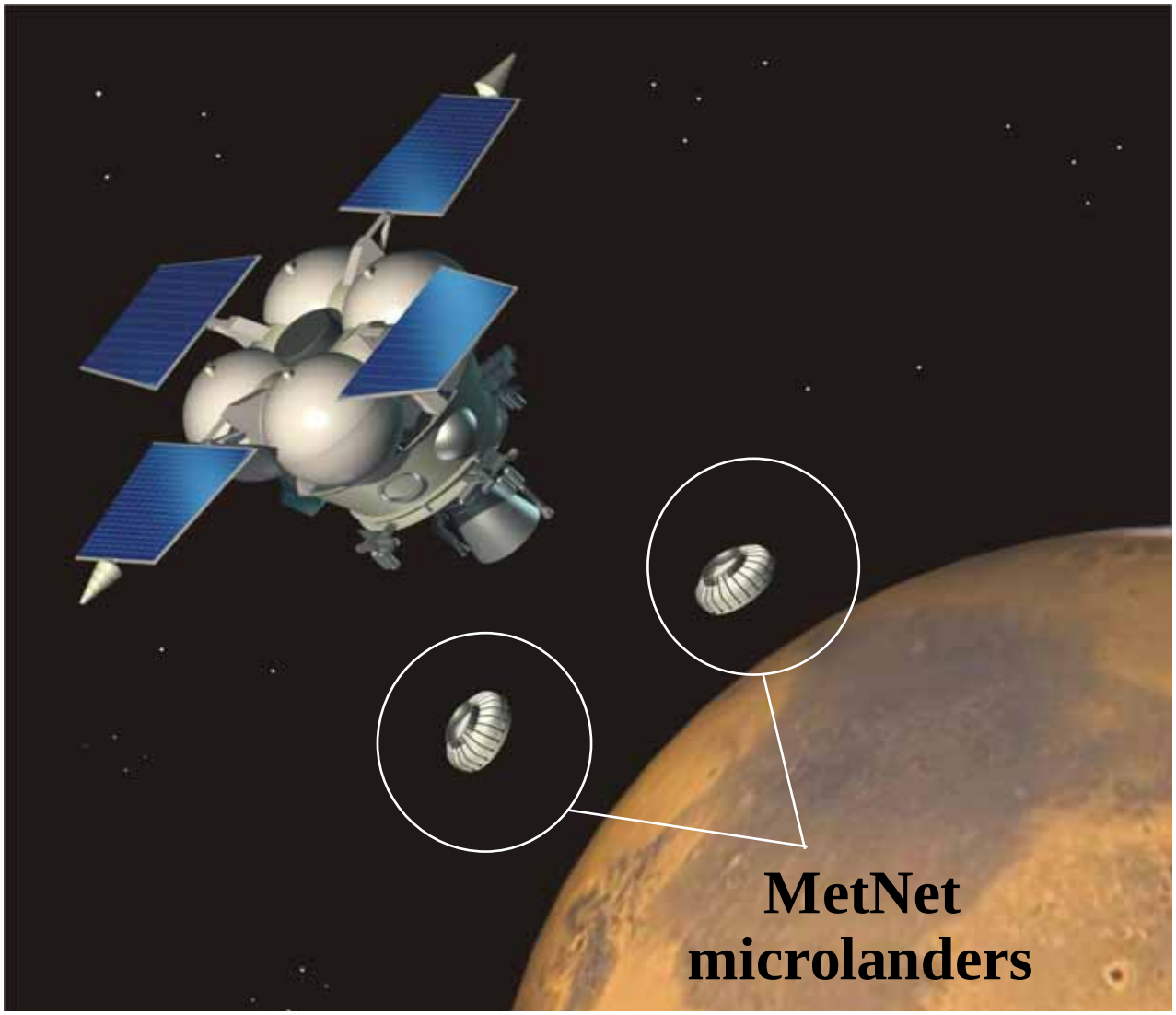
MetNet
Atmospheric science network for Mars

A.-M. Harri (1), R. Pellinen (1), V. Linkin (2), K. Pichkadze (3),
M. Uspensky (1), T. Siili (1), A. Lipatov (2),
H. Savijärvi (4), V. Vorontsov (3), J.Semenov (4)

(1) Finnish Meteorological Institute, Helsinki, Finland
(2) Russian Space Research Institute, Moscow, Russia
(3) Babakin Space center, Moscow, Russia
(4) University of Helsinki, Finland

Mission Concept



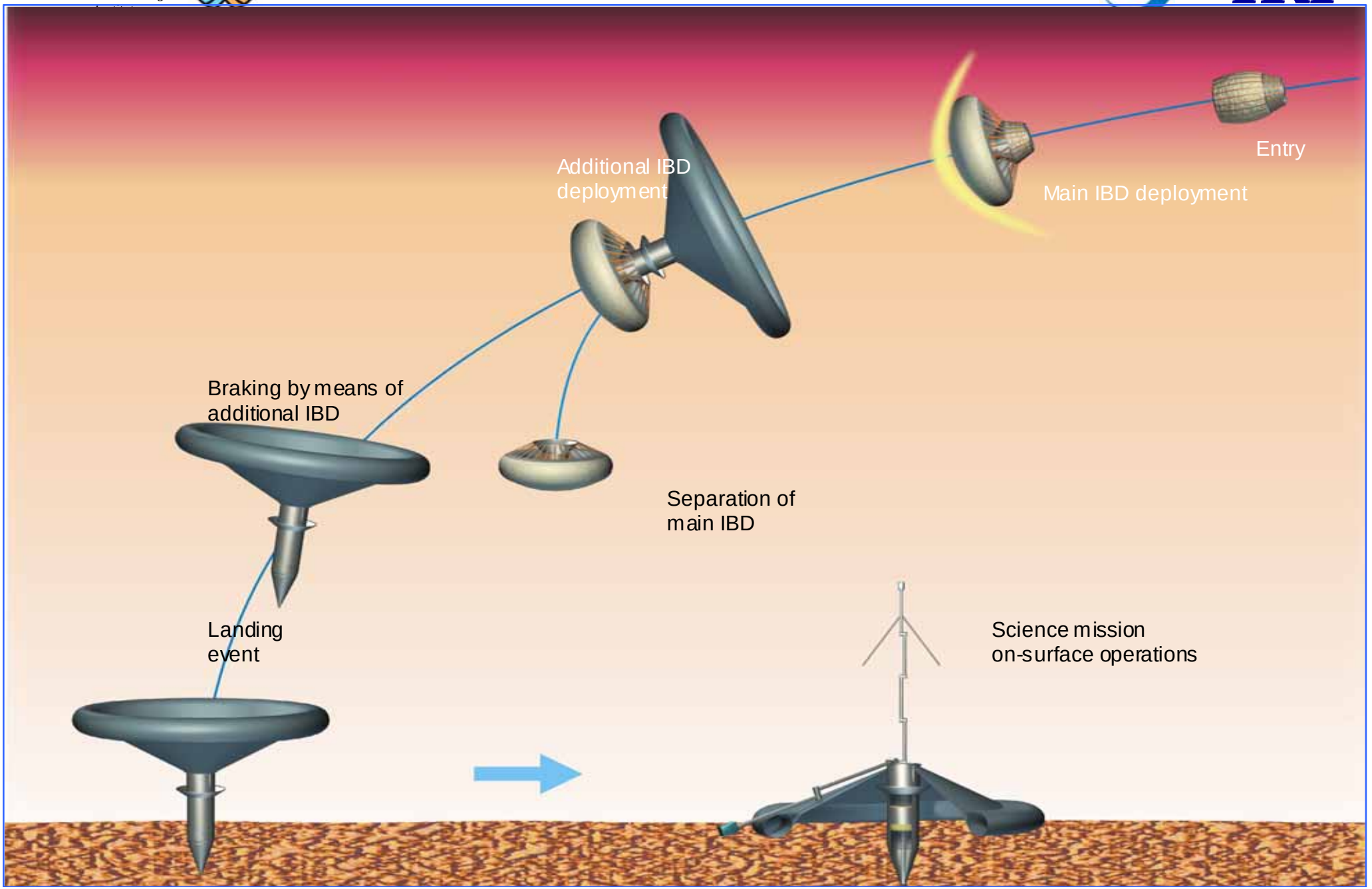
- Goal: wide-spread surface observations network around Mars to investigate atmospheric structure, physics, meteorology.
- Secondary goal: Landing safety
- Protype development performed in 2001 -2004
- Entry, descent and landing system qualified for Mars (2003-2005)
- Re-entry system will be tested for dynamical stability by a suborbital flight (2008)
- Precursor mission and a series of missions likely to start in 2011 and to extend over several subsequent launch windows.

The METNET mission concept

- ”Successor” of the Netlander Mission’s atmospheric leg.
- Mission lead : FMI
  Systems lead : BSC
  Payload lead : FMI / IKI

Other collaborators will be invited to join the mission efforts

METNET Mission for Mars

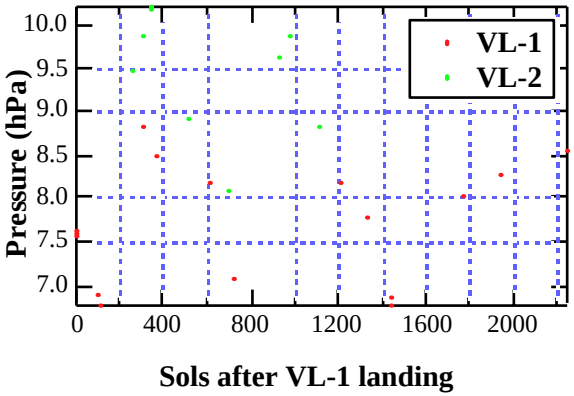


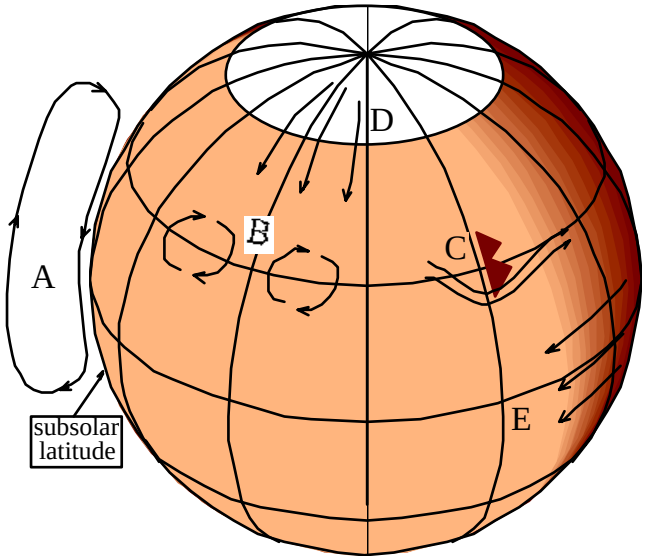
MetNet Scientific Objectives

*** Atmosphere**

- **Surface to Atmosphere interactions & the Planetary Boundary Layer (PBL)**
- **Atmospheric dynamics and circulation**
- **Cycles of CO_2, H_2O and dust.**
- **Dust raising mechanisms**

