

G4MRES

A Geant4-based operational tool to evaluate space weather effects on satellites

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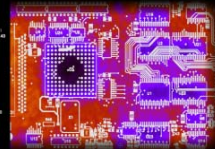
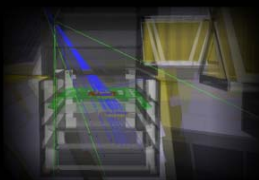
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⁽³⁾ Deimos Space S.L.U

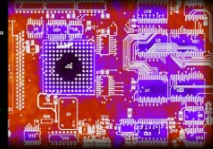
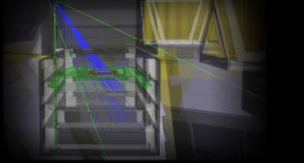
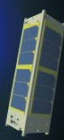




OUTLINE

- MOTIVATION
- SEISOP: An operational SW information system
 - OVERVIEW
 - PLUGIN Capability
- G4MRES
 - CONCEPT
 - ARQUITECTURE
 - FUNCTIONALITY / MODULES
 - DEMO
- SUMMARY, STATUS & FUTURE

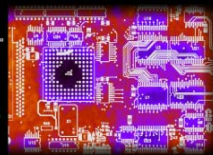
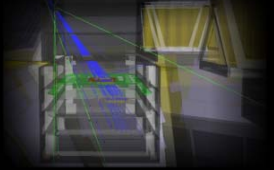
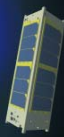




MOTIVATION

- Lack of available tools linking SW real-time conditions and direct effects on S/C
 - Lot of SW data providers (NOAA/SWPC, SWENET, On-board monitors)
 - No useful information for operators (TID, etc)
 - No real-time correlation with S/C anomalies
- S/C geometry and materials properties are not enough reflected in existing tools
 - Only very simple geometry cases are available to satellite operators
- Several radiation transport codes (MCNPX, Geant4, FLUKA, etc) can provide very precise results
 - they are not adapted to fulfil operation reqs
 - they are not operations-oriented
- In case of an Event ¿can we quantify its effects? ¿TID rate? ¿Power drop? Etc,...





PROPOSED SOLUTION:

Use SW real-time data and Monte-Carlo capabilities

Precursors: SESS & G4SESS

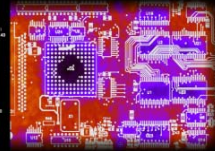
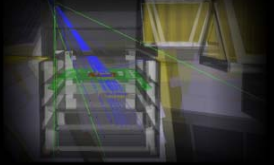
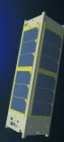


G4MRES

Geant4 for Mission Radiation Effects Simulation

- Mission: It is oriented to support mission operations...
- Radiation: ... propagates real-time radiation conditions ...
- Effects: ... and calculates radiation damages on S/C parts ...
- Simulation: ... by means of Geant4 simulation and SW analysis





SEISOP

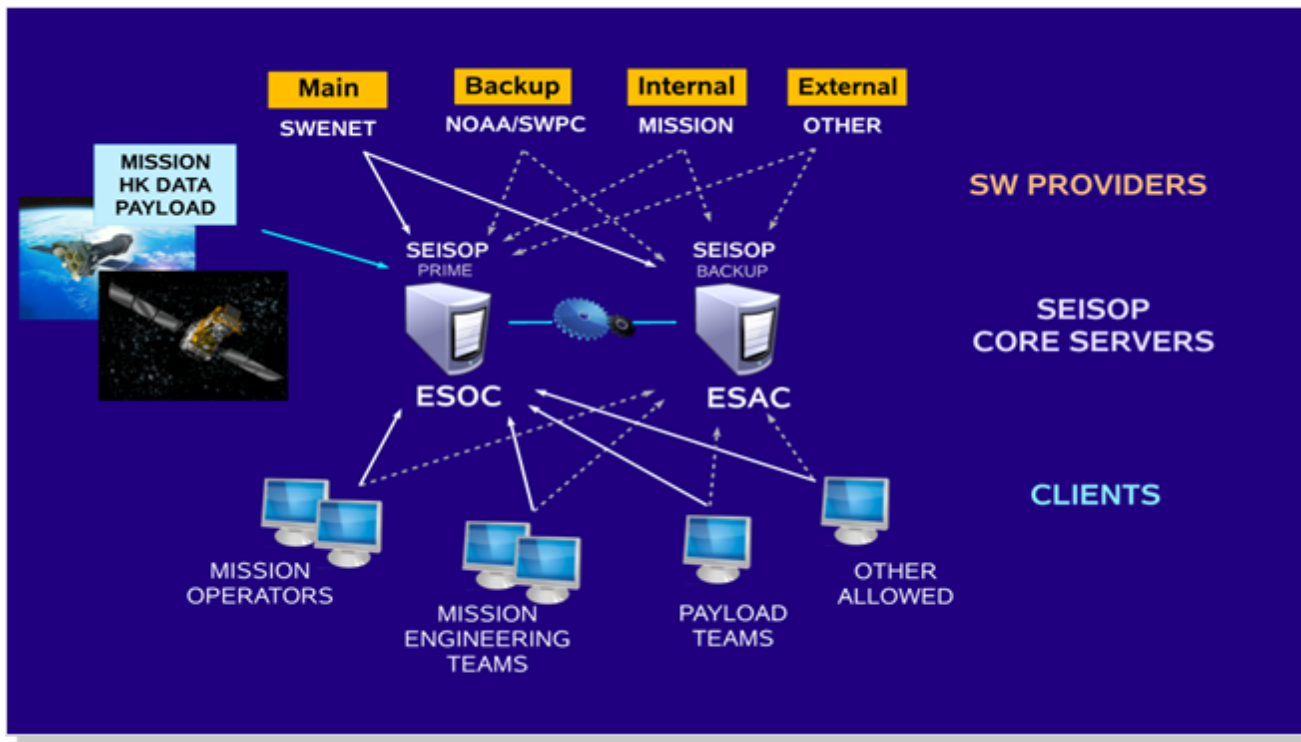
Space Environment Information System for Operations

*“provides satellite operators, mission teams and scientists with a **multi-mission** environment, **modular** and **expandable**, capable to supply, in a structured manner, **information** and extracted **knowledge** related to the **space environment** and its **effects** on the monitored spacecraft”*





SEISOP: An operational SW system



Heritage

- SEIS** (Space Environment Information System) In operation at ESOC for INTEGRAL
- SESS** (Space Environment Support System) Precursor of SEISOP





