



7th International Conference on Astrodynamics Tools and Techniques

DESIGN AND ENGINEERING SUITE FOR EARTH OBSERVATION

6-9 November 2018

DLR Oberpfaffenhofen, Germany



@ElecnorDeimos



AGENDA



desEO - Design Engineering Suite for Earth Observation

- Introduction
- Tool Background
- desEO Implementation
- desEO in Mission Analysis
- Creating Advanced Specialized Tools using desEO



INTRODUCTION



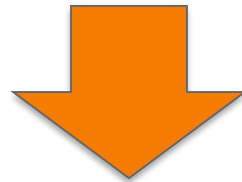
- A toolkit aimed at supporting **mission analysis** and **system/subsystem design** activities for **all phases** of **EO Missions**
 - **Accurate** quantitative results to support trade-offs and analyses
 - Meaningful results in **few minutes**
 - User friendly, multi-platform and self-standing application
 - Modular and flexible to be **easily upgraded, extended** and **modified**

- A specialized, comprehensive and complex collection of tools
 - Capable of **complete Phase A/B1 mission analyses**
 - Provides analyses able to **cover needs in more advanced phases**
 - Provides **building blocks for very specialized tools**



THE INHERITANCE OF AN EARTH OBSERVATION TOOLKIT

- desEO is a tool designed on a **decennial experience** as leaders in EO MA
 - Historical activity overview over 16 years (2003 – 2018)
 - **83** past and on-going systems studies and tool developments
 - **Consolidation** of SW development **techniques** and **methodologies**
 - Consolidation of work methodology and rationalization of scripting and analysis techniques into an all-around and exhaustive tool

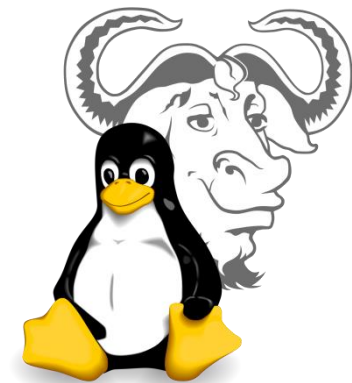
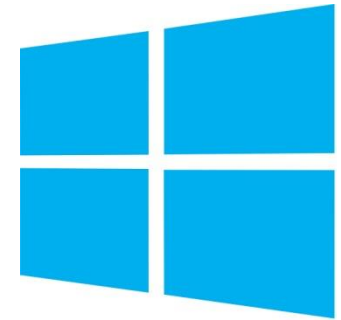
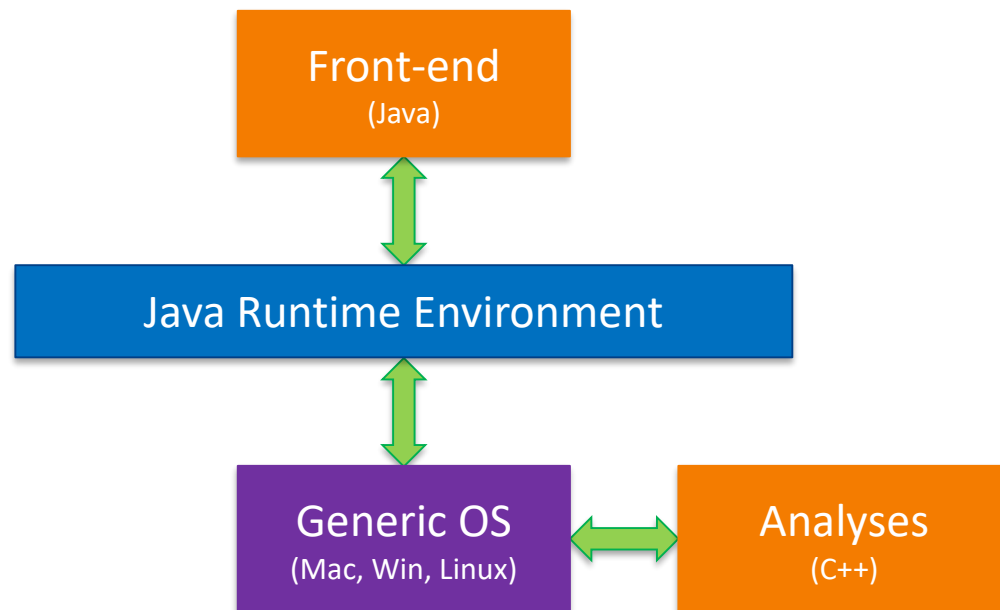


- A **reliable** and **powerful** tool that covers all the systematic analyses
 - Increases **efficiency** (not re-inventing the wheel)
 - Provides capacity to **focus** on mission specific problems
 - Represent the back-bone upon which building more complex tools



MULTI-PLATFORM

- Platform independent Java Eclipse RCP user interface
- Standard C++ analysis modules

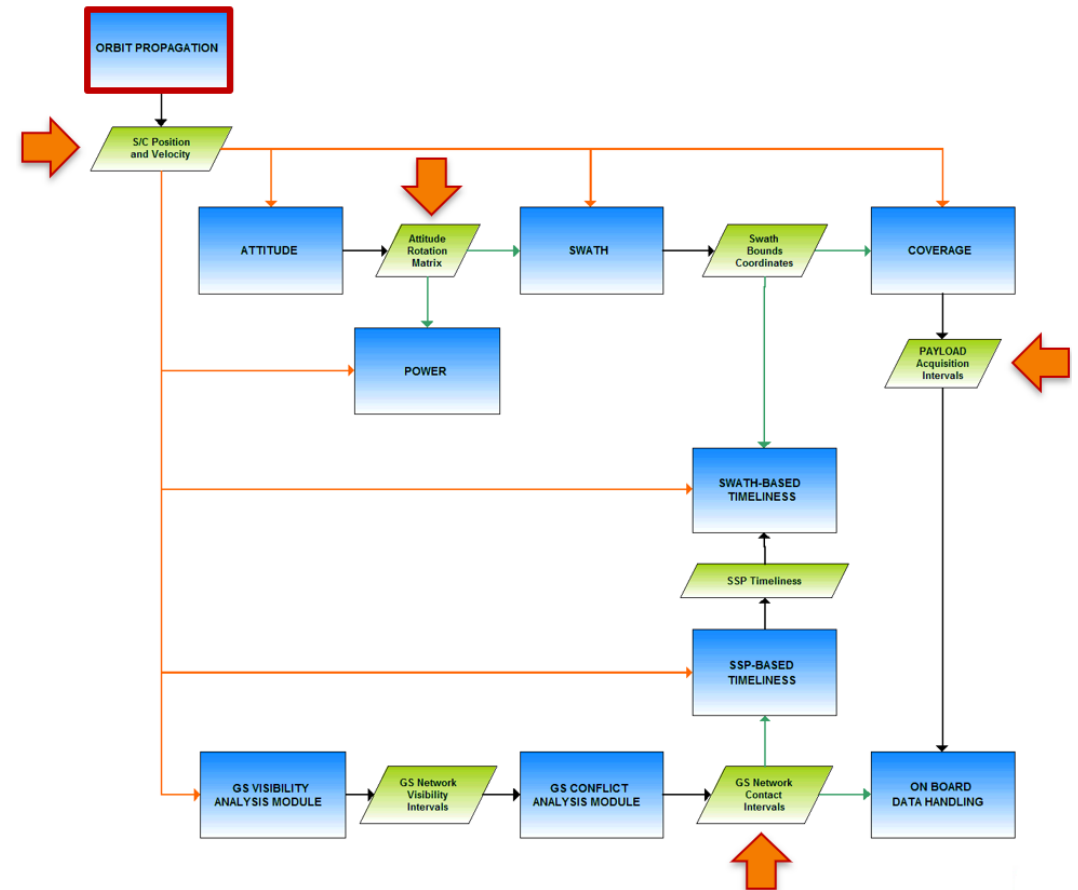
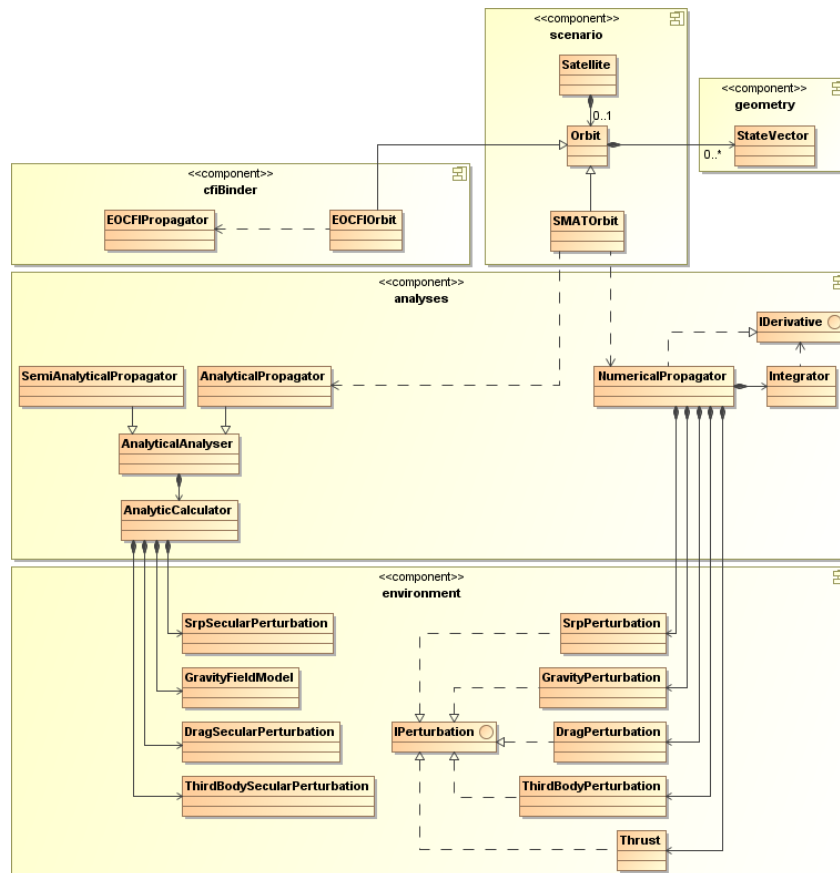




