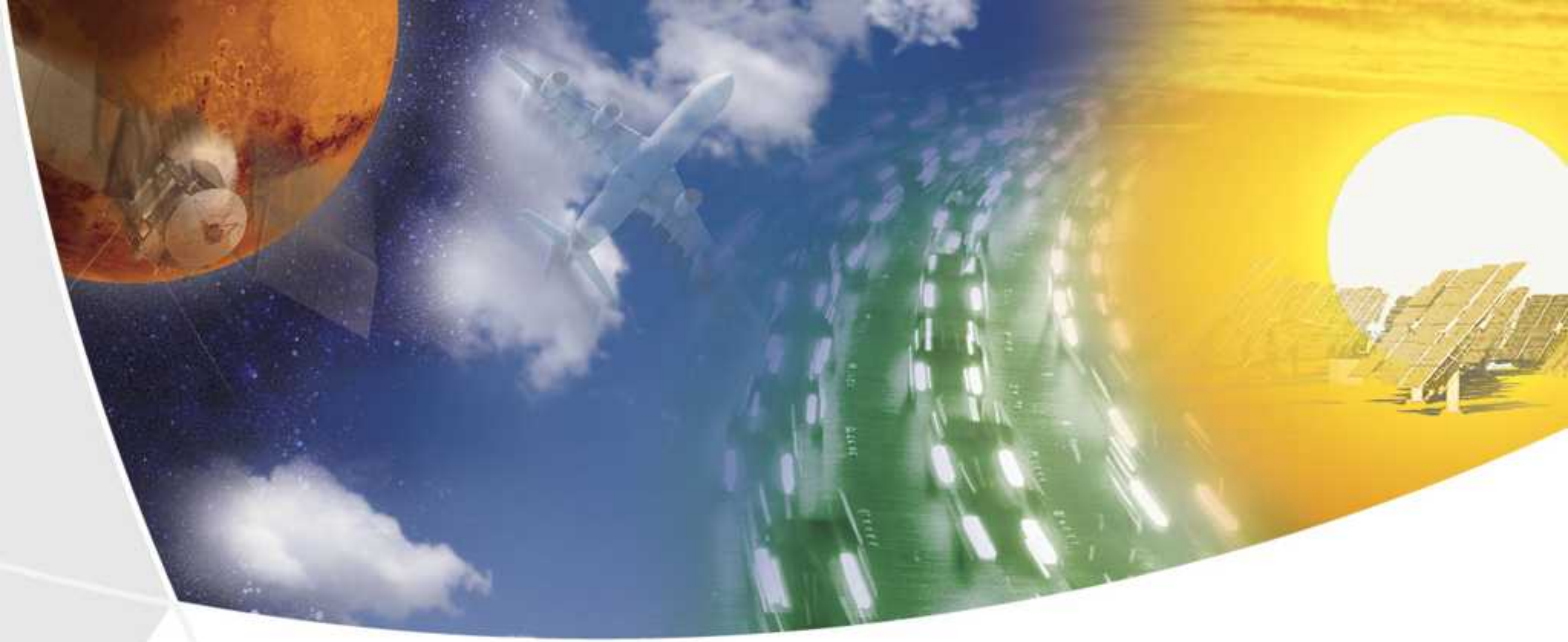


Lander Concepts for MarcoPolo-R

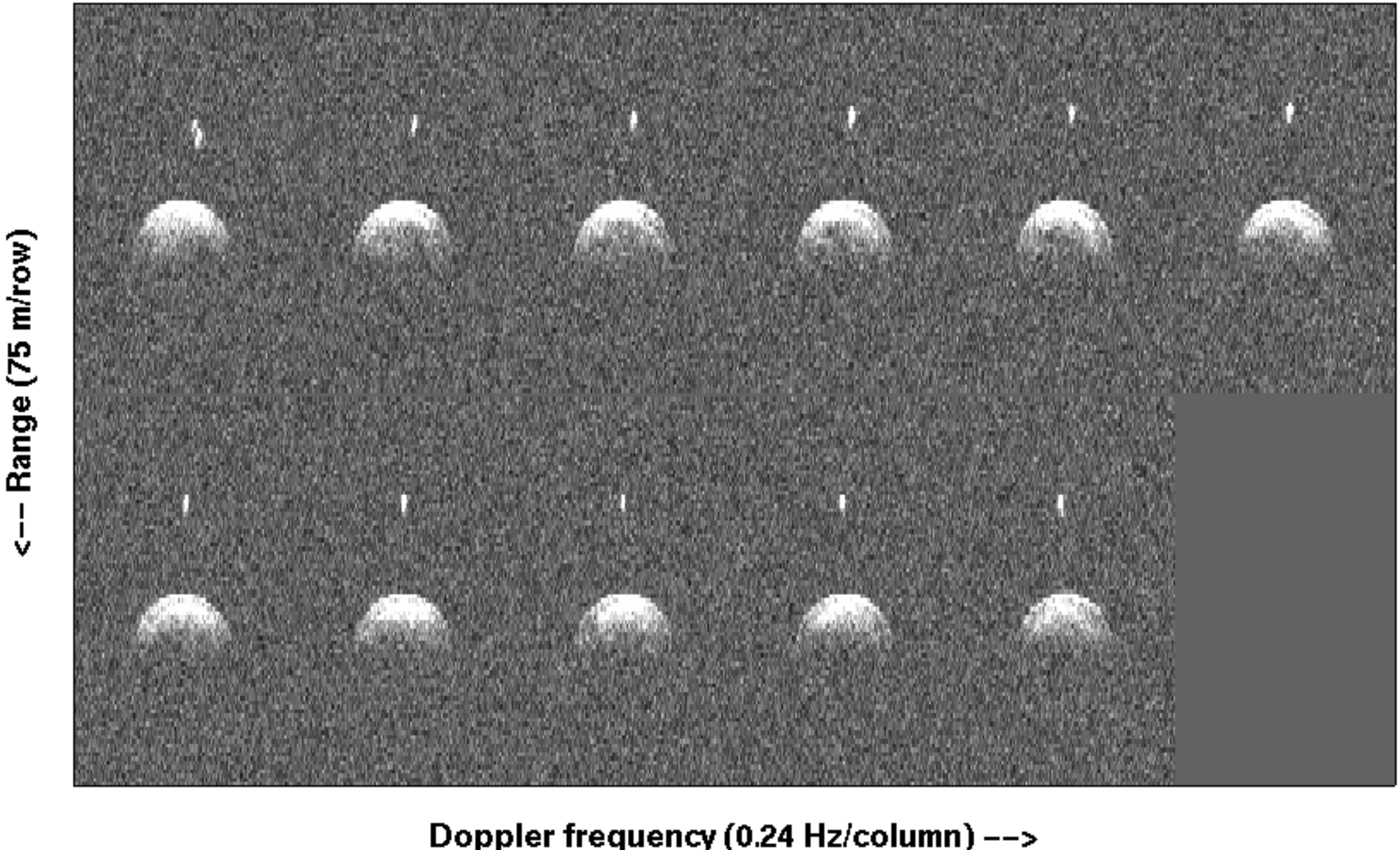
S. Ulamec, <u>J. Biele,</u> H.-W. Hübers,
A. Herique, T. van Zoest, T.-M. Ho ,
C. Krause, A. Barucci and P. Michel

DLR, Germany , IPAG - UJF , Paris Observatory, LESIA,
Côte d'Azur Observatory , France

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

MarcoPolo-R Baseline mission

Arecibo Images of 1996 FG3: 2011 Nov. 22, 0.5 usec x 0.24 Hz, 3 runs/frame



Background

- Surface Science Package is in MarcoPolo-R proposal as Optional Payload
- Various aspects (and possible payload complements) would strongly enhance the scientific outcome of the mission
- Call for Declaration of Interest in Science Instrumentation Cosmic Vision Mission: MarcoPolo-R
  - Two Lander Proposals (both based on the MASCOT bus)
    - MAPOSSI (LIBS, APX, Camera, IR-spectrometer etc..)
    - FANTINA (Imaging Radar, etc..)
  - Additional Instrument Proposals requiring an SSP
  - All rated „category 2“ (high quality – not nominal P/L)

Rationale for a Surface Science Package as part of a Sample Return Mission

- **Context measurements**

  Samples would be taken from only a few (or even only one) dedicated sites from the target asteroid. It is important to identify the context of these particular samples as well as to evaluate the variability of possible samples.
  A mobile lander might even support sampling site selection when investigating several surface areas before the sampling manoeuvre.

- **In situ characterization of surface material**:

  Due to the sampling (e.g. by drilling, grabbing, sputtering etc.) the physical properties (e.g. porosity) of the samples will be modified in a certain respect. Also insertion into a container, as well as accelerations during re-entry and possibly radiation and temperature variations during cruise may cause alteration of material properties. Since the characterization of the original condition on the asteroid, comparative in-situ characterization is important.