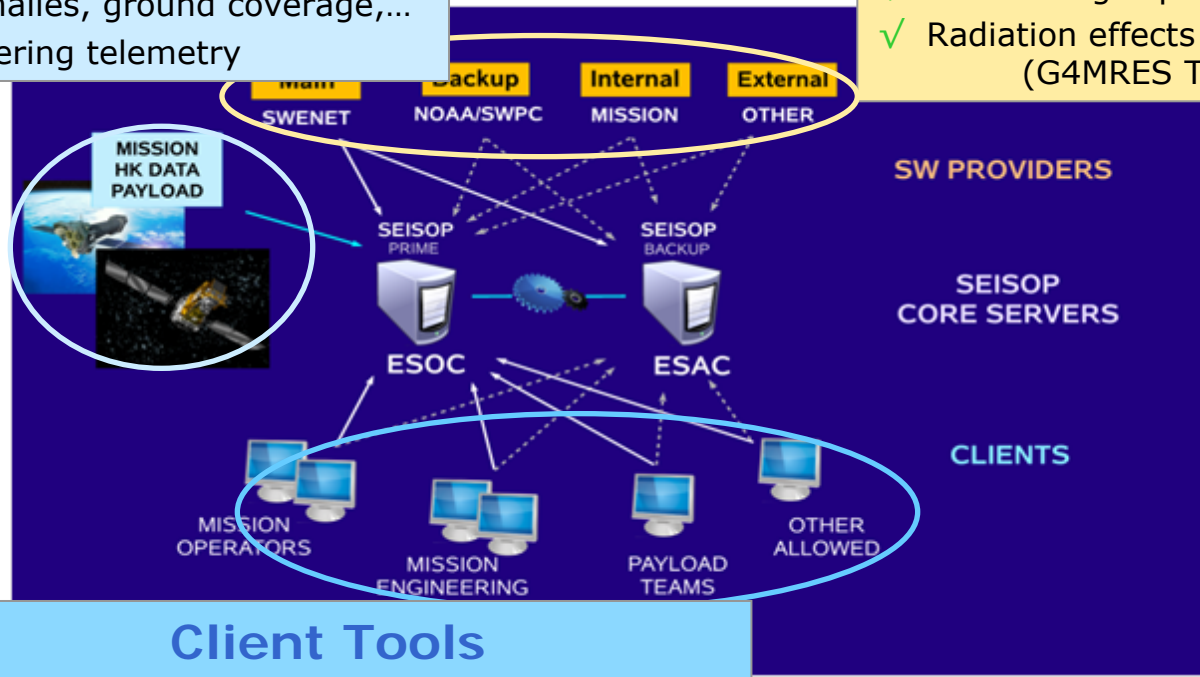
SEISOP: An operational SW system

Mission Data

- ✓ Archiving HK data
- ✓ Archiving Payload data
- ✓ Mission orbital information
- ✓ S/C events, anomalies, ground coverage,...
- ✓ Any other engineering telemetry

Space Weather

- ✓ Monitoring SW real-time data
- ✓ Structured archiving of SW data
- ✓ Retriving data from any provider
- ✓ Forecasting capabilities models
- ✓ Radiation effects on 3D S/C models (G4MRES TOOL)

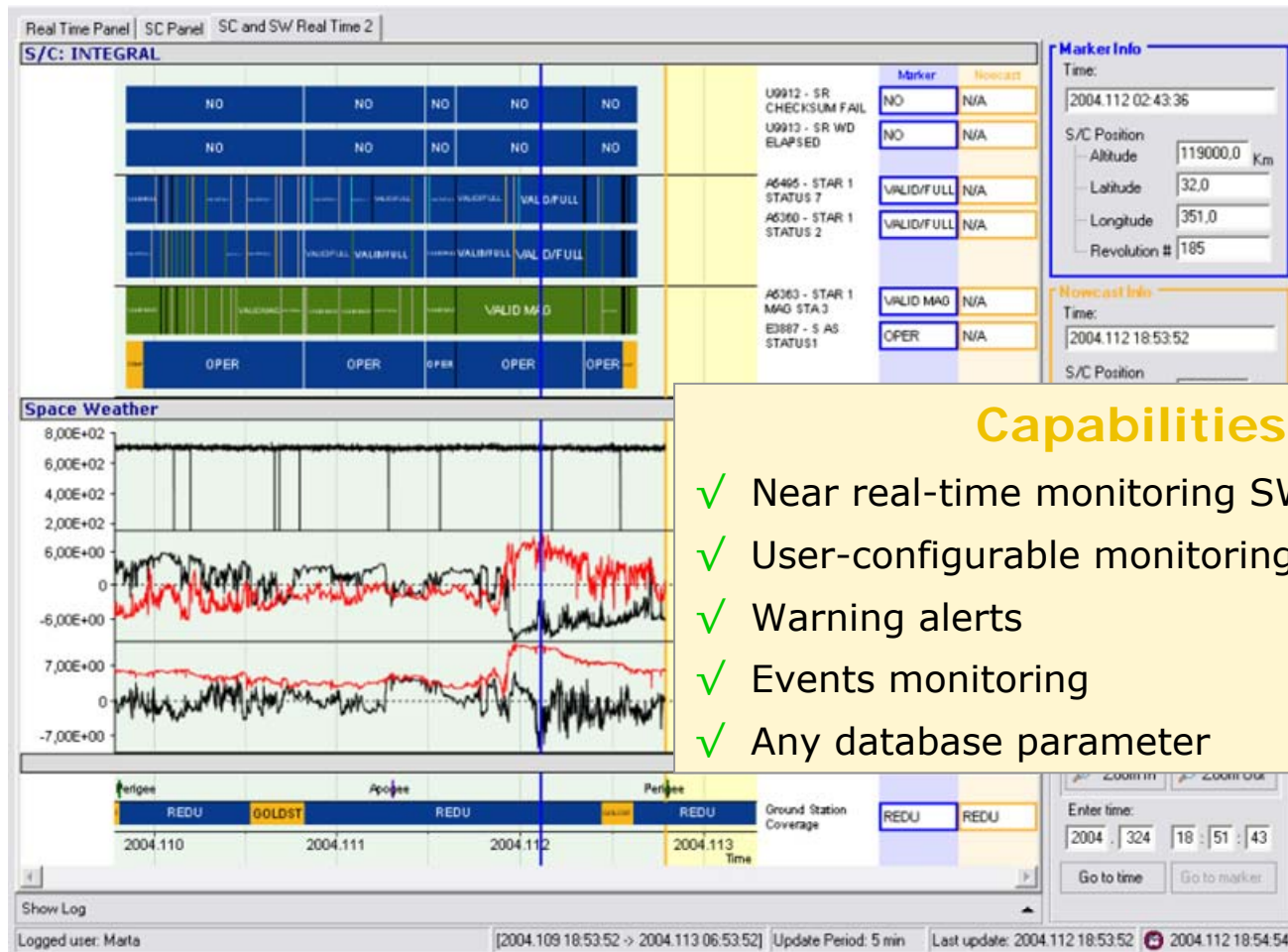


Client Tools

- ✓ Monitoring SW/HK data - Fully Configurable
- ✓ Automatic anomalies reporting
- ✓ Warning/Alarm defintion
- ✓ Correlation SW Event vs. HK anomaly

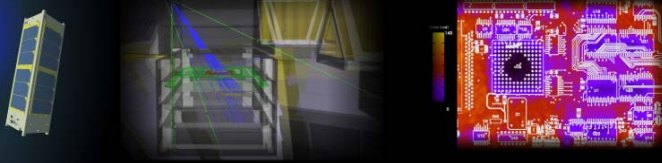


CLIENT MONITORING TOOL



Capabilities

- ✓ Near real-time monitoring SW and S/C
- ✓ User-configurable monitoring panels
- ✓ Warning alerts
- ✓ Events monitoring
- ✓ Any database parameter



