Adapting Mars Entry, Descent and Landing System for Earth

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In 2001 - 2011 an inflatable Entry, Descent and Landing System (EDLS) for Martian atmosphere was developed by FMI and the MetNet team. This MetNet Mars Lander EDLS is used in both the initial deceleration during atmospheric entry and in the final deceleration before the semi-hard impact of the penetrator to Martian surface (see figure 1). The EDLS design is ingenious and its applicability to Earth's atmosphere is studied in the on-going project. In particular, the behaviour of the system in the critical transonic aerodynamic (from hypersonic to subsonic) regime will be investigated. This project targets to analyse and test the transonic behaviour of this compact and light weight payload entry system to Earth's atmosphere. Scaling and adaptation for terrestrial atmospheric conditions, instead of a completely new design, is a favourable approach for providing a new re-entry vehicle for terrestrial space applications.

Main Objective

The main objective is to provide a demonstrated and verified EDLS design for the entire relevant range of aerodynamic regimes expected to be encountered in Earth's atmosphere during the entry, descent and landing. Low Earth Orbit (LEO) and Lunar applications envisaged include use of the EDLS approach in return of payloads from LEO spacecraft, from the International Space Station and even from a Lunar base. The verified EDLS would also add an option for the design of European and Russian missions with applications in planetary surface exploration missions to other celestial bodies with significant atmospheres, such as Titan.