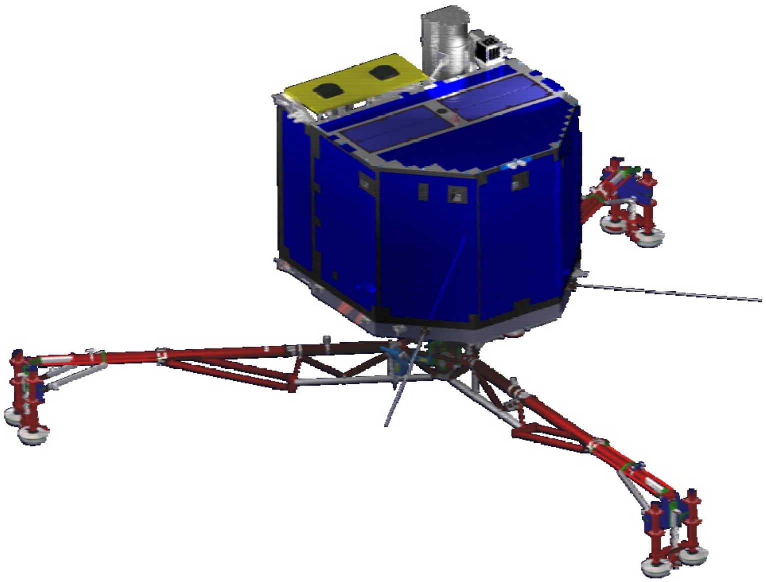
- **Global characterization**:

  Since samples can only be collected at a few dedicated areas, the information they provide regarding the global characteristics of the asteroid or comet are limited. A surface station could well close this gap (in particular, together with the main spacecraft).
  A radar tomographer (see ASSERT) or seismic instruments could fulfil this objective very well.

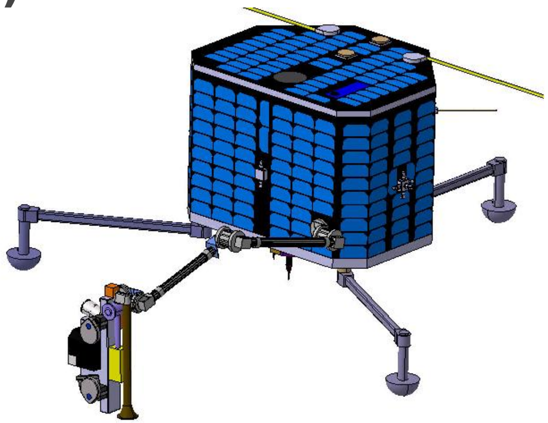
- **Redundancy**

  At least "unofficially", a good point.

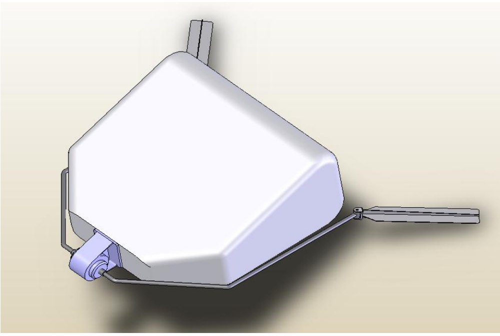
Designs studied (DLR)



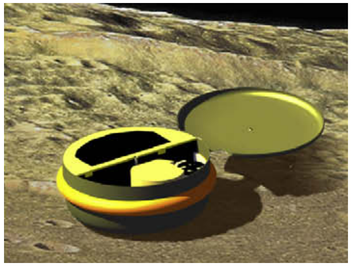
Philae (100 kg)



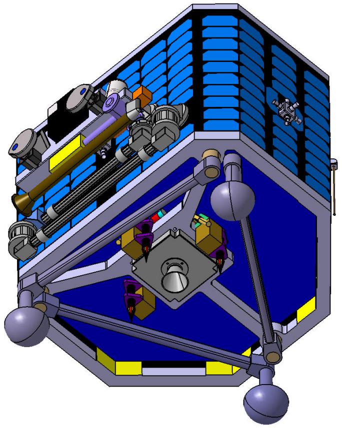
MASCOT (30, 70 kg)

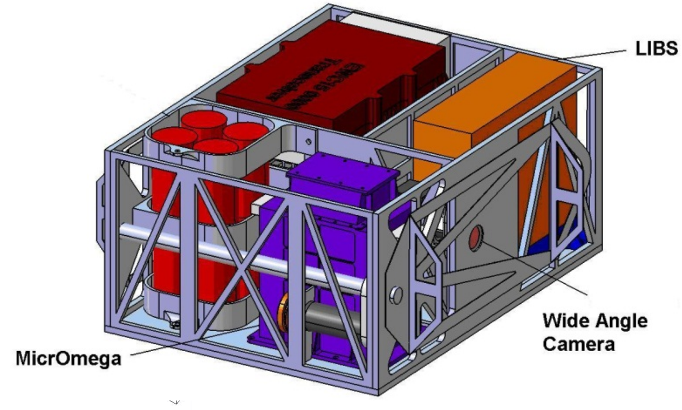


Hopper(10-25 kg)



Leonard

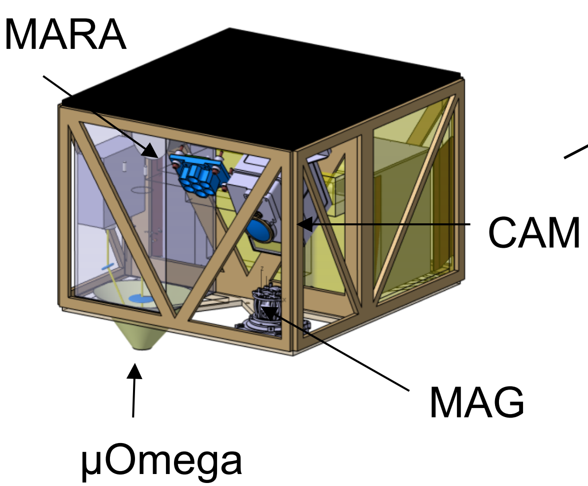




MASCOT (10 kg)

MarcoPolo-R   Proposed Lander Packages

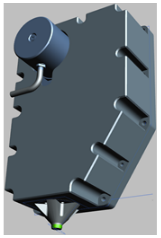
- On the basis of MASCOT (a ~10kg lander for the Hayabusa 2 mission), landers with various instrument complements are studied as optional payload for MP-R



MASCOT

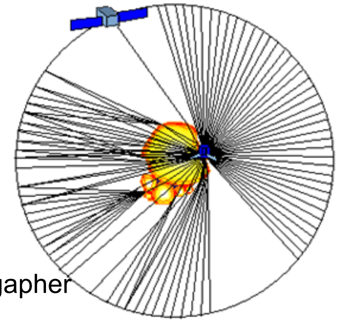
MAPOSSI
- LIBS,
- APX
-Thermal Mapper,
- Mößbauer Spectrometer,
I- R-spectrometer (MicrOmega),
- Camera,
- optional elements