CLIENT MONITORING TOOL

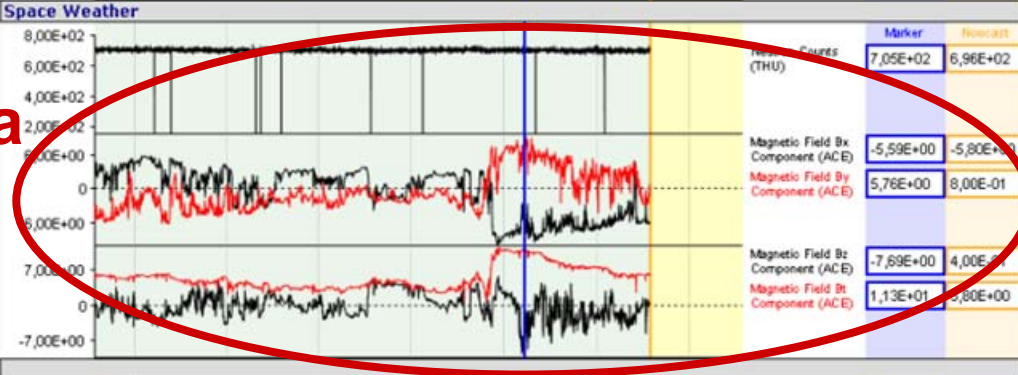
HK Data

NO	NO	NO	NO	NO
NO	NO	NO	NO	NO
VALID/FULL	VALID/FULL	VALID/FULL	VALID/FULL	VALID/FULL
VALID/MAG	VALID/MAG	VALID/MAG	VALID/MAG	VALID/MAG
OPER	OPER	OPER	OPER	OPER

Marker Info	
Time:	2004.112 02:43:36
S/C Position	
- Altitude	119000,0 Km
- Latitude	32,0
- Longitude	351,0
- Revolution #	185

Orbital Info

SW Data

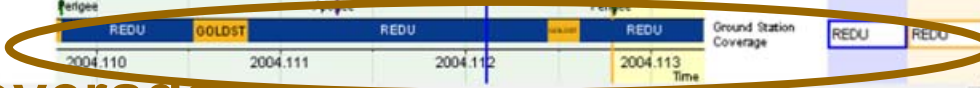


Nowcast Info	
Time:	2004.112 18:53:52
S/C Position	
- Altitude	11600,0 Km
- Latitude	-65,0
- Longitude	234,0
- Revolution #	185

Events Alarms

S/C events:	25	7
S/W events:	220	0
Alarms:	540	540

Station coverage

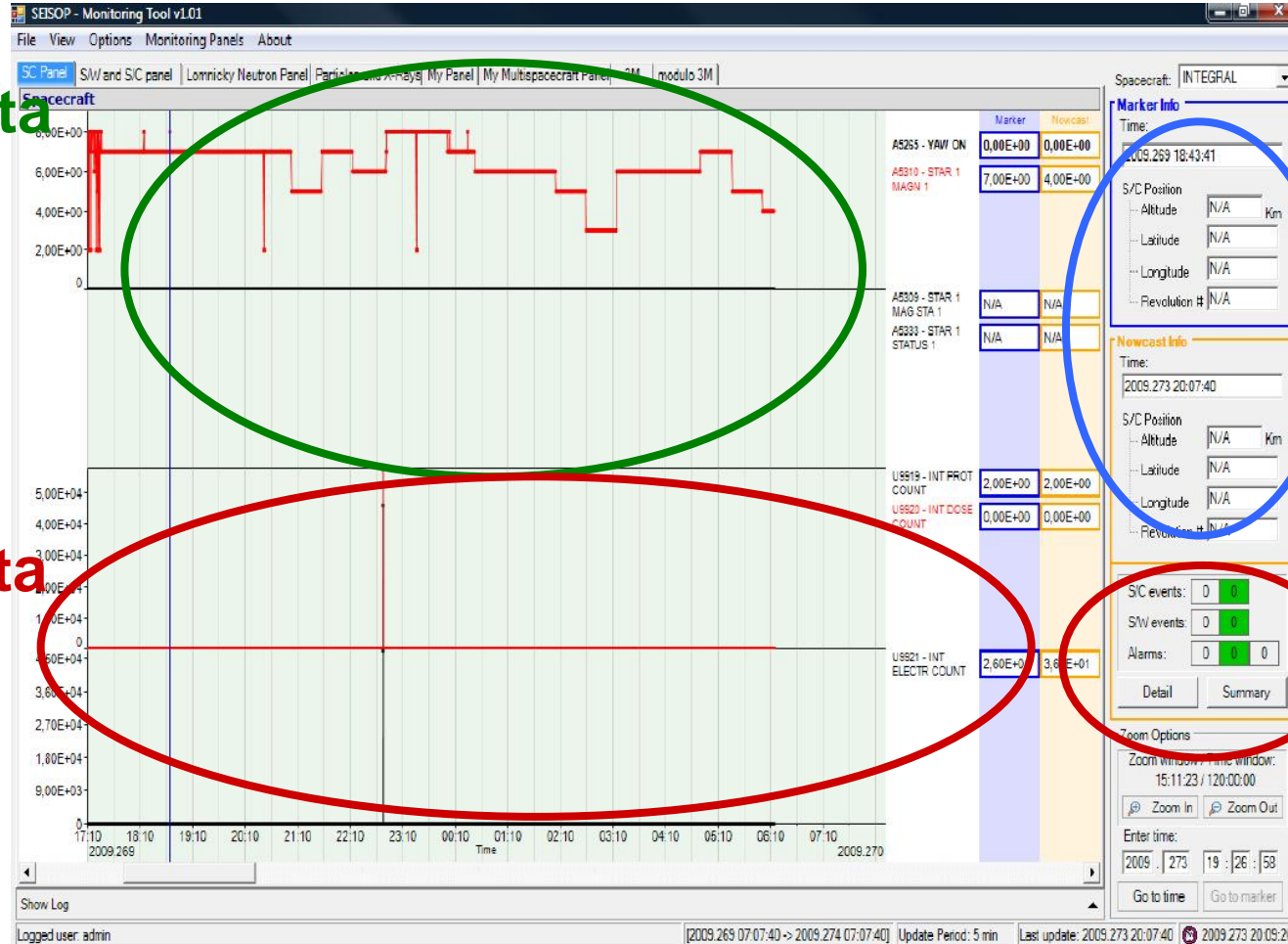




CLIENT MONITORING TOOL

HK Data

SW Data



Orbital
Info

Events
Alarms



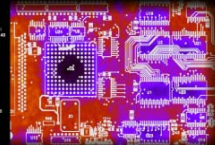
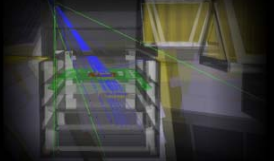
CLIENT REPORT and ANALYSIS TOOL

The screenshot displays the SEISOP software interface. On the left is a 'Complete Tree' showing a hierarchical structure of 'All Sources and Parameters' including Alarms, S/C, Events (ENVISAT, INTEGRAL), Parameters (INTEGRAL, XMM), and S/W (Events, Parameters, Atmospheric Data, Electron Flux, Electron Fluence). The 'Details' panel shows 'Data Info' for 'Elect Flux' with a unit of 'e/cm2.s.ster.MeV'. Below this are options for 'Time Format' (Standard or Day of year) and 'Time Window' (From: 2005.207 09:02, To: 2005.210 09:02). The 'Sample Data' table shows 759 rows of data with columns for 'UTC Date and Time', 'Electron Flux keV', and 'Electron Flux keV'. The 'Sample Chart' shows a line plot of 'Electron Flux keV 38-53 (ACE)' over time, with a legend and a 'Mark Points' option.