MODULAR DESIGN



- More efficient upgrades and extensions





GRAPHICAL USER INTERFACE

- Easy inputting
 - Guide in input definition
 - Boundary values check
 - Semantic integrity check
- Output capabilities
 - 3D globe
 - Earth Maps
 - Cartesian plots
 - Polar plots
 - Tables
 - Exporting to image format and CSV





GRAPHICAL USER INTERFACE

The screenshot displays the deimOS graphical user interface with several key components labeled:

- Scenario Tree:** A tree view on the left side of the 'Input Tabs' window, listing analysis elements like Scenario, Environment, Ground Segment, Kinura, Space Segment, Satellite, OLCI, Target Areas, and Water.
- Input Tabs:** The central workspace containing configuration options for 'Propagation Numerical propagation', 'Epoch Calendar' (Year: 2,017, Month: 1, Day: 1, Hours: 0, Minutes: 0, Seconds: 0), 'Duration' (1 Days, 20 s), 'Time step' (20 s), and 'Interpolation Time Step' (1 s).
- Output View:** A large window on the right showing a 3D globe with green orbital paths and visibility areas, labeled 'Output Tabs'.
- Integrity Check:** A window at the bottom left showing 'Messages Ready for Run!'.
- Log:** A window at the bottom right displaying a log of execution events with columns for Date, Time, Level, and Message.
- Executed Analyses:** A window at the bottom center showing a list of analysis instances.
- Execution History (instances of the selected analysis):** A window at the bottom center showing details for a specific analysis instance (20170927-144902).
- Graphical Outputs (of the selected analysis instance):** A window at the bottom center showing a table of output files for the selected instance.

INPUT VIEW

OUTPUT VIEW



DUAL INTERFACE



- Graphical User Interface for user friendliness
- Command Line Interface to exploit all the toolkit capabilities

The screenshot displays the Deimos graphical user interface. The central focus is a 3D globe of Earth with satellite coverage data overlaid in various colors (red, yellow, green, blue). The interface is divided into several panels:

- Left Panel:** Contains configuration options for the analysis, including Scenario, Environment, Ground Segment, Kinura, Space Segment, Sentinel-1A, Payloads, OICI, and Target Areas.
- Top Panel:** Shows the current analysis name (WS1) and a 'Run' button.
- Right Panel:** Displays the 'Default Layers' and 'Deseo Layers' for the visualization, including Stars, Atmosphere, NASA Blue Marble Image, Blue Marble May 2004, Place Names, World Map, Scale bar, Compass, and Grid.
- Bottom Panel:** Shows the 'Execution History' and 'Outputs' for the analysis, including a table of results and a 'Messages' section.

```
mars@marsmain ~ $ pwd
/home/mars
mars@marsmain ~ $ cd /usr/portage/app-shells/bash
mars@marsmain /usr/portage/app-shells/bash $ ls -al
total 130
drwxr-xr-x  3 portage portage 1024 Jul 25 10:06
drwxr-xr-x 33 portage portage 1024 Aug  7 22:39
-rw-r--r--  1 root   root    35808 Jul 25 10:06 ChangeLog
-rw-r--r--  1 root   root    27002 Jul 25 10:06 Manifest
-rw-r--r--  1 portage portage 4645 Mar 23 21:37 bash-3.1_p17.ebuild
-rw-r--r--  1 portage portage 5977 Mar 23 21:37 bash-3.2_p39.ebuild
-rw-r--r--  1 portage portage 6151 Apr  5 14:37 bash-3.2_p48-r1.ebuild
-rw-r--r--  1 portage portage 5988 Mar 23 21:37 bash-3.2_p48.ebuild
-rw-r--r--  1 portage portage 5643 Apr  5 14:37 bash-4.0_p10-r1.ebuild
-rw-r--r--  1 portage portage 6238 Apr  5 14:37 bash-4.0_p10.ebuild
-rw-r--r--  1 portage portage 5648 Apr 14 05:52 bash-4.0_p17-r1.ebuild
-rw-r--r--  1 portage portage 5532 Apr  8 10:21 bash-4.0_p17.ebuild
-rw-r--r--  1 portage portage 5660 May 30 03:35 bash-4.0_p24.ebuild
-rw-r--r--  1 root   root    5660 Jul 25 09:43 bash-4.0_p28.ebuild
drwxr-xr-x  2 portage portage 2048 May 30 03:35 files
-rw-r--r--  1 portage portage 468 Feb  9 04:35 metadata.xml
mars@marsmain /usr/portage/app-shells/bash $ cat metadata.xml
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE pkgmetadata SYSTEM "http://www.gentoo.org/dtd/metadata.dtd">
<pkgmetadata>
<herd>base-system</herd>
<use>
<flag name="bashlogger">Log ALL commands typed into bash; should ONLY be
used in restricted environments such as honeypots</flag>
<flag name="net">Enable /dev/tcp/host/port redirection</flag>
<flag name="plugins">Add support for loading builtins at runtime via
enable</flag>
</use>
</pkgmetadata>
mars@marsmain /usr/portage/app-shells/bash $ sudo /etc/init.d/bluetooth status
Passwoord:
* status: started
mars@marsmain /usr/portage/app-shells/bash $ ping -b -c1 en.wikipedia.org
PING rr.esams.wikimedia.org (91.198.174.2) 56(64) bytes of data.

--- rr.esams.wikimedia.org ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 2ms
rtt min/avg/max/mdev = 49.820/49.820/49.820/0.000 ms
mars@marsmain /usr/portage/app-shells/bash $ grep -i /dev/sda /etc/fstab | cut --fields=3
/dev/sda1          /boot              none
/dev/sda2          /dev/sda2          none
/dev/sda3          /

mars@marsmain /usr/portage/app-shells/bash $ date
Sat Aug  8 02:42:24 HSD 2009
mars@marsmain /usr/portage/app-shells/bash $ lsmod
Module              Size  Used by
rndis_wlan          23424  0
rndis_host          8696  1 rndis_wlan
cdc_ether            5672  1 rndis_host
usbnet              10600  0 rndis_wlan,rndis_host,cdc_ether
parport_pc          38424  0
fglrx                2388128  20
parport             39648  1 parport_pc
itCO_udt            12272  0
itCO_i801           9380  0
mars@marsmain /usr/portage/app-shells/bash $
```



