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METEOROLOGISKA INSTITUTET
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ADAPTING MARS ENTRY, DESCENT AND LANDING SYSTEM FOR EARTH

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SEVENTH FRAMEWORK PROGRAMME

RITD Project team

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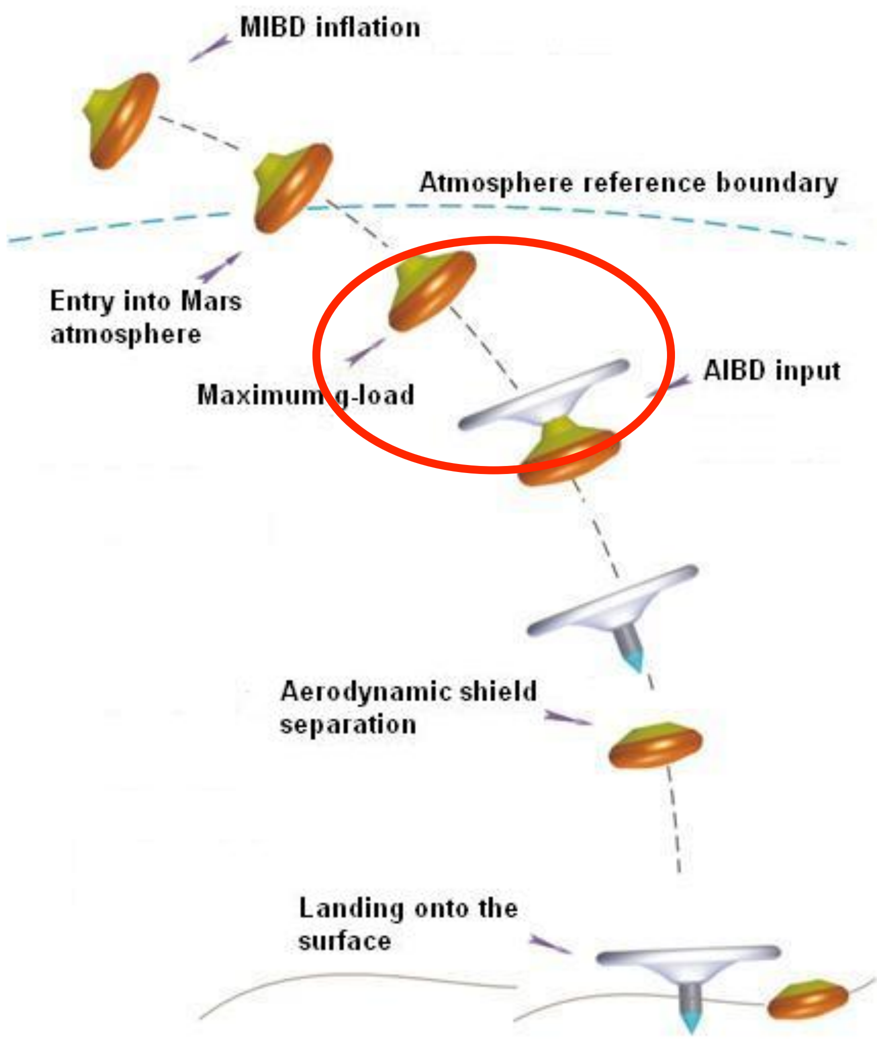
http://ritd.fmi.fi

RITD Project scope

- Mars MetNet Landers (MML)
  - Semihard landing to Mars
  - Two phase Inflatable EDLS

- Can the same EDLS be used for Earth entry?
- Stability during transsonic phase?
- Scaling and modifications required?



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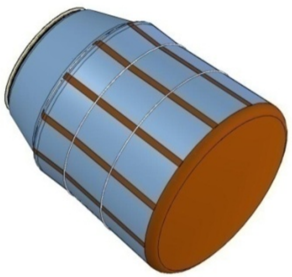
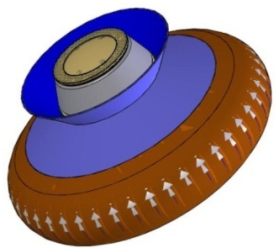
MetNet Descent Vehicle