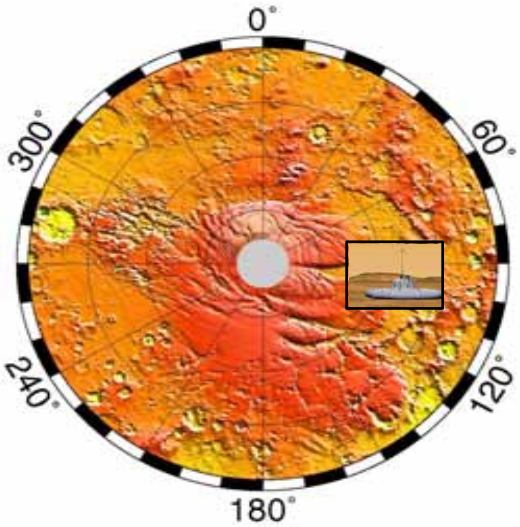
*** The evolution of Martian climate**

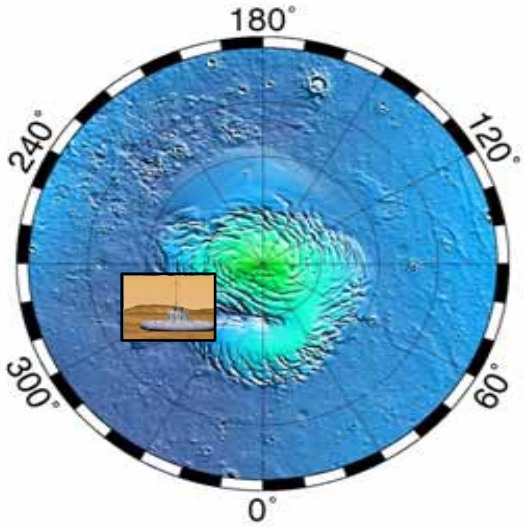


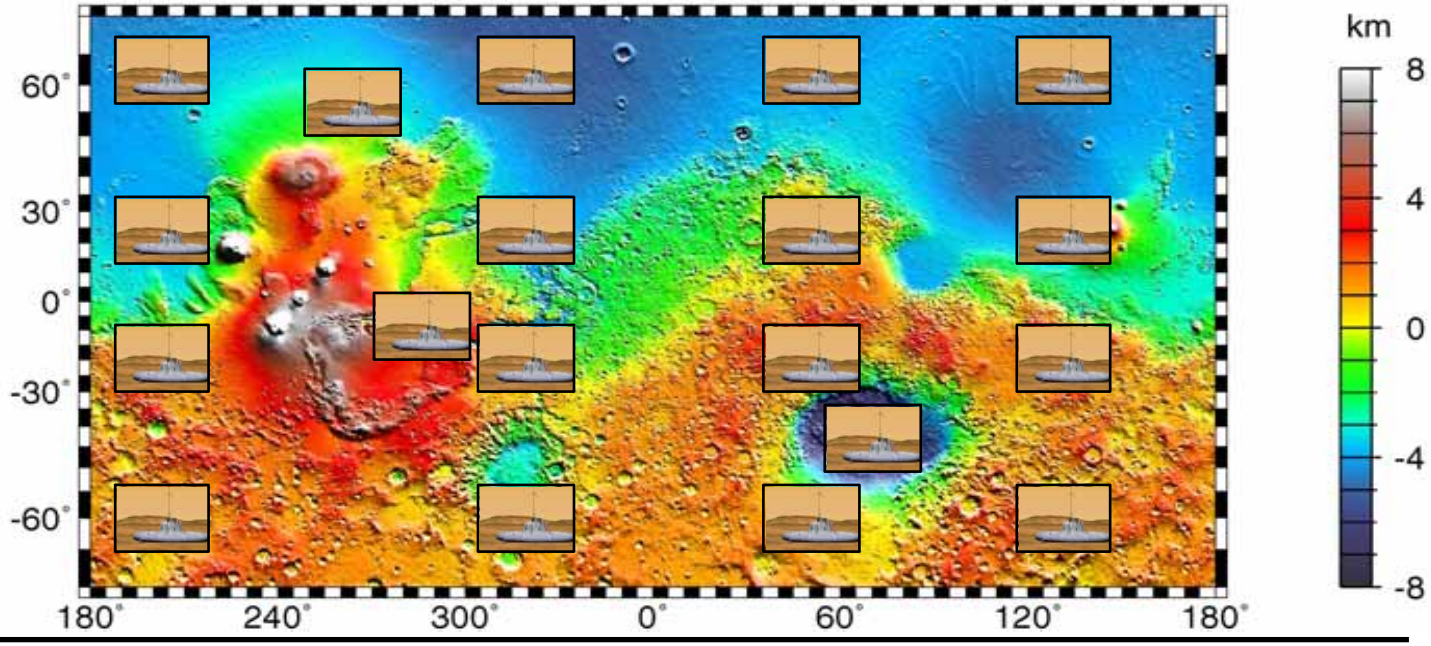


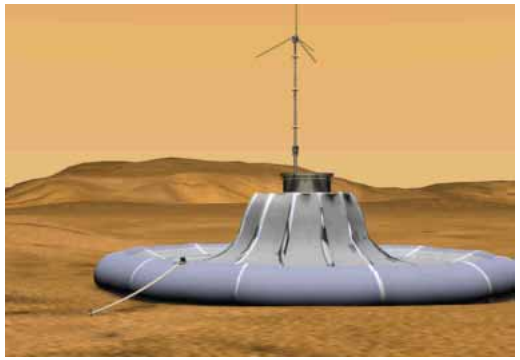
Schematic of the major general circulation patterns occurring in the Martian atmosphere (adapted from Fig. 5 of Pollack, 1990a). A: (solstitial) Hadley circulation, B: baroclinic eddies, C: stationary eddies resulting from flow over topography, D: CO_2 sublimation flow, E: thermal tides (the Kelvin or normal modes not incl)

Landing site candidates





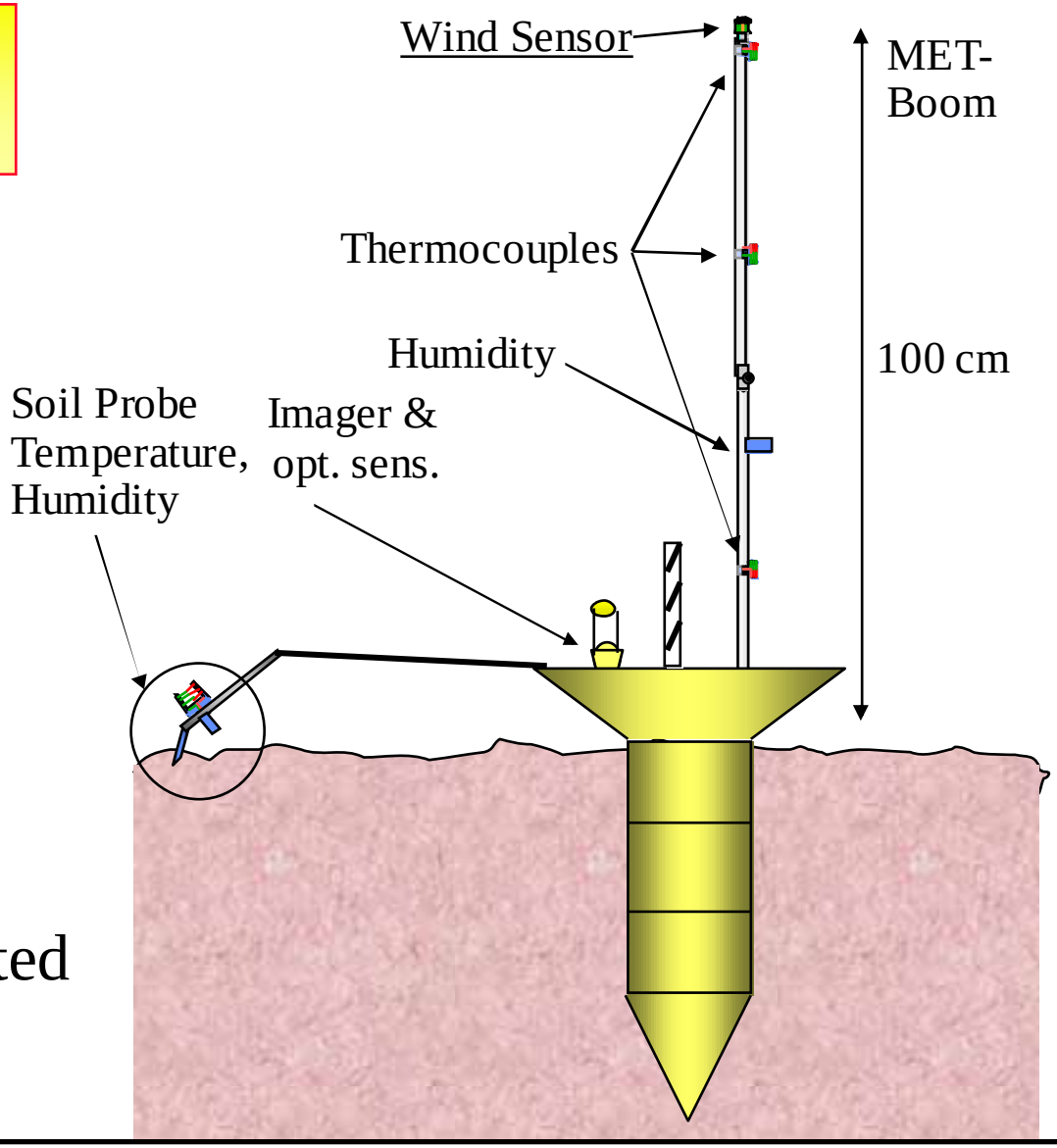




Strawman payload

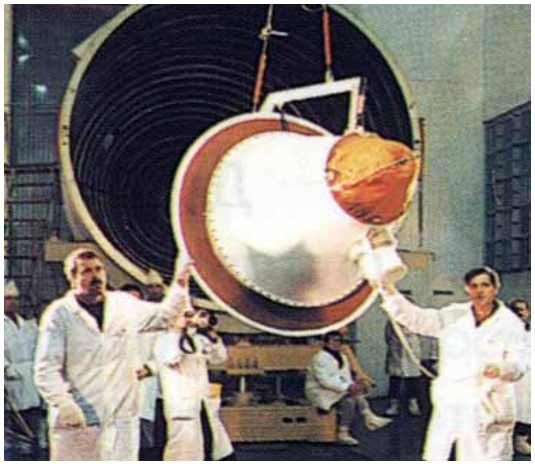
- Descent phase instr. Package
  P, T, Acc
- Surface phase instruments:
  - Pancam
  - Wind vel.
  - Pressure
  - Atm. temperature
  - Soil temperature
  - Humidity
  - Optical depth

Option for competitively selected payload exists

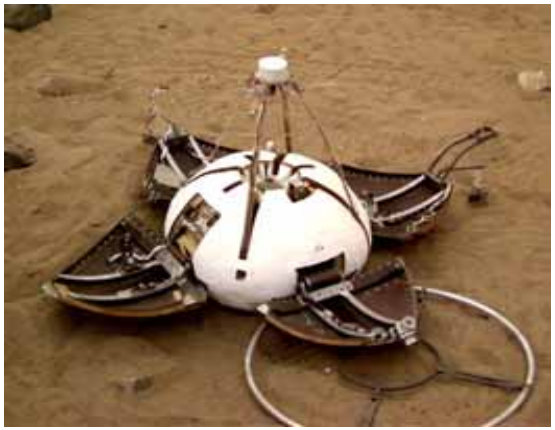


BACKGROUND TECHNOLOGIES: MARS-96 SPACECRAFT

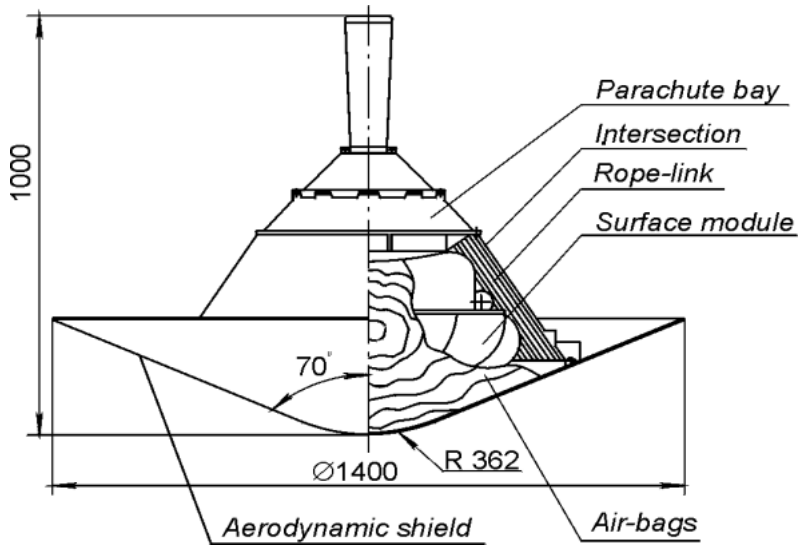
SMALL STATION



Small station in launch configuration



Surface module of the small station



Mass before entry……86 kg
Surface module mass……31 kg
Payload mass……11.5 kg
Soft landing system……air bags
Landing velocity……20 m/s
Operation lifetime……1 year