desEO IN MISSION ANALYSIS



	CarbonSat	FLEX	Biomass	Deimos-2	NGGM	Sentinel-3 (*)	Sentinel-5	PARIS IoD	UrtheDaily	OptiSAR	Landmapper	sat4EO	DRR	DESIRE	H2020 ONION Operational Network of Individual Observation Nodes
	MA Phase A/B1	MA Phase 0/A/B1	MA Phase 0/A/B1	MA Phase A/B/C/D/E	MA Phase 0	MA Phase A/B/C/D	MA Phase A/B	Phase A	MA Phase A	MA Phase A/B	MA Phase A	MA Phase A/B1	Capacity Study	Capacity Study	
Orbit Propagation	V	V	V	V	V	V	V	V	V	V	-	V	-	-	V
Attitude Coverage	-	-	-	V	-	-	V	-	-	-	-	-	-	-	-
Ground Stations Visibility	V	V	V	V	V	V	-	V	V	V	V	V	V	V	V
Ground Stations Conflict	V	V	V	V	V	V	-	V	V	V	V	V	V	V	V
Timeliness	-	V	V	-	-	V	-	-	V	V	-	-	V	V	V
Swath Properties	V	V	V	V	-	V	V	V	V	V	V	V	V	V	V
Sun-Zenith Angle	V	V	-	V	-	V	V	-	V	V	V	V	V	V	V
Observation-Zenith	V	V	V	V	-	V	V	V	V	V	V	V	V	V	V
SC Topocentric Coordinates	V	V	-	V	-	V	-	-	V	V	-	-	-	-	V
Pointing Analysis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Semi-analytical Propagation	-	-	-	V	V	-	-	V	V	V	-	V	-	-	V
Atmospheric Properties	V	V	V	V	V	V	-	V	V	V	-	V	-	-	V
Altitude Control	V	-	-	V	V	-	-	-	V	V	-	V	-	-	V
Inclination Control	V	-	V	-	-	-	-	-	V	V	-	-	-	-	-
Eq. Ground Track	-	V	V	-	-	V	-	-	V	V	-	-	-	-	-
OA + OI Control	-	-	-	-	-	-	-	-	V	-	-	-	-	-	-
EGT + OI Control	-	-	V	-	-	V	-	-	V	-	-	-	-	-	-
EOL Decay	V	V	V	V	V	V	-	V	V	V	-	V	-	-	V
Beta Angle	V	V	V	V	V	V	-	V	V	V	-	V	-	-	-
Eclipses	V	V	V	V	V	V	-	V	V	V	-	V	-	-	-
Ground Illumin. Time Tran.	-	-	-	-	-	-	V	-	-	-	-	-	-	-	-
Coordinates Tran.	-	-	-	V	-	V	V	-	-	-	-	-	-	-	-
Injection Errors Correction	V	V	V	V	V	V	-	-	V	V	-	V	-	-	V
Collision Avoidance	V	V	V	V	V	V	-	-	V	V	-	V	-	-	V
Orbit Transfer	-	V	V	V	V	V	-	-	V	V	-	-	-	-	V
Master-Drone	-	V	-	-	V	-	-	-	-	V	-	-	-	-	-
Orbit Wizard	-	-	-	V	-	-	-	-	-	-	-	V	V	V	-
LEO Selection	V	-	V	V	V	V	-	V	V	V	V	V	V	V	V
SSO Inclination	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Frozen Eccentricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RAAN Drift Rate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Basic Swath	V	-	-	V	-	V	V	V	V	V	V	V	-	-	V
Geodetic Distance	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DV & Fuel Budget	V	V	V	V	V	V	-	-	V	V	-	V	-	-	V
OBDH	-	-	V	V	-	V	-	-	V	V	V	V	V	V	V
Power Budget	-	-	-	V	-	-	-	-	-	-	-	-	-	-	V



AN EARTH EXPLORER 8 MISSION ANALYSIS

- Orbit Propagation
 - Attitude
 - Coverage
- Ground Stations Visibility
- Ground Stations Conflict
- Timeliness
- Swath Properties
 - Sun-Zenith Angle
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 - OBDH
 - Power Budget



Orbit Propagation

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RAAN Drift Rate

Basic Swath Geometry

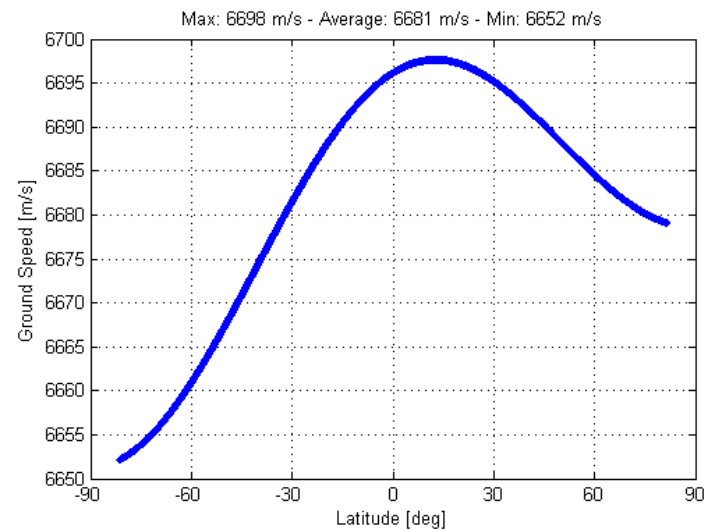
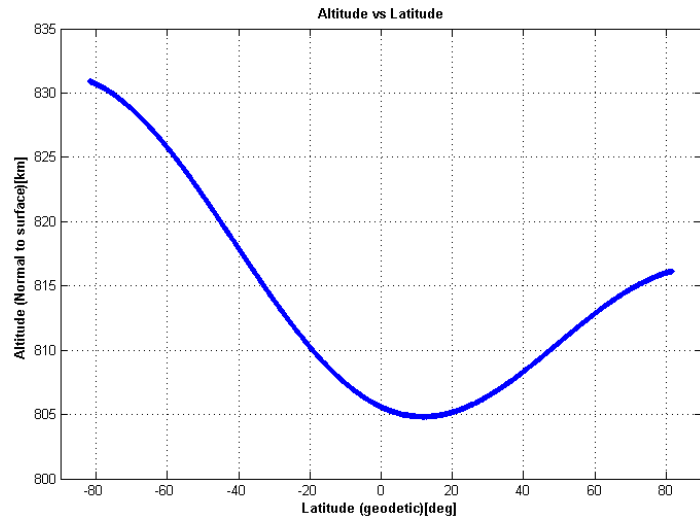
Geodetic Distance

DV & Fuel Budget

OBDR

Power Budget

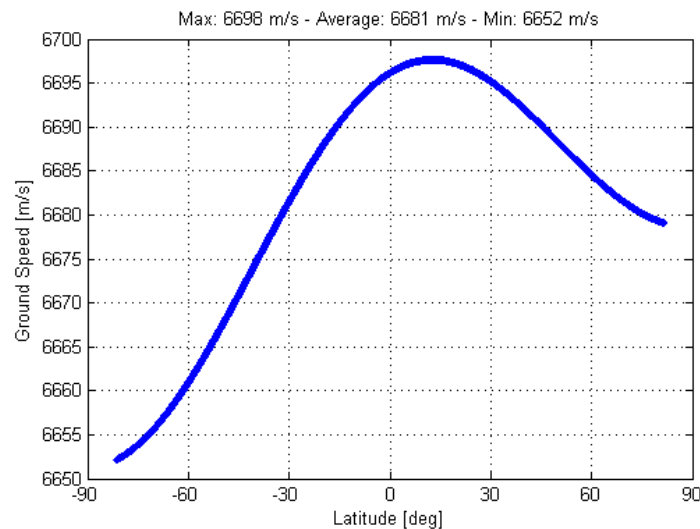
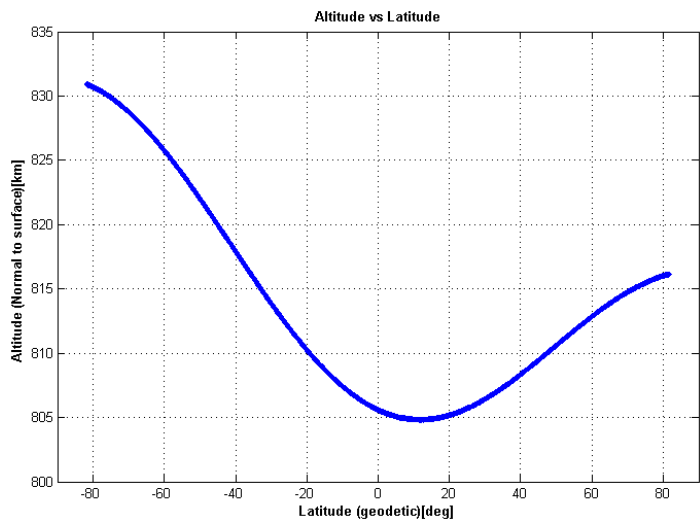
ORBIT PROPAGATION





