RITD Re-entry: Inflatable Technology Development in Russian Collaboration

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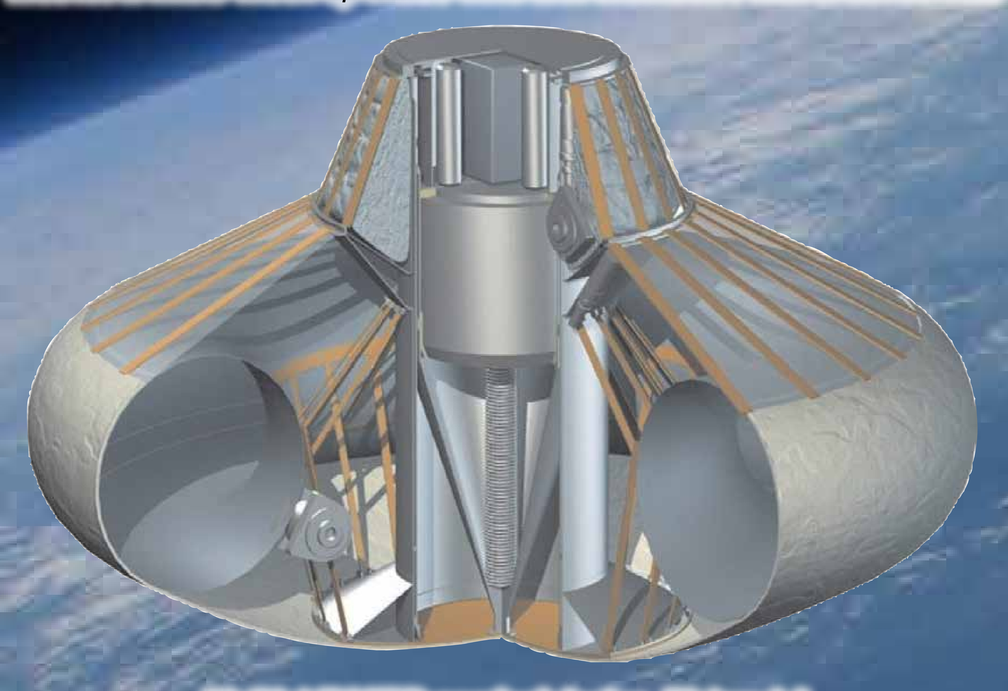
The inflatable entry system concept have been studied previously for higher payload masses. From 2001 to 2009 the inflatable entry descent and landing system (EDLS) for Martian atmosheric entry was developed by FMI and the MetNet team. The RITD project targeted to analyze and test the transonic behavior of a small payload entry system in Earth's atmosphere. The concept and design studied and tested in this project has already been developed for Martian atmospheric entry.Scaling and adaptation of existing design for terrestrial conditions, instead of a completely new design, was considered favorable approach for providing a new re-entry vehicle for terrestrial applications.

MetNet-E MIBD mock-up inside wind test chamber. Picture: Lavochkin.



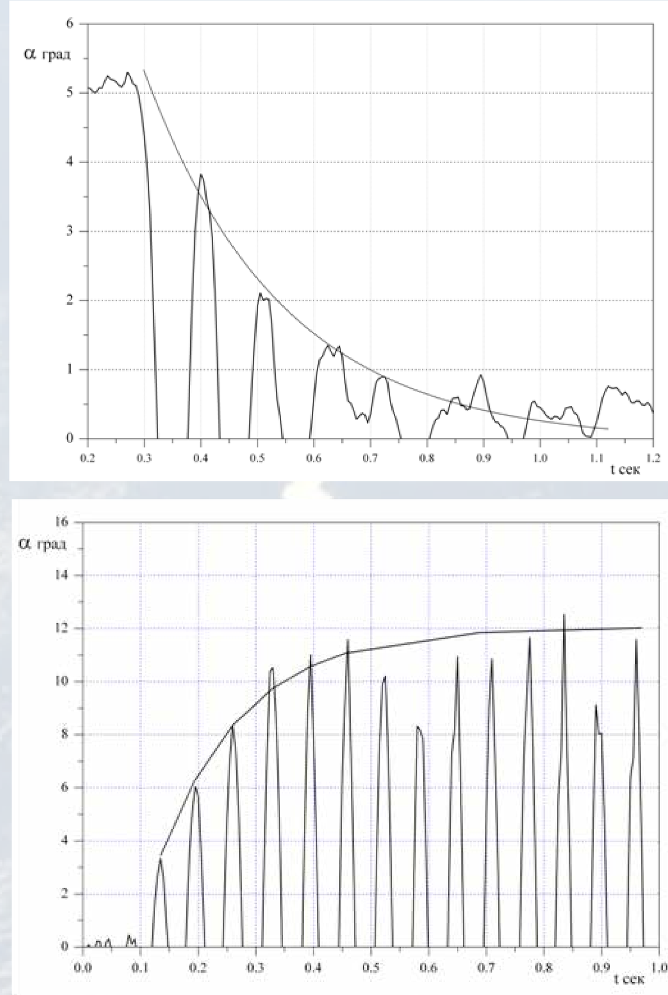
MetNet-E MIBD nominal design. Picture:LA.