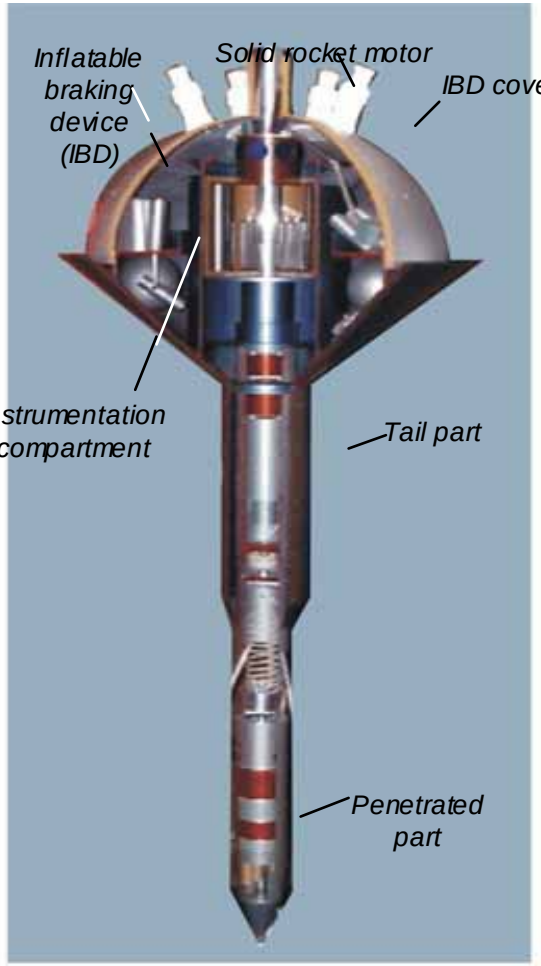
BACKGROUND TECHNOLOGIES: MARS-96 SPACECRAFT PENETRATOR

S/C MARS-96

MARS-96 spacecraft

PENETRATOR AT PLANT

Penetrator general view

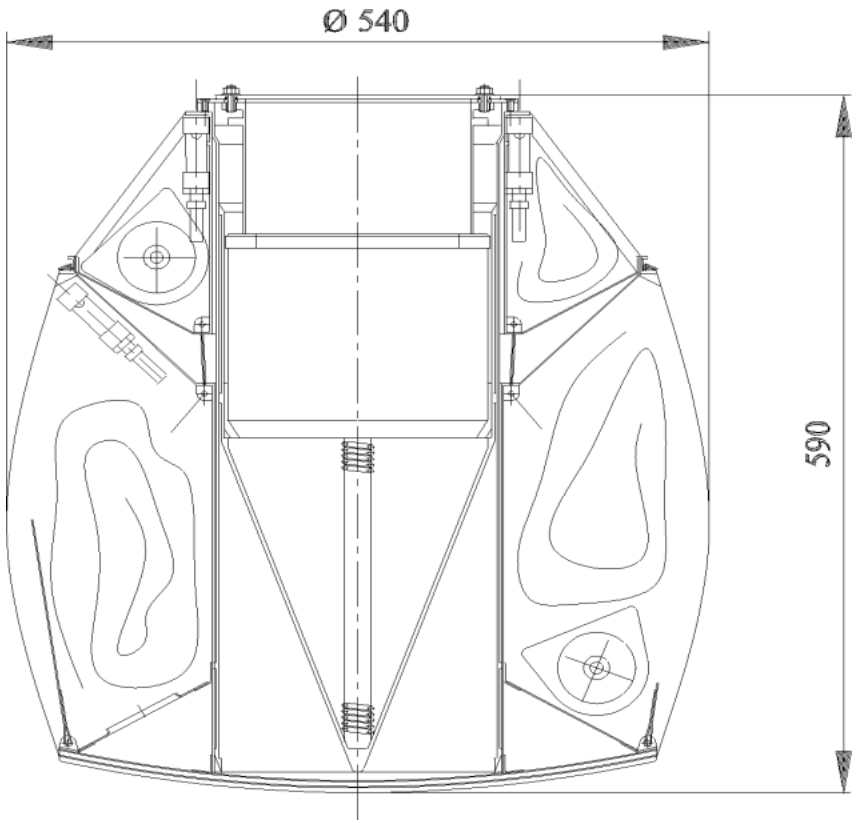


PENETRATOR'S INTERNAL CONFIGURATION

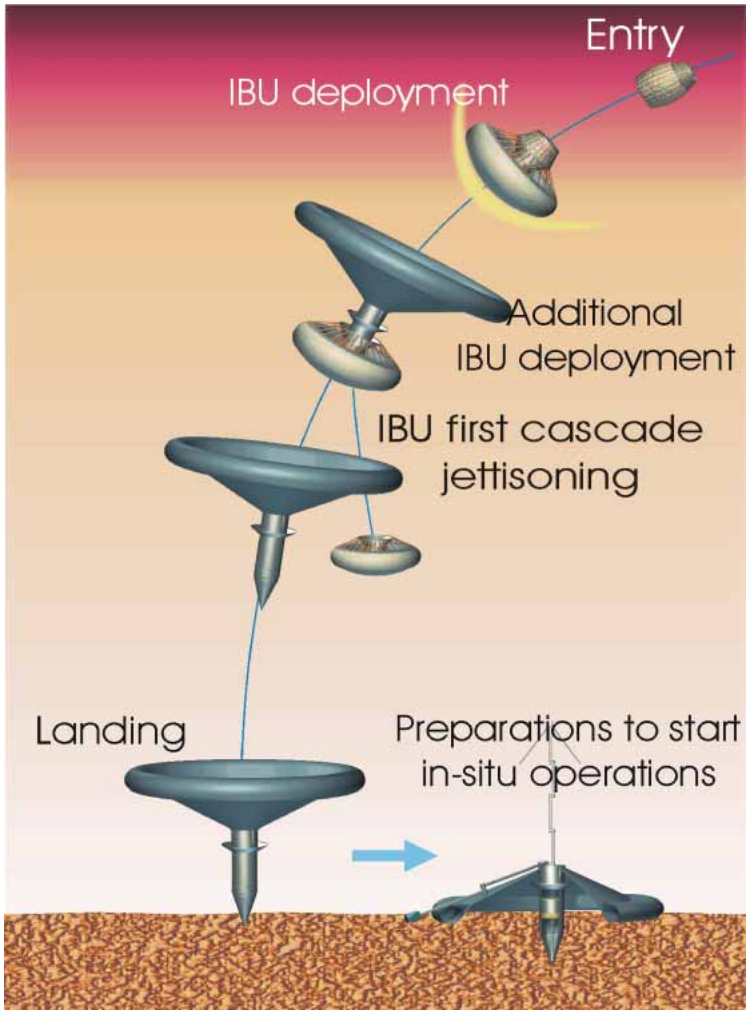
Balloon drop test of the penetrator
(penetrator with inflatable braking device)

Mass before entry	110 kg
Inflatable braking device (IBD) mass	29 kg
Main IBD diameter	2.3 m
Additional IBD diameter	3.8 m
Scientific package mass	5 kg
Impact velocity	80 m/s
Maximal g-load	< 500
Depth of penetration	0.5-3 m
Operation lifetime	1 year

Stowed configuration **CHOSEN CONCEPT (5 candidates)**

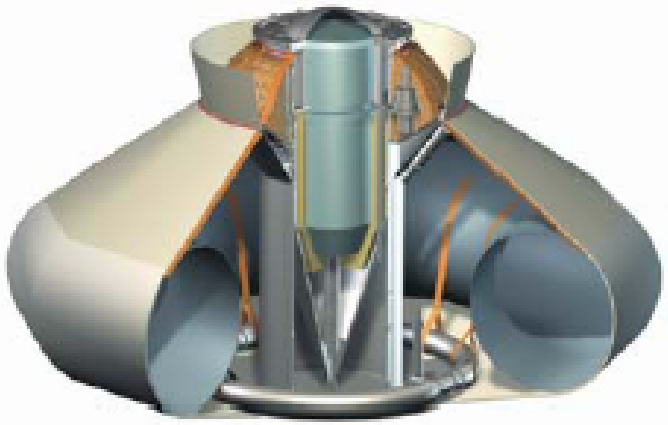


- Inflatable heat shield
- Inflatable aerobrake



ENTRY

LANDING



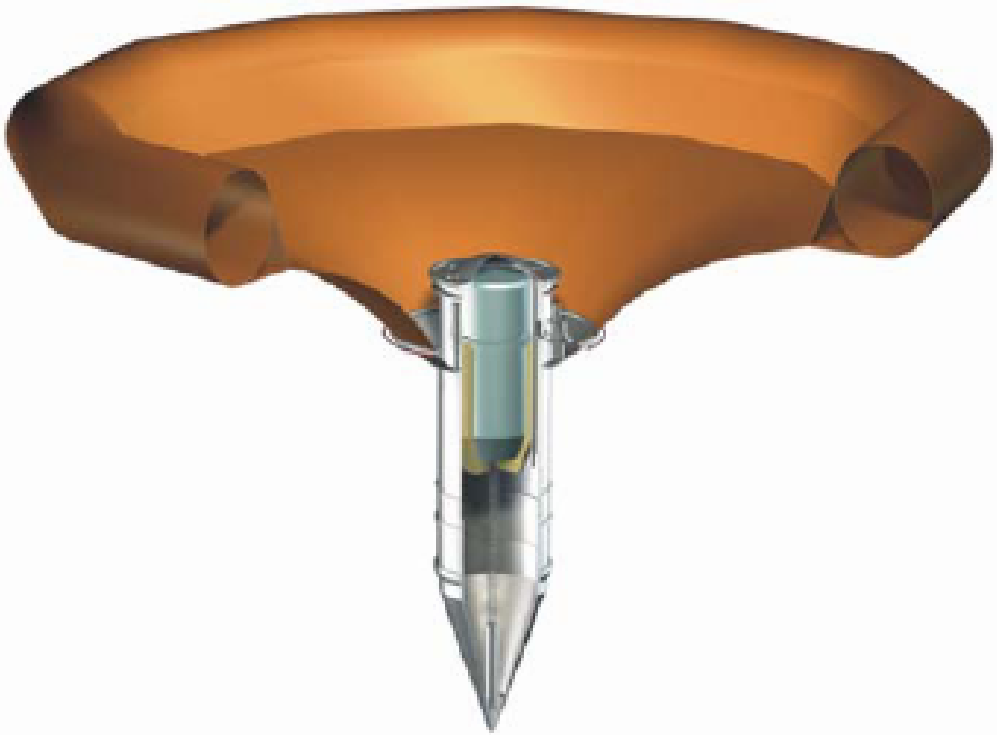
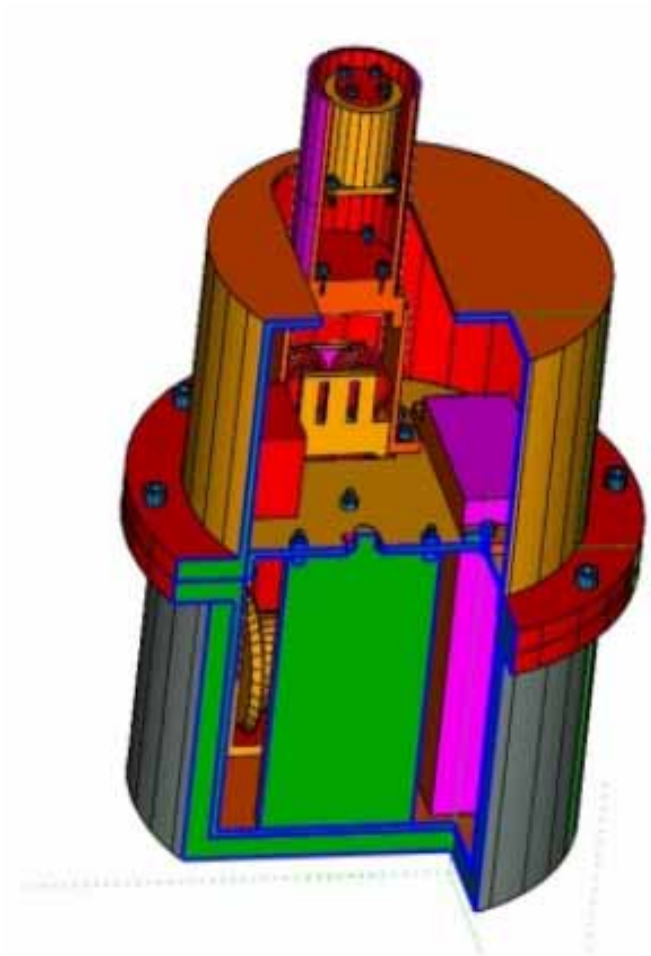


