IT Solutions to Facilitate Micro Launcher Developments

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IT Solutions - Overview

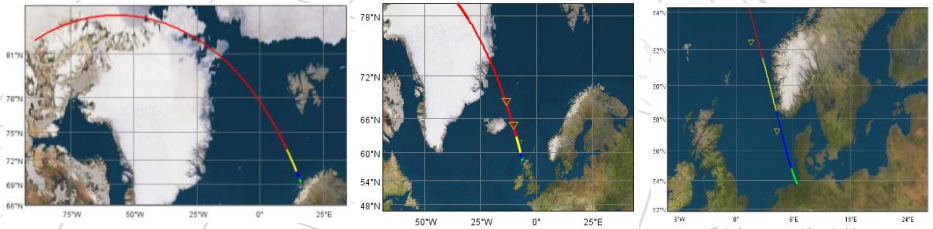
1. Design
   - Trajectory Optimization
   - Launch vehicle design optimization
   - Guidance, navigation and control
   - Flexible dynamics simulation
   - On-board software*
2. MAIT
   - Verification and validation facilities for avionics/GNC
   - Digital processes supporting MAIT
   - Logistics*
3. Ground Segment
   - Logistics*
   - Launch safety and risk analysis
   - Flight operations*
   - Post flight analysis*
4. Challenges
5. Solutions

* not addressed

First Guess & Performance

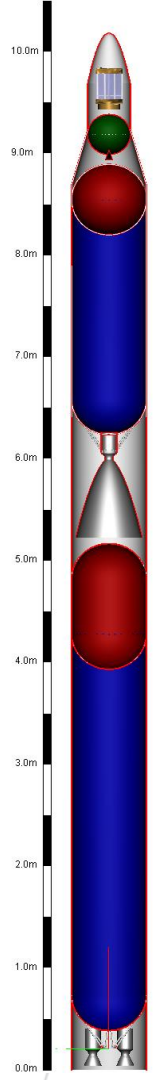
Performance - any Phase

- Different levels of maturity
- Aspects impacting performance
  - Load constraints (maxQ, g-load, …)
  - Stage impact points
  - Dog-leg manoeuvres (goundtrack, inclination)
  - Station visibility
  - Plume disturbance of ground link



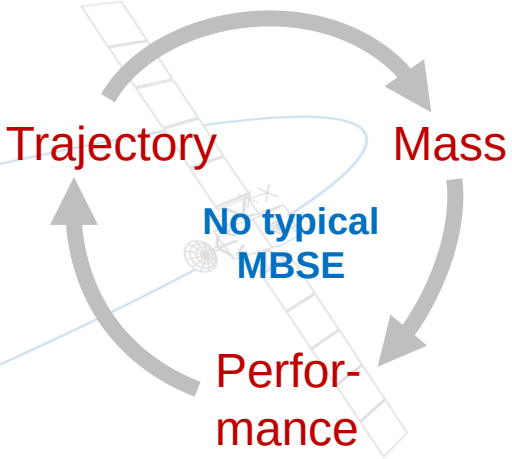
Design - Phase 0/A

- Stage sizing: point mass, thrust
- Selection of launch site(s)
- Rarely known impact of subsystems
- Trade-off and selection of concepts
  - Launch type (vertical, rail, horiz., air)
  - Reusability aspects
  - Propellant
  - Selection: Top-Down Cost
    - Cryogenic vs storable?
    - Solid vs hybrid vs liquid?
    - Rarely TRL9 data available for micro-LV
    - ➢ high uncertainties!



