deimos
elecnor group

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

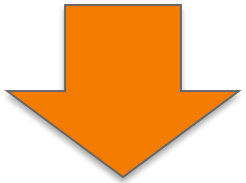
INTRODUCTION

- 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

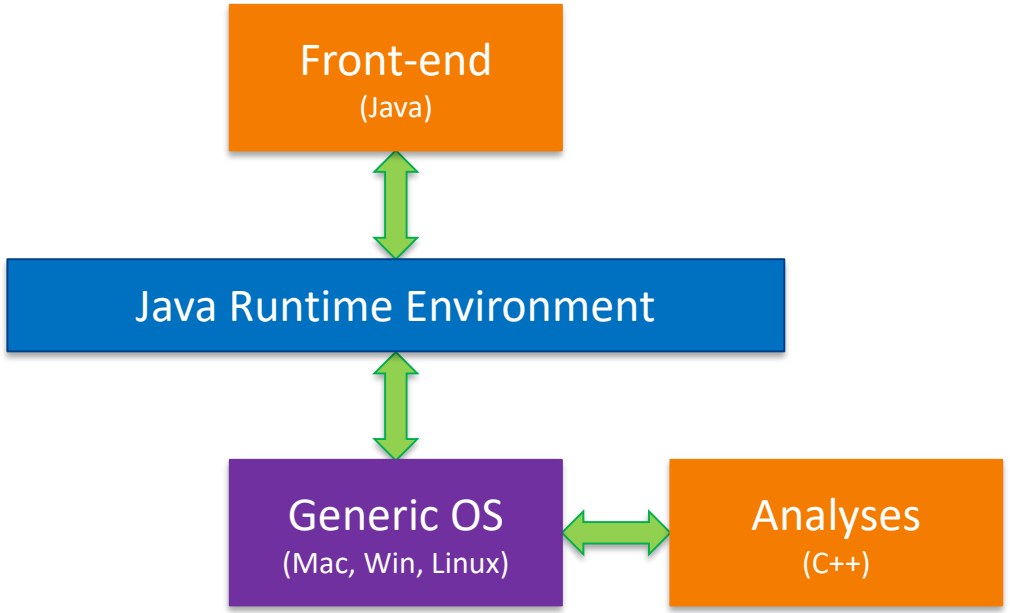
- desEO is a tool designed on a **decennial experience** as leaders in EO MA
  - Historical activity overview over 16 years (2003 – 2018)
  - **83** past and on-going systems studies and tool developments
  - **Consolidation** of SW development **techniques** and **methodologies**
  - Consolidation of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

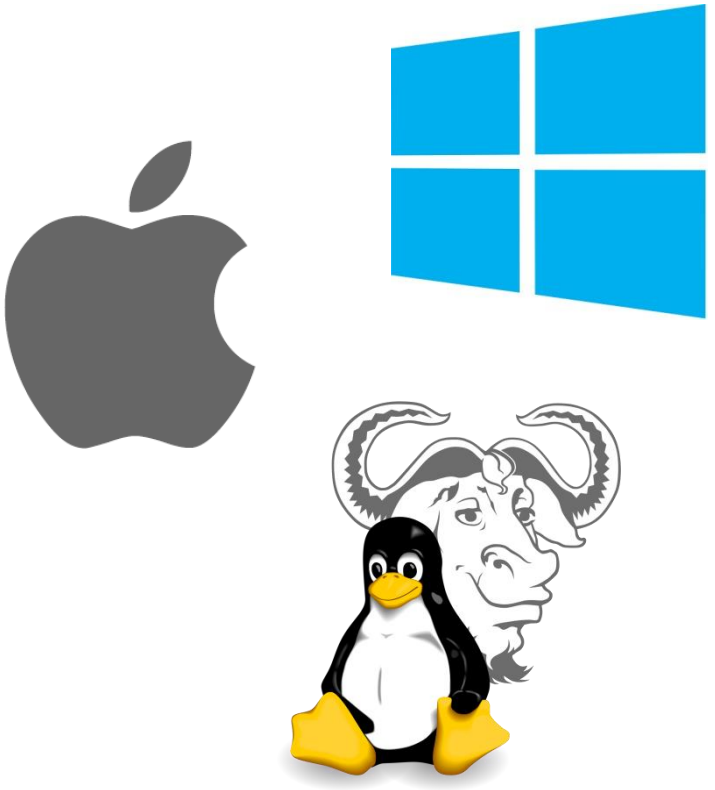


- A **reliable** and **powerful** tool that covers all the systematic analyses
  - Increases **efficiency** (not re-inventing the wheel)
  - Provides capacity to **focus** on mission specific problems
  - Represent the back-bone upon which building more complex tools

