ASTOS®

Space Programmes

- Launch and re-entry vehicles
- Satellite communication
- Satellite navigation
- Earth observation
- Science missions
- Exploration

Targeted Technology Areas

- Trajectory & mission
- Aerothermodynamics
- Propulsion systems
- AOCS/GNC
- Structure

Engineering Tasks

- Feasibility studies
- Performance calculation
- Detailed mission analysis
- Preliminary vehicle design
- Mission design and performance analysis
- Launch and re-entry risk assessment
- Life-time prediction
- System concept analysis and verification
- Preliminary functional engineering simulation
- Validation test bed
- Support of operations

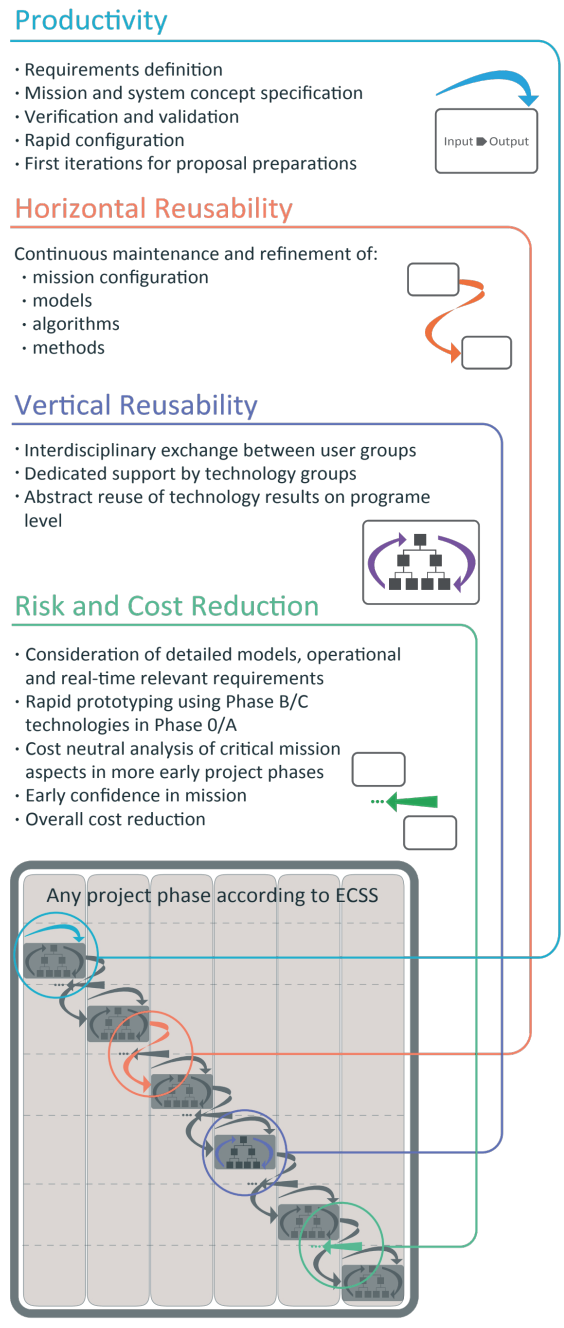
Functionalities

- Multi-body simulation
- Short/long time propagation
- Control and parameter optimization
- Vehicle design optimization (MDO)
- GNC analysis and design
- Sensitivity analysis
- Batch processing

Key Sales Arguments

- Coverage of nearly all space flight scenarios
- Full optimisation support by any ASTOS model
- Multi-body simulation and flexible dynamics
- Work flow with added values

Added Values



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Bundles

ASTOS is composed of several options. Bundles represent a combination of options for dedicated engineering tasks:

Launch and Re-entry
Simulation and trajectory optimization of conventional and advanced space launchers, suborbital space-planes, sounding rockets and amateur rockets. Re-entry vehicles like capsules and lifting bodies can be optimized as well.

Design
Vehicle design and trajectory optimization of ascent and re-entry vehicles. It can be extended with propulsion analysis (RPA interface) and with load case analysis for structural mass estimation.