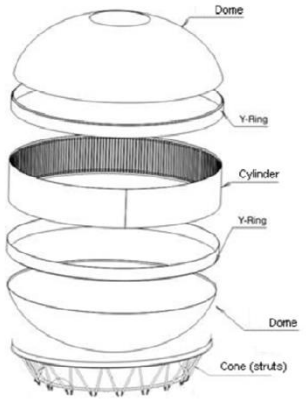
Preliminary Design

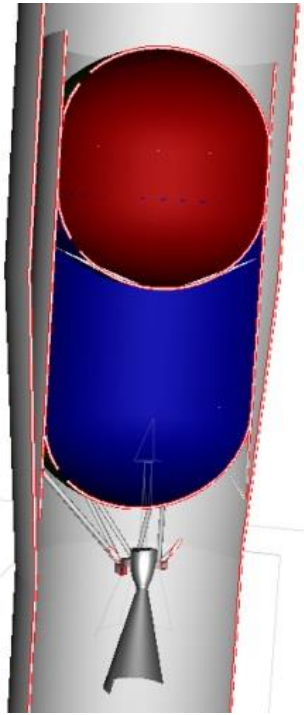
- Improved mass estimation
  - Break-up of stage definition to improve sensitivity
  - Stage and tank configurations (separated, common bkh, suspended, under fairing, ...)
  - Tanks, skirts, insulation, avionics, propulsion, …
  - Mass estimation regression, …
- Propulsion system
  - Performance, losses, weight, size, PMS
- Geometry
  - Number of engines in one stage
- Controllability
  - TVC, RCS, location, propellant mass
- Bottom-up cost estimation based on preliminary product tree



Detailed Design

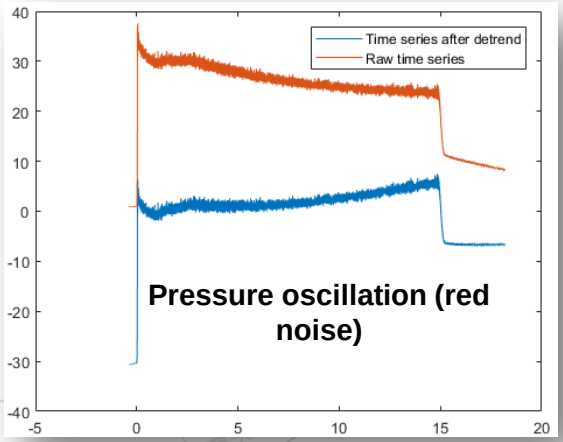
- LV design sensitivity depends mainly on mass estimation
- Detailed structural mass estimation
  - Tank and stage configurations
  - Substructures
    - cylinder, bulkhead, y-ring, cone, struts
  - Material (metal, CFRP)
  - Stiffening concept
    - isotropic, orthogrid, isotropic sandwich
  - Dimensioning load case based on beam approximation
- Distributed aerodynamic forces
  - beam approximation & flexible body dynamics