EDLS for Earth

The project has contributed towards assessment of the feasibility and applicability of the EDLS system for Earth's atmosphere by focusing on an aerodynamic transition regime. The focus has translated to computational model and limited-scope testing, allowing evaluation of the current EDLS/MNL design for Earth conditions and modifications required.

The RITD project has been built upon earlier and ongoing collaborative development between organizations in EU member countries and Russia. The goal is to offer the EDLS as a Russo-European contribution to relevant future missions and programmes utilizing and exploring the space and its resources.

This project was structured to start from a background and feasibility analysis and then progressing to an analysis of development and modification needs of the existing MetNet design and eventually aerodynamic analysis and wind tunnel testing of a mock-up model.



Dynamic stability of the MetNet-E in wind tunnel tests. Above with factors: $M_\infty = 0.85$ and $A_H = 5$ deg. Below with factors: $M_\infty = 1.25$ and $A_H = 0$ deg. Graphs: Lavochkin.

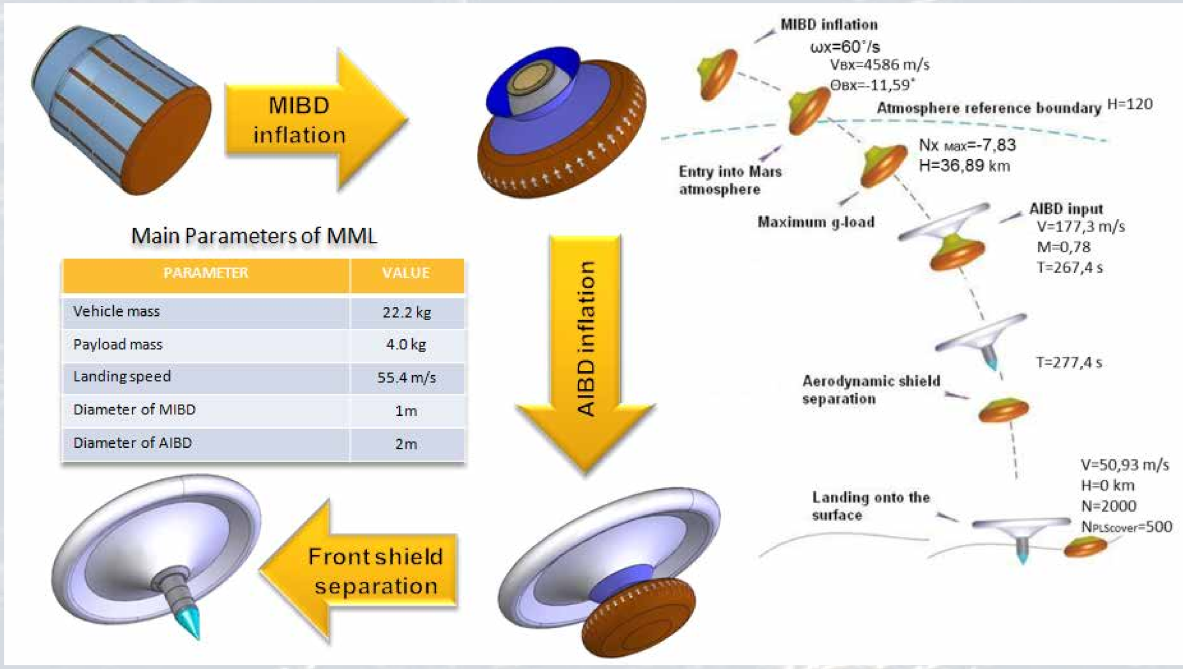
Science and Technology results

The mission constraints of the Mars MNL descent system were studied to evaluate the possibility of using a similar system for returning payloads to the Earth's surface. We developed a way of finding such atmospheric re-entry parameters with which MetNet-E will experience dynamic and thermal loads similar to those expected for the MNL at Mars. It is also apparent that the MNL descent system is conducive to the aerodynamic and thermal environment expected during descent through the Earth's atmosphere. Accordingly, the investigations of this project suggest that MetNet-E as such can be used for Earth re-entry missions.