UTC Date and Time	Electron Flux keV	Electron Flux keV
2005.207 09:05	4.560000E+002	6.340000E+003
2005.207 09:10	4.520000E+002	6.310000E+003
2005.207 09:15	4.500000E+002	6.270000E+003
2005.207 09:20	4.600000E+002	6.310000E+003
2005.207 09:25	4.240000E+002	6.220000E+003
2005.207 09:30	4.450000E+002	6.200000E+003
2005.207 09:35	4.480000E+002	6.200000E+003
2005.207 09:40	4.580000E+002	6.360000E+003

Capabilities

- ✓ Browse/search any SW or S/C parameter
- ✓ Multiple data visualization (time series, events, ...)
- ✓ Plotting of data
- ✓ Report generation – Custom design
- ✓ SW vs. HK Data analysis
- ✓ Export data to multiple formats



SEISOP Plugin Architecture

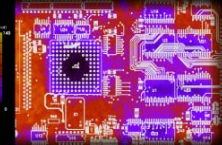
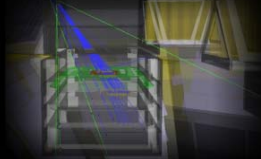
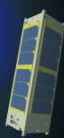
- SEISOP is a framework that unifies HK data, SW data, forecasting models and tools
 - Advanced data warehousing techniques to integrate the huge amounts of heterogeneous data (multi-mission)
- SEISOP imports data from any of data source, including
 - ESA mission's telemetry
 - SW data available from other sources (e.g. NOAA, SIDC, SWENET)
 - Ground-based measurements or relevant physical/numerical data from models
- SEISOP's design is based on a Service Oriented Architecture (SOA)
 - provides a flexible and modular environment
 - easy to plug-in new components to the existing "core"
 - well-defined web service interfaces