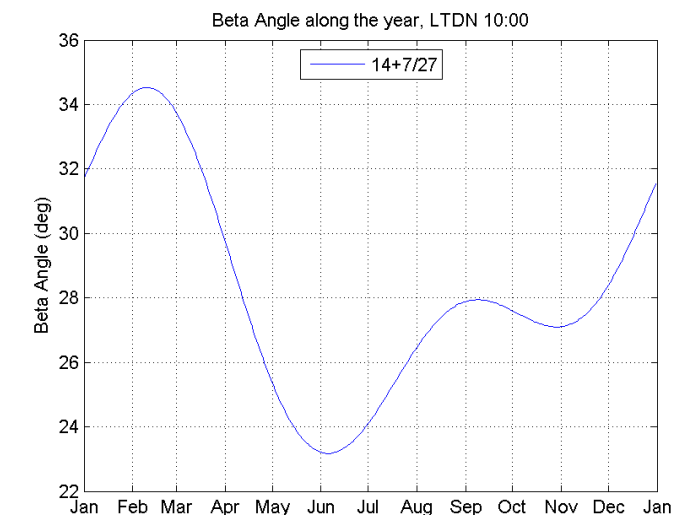
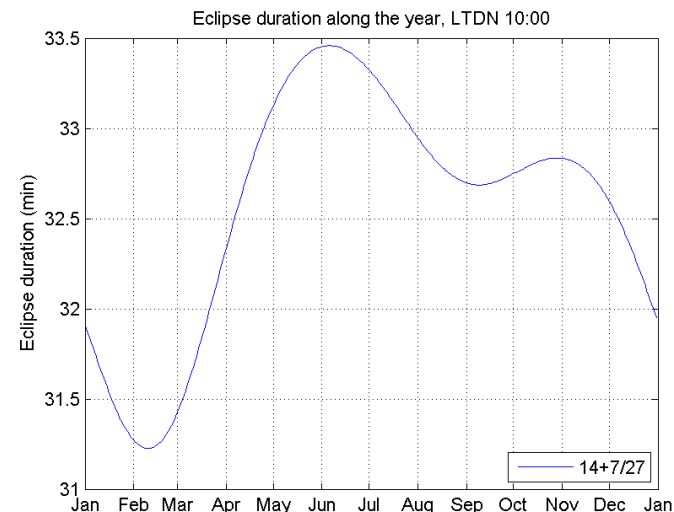
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ORBIT PROPAGATION



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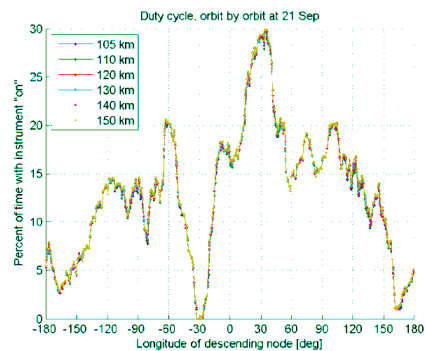
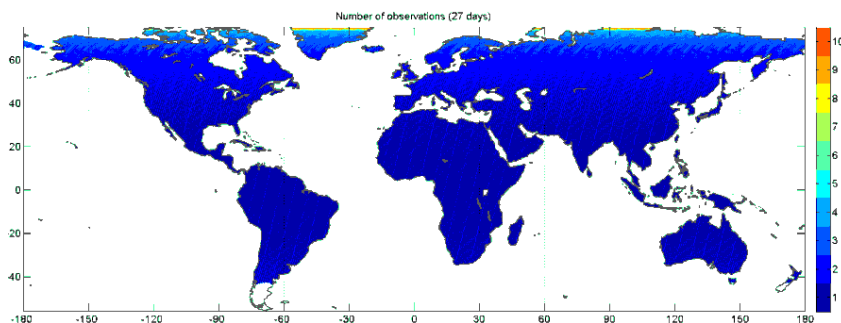
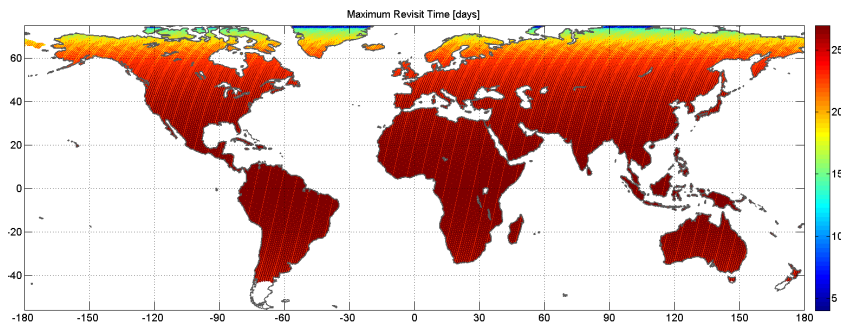
ECLIPSE & β -ANGLE





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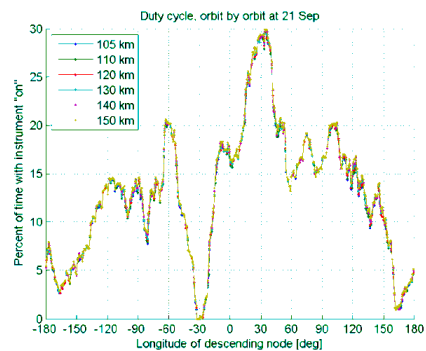
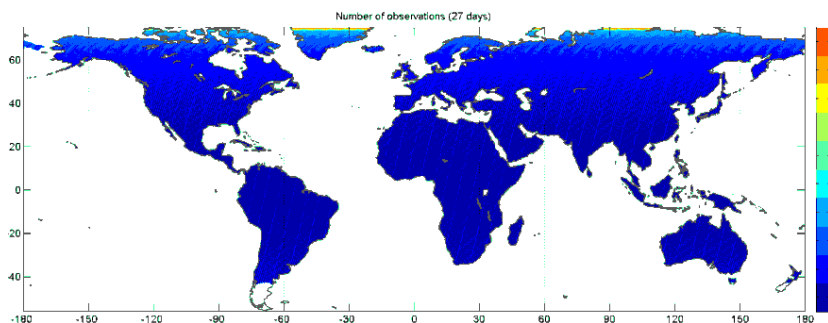
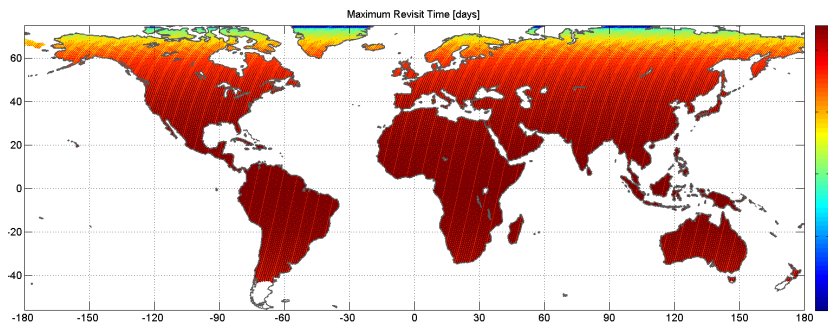
COVERAGE





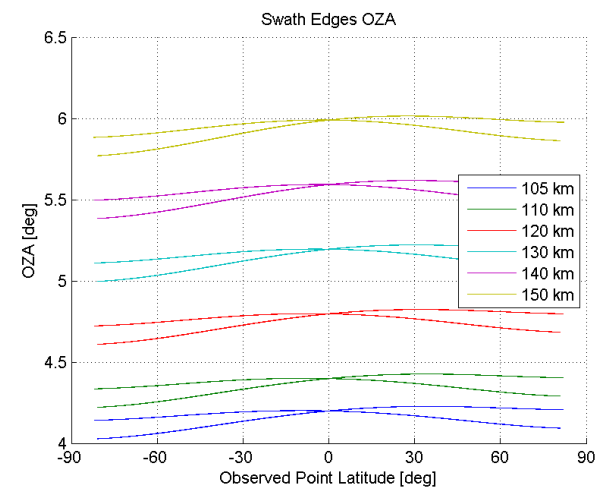
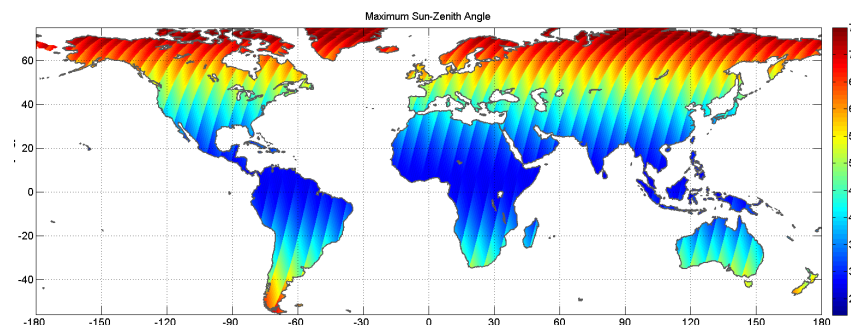
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OZA, SZA & SWATH

