HYPMOCES

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HYPersonic MOrphing for a Cabin Escape System (HYPMOCES)

Project Coordinator: Davide Bonetti davide.bonetti@deimos-space.com Tel: +34 91 806 3450
DEIMOS Space S.L.U. Ronda de Poniente, 19 Edificio FITENI VI, 2-2 28760 Tres Cantos (Madrid), Spain

Passenger **safety** is one of the main drivers for the development of future trans-atmospheric transportation systems. The high levels of energy associated to this type of flight (hypersonics) as well as the level of reliability of the enabling technology leads to the need of a passenger escape system in case of flight abort.
The implementation of a **cabin escape system** for a hypersonic aircraft is challenged by the integration within a larger structure, the load factors for the passengers, the ejection propulsion concept, the capability to withstand extreme thermal environment (plasma flow) and the adaptability to a wide range of abort scenario conditions (low and high speed and altitude).

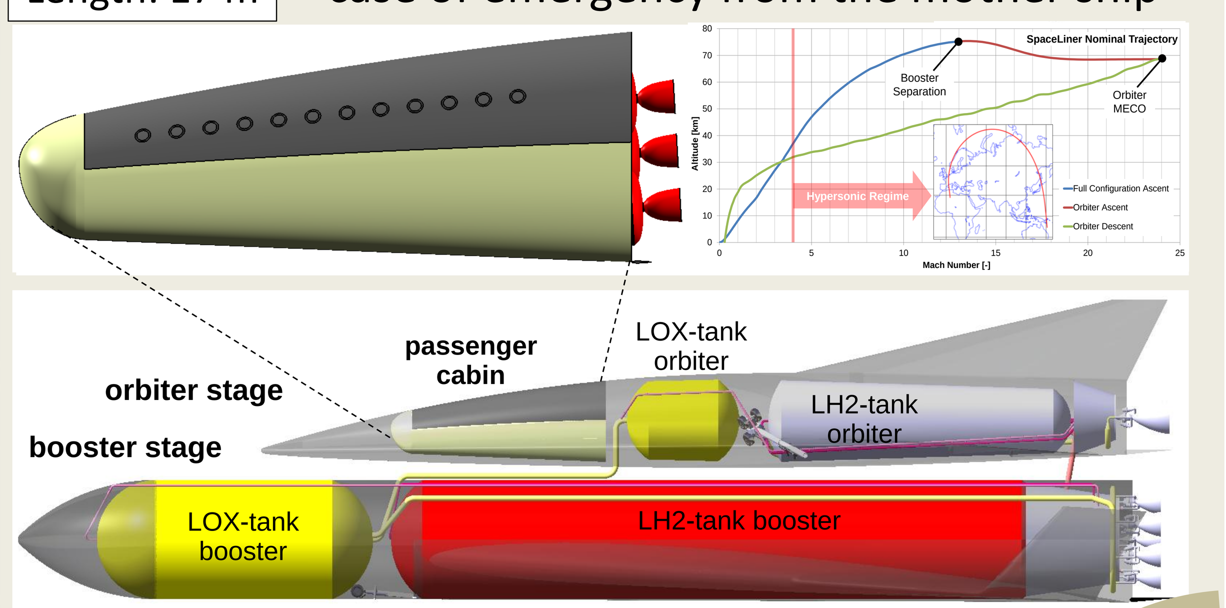
This **multi-phase nature** of the return flight makes morphing an attractive solution for a hypersonic escape system. The abort scenarios cover a wide range of flight conditions and the integration within the mother spacecraft requires compact solutions in terms of shape (ex: capsule adapted to outer mold line).
A single shape cannot provide adequate performance and it can be challenging (ex: load factors) for the wellness of the ordinary passengers expected in the cabin. The increase of the **lifting capability** after ejection of a escape capsule and the increase of aerodynamic control surfaces is a strong requirement in order to safely return to ground the crew – composed by non-trained persons.