LIBS for ExoMars
© DLR



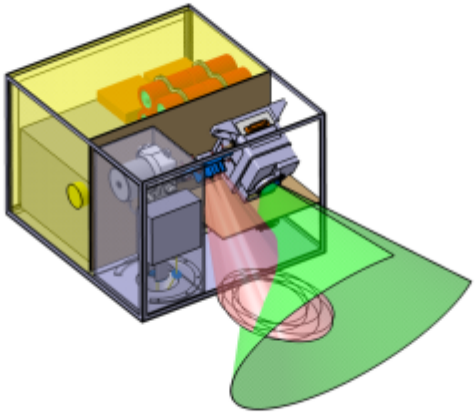
MicrOmega
for MASCOT
© IAS

FANTINA
-Radar Tomographer
- Camera
- optional elements



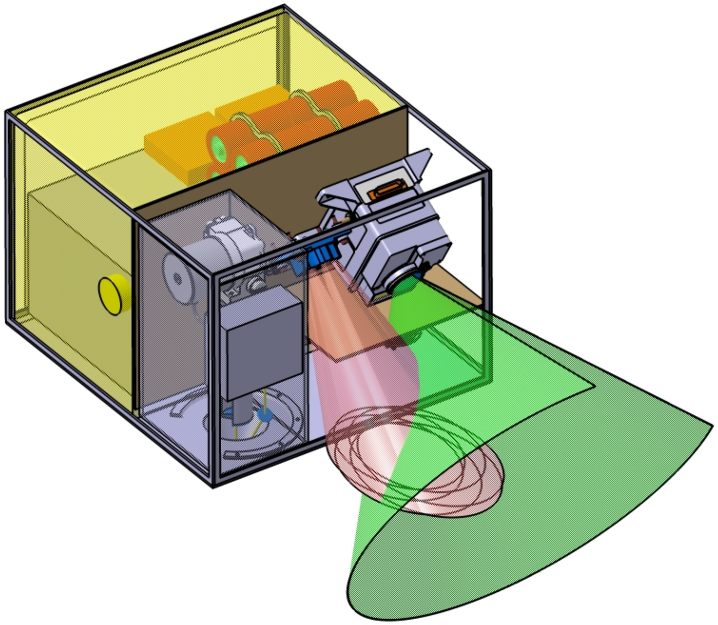
Concept of
Radar Tomogapher
Image: IPAG

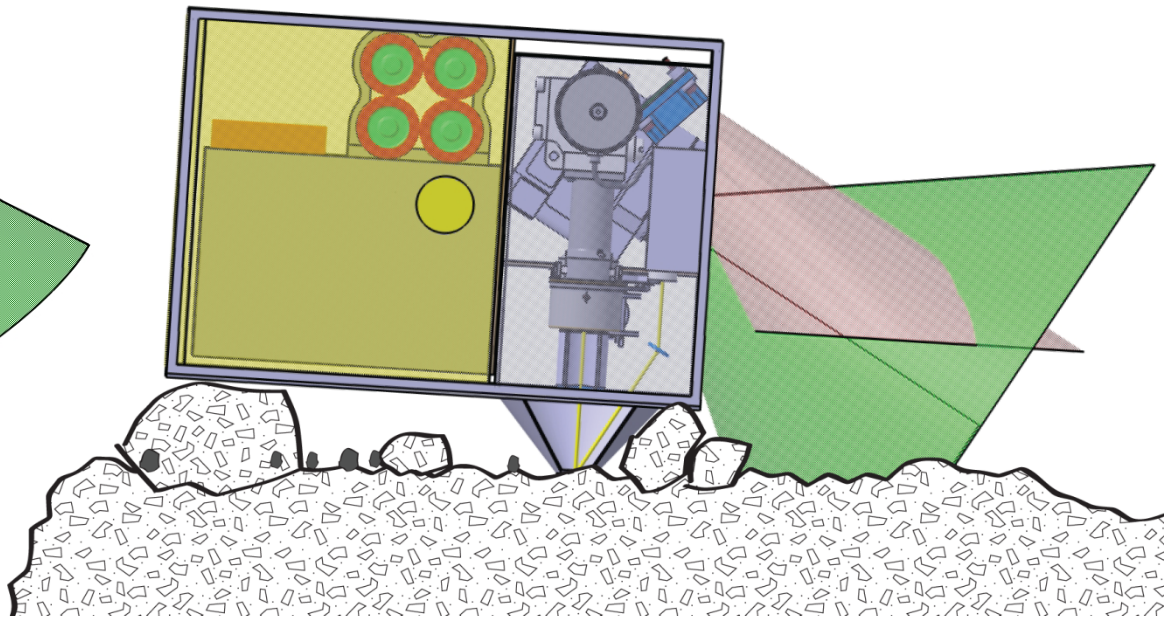
MASCOT Introduction: Objectives



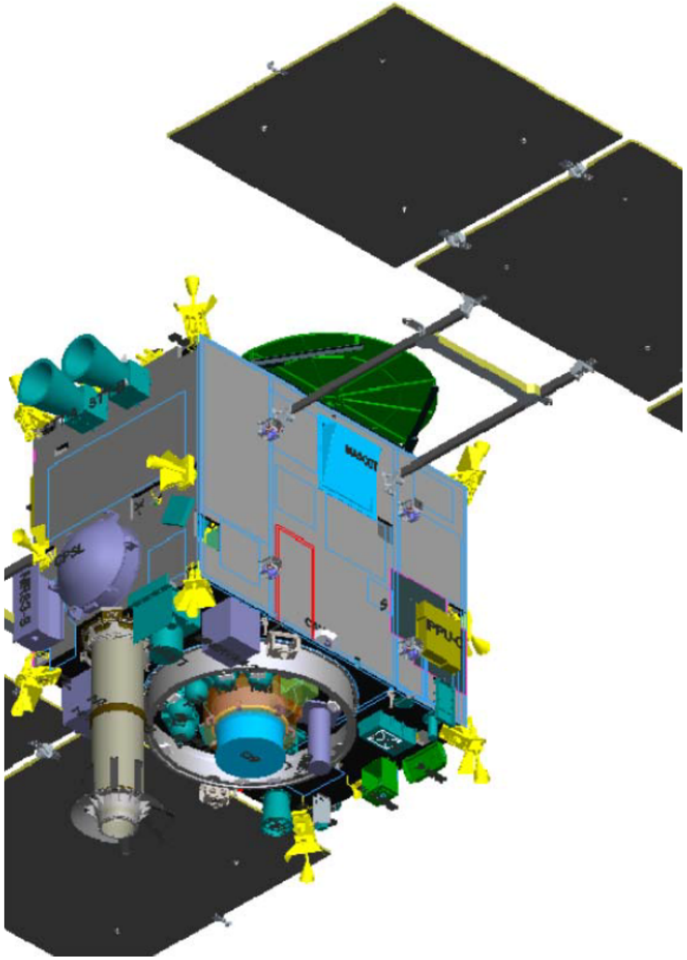
- MASCOT („Mobile Asteroid Surface Scout“)
  - 10kg mobile surface science package for Hayabusa-2
- Measurements of MASCOT PL will
  - accomplish **‘context science’** by complementing remote sensing observations from HY-2 and sample analyses → ground truth info
  - accomplish **‘stand-alone science’** such as geophysics
  - serve as a **‘reconnaissance and scouting’** vehicle to guide the sampling site selection of the main spacecraft
- In-situ analysis of NEA 1999 JU3 with four scientific instruments
  - **I. Wide Angle Camera** to obtain multispectral images of the landing site and provide geological context for MASCOT PL
  - **II. MicrOmega** to determine mineralogic composition and characterize grains size and structure of surface soil samples at μ-scale
  - **III. MARA radiometer** to map NEO‘s surface temperature to determine the thermal inertia → Yarkovsky effects
  - **IV. Magnetometer (MAG)** to determine magnetization of the NEO → formation history

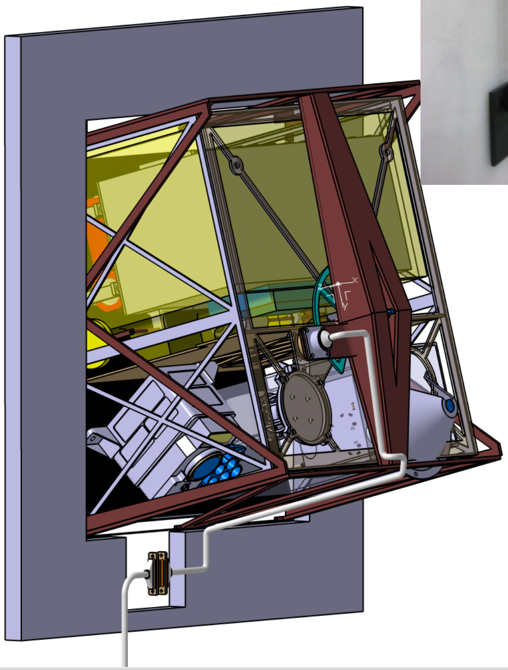
Configuration (Schematic, Payload Accomodation)



