ARCHIMEDES — A balloon mission to Mars led by the German Mars Society

Max-Planck-Institut für Sonnensystemforschung

Björn Grieger

Universität der Bundeswehr München

Hannes S. Griebel

and the ARCHIMEDES Science Team
(http://archimedes.space-vision.biz/Team)

Mars Society Deutschland e.V.

AMSAT-DL

The game of the name

Aerial
Robot
Carrying
High Resolution
Imaging, a
Magnetometric
Experiment and
Direct
Environmental
Sensing **I**nstruments

Archimedes of Syracuse
287-212 BC
Scientitist and discoverer of the law of hydrostatics.
(G.Cooke, London 1807)

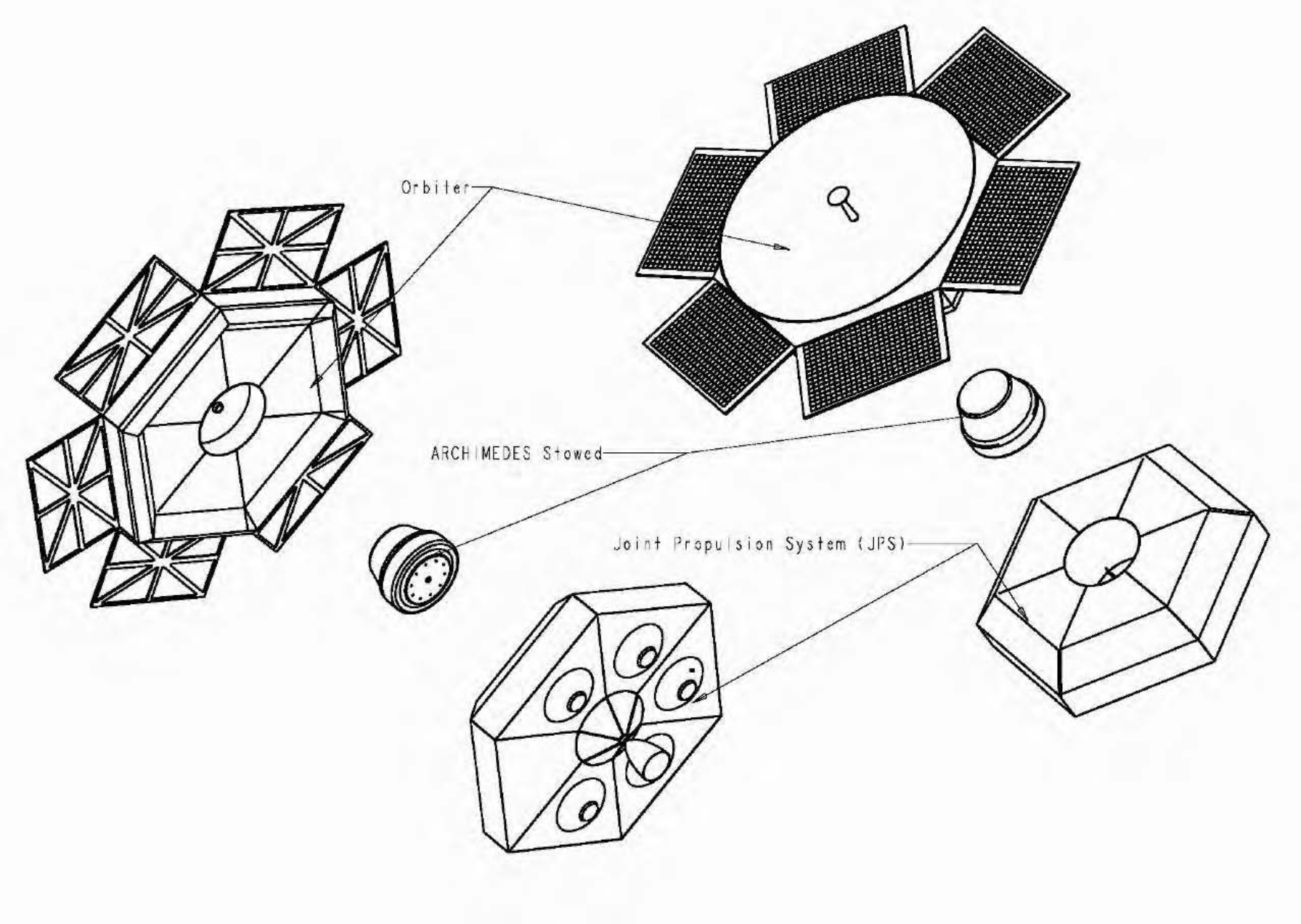
Outline

- The piggyback-piggyback ride to Mars
- The *(inflated!)* entry
- Lower atmosphere and surface science
- Status and outlook

Part 1: The piggyback-piggyback ride to Mars

- Cruise of ARCHIMEDES to Mars piggyback aboard the Mars orbiter AMSAT P5-A
- Launch of AMSAT P5-A piggyback a commercial payload with Ariane 5 in 2009

Joint Propusion System (JPS)