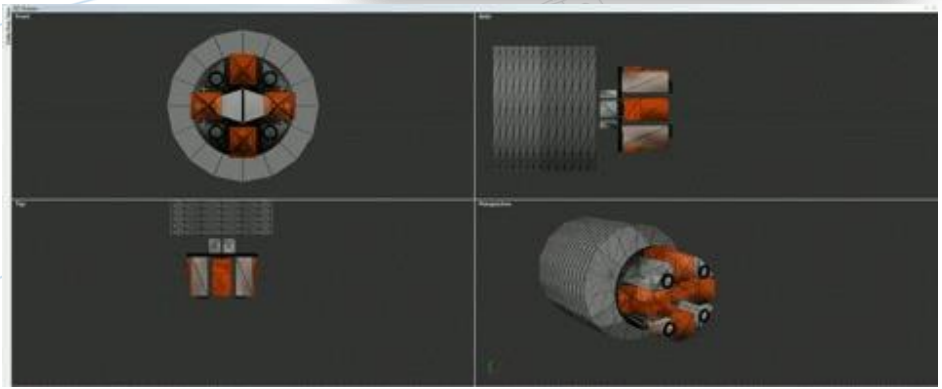




Iterations with Subsystems

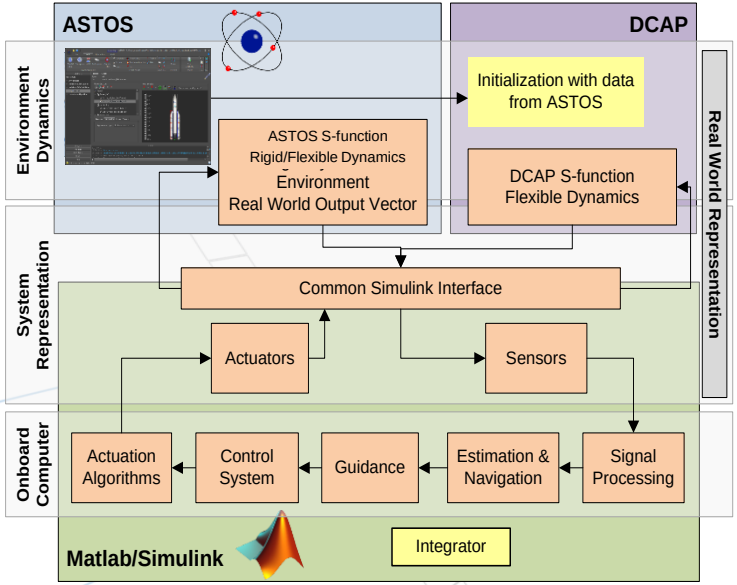
- Propulsion System
  - Combined engine cycle analysis in case of
    - throttleable engines, e.g. hybrid motors
    - critical coupling with system and subsystem
- Aerothermodynamics, acoustics, …
- Mechanical and Structural Analysis
  - Multi-Payload separation with separation devices
  - Sloshing (2D spring-damper model)
  - High frequency input from
    - Separation shocks
    - Pressure oscillations





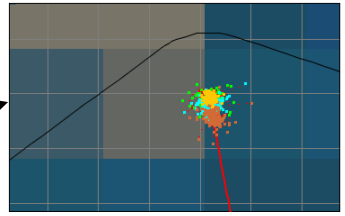
GNC and Verification Facilities

- Export of information for controller design
  - Linearized dynamics using mode shapes from flexible dynamics
- Development of GNC algorithms in Matlab/Simulink
- Selection of navigation sensors and actuators
- Verification and validation tests
  - MIL/PIL/HIL simulation
  - error injection
  - FES, SVF, FVT, AIV, ATB
  - SCOE: emulation and stimulation of EM/FM avionics equipment

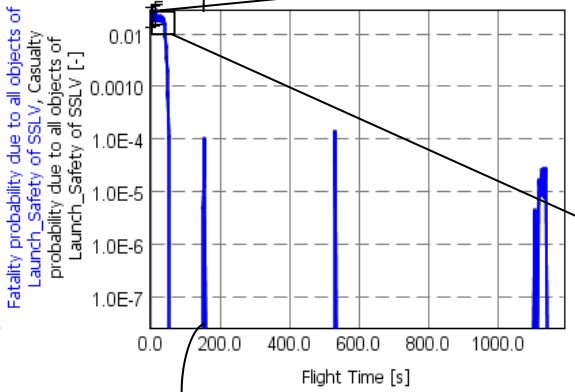


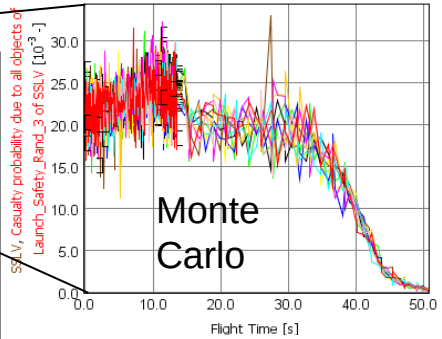
Operations – Launch Safety

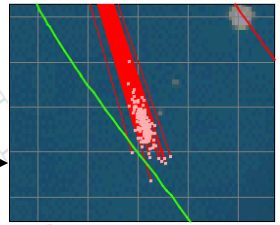
- Explosion
  - Risk of casualty and fatality in case of failure
  - Blast wave on launch pad
    - Envelope of the destruction area caused by the shockwave generated by an explosion
- Flight corridor



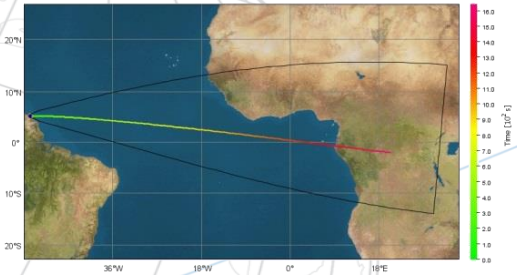
Explosion on LP







Explosion at 153 seconds



Challenges and Solutions 1/2

Low confidence at time of concept selection

- Time pressure and low budget in Phase 0/A
- Missing consideration of maybe critical subsystem information
- Weak cost estimation