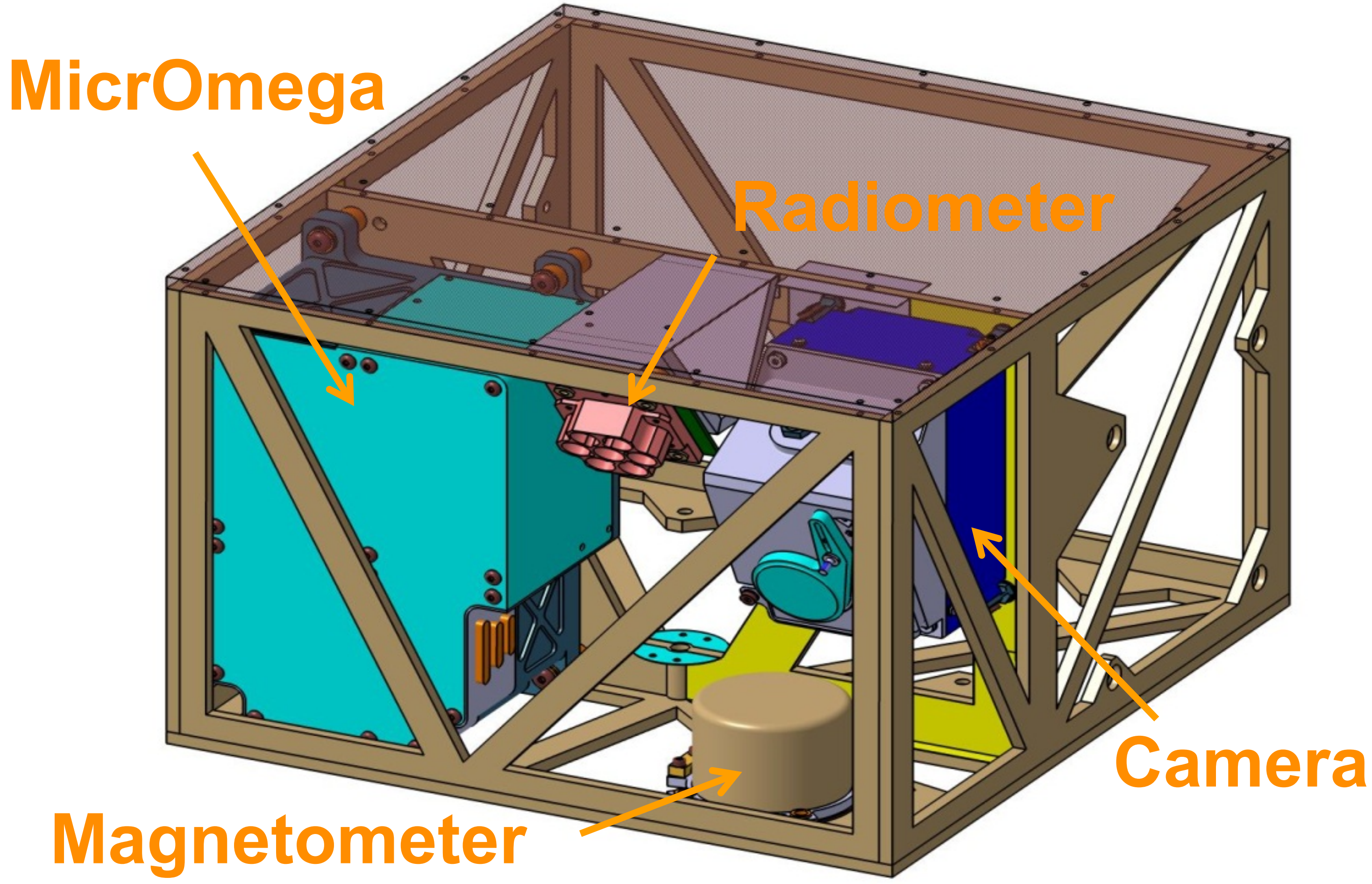


Configuration (Mechanical & Electrical Support System)

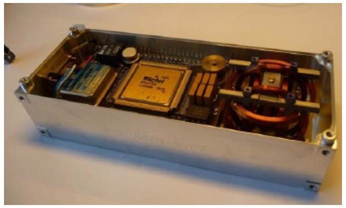
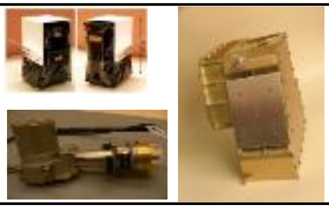
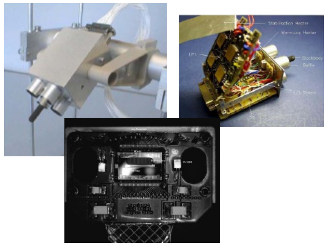
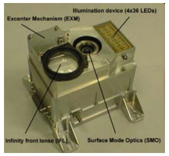




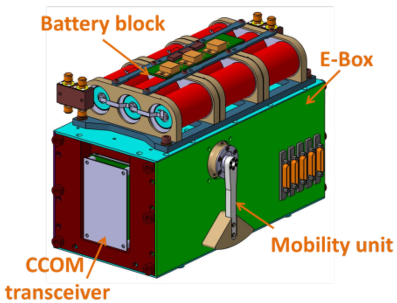
Payload



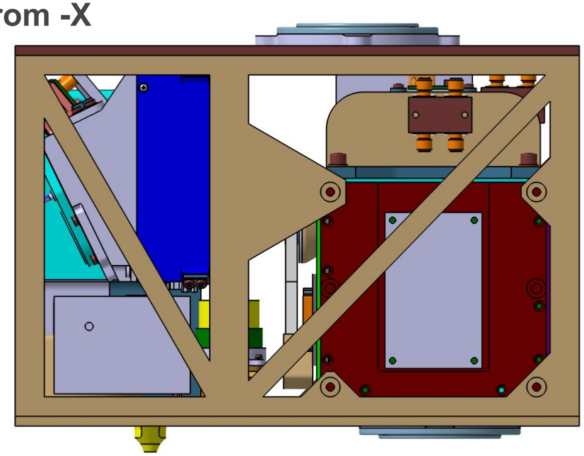
MASCOT Payload

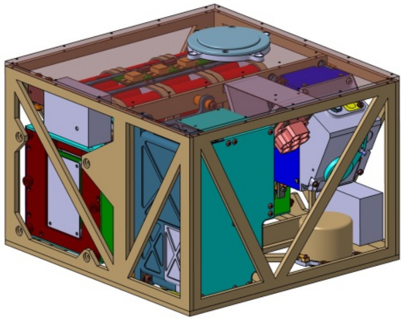
Instrument	TRL	Heritage	Institute; PI/IM	images of heritage flight hardware
MAG	9	MAG of ROMAP on Rosetta Lander (Philae), ESA VEX, Themis	Technical University Braunschweig, K.H. Glassmeier / U. Auster	
MicrOmega	6	ESA ExoMars, Russia Phobos GRUNT, ESA Rosetta, ESA ExoMars rover 2018, Rosetta / Philae / CIVA/MI Infrared hyperspectral microscope	IAS Paris, Jean-Pierre Bibring / Corinne Evesque	
MARA radiometer	8 (5)	MUPUS-TM on Rosetta Lander (Philae); MERTIS-RAD on BepiColombo	DLR PF (Berlin); Matthias Grott	
CAM visible camera	8	ExoMars PanCam heads, Rosetta-ROLIS head, ISS-RokViss head	DLR PF (Berlin); Ralf Jaumann / Nicole Schmitz	