Part 2: The *(inflated!)* entry

1. Separation and deorbit
2. Inflation (ca. one hour after separation)
3. Entry with 2–9 passes through the atmosphere

GATG vs. GATF

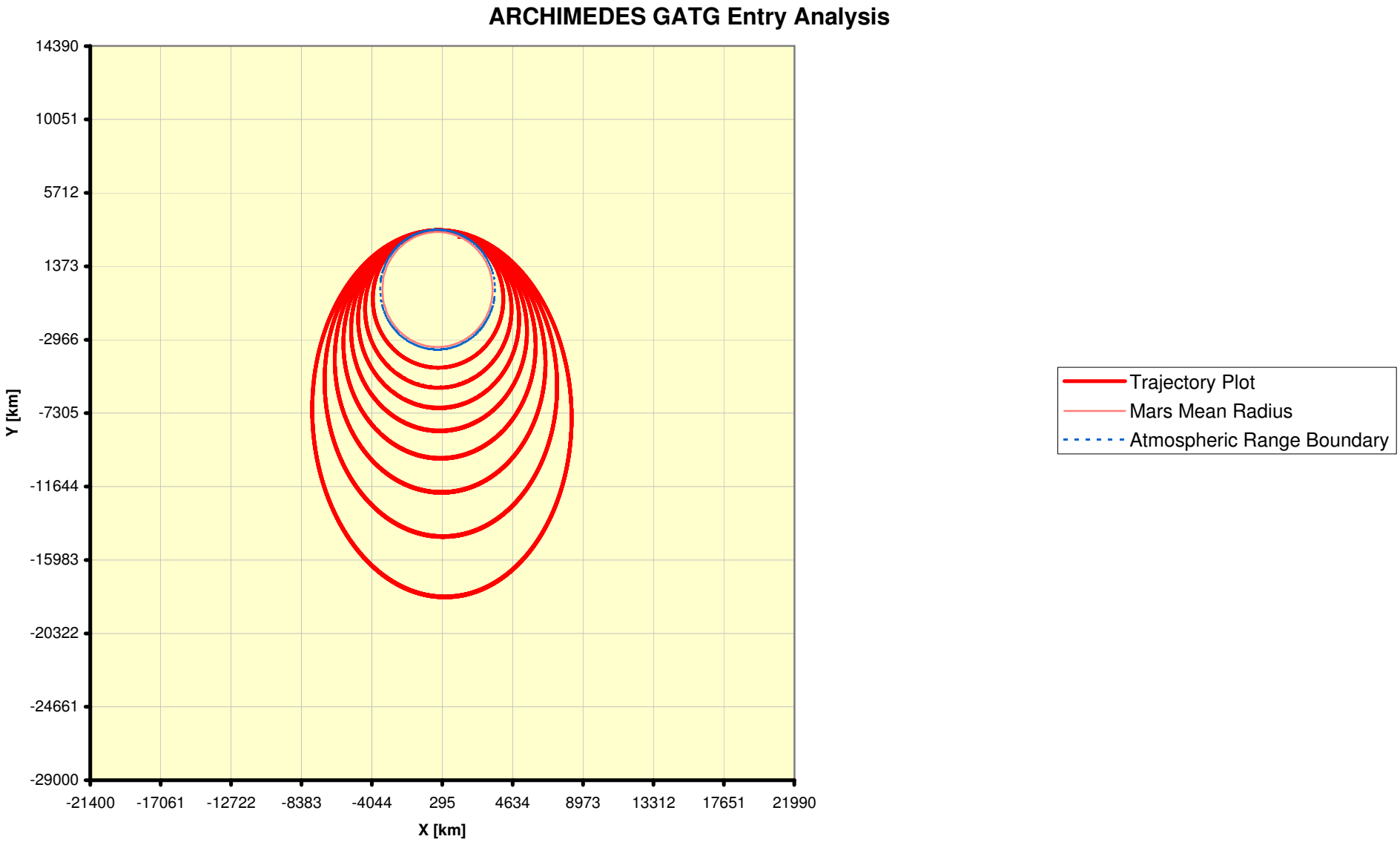
Go Around To Ground:

- Heavier and more robust balloon skin possible
- Primary batteries only, no solar cells, no bridle

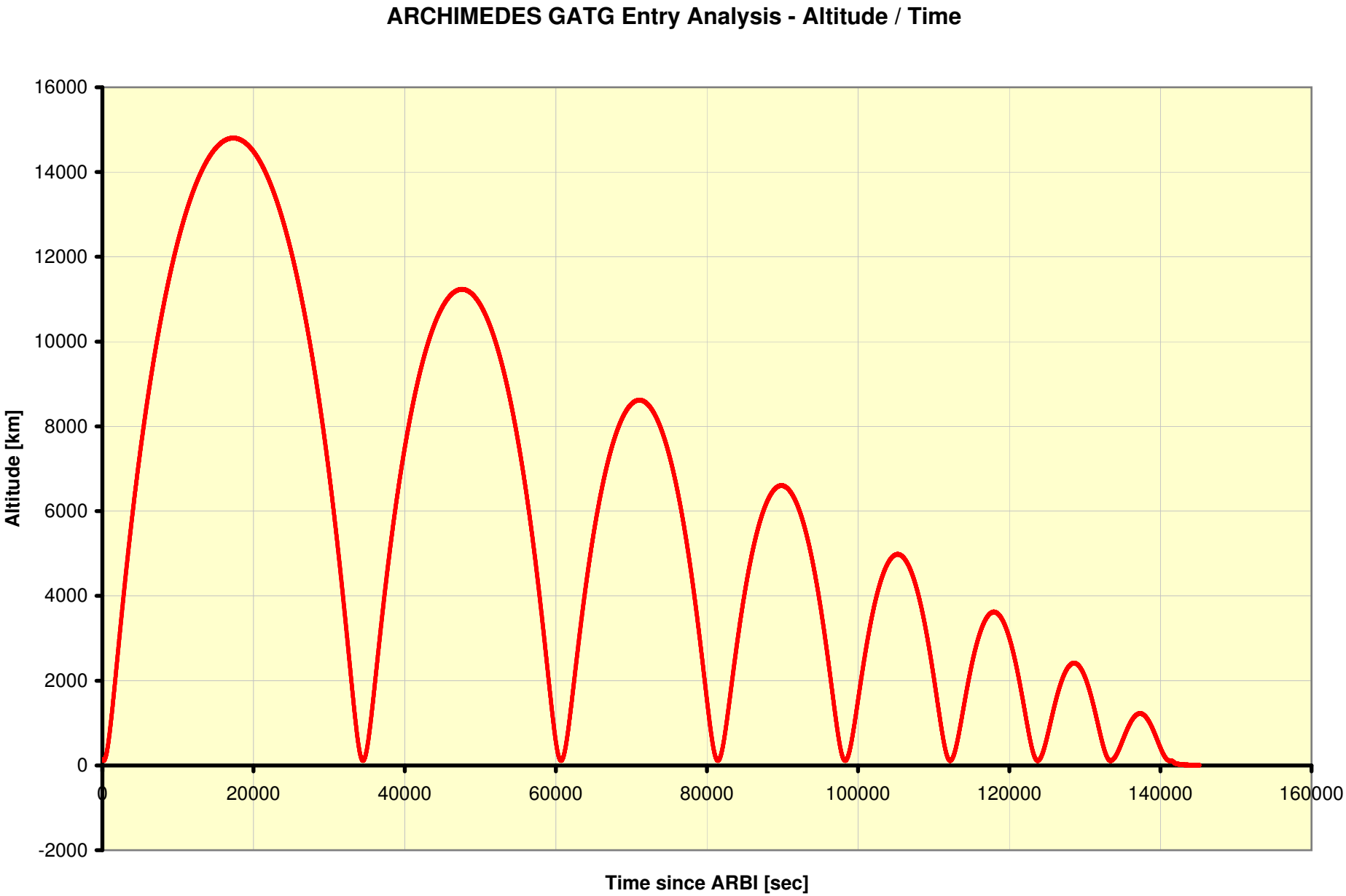
Go Around To Float:

- Sustained floating in lower atmosphere
- Only possible with transparent Polybenzobisoxazole (PBO) as balloon skin material

