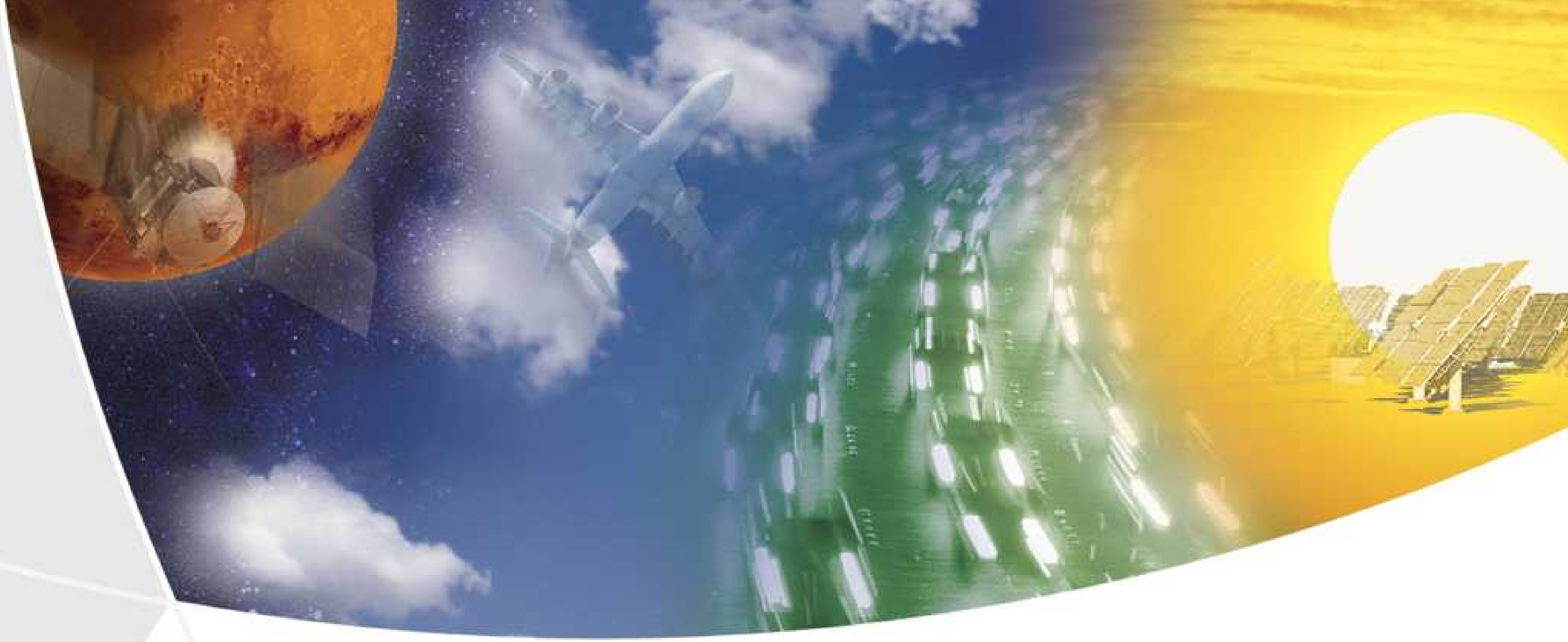


Science benefits for Marco Polo with surface station

S. Ulamec and J. Biele

DLR*, *Germany

Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

Why to have a Lander on a Sample Return Mission

- The prime scientific objective of Marco Polo is to return samples to Earth
- Analytical methods for in-situ analysis, obviously, are less sensitive than those applied in Labs on ground

However:

- There is a need to investigate the asteroidal material in its original environment
- The characterization of the context, from which the samples are taken is important for their interpretation

