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

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A new generation of inflatable Entry, Descent and Landing System (EDLS) for Mars has been developed. It is used in both the initial atmospheric entry and atmospheric descent before the semi-hard impact of the penetrator into Martian surface. The EDLS applicability to Earth's atmosphere is studied by the EU/RITD project. It focuses to the analysis and tests of the transonic behaviour of this compact and light weight payload entry system at the Earth re-entry.

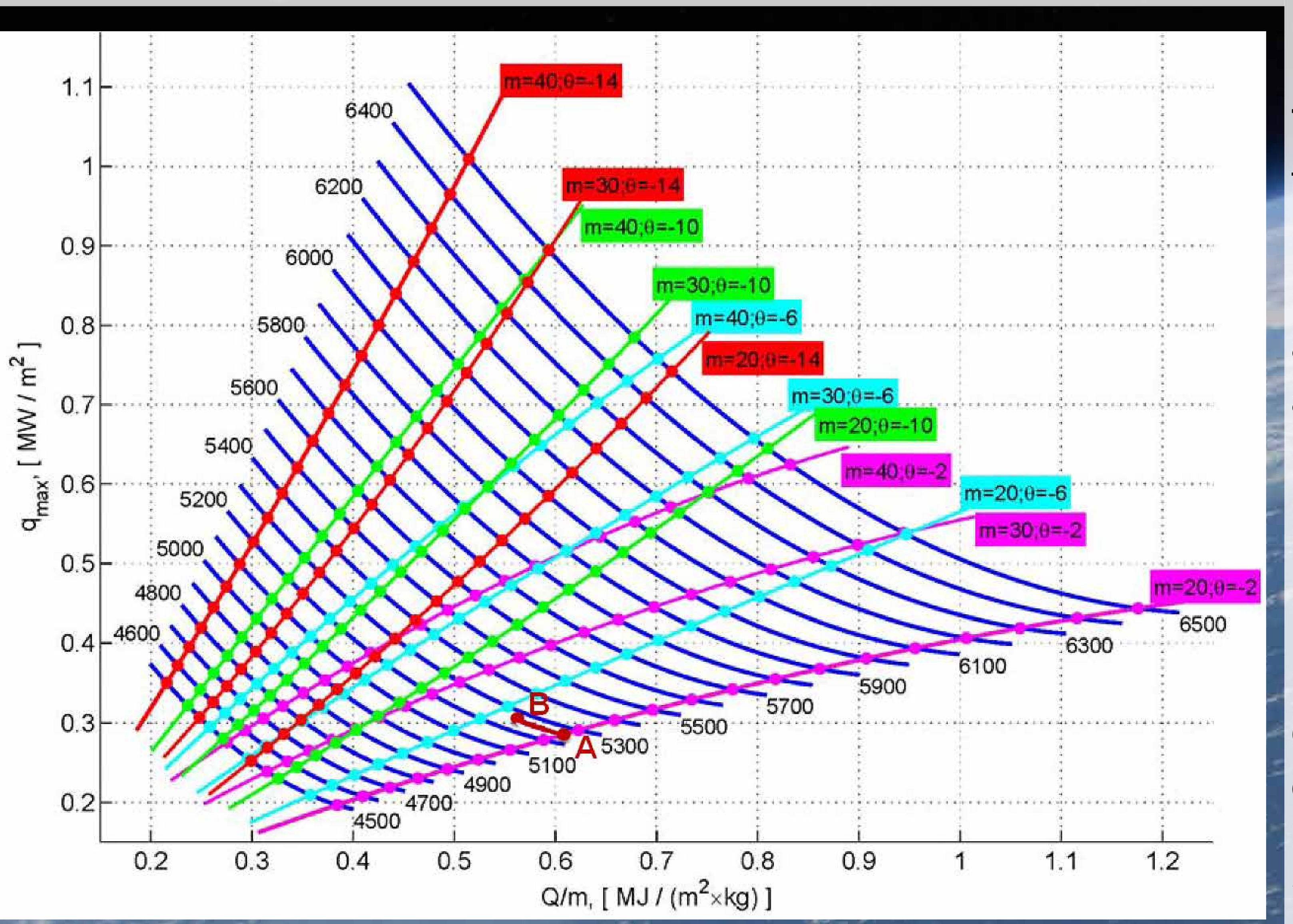

Figure 1: MetNet type of lander of DV angles of re-entry into Earth atmosphere. Picture: Lavochkin.

Defining the Earth re-entry

The key parameters for the Earth re-entry definition are:

- q_{max} (kW/m^2): maximal specific heat flux,
- **Q** (MJ/m^2): specific integral heat flux to DV front shield,
- **m** (kg): descent vehicle (DV) mass,
- **V** (m/s): re-entry velocity and
- **Θ** (deg.): flight-path angle at Earth re-entry

The parameters in the velocity curve plot (in figure 1) are as follows:

A) According to the thermal parameters of the DV motion in the Earth atmosphere the plotted velocity curves correspond to specific values of ***m*** and ***Θ*** (figure 1). The curves are approximated by second-order polynomials.