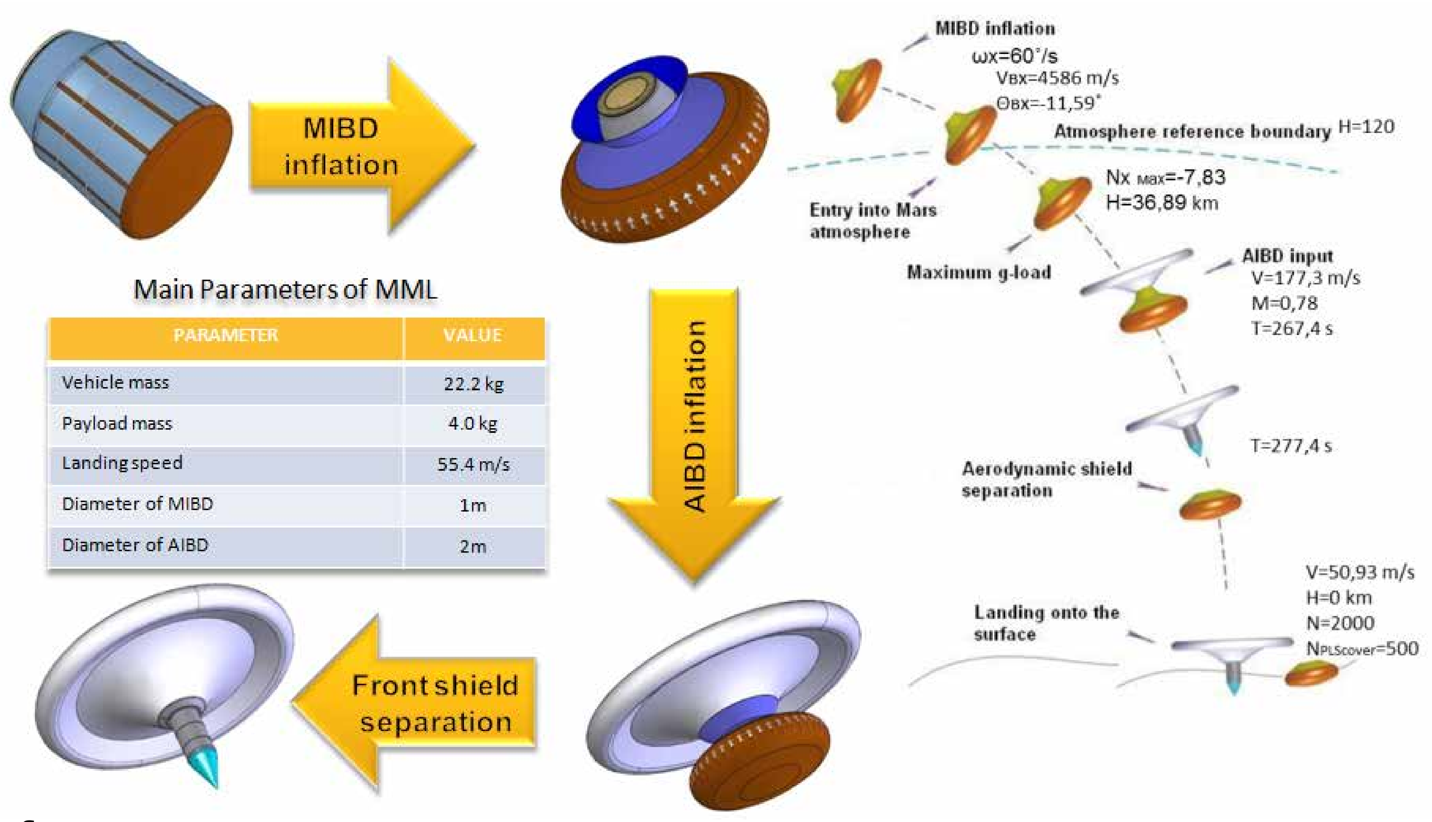

Figure 1: MetNet lander landing scheme. Picture: Lavochkin.

EDLS for Earth

The dynamical stability of the craft is analysed, concentrating on the most critical part of the atmospheric re-entry, the transonic phase, i.e. the phase when the speed of the vehicle is decelerated from hypersonic speeds to subsonic speeds. In Martian atmosphere the MetNet Lander's stability during this very turbulent phase is well understood and known. However, in the much more dense Earth's atmosphere, the transonic phase is much shorter and turbulence more violent. Therefore, the EDLS has to be sufficiently dynamically stable to overcome the forces tending to deflect the craft from its nominal trajectory and attitude. Due to the criticality of this phase most of the investigations in this study are focused to this regime. Once the scaling of the re-entry system and the dynamical stability analysis have matured enough, the preliminary design of the inflatable EDLS for Earth can be commenced. The scaled-down design model will be then put to wind tunnel tests, to verify performance of the design in the transonic phase.

Preliminary Analysis of Conditions of DV Entry into the Earth Atmosphere Meeting Thermal Loading Parameters

Preliminary results of analysis of 120 variants of trajectories were V_{entry} = 5250 m/s and θ_{entry}=-3 deg. With these values, the following table 1 of correspondence of thermal parameters at DV (Descent Vehicle) descending in the Earth and Mars atmospheres were calculated.

Table 1: Thermal parameters at DV descending in the Earth and Mars atmospheres. Table: Lavochkin.

Entry velocity, m/s	Angle of entry, deg	Time of thermal action, s	Heat flux, KW/m²	Quantity of heat, MJ/m²	TPC ablation, mm	Sublimation duration, s	Dynamic pressure, kPa
The Earth – 5250	- 3.00	150	303	12.5	1.40	56	2.29
Mars – 4586	- 9.49	200	190	11.7	1.38	72	1.2