MASCOT Overview: Configuration

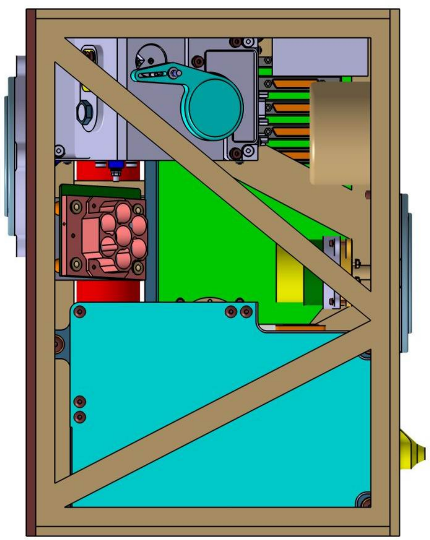


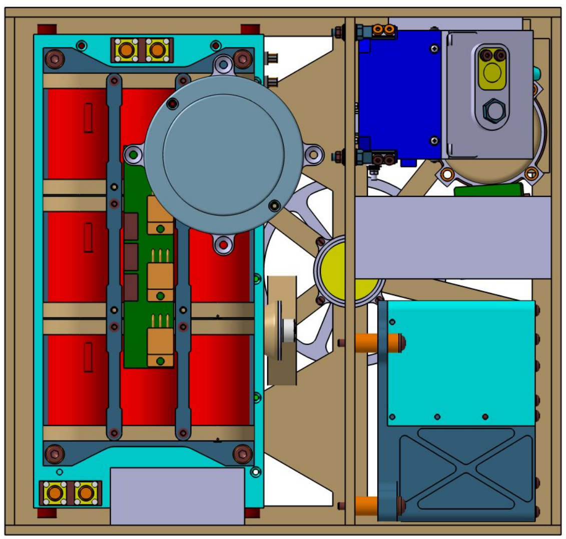
From -X



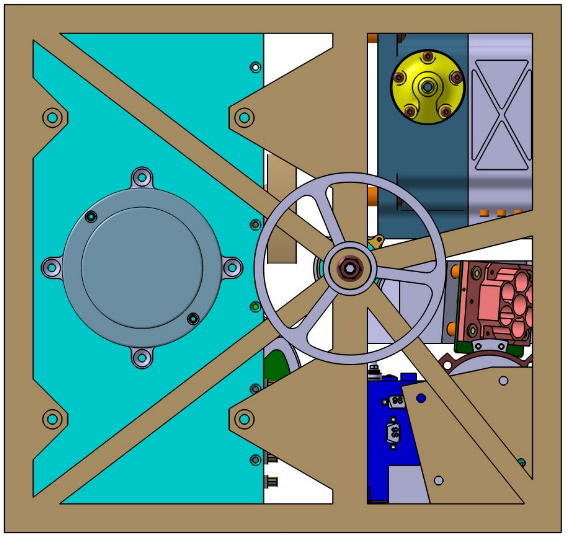


From +Y



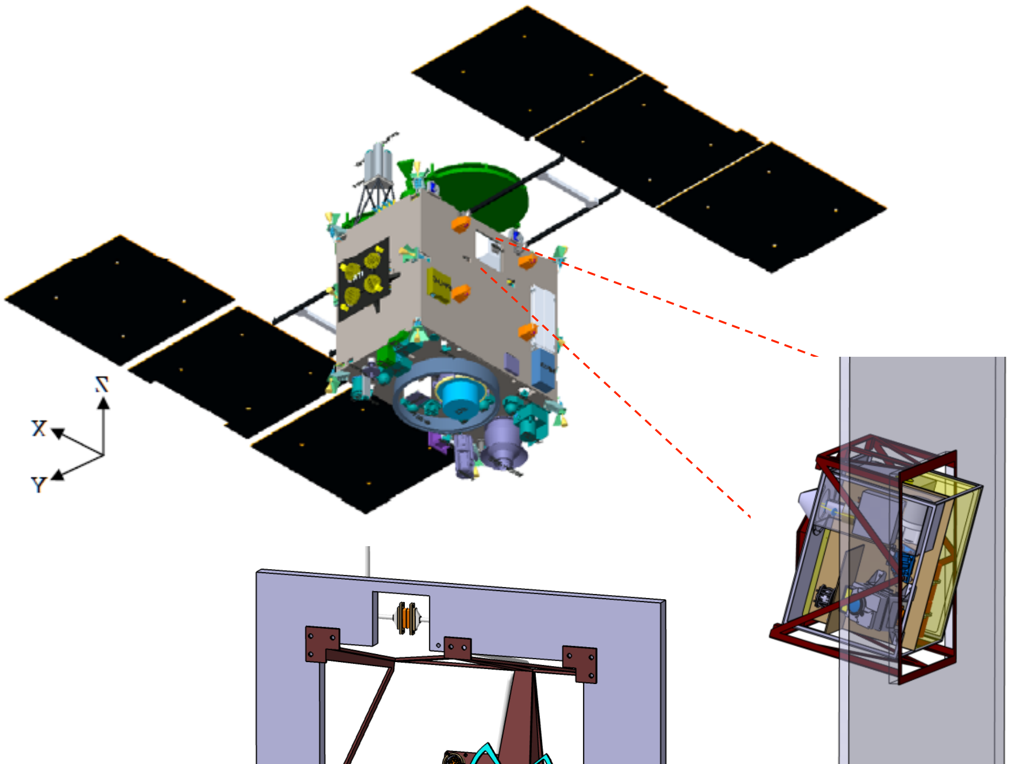


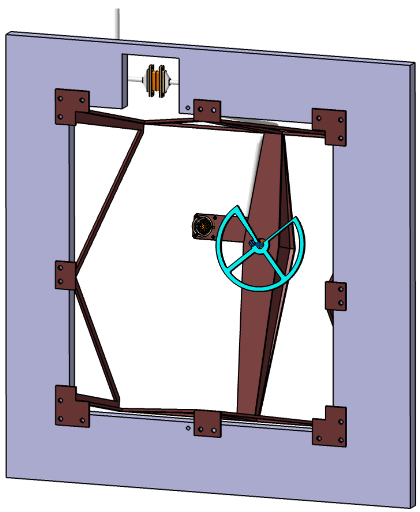
From bottom



From Top (w/o lid)

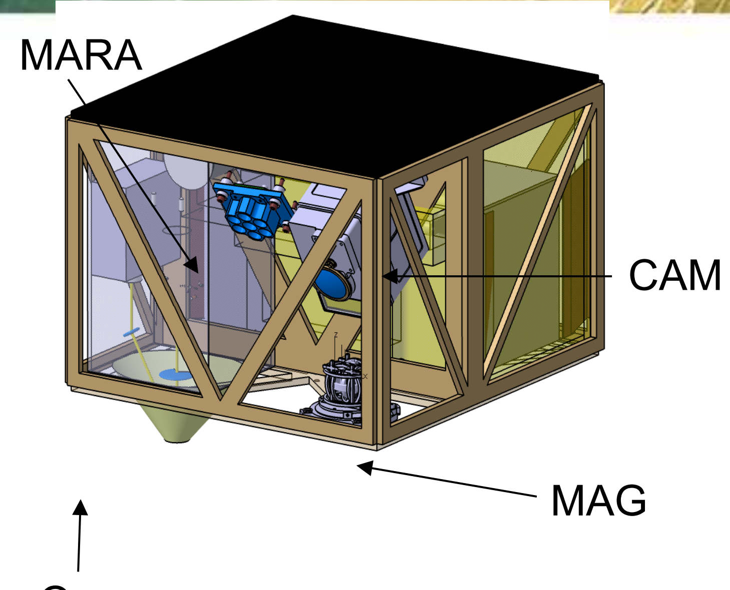
MASCOT aboard Hayabusa 2

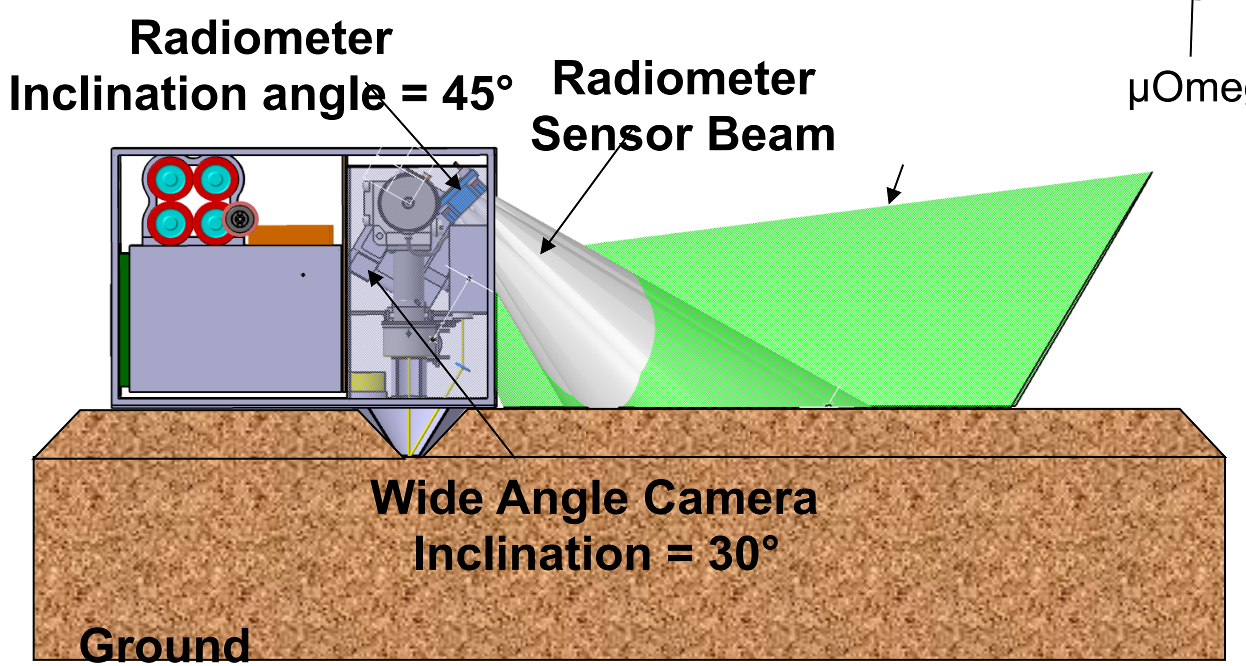


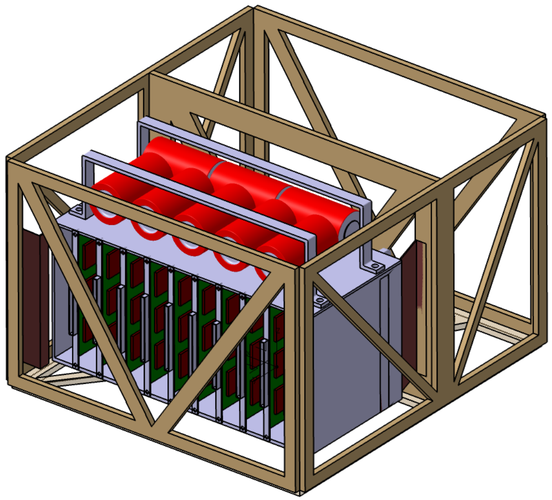


- MASCOT is a contribution to JAXA by 4 DLR Institutes and CNES
- Mounting to main S/C via a mechanical and electrical support system (MESS)
- MSC is attached to MESS via fasteners
- MSC will be deployed under an angle > 15° wrt the –Y axes of the mother S/C
- MASCOT is ejected via non explosive actuators & spring
- Electrical connection to HY-2 via umbilical

