RITD - Adapting Mars Entry, Descent and Landing System for Earth

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We have developed an atmospheric re-entry and descent system concept based on inflatable hypersonic decelerator techniques that were originally developed for Mars. The ultimate goal of this EU-funded RITD-project (Re-entry: Inflatable Technology Development) was to assess the benefits of this technology when deploying small payloads from low Earth orbits to the surface of the Earth with modest costs. The principal goal was to assess and develop a preliminary EDLS design (Figure 1) for the entire relevant range of aerodynamic regimes expected to be encountered in Earth's atmosphere during entry, descent and landing. Low Earth Orbit (LEO) and even Lunar applications envisaged include the use of the EDLS approach in returning payloads of 4-8 kg down to the surface (Figure 2).

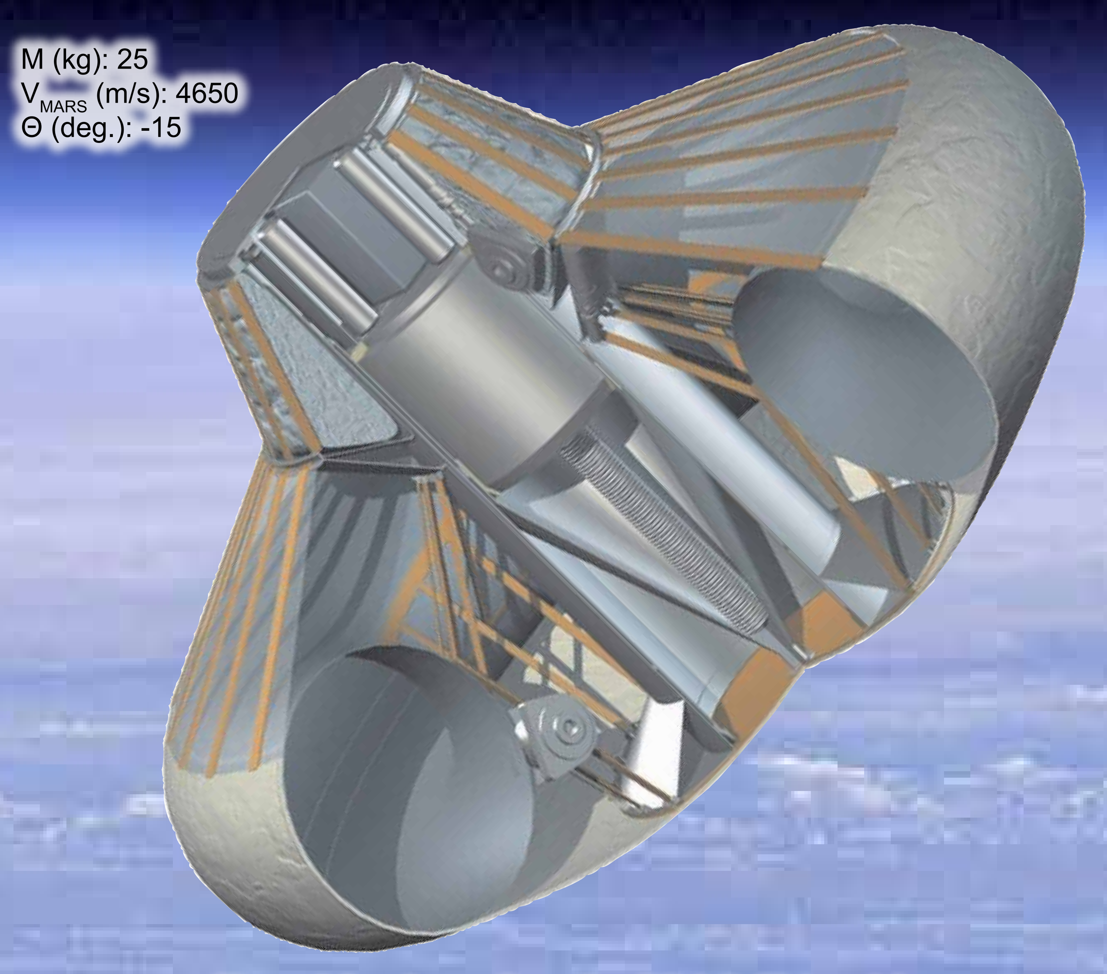

Figure 1: Lander configuration (Mini-1). Picture: LA.