The main goal of HYPMOCES is to investigate and develop the technologies in the area of control, structures, aerothermodynamics, mission and system required to enable the use of **morphing in escape systems for hypersonic transport aircrafts**. A large cabin escape system able to change its shape and automatically reconfigure during an abort event after ejection will balance the compromise between the constraints for the integration within the mother aircraft (compactness), the adaptability to the unpredicted environment in case of abort and the required flight performance to ensure safe landing. The HYPMOCES project addresses multiple key technological areas through Concurrent Engineering and a Multi-disciplinary Design Optimization (**MDO**) process to enable the use of morphing in hypersonic escape systems.

SpaceLiner: long range transport vehicle concept (mother ship)

Mass: 38 t
Length: 17 m

The 50 seats passenger cabin separates in case of emergency from the mother ship



Hypersonic passenger transport vehicle (Europe to Australia in 90 min)
Two stages, powered by LOX/LH2 staged combustion rocket engines

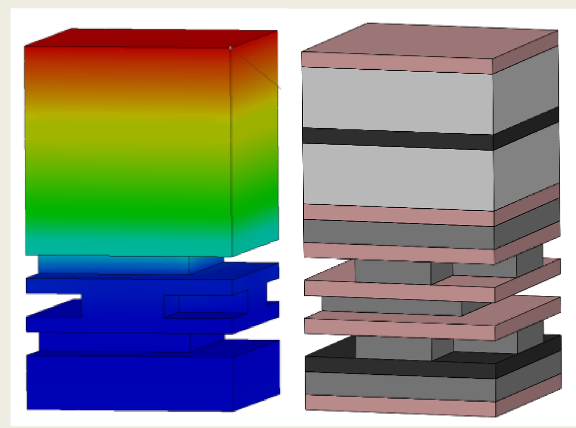
Flexible TPS design:

- Total areal density of 21.6 kg/m^2.
- 6 layers of Nextel; 5 layers of Pyrogel
- 2 layers of Saffil; 2 layers of T300J carbon fiber

Thermal analysis results:

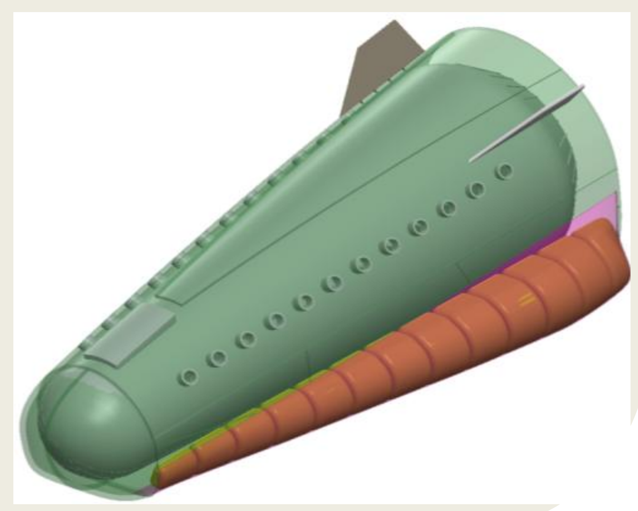
- Maximum T on external surface: 1150 °C
- Internal layer: 200 °C after 1900 s

Thermal Analyses



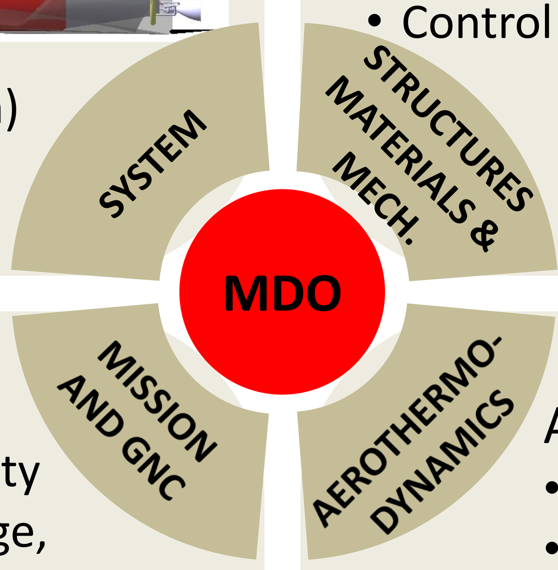
Inflatable system design (multi-layer sandwich):