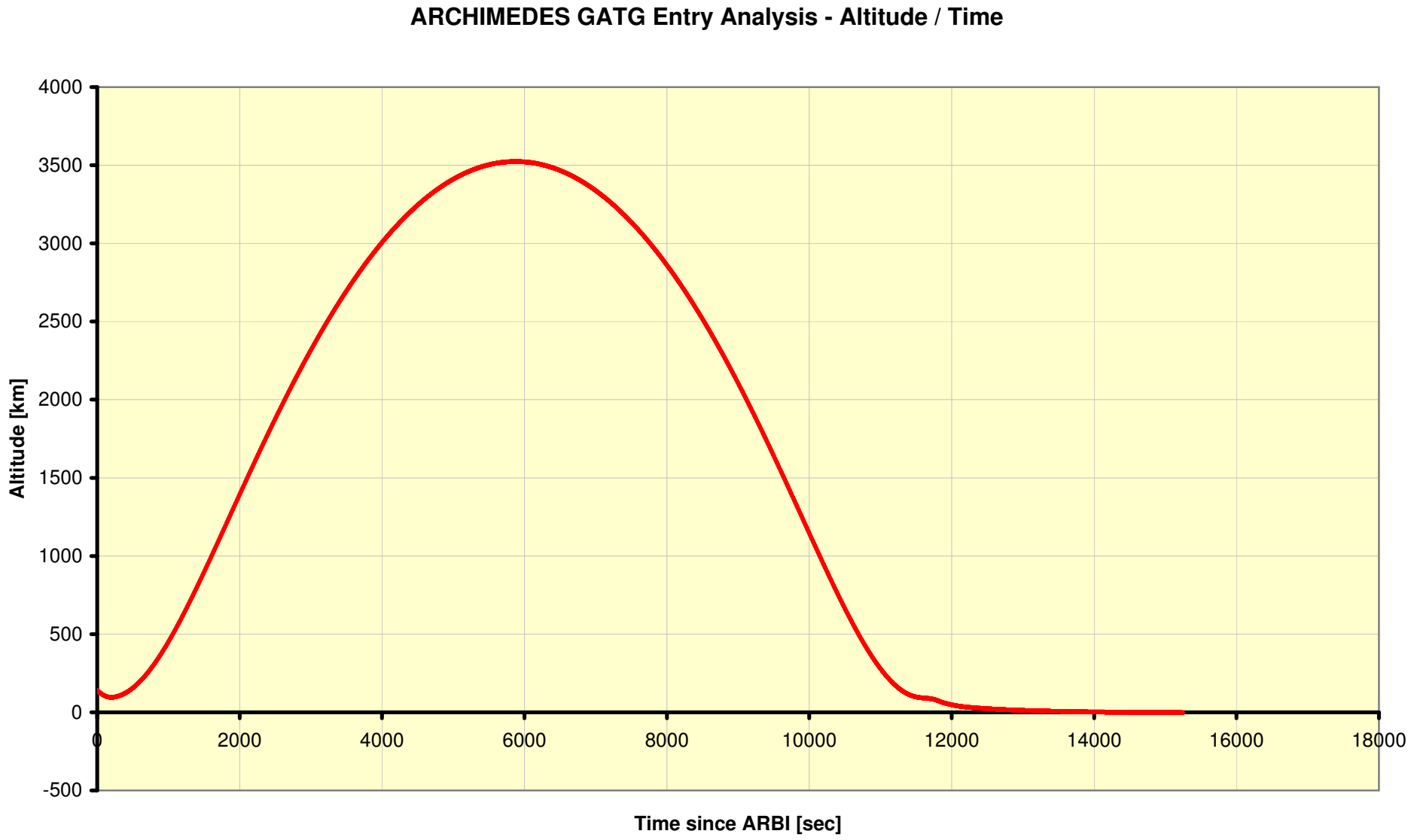
Composite balloon skin, nominal entry -15°



Composite balloon skin, nominal entry -15°



Composite balloon skin, nominal entry



GATG profile summary

Maximum g-load	2.11	g
Maximum dynamic pressure	8	N/m^2
Maximum temperature	464	K
Maximum heat flux	2358	W/m^2
Absorbed heat	$1.11 \cdot 10^6$	J/m^2

Touchdown		
Terrain elevation	Vertical velocity	Elapsed time
-4 km	< 0.5 m/s	4h 13m
0 km	< 7 m/s	3h 53m
8 km	< 14 m/s	3h 36m

GATG vs. GATF

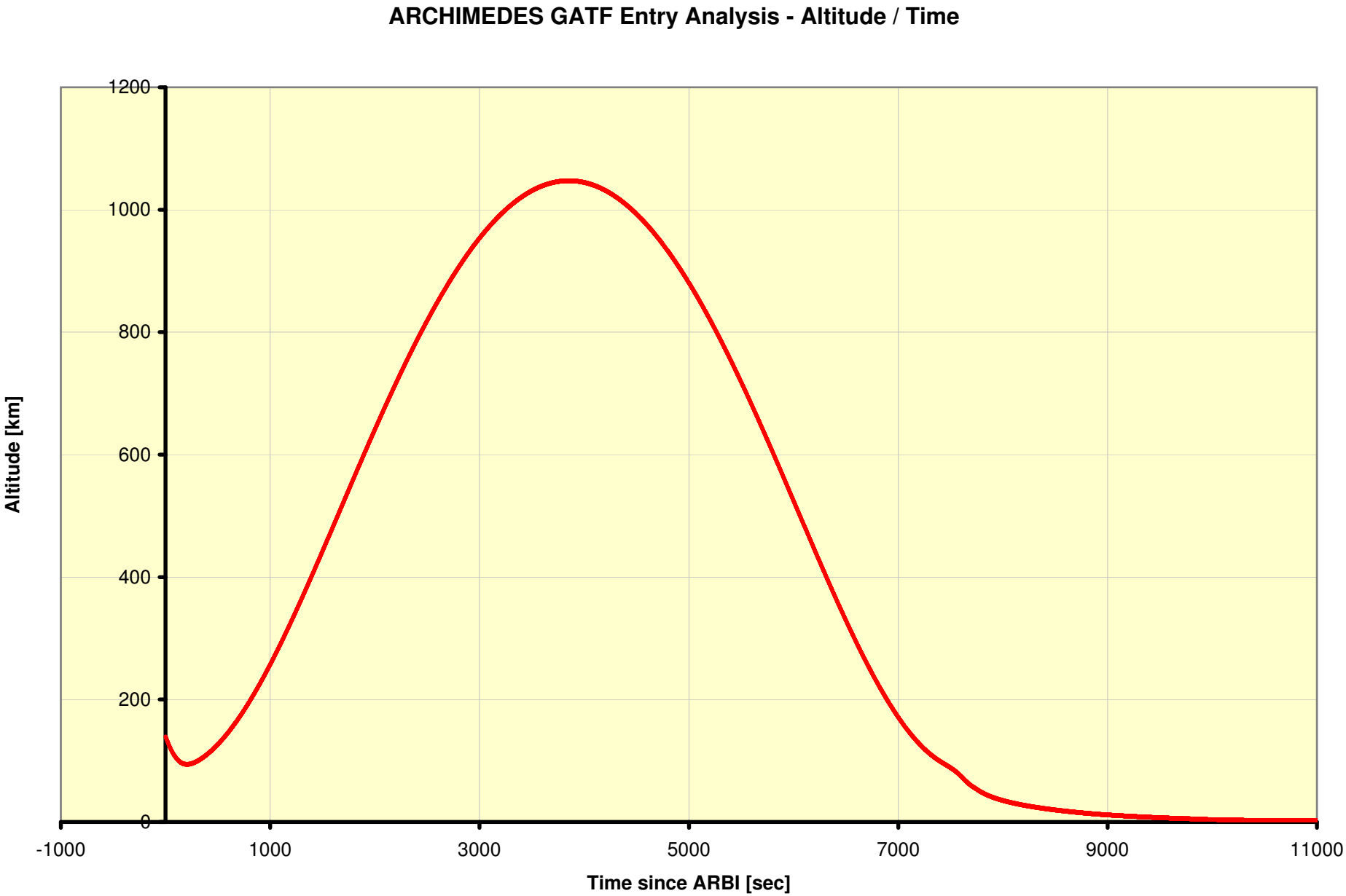
Go Around To Ground:

- Heavier and more robust balloon skin possible
- Primary batteries only, no solar cells, no bridle

Go Around To Float:

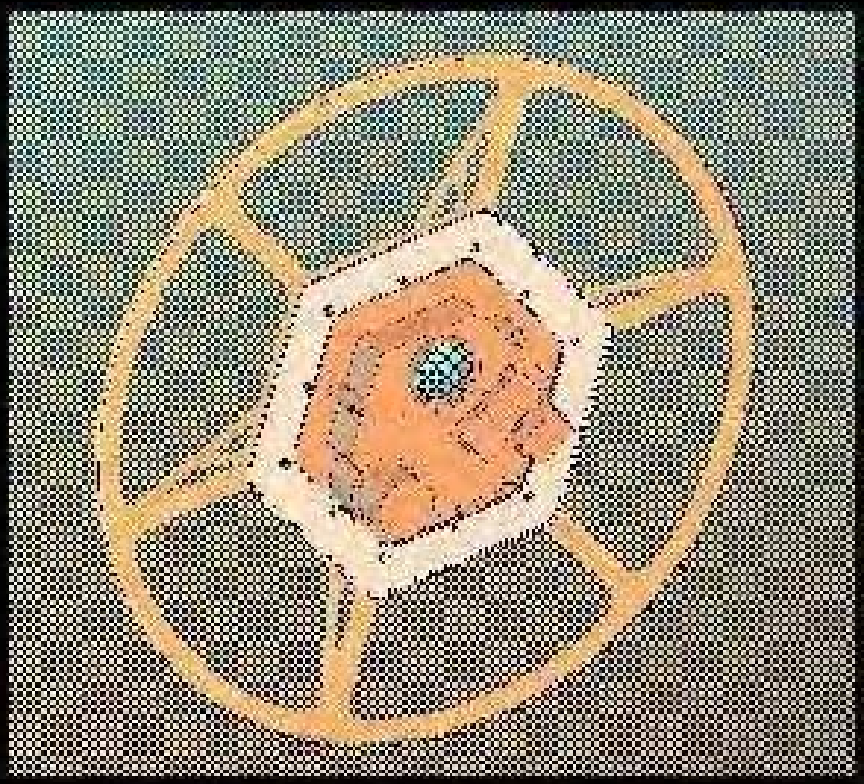
- Sustained floating in lower atmosphere
- Only possible with transparent Polybenzobisoxazole (PBO) as balloon skin material

PBO balloon skin, nominal entry



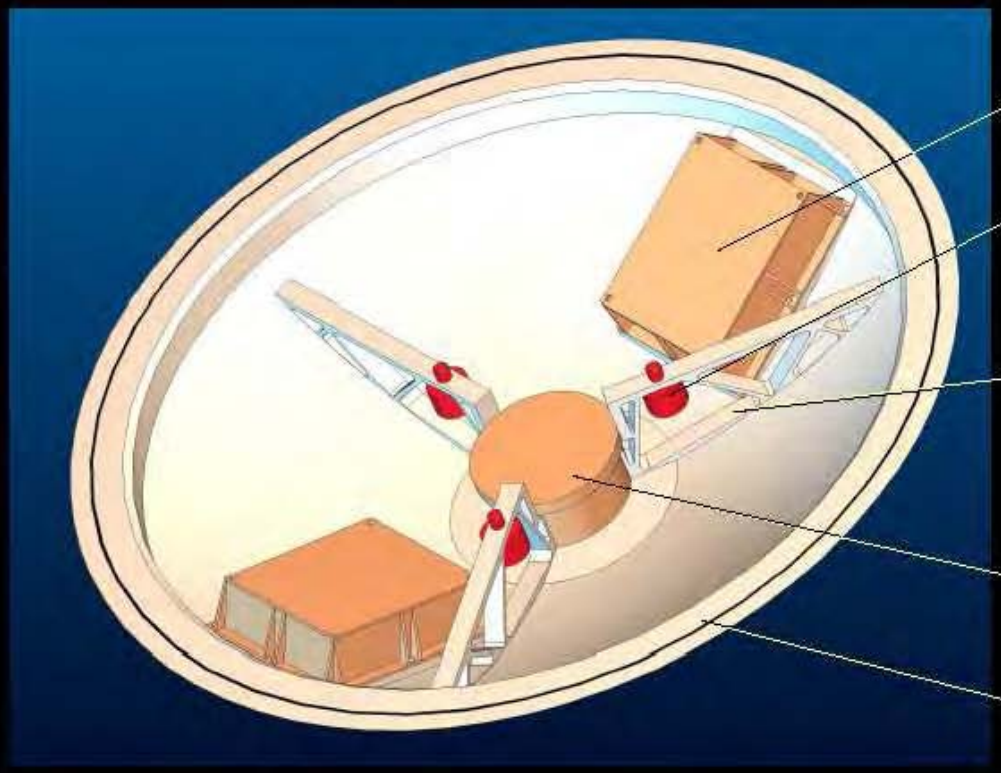
Clamped gondola

- With Nose Cone Assembly
  (Sky Configuration)



- Without Nose Cone Assembly
  (Subsonic Configuration)