MASCOT

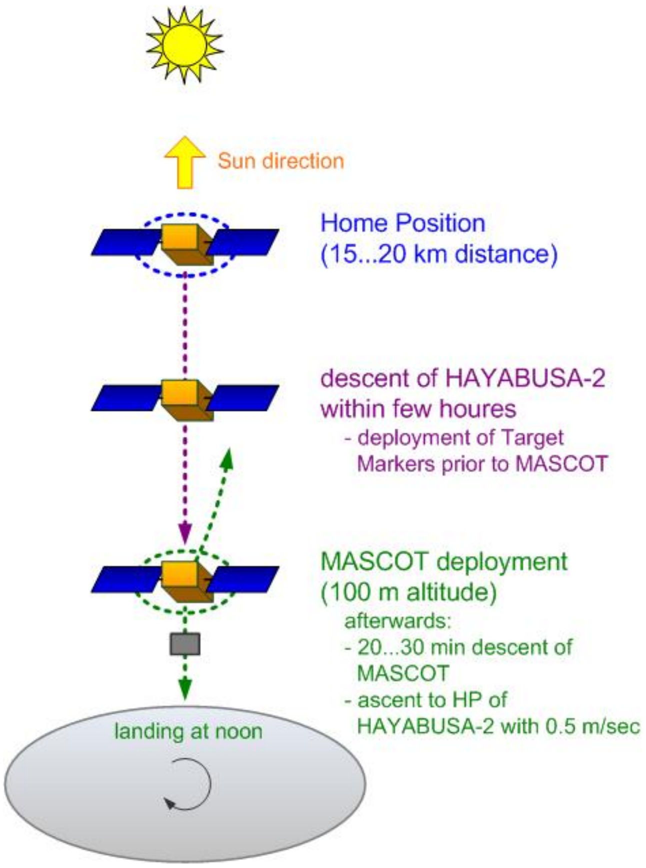

MARA
CAM
MAG
µOmega


Radiometer
Inclination angle = 45°
Radiometer
Sensor Beam
Wide Angle Camera
Inclination = 30°
Ground

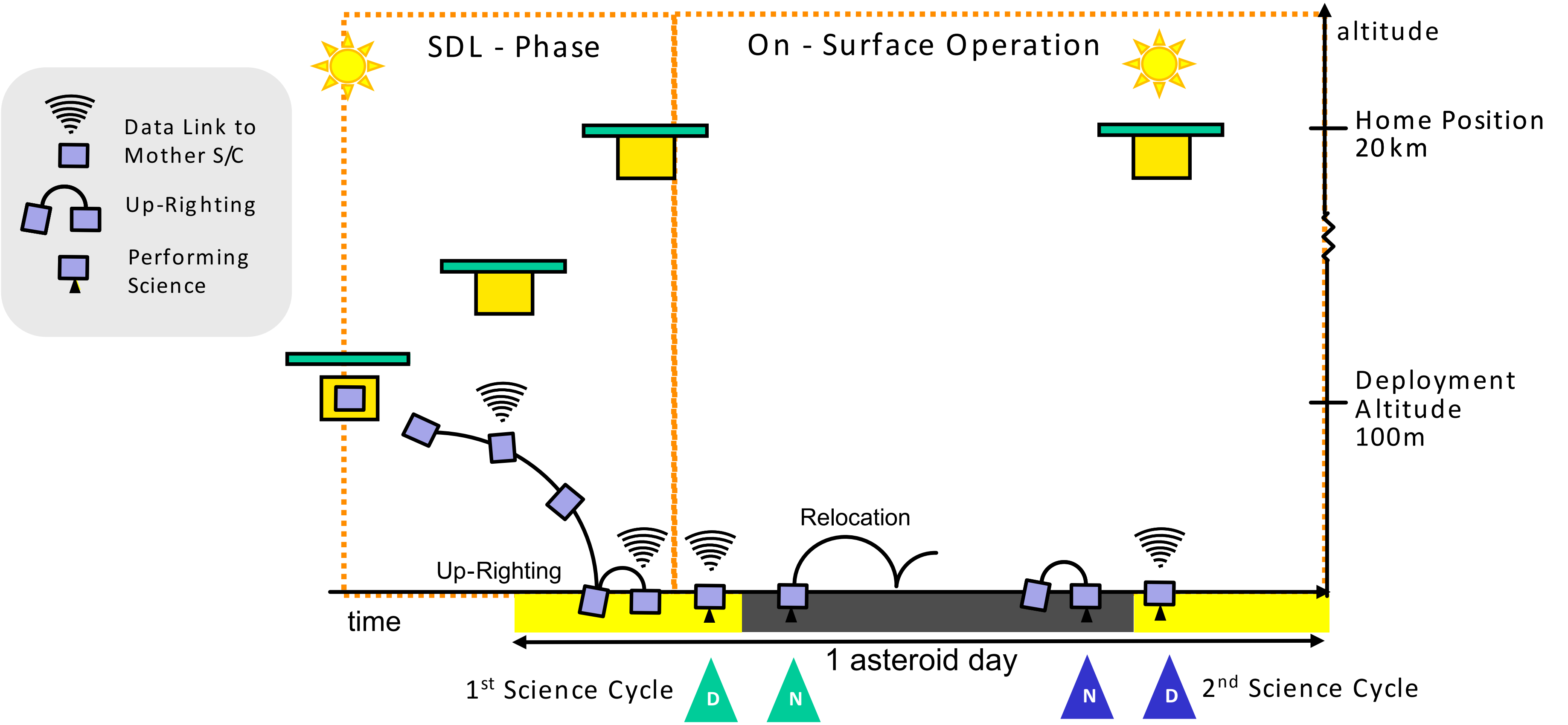


Mission Analysis

- Landing constraints:
  - landing velocity limited to 50% escape velocity → 3 cm/s separation velocity for descent from h = 100 m
  - Surface temperature driving landing site selection
  - Landing time: release around noon (subsolar point +- TBD deg)



MASCOT delivery + surface Ops

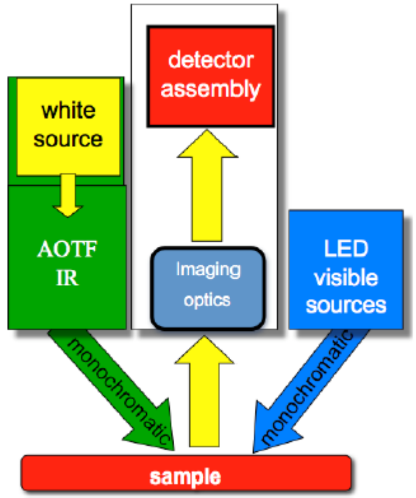


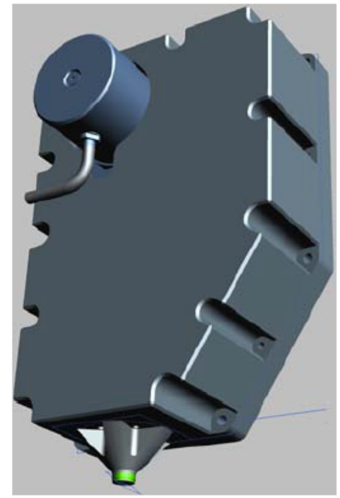
MAPOSSI

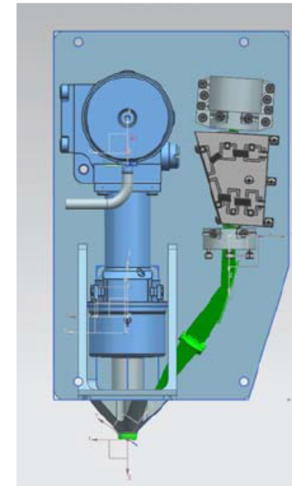
- Coordinator: Heinz-Wilhelm Hübers (DLR-PF, Berlin)
- MASCOT-type Lander with P/L emphasizing on analytical measurements
  - LIBS, APX, Thermal Mapper, Mößbauer Spectrometer, IR-spectrometer (MicrOmega), Camera, optional elements
  - Mobility / Hopping
  - Lifetime tbd

LIBS laser (left) and LIBS echelle spectrometer (right).
Both were developed for the ExoMars breadboard.