Figure 2-1 Descent configurations

MetNet Team & Test Prototype

FMI Team inspecting MetNet prototype H/W in the BSC in Moscow

P/L Bay



Mass Budget

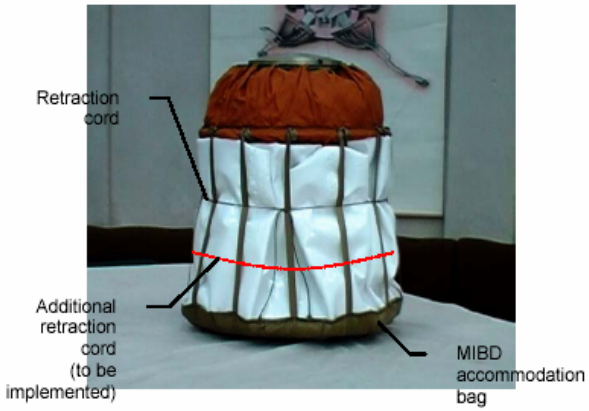


Figure 3-5 MML prototype (folded)

Figure 3-6 MIBD is being inflated

System:	kg	kg
Entry, Descent and		**7,9**
Landing System		
Lander body	4,9	
Equipment module	4	
Landing module		**8,9**
Total Entry Mass		**16,8**

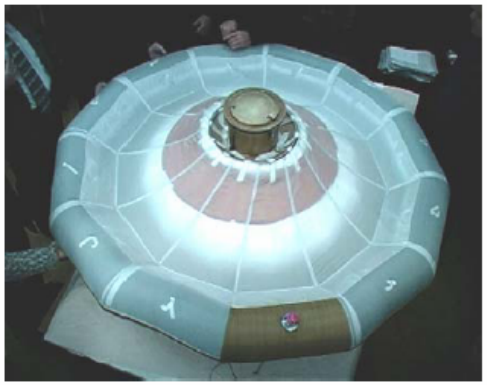


Figure 3-7 MIBD and AIBD fully inflated

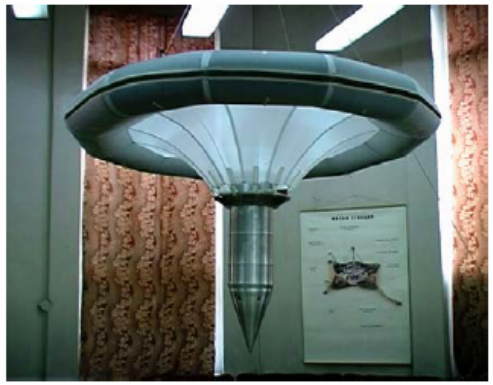
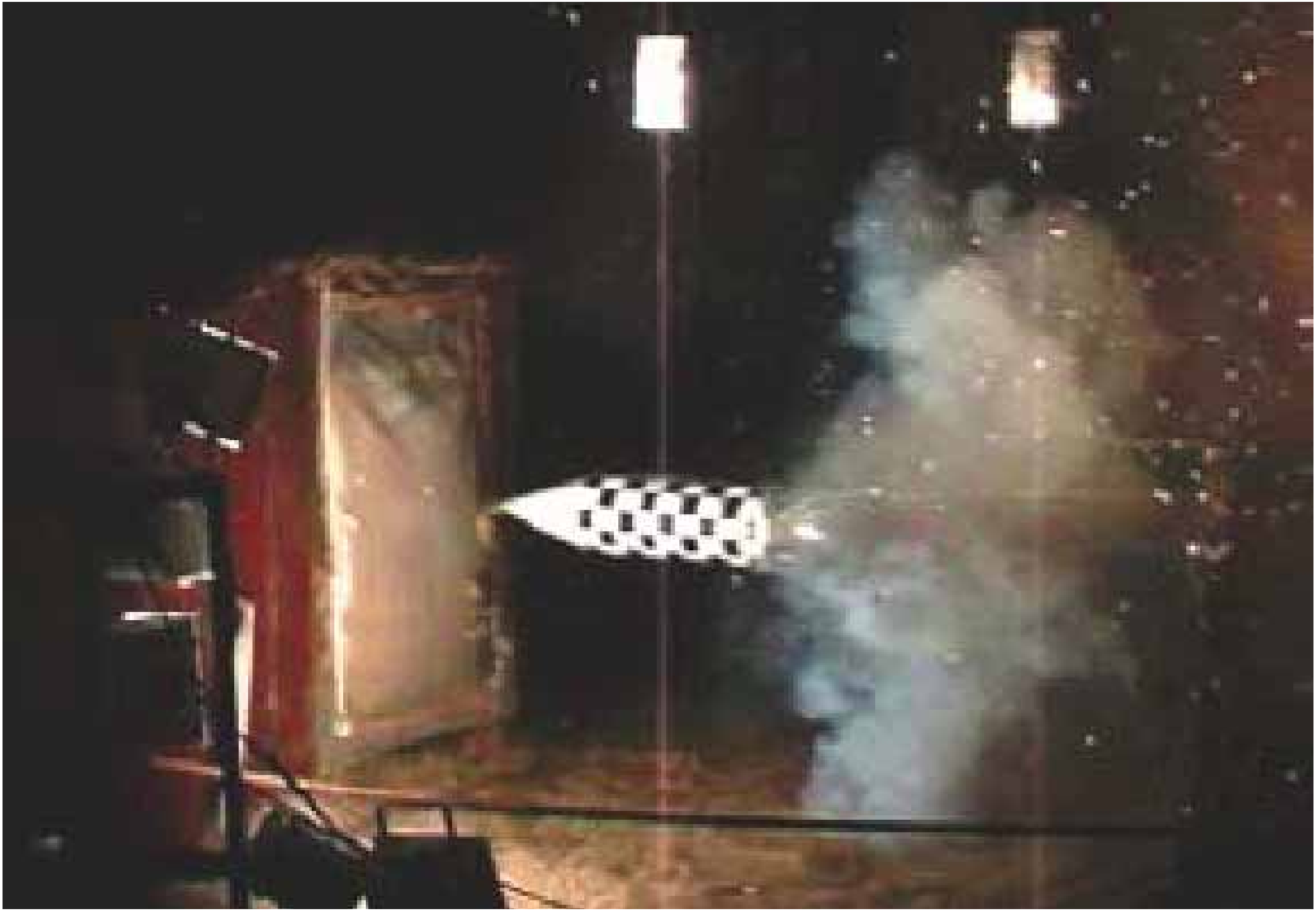
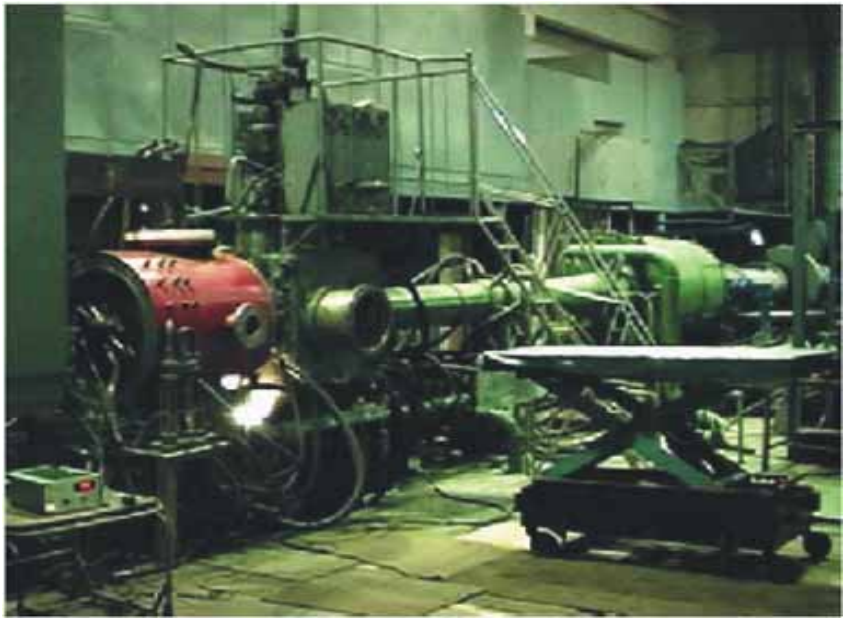
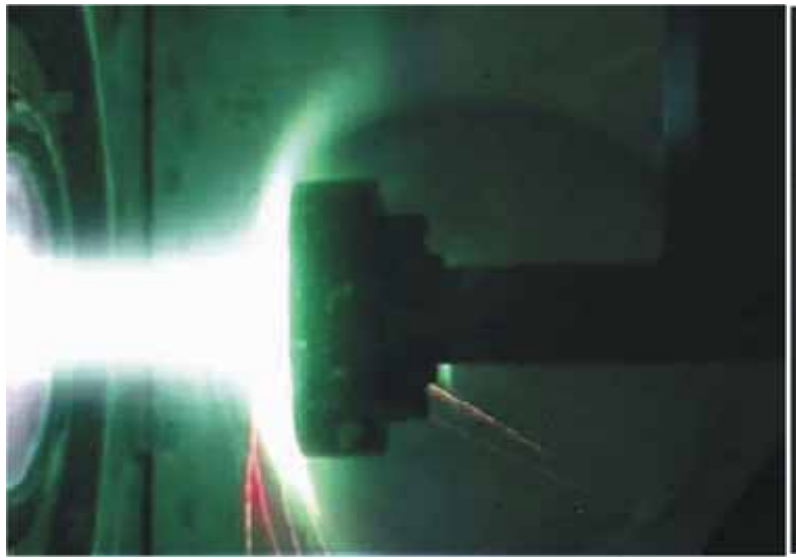


Figure 3-8 MML's landing configuration

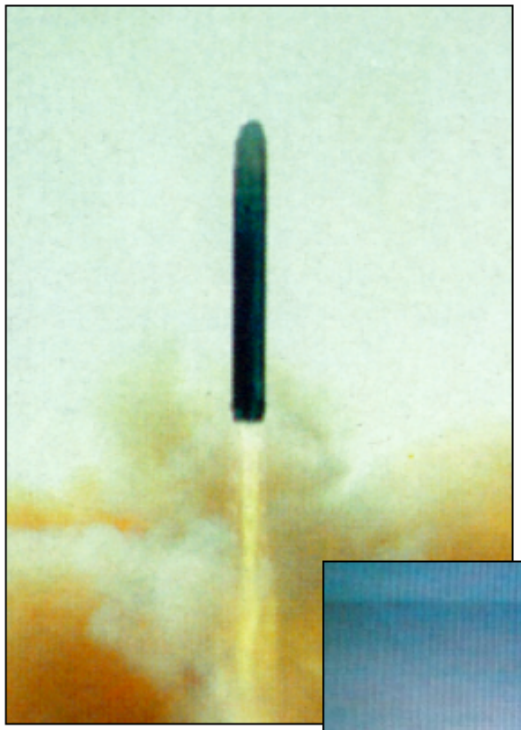


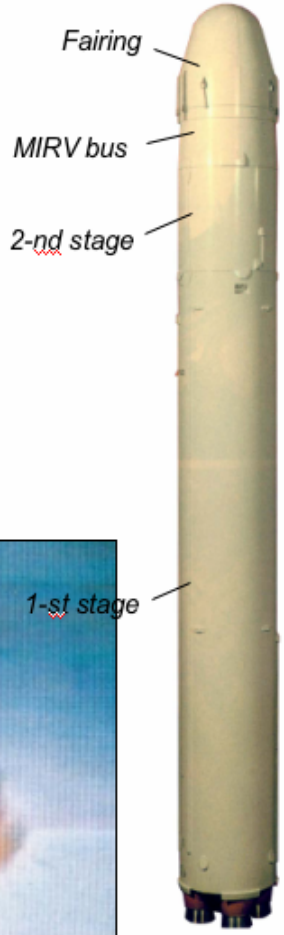
Thermal protection system tests





METNET Test Launch





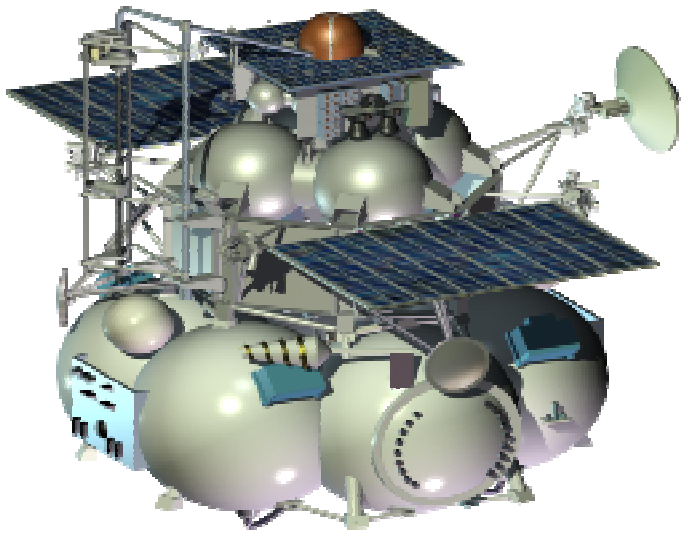
Inflatable heat shield tested using Volna launcher for suborbital flight