The nose cone assembly



- Batteries
- Pyro
- Support Structure
- COMPARE & Accelerometers
- Sealing Ring

Accelerometers

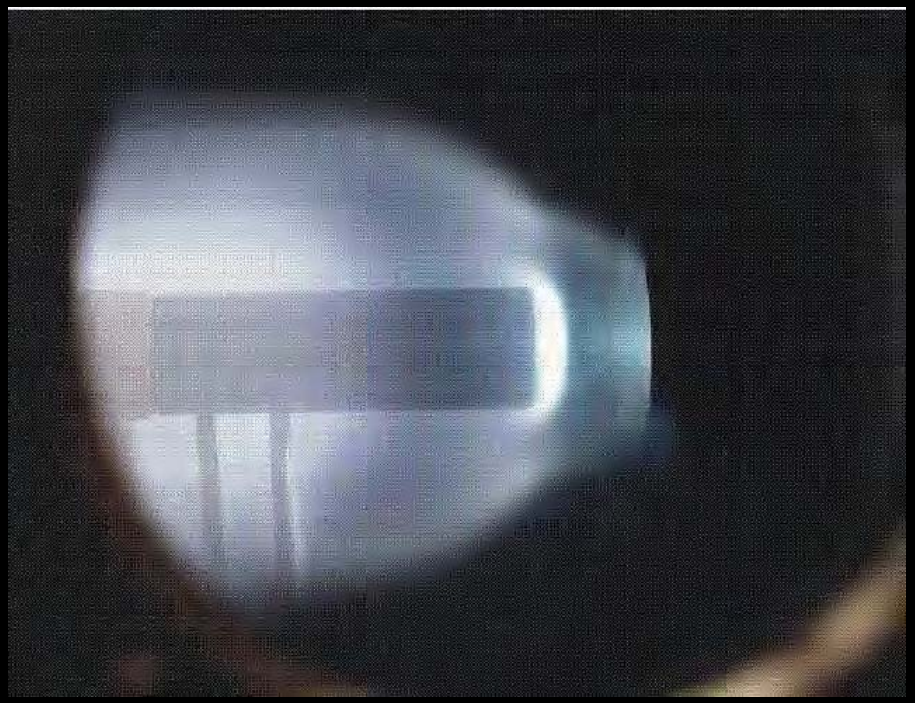
- Provided by the TU Iasi, Romania.
- Unprecedented data on the density of the Martian higher atmosphere (70 to 140 km altitude).

Entry flow experiment COMPARE

COMbined Planetary entry And trajectory Rebuilding Experiment provided by the TU Stuttgart, Germany

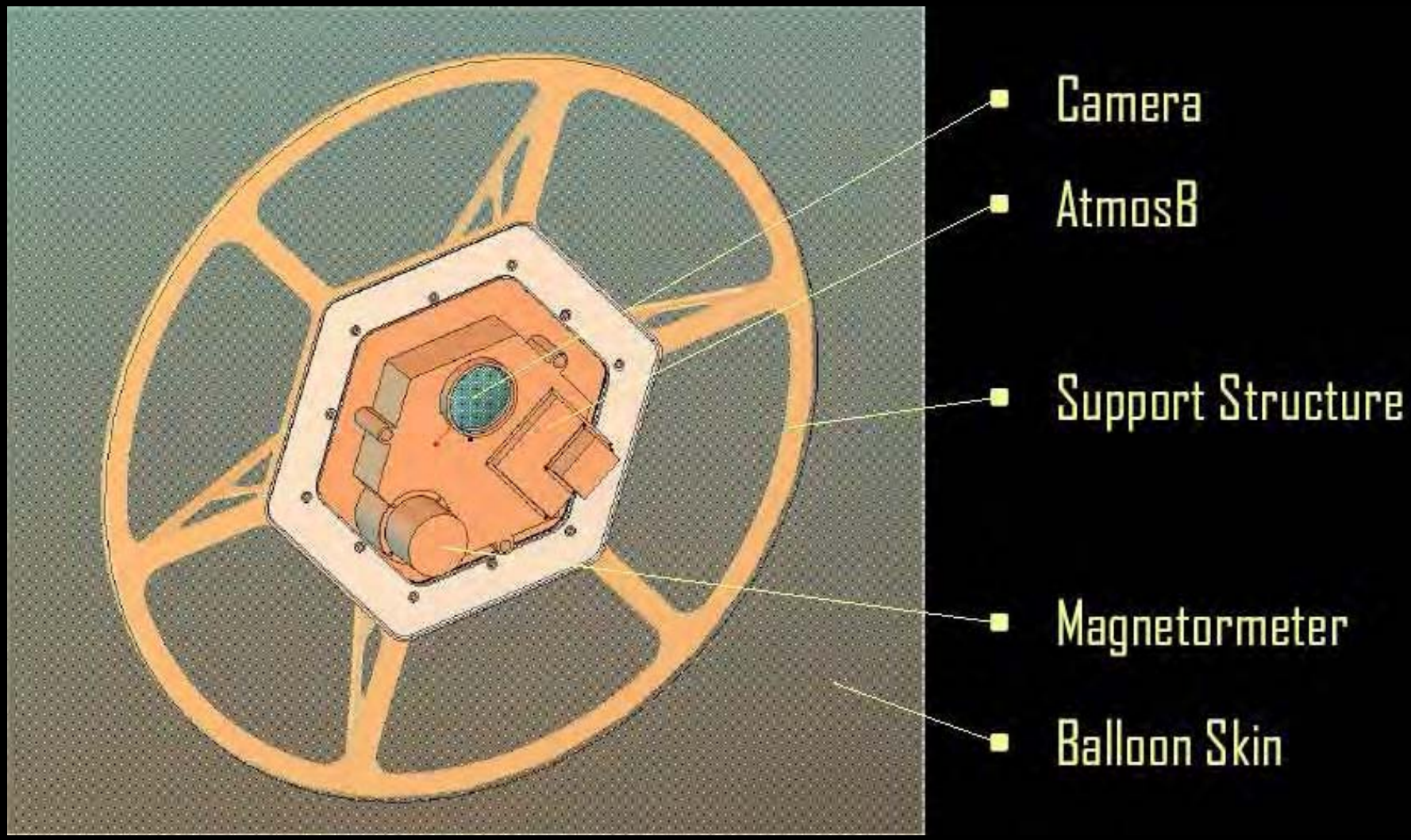
Simultaneous measurement of

- stagnation point temperature,
- convective heat flux,
- plasma radiative heat flux, and
- total pressure.



