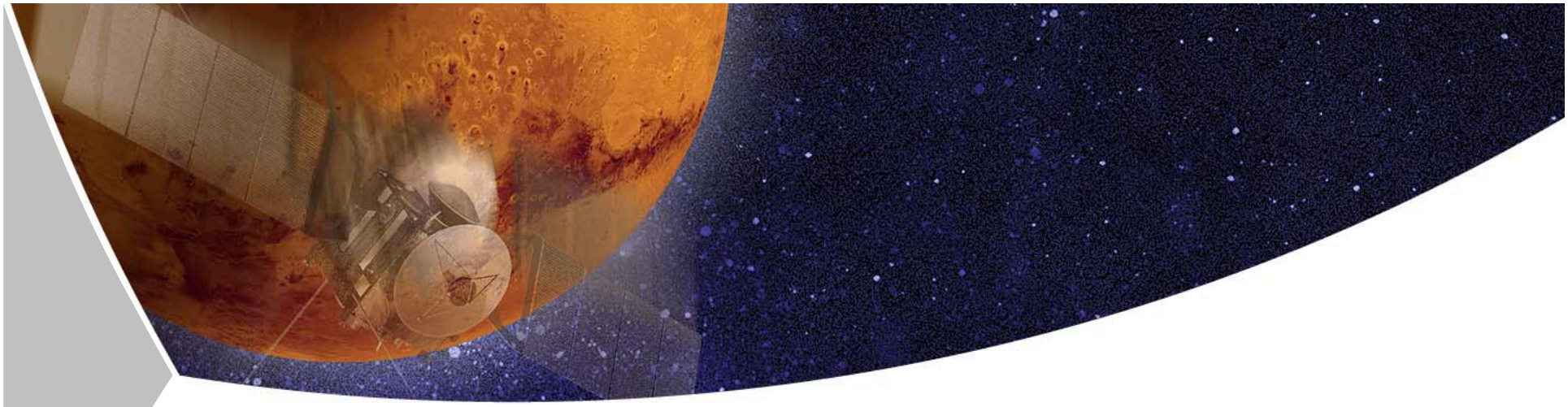

Exploration of Small Bodies – Activities at DLR

S. Ulamec

(DLR. Cologne)

Background

- DLR embedded in Exploration strategy of ESA
- DLR consists of
  - Management (Agency)
  - Research Institutes
- During Ministerial Conference (Nov 21, 2012) ESA programs were signed by National Delegates (incl Germany)

- DLR supports Human Exploration
  - Contributions to ISS
  - Support of contributions to NASA Program, e.g. MPCV

- Activities in robotic exploration of Small Bodies (NEOs and Comets)

DLR Space Exploration Definition & Strategic Considerations

- **Space exploration** encompasses all activities for the preparation and implementation of **robotic and human missions** that will explore other planetary bodies (**particularly Moon and Mars**) and open up opportunities for their exploitation. Thus, exploration **extends the human sphere of influence** beyond the boundaries of Earth into space. To do so, **new developments in technology and infrastructures** are required.

- **German National Space Strategy (2010)**
  - Concentrate human spaceflight on ISS
  - Engage into science-driven robotic exploration
  - Maintain and further discussions with our international partners on future missions (with particular focus on the Moon)
  - Strengthen ESA as European institution

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Post ATV-5 Barter Element – MPCV-SM

Abstract of ESA declaration (21 Nov. 2012):

•Enable ESA to compensate obligations from NASA (ops & transportation cost)

•Manufacturing and delivering to NASA of one integrated Service Module flight unit

•Manufacturing and assembling of certain subsystems required for a second Service Module flight unit

•Providing NASA with related hardware, software & data

•Participating in NASA boards, including, but not limited to MPCV Project Control Board (MPCB)