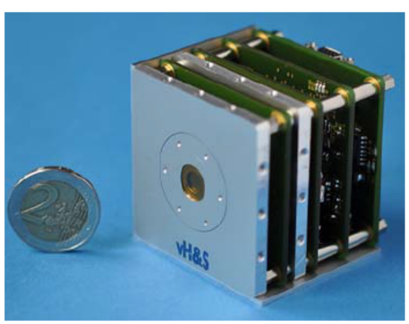
MAPOSSI 2

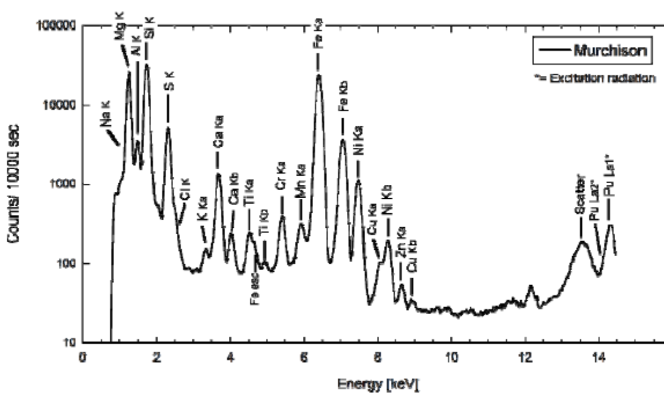






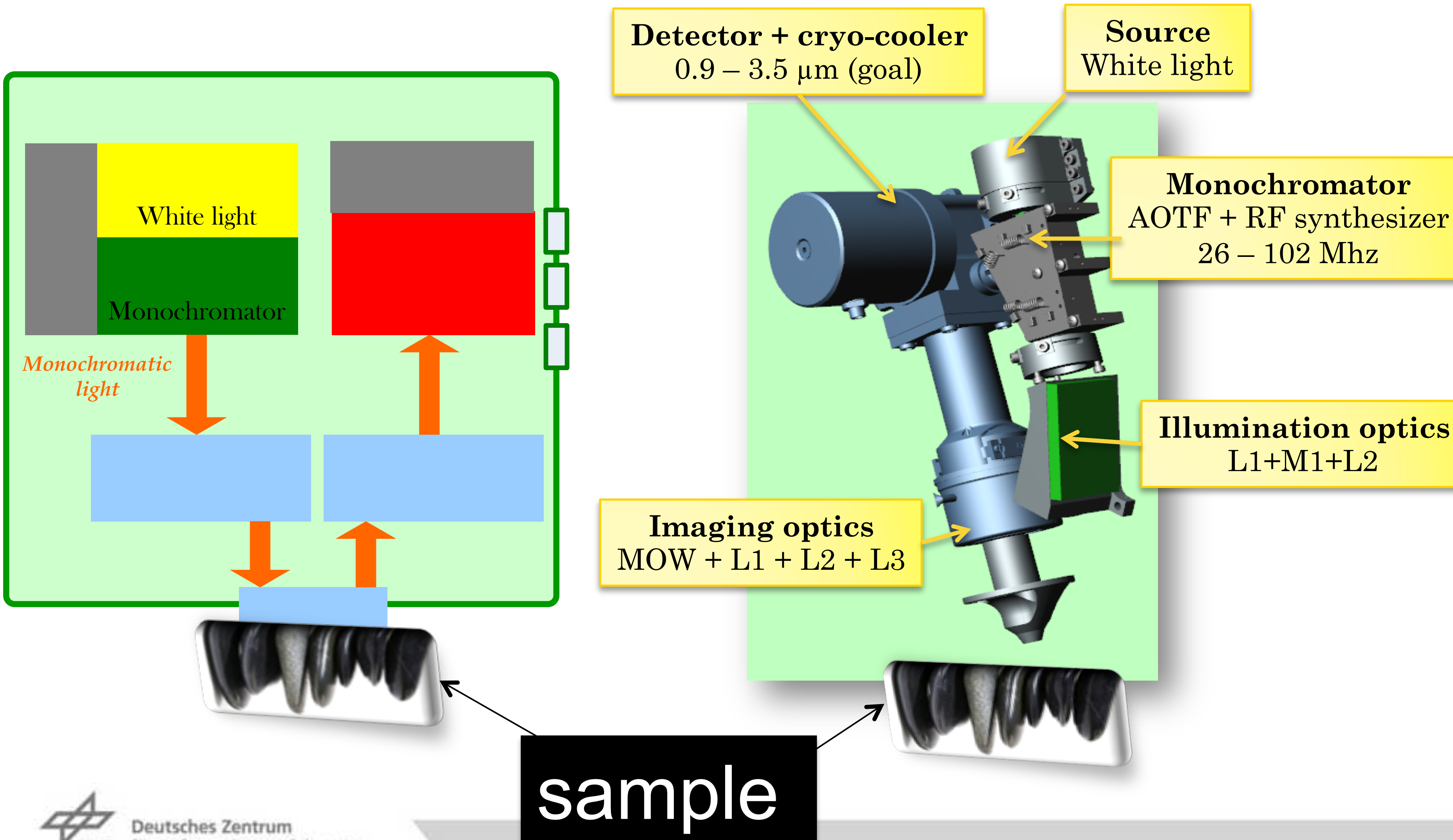
MicrOmega (IAS): Block diagram and (center, right) possible implementation of the instrument/sensor head





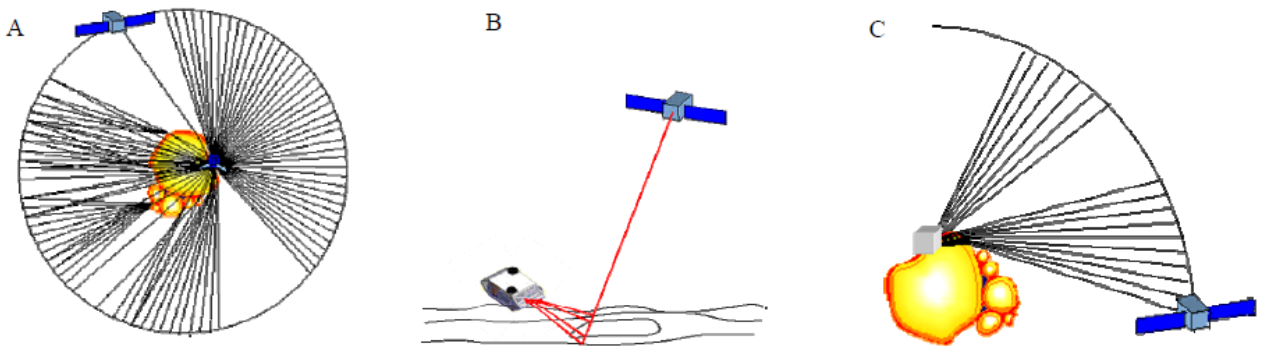
New APXS instrument (50 x 50 x 50 mm³); (right) APXS XRF-spectrum of the meteorite Murchison, taken with the ROSETTA instrument.

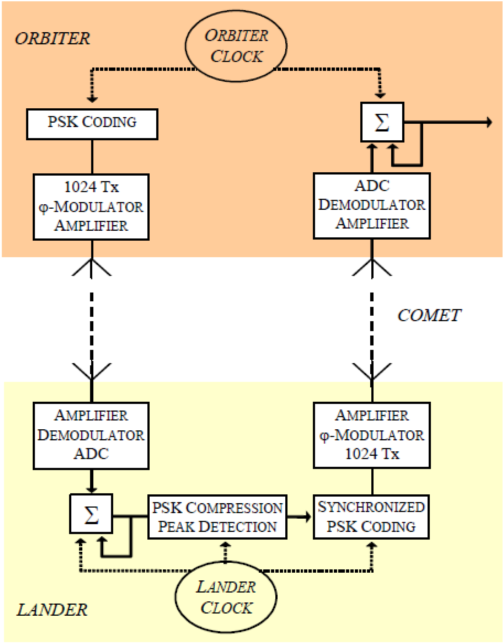
MicrOmega – General Design



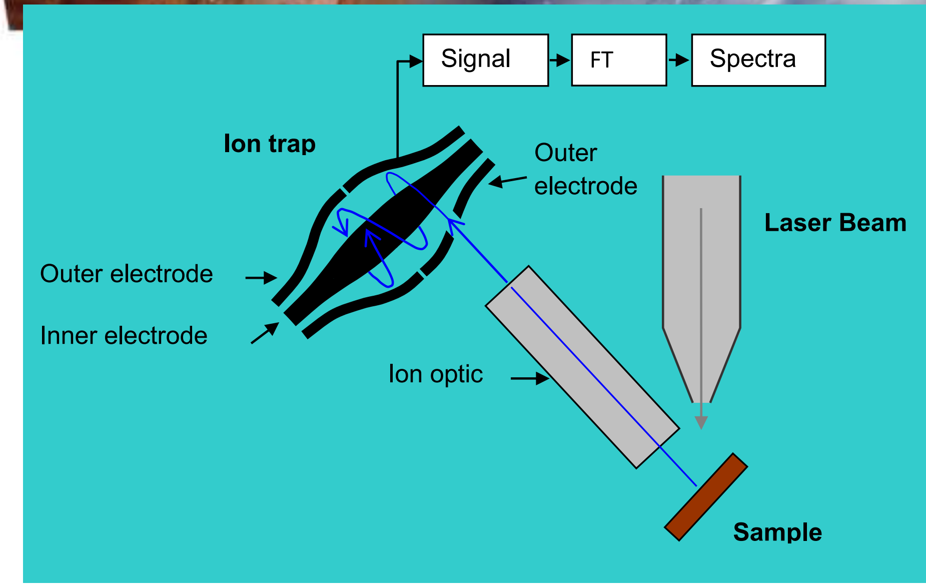
FANTINA*

- Coordinator: Alain Herique (IPAG, Grenoble)
- Bi-static Radar for global characterization (+ tbd optional P/L)
- Heritage from CONSERT (Rosetta) and MASCOT (bus)
- Long-lived





*Fantina was a daugter of Marco Polo; Fathom Asteroids Now: Tomography and Imagery of a NEA