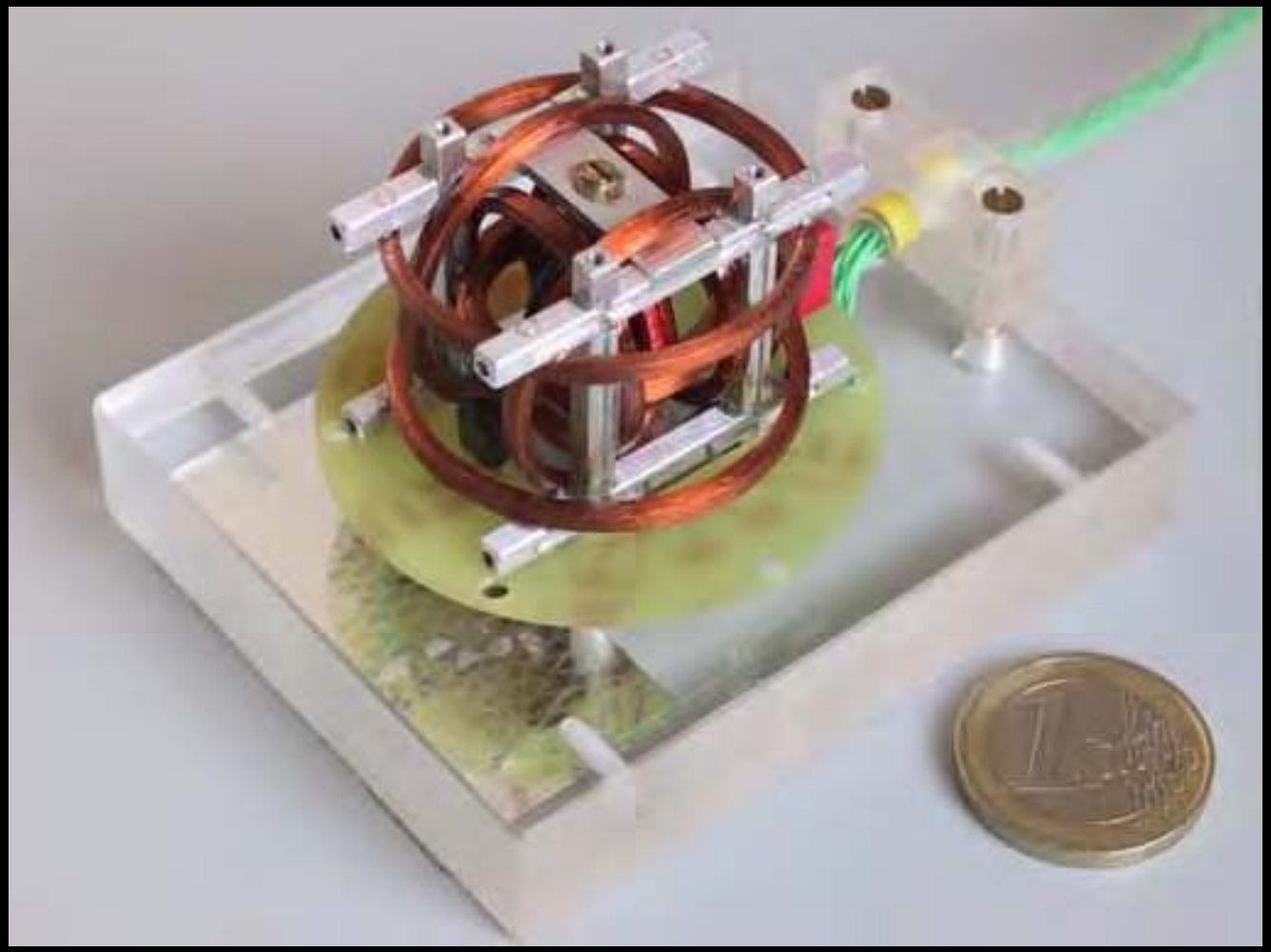
Part 3: Lower atmosphere and surface science

Experiments in the gondola

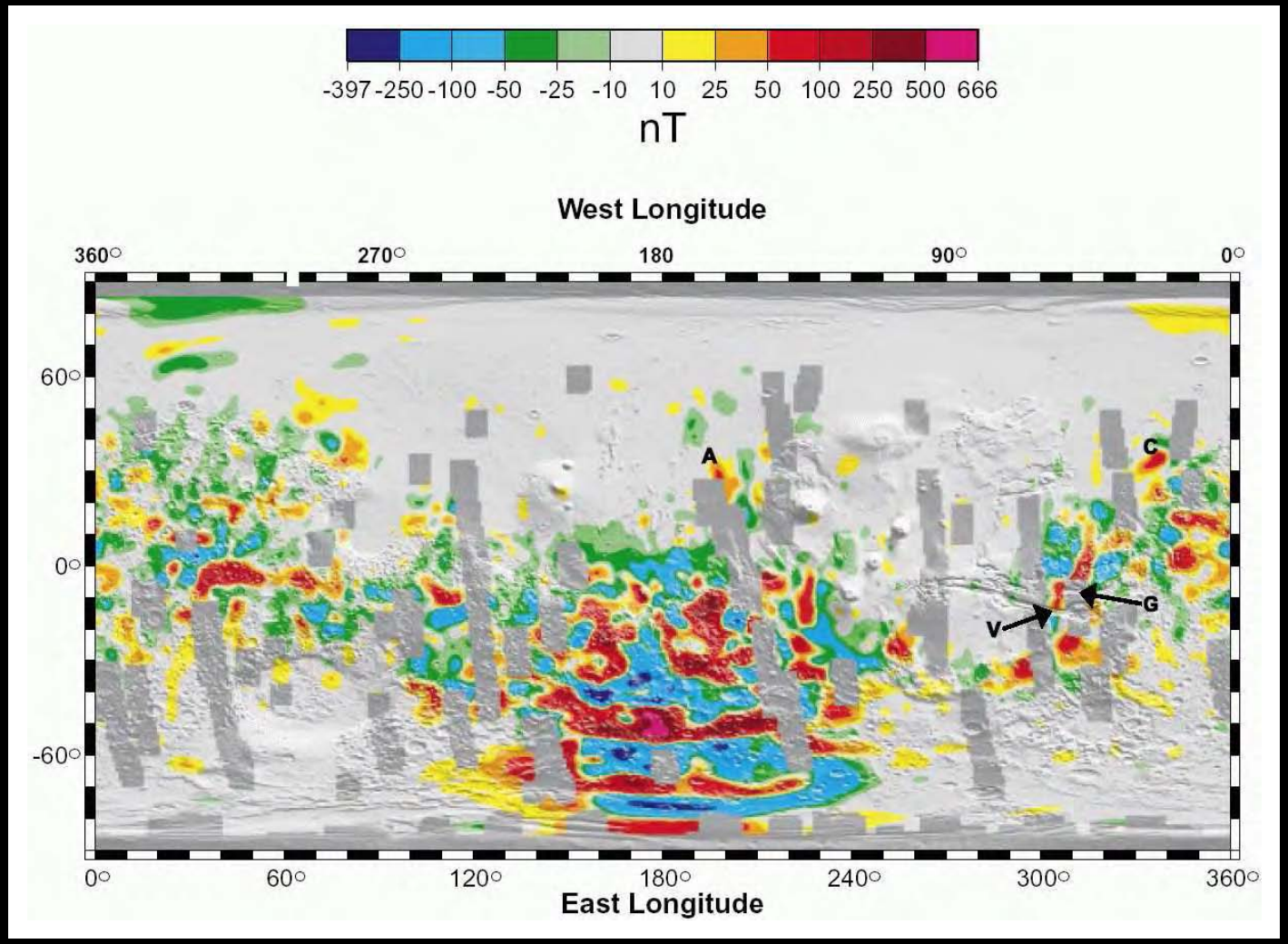


Magnetometric experiment

Vector compensated 3 component fluxgate sensor provided by TU Braunschweig, Germany.