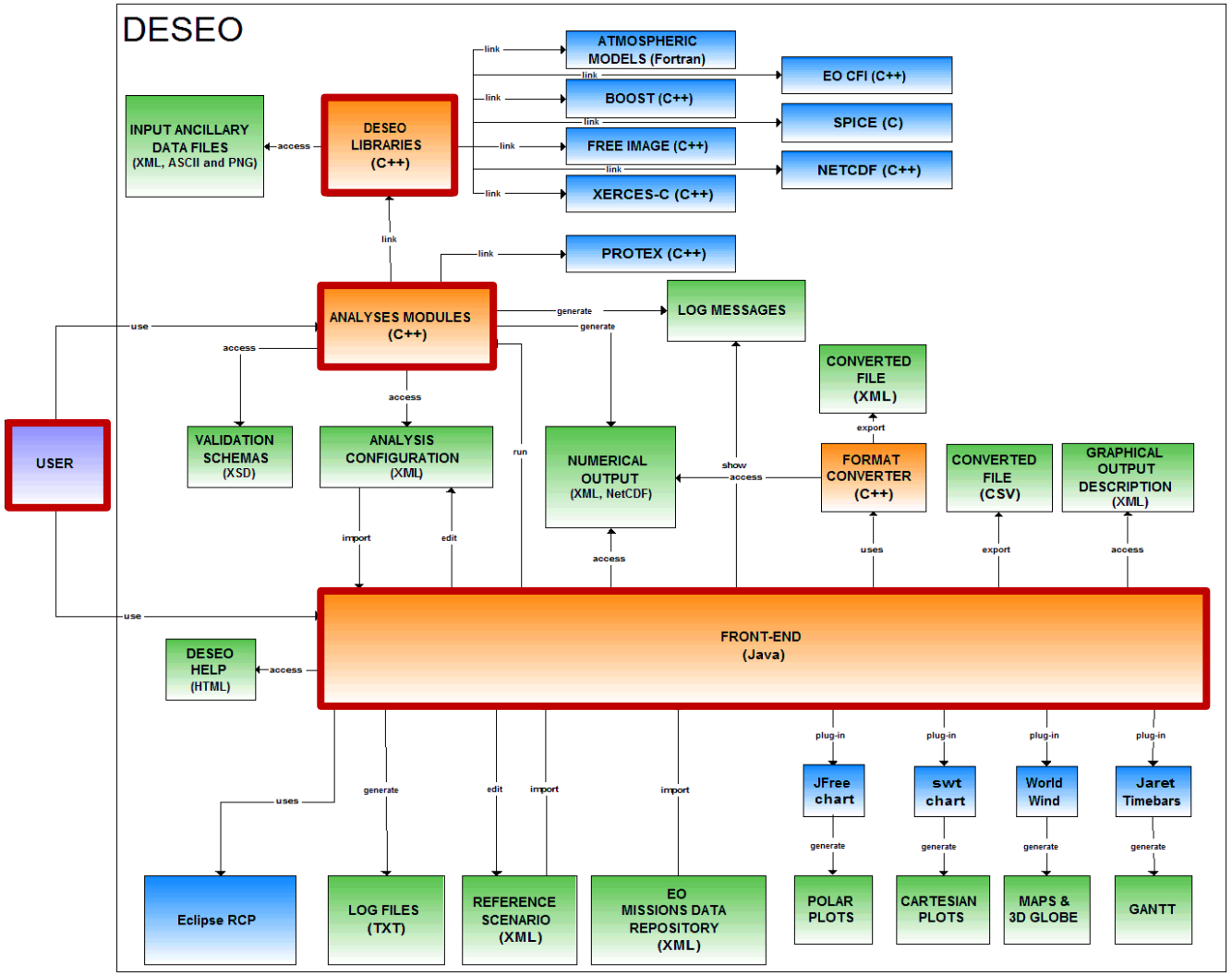
MULTI-PLATFORM

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

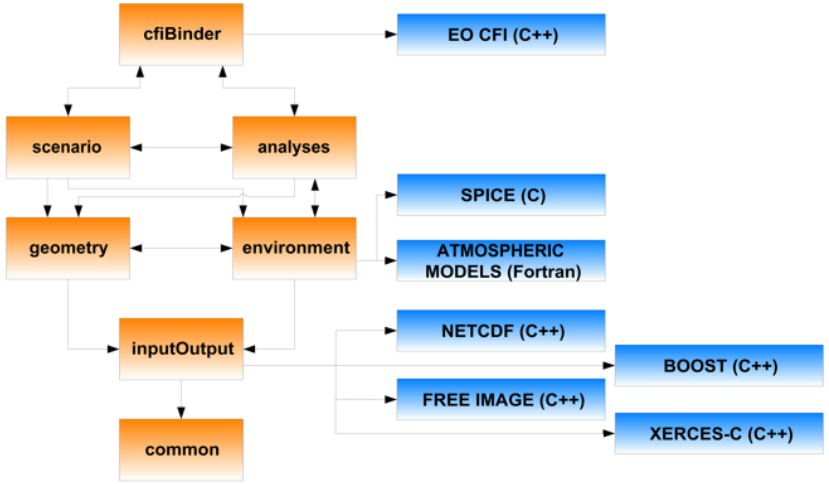




HIGH-LEVEL ARCHITECTURE

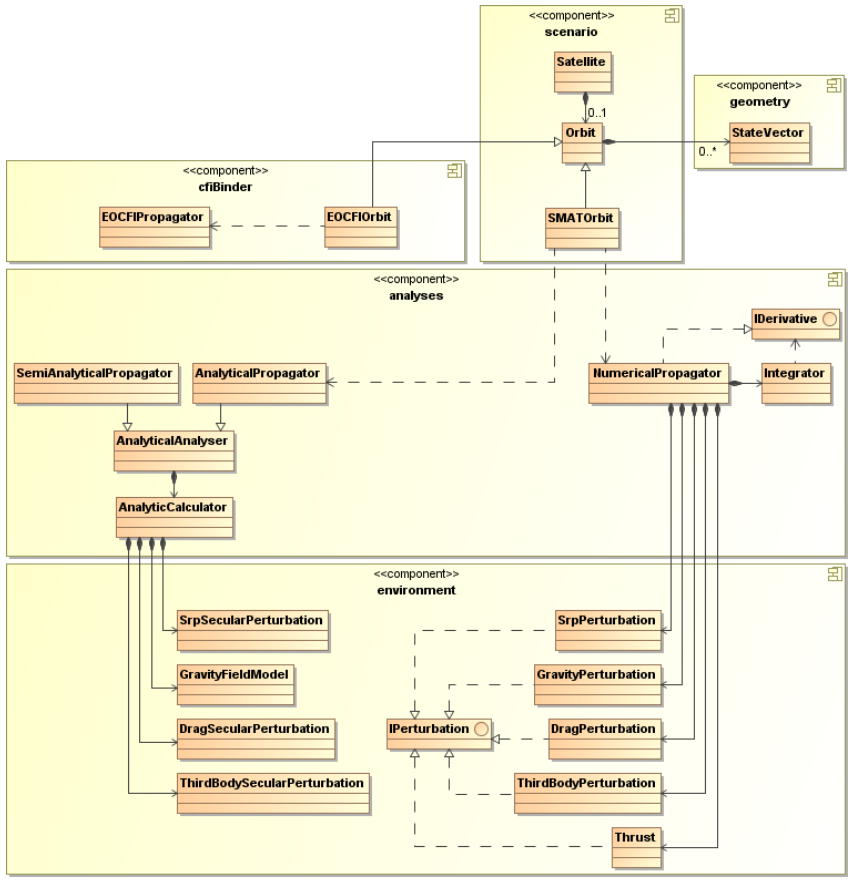


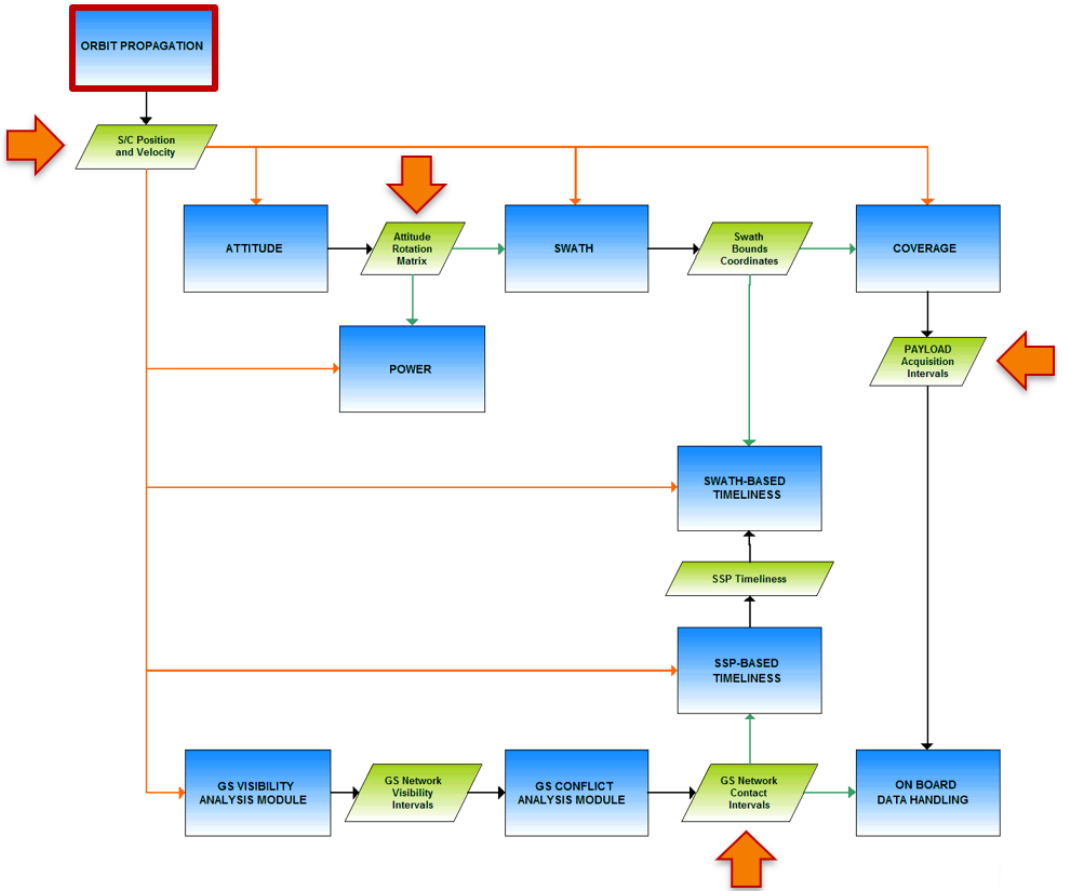
desEO libraries



MODULAR DESIGN

- More efficient upgrades and extensions



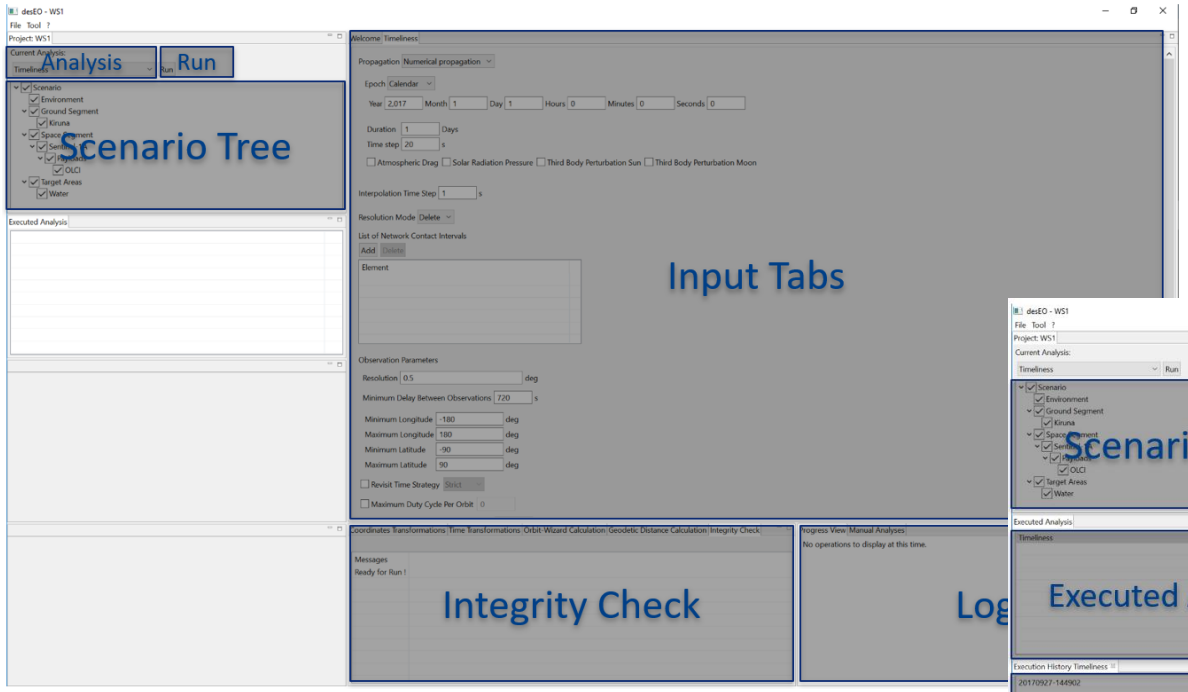


GRAPHICAL USER INTERFACE

- Easy inputting
  - Guide in input definition
  - Boundary values check
  - Semantic integrity check