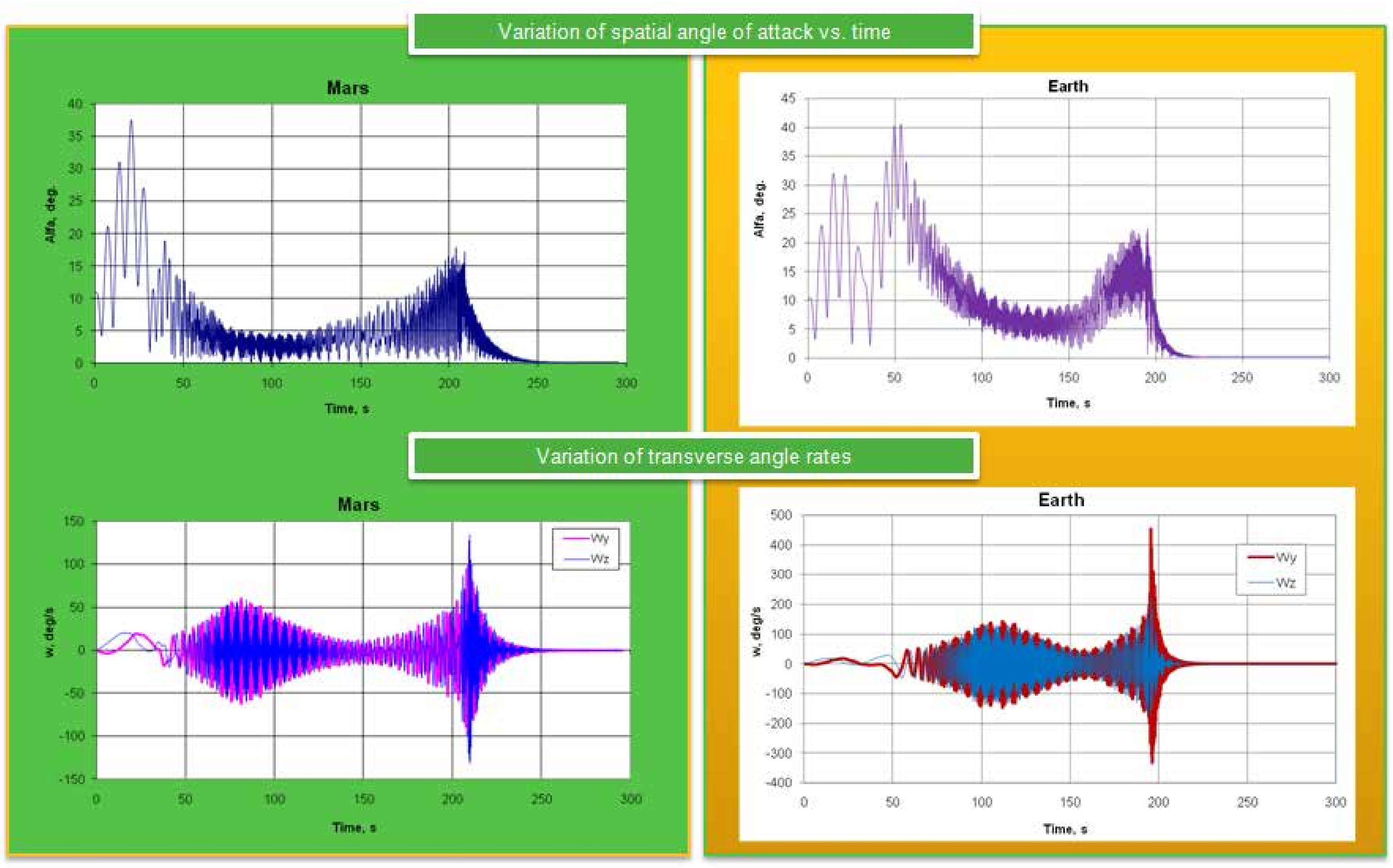

Figure 2: Dynamics of MetNet DV (Descent Vehicle) angular motion at its descending in the atmosphere. Picture: Lavochkin.