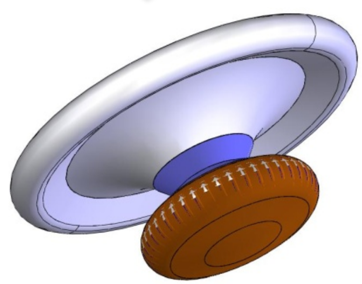
MIBD inflation



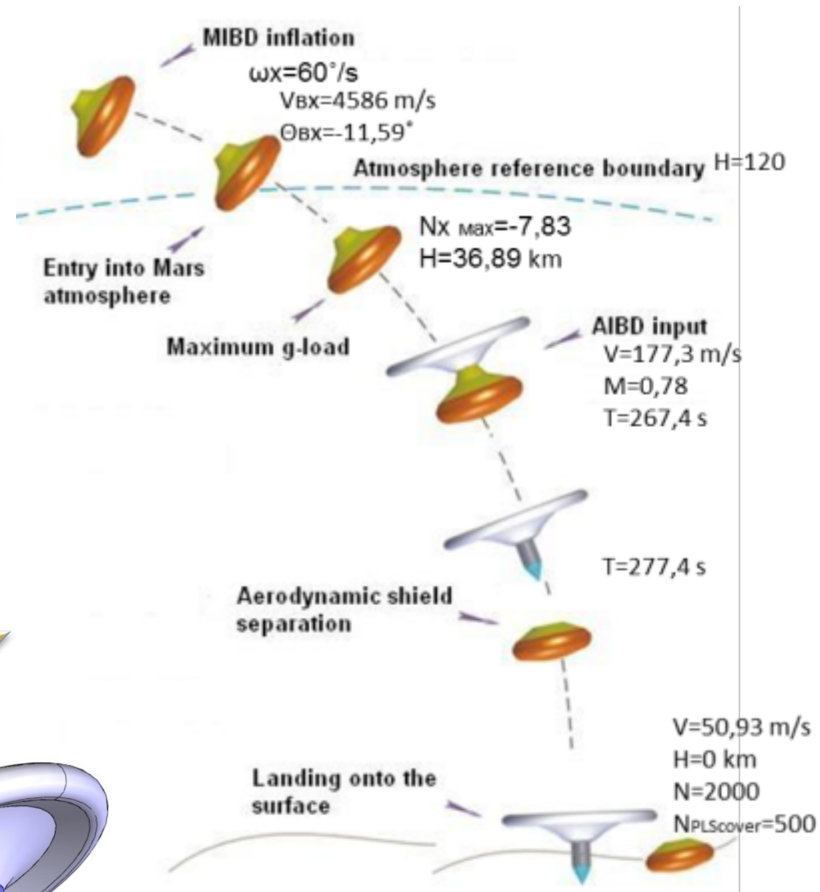
Main Parameters of MML

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

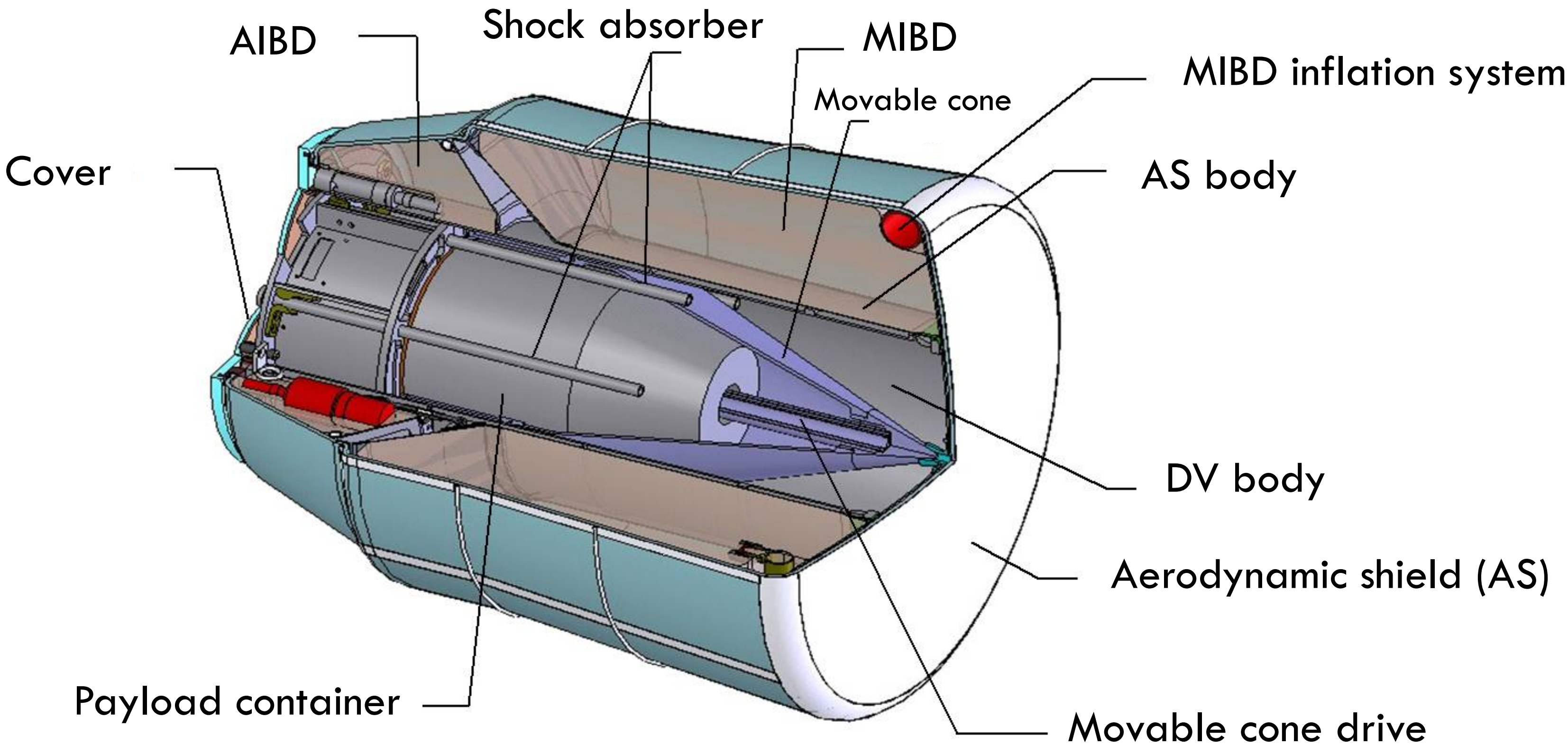
AIBD inflation



Front shield separation



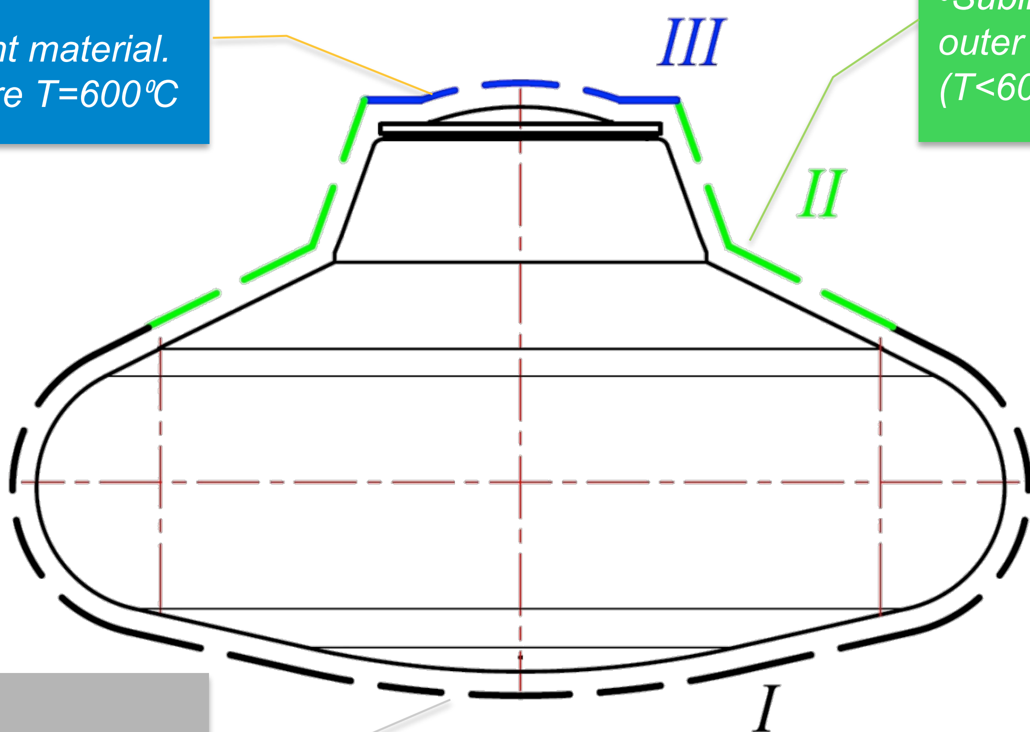
MetNet descent vehicle structure



Structure of MetNet DV TPC

Rigid TPC:
•*Sublimating radiolucent material. Sublimation temperature T=600ºC*

Flexible TPC:
•*Heat-insulating mat – MLI*
•*Sublimating material on outer surface of the mat (T<600ºC)*



Flexible TPC:
•*Thermal protection jacket*
•*two layers of MLI fabric (T<1200 ºC), sublimating material*

Aim: study of feasibility of MetNet DV entry into the Earth atmosphere.