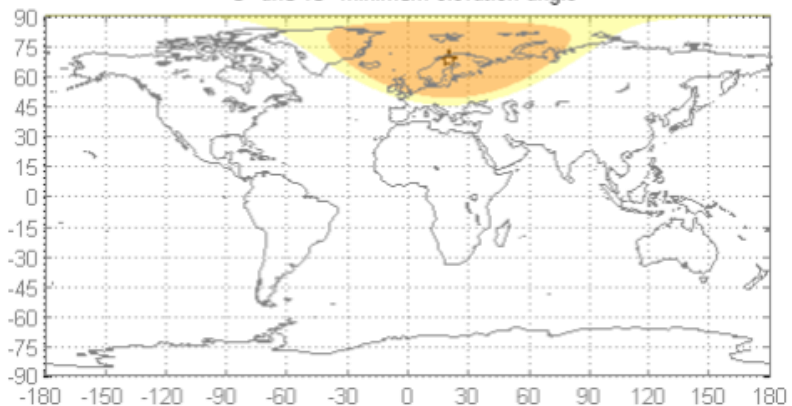




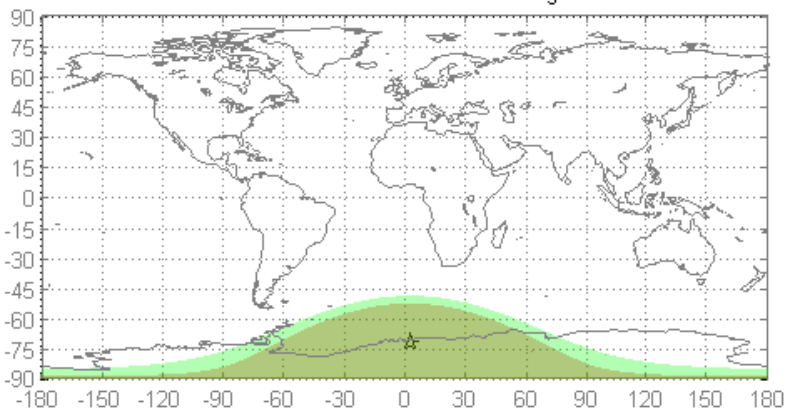
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GS CONTACTS

Orbit and Associated Visibility Zones for Kiruna
5° and 10° minimum elevation angle



Orbit and Associated Visibility Zones for Troll
5° and 10° minimum elevation angle

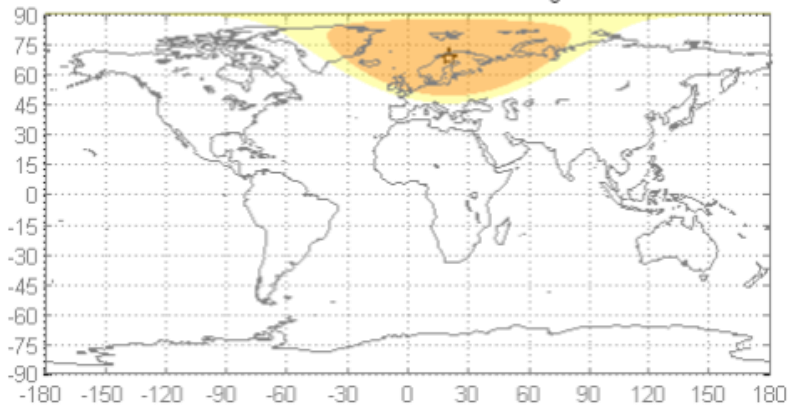




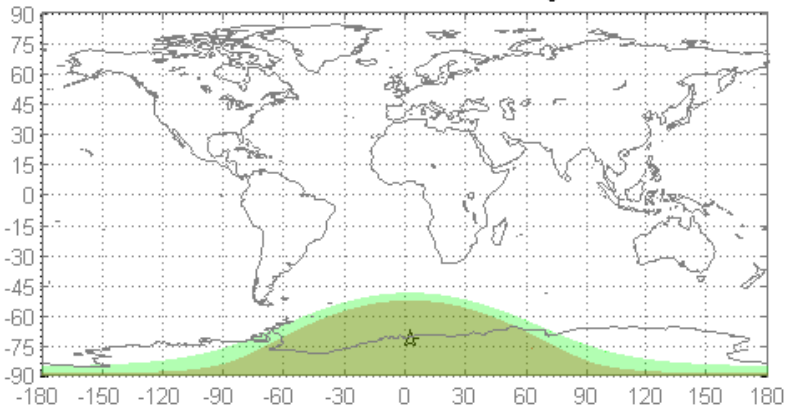
GS CONTACTS

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- Basic Swath Geometry
- Geodetic Distance
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- OBDDH
- Power Budget

Orbit and Associated Visibility Zones for Kiruna
5° and 10° minimum elevation angle

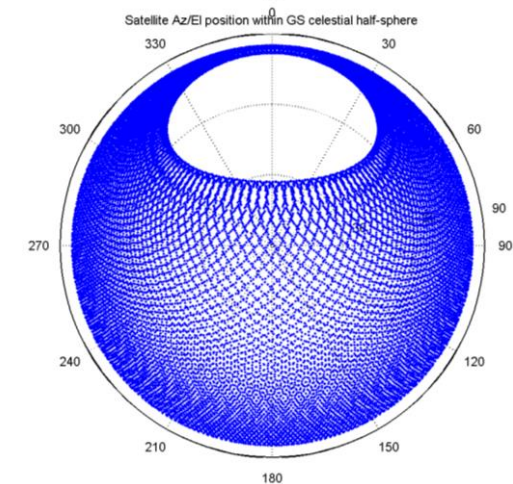
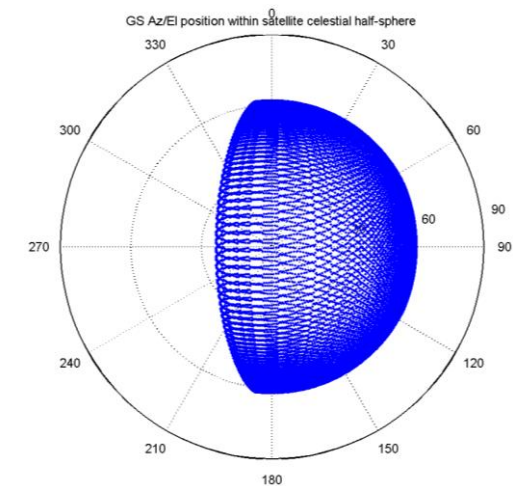


Orbit and Associated Visibility Zones for Troll
5° and 10° minimum elevation angle



RELATIVE GEOMETRY

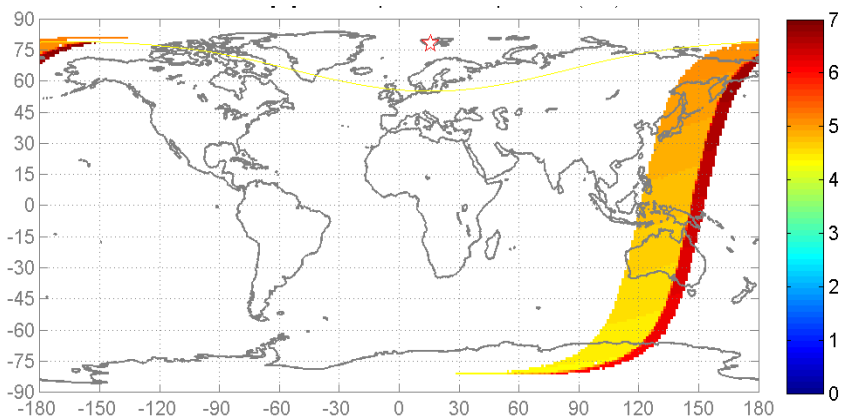
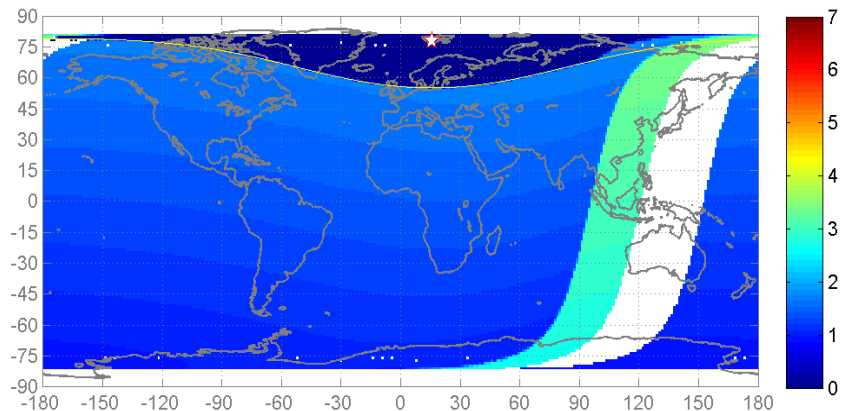
- Orbit Propagation
- Attitude
- Coverage
- Ground Stations Visibility
- Ground Stations Conflict
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TIMELINESS