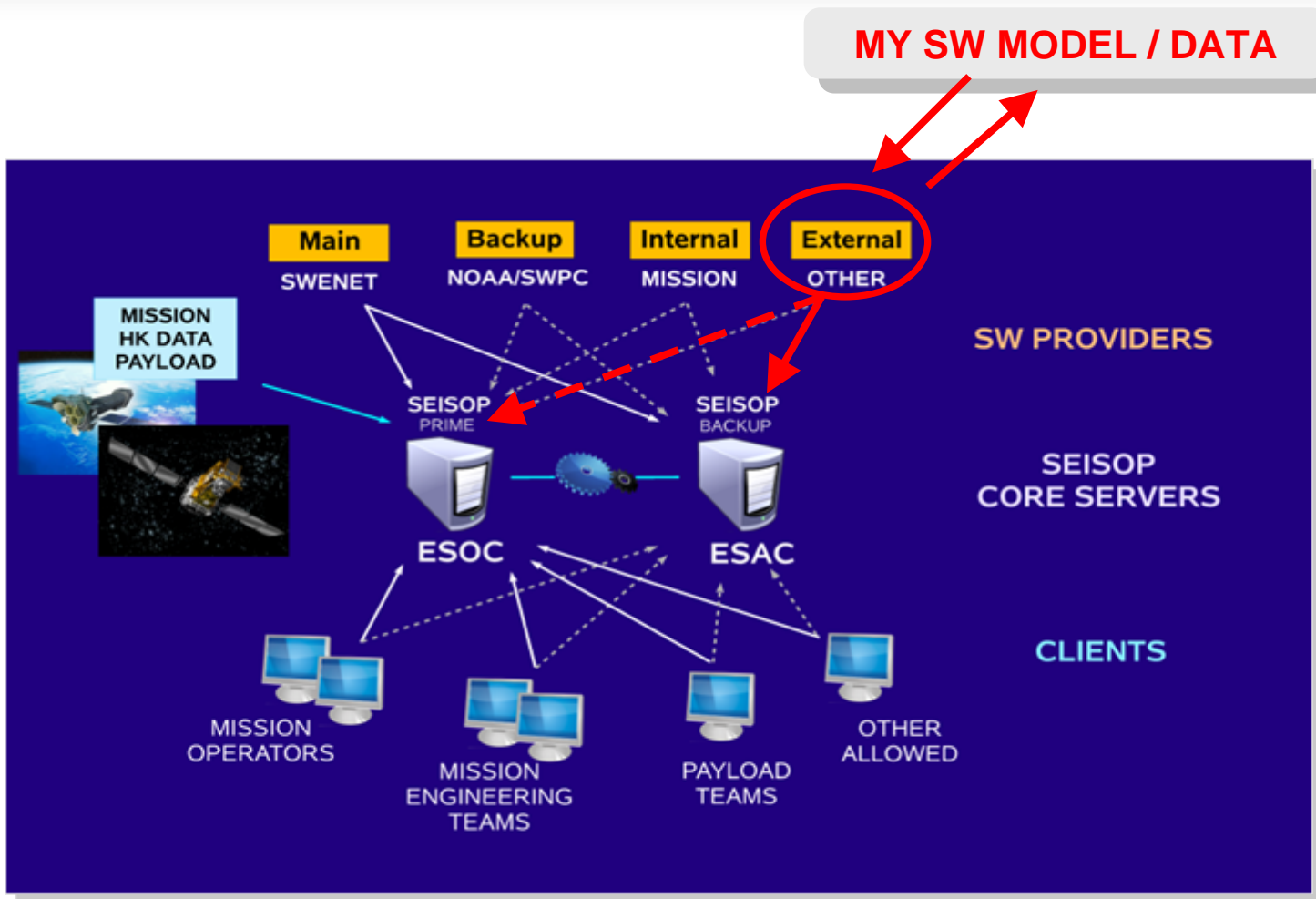
ANY USER CAN **"PLUG-IN"** ITS OWN

- SW DATA
- MODEL RESULTS, etc

GOBIERNO
DE ESPAÑAMINISTERIO
DE DEFENSA



SEISOP: An operational SW system



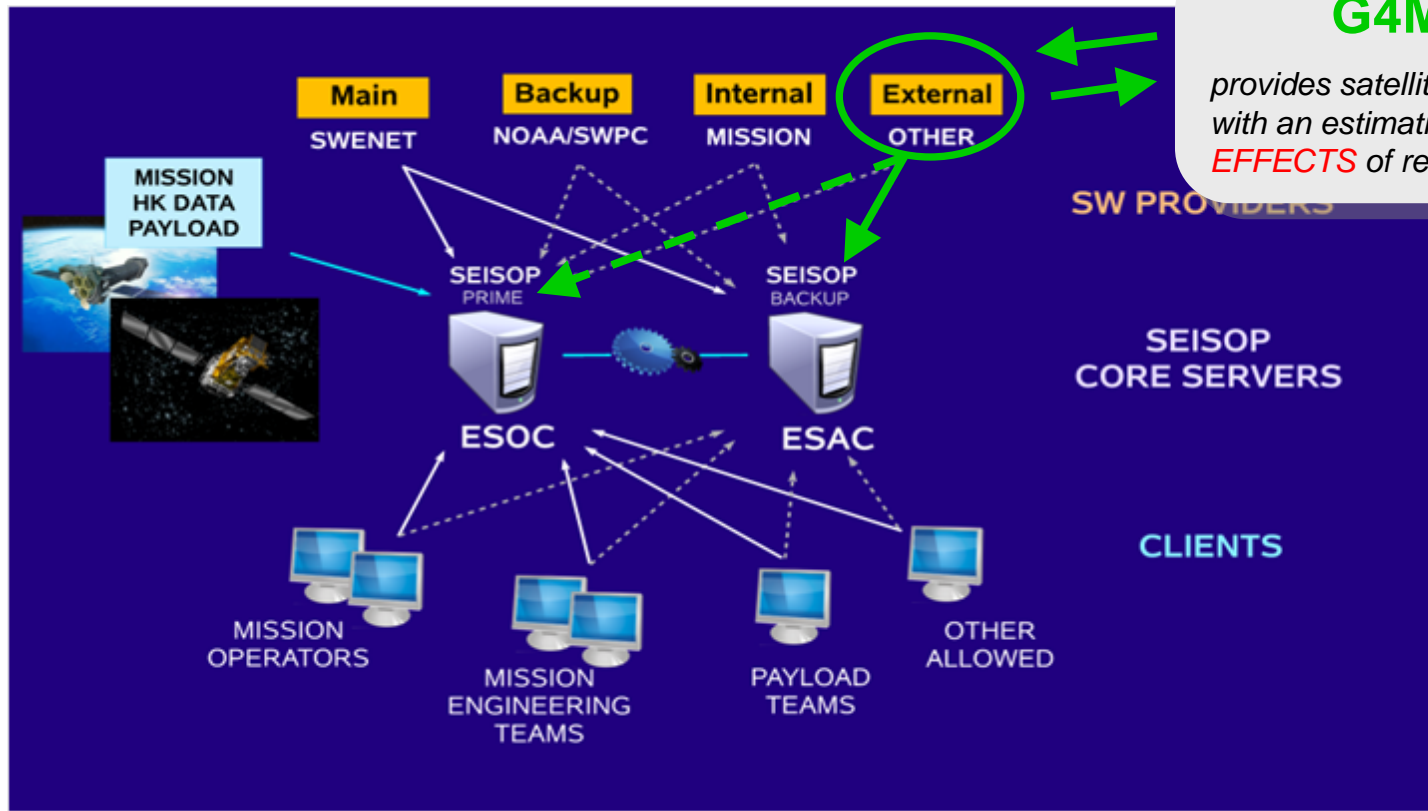


G4MRES

“A Monte-Carlo plug-in to estimate radiation effects on any S/C part”

G4MRES

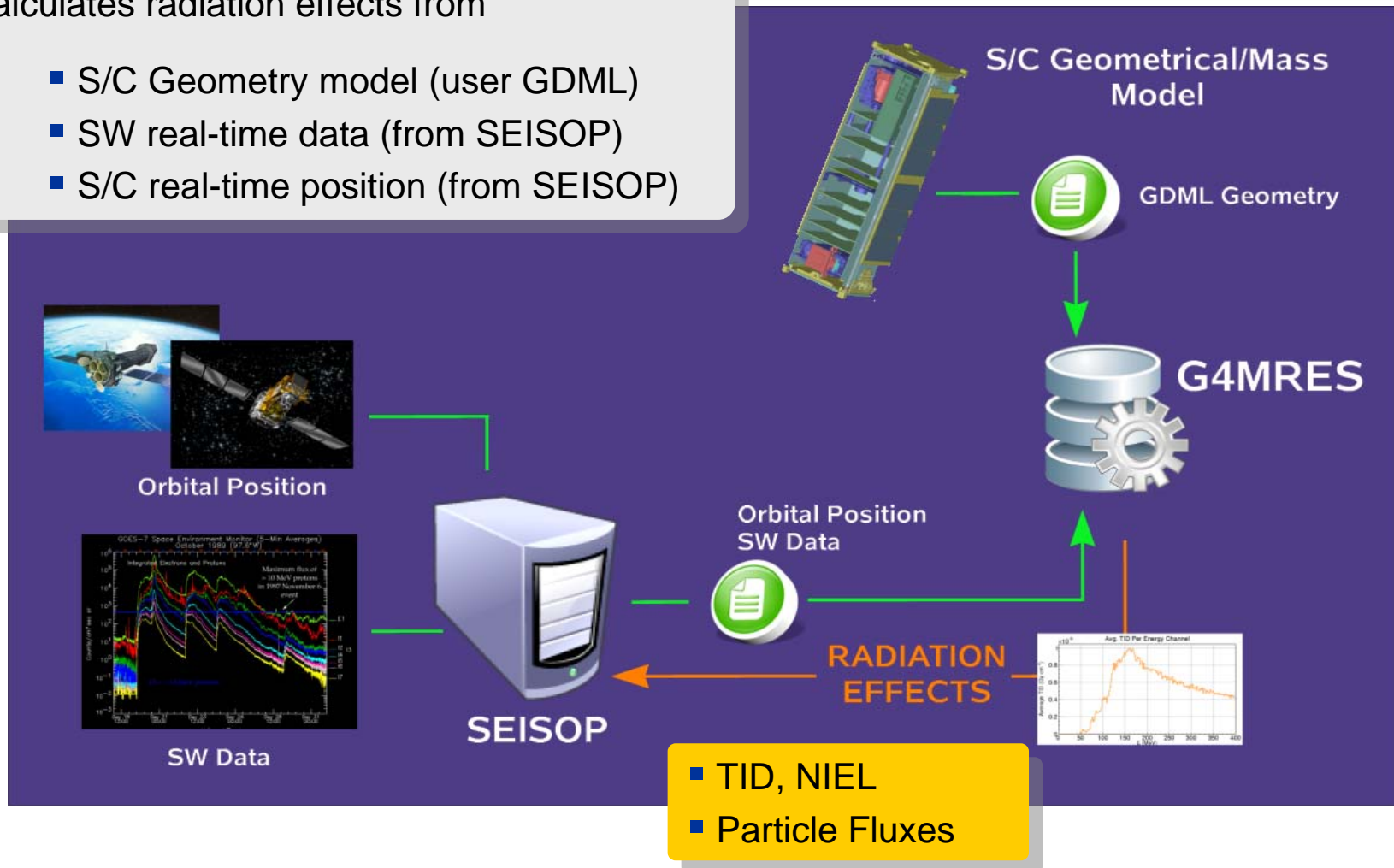
provides satellite operators,..
with an estimation of the
EFFECTS of real-time SW