The aerodynamic analysis shows that non-spinning Descent Vehicle (DV), is statically unstable for Kn>0.3, at altitudes above 87 km, under Martian conditions. In Earth conditions same happens at altitudes above 105 km. Descent from from atmospheric entry (~120km) to above mentioned altitudes takes about 30 s in Mars and 41 s in Earth respectively. In order to maintain the stability of the MetNet DV within this region, spin-stabilization w.r.t. the longitudinal axis is required. The stability can be achieved with an angular velocity of $w_x \geq 60$ deg/s. the DV flying in hypersonic and supersonic velocities, is dynamically stable.

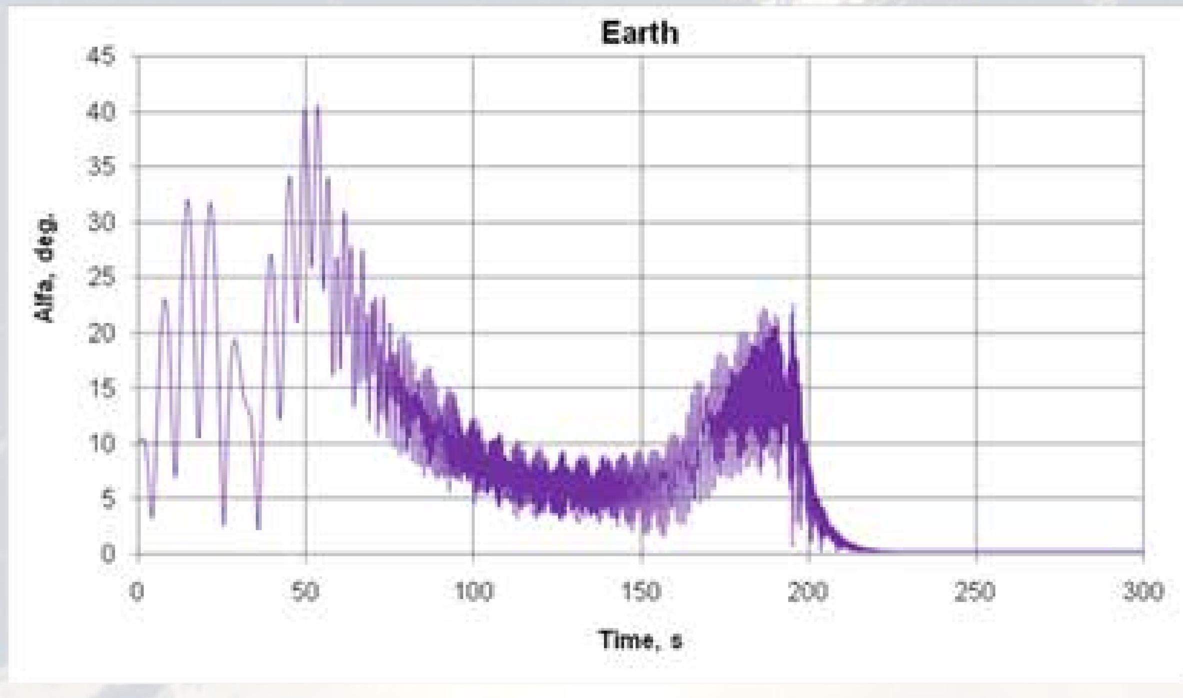
During the transonic phase of the trajectory the spatial angle of attack of the MetNet DV with deployed MIBD can grow due to dynamic instability. At the same time the damping coefficient C_{mq} becomes positive with decreasing Mach number down to 1.5. At subsonic velocities counter-damping occurs both at small attack angles (α<10°), as well as at relatively large ones (α>22°). However, in this case MetNet DV fluctuation process becomes stable (auto fluctuation mode), when the attack angle does not exceed 11.5° (fluctuation amplitude A<23°). In any case, deployment of AIBD stabilizes the DV. Analysis of angle of attack variation during the descent (spin angular ..., similar mass...), shows that angle of attack changes in similar manner for both Mars and Earth atmospheres. Under Earth conditions the maximum values of the angle of attack along the whole flight trajectory, up to deployment of AIBD, are slightly higher than similar characteristics for the trajectory under Martian conditions.