- One internal layer of Kapton (gas barrier)
- Several Kevlar layers (structural elements)
- Reinforcements of Kevlar/Zylon wires
- Belts attached to the supporting structure
- Control valves at the base to inflate the bags



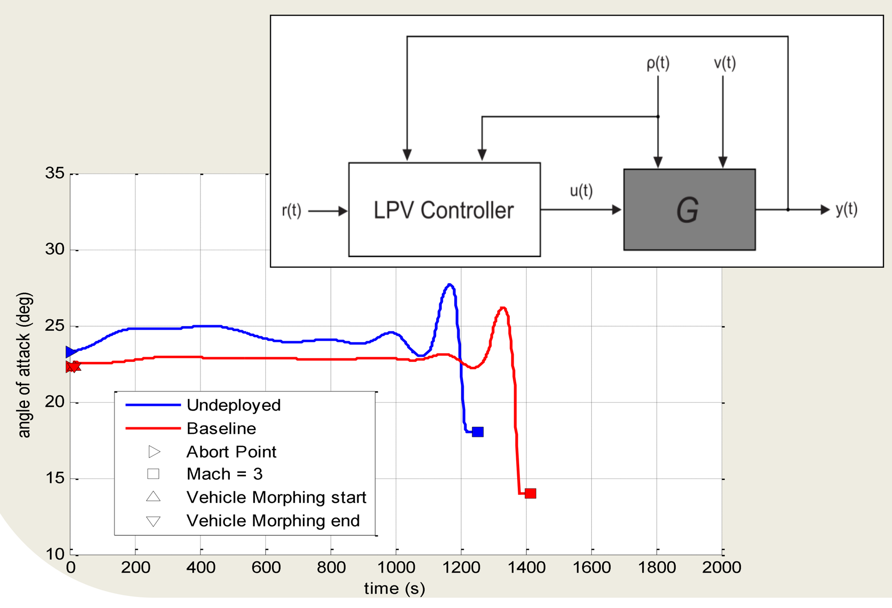
Rudders design:

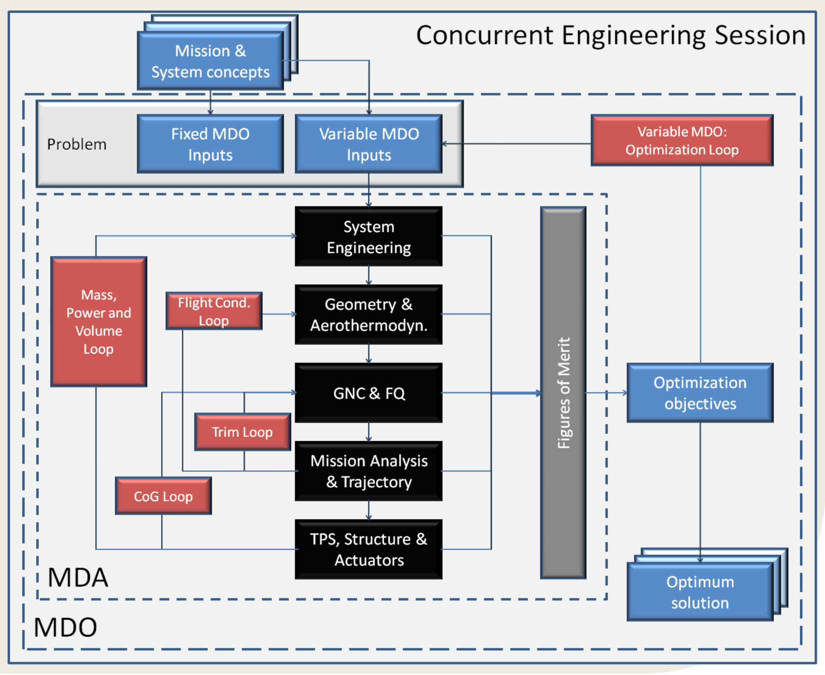
- C/SiC and Inconel



Mission and GNC Engineering:

- Morphing on a hypersonic capsule allows increasing passengers safety and comfort through increased flying qualities performance (L/D, range, lower thermo-mech. loads, stability) and mission flexibility
- LPV control is adopted to cope with model uncertainty, time-varying vehicle dynamics (reconfiguration during morphing) and stringent specifications
- Highly coupled E2E optimization process