Criteria:

- Minimum deformation of MIBD shape;
- Thermal and mechanical loads to DV structure shall within limits;
- Descent Vehicle dynamic stability during descent.

Factors affecting DV atmospheric motion:

- Atmospheric density and composition;
- Re-entry velocity - Ventry;
- Angle of re-entry - θentry.

Parameters of thermal loading simulation:

- level of specific heat flux to MetNet DV mockup surface;
- value of specific quantity of heat falling to MetNet DV mockup surface;
- value of MetNet DV mockup thermal protection ablation.

Analysis of conditions of DV entry into the Earth atmosphere, meeting thermal loading design parameters

V_{entry}
θ_{entry}

Estimation of the trajectory of DV motion in the Earth atmosphere

Analysis of DV motion dynamics with regard to the center of gravity

Conclusions

Analysis of conditions of DV entry into the Earth atmosphere meeting thermal loading parameters

Results of analysis of 120 variants of trajectories

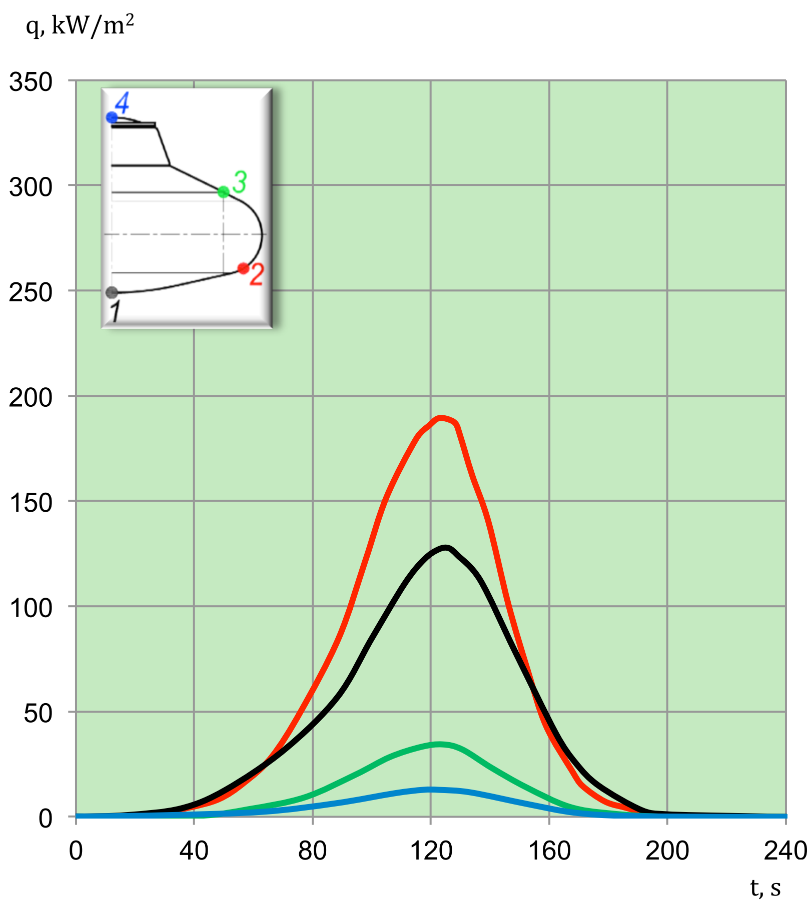
V_{entry}= 5250 m/s
θ_{entry}=-3 deg.

Table of correspondence of thermal parameters at DV descending in the Earth and Mars atmospheres

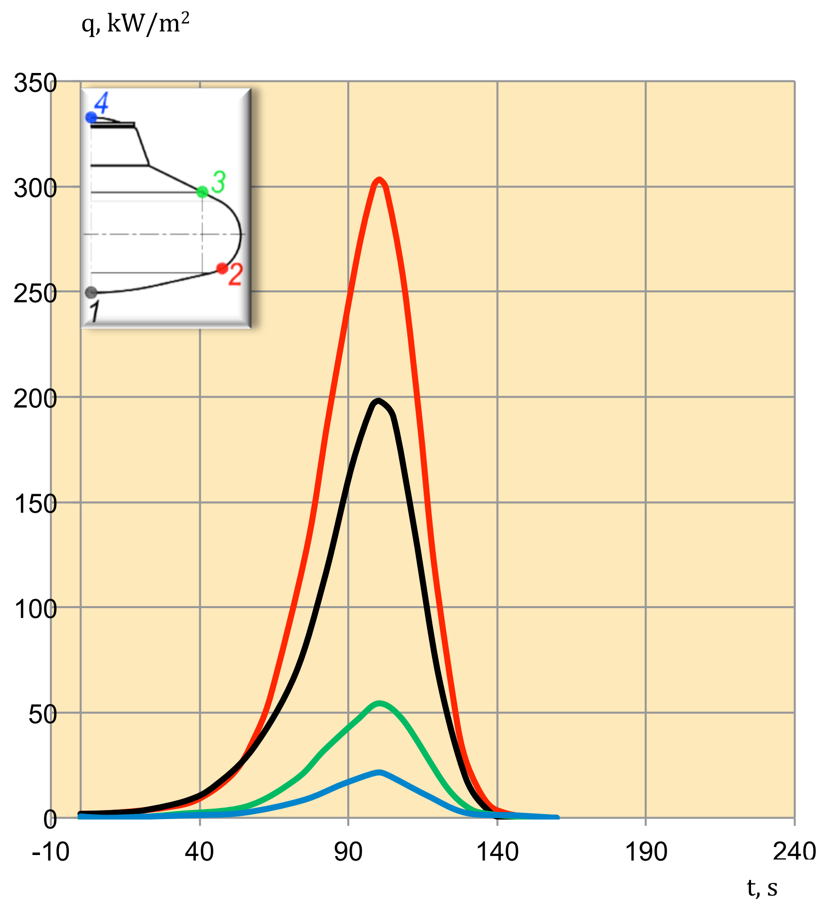
Entry velocity, m/s	Angle of entry, deg	Time of thermal action, s	Heat flux, KW/m^2	Quantity of heat, MJ/m^2	TPC ablation, mm	Sublimation duration, s	Dynamic pressure, kPa
The Earth – 5250	- 3.00	150	303	12.5	1.40	56	2.29
Mars – 4586	- 9.49	200	190	11.7	1.38	72	1.2

Heat flux to MetNet DV TPC

Mars ([illegible]$_{entry}$ = – 9.49[illegible]; V_{entry} = 4586 m/s)