Scientific Benefits: Categorization

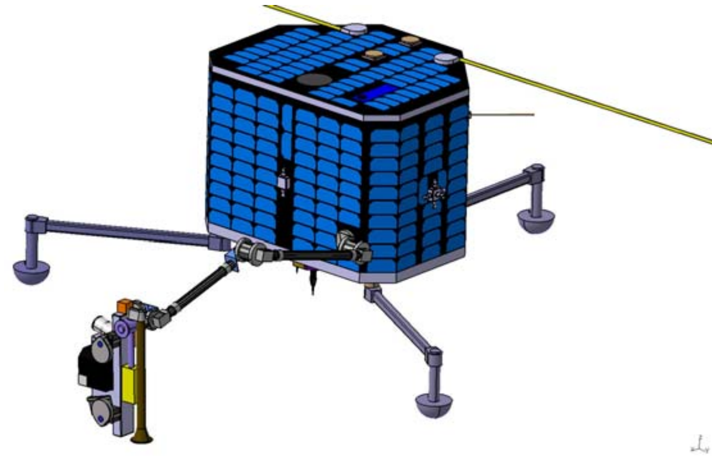
- **Context Measurements**
  - Support in sampling site selection
  - Variability of surface (locally)
  - Characterization of sample alternation during cruise / re-entry
    - Chemical (due to temperature (?), storage)
    - Physical (due to sampling process, compression, acceleration)
- **Ground truth for Orbiter Measurements**
- **Global Characterization of Asteroid**
  - Radio-sounding, together with Orbiter
  - Seismic
- **Long Term Measurements**
  - Radio tracking (Asteroid to Earth)

MASCOT strawman payload: to be revisited, modified and consolidated during the study

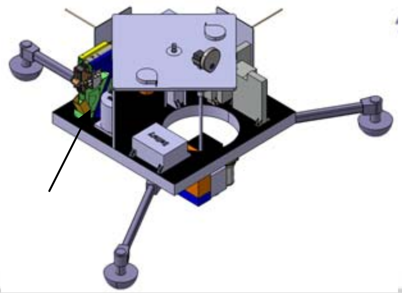
- Context science by the lander instrumentation (Choice and characterization of the sampling site(s))
  - Texture
  - Thermal and mechanical properties
  - Microscale dust & regolith
  - Elemental composition
  - Microscale geology
  - Microscale chemical composition
  - Sub-surface volatiles
- Combined Orbiter/Lander science
  - Radio tomographer (bistatic radar) (geophysics)
- Stand-alone science by the lander instrumentation
  - Geophysical experiments (instrumented mole, μ-seismometer)

Options studied for MASCOT

- In the frame of the MASCOT CEF study at DLR-Bremen, three options for possible Landers were studied:
  (see presentation by Lutz Richter)



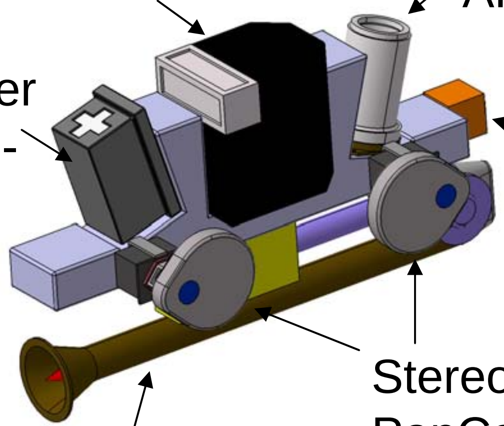
- 95 kg (Philae-size; 3-axis attitude controled)
- 70 kg (Flywheel for attitude stabilization)
- 35 kg



Different lander options considered in CDF study of DLR Bremen

- Option 1 P/L:

Arm-mounted P/L



Instruments	Mass [kg]
APXS (Alpha-Particle-X-ray Spectrometer)	0.7
Raman Spectrometer	1.2
Mössbauer Spectrometer	0.5
Neo-Mole	0.9
EVITA (Evolved Volatiles Ion Trap Analyzer)	0.6
Voldet (Mid-IR ATR spectr., volatile detect., microsc.)	0.2
ILMA (Ion Laser Mass Analyzer)	2.5
XRD (X-ray diffractometer)	2
MicrOmega (Optical microscope & IR spectr.)	0.5
Mikroseismometer	0.3
Stereo/panoramic camera (WAC)	0.8
New Consert	1.8
MPBeacon	1
Laser Retroreflectors	0.5
Σ	**13.5**

Different lander options considered in CDF study of DLR Bremen

- Option 2: ~70 kg, flywheel for attitude stabilization, post-landing mobility by hopping

Instruments	Mass [kg]
APXS (Alpha-Particle-X-ray Spectrometer)	0.7
Raman Spectrometer	1.2
Neo-Mole	0.9
Voldet (Mid-IR ATR spectr., volatile detect., microsc.)	0.2
ILMA (Ion Laser Mass Analyzer)	2.5
MicrOmega (Optical microscope & IR spectr.)	0.5
Mikroseismometer	0.3
Stereo/panoramic camera	0.8
New Consert	1.8
MPBeacon	1
Σ	**9.8**

Different lander options considered in CDF study of DLR Bremen

- Option 3 P/L:

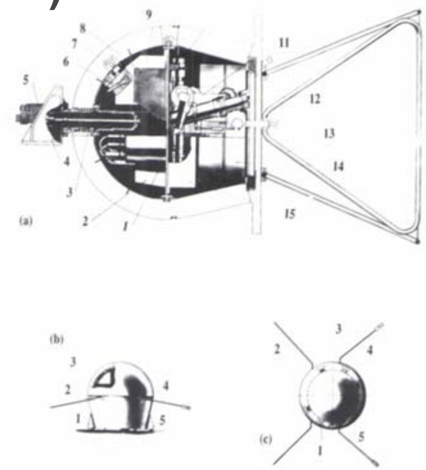
Instruments	Mass [kg]
APXS (Alpha-Particle-X-ray Spectrometer)	0.7
Neo-Mole/HP3	0.9
ILMA (Ion Laser Mass Analyzer)	2.5
MicrOmega (Optical microscope & IR spectr.)	0.5
Mikroseismometer	0.3
Stereo/panoramic camera	0.8
New Consert	1.8
Σ	**7.5**

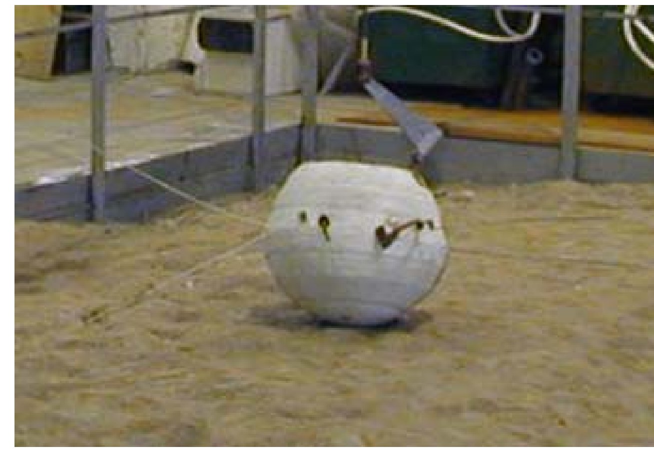
Could we go even smaller ?

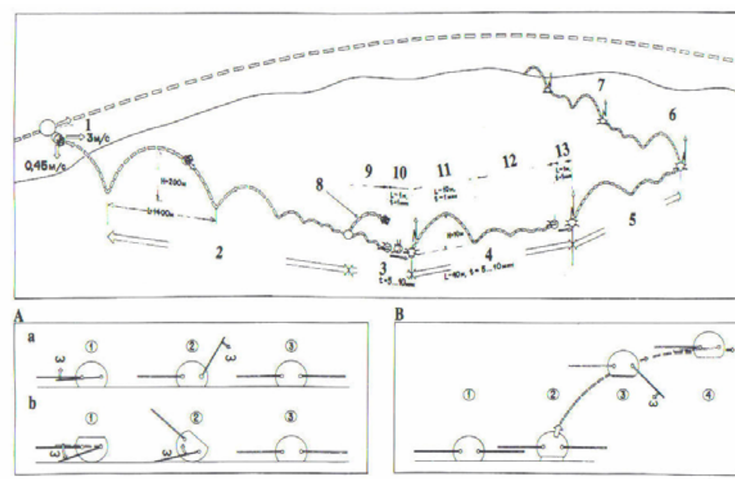
- Smaller Landers (or Surface Science Packages) are, of course, possible (see Minerva !)
- Such devices, however, would have to emphasize on one (two ?) science aspects / instruments only!
- Examples:
  - Analysis Lander (e.g. Raman or ILMA)
  - Investigstion of internal structure (CONSERT)
  - Radio Beacon (long lived; LARA-type)
  - Close-up imager (camera, Micromega)
- A definition of the payload, consequently, shall be done before the respective lander design is studied

Possible Heritage from Phobos Hopper ?