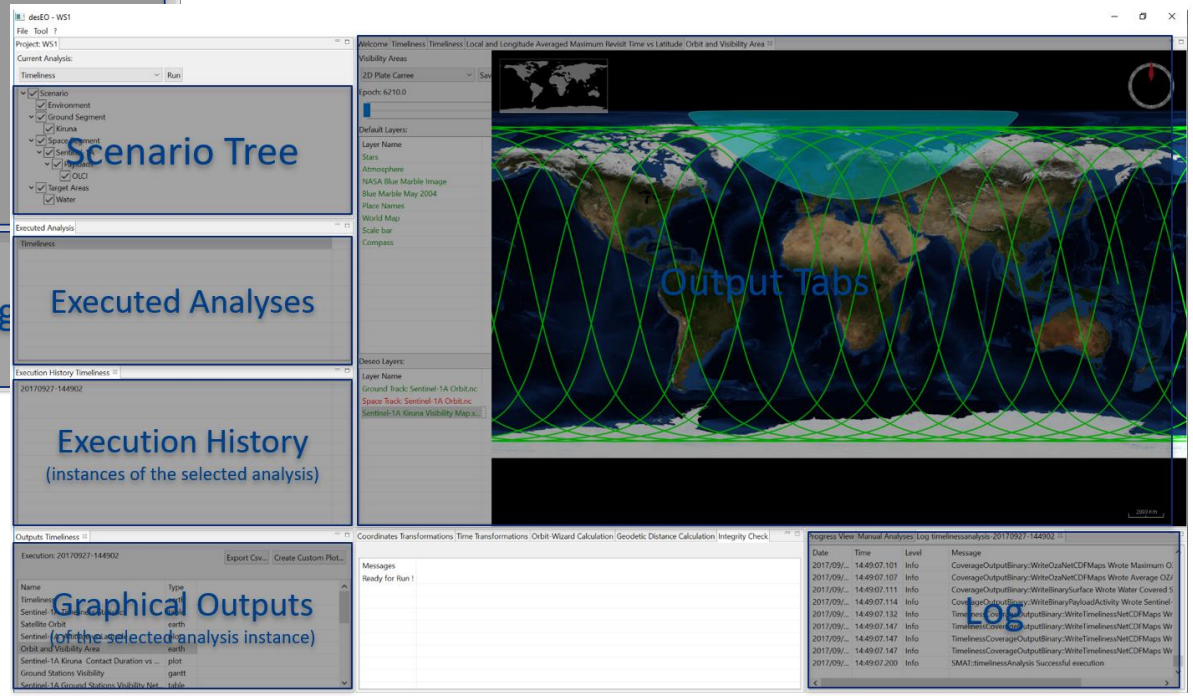
- Output capabilities
  - 3D globe
  - Earth Maps
  - Cartesian plots
  - Polar plots
  - Tables
  - Exporting to image format and CSV

GRAPHICAL USER INTERFACE



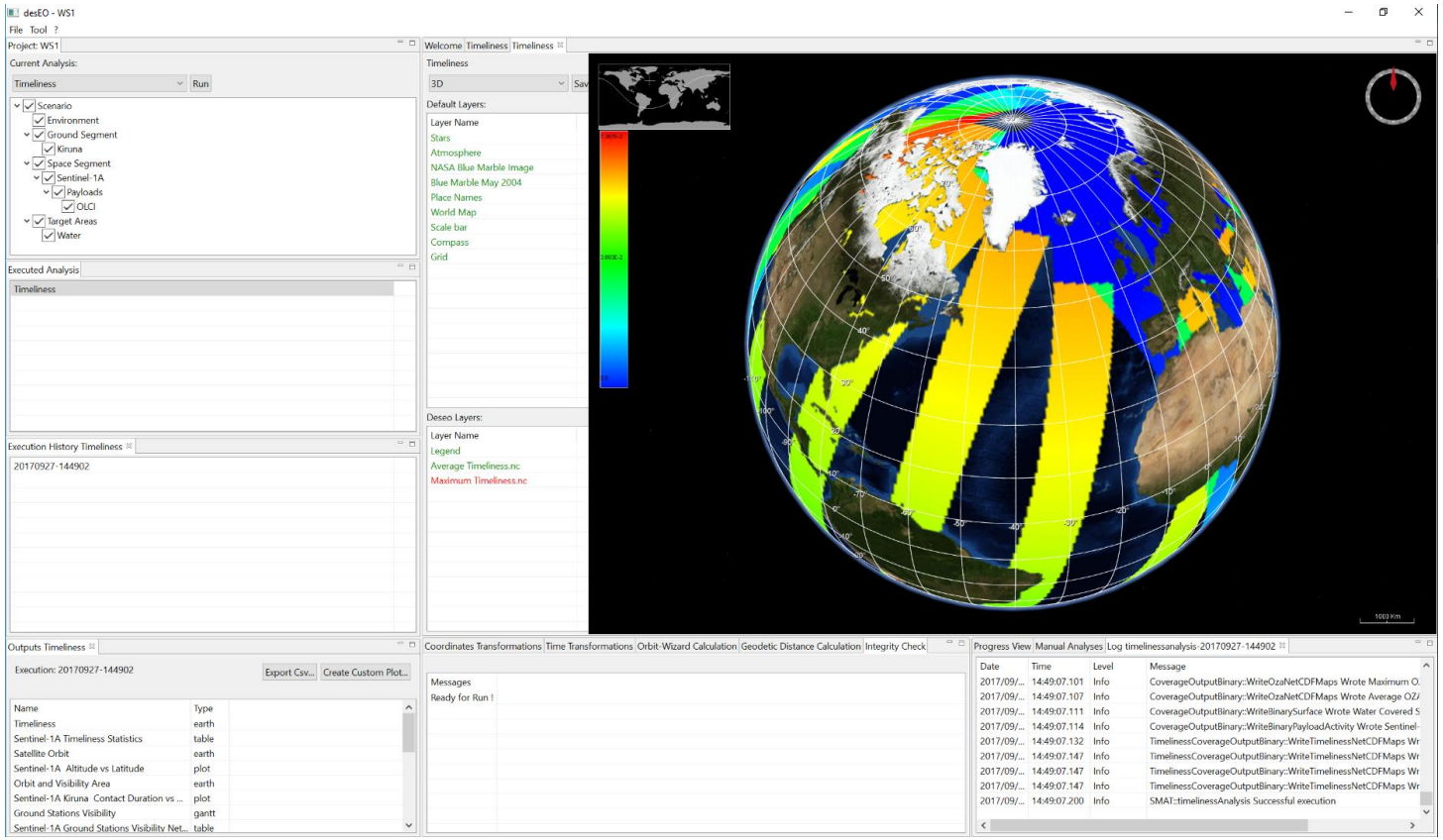
INPUT VIEW

OUTPUT VIEW



DUAL INTERFACE

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




```
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  6230 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
Password:
 * status: started
mars@marsmain /usr/portage/app-shells/bash $ ping -q -c1 en.wikipedia.org
PING rr.esams.wikimedia.org (91.198.174.2) 56(84) 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
/dev/sda2               none
/dev/sda3               /
mars@marsmain /usr/portage/app-shells/bash $ date
Sat Aug  8 02:42:24 MSD 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                 18688  3 rndis_wlan,rndis_host,cdc_ether
parport_pc             38424  0
fglrx                2388128  20
parport                39648  1 parport_pc
iTCO_wdt               12272  0
i2c_i801                9380  0
mars@marsmain /usr/portage/app-shells/bash $
```

desEO IN MISSION ANALYSIS

	CarbonSat MA Phase A/B1	FLEX MA Phase 0/A/B1	Biomass MA Phase 0/A/B1	Deimos-2 MA Phase A/B/C/D/E	NGGM MA Phase 0	Sentinel-3 (*) MA Phase A/B/C/D	Sentinel-5 MA Phase A/B	PARIS IoD Phase A	UrtheDaily MA Phase A	OptiSAR MA Phase A/B	Landmapper MA Phase A	sat4EO MA Phase A/B1	DRR Capacity Study	DESIRE Capacity Study	H2020 ONION Operational Network of Individual Observation Nodes
Orbit Propagation	V	V	V	V	V	V	V	V	V	V	-	V	-	-	V
Attitude	-	-	-	V	-	-	V	-	-	-	-	-	-	-	-
Coverage	V	V	V	V	-	V	V	V	V	V	V	V	V	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.	-	-	-	-	-	-	V	-	-	-	-	-	-	-	-
Time Tran.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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

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AN EARTH EXPLORER 8 MISSION ANALYSIS

- Orbit Propagation
- ~~Attitude~~
- Coverage
- Ground Stations Visibility
- Ground Stations Conflict
- Timeliness
- Swath Properties
- Sun-Zenith Angle
- Observation-Zenith Angle
- SC Topocentric Coordinates
- ~~Pointing Analysis~~
- ~~Semi-ana. Propagation~~
- Atmospheric Properties
- ~~Altitude Control~~
- ~~Inclination Control~~
- Eq. Ground Track Control
- ~~OA + OI Control~~
- ~~EGT + OI Control~~
- EOL Decay
- Beta Angle
- Eclipses
- ~~Ground Illumination~~
- ~~Time Transformation~~
- ~~Coordinates Trans.~~
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- ~~RAAN Drift Rate~~
- ~~Basic Swath Geometry~~
- ~~Geodetic Distance~~
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- ~~OBDH~~
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ORBIT PROPAGATION