•providing support to ground and flight operations for the MPCV mission

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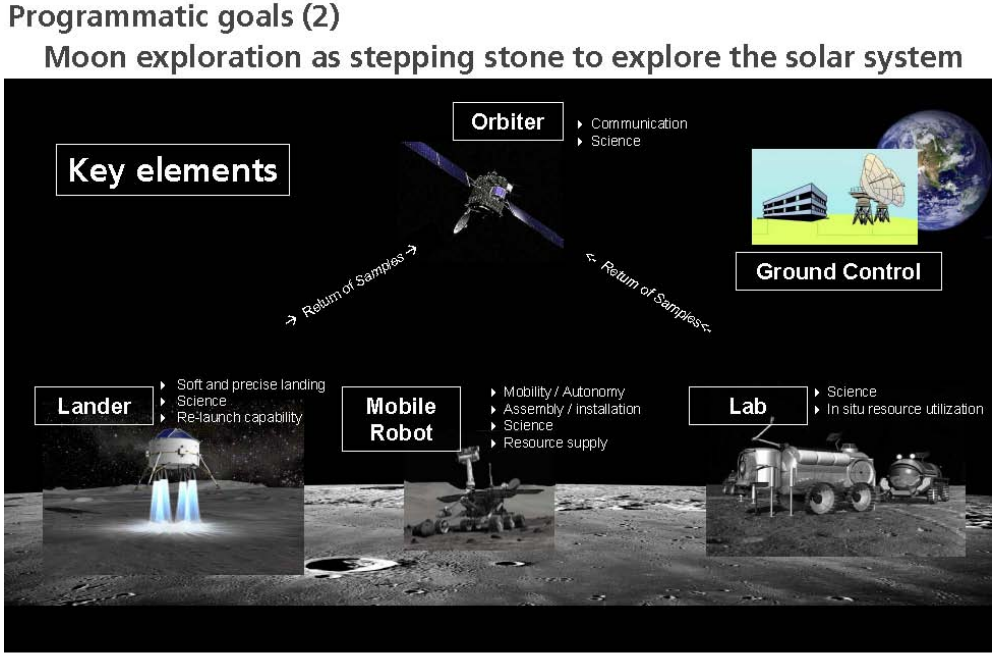
Automation & Robotics

- German Robotics Strategy as technology motor between space and terrestrial applications
- Key technologies through robotic exploration with focus on
  - Planetary mobility
  - Robotic manipulation
  - Sensorics, GNC, vision systems
  - Multi-robot systems
- Current Mission Elements
  - Philae (ROSETTA)
  - MASCOT (HAYABUSA-2)
- DLR facilities for ground testing and verification
  - LAMA
  - EPOS
  - Rover Testbed