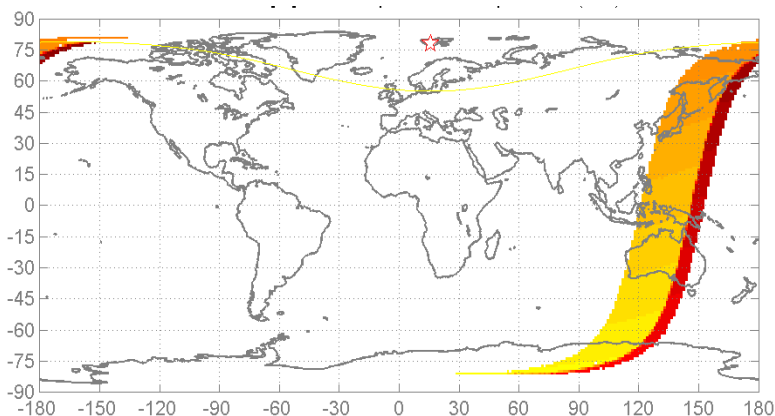
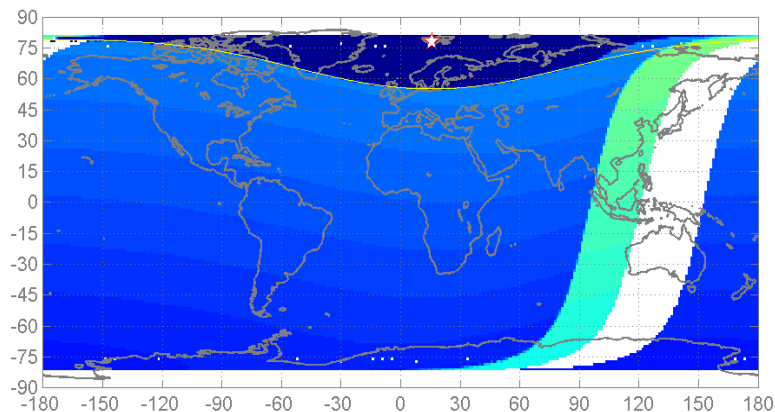
Orbit Propagation
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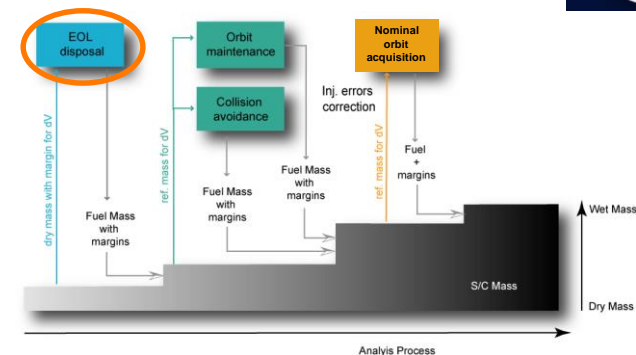
- Orbit Propagation
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TIMELINESS

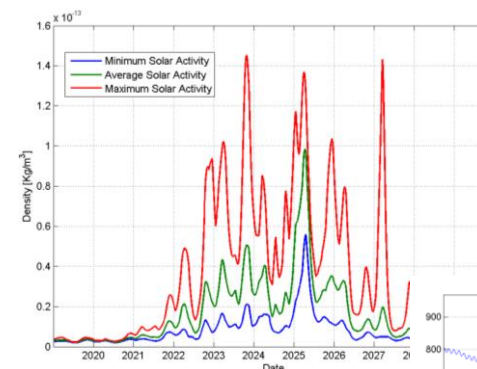


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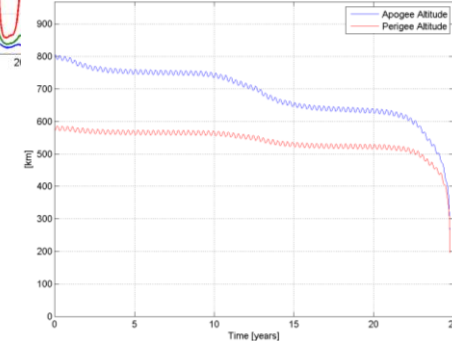
EOL DISPOSAL



Orbit-Averaged Atmospheric Density



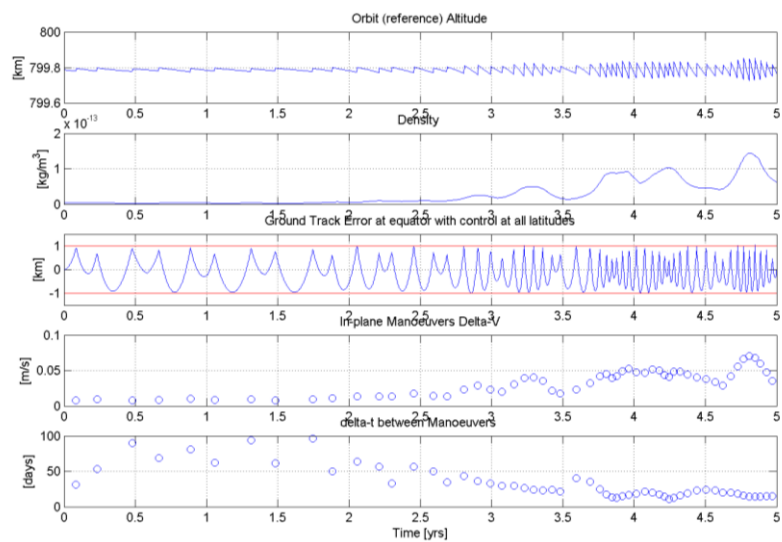
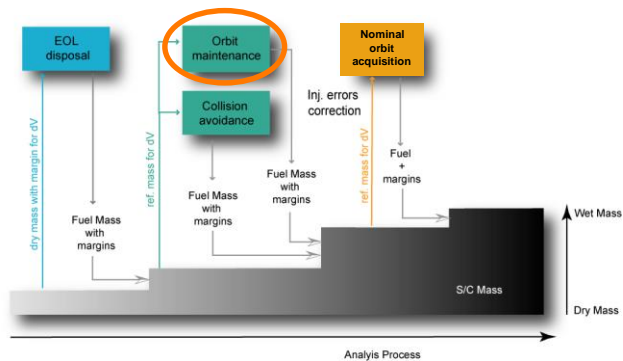
Perigee and Apogee Altitude Evolution





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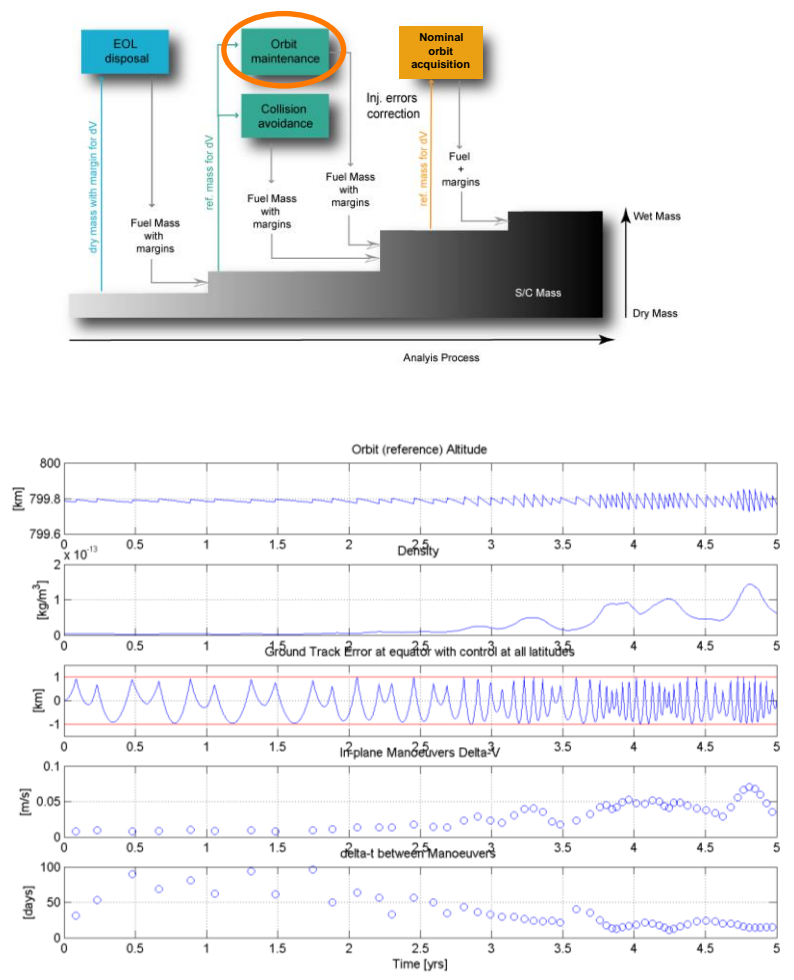
GROUND TRACK CONTROL