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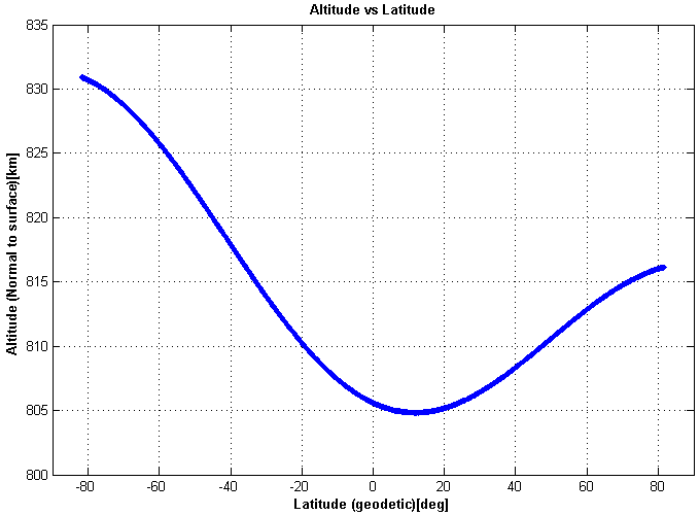

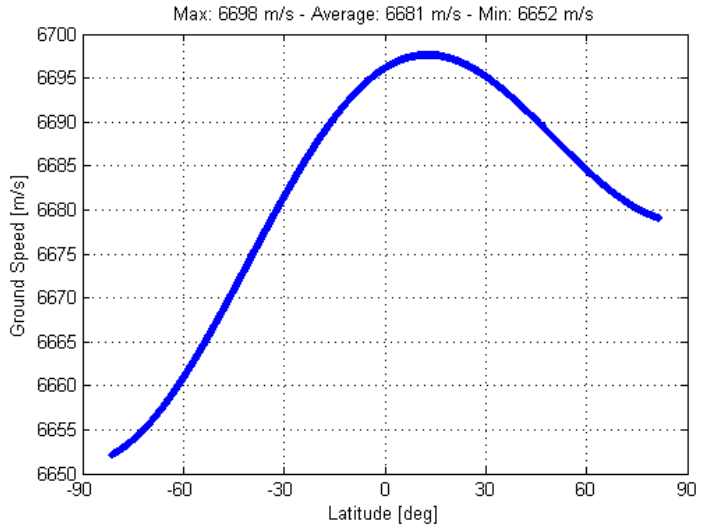

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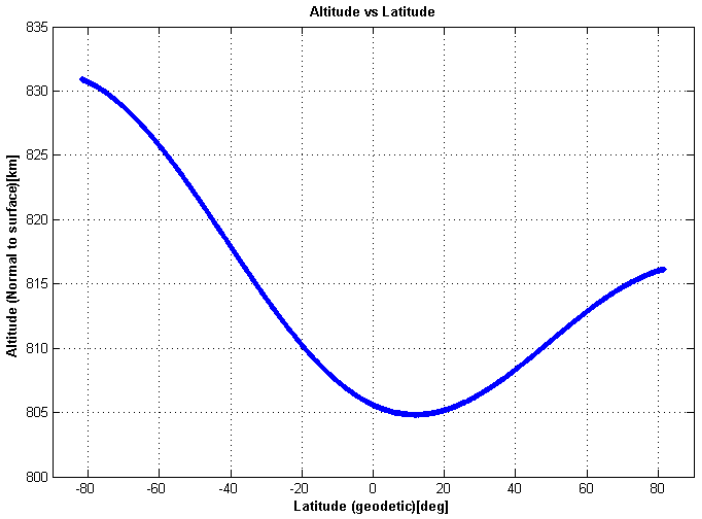

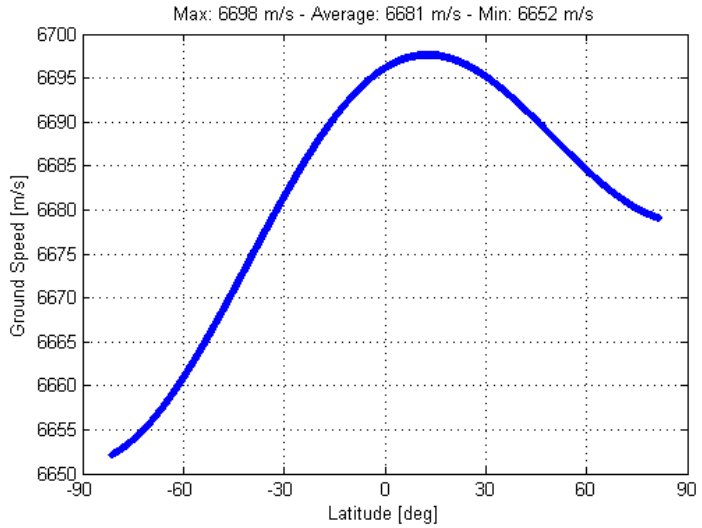

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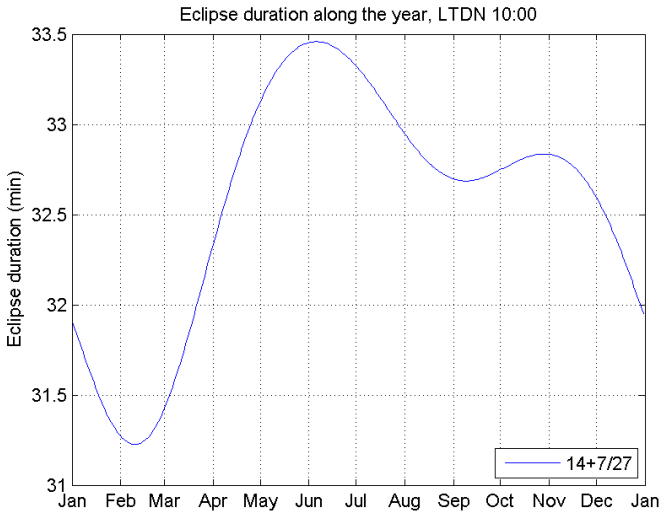
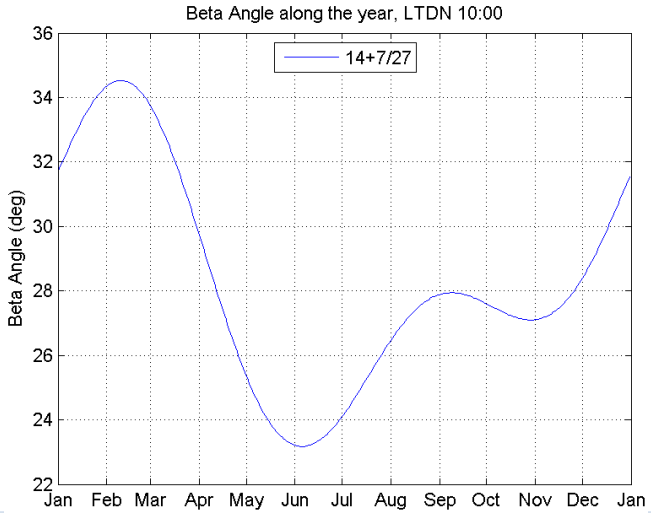
ECLIPSE & β-ANGLE





COVERAGE

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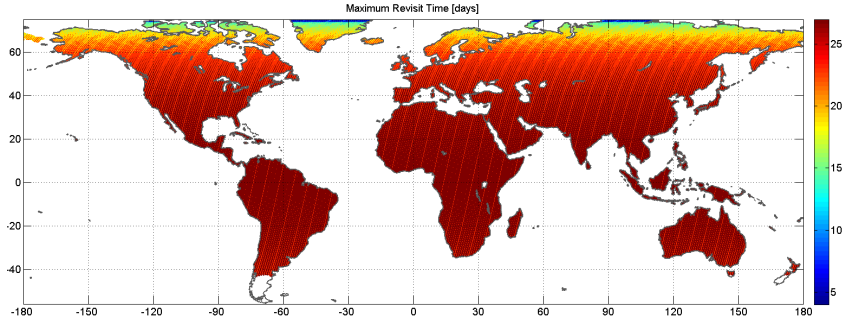

