Advanced Electric Orbit-Raising Optimization and Analysis with LOTOS 2

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Outline

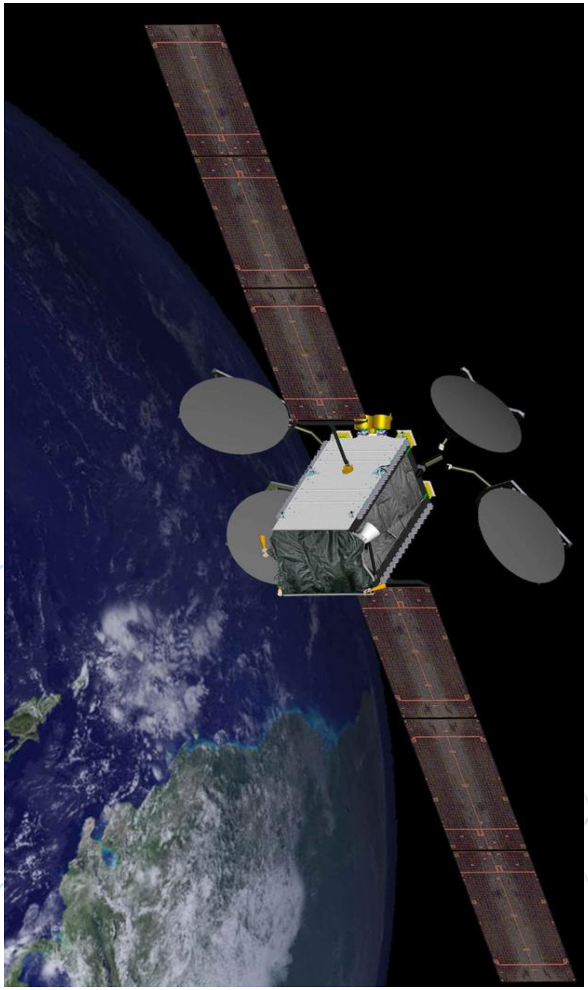
Orbit Raising

Motivation

Key Features

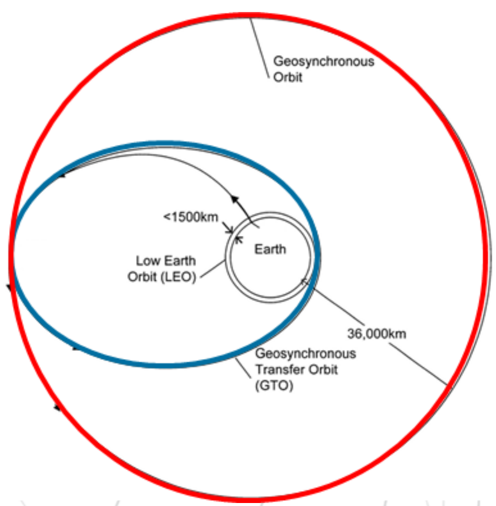
Software Overview

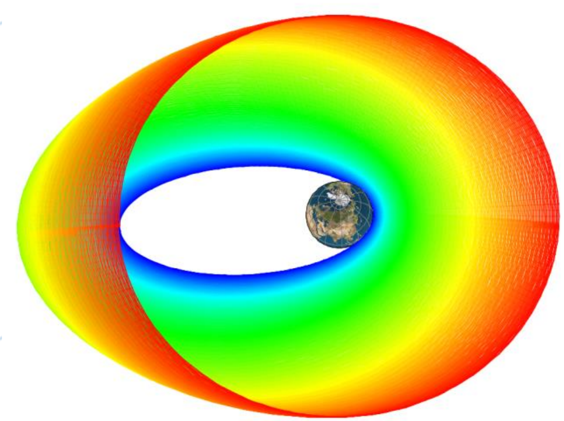
Conclusion



Electric Propulsion for Orbit Raising

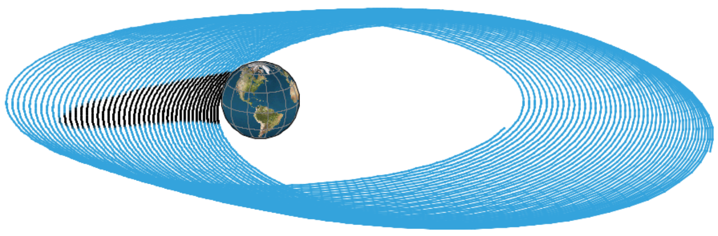
1. Most telecom spacecraft are launched into a transfer orbit
2. Spacecraft employs electric propulsion to transfer from launch orbit to the mission orbit
3. GTO-GEO transfer
   - ~12% propellant consumption (vs. 40% chemical)
   - Transfer duration prolonged up to several months