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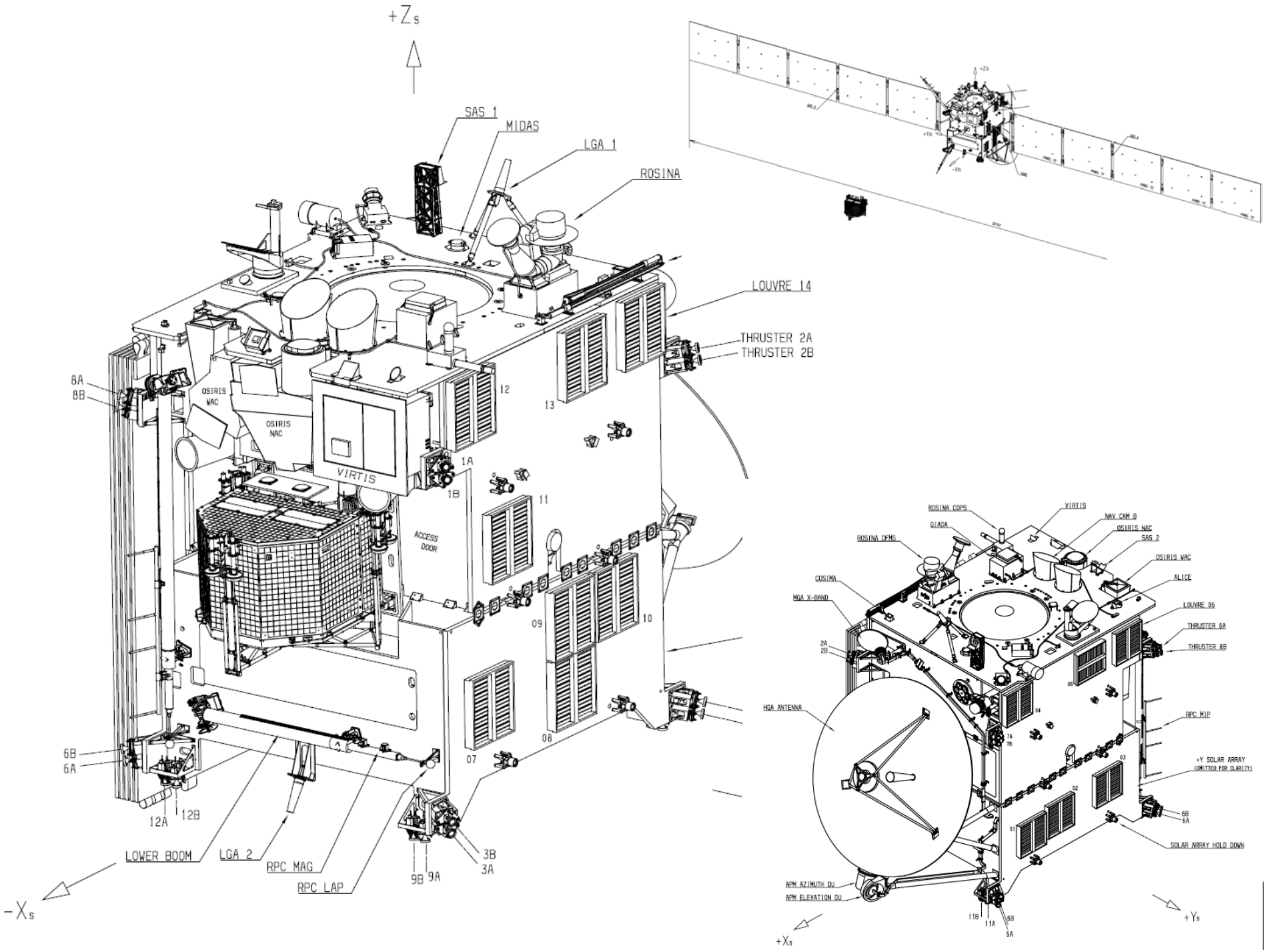
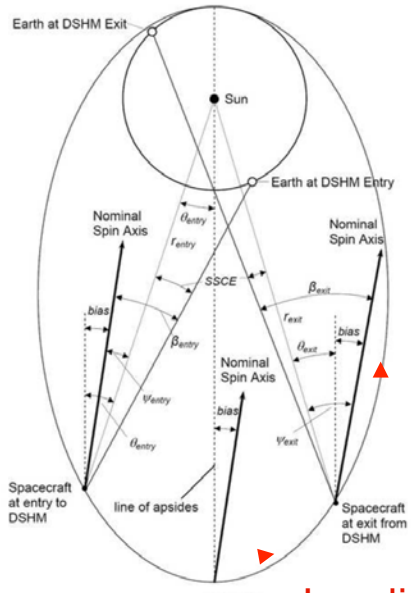
•Rosetta is an ESA cornerstone Mission to Comet 67P/Churyumov Gerasimenko
•11 Orbiter Instruments plus the Lander
•Launch: March, 2004
•Arrival: May 2014,
Lander separation: Nov.2014


+Zs
SAS 1
MIDAS
LGA 1
ROSINA
LOUVRE 14
THRUSTER 2A
THRUSTER 2B
8A
8B
OSIRIS WAC
OSIRIS NAC
VIRTIS
ACCESS DOOR
12
13
1A
1B
11
09
10
08
07
6B
6A
12A
12B
LOWER BOOM
LGA 2
RPC MAG
RPC LAP
9B
9A
3B
3A
-Xs
ROSINA COPS
VIRTIS
NAV C&H B
GIADA
OSIRIS NAC
SAS 2
ROSINA DFMS
OSIRIS WAC
COSIMA
ALICE
MGA X-BAND
LOUVRE 06
THRUSTER 8A
THRUSTER 8B
2A
2B
HGA ANTENNA
RPC MIP
+Y SOLAR ARRAY (OMITTED FOR CLARITY)
SOLAR ARRAY HOLD DOWN
APM AZIMUTH DU
APM ELEVATION DU
11B
11A
5B
5A
+Xs
+Ys