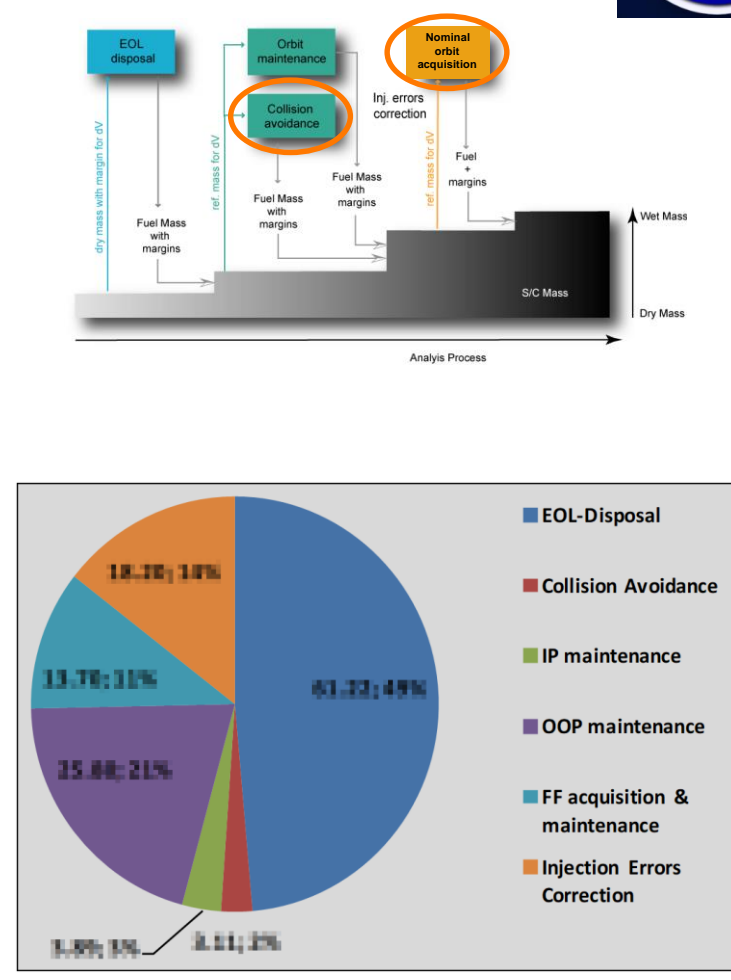
- Orbit Propagation
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GROUND TRACK CONTROL



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ΔV & FUEL BUDGET

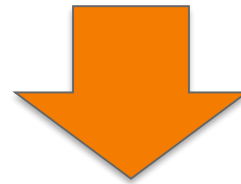




desEO TO CREATE ADVANCED SPECIALIZED TOOLS



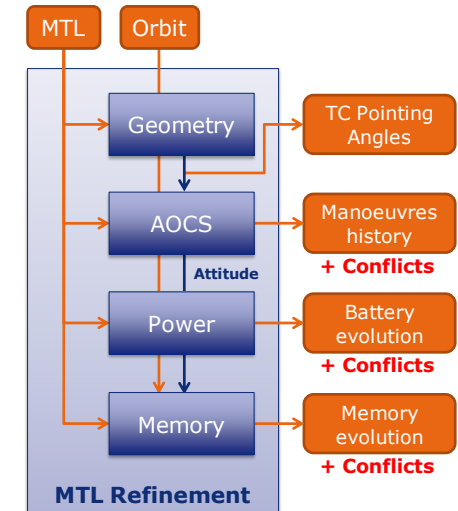
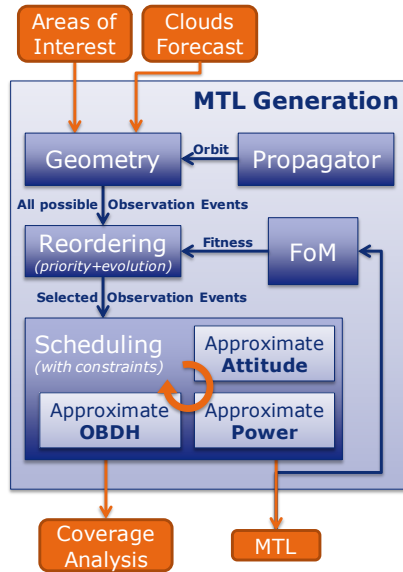
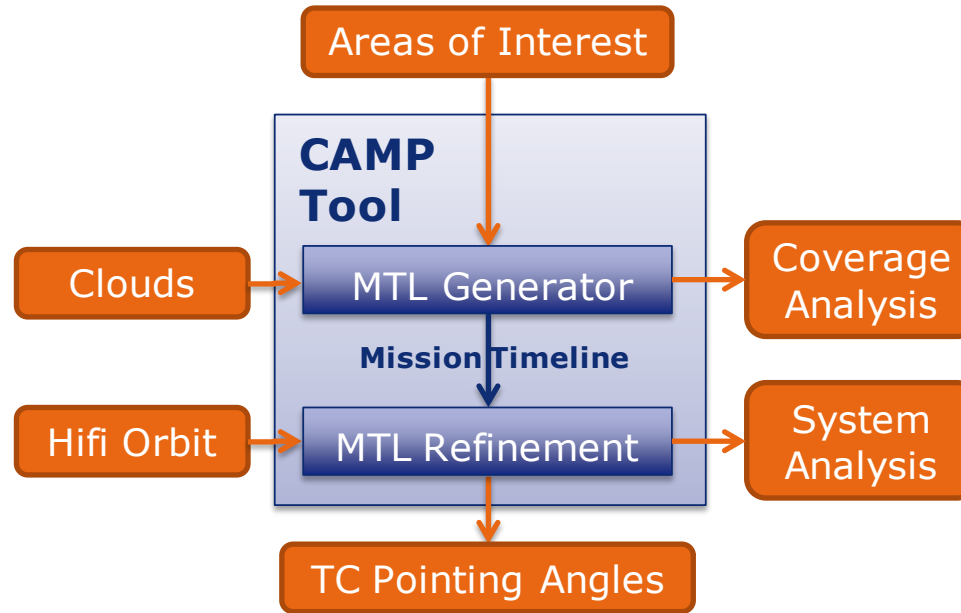
- Success case: Fully Automated **Mission Planning** and **Capacity Analysis Tool** (CAMP) for the Deimos-2 Agile Satellite
 - Advantages → platform agility to improve mission return, reducing revisit time and increasing operational flexibility
 - Drawbacks → platform agility makes mission planning a complex optimization problem with a high number of degrees of freedom, which is cumbersome for human operators



- Automation as a key enabler for the mission planning and exploitation process
 - Capacity analysis → study long-term coverage with real-life constraints (simplified geometrical analyses are unreliable)
 - Simulate resources for system compliance cross-checking