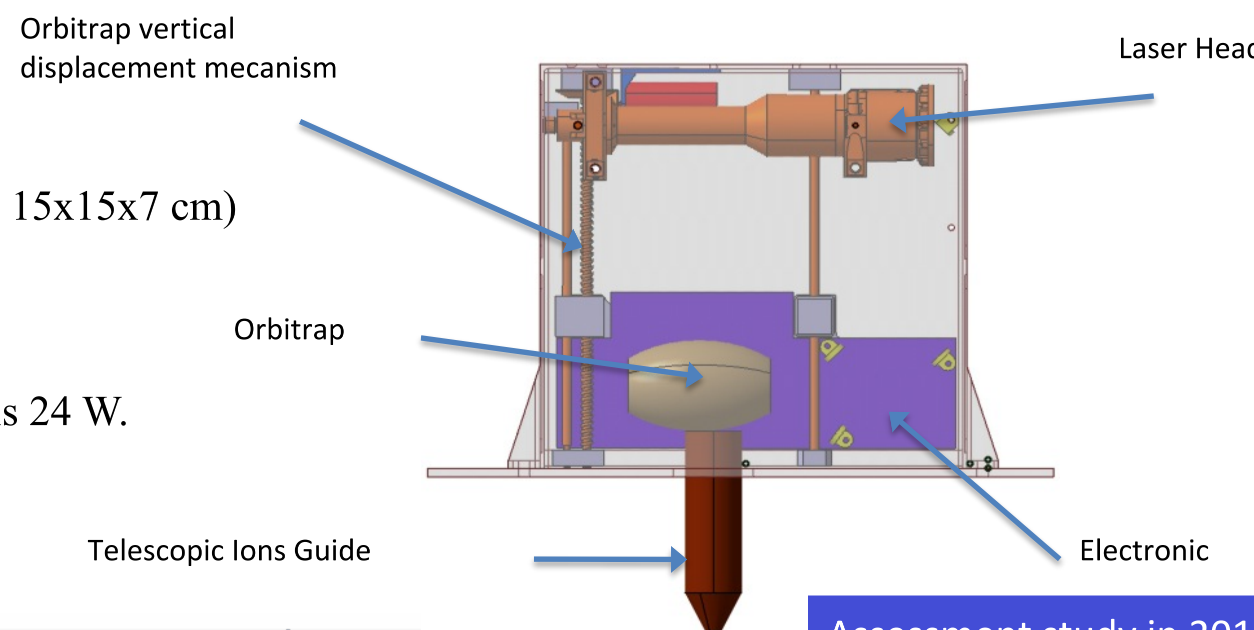


ILMA
Ion Laser Mass Analyser

Ultra High Resolution Mass spectrometer for mineral and organic analysis

Resolution ~ 100 000

Best achieved in space so far: ~ 3 000
(ROSINA onboard ROSETTA)



Volume Properties
15x15x6 cm (+ electronic unit : 15x15x7 cm)
Mass Properties and Budget:
3 kg (including 20% margin)
Power and Energy Budgets:
Maximum power consumption is 24 W.
Data budget:
1Mo for one sample analysis.

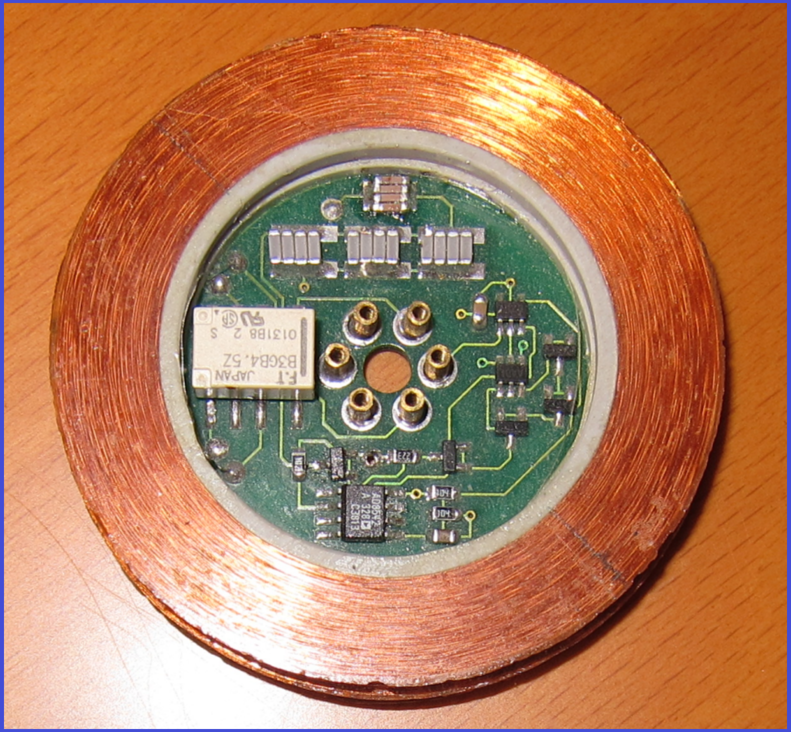
Assessment study in 2012
TRL 5 in 2014/2015

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

MSM – Magnetic susceptibility meter for asteroid regolith composition studies

Purpose:

- Characterization of asteroid regolith composition and its (in)homogeneity through magnetic susceptibility measurements.
- Search for space weathering products (nanophase iron).
- Regolith temperature measurement.



Design:

- Single coil concept
- Low mass (~ 100 g)
- Compact and robust (~ 5 cm, encapsulated coil)
- Low power consumption (< 50 mW)
- Fast measurement (~2-3 s)

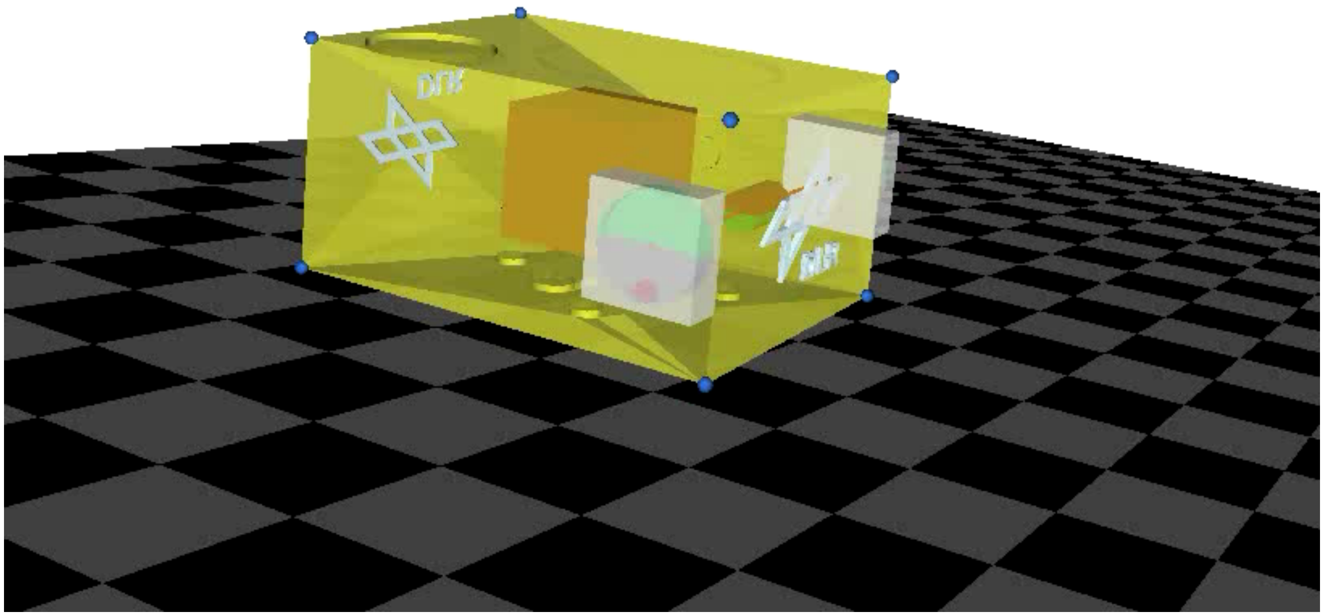
Status:

- The design is based on proven commercial product.
- Development of a space qualified version is ongoing.
- Instrument performance in near asteroid environment is being evaluated.

Various „Classes“ of Landers to be considered

- **Sampling Lander (not analyzed here)**
- **Large, longlived option (like Philae)**
  - In the 100 kg range; 25 kg scientific payload
  - Lifetime in the order of months
    (nota: Philae may die due to dust & thermal environment, this would not apply for a NEO mission)
- **Smaller options (as studied for the „early MASCOT“)**
  - In the 30 to 70 kg range; 10 to 15 kg payload
- **Very small packages (like actual MASCOT design)**
  - 10 kg overall mass; 3 kg payload
  - MASCOT design is short-lived (~16 hours)
  - MASCOT design allows mobility
- **MINERVA type rover** (see presentation by T. Yoshimitsu)
  - ~1 kg

Upright Mechanism



F. Herrmann / DLR-RM

Summary

- Surface Science Packages increase significantly the overall value of any asteroid mission !
  (…explicitly also Sample Return missions)

- Surface packages, based on MASCOT, have been proposed with various payload complements

- Teams are working on instruments and (10kg) lander accommodation.
  Industrial studies shall include lander accommodation!

- A final selection of lander and payload can be taken after MP-R selection and AO process