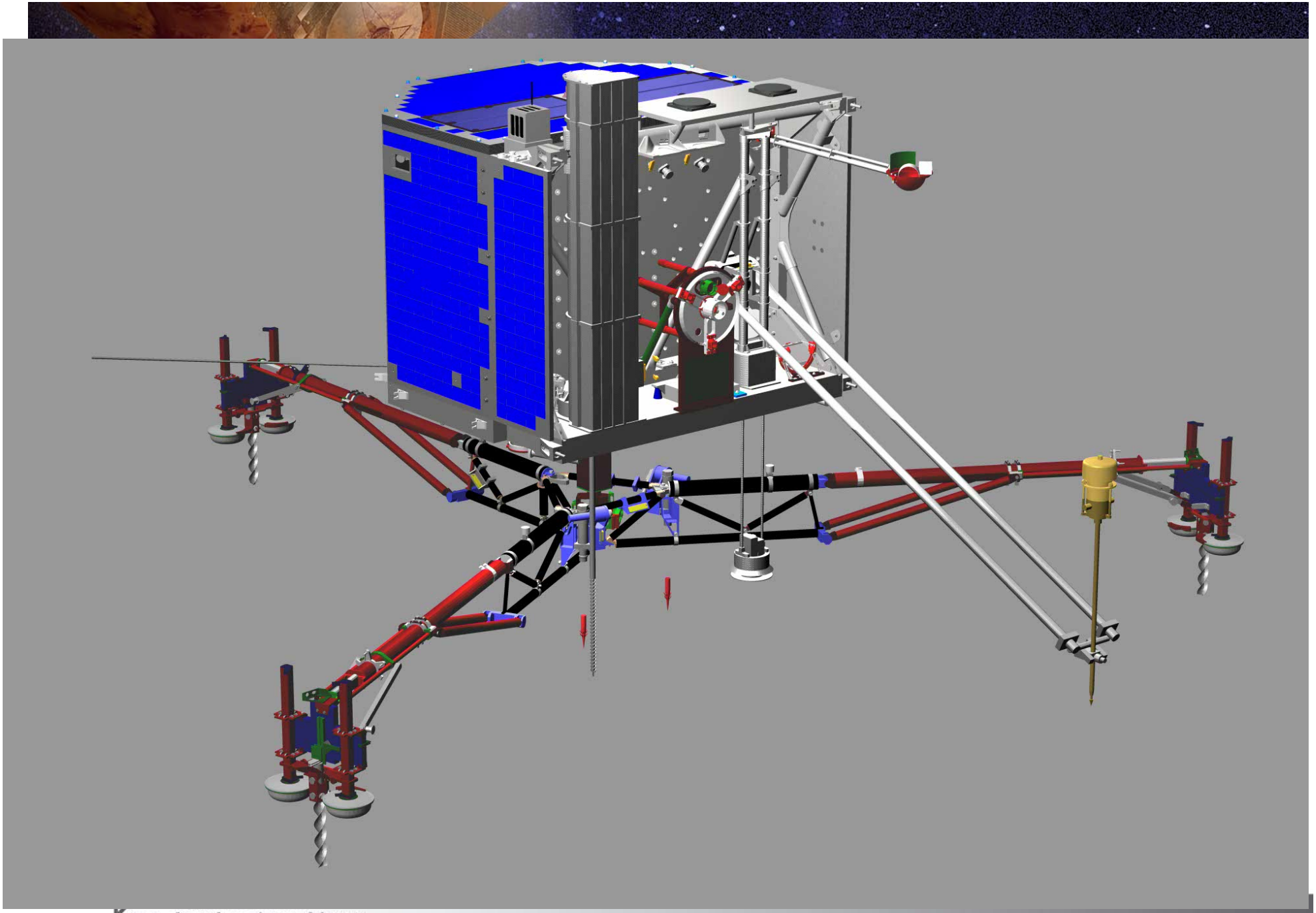
Rosetta Mission Outline

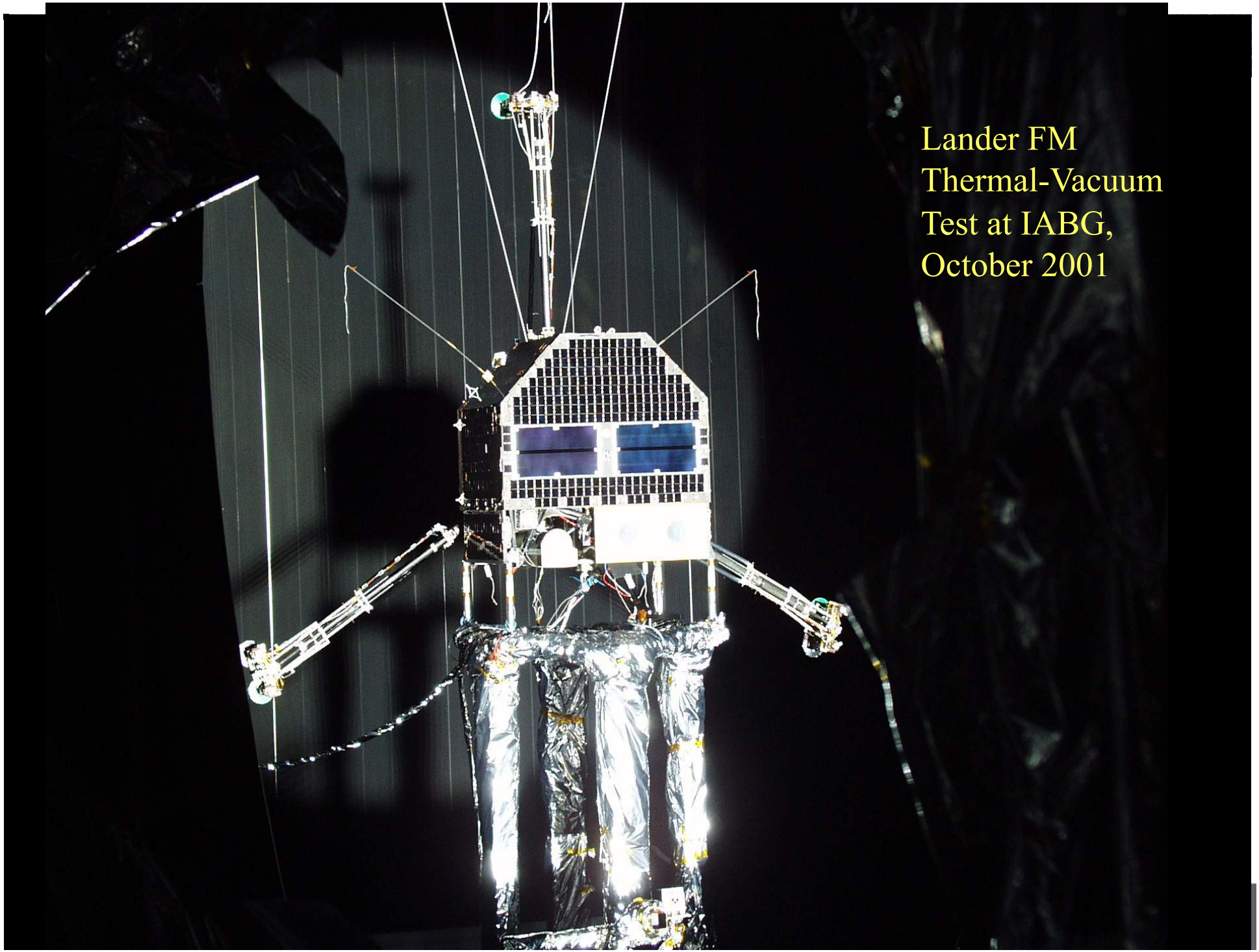
- Rosetta launched Mach 2nd, 2004; 3 Earth and 1 Mars swingby and 2 asteroid flybys at Šteins and Lutetia
- Rosetta and Philae are nowin hibernation since June 8th 2011; wake-up foreseen for January 2014