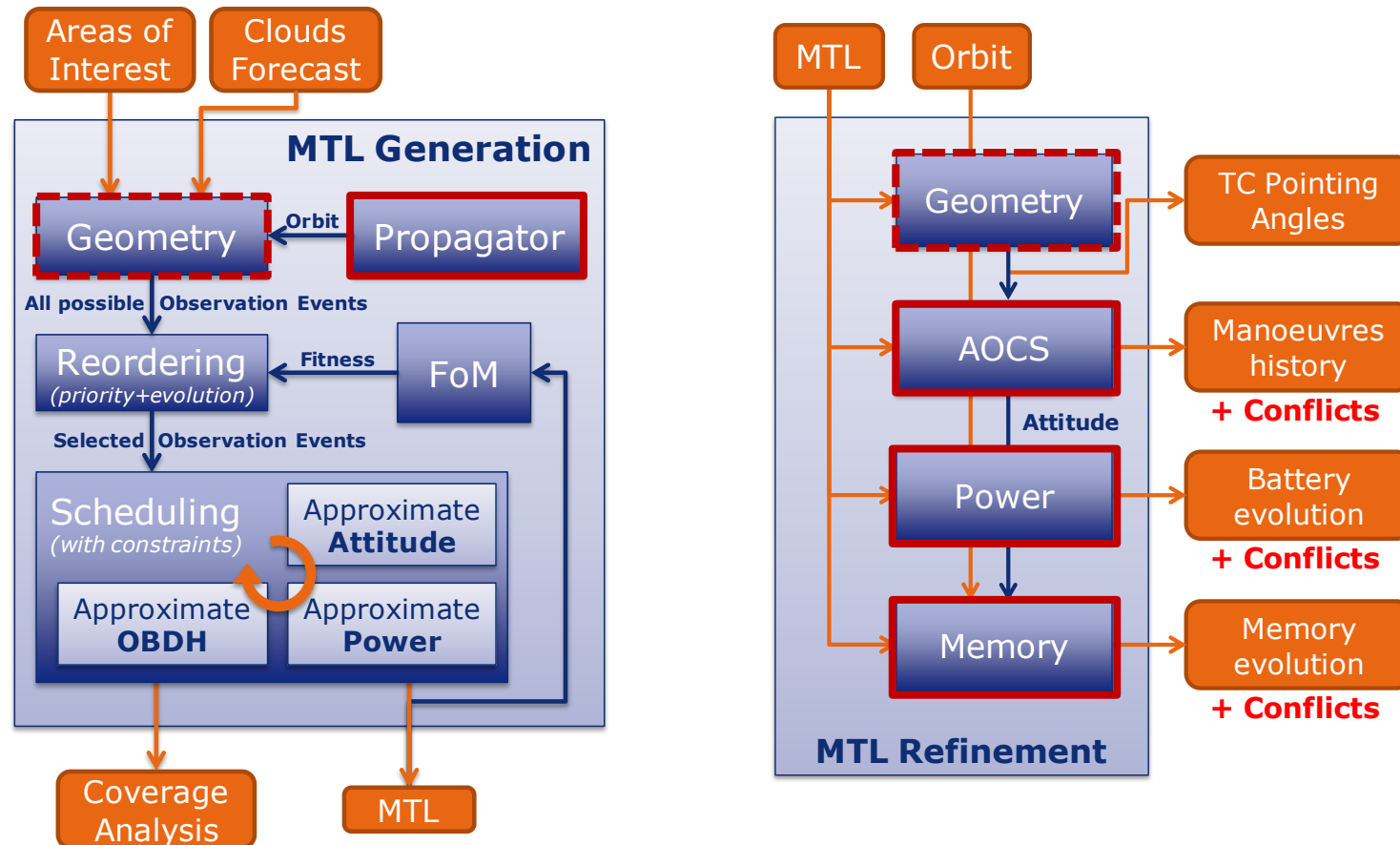
CAMP HIGH-LEVEL ARCHITECTURE





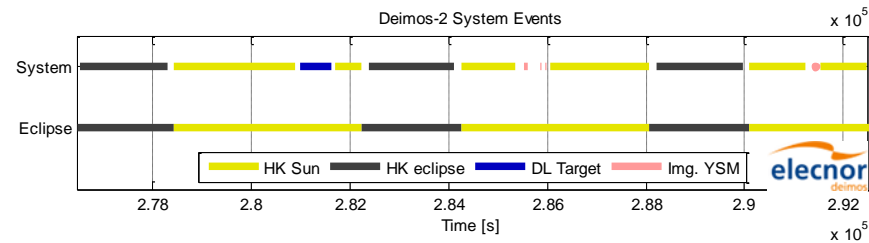
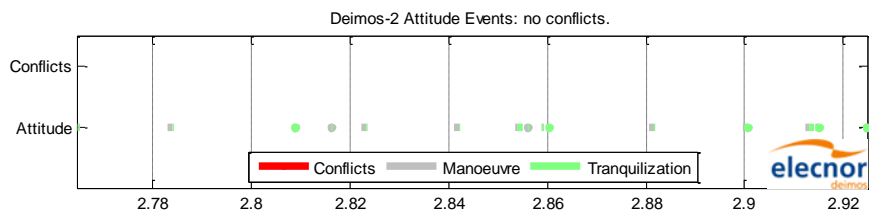
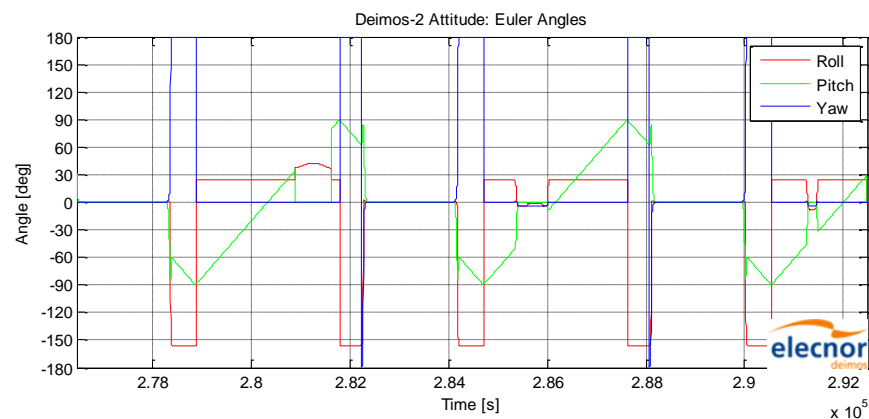
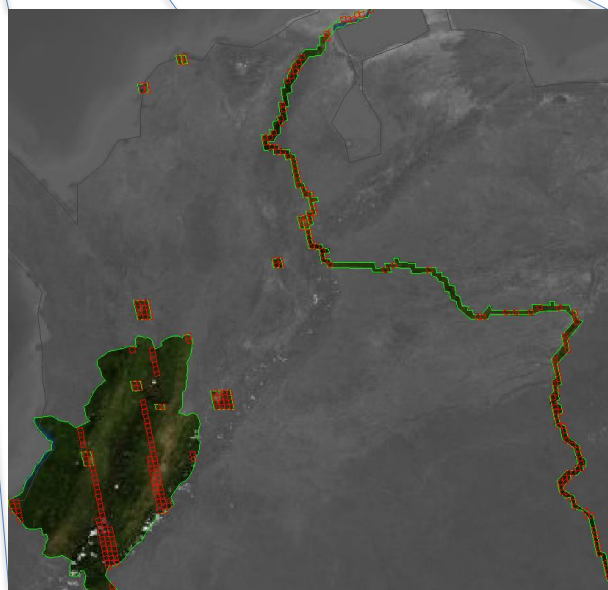
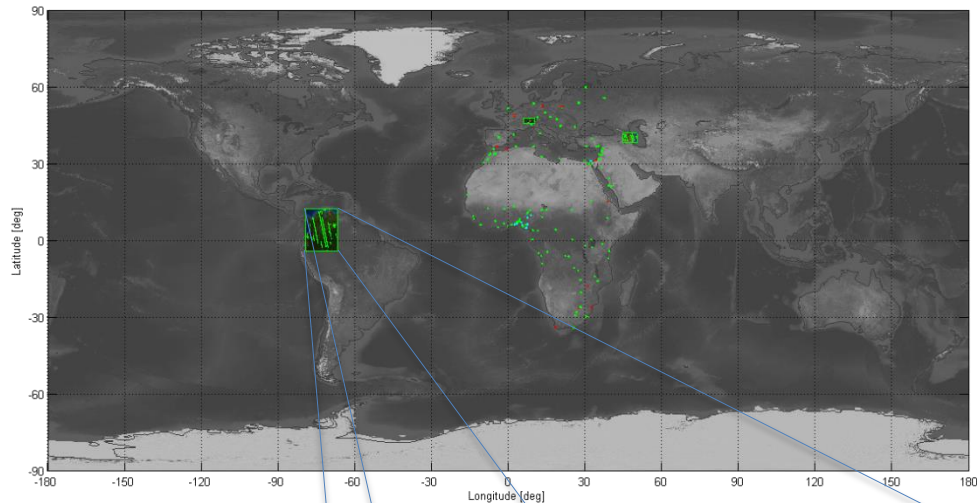
CAMP HIGH-LEVEL ARCHITECTURE

- desEO executables as stand-alone building blocks within CAMP





CAMP OUTPUT EXAMPLES





CONCLUSIONS



- **desEO** is a powerful toolkit able to:
 - support **mission analysis** and **system/subsystem design** activities for **all phases** of **EO Missions**
 - provide **accurate quantitative results** to support trade-offs and analyses
 - provide **meaningful** results in **few minutes**
 - be **easily upgraded, extended** and **modified**

- **desEO** is a specialized, comprehensive and complex collection of tools
 - user friendly, multi-platform and self-standing application
 - providing **building blocks for very specialized tools**



THANK YOU

federico.letterio@deimos-space.com