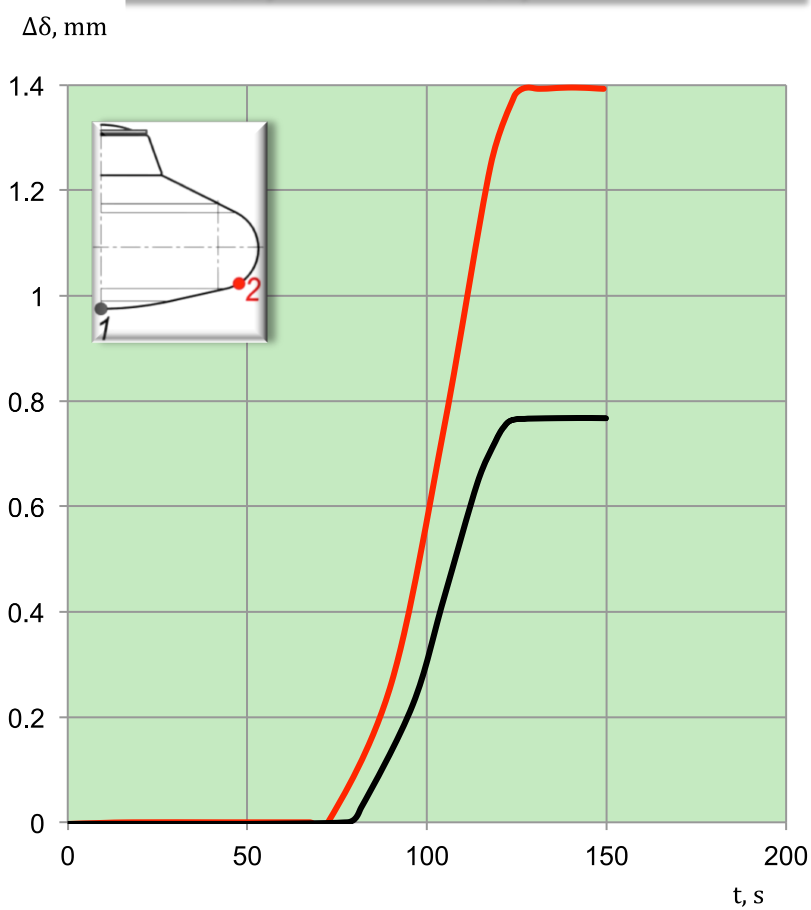


The Earth ([illegible]$_{entry}$ = – 3.00[illegible]; V_{entry} = 5250 m/s)

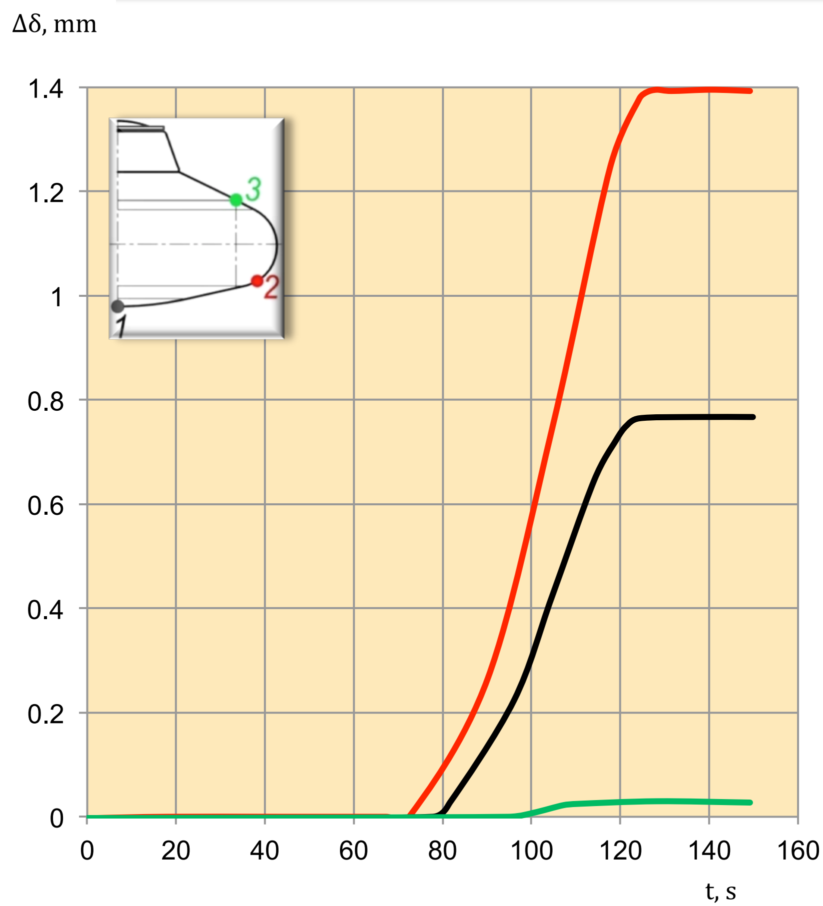


Ablation of sublimating material from TPC surface

Mars (▯$_{entry}$ = – 9.49▯; V $_{entry}$ = 4586 m/s)



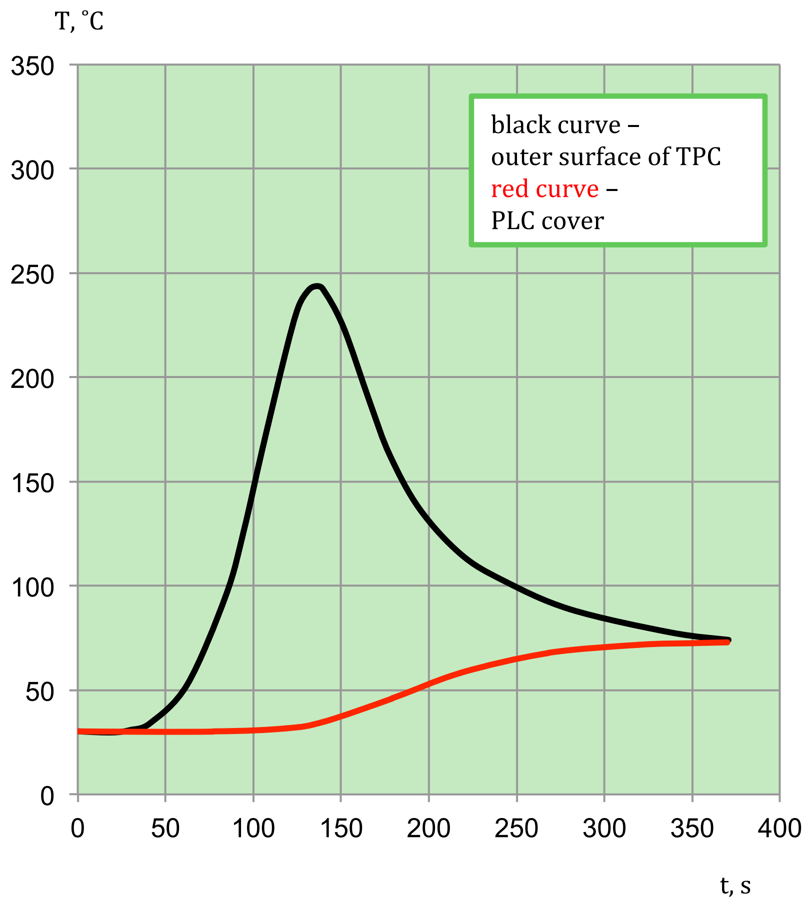
The Earth (▯ $_{entry}$ = – 3.00▯; V $_{entry}$ = 5250 m/s)



