Adapting Mars Entry, Descent and Landing System for Earth

J. Heilimo [1], A.-M. Harri [1], S. Aleksashkin [2], V. Koryanov [3], H. Guerrero [4], W. Schmidt [1], H. Haukka [1], V. Finchenko [2], M. Martynov [2], B. Ostresko [2], A. Ponomarenko [2], V. Kazakovtsev [3], I. Arruego [4], S. Martin [4] and T. Siili [1]

(1) Finnish Meteorological Institute, Helsinki, Finland (jyri.heilimo@fmi.fi), (2) Federal Enterprise Lavochkin Association, Khimki, Russia, (3) Bauman Moscow State Technical University, Moscow, Russia, (4) Institutio Nacional de Técnica Aerospacial, Madrid, Spain

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 (see figure 1). 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.

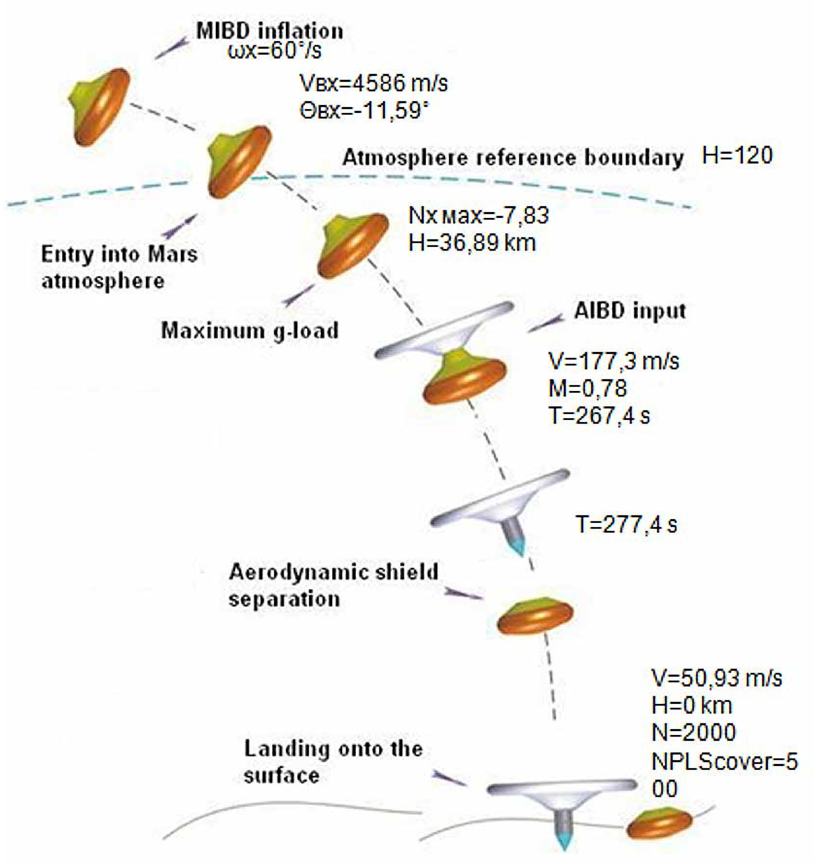

Figure 1: MetNet type of lander category landing scheme. Picture: Lavochkin.

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. 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 inflatable 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 mission and applications achievable with the current MetNet-type (i.e. "Mini-1" category) of lander, and on requirements posed by other type Earth re-entry concepts (figure 2).