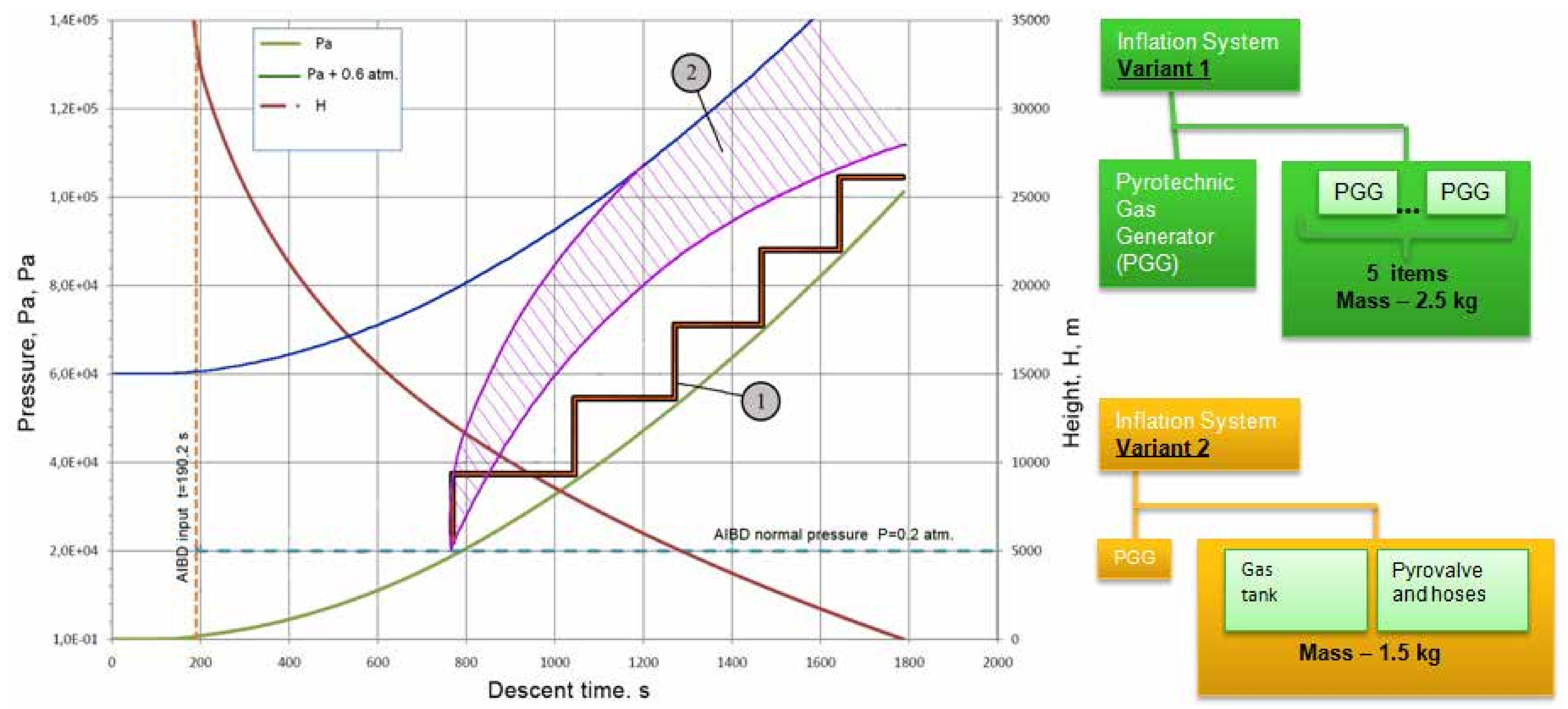

Figure 3: AIBD (Additional Inflatable Braking Device) pressurization scheme. Picture: Lavochkin.

Preliminary Results

- Entry conditions V_{entry} = 5250 m/s, θ_{entry} = -3 deg are feasibile for MetNet DV descend and landing to the Earth atmospere.
- TPC ablation and thermal protection temperature conditions are comparable.
- At stabilization of DV by spinning and oriented entry into the Earth atmosphere the MetNet DV preserves stability along the whole path. Angular motion characteristics are preserved (see figure 2).
- The mechanical loads to MIBD (Main Inflatable Braking Device) due dynamic pressure interaction practically coincide.
- In Earth conditions, due to more dense atmosphere at altitudes below 12 km, staged pressurization of AIBD (Additional Inflatable Braking Device) is required (see figure 3). The pressurization system will increase DV mass by 1.5-2.5 kg (depending of chosen variant).

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More information from the RITD website http://ritd.fmi.fi

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