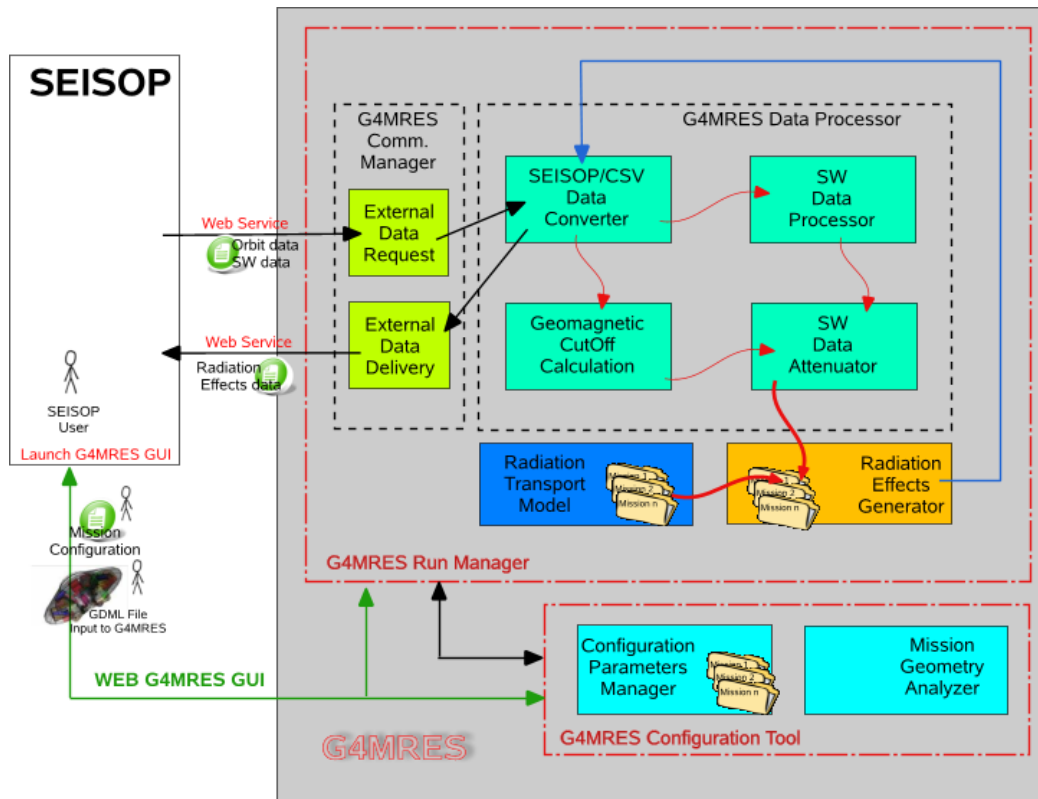
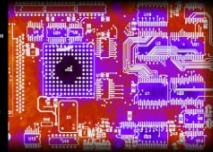
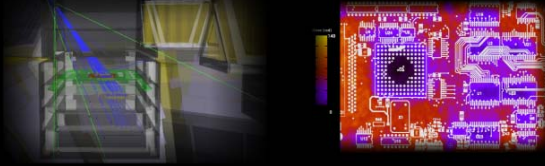
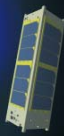


Calculates radiation effects from

- S/C Geometry model (user GDML)
- SW real-time data (from SEISOP)
- S/C real-time position (from SEISOP)



- TID, NIEL
- Particle Fluxes



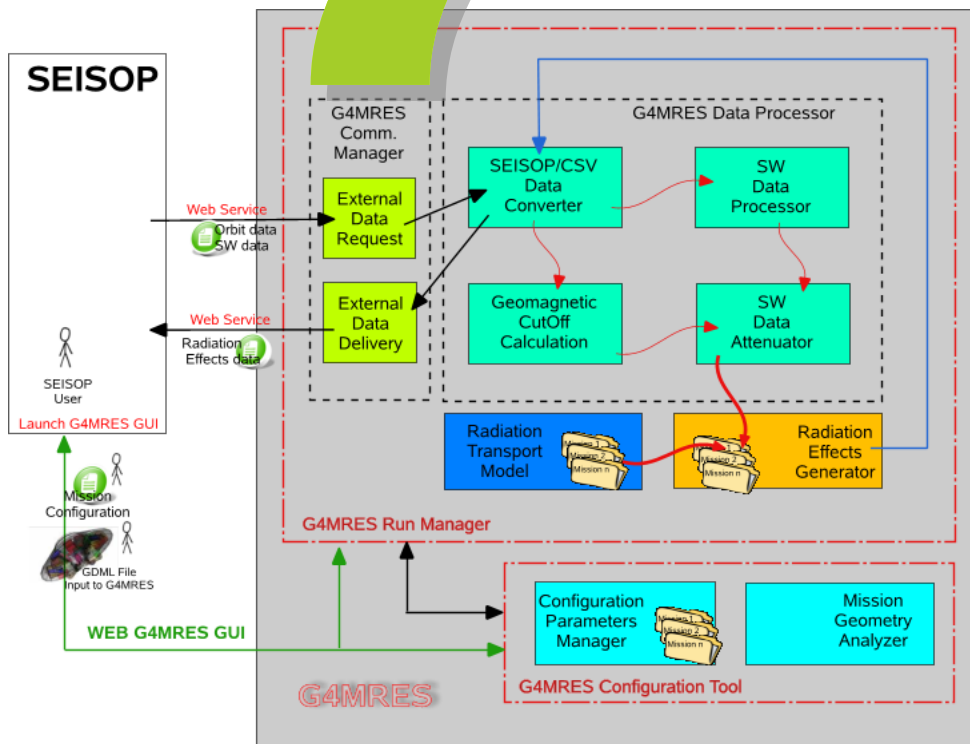
ARCHITECTURE

Main Modules

- **COMM**
Communication with SEISOP
- **DP**
SW & Orbital data processing
- **REG**
Radiation effects calculation
- **RTM**
Radiation Model of S/C
- **CT**
Configuration and control
- **GUI**
Graphical IF for control & monitoring