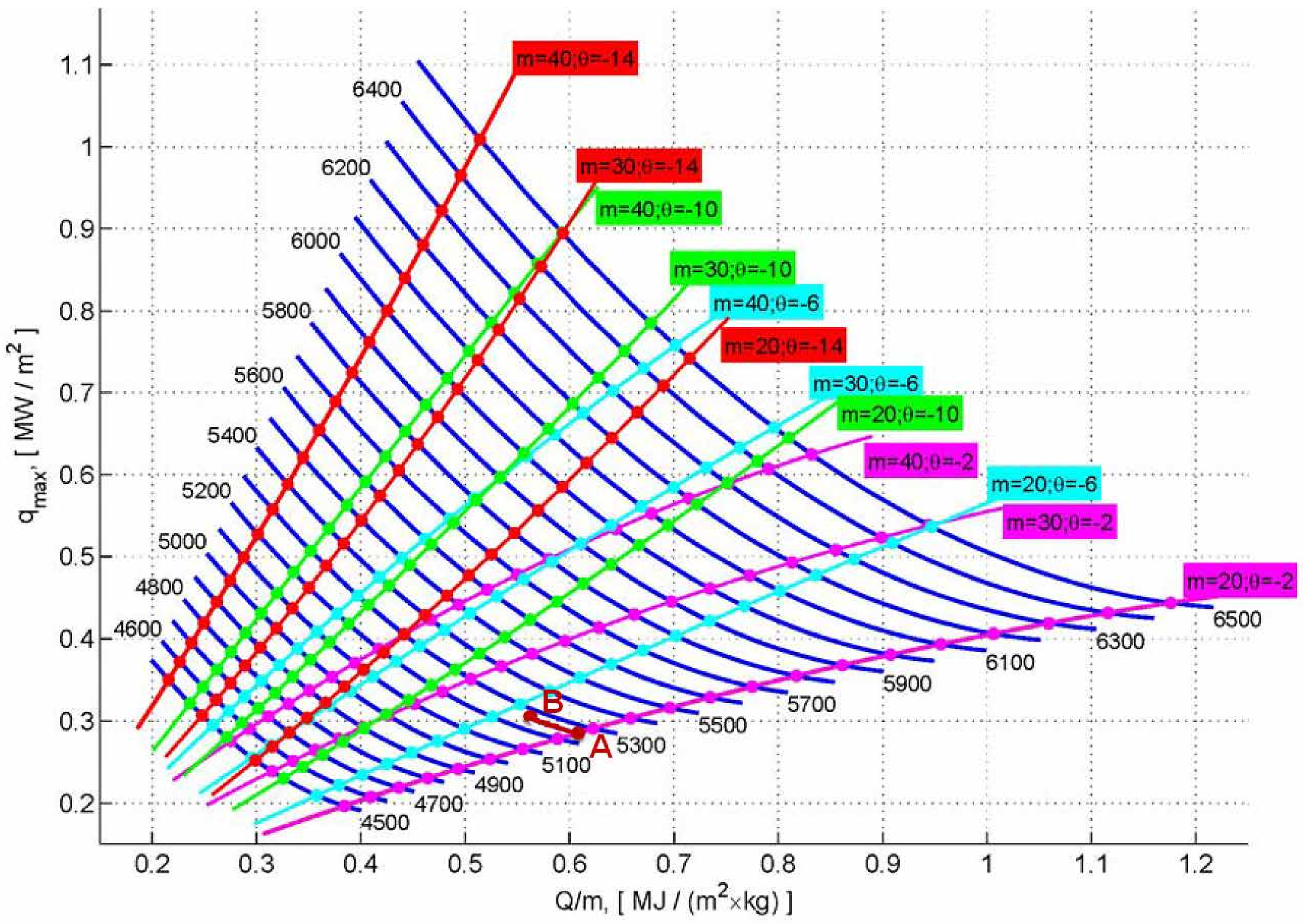

Figure 3: MetNet type of lander of DV angles of re-entry into Earth atmosphere. Picture: Lavochkin.

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 3) 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 3). 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 3) are defined.

C) Lengths of the velocity curve portions (as an example, A to B in figure 3) 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.

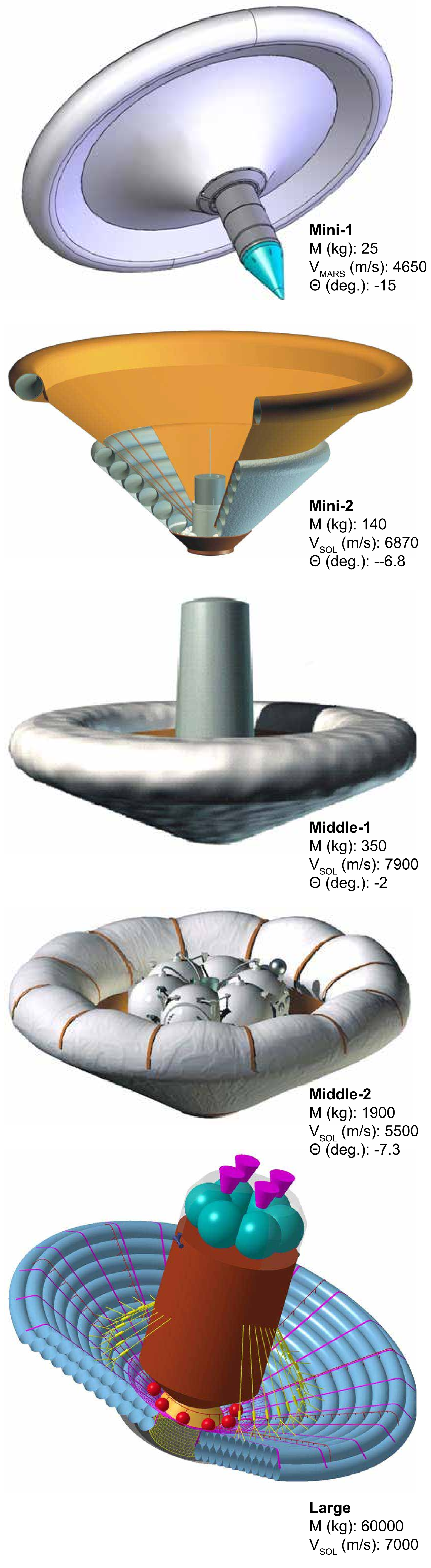

Figure 2: Examples of the each lander category. From the top: Mini-1, Mini-2, Middle-1, Middle-2 and Large Pictures: LA.

Entry angle for Mini-1 - lander

The suitable re-entry angle and velocity with specific DV mass and heat flux parameters need to be determined. For Earth re-entry the calculation results in the optimal value of entry velocity for MetNet (Mini-1) type lander being V_{SOL} = 5268 m/s (figure 3). that can be presented in the diagram showed in figure 3. The length of the arc A to B in figure 3 and the mass m determine the angle of re-entry. Using the Table 1 parameters we get the optimal angle Θ = -3.06 degrees for Earth re-entry.

Table1: The basic parameters for MetNet type of lander in Mars atmosphere. Table: FMI / LA.

#	Parameter	Value
1	DV mas at the stage of re-entry (m),kg	22.17
2	Re-entry velocity (V), m/s	5250
3	Angle of trajectory inclination at re-entry (Θ), degree	-3
4	Heat flux (q_{max}), MW/m²	0.303
5	Quantity of heat (Q), MJ/m²	12.5

Payload Mass

One of the key elements in Earth entry lander is the amount of available payload mass. The payload mass depends on, e.g., the lander size, landing type (soil or water), heat shield durability and additional landing gear. The payload mass will have an impact to the center of gravity of the lander. The payload with a "low" CoG (compared the the lander structure) has a larger tolerance than the payload with "high" CoG. In cases where payload CoG causes instability, the extra balance mass can be used to adjust CoG. This balance mass will reduce the available payload mass. A major limitation for payload mass is the heat shielding.

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

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