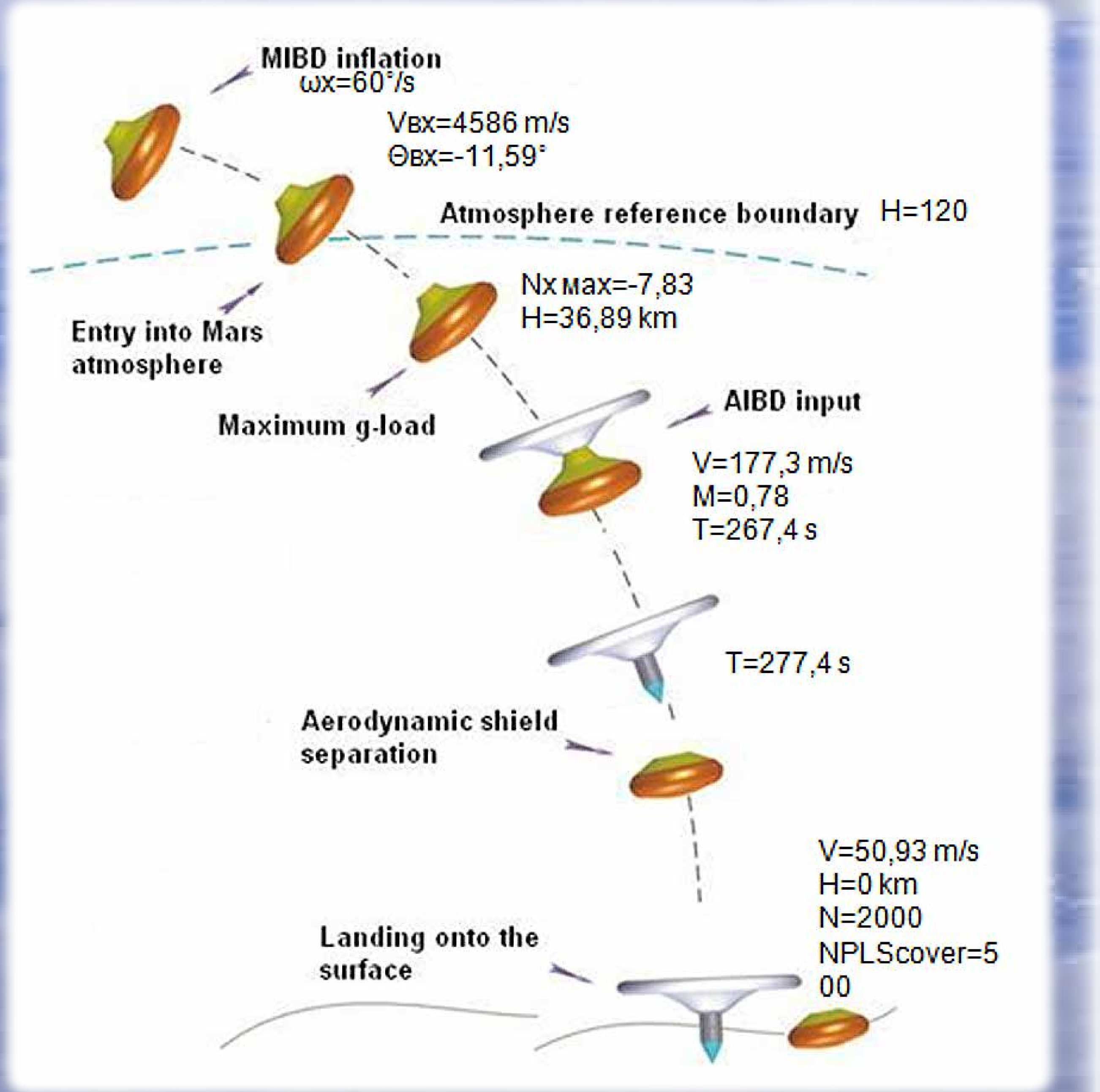

Figure 2: Mini-1 Lander nominal landing scheme. Picture: LA.

Our development and assessments show clearly that this kind of inflatable technology originally developed for the Martian atmosphere, is feasible for use by Earth entry and descent applications (Table 1). The preliminary results are highly promising indicating that the current Mars probe design could be used as it is for the Earth (Table 2). According to our analyses, the higher atmospheric pressure at an altitude of 12 km and less requires an additional pressurizing device for the inflatable system increasing the entry mass by approximately 2 kg. These analyses involved the calculation of 120 different atmospheric entry and descent trajectories (Figure 3).

The analysis of the existing technologies and current trends have indicated that the kind of inflatable technology pursued by RITD has high potential to enhance the European space technology expertise. This kind of technology is clearly feasible for utilization by Earth entry and descent applications.

Mission Concept Plans

Deployment of Cargo from ISS to Earth Surface

ISS has limited resources for bringing down the experiments and other valuable cargo to Earth for further analysis. Here is the application area where the inflatable landers would be an ideal solution. The advantages of the inflatable structures (mass, size and payload overall mass -ratio) enables the use of the RITD based landers as part of the ISS small cargo Earth return system.

De-orbiting of Low Earth Orbit Spacecraft

To expedite the de-orbiting time, the RITD based inflatable lander vehicle concept e.g. Mini-1 MIBU can be installed to the spacecraft to act as a decelerator/dragger. For the satellites, especially low-orbiting satellites, this de-orbit inflatable dragger will dramatically decrease the orbiting time compared to the passive free-fall situation.

Sample Return

One of the critical phases in sample return missions is the EDL of the lander vehicle, and the precious samples located in the cargo container inside, onto the Earth surface. The RITD Mini-1 based inflatable lander vehicle concept is designed to withstand the hard landing on the Earth surface. Therefore the concept payload (cargo) compartment design already takes into account the effects caused by the hard landing.

Table 1: Possible applications for the inflatable decelerators (categories 1 to 5.). Table: FMI and LA.

Category	Application	Key technical requirements
Mini-1	Technology demonstration	- Safety of science devices
	Science mission	- Safety of landing (accuracy)
	Planetary exploration	- Aerodynamics
	Sample return mission	- Flight quality of inflatable tech.
Mini-2	Technology demonstration	- Safety of science devices
	Science mission	- Safety of landing (accuracy)
	Planetary exploration	- Aerodynamics
	Down-mass mission	
	Sample return mission	
Middle-1	Down-mass mission	- Safety of landing (accuracy)
	Space laboratory mission	- Aerodynamics
	Science mission	- Safety of science devices
	Planetary exploration	- Safety of science experiments
	Sample return mission	
Middle-2	Space laboratory mission	- Safety of landing (accuracy)
	Planetary exploration	- Aerodynamics
	Sample return mission	- Safety of science devices
		- Safety of science experiments
Large	Manned mission (emergency)	- Safety of landing (accuracy)
	Planetary exploration	- Aerodynamics
		- Crew safety (life-support system)

Table 2: Comparison of thermal parameters at DV descending in the Earth and Mars atmospheres. Table: LA.

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

V_{entry} = 5250 m/s

θ_{entry} = -3 deg.

Figure 3: Results of analysis of 120 variants of trajectories and optimal key parameters. Picture: LA.

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

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