- **Suborbital test launch in**
- **Financed via the debt conversion program**
- **Launched from a submarine**

MetNets piggy-backed with the Phobos Sample Return Mission

Subjects of research:

- **Laboratory examination of Fobos substance, delivered to Earth;**
- **Research of Fobos and monitoring of Mars from landing module;**
- **Research of Fobos and its surrounding space from orbital module.**

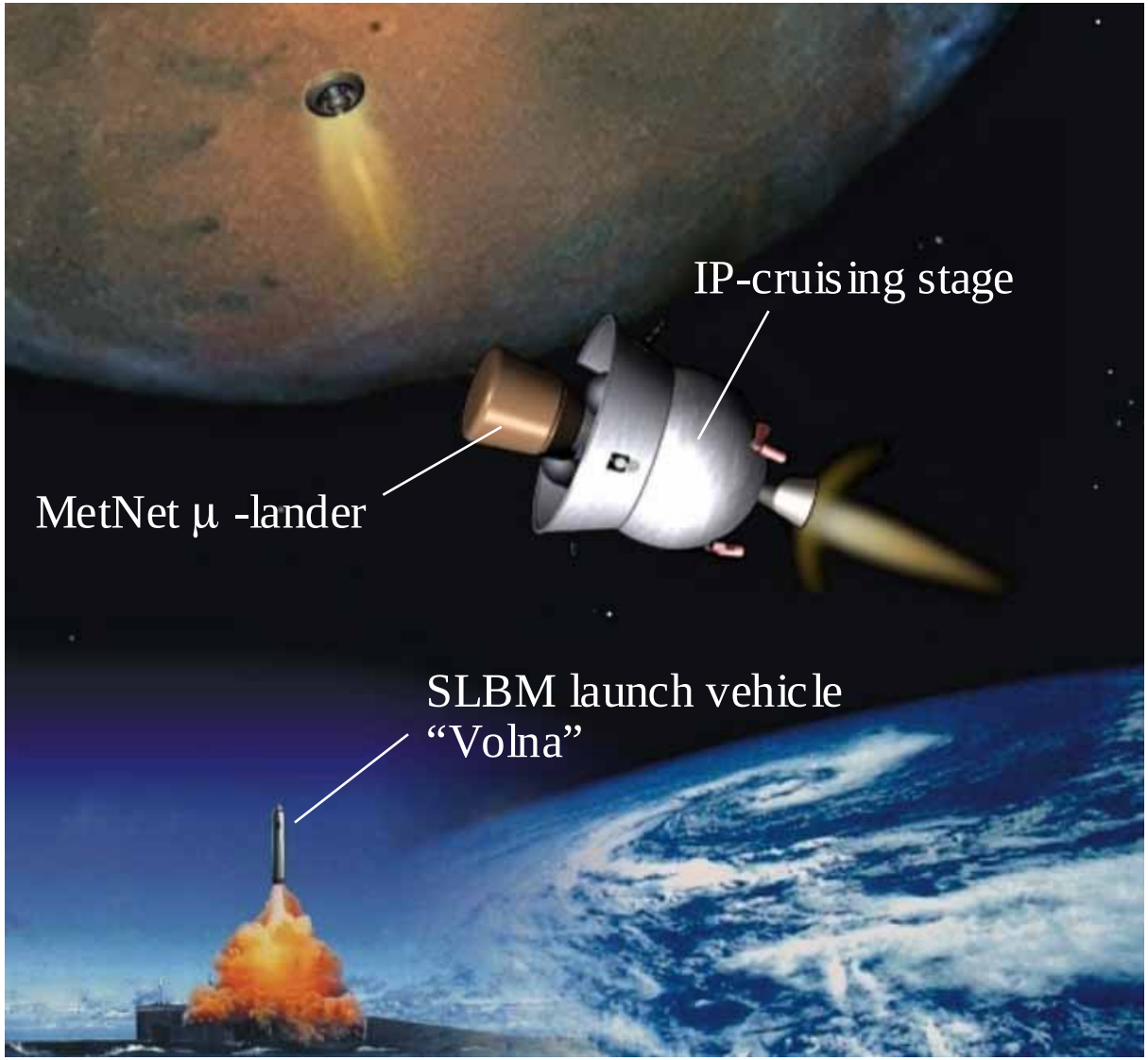


MAIN FACTS:

Launch Vehicle (LV)……..Soyuz-2/1b
Launch site…….....Baikonur Cosmodrome
Launch date…….....….October, 2009
Interplanetary Earth – Mars cruise time……..…...10 – 11.5 months
Launch from Phobos……..July –August, 2011
Interplanetary Mars – Earth cruise time.....10.5 – 11.5 months
Return to Earth ……..…….…….....June – July, 2012
Mission total time…….....….~ 33-34 months
SC mass……..……..8120 kg
Scientific equipment mass……..50 kg
Phobos soil samples mass……..…….……..0.2 kg

Low Cost Mars Mission

- A single MetNet μ-Lander could be sent to Mars using SLBM LV
- Acceleration from LEO by electric propulsion engine (used for more than decade)
- Small interplanetary cruise stage (heritage from earlier missions)
- Low cost
- Requires communications satellite around Mars (MEX, NASAs orbiters, special comsat)



TAL-38

TAL-38 elaborated under NASA support for satellites orbit keeping and attitude control.
Status - engineering model based on D-38.

TAL-WSF

TAL-WSF elaborated under NASA/BMDO RHETT - II program for flight tests.
Purpose - orbit keeping.
Status - flight hardware based on D-55.

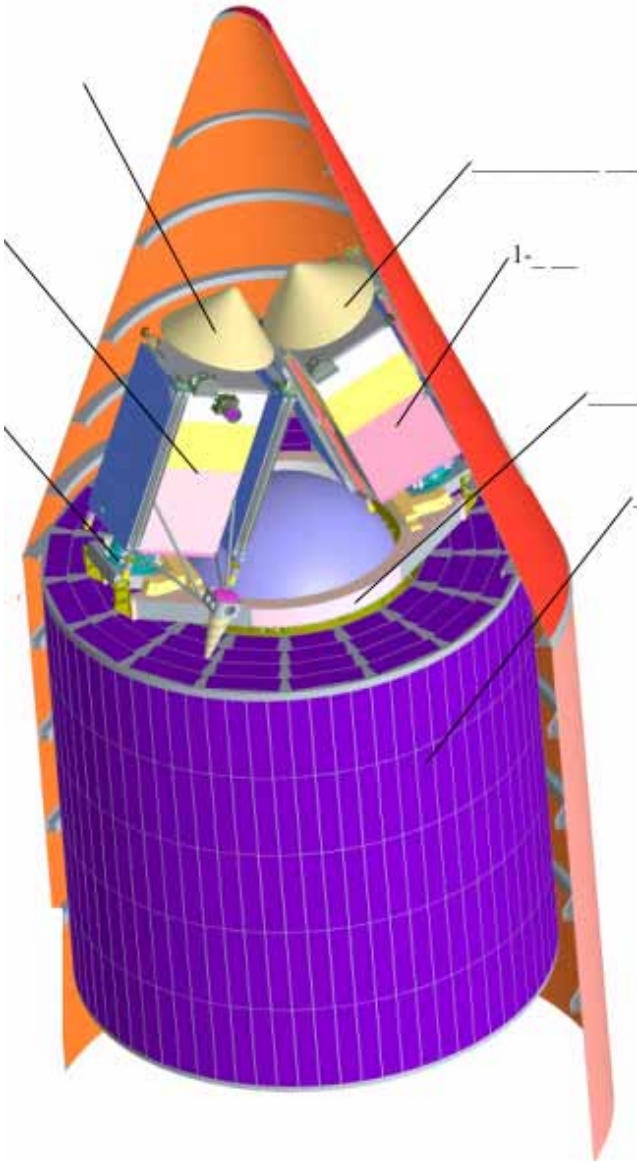
TAL-100

TAL-100 elaborated under NASA/BMDO program.
Purpose - orbit keeping and orbit rising.
Status - engineering model based on D-100.

TSNIIMASH basic set of laboratory hall effect thrusters with anode layer

	D-20	D-38	D-55	D-100-I	D-100-II	TM-50
Thrust	0.5-1.5	2.5-8	4-12	8-34	6-65	100-250
Power, kW	0.2-0.4	0.4-1.0	0.8-2.5	1.3-7.5	3.5-15	20-50
Isp, s	1400-2500	1300-2500	1350-1700	1450-2800	1800-4250	3000-7000
Efficiency	0.4	0.45	0.55	0.6	0.65	0.7-0.75