Implementation

- Geant4/GRAS
- MAGNETOCOSMICS
- Python
- Django



ARCHITECTURE

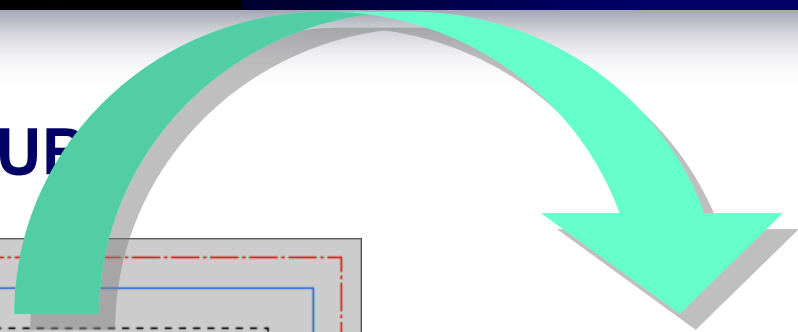
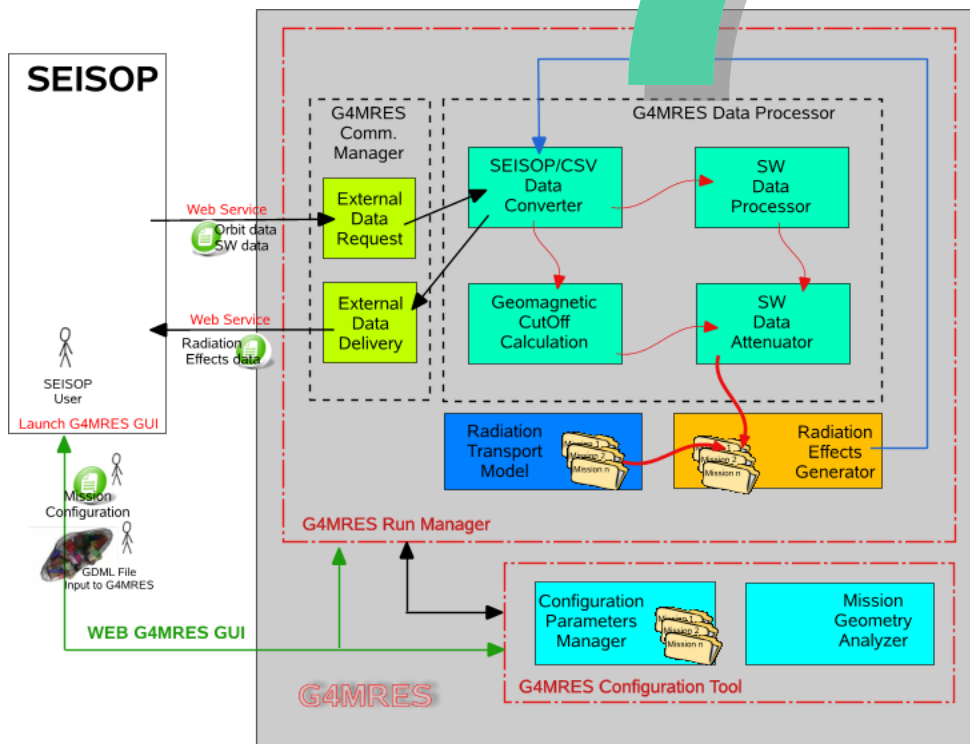
COMM

Manages communication with SEISOP via web-services

- SW data retrieving from SEISOP
- Orbital data retrieving from SEISOP
- Delivering of final radiation products to SEISOP



ARCHITECTURE



DP

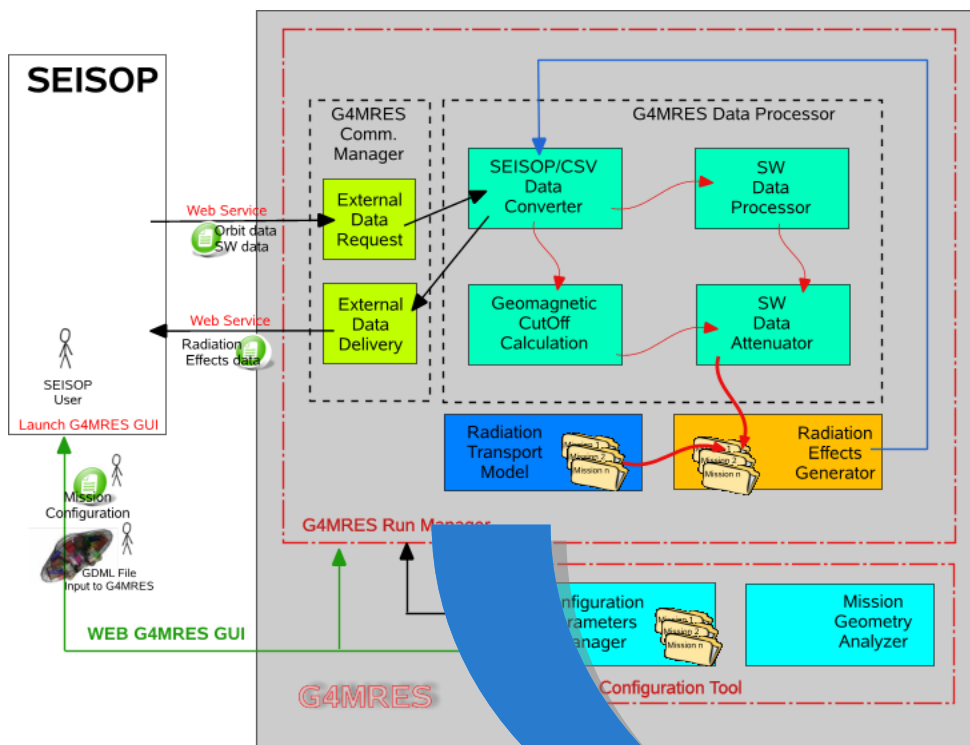
Processing of SW and Orbital data

- Particle spectrum building
- Geomagnetic cutoff at S/C location
- Spectrum geomagnetic attenuation

- Parsing & formatting of data



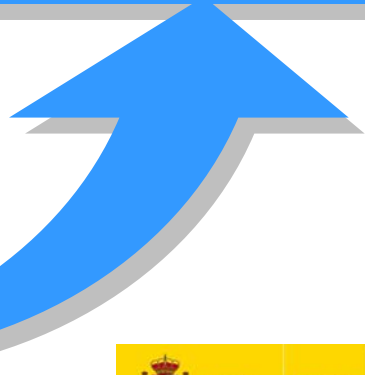
ARCHITECTURE



RTM

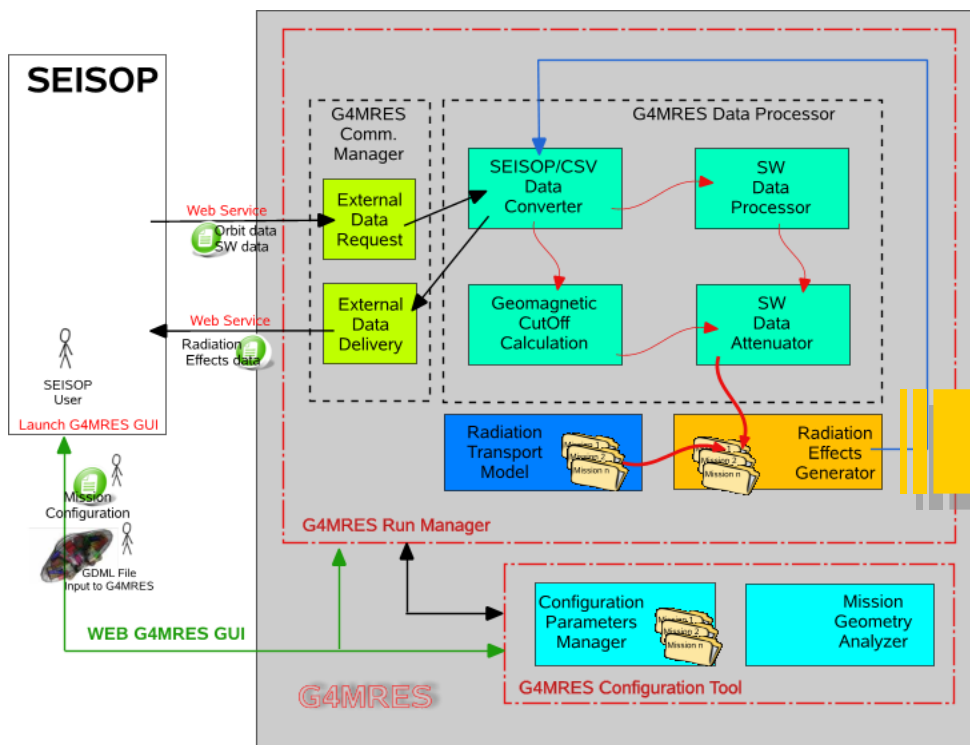
Radiation response of S/C

- Performs detailed G4 simulation
- Characterizes each sensor response
 - per energy channel
 - per particle
 - per omnidirectional flux unit