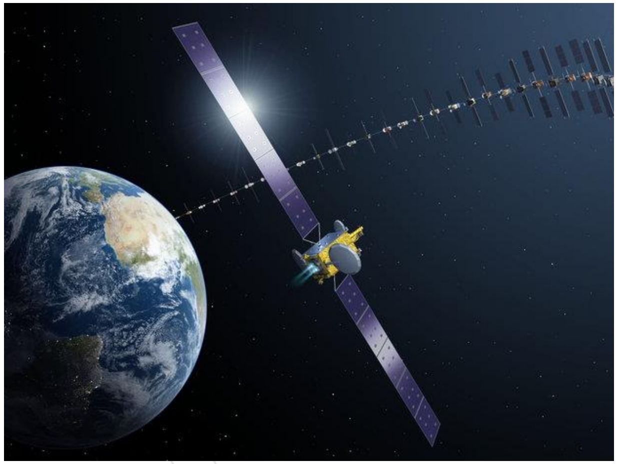
Motivation

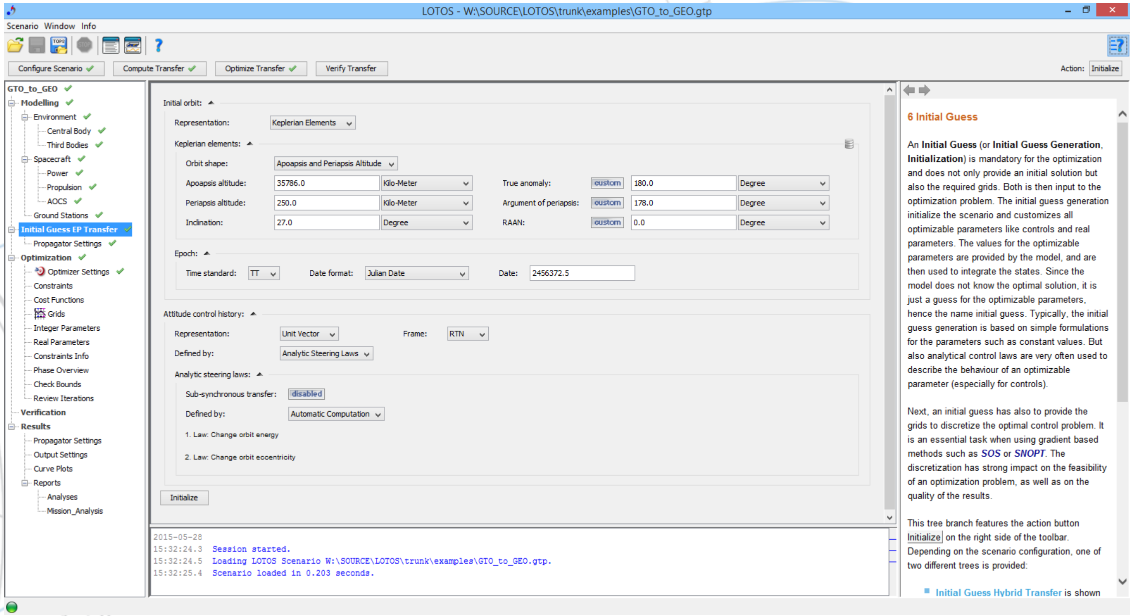
- Optimization and analysis of high-fidelity transfer trajectories
- Optimized maneuver planning
- Software for Guidance & Navigation
- Mission Analysis



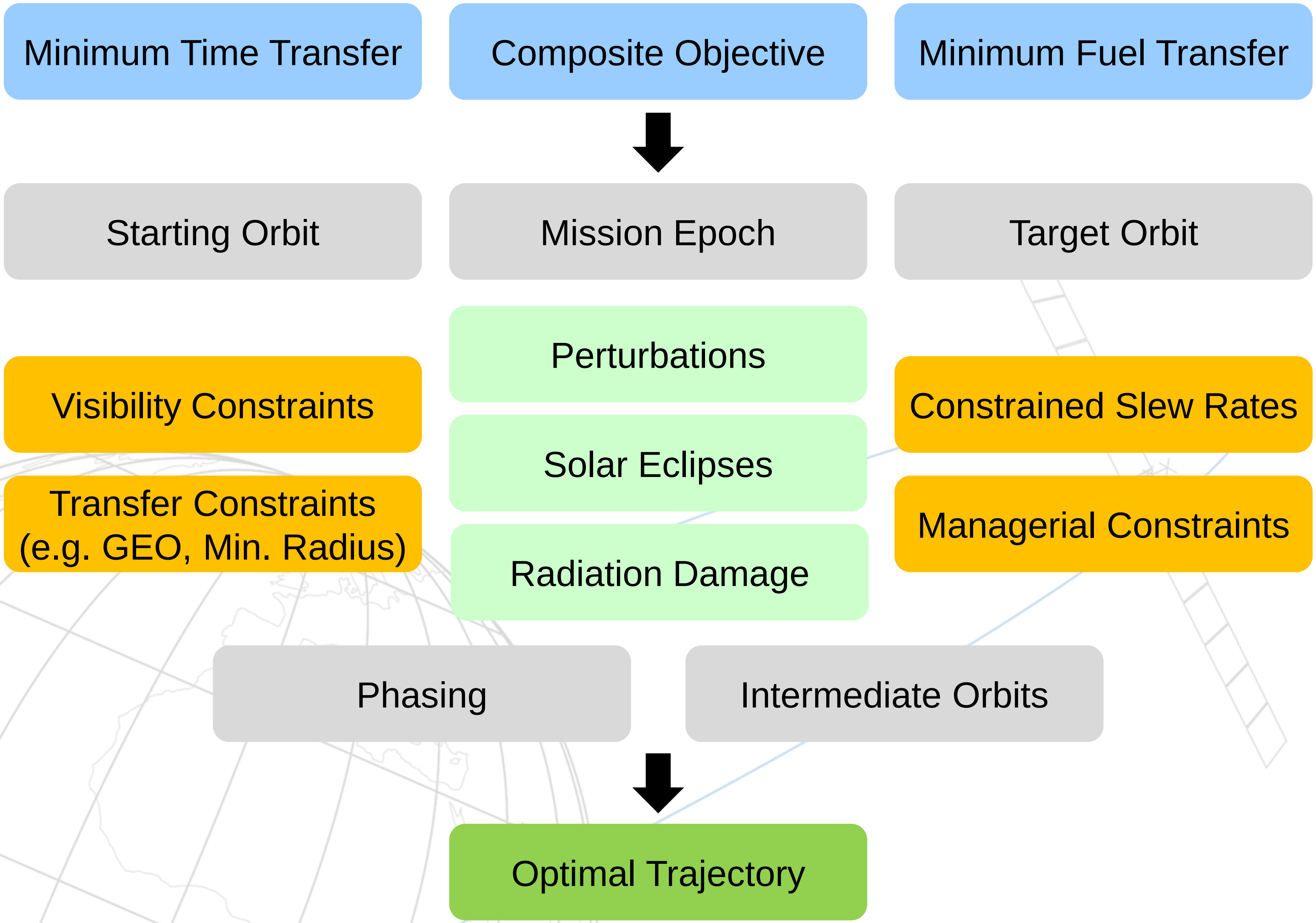
Key Features

- Hybrid transfers and pure electric orbit-raisings
- Support of operational trajectories
- Controlled 6DoF attitude
- Verification of trajectories
- Database
- Post-processing
- Reports
- Windows & Linux platform