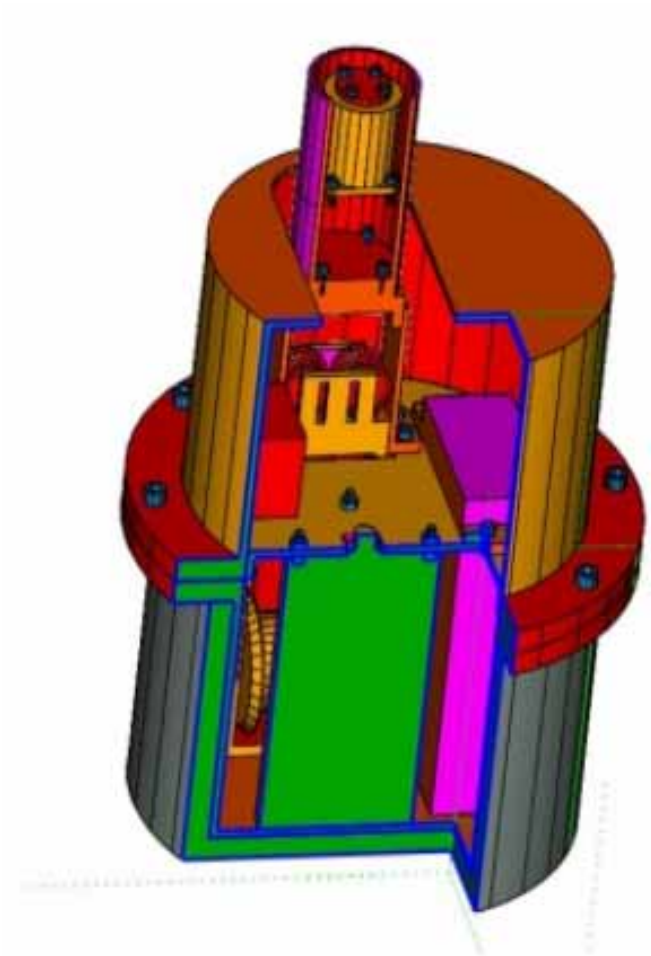
Kosmos 3M launcher

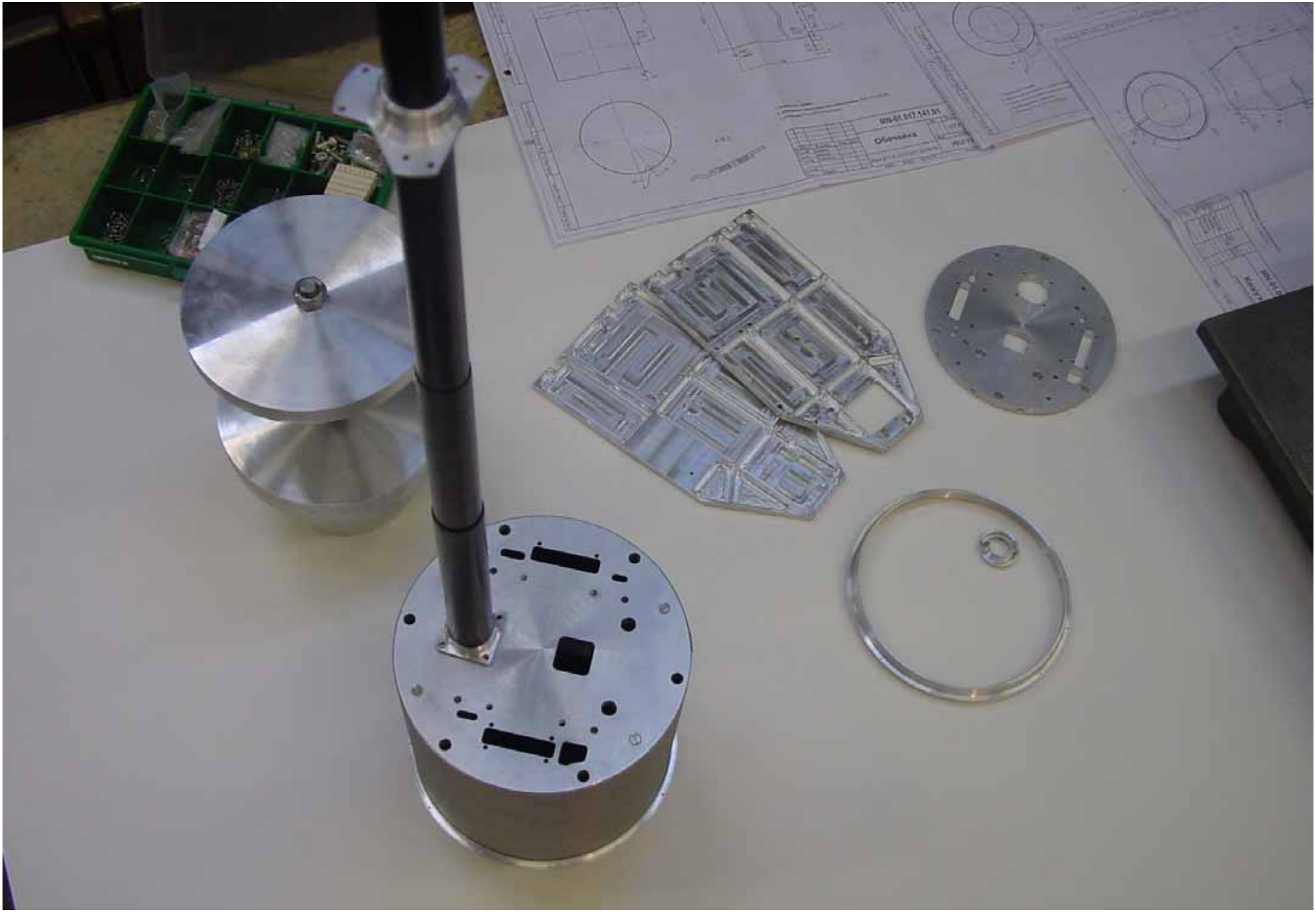


Payload Prototyping

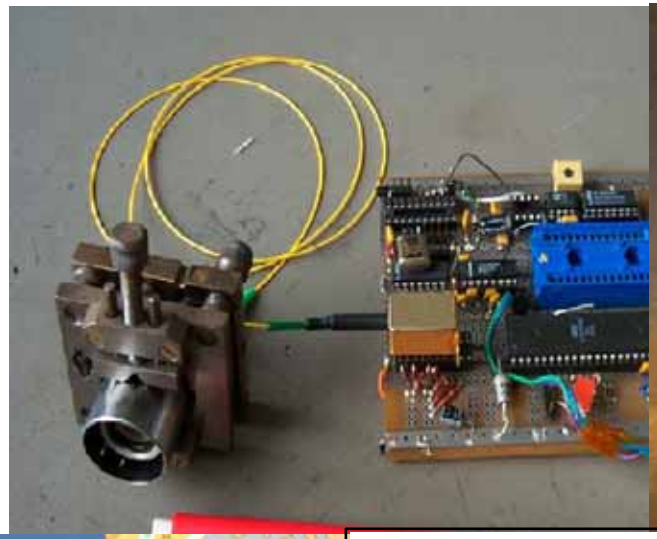
Performed With Flight Dimensions

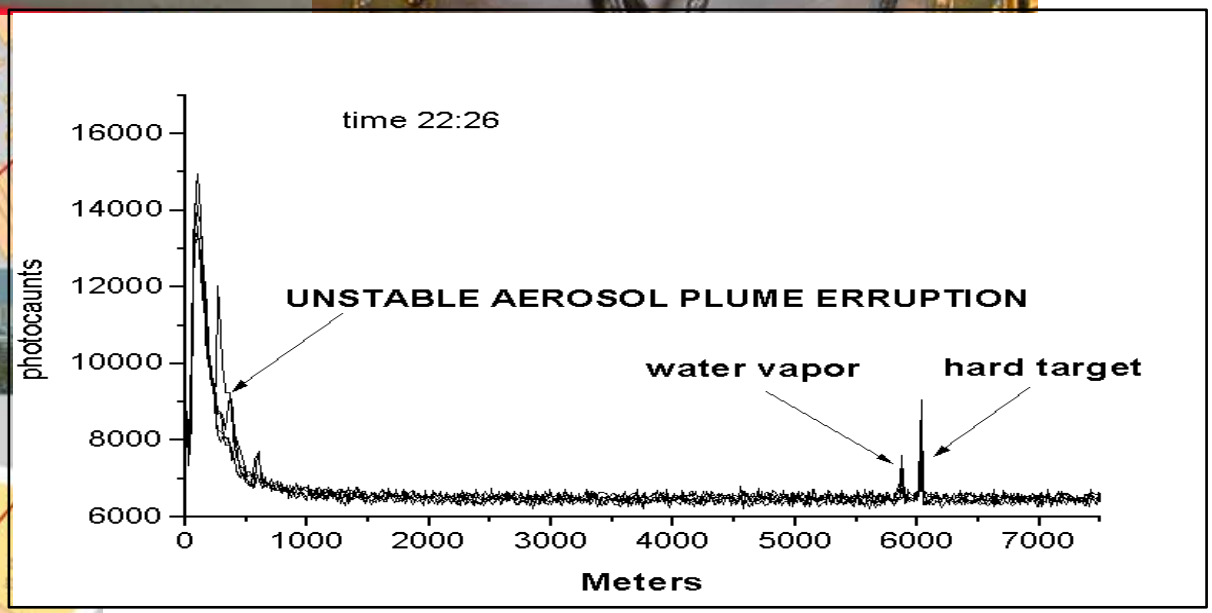
P/L Bay





LIDAR Proto

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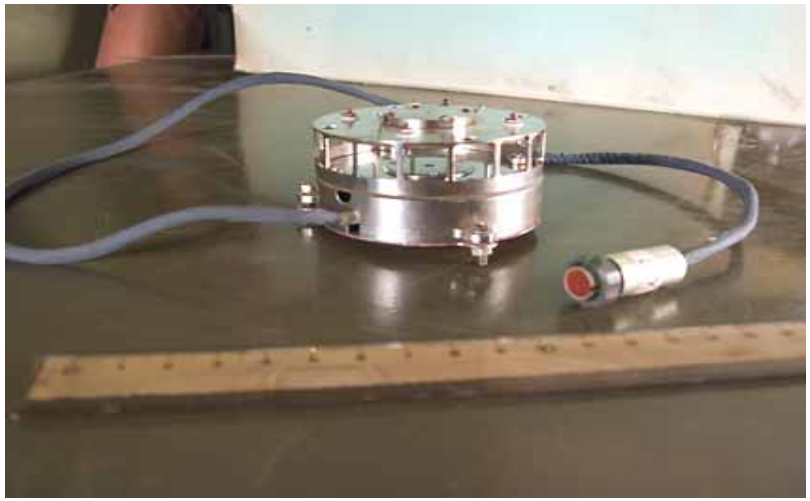
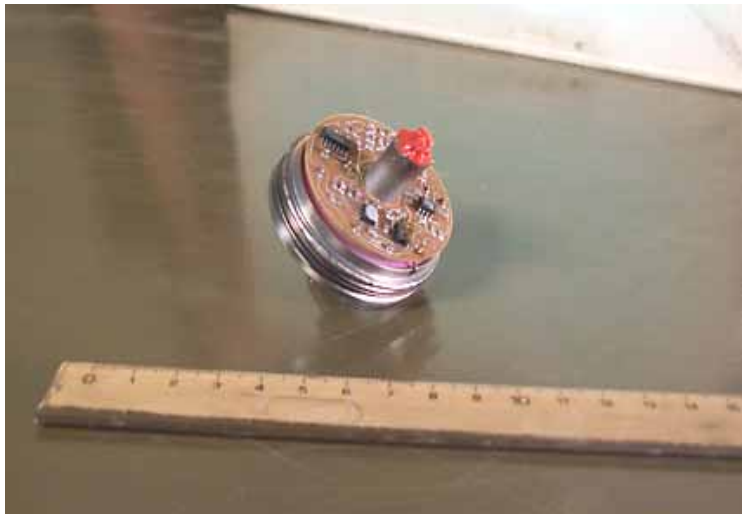
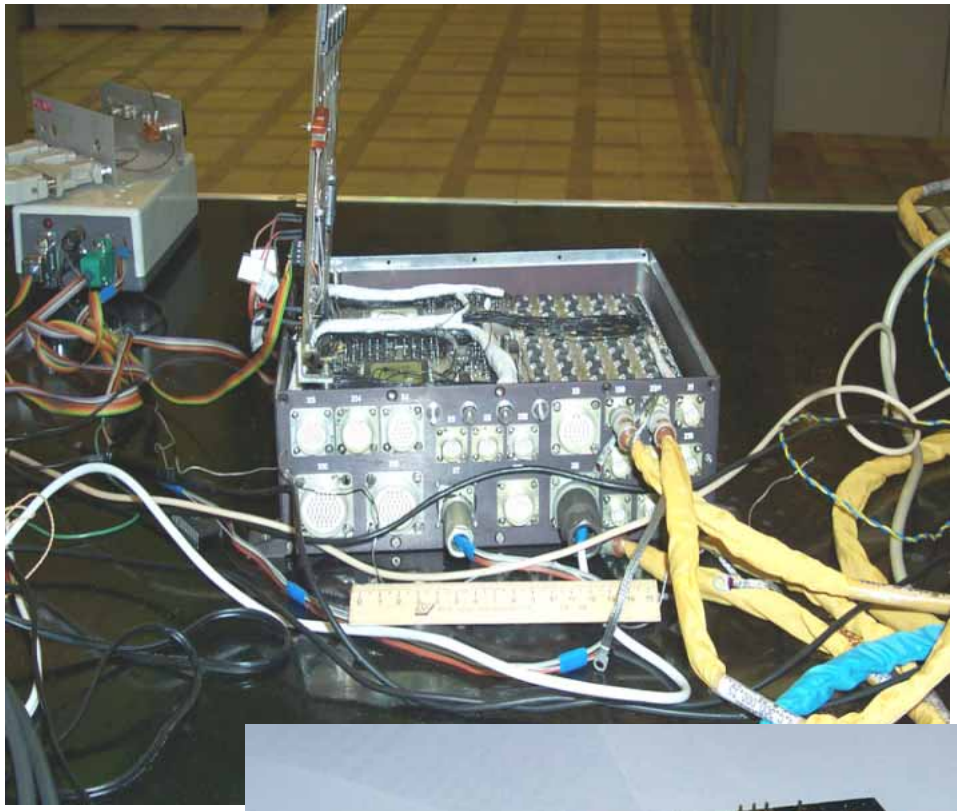
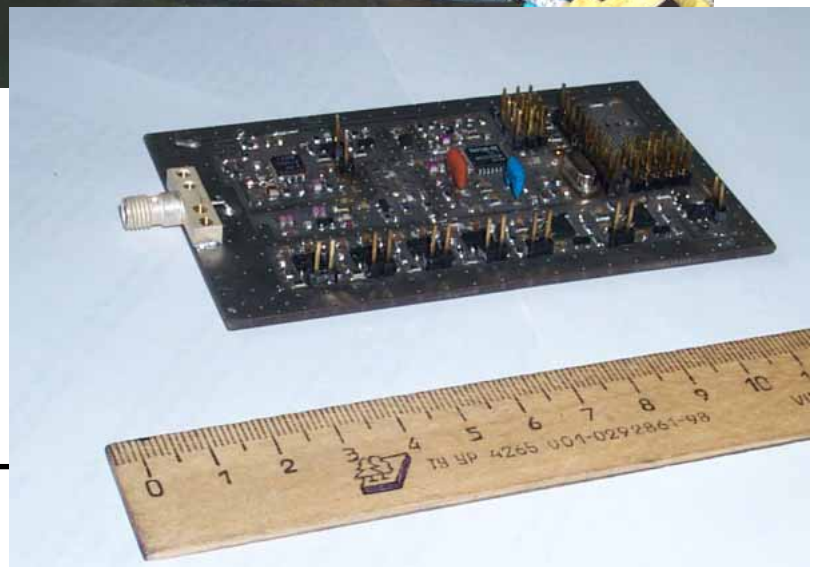
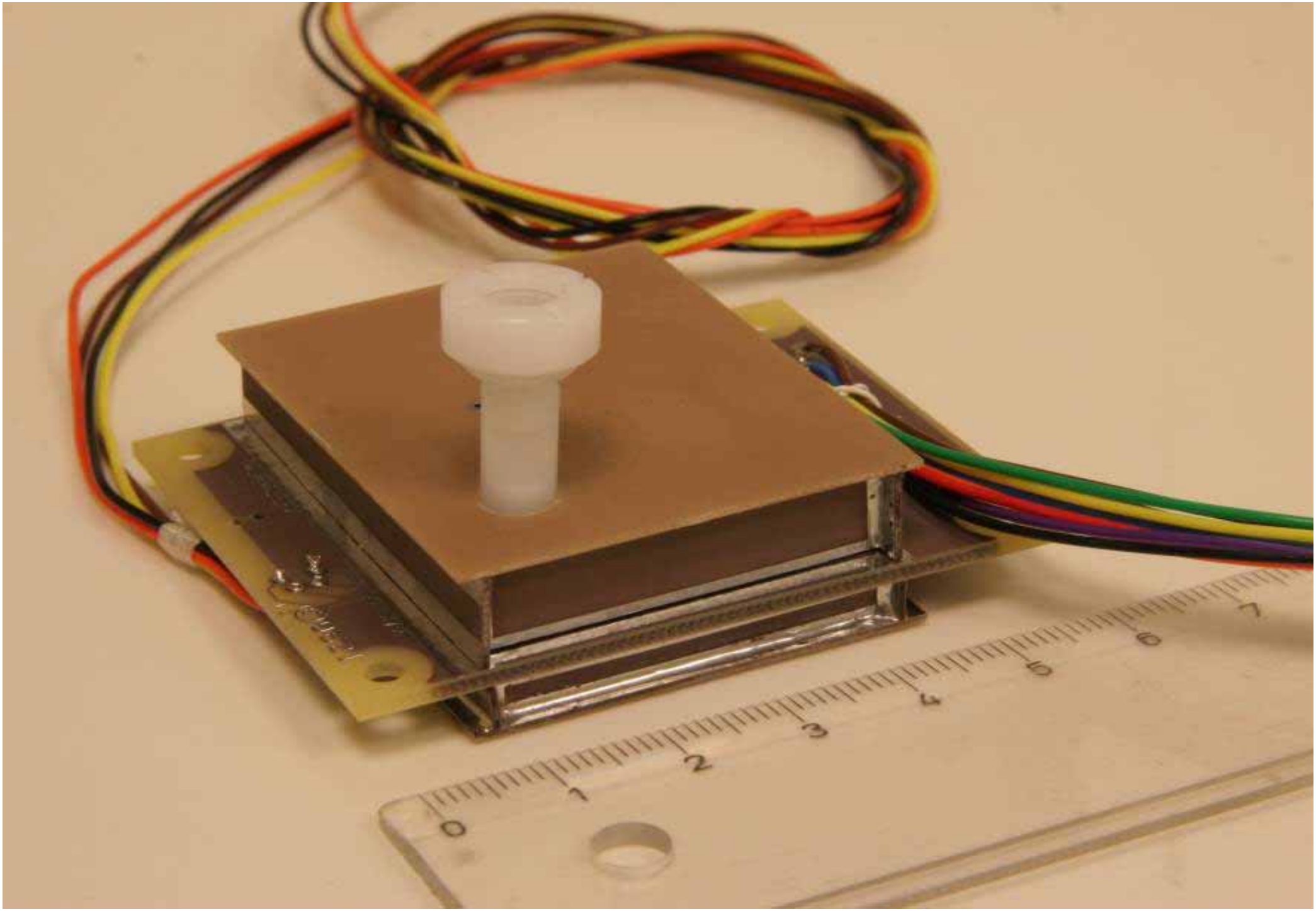
METNET Mission for Mars