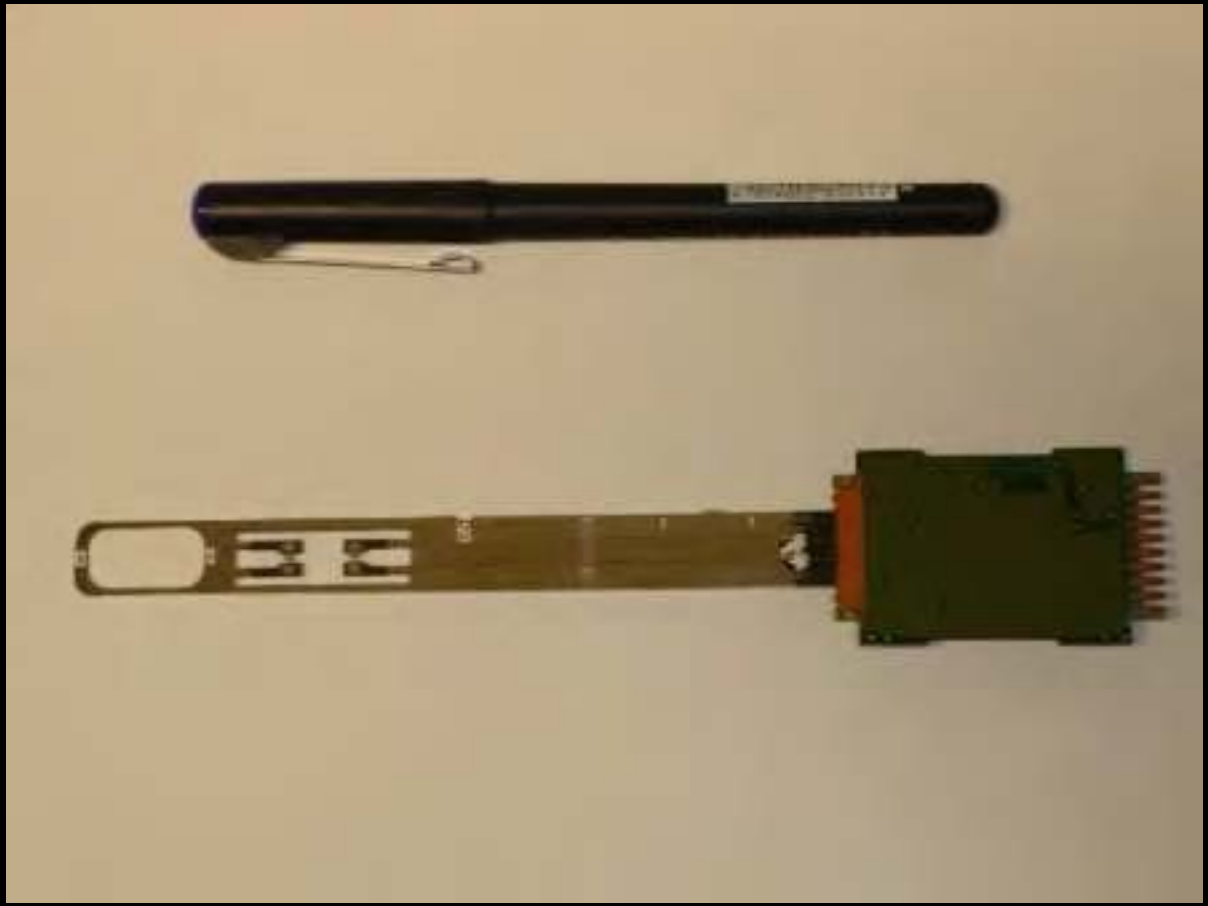


Magnetometric experiment



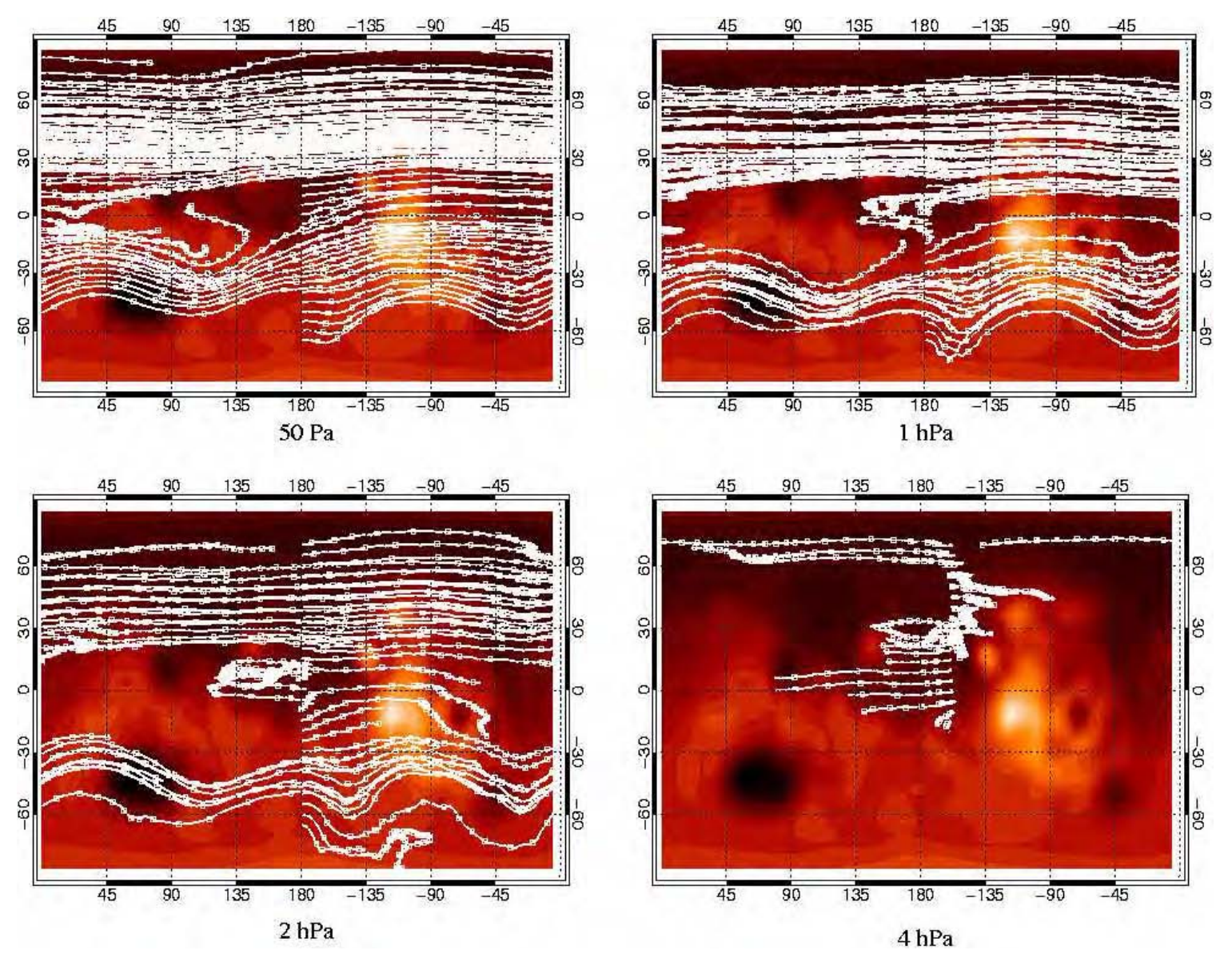
The resolution of magnetic sources on the surface equals the altitude of the sensor!

