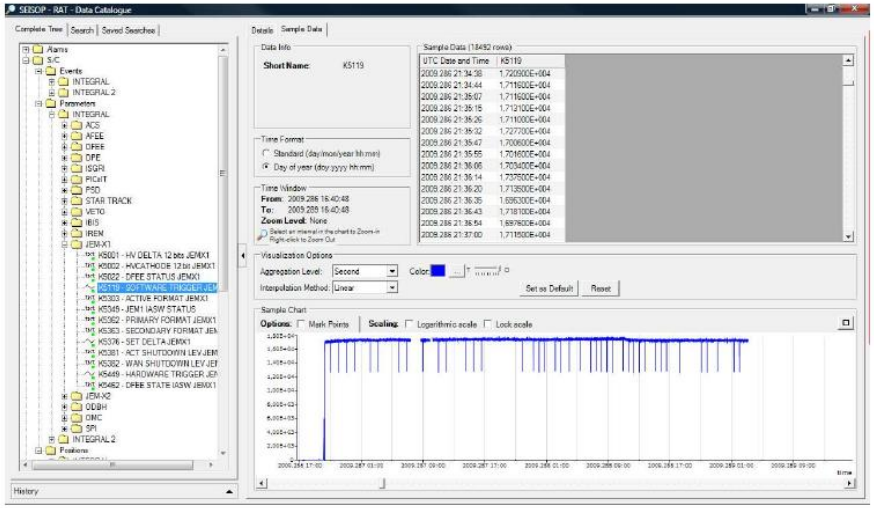
Another critical component of the SEISOP system is the stored data. This data is key to provide users with the accurate predictions for their missions, designs or scientific assessments.

The data in SEISOP covers two main domains which are:

- satellite orbits and Spacecraft telemetry

- Space Weather data.

Most of the data present in the system will be publicly available



SEISOP – Available data and data sources

In regards to **Spacecraft data** stored in the system, it is divided in two categories:

- **Parameters**:
  - the S/C parameters are housekeeping telemetry parameters that asses the health and status of the S/C and its subsystems.
  - These parameters can be measured by sensor in that system.
  - These data is organized by instruments or subsystems (sensors).
  - These data is retrieved from the mission control system of specific missions and, as such, is not publicly available.
- **Positions**:
  - S/C position is described both by the geodetic coordinates in the Earth plane (Latitude, Longitude and Altitude)
  - and a time–tagged state vector

SEISOP – Available data and data sources

In regards to **Space Weather data** stored in the system, these data may be data *generated from the models* implemented within the system or *publicly available scientific data* that is taken from different sources and incorporated into the system. The sources from which these data is taken are:

- SIDC – http://ww.sidc.be/sunspot-data/
- Space Sciences Center – http://www.usc.edu/dept/space_science/sem_data
- NGDC (NOAA) – http://ftp.ngdc.noaa.gov
- SWPC (NOAA) – http://ftp.swpc.noaa.gov
- SEC (NOAA) – http://ftp.sec.noaa.gov
- WDC-C1 Chilton – http://www.ukssdc.ac.uk
- WDC-C2 Kyoto – http://wdc.kugi.kyoto-u.ac.jp

SEISOP – Summary

In terms of avoiding or assessing the risks for missions or designs, **SEISOP**, giving access to Space Weather Prediction data, alerts and warnings, enables the user to:

- Define the set of parameters of special interest for a mission.
- Monitoring the system parameters
- Forecasting the Space Weather Events that may produce effects on sensible components.
- Automatic generation of alarms (sent by SMS, email…)
- Establish procedures (automatic/manual) to respond to alerts
- Automatic reporting capabilities
- Automatic correlation between Space Weather events and its effects on the system → Improve Lessons Learnt loop

Thank you

www.deimos-space.com