T.C. / s

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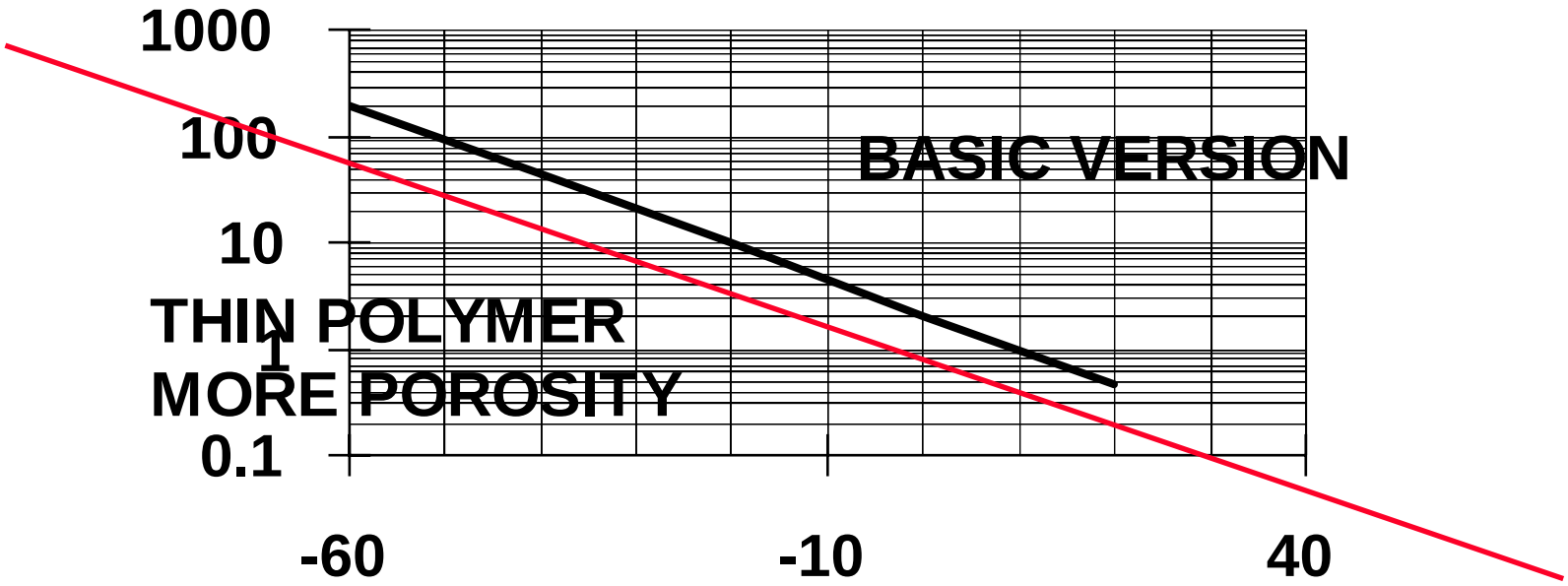
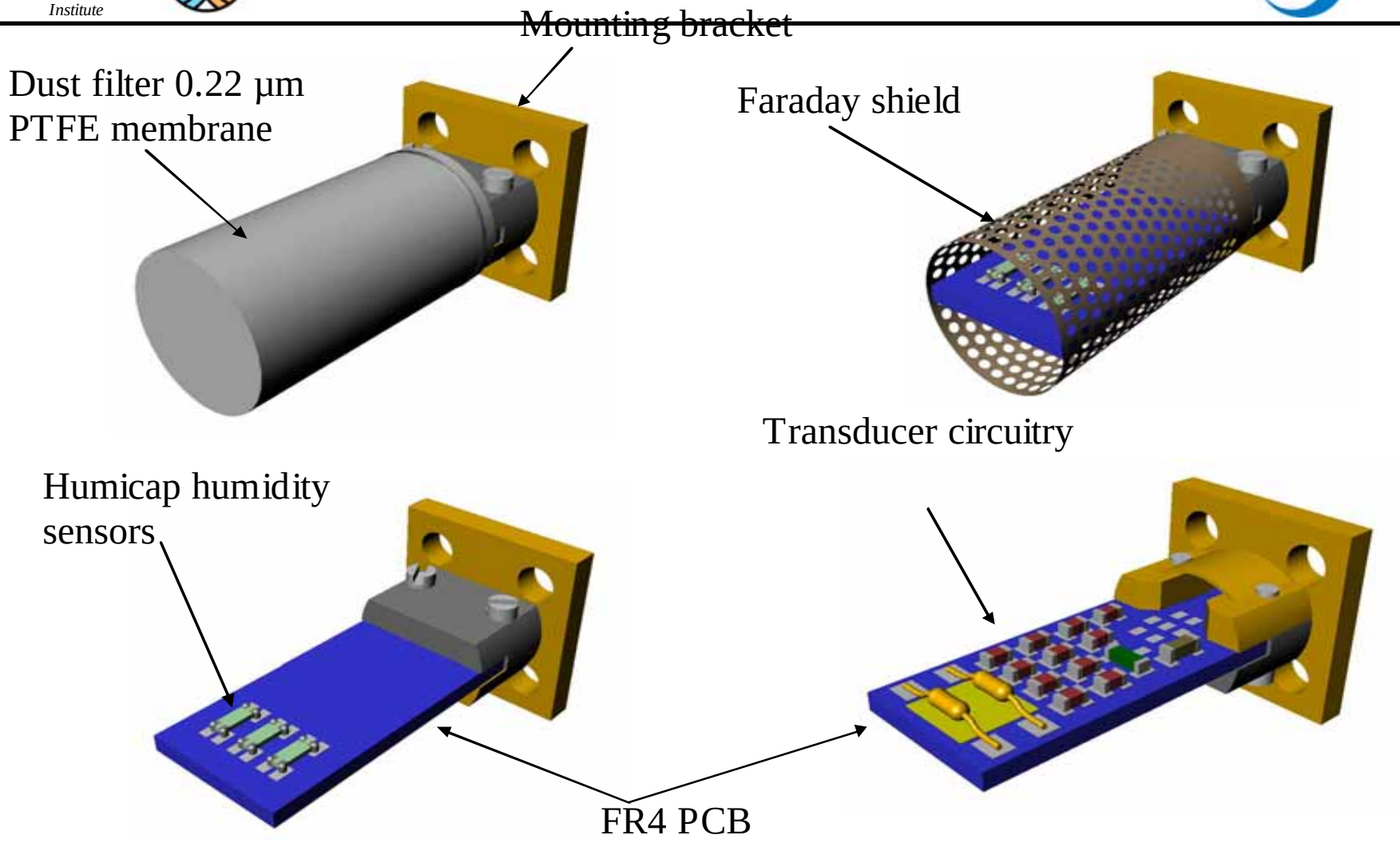
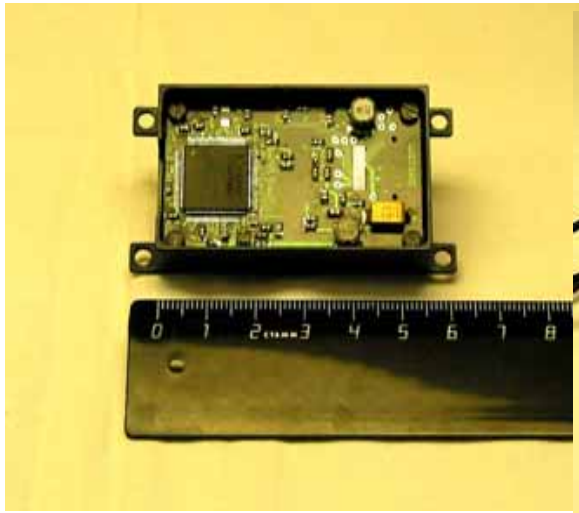
VAISALA

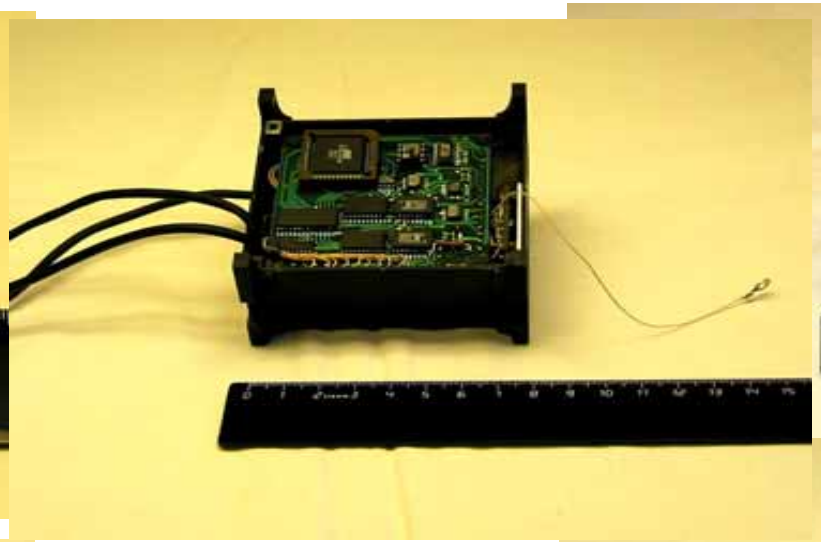


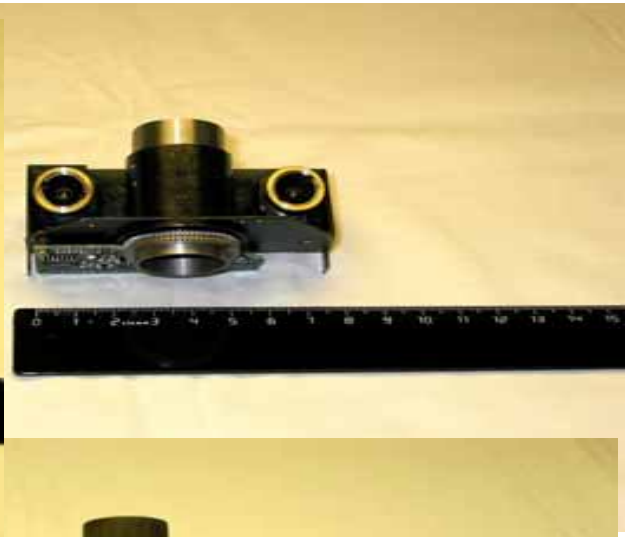


Flight configuration. EQM- and VM-models will be manufactured in Oct. -06
Dimensions 35 mm x Ø16, mass ~15 g

METNET Mission for Mars







Flight test

Event	Time of test cyclogram, sec	Real time, sec	Note
Timer activation	0	0	Standard Moscow time 17h 25 min
Separation from the carrier	5-10	7.8	
AIBD deployment	25	25.0	
AIBD inflation system activation, start of AIBD inflation	27	27.0	
Stop of AIBD inflation, cutting of tube and AIBD inflation system pyro-cartridge cable	127	127.0	
Cutting of front shield connections, front shield separation	130	130.0	
Front shield lowering	-	133.2	
Landing	191	182.8	

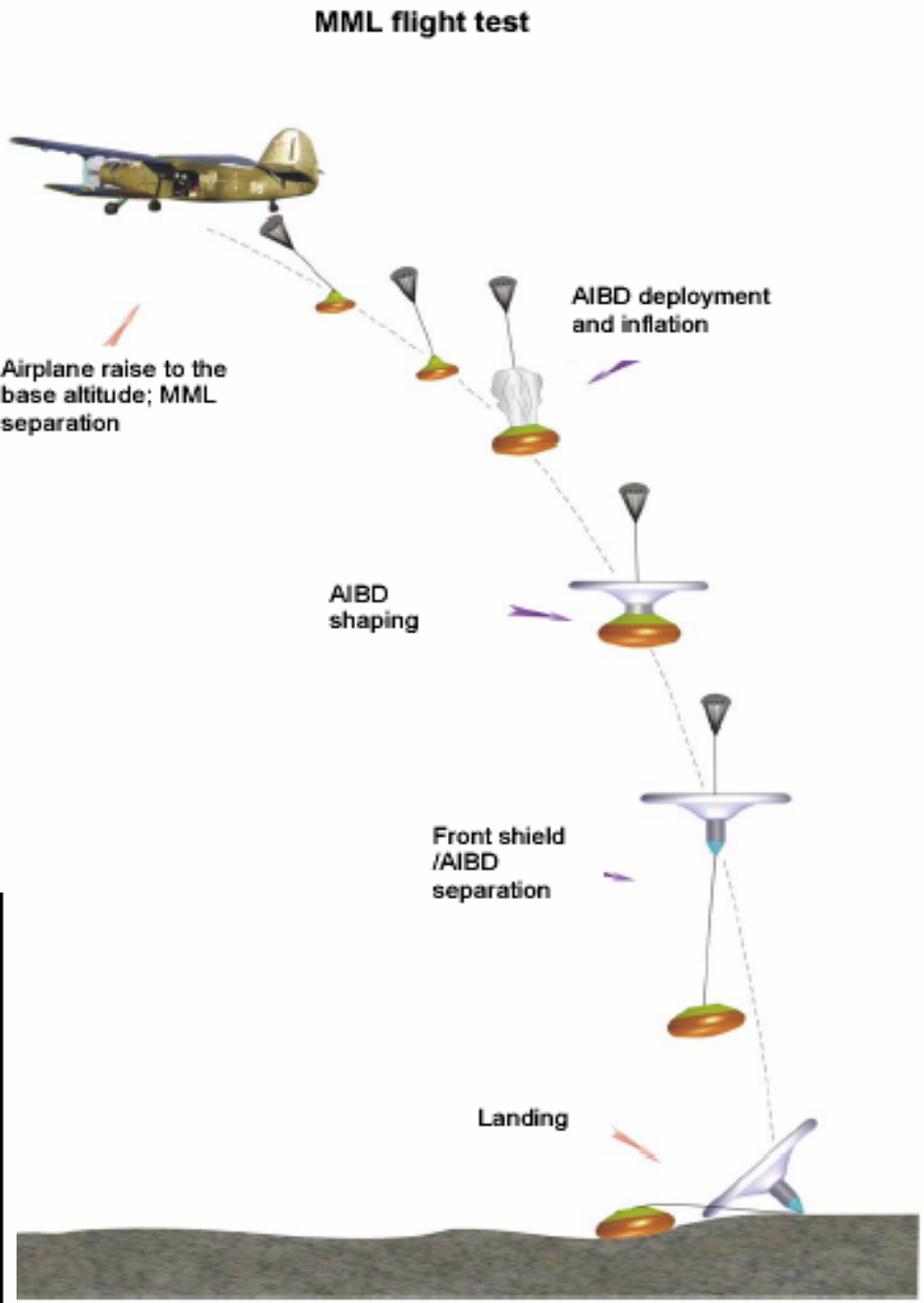


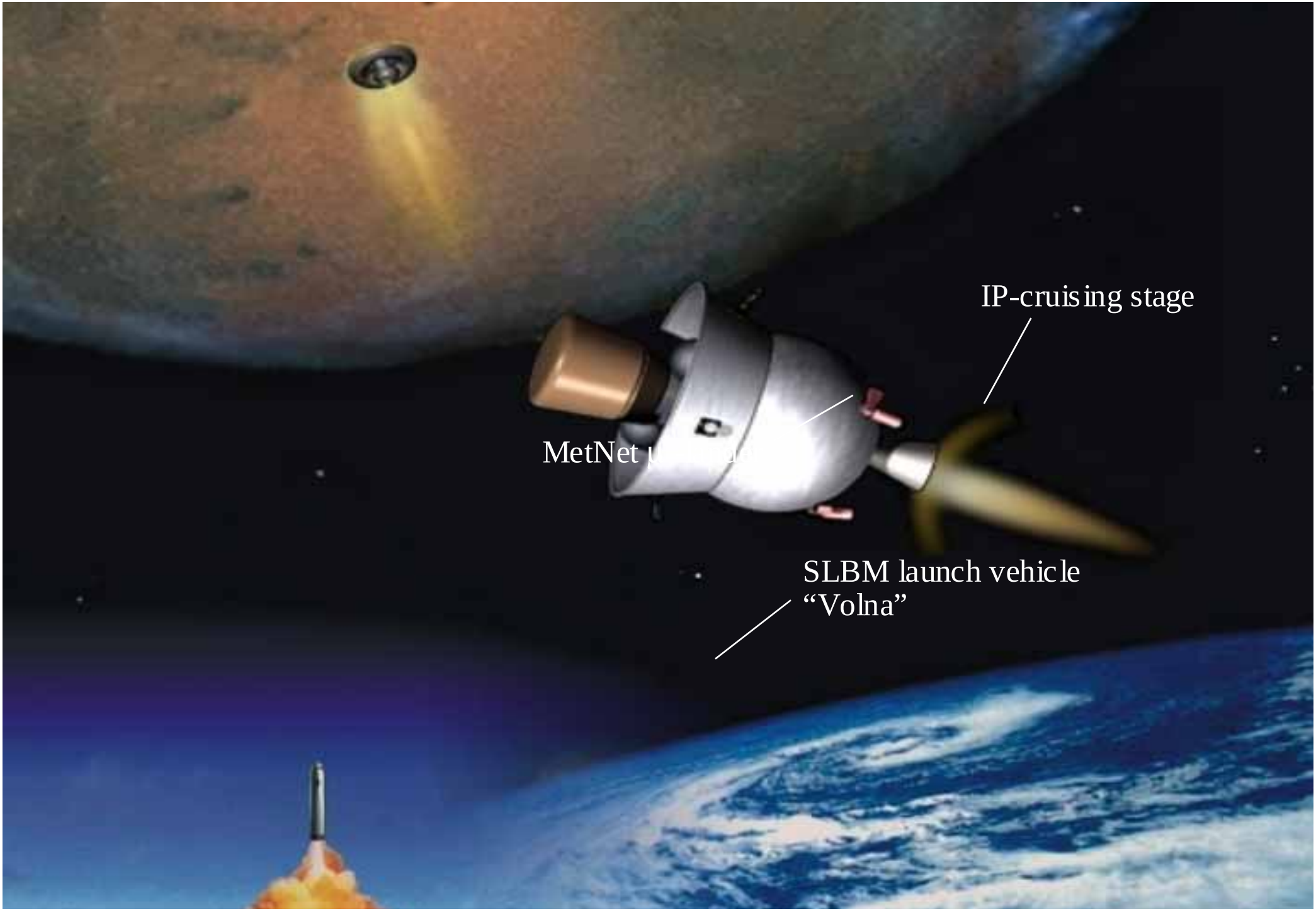
Fig. 4-1 Flight test set-up

Phase of descent	T, sec	H, m	V, m/sec	θ, degree	q, Pa	M	Re
1	2	3	4	5	6	7	8
MML separation from the airplane	0	2500	42.0	0	854	0.128	2.48·106
AIBD deployment; start of AIBD inflation	15.0	2136	29.0	-89.372	423	0.088	1.77·106
Front shield separation	110.0	820	12.28	-90.0	87	0.037	1.63·106
Landing	185.76	0	10.68	-90.0	72	0.032	1.55·106

Two MetNet Probes

Fabricated to Flight Spec (w/o flight payload)

METNET Mission for Mars


IP-cruising stage
MetNet
SLBM launch vehicle
“Volna”