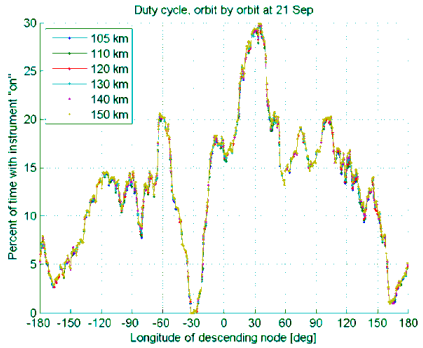

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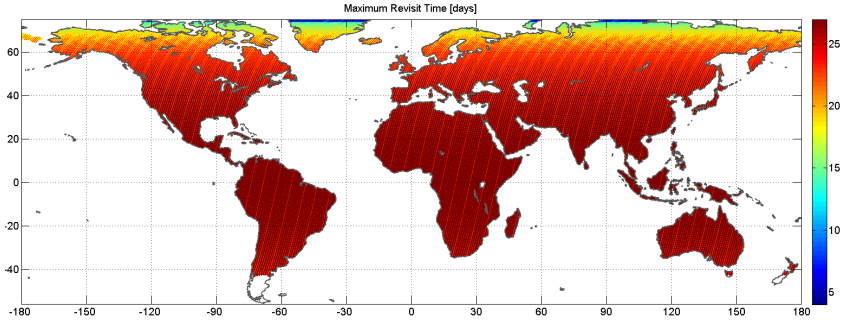

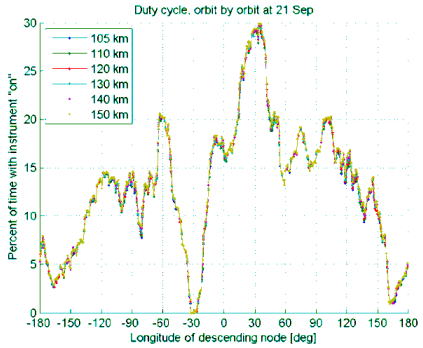

OZA, SZA & SWATH

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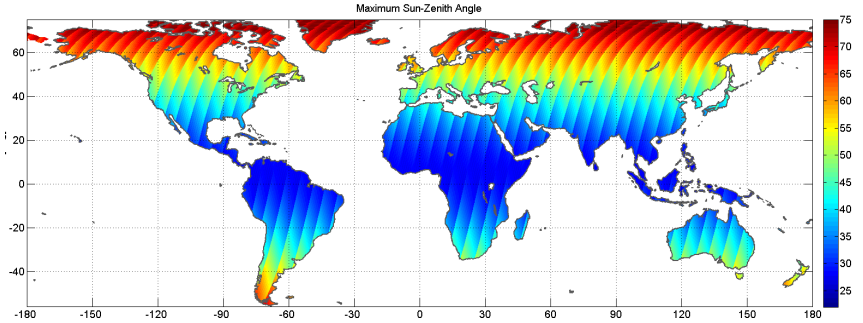

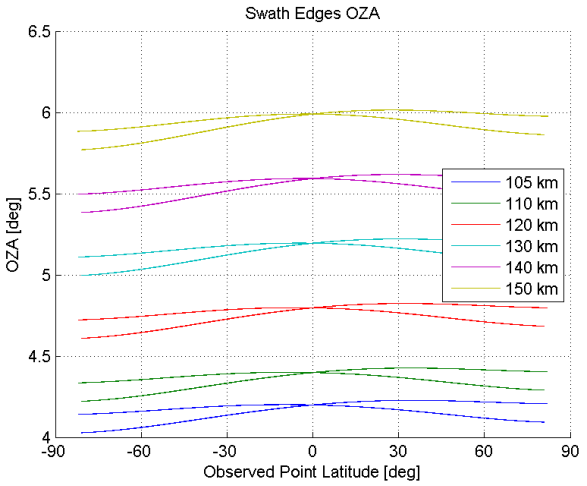

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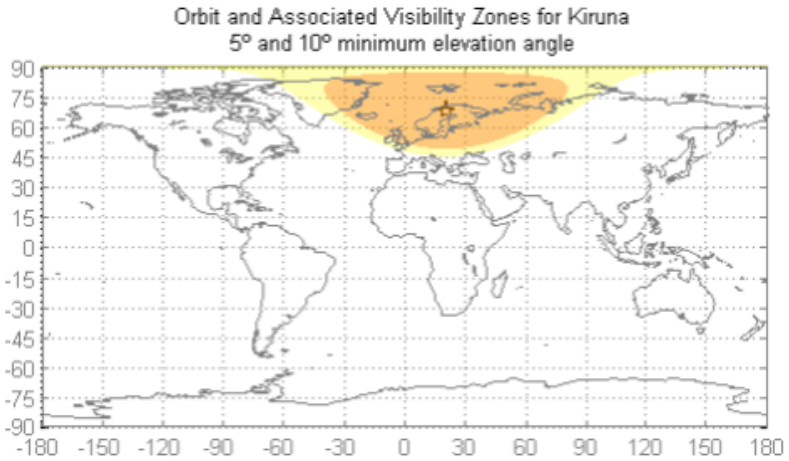

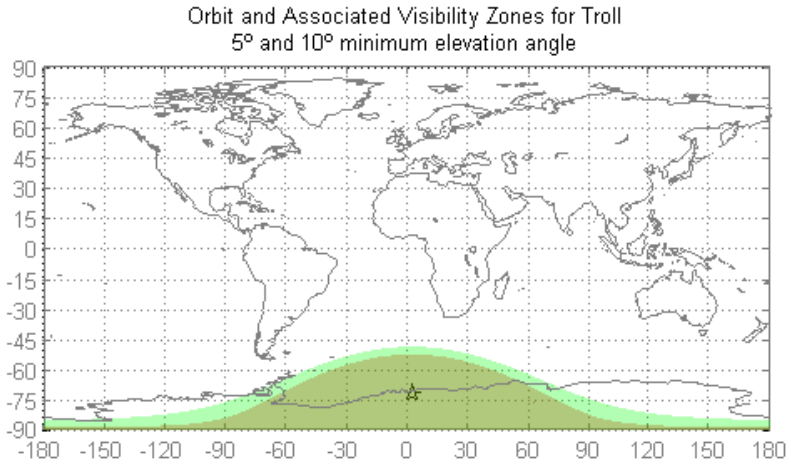

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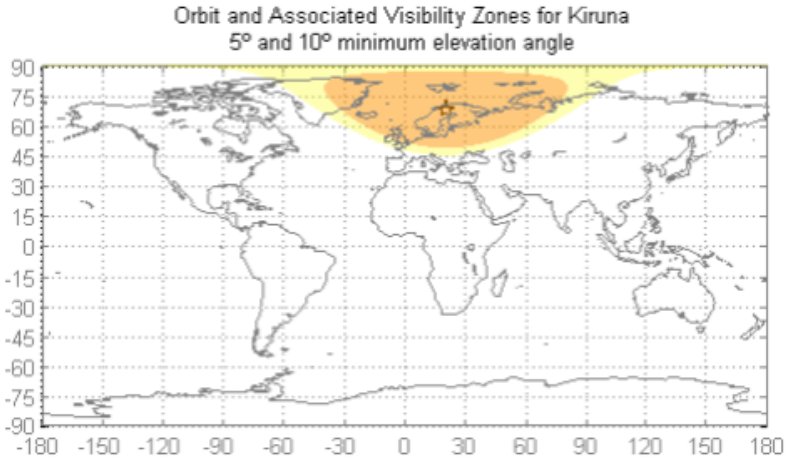

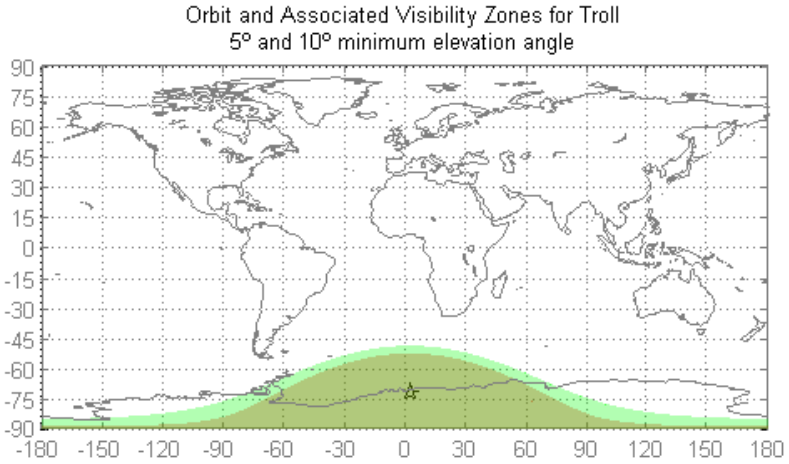

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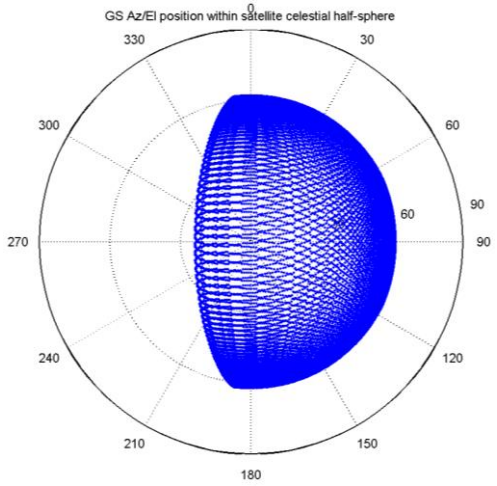
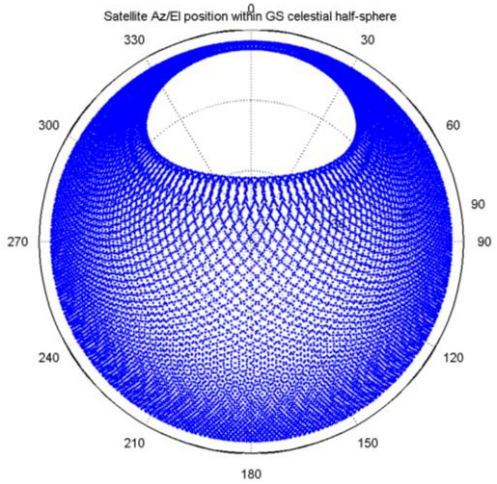
RELATIVE GEOMETRY