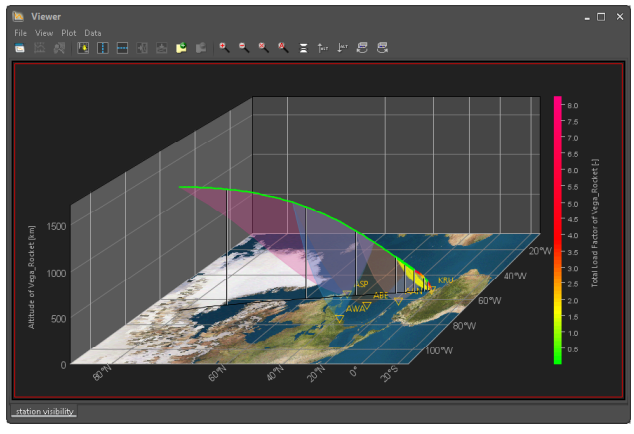
GNC
Complete platform to analyse open and closed loop AOC-S/GNC. It includes the Simulink interface and sensors to consider realistic navigation. It can be extended with flexible dynamics via the “mb linearize” option (DCAP interface).

Risk Assessment
Analysis of the human risk associated to re-entering vehicles considering multiple fragmentations and explosions. It considers the population density, air- and ship-traffic. Monte Carlo analysis can be performed via batch processing. Launch safety provides automatic procedure to perform a vehicle explosion during the mission evaluating the risk due to fragments and the overpressure due to shock wave.

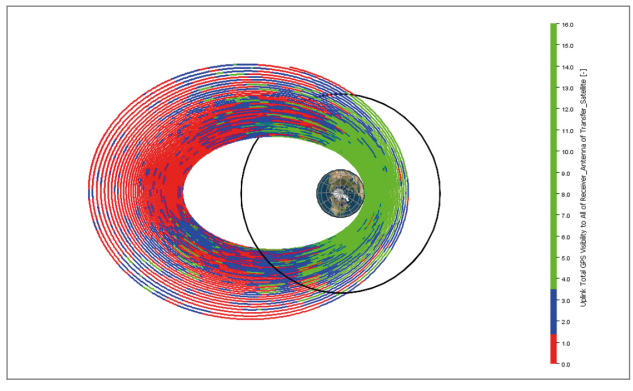
Trajectory Analysis
Complete trajectory optimization capability including multiple vehicles and basic mission analysis features (e.g. visibility, link budget, eclipses, life-time, etc.).

Mission Analysis Lite
Simulation of scenarios with single spacecraft and ground stations analysing link budget (SNR, C/N0, BER, Data-rate/volume), field of view, visibility of sensors and points of interest, eclipses duration, etc.

Mission Analysis Complete
Augmentation of the capabilities provided by “Mission Analysis Lite” with multiple vehicles (constellations),



Ground station visibility during launcher ascent



GPS navigation accuracy during electric propulsion orbit raising

coverage and navigation. For the coverage analysis (GPU accelerated*) it is possible to define the target (e.g. vehicle, ground station, geographical point or region) and the set of conditions (e.g. visibility, link, and relay). The navigation accuracy (e.g. UERE, PDOP, etc.) is based on GPS, Galileo and GLONASS.

System Concept
The ultimate solution for all space scenarios including multiple satellites, ascent and re-entry vehicles. It allows the complete vehicle design, the general (continuous and discrete) optimization and the detailed analysis of aspects related to propulsion, power, communication, navigation, thermal, AOCS/GNC and in general mission analysis. This bundle is the perfect tool to assist the project engineer from the proposal preparation till the conclusion of phase B. A must-have for each company that acts as prime contractor.

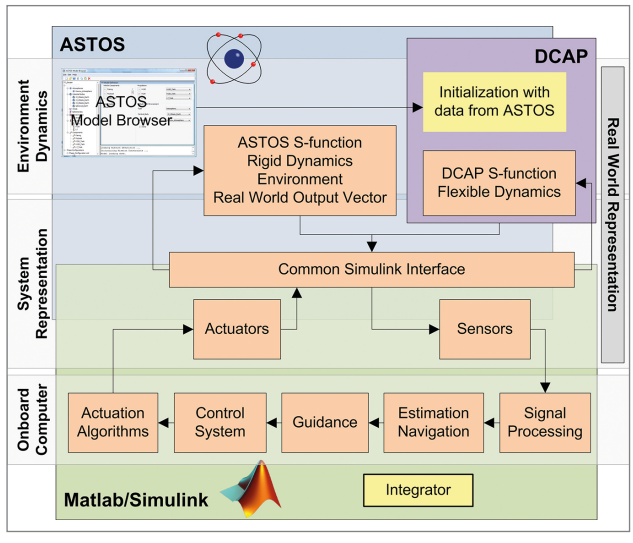
Functional Details

ASTOS is designed to cover most space flight scenarios with its model library supporting all project phases but focusing on preliminary design.