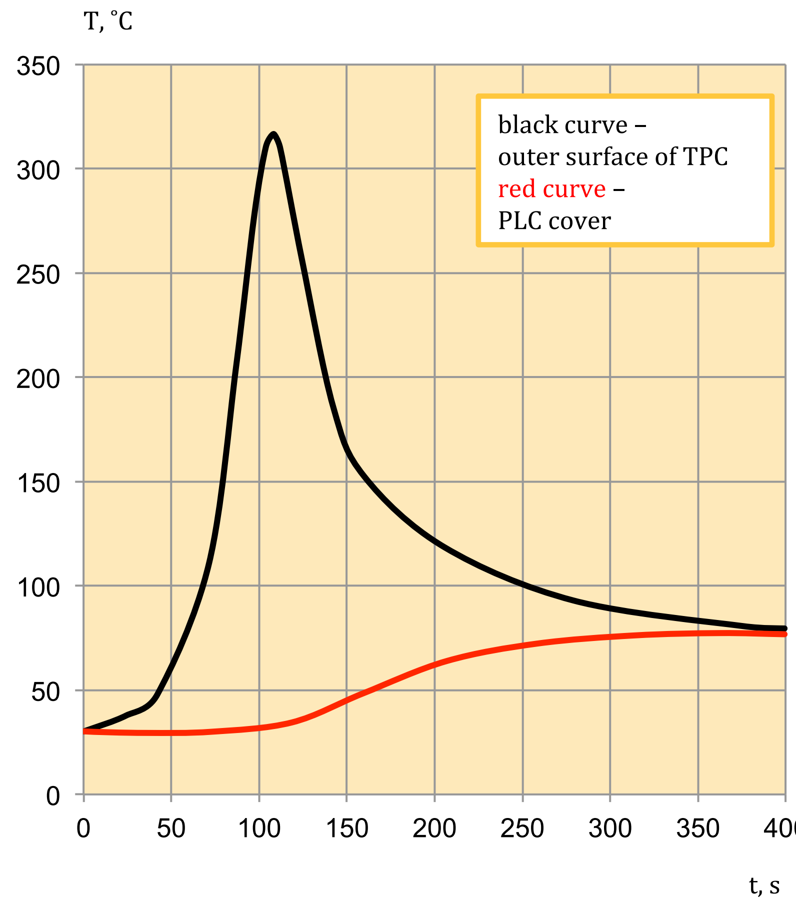
Linear ablation of sublimating material along the trajectory of descent

PLC cover temperature

Mars (☒$_{entry}$ = – 9.49☒; V $_{entry}$ = 4586 m/s)



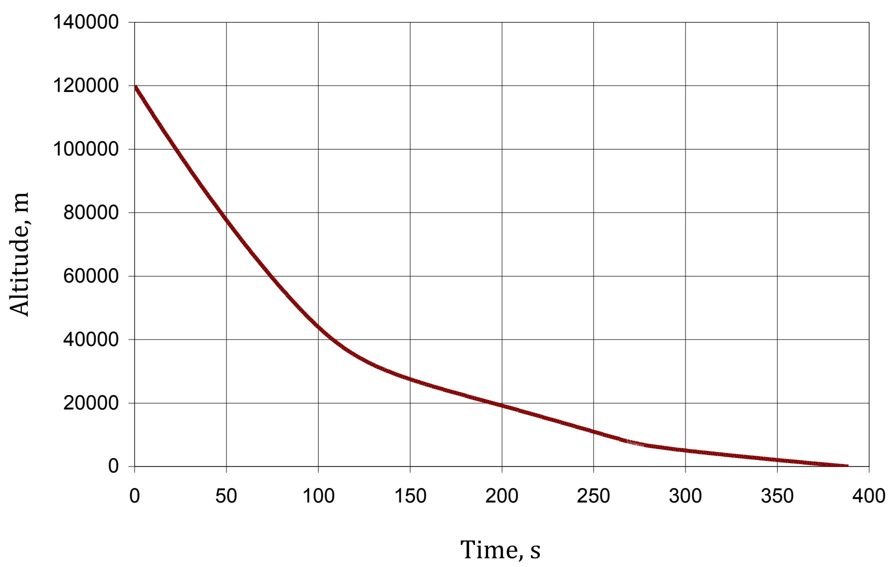
The Earth (☒ $_{entry}$ = – 3.00☒; V $_{entry}$ = 5250 m/s)



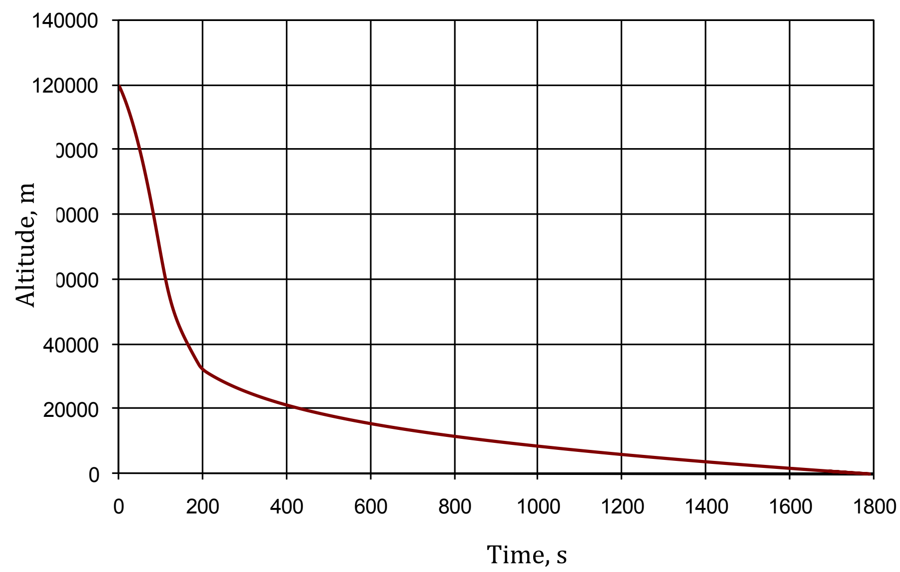
Dynamics of DV PLC cover temperature condition along the trajectory of descent