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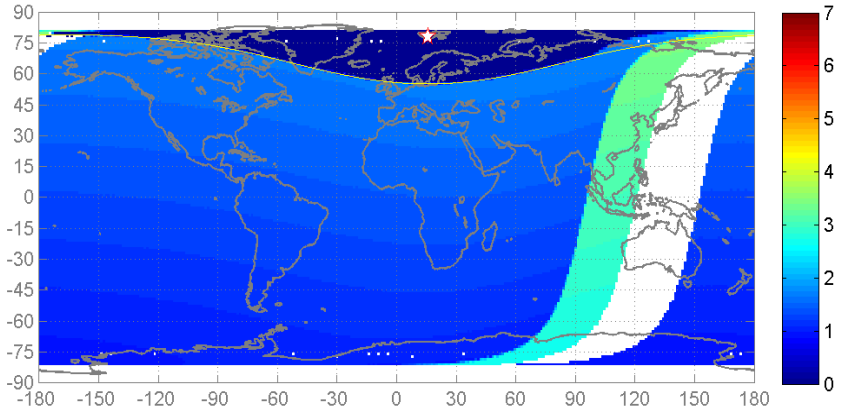

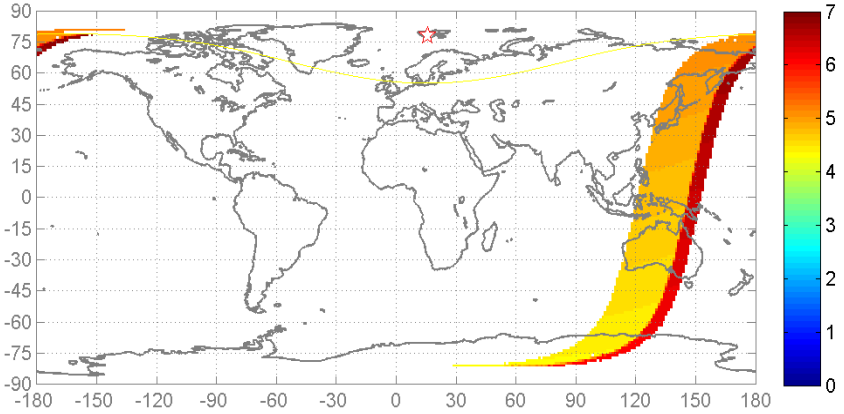

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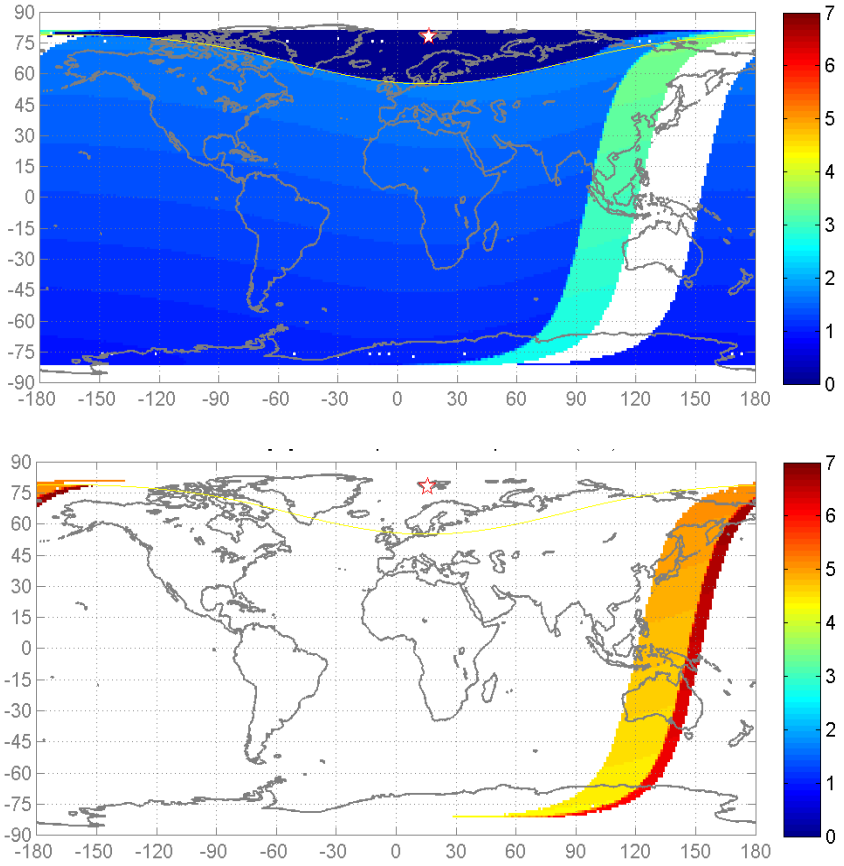

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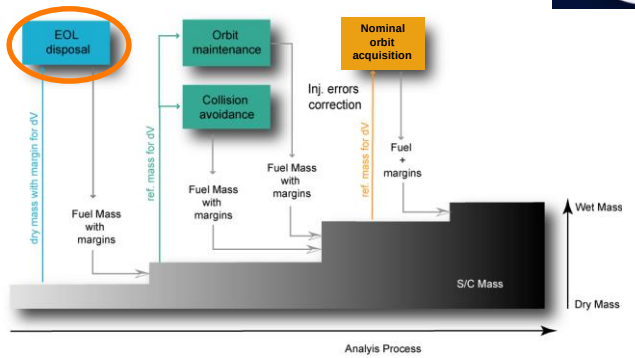
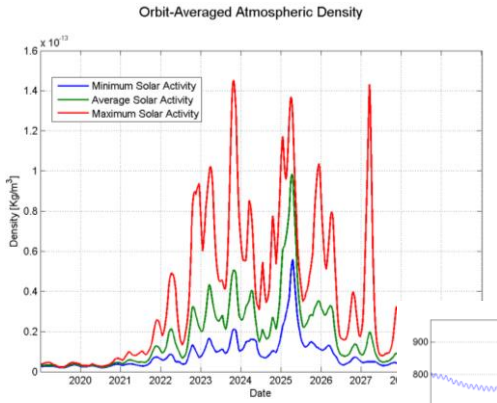
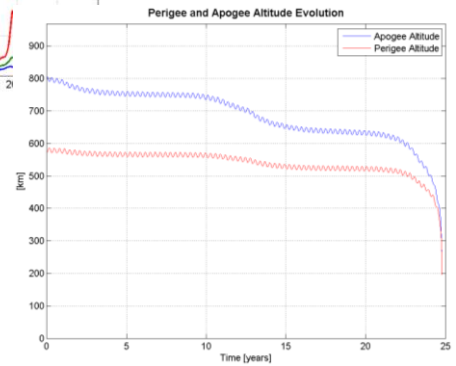
EOL DISPOSAL







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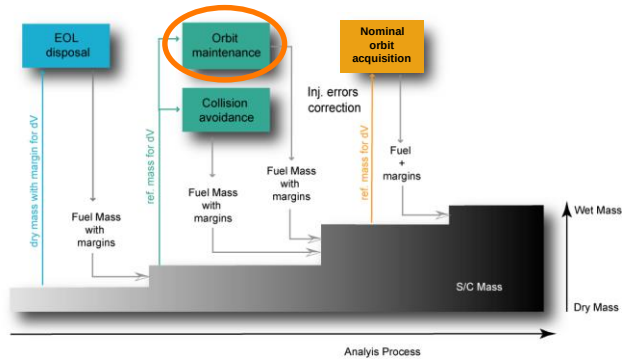
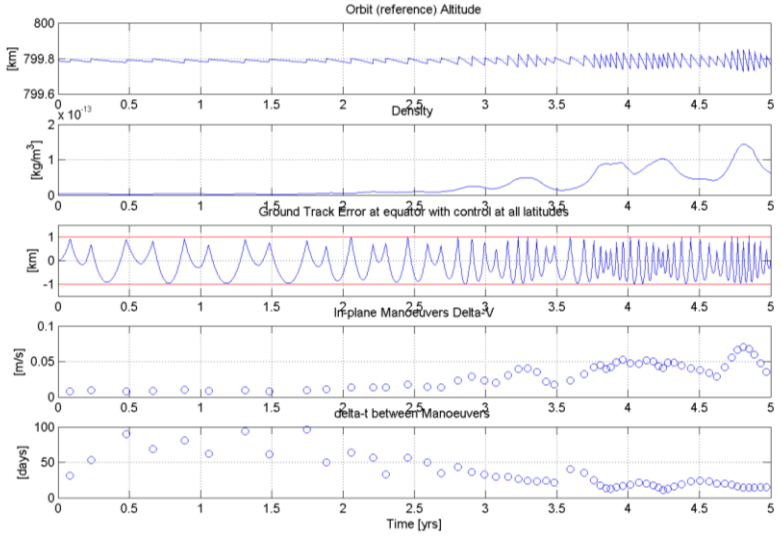
GROUND TRACK CONTROL