Model Library

Multitude of environment models:

- Gravity field (spherical & tesseral harmonics)
- Celestial body shape (e.g. WGS84)
- Atmosphere (e.g. NRLMSISE-00, JB2006, EMCD)
- Wind
- Air breathing and rocket propulsion models (e.g. mono and dual propellant, throttling, engine design models); RPA and CEA interface
- Database of launcher and winged vehicle models
- Vehicle design models for optimization
- Branching and docking capability of multi spacecraft scenarios
- Aerodynamic coefficients applied in user-defined frames
- Sensor models, e.g. star tracker, imaging sensor
- Power and thermal models that consider shadowing and eclipses
- Translational and attitude dynamics: polar and Cartesian representations; relative and inertial coordinate systems; Keplerian or equinoctial orbit elements; relative motion and special applications (e.g. launch pad, movement along rail); aerodynamics or Euler angles, quaternions
- Analytic, semi-analytic and numerical propagators
- Various time bases (e.g. TT, TAI, UTC, GPS)
- Predefined coordinate frames, e.g. J2000, ICRF, ECEF, TOD, Mean of Date or Mean of Epoch
- Aerodynamic models: axis-symmetric 3DoF, complete 3DoF; full 6DoF; interfaces to DrNUM, SOSE, Missile Datcom and other external libraries
- Vehicle attitude control: 6DoF inverse dynamics, profiles, 3DoF control laws (more than 30 different laws)
- Vehicle state definition types: equinoctial, Keplerian, polar, Cartesian, geodetic, etc.
- User model DLL (shared object) interface (actuators, environment models, vehicle components, actuators and aerodynamics)



ASTOS-GNC architecture with real world (ASTOS and DCAP), system (ASTOS and/or Simulink) and on-board (Simulink) representation

Optimisation

- Gradient-based parameter and control optimisation for small to very large problems (more than 1,000,000 parameters and constraints) using e.g. CAMTOS/WORHP or SOS
- Global optimisation techniques using e.g. MIDACO
- Vast library of mission related objective functions, boundary and path constraints
- Graphical editor for optimization problem

Multi-Body Simulation

- DCAP module provides multi-body and flexible body dynamics
- Simulation of e.g. robotic arms, solar panel distribution, flexible dynamics of structures and fuel sloshing inside tanks
- Coupling with Simulink® for controller design

Simulink® Interface

- ASTOS is linked as s-function to Simulink and provides environment and dynamics simulation
- Rapid configuration is done with ASTOS GUI
- Detailed system models (actuators, sensors) and on-board algorithms need to be provided by the user in Simulink

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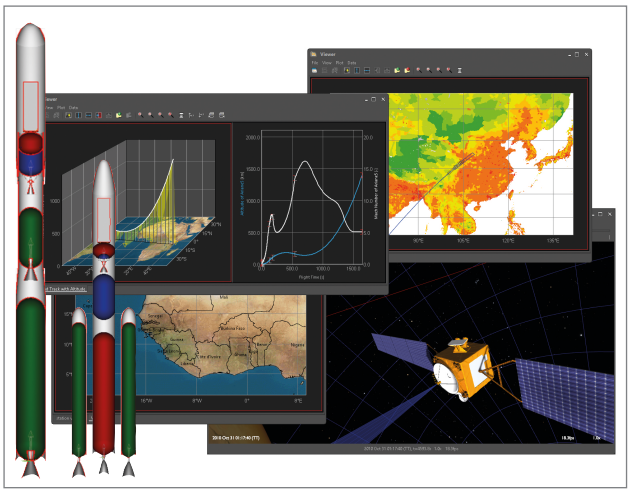
Visualisation

- Customizable reports
- Plots (2D, 3D, map plots, 3D map plots)
- Schedules (Gantt charts)
- Realistic animations with overlaid mission analysis data (with support for VR glasses*)
- ESRI ArcGIS™ and GeoTIFF support
- Textures for all major planets and moons
- Digital Elevation Map for Earth, Moon and Mars*
- Export to KML and CCSDS Navigation data messages

Generic Characteristics

- Completely data driven modelling solution via user friendly GUI
- XML-based configuration files
- Built-in batch processing configurator
- Uncertainty analysis (covariance analysis, Monte Carlo simulations)
- Data export to Excel®, MySQL, XML, MATLAB®, STK®, text file
- FMI interface
- COMET MBSE interface*
- Graphical scripting support* for customized output generation, extended control options and enhanced behaviour modelling



Visualization capabilities of ASTOS with 2D/3D-plots, projections with GIS information, 3D animations and sectional drawings

License Policy

- All bundles include a one-year node-lock license, 10 hours support and free software updates within the licensing period.
- Floating licenses are available on request.
- On-premise and webinar trainings as well as further software support can be ordered separately

*From ASTOS 10 onwards

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