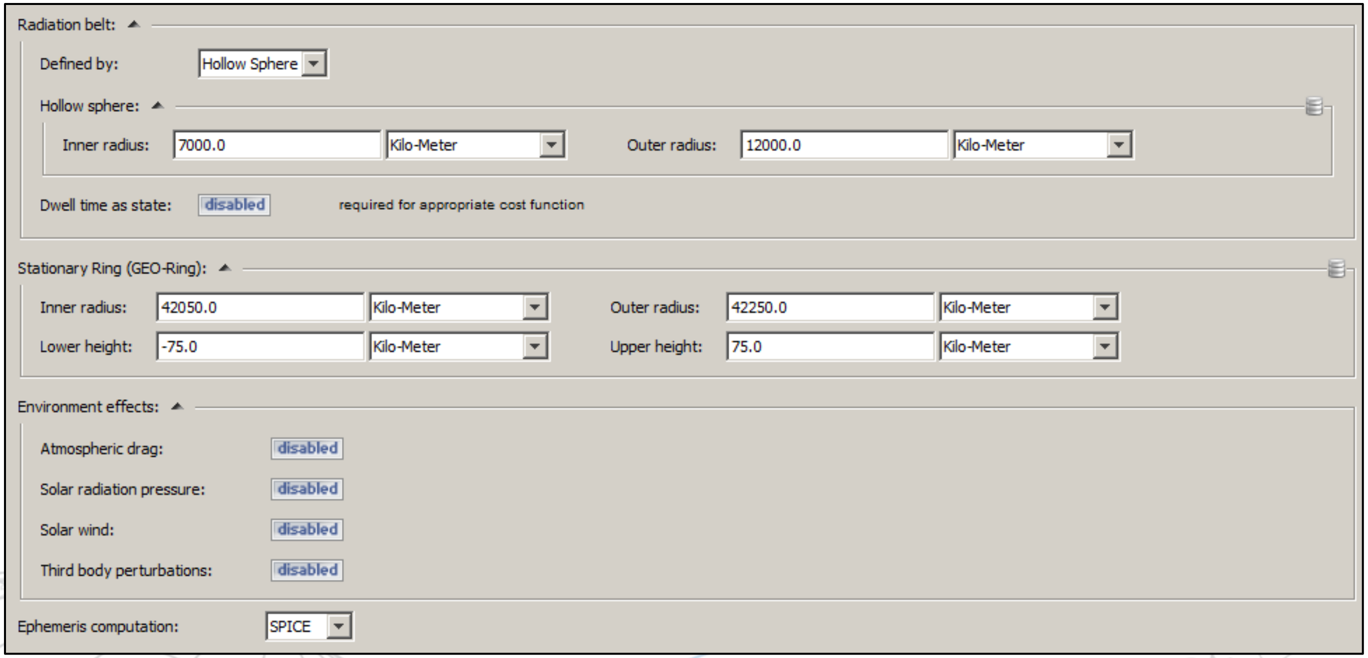


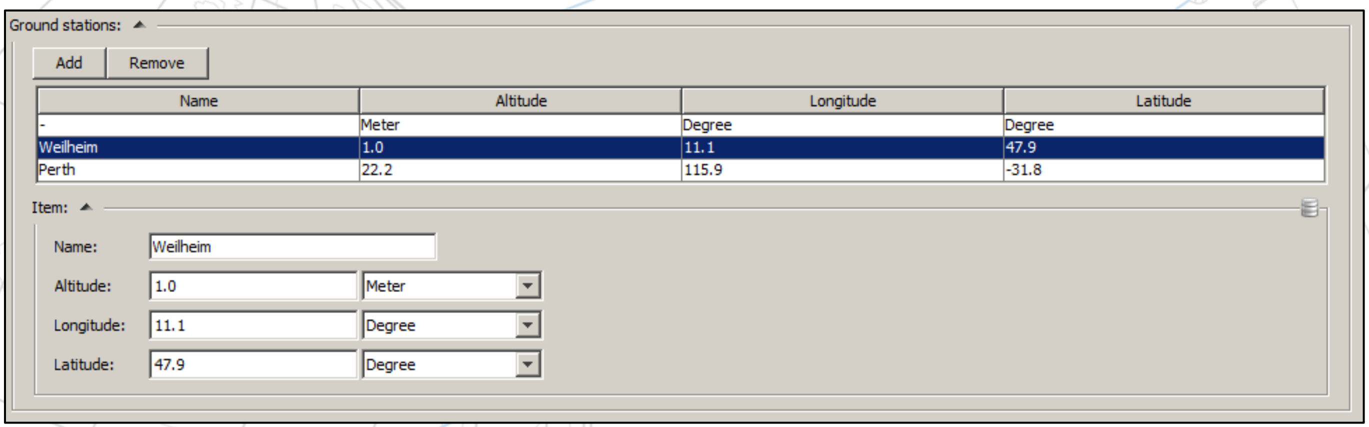


Software Scheme

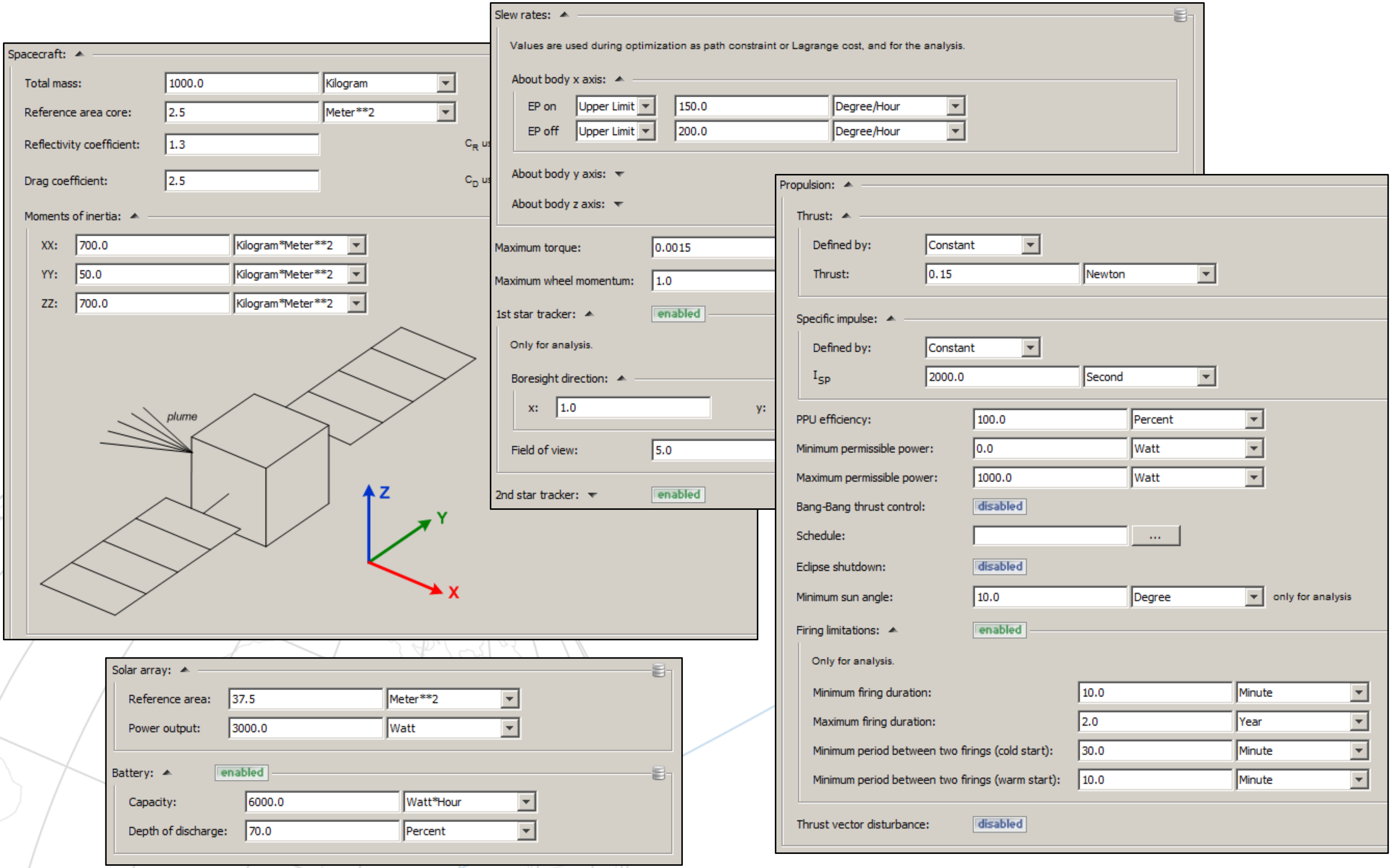


Environment

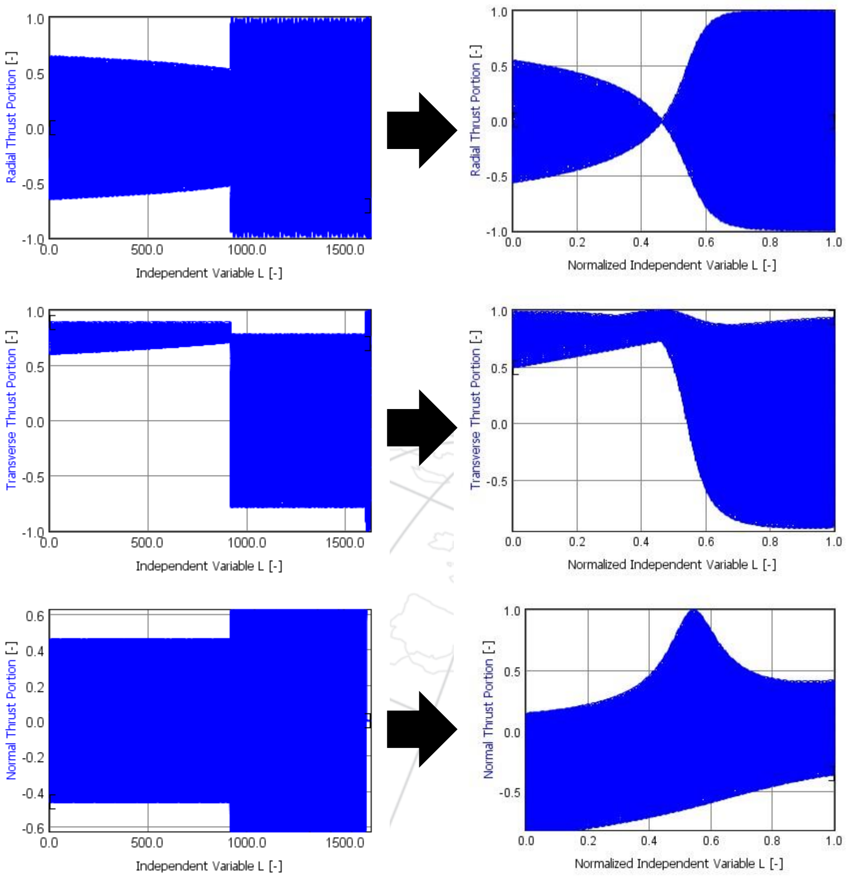


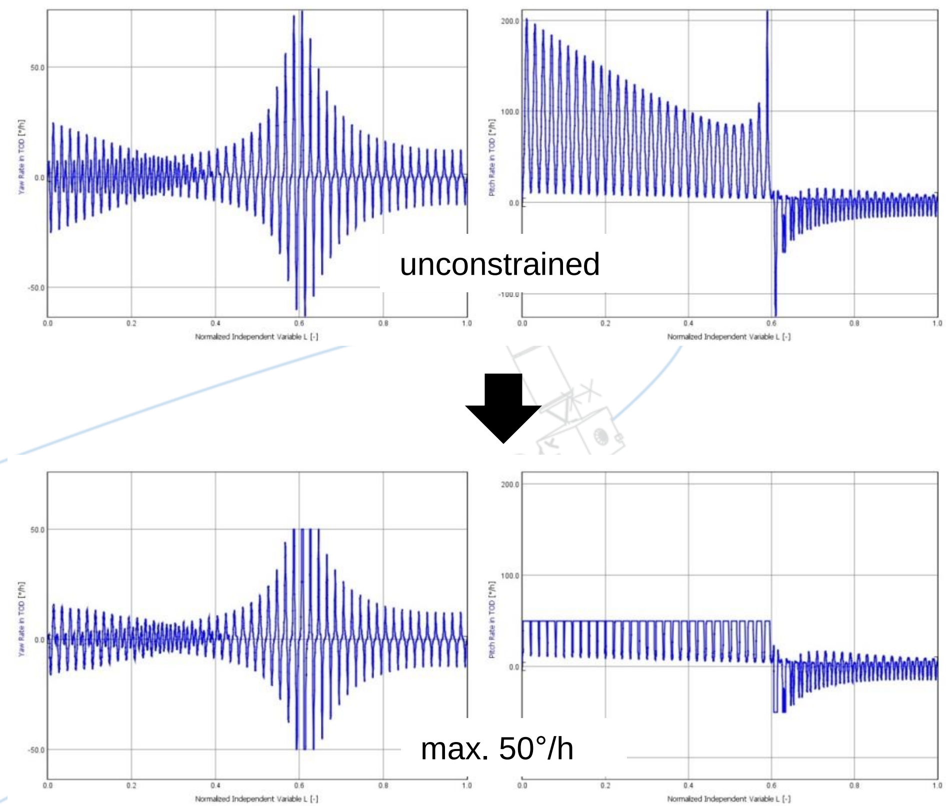


Spacecraft


Spacecraft:
Total mass: 1000.0 Kilogram
Reference area core: 2.5 Meter**2
Reflectivity coefficient: 1.3
Drag coefficient: 2.5
Moments of inertia:
XX: 700.0 Kilogram*Meter**2
YY: 50.0 Kilogram*Meter**2
ZZ: 700.0 Kilogram*Meter**2
plume
Z
Y
X
Slew rates:
Values are used during optimization as path constraint or Lagrange cost, and for the analysis.
About body x axis:
EP on Upper Limit 150.0 Degree/Hour
EP off Upper Limit 200.0 Degree/Hour
About body y axis:
About body z axis:
Maximum torque: 0.0015
Maximum wheel momentum: 1.0
1st star tracker: enabled
Only for analysis.
Boresight direction:
x: 1.0
y:
Field of view: 5.0
2nd star tracker: enabled
Propulsion:
Thrust:
Defined by: Constant
Thrust: 0.15 Newton
Specific impulse:
Defined by: Constant
Isp 2000.0 Second
PPU efficiency: 100.0 Percent
Minimum permissible power: 0.0 Watt
Maximum permissible power: 1000.0 Watt
Bang-Bang thrust control: disabled
Schedule: ...
Eclipse shutdown: disabled
Minimum sun angle: 10.0 Degree only for analysis
Firing limitations: enabled
Only for analysis.
Minimum firing duration: 10.0 Minute
Maximum firing duration: 2.0 Year
Minimum period between two firings (cold start): 30.0 Minute
Minimum period between two firings (warm start): 10.0 Minute
Thrust vector disturbance: disabled
Solar array:
Reference area: 37.5 Meter**2
Power output: 3000.0 Watt
Battery: enabled
Capacity: 6000.0 Watt*Hour
Depth of discharge: 70.0 Percent

Dynamics

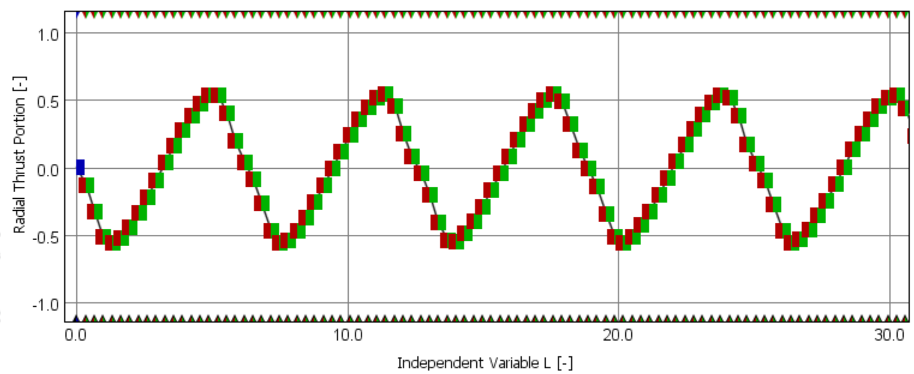

Radial Thrust Portion [-]
Transverse Thrust Portion [-]
Normal Thrust Portion [-]
Independent Variable L [-]
Normalized Independent Variable L [-]