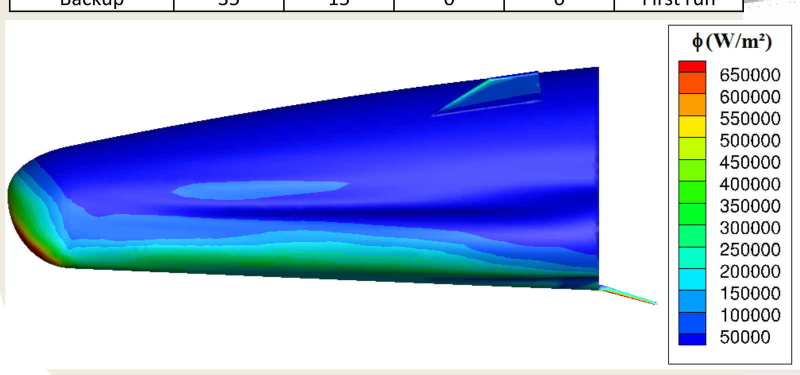




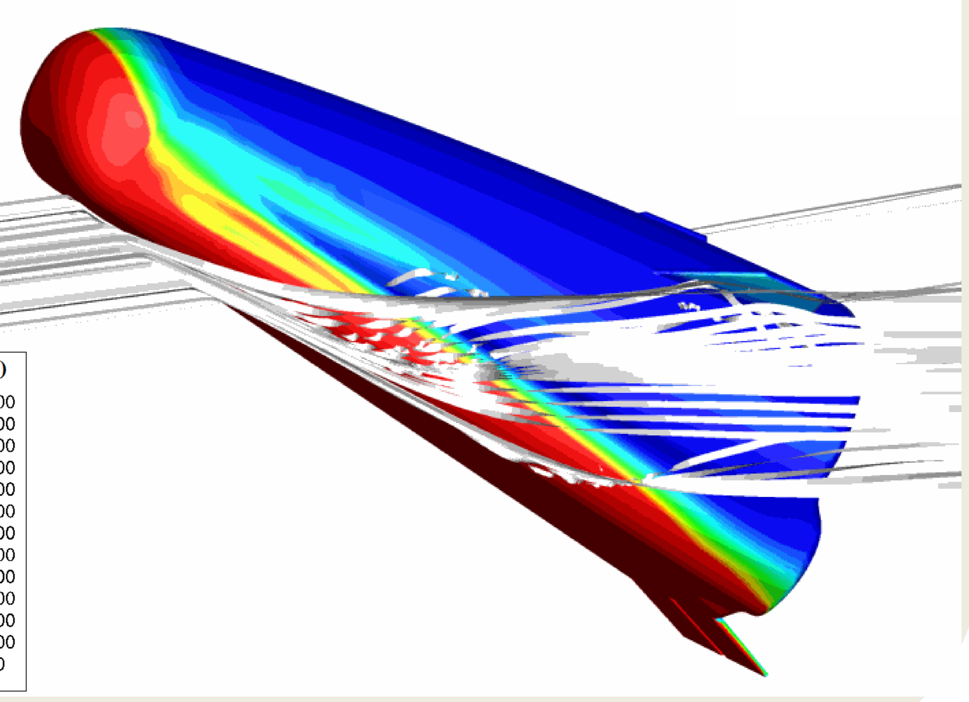
Aerothermodynamic analyses:

- AETDB construction through CEDRE detailed NS simulation
- Systematic comparison to FAST pre-design tool
- Micro - and transient - aerothermodynamics under analyses

Matrix of CFD cases run					
Vehicle	AoA	Elevator	AoS	Aileron	Scope
Undeployed	35	15	0	0	First run
Undeployed	35	-10	0	0	Elevator
Baseline	35	15	0	0	First run
Baseline	35	15	-5	0	Sideslip
Baseline	35	15	-10	0	Sideslip
Baseline	35	-10	0	0	Elevator
Baseline	10	15	0	0	AoA
Baseline	20	0	0	5	Aileron
Baseline	20	0	-10	0	Sideslip
Backup	35	15	0	0	First run



Heat fluxes on inflatable sidewalls



Pressure field and streamlines

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