- Philae has been launched 3240 days ago
- Currently in hibernation (after 2498 hrs of FM Operat
- Landing in 666 days (nominal date: 11.11.14)
- Rosetta “wake-up” in 371 days
- We are getting close!!



14.01.2013 Landing

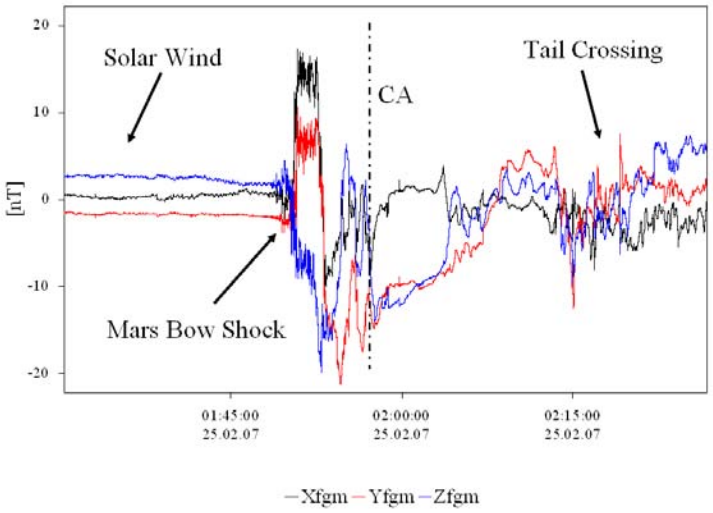
Drawings: ESOC