Variation of DV altitude vs. time of descent

Mars



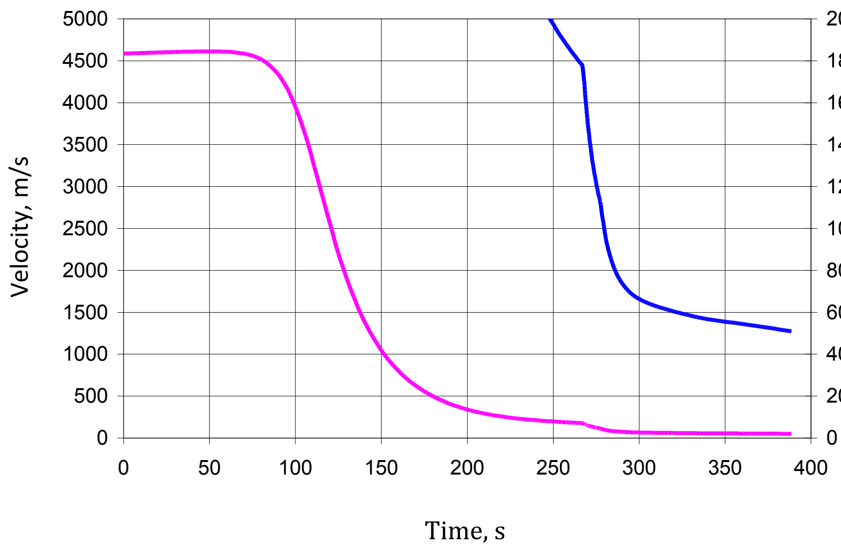
The Earth



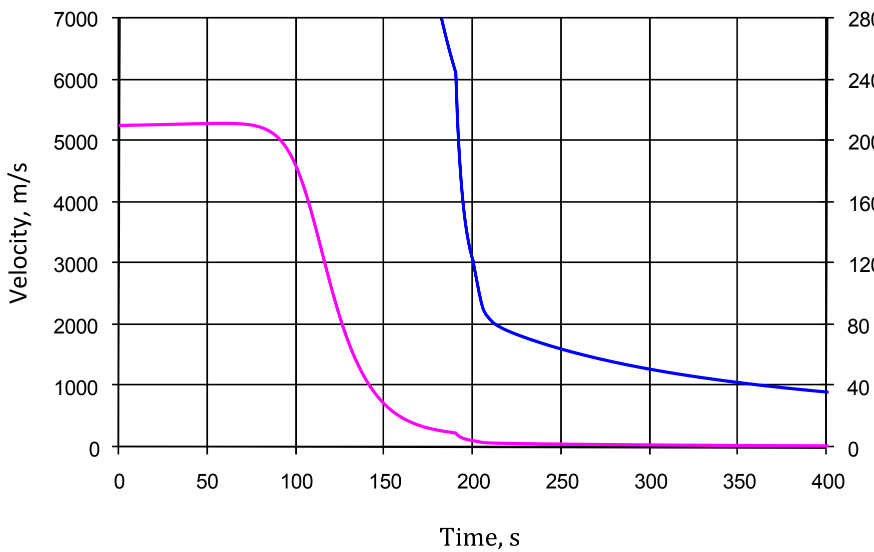
Descent trajectory

DV velocity vs. time of descent

Mars



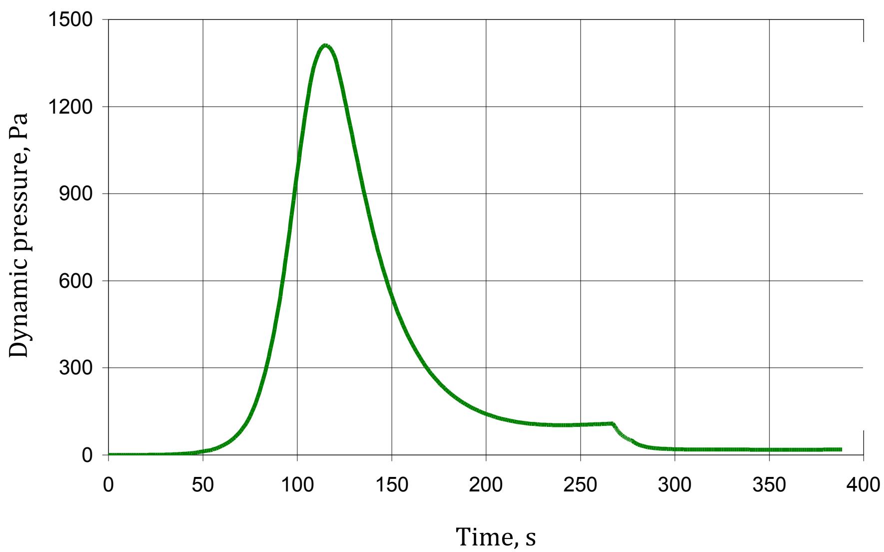
The Earth



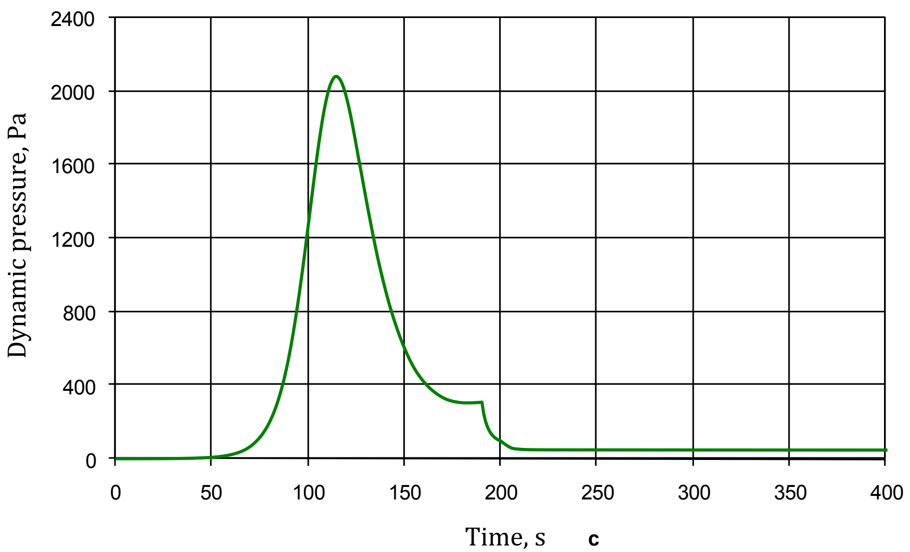
Velocity variation along the trajectory of descent