- Representative subsystem models to estimate system impact and to achieve earlier confidence
- Reconfigurable tool chain
  - maintaining level of maturity through life cycle
  - covering critical design decisions in earlier phases
- Cost modelling considering more level of details and uncertainties

Challenges and Solutions 2/2

Increasing cost pressure

- Commercial market of micro and nano satellites
- NewSpace market with lower budget
- Competition

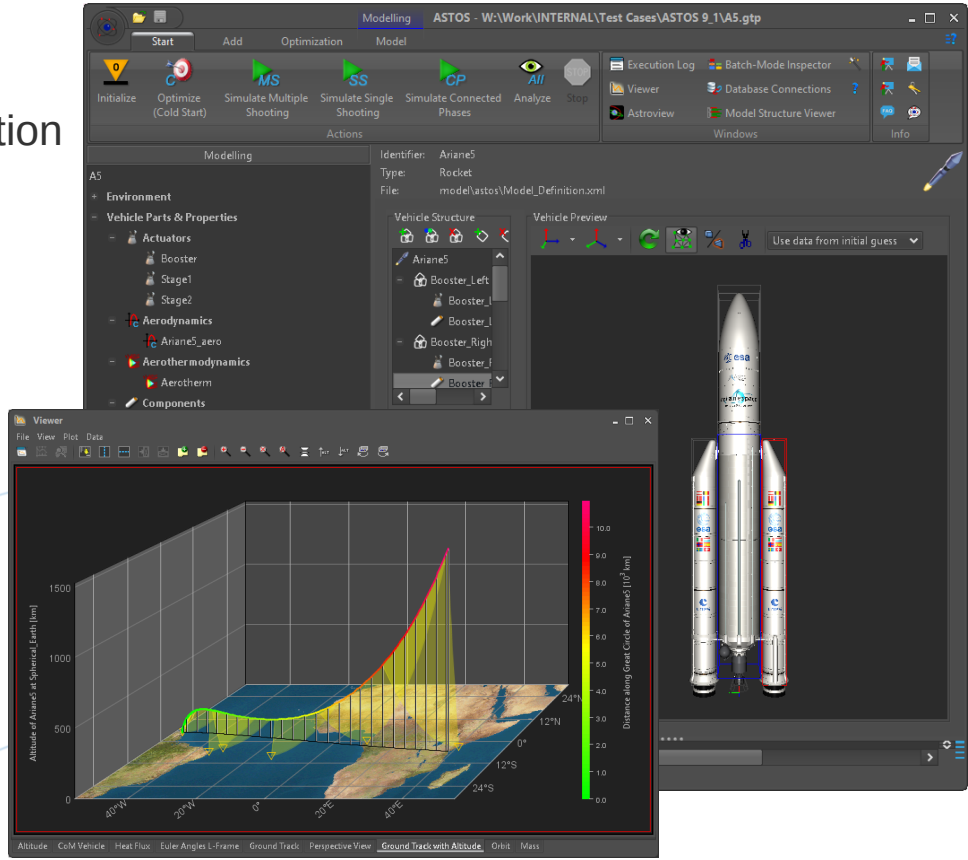
➢ Increased use of digitalization
  - Digital twin & Virtual testing
  - Digital processes in AIT
  - Requirements, ICD, PA docs as machine readable and interpretable information

➢ Cost reduction
  - More SW than HW tests
  - Higher efficiency, faster results, less person hours

Solution: ASTOS Tool Chain

Functionality

- Trajectory and detailed LV design optimization
- Launch range safety
- ODIN interface (structure, MT Aerospace)
- RPA and ESPSS interface (propulsion)
- Simulink interface for GNC
- Multi-body flexible-body dynamics for separation and high frequency analysis
- Real-time test with dSPACE SCALEXIO up to AOCS-SCOE, ATB
- Visualization



Solution: ASTOS Tool Chain

Advantages

- Over 20 years of experience
- Continuous improvement of SW
- Many (launcher) customers worldwide

THANKS FOR YOUR YEARS OF TRUST!