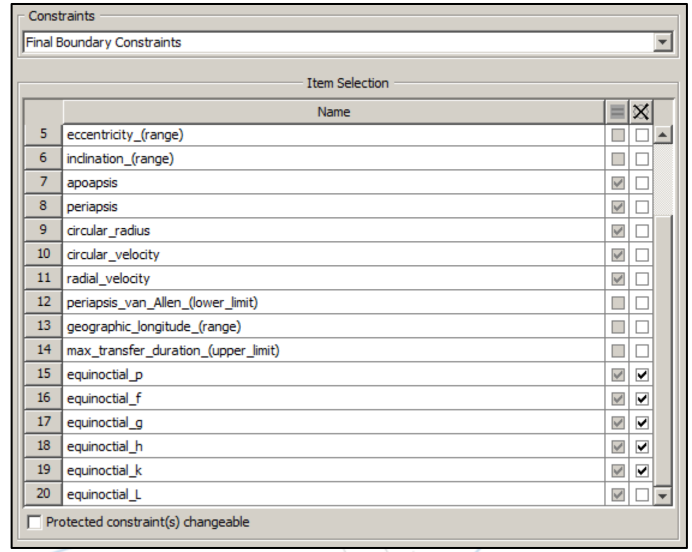

unconstrained
max. 50°/h

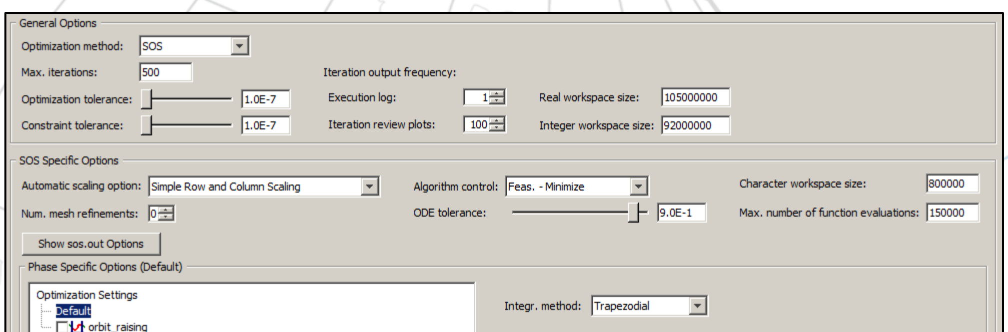
Optimization

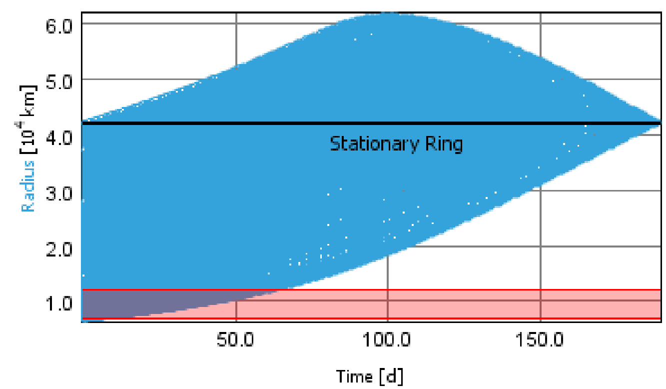
Solvers

- MIDACO (ant colony optimization)
- SOS (Sparse Optimization Software)
- WORHP (European sparse NLP solver)

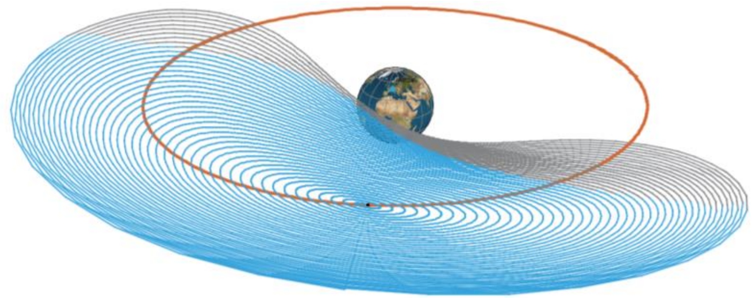








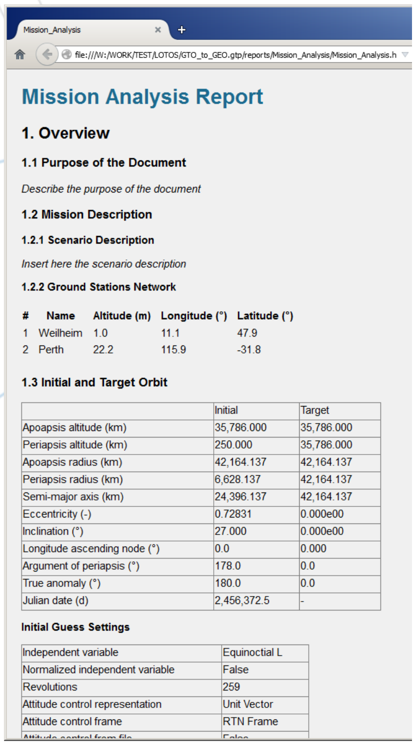
User Interface



Frontend and command line interface

Customizable output

- Scenario input and output (scalars, functions, …)
- Maneuver plan and eclipses as dedicated output files



Mission_Analysis

file:///W:/WORK/TEST/LOTOS/GTO_to_GEO.gtp/reports/Mission_Analysis/Mission_Analysis.h

Mission Analysis Report

1. Overview

1.1 Purpose of the Document

Describe the purpose of the document

1.2 Mission Description

1.2.1 Scenario Description

Insert here the scenario description

1.2.2 Ground Stations Network

#	Name	Altitude (m)	Longitude (°)	Latitude (°)
1	Weilheim	1.0	11.1	47.9
2	Perth	22.2	115.9	-31.8

1.3 Initial and Target Orbit

	Initial	Target
Apoapsis altitude (km)	35,786.000	35,786.000
Periapsis altitude (km)	250.000	35,786.000
Apoapsis radius (km)	42,164.137	42,164.137
Periapsis radius (km)	6,628.137	42,164.137
Semi-major axis (km)	24,396.137	42,164.137
Eccentricity (-)	0.72831	0.000e00
Inclination (°)	27.000	0.000e00
Longitude ascending node (°)	0.0	0.000
Argument of periapsis (°)	178.0	0.0
True anomaly (°)	180.0	0.0
Julian date (d)	2,456,372.5	-