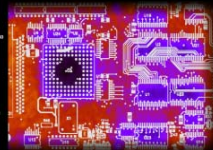
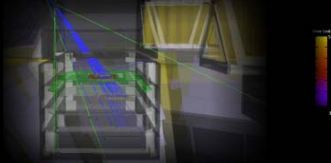
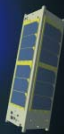
ARCHITECTURE



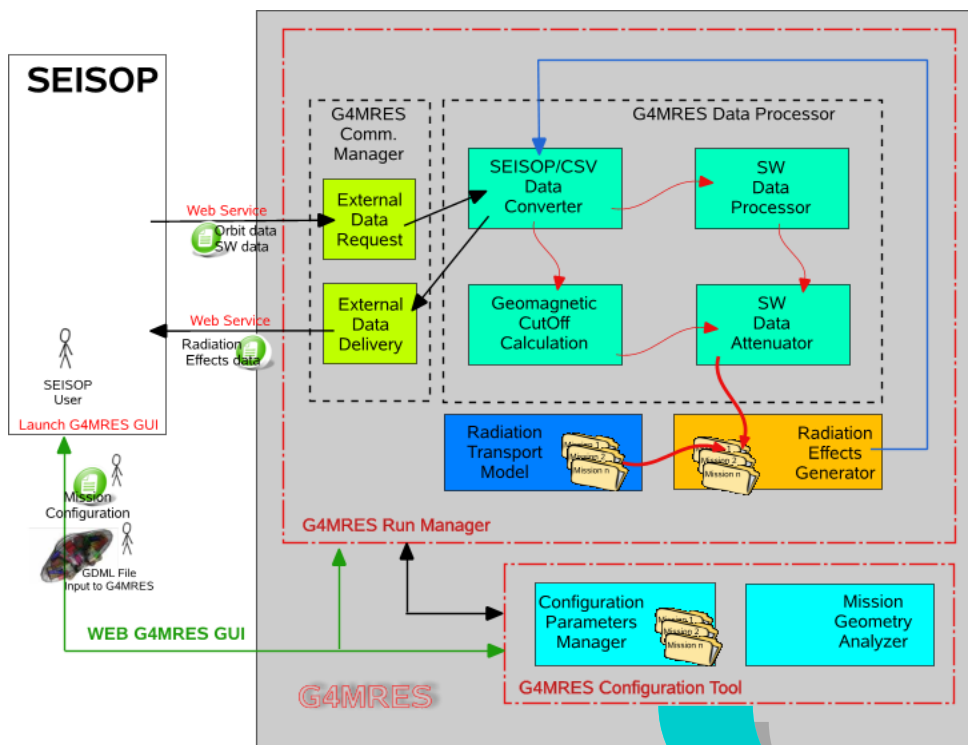
REG

Generates real-time effects for each sensor from

- Real-time spectrum (from DP)
- Effects matrix (from RTM)



ARCHITECTURE



CT & GUI

Control, configuration and running of the tool

- Define users, missions
- Load Geometry
- Define Geant4 settings for RTM
- Define SW/Orbital parameters
- Define SEISOP comm. Settings
- Monitor tool status
- Launch/stop tool



G4MRES
Geant4 for Mission Radiation Effects Simulation

Login...

User:

Password:

G4MRES
Geant4 for Mission Radiation Effects Simulation

Start | Logout

Mission: newMission
New mission description: G4SUWS Seattle 2010

Geometry configuration

Available Radiation Effects Matrices

New Radiation Effects Matrix

Configuration form

Mission details

Choose matrix to use.

Available Radiation Matrices:

SEISOP connection configuration

These data is needed to access and deliver data to SEISOP should be requested to SEISOP admin.

Connection details:

Introduce your username and password to SEISOP:

User for login to SEISOP:

User password for login to SEISOP:

Data details:

Introduce the Global IDs of the spacecraft position per altitude and longitude.

Satellite altitude:

Satellite latitude:

Satellite longitude:

Save | Reset

Available actions

Mission newMission status: Not running

G4MRES
Geant4 for Mission Radiation Effects Simulation

Start | Logout

Mission configuration

Detectors configuration

Radiation Effects Matrix

Geometry details

A geometry file already exists.

Replace file

Delete geometry file

Check geometry file

Check geometry

Est_Al_Volume
TopLi4_Volume
BottomLi4_Volume
PCB1_Volume
PCB2_Volume
PCB3_Volume
PCB4_Volume
PCB5_Volume
Detector1_Volume
Detector2_Volume
Detector3_Volume
Detector4_Volume
Detector5_Volume
Detector6_Volume

Submit | Reset

Please check that the output is correct before continuing. There may be overlapping volumes in the geometry file submitted.

Files generated by the geometry check:

Geometry check: output
Geometry list
Geometry.xml

Detectors list

The following detectors were chosen previously:

Name	Delete
Detector3_Volume	<input type="button" value="X"/>
Detector4_Volume	<input type="button" value="X"/>

For choosing a new set press **Check geometry** to reload geometry.

G4MRES
Geant4 for Mission Radiation Effects Simulation

Start | Logout

Mission configuration

Detectors configuration

Geometry configuration

Mission: newMission

Radiation Effects Matrix Configuration

Detectors Selected

Detector3_Volume
Detector4_Volume

Radiation Matrix Setup

Radiation matrix details:

Introduce a name for the matrix to generate.

Matrix name:

Primary particles:

Introduce the primaries.

Primary particle:

Primaries Minimum Energy:

Primaries Maximum Energy:

Secondary particles:

Introduce the secondaries.

Primary particle:

Secondaries Minimum Energy:

Secondaries Maximum Energy:

Physics:

Introduce physics details.

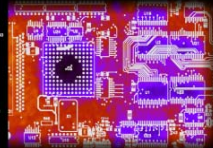
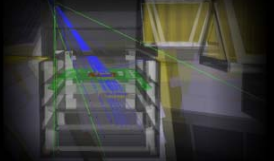
Physics Lists:

Primary Energy distribution type:

Cut:

Save | Reset





- G4MRES provides operators an easy-to-use tool to
 - Get an estimation of SW events impact...
 - ... in real-time!!
 - Mission oriented and designed to support operations

- It takes advantage of
 - SEISOP as advanced SW data system
 - Geant4 as reliable and accurate particle propagator

- Current status
 - Delivery to ESA and installation at ESOC
 - First tests with INTEGRAL mission are on-going