Dynamic pressure

Mars



The Earth



Dynamic pressure variation during the descent

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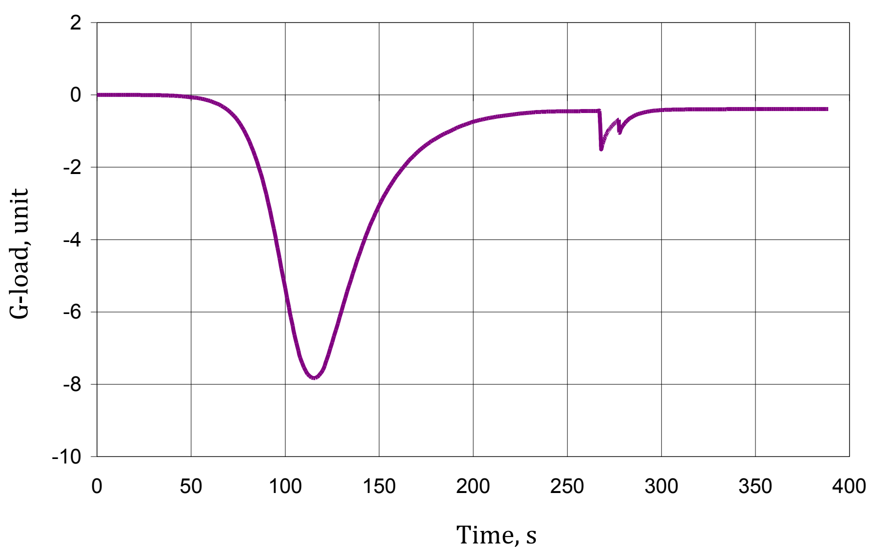
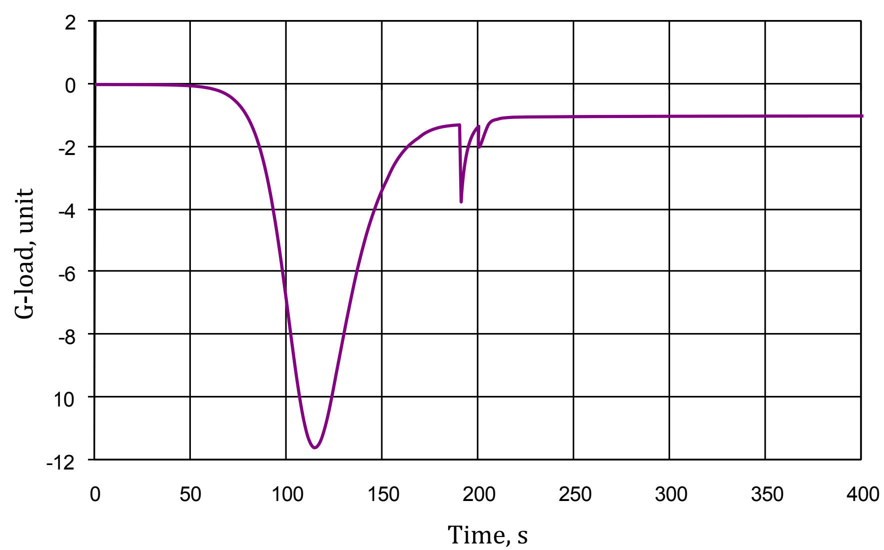
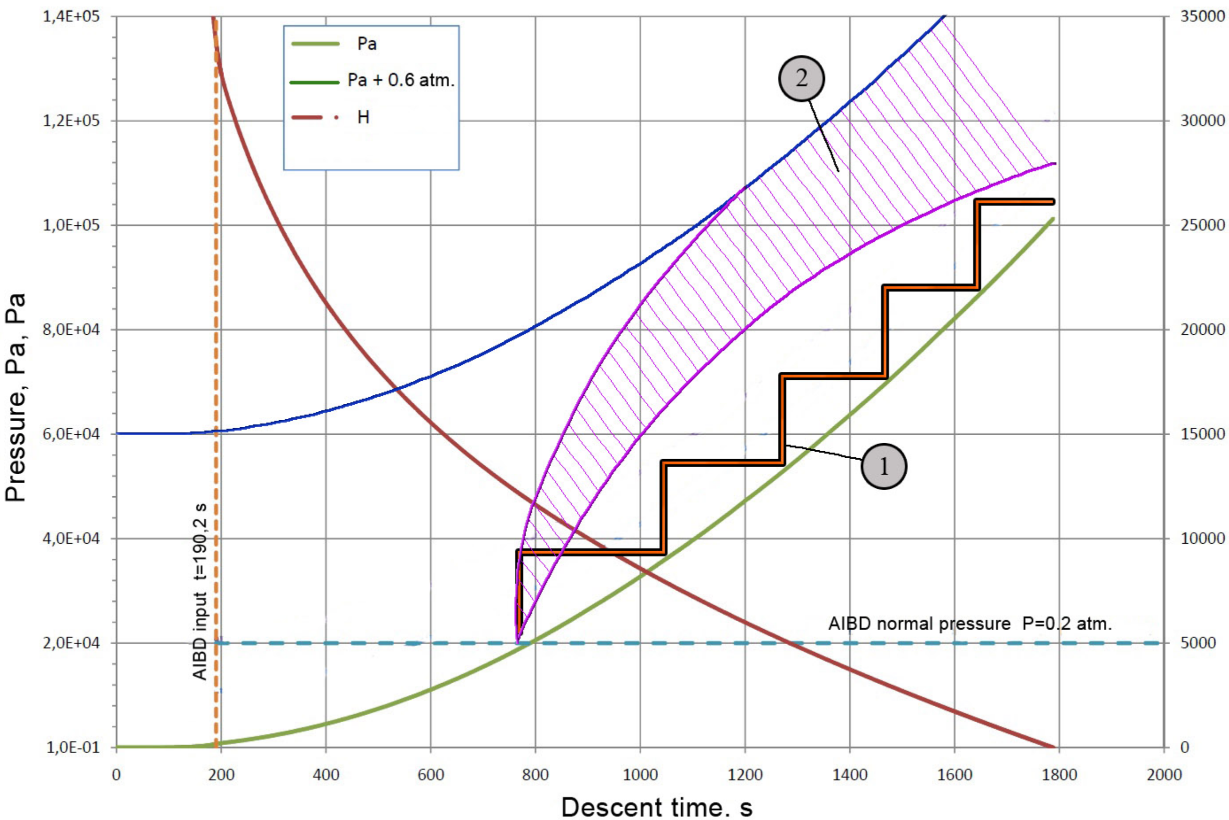
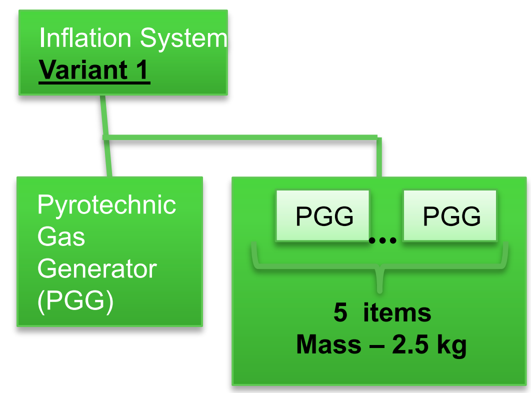
G-load