Initial Guess Settings

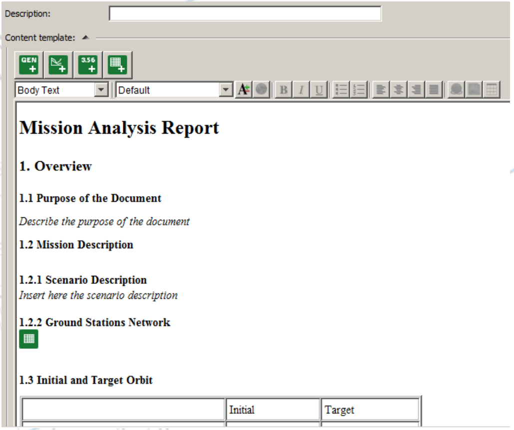
Independent variable	Equinoctial L
Normalized independent variable	False
Revolutions	259
Attitude control representation	Unit Vector
Attitude control frame	RTN Frame

Automatic post-processing

- Customizable (e.g. AOCS, EP, eclipses, …)

Reports

- Customizable
- Automatic (1-click)



Description:

Content template:

Body Text | Default

Mission Analysis Report

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1.2 Mission Description

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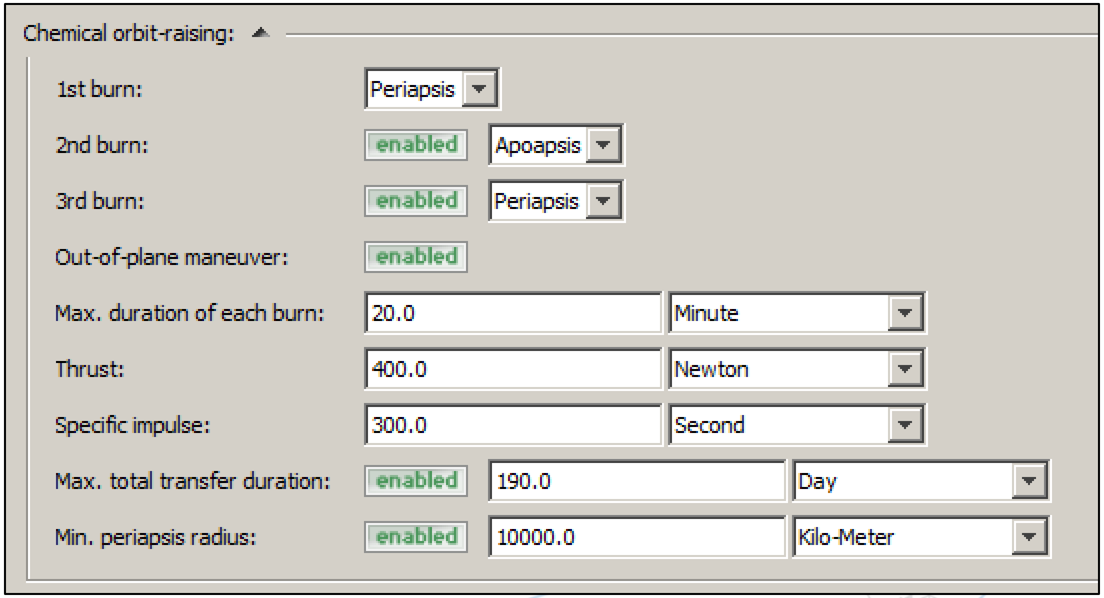
1.2.2 Ground Stations Network