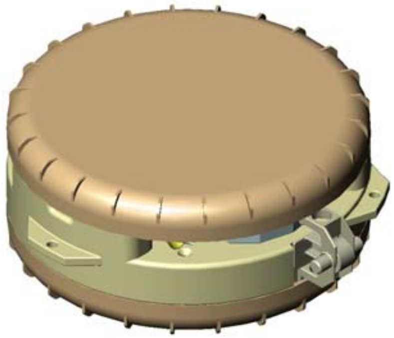
(VNIITransmash / Lavochkin)

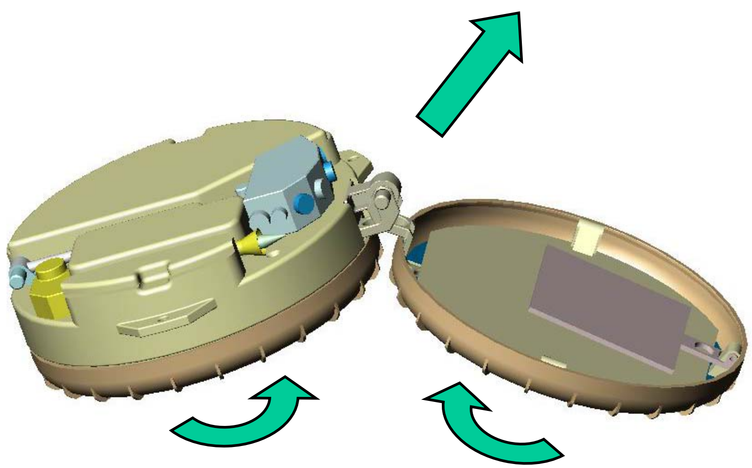




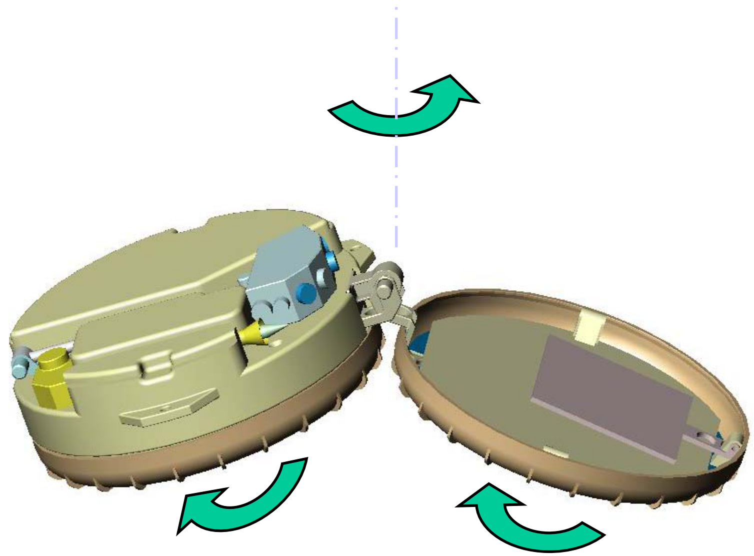


Hopper Concepts (Study DLR/VNII envisaged)



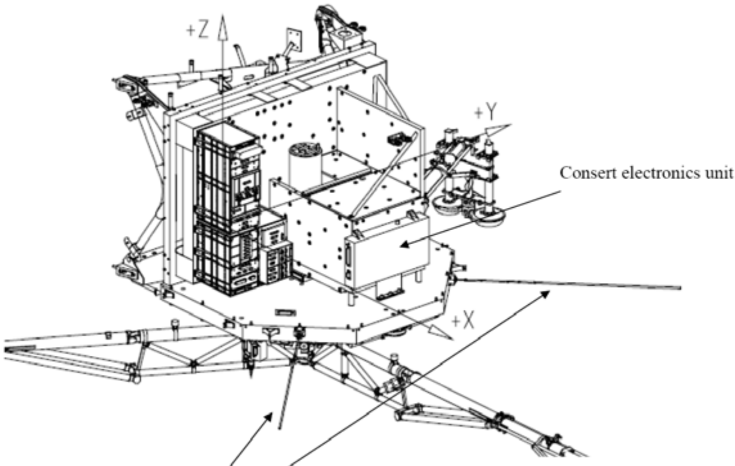


Straight and curved locomotion



Point turning

A 10 kg Option ?



- Possible Scenarios, even with Hopper
- Limited Payload. E.g. CONSERT-only
- Mass estimate:

Structure+Machanism	4 kg
Payload	2 kg
Electronics (CDMS+PCU)	1kg
Communications (/antenna)	0.7 kg (100g antenna)
Power (Batteries, SG?)	2,3 kg

- CONSERT transponder reacts whenever Ping is sent (limited intelligence required; operates whenever power available)
- Mass of elements on Orbiter to be considered ! (2kg + 3kg [instr.])

Summary

- A Lander is, indeed, valuable, also for a Sample Return Mission
  - Redundancy arguments not even addressed...
- Various concepts for various classes of Landers, between 90 kg and 10 kg looked into. All have their justification.
- Decision on Lander Class depending on evolvement of Marco Polo