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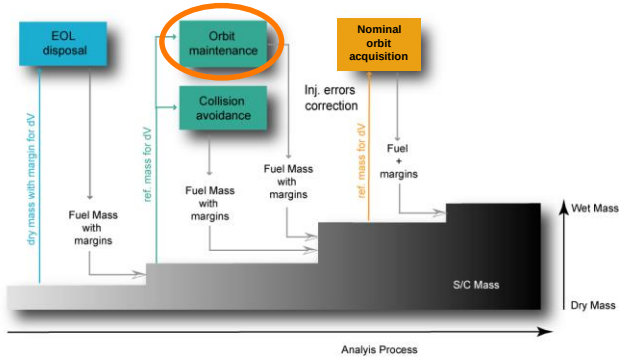

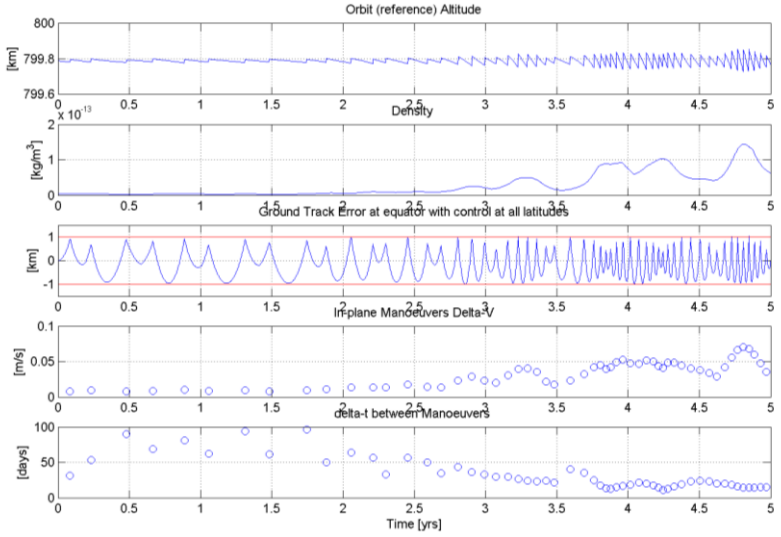

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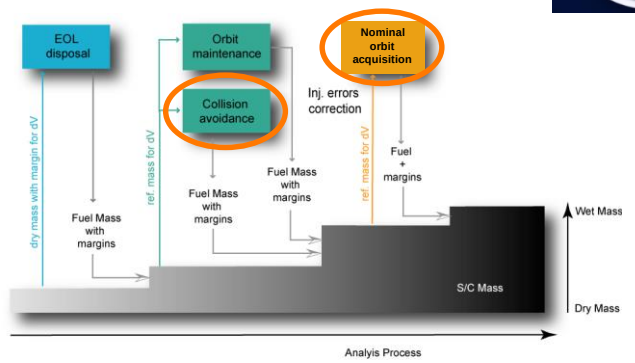
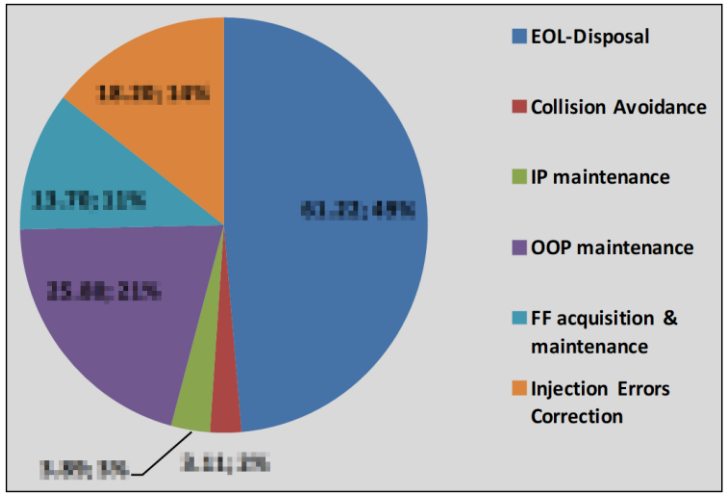
ΔV & FUEL BUDGET



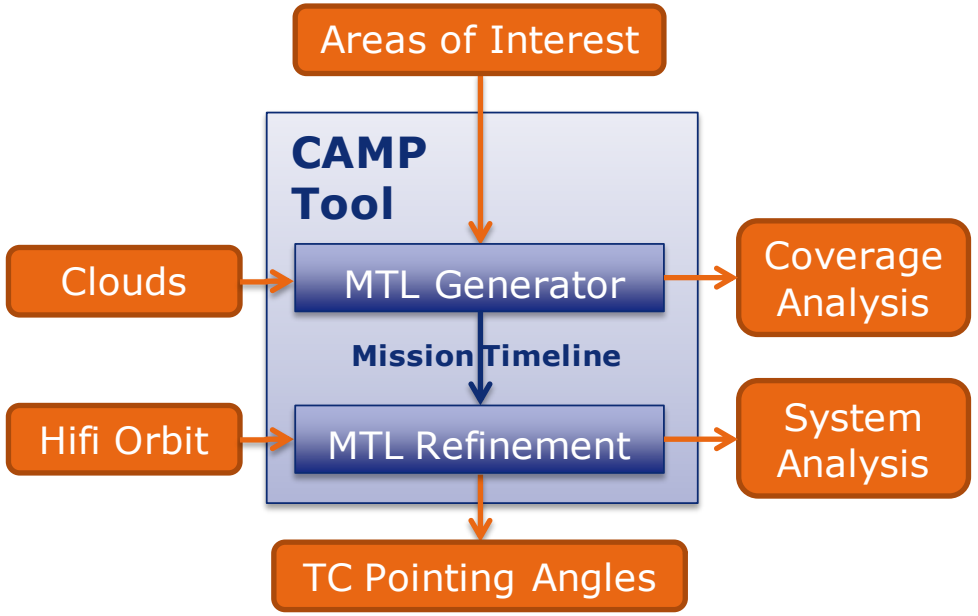


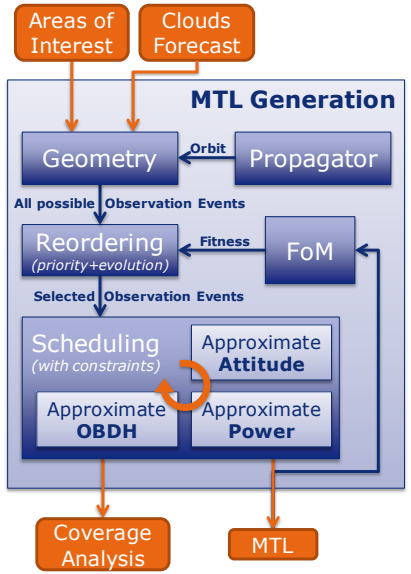
desEO TO CREATE ADVANCED SPECIALIZED TOOLS

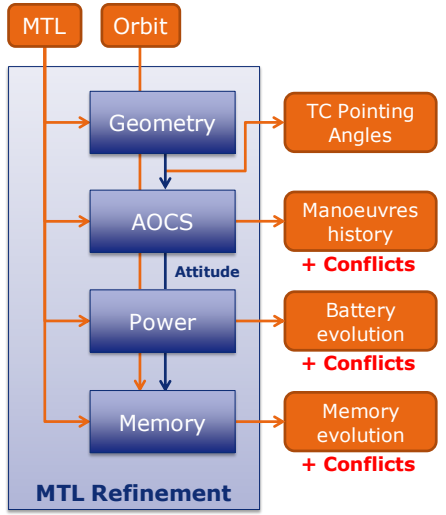
- Success case: Fully Automated **Mission Planning** and **Capacity Analysis Tool** (CAMP) for the Deimos-2 Agile Satellite
  - Advantages → platform agility to improve mission return, reducing revisit time and increasing operational flexibility
  - Drawbacks → platform agility makes mission planning 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