The payload mass will have an impact on the center of gravity of the lander. From the stability point of view, the studies show that the DV with a "low" CoG (compared the the lander structure) payloads are considerably stable than the payload with "high" CoG. Stability estimates have been calculated for payloads with mass between 4 to 8 kg for which the mini-lander version of MetNet-E was found to be stable.

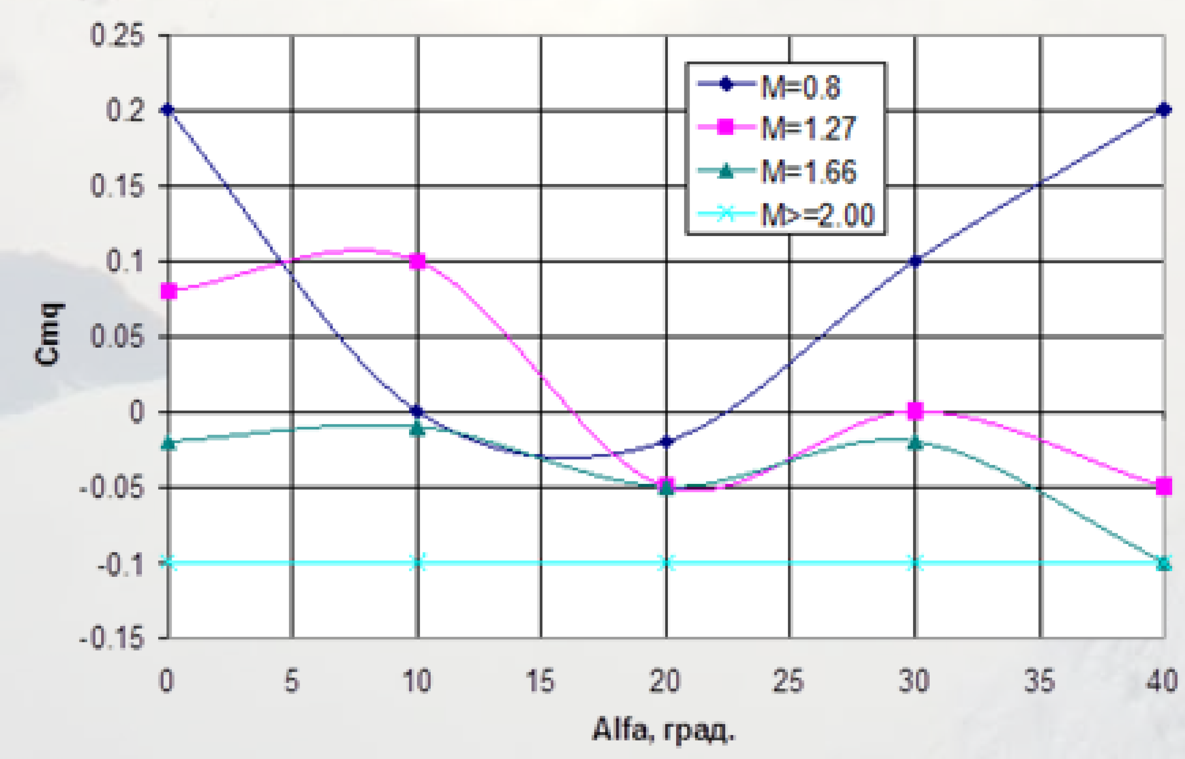


PARAMETER	VALUE
Vehicle mass	22.2 kg
Payload mass	4.0 kg
Landing speed	55.4 m/s
Diameter of MIBD	1m
Diameter of AIBD	2m

MetNet type of lander landing scheme. Picture: Lavochkin.



Variation of spatial angle of attack vs. time (Earth conditions). Picture: Lavochkin.



Aerodynamic coefficient C_{MQ} (MIBD is inflated) for the mode of continous flow (Mars conditions). Picture: Lavochkin.

Acknowledgements

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

Poster design: Harri Haukka, FMI