B) The interaction points of velocity curves and curves of [***m***,***Θ***] (round painted markers in figure 1) are defined.

C) Lengths of the velocity curve portions (as an example, A to B in figure 1) to the points of intersection with the curves corresponding to certain ***m*** and ***Θ*** are defined. The length of the arc (A to B) and the DV mass determines the optimal angle of DV re-entry.

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. In Martian atmosphere the MetNet vehicle stability during the transonic phase understood. However, in the more dense Earth's atmosphere, the transonic phase is 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. The preliminary design of the EDLS for Earth will be commenced once the scaling of the re-entry system and the dynamical stability analysis have been performed. The RITD-project concentrates on the current MetNet-type (i.e. Mini-1 category) of lander, and on requirements posed by other type Earth re-entry concepts (figure 2).

Mini-1 Category Lander

Mini-1 category includes the descent vehicles with the mass of 20 kg to 50 kg. The descent vehicle of the given category is mainly designed and intended for descending in the Mars atmosphere and landing onto its surface. Mini-1 lander category is the baseline for the MetNet-type of lander and it has been fully tested and qualified for Mars atmospheric entry with Mars parameters.

Application Opportunities

The following Table 1 presents applications that can be realized with the landers categorized in the figure 2 (Mini-1 highlighted). Proposed applications are only as an example and other similar type of applications can be realized also.

Same type of missions can be carried out with one or more type of category landers. The manned missions are exception according to the RITD-experts and only Large category landers can be used for manned missions.

Table 1: Possible applications for category 1 to 5 landers. Table: Lavochkin /FMI.

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 technology
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)

Wind Tunnel Tests

Figure 3: Wind tunnel test mock-up. Picture: FMI.

The aim of the wind tunnel test is an experimental determination of the Mini-1 -lander damping factors in the Earth atmosphere and recalculation of the results for the case of the vehicle descent in the Mars atmosphere.

Mini-1 wind tunnel tests are performed by the method of oscillation process analysis at air flow of the model fixed to the holder through free-oscillation mechanism.

The program of the planned wind tunnel tests and realized parameters of the flow at chosen wind tunnels are shown in Table 2. Figure 3 shows the Mini-1 EDLS wind tunnel mock-up model that is in scale of 1:15. The mock-up model is manufactured in a single copy and it will be tested at all the values of Mach numbers, provided in Table 2.

Table 2: Conditions of test performance in wind tunnel tests.

Condition number	1	2	3	4	5	6	7
M_∞	0.85	0.96	1.05	1.19	1.25	1.30	1.55
$Re_{\infty D} \cdot 10^{-5}$	1.17	1.26	1.31	1.42	2.35	4.30	6.40
q_∞[kg/m^2]	3427	4164	4782	5442	8013	9320	6477

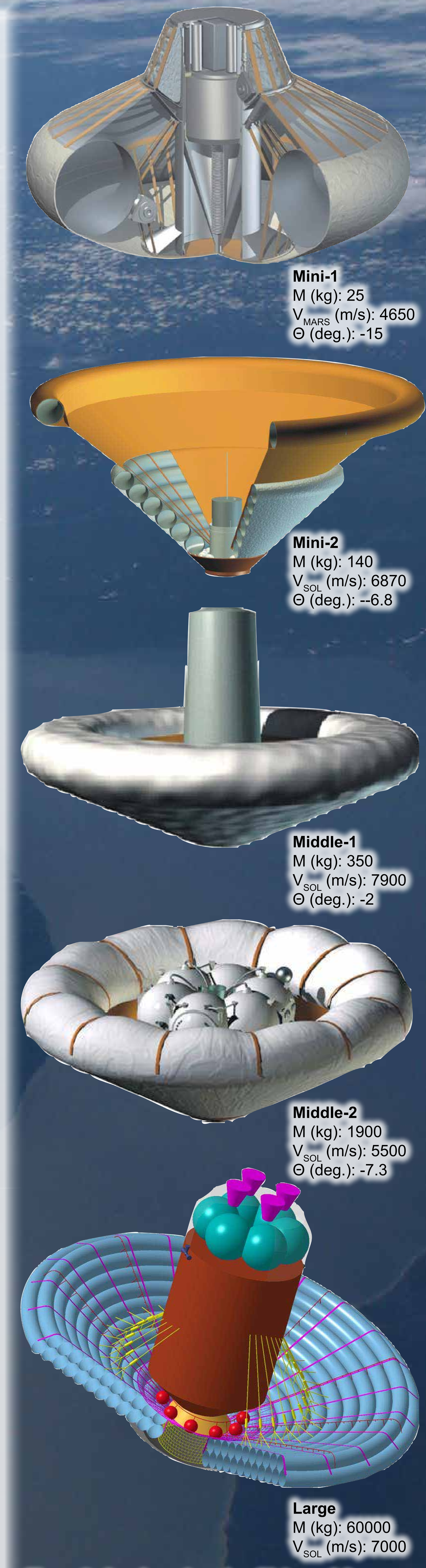

Figure 2: Lander categories. Pictures: LA.

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

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