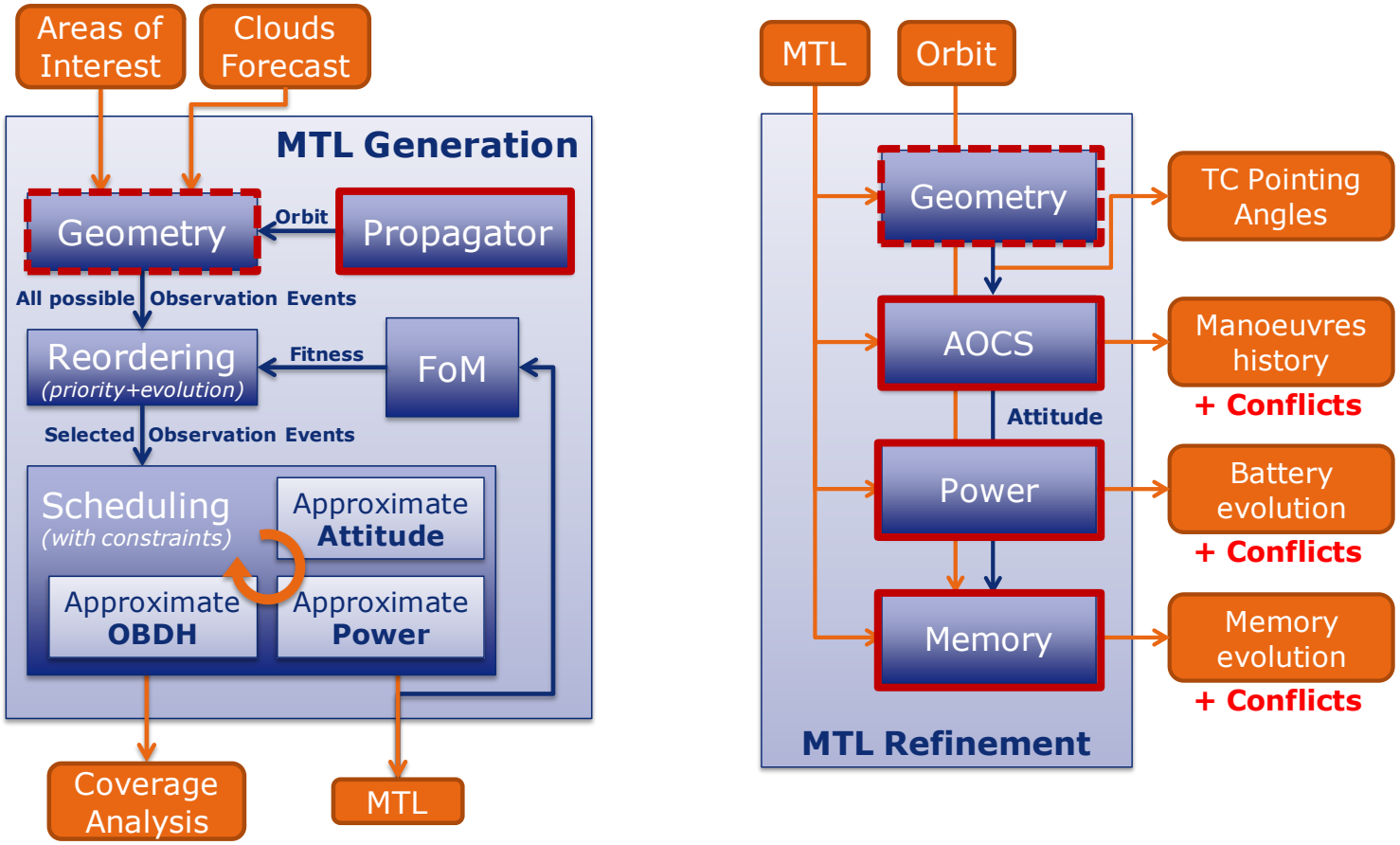




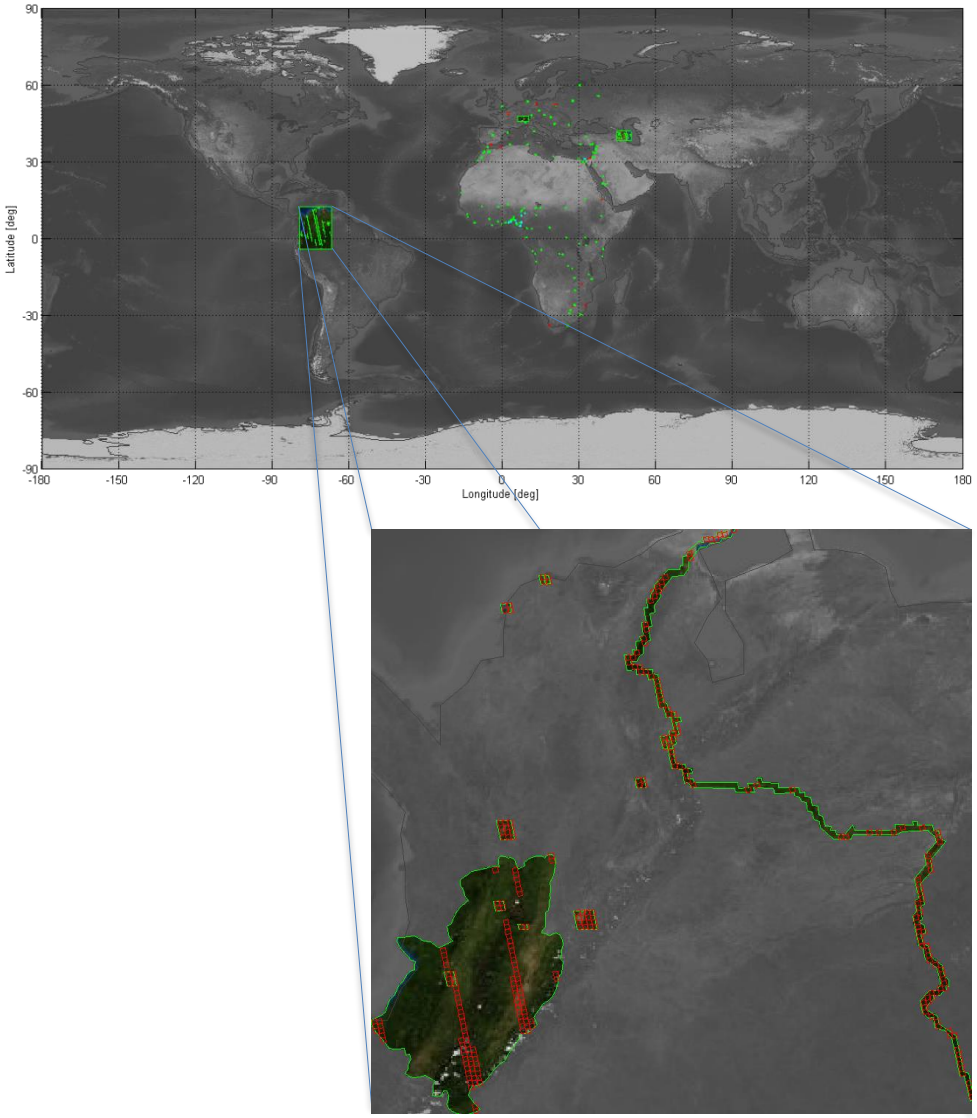


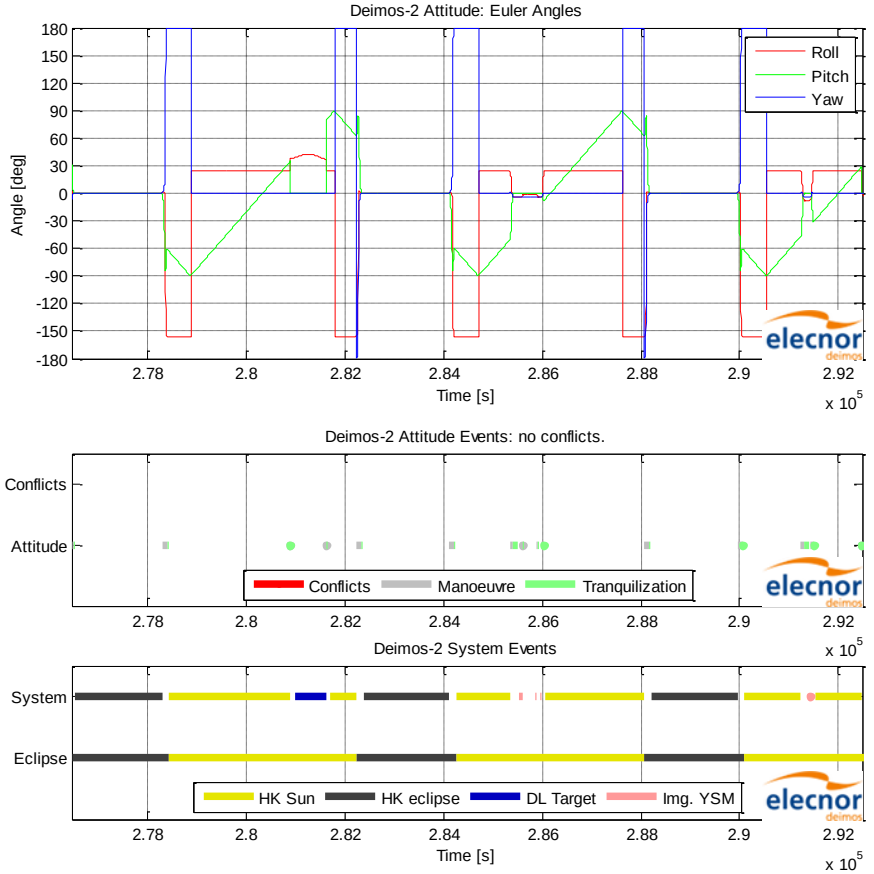
CAMP HIGH-LEVEL ARCHITECTURE

- 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**

deimos
elecnor group

THANK YOU

federico.letterio@deimos-space.com