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Adapting Mars Entry, Descent and Landing System for Earth

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Abstract

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. The EDLS design is ingenious and its applicability to Earth's atmosphere is studied in the on-going project. In particular, the behavior of the system in the critical transonic aerodynamic (from hypersonic to subsonic) regime will be investigated. This project targets to analyze and test the transonic behavior of this compact and light weight payload entry system to Earth's atmosphere [1]. Scaling and adaptation for terrestrial atmospheric conditions, instead of a completely new design, is a favorable approach for providing a new re-entry vehicle for terrestrial space applications.

1. Main Phases of MetNet Descent Vehicle (DV) Descenting

The main task of atmospheric phase of MetNet DV functioning is to slow the hypersonic speed of reentry down to permissible landing speed. Aerodynamic braking of the vehicle at which the most part of kinetic energy is translated into heat energy and dissipated in the atmosphere meets the given task in the best way. Such method of energy suppressing is energy-optimal.

Table 1: Main phases of MetNet DV descent in the Earth's atmosphere

Phase of descent	Time, s	Altitude, km	Velocity, m/s	Trajectory angle, deg	Dynamic pressure, Pa	Mach Number	Remarks
Entry into the atmosphere	0	120	5250	-3	0	14,28	
Maximum g-load	114,5	57,78	3201	-10,34	2048	10,04	N_{xmax}= -11.58
AIBD input	190,2	33,75	245,1	-64,44	308,8	0,8	
AS jettisoning	200,2	32,23	121,22	-76,21	95,8	0,4	
Landing onto the level H=0 km	1788,4	0	8,8	-90	46,43	0,03	Range L = 637.1, km

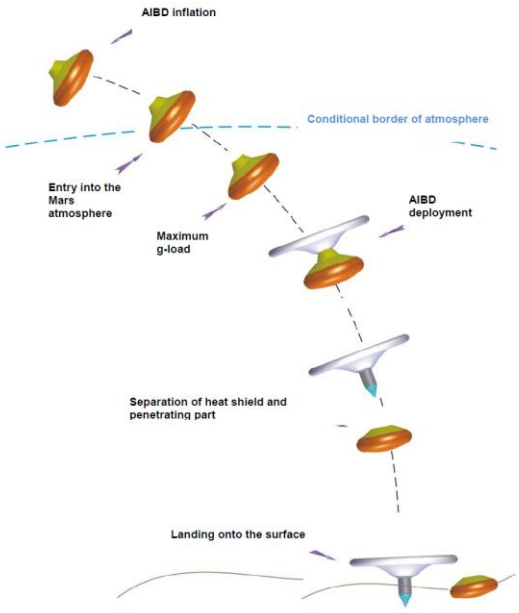

Figure 1: Profile of MetNet DV descent in the Earth's atmosphere.

2. Dynamics of MetNet DV Angular Motion

The main The MetNet landing vehicle will be affected by following main parameters:

- Aerodynamic characteristics of DV;
- Mass-inertial characteristics;
- Orientation and parameters of DV rotation at re-entry.

The analysis has shown that the stabilization by spinning the DV with angular velocity ω_x=60 °/s during Earth atmospheric re-entry, the solid angle of attack of the vehicle does not exceed 41° at the phase of free molecular flow. Taking into account the increase of the moment of DV inertia after Main Inflatable Breaking Device (MIBD) inflation the initial angular velocity at separation from orbiter should be ~150 °/s.

During transonic airflow over DV with deployed MIBD the solid angle of attack is increased quickly due to dynamic instability of the vehicle. Taking into account all the disturbances acting to the vehicle at extra-atmospheric portion of flight the angle of attack is increased up to 40° when DV achieves Mach number ≤0.65 and the DV motion becomes instable.

Therefore Additional Inflatable Breaking Device (AIBD) should be deployed at maximum possible Mach number, which will improve the damping characteristics of the vehicle significantly. In this paper, the results of the analysis and consideration of angular parameters of MetNet DV motion at reentry phase will be shown.

Acknowledgements

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References

[1] http://ritd.fmi.fi