1.3 Initial and Target Orbit

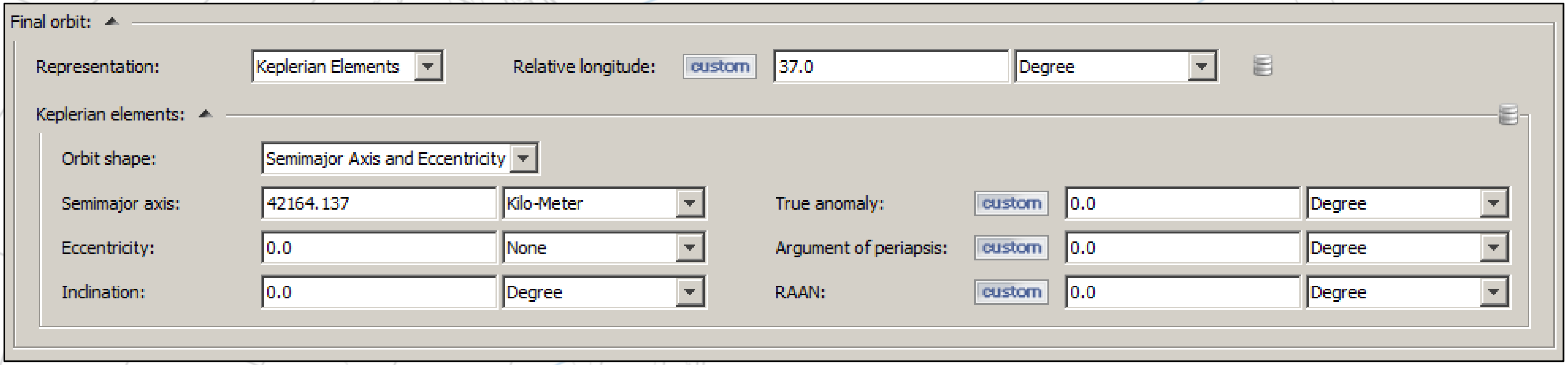
	Initial	Target

Hybrid Transfer

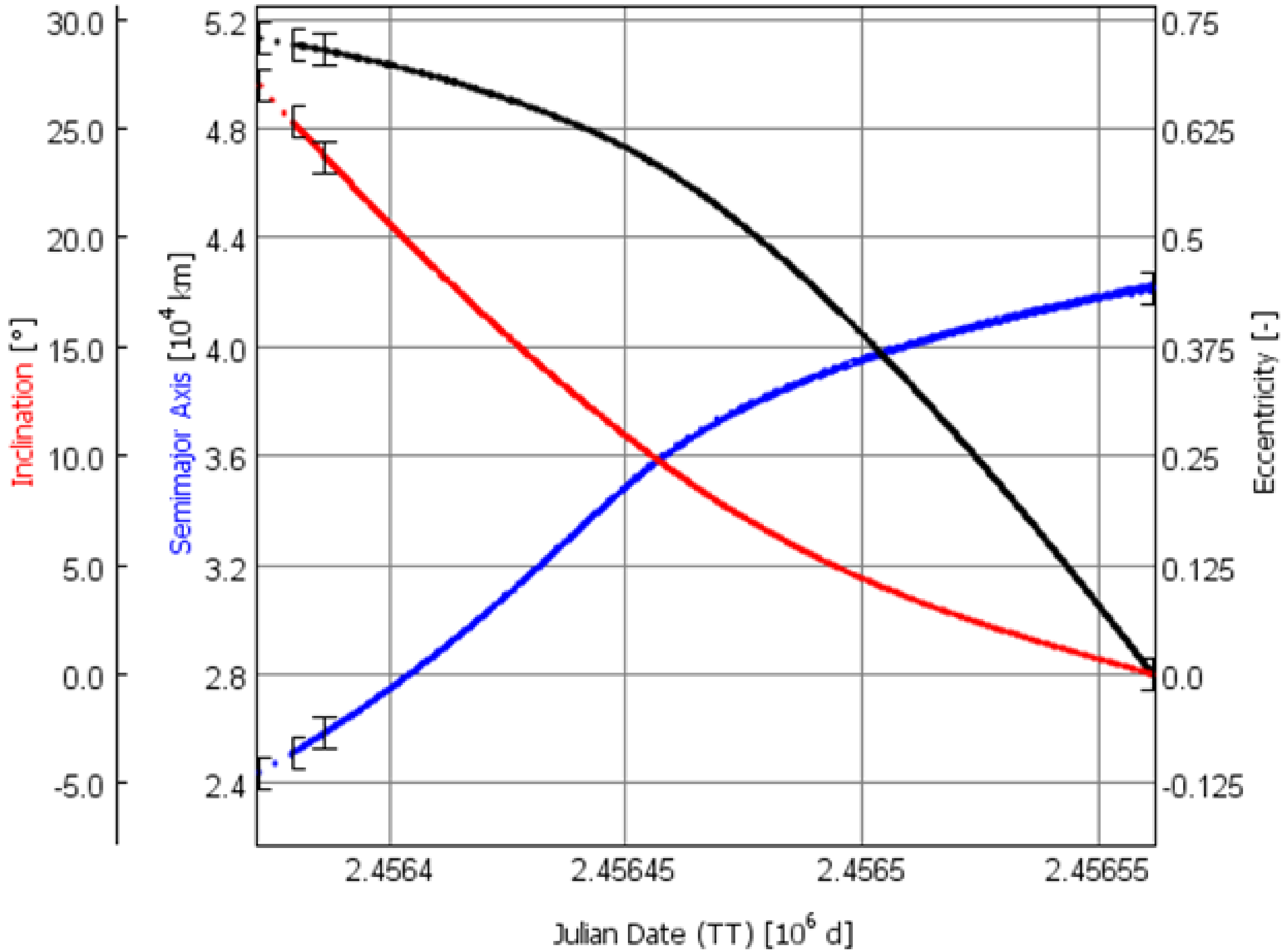
Chemical orbit-raising



followed by electric orbit-raising to target orbit



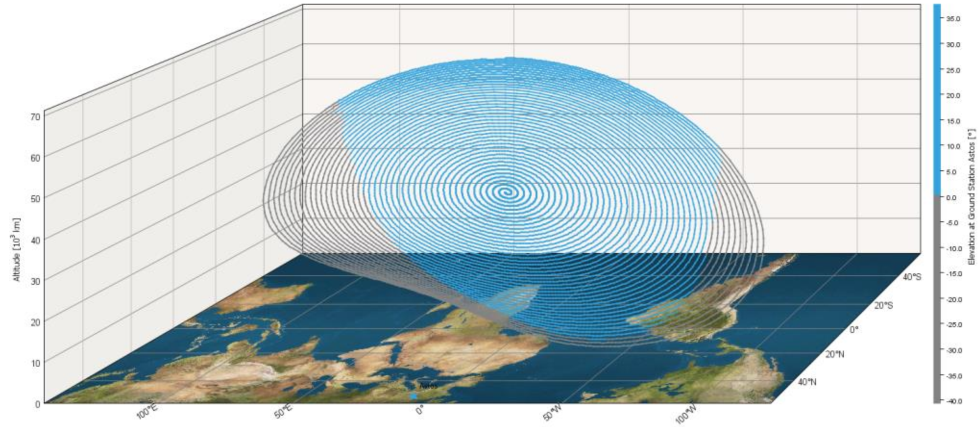
Operations



Inclination [°]
Semimajor Axis [10^4 km]
Eccentricity [-]
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
0.75
0.625
0.5
0.375
0.25
0.125
0.0
-0.125
2.4564
2.45645
2.4565
2.45655
Julian Date (TT) [10^6 d]

Conclusion

- Advanced tool for EOR
- Optimization & Analysis
- Hybrid Transfers
- Support of Spacecraft Operations



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Contact: service@astos.de