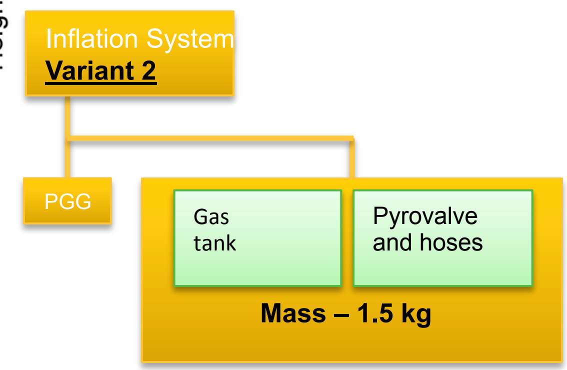
Mars	The Earth
	

Axial g-load variation during the descent

AIBD pressurization scheme

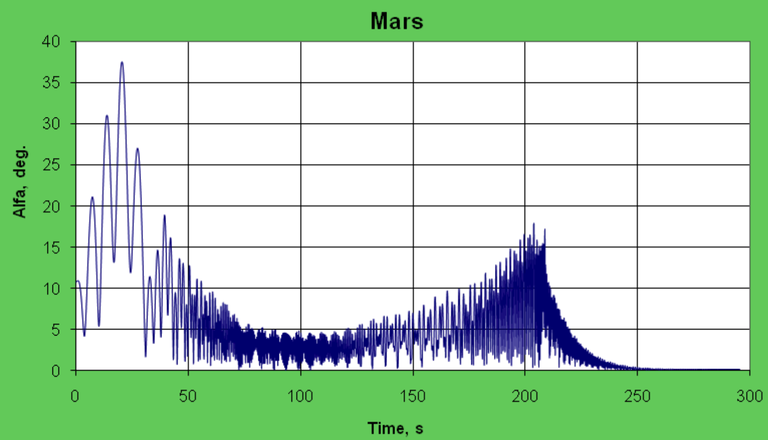


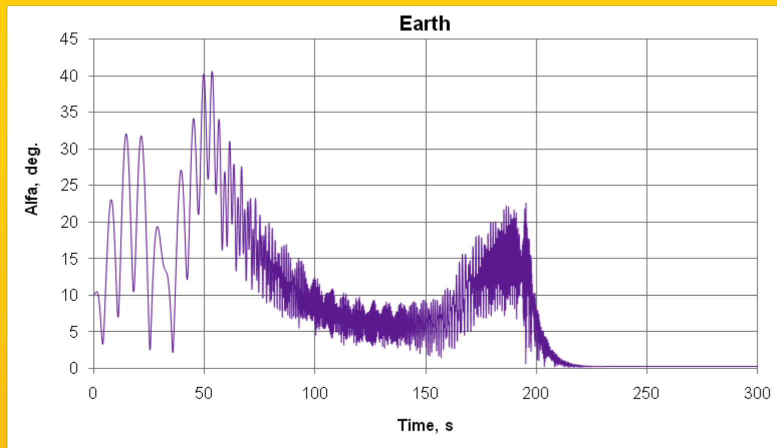




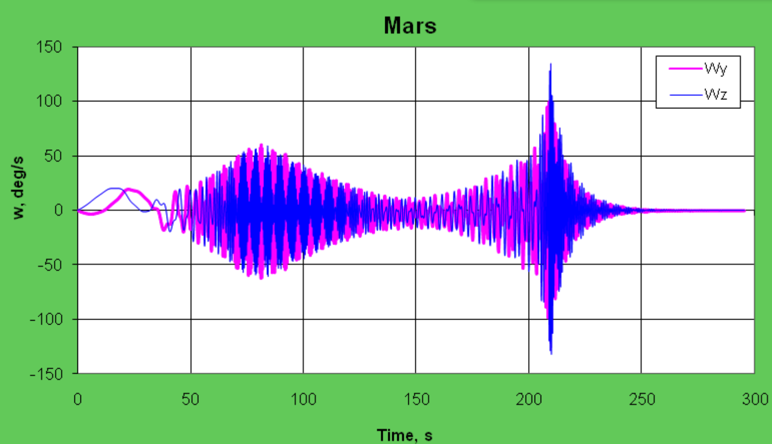
Dynamics of MetNet DV angular motion at its descending in the atmosphere

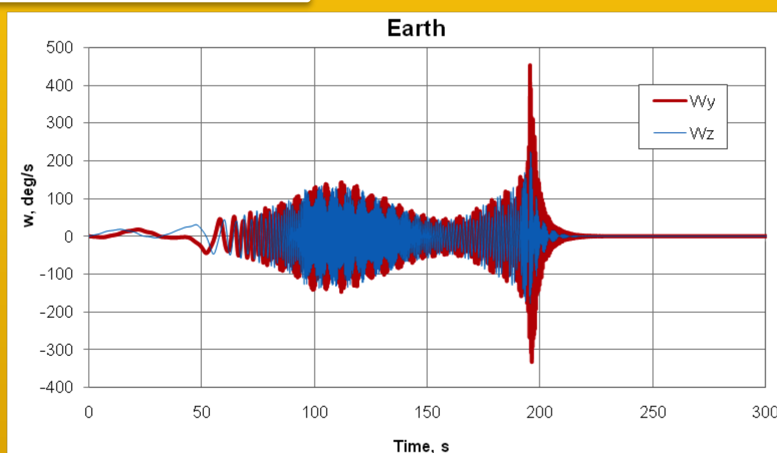
Variation of spatial angle of attack vs. time





Variation of transverse angle rates





Conclusions

- Entry conditions V_{entry} = 5250 m/s, θ_{entry} = -3 deg are feasibile for MetNet DV descend and landing to the Earth atmospere.
- TPC ablation and thermal protection temperature conditions are comparable.
- At stabilization of DV by spinning and oriented entry into the Earth atmosphere the MetNet DV preserves stability along the whole path. Angular motion characteristics are preserved.
- The mechanical loads to MIBD due dynamic pressure interaction practically coincide.
- In Earth conditions, due to more dense atmosphere at altitudes below 12 km, staged pressurization of AIBD is required. The pressurization system will increase DV mass by 1.5-2.5 kg (depending of chosen variant).