Direct Environmental Sensing (ATMOS-B)



Compact miniatyre sensor suite accommodating pressure, temperature, and humidity sensors provided by the Finish Meteorological Institute

In situ probing of winds

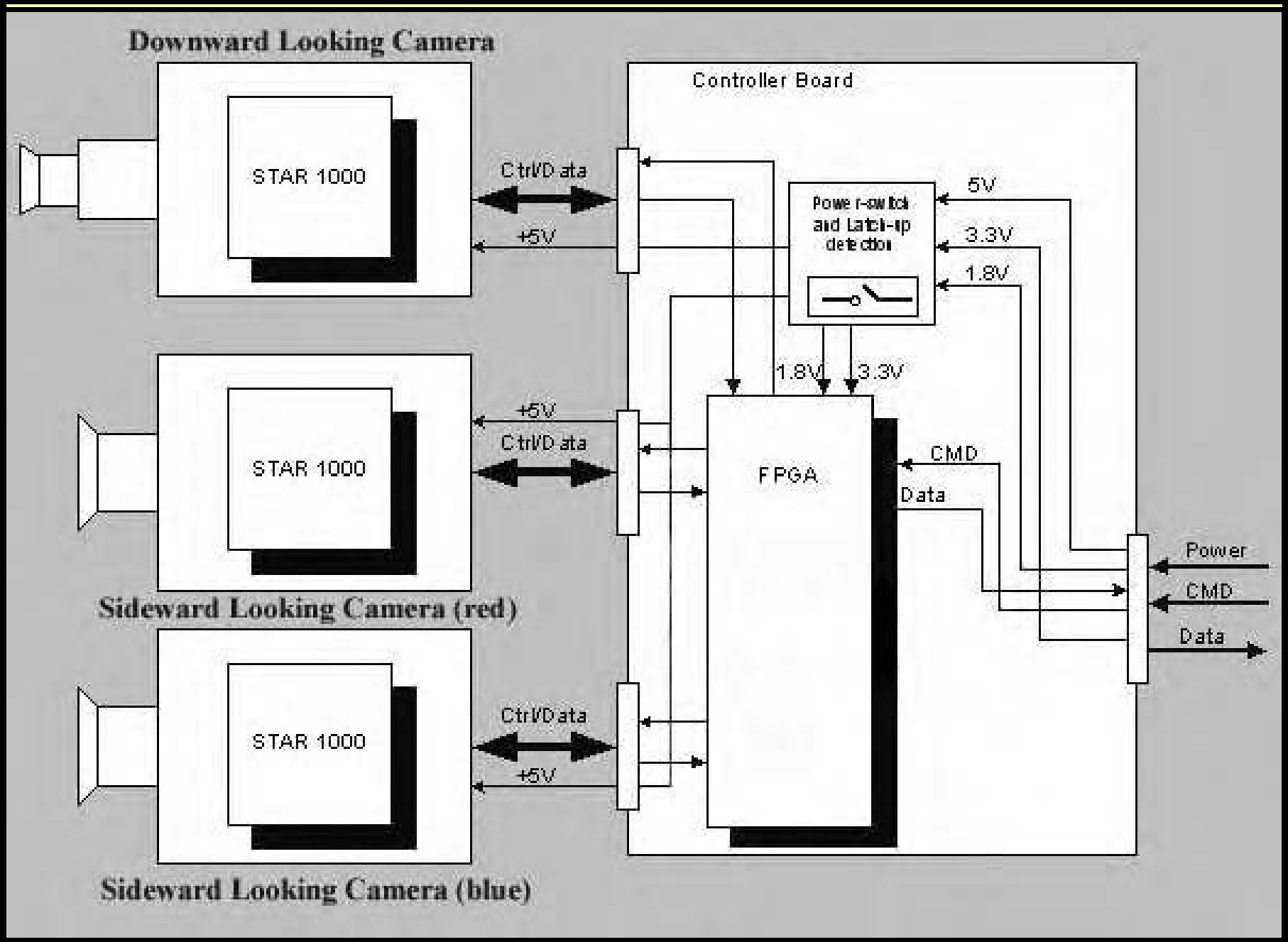


Camera experiment

Two different cameras provided by DLR Berlin, Germany:

	Down looking	Side looking
Pointing:	$< 3^\circ$ out of nadir	75° out of nadir
FOV:	$5.9^\circ \times 5.9^\circ$	$60^\circ \times 60^\circ$
Pixels:	1024×1024	1024×1024
Res. from 7 km:	0.7 m/pixel	> 14 m/pixel
Spectral range:	400–1000 nm	400–530 and 650–750 nm

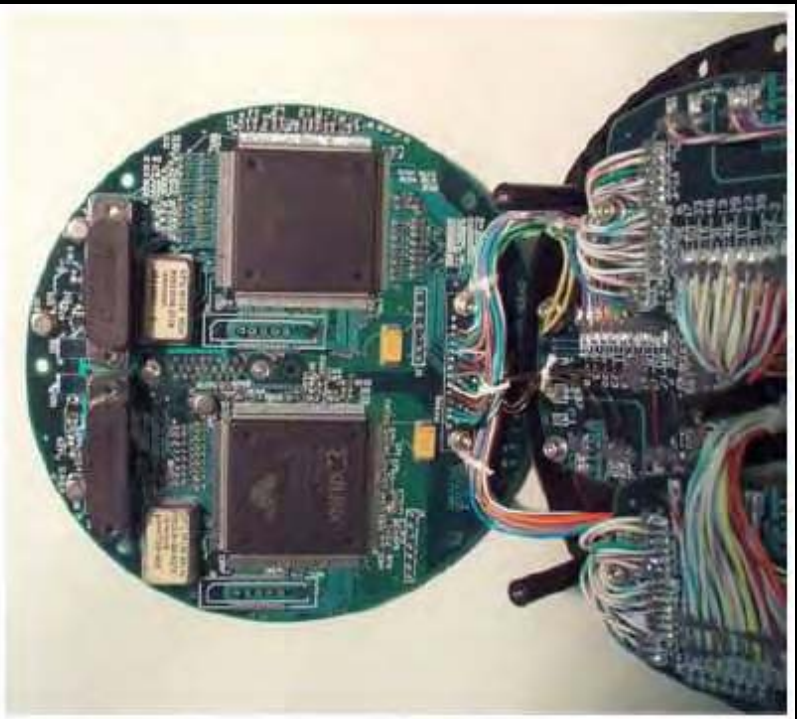
Camera experiment



Camera optics

Side looking camera: Wide-angle lens of the ROsetta Lander Imaging System (ROLIS)

Down looking camera: Optics derived from the ROKVISS Earth observation channel



Part 4: Status and outlook

Ongoing testing programs:

- Flow field and flight dynamics
- Suitable balloon skin materials
- Packaging and deployment
  - Parabolic flight tests
  - (– Sounding rocket flight test)

Inflation test in the Olympia Hall in Munich 21 June 2004

Zero g release test

Parabolic flight test campaign ongoing right now!

Forthcoming milestones

- Decision about the final configuration in the first half of 2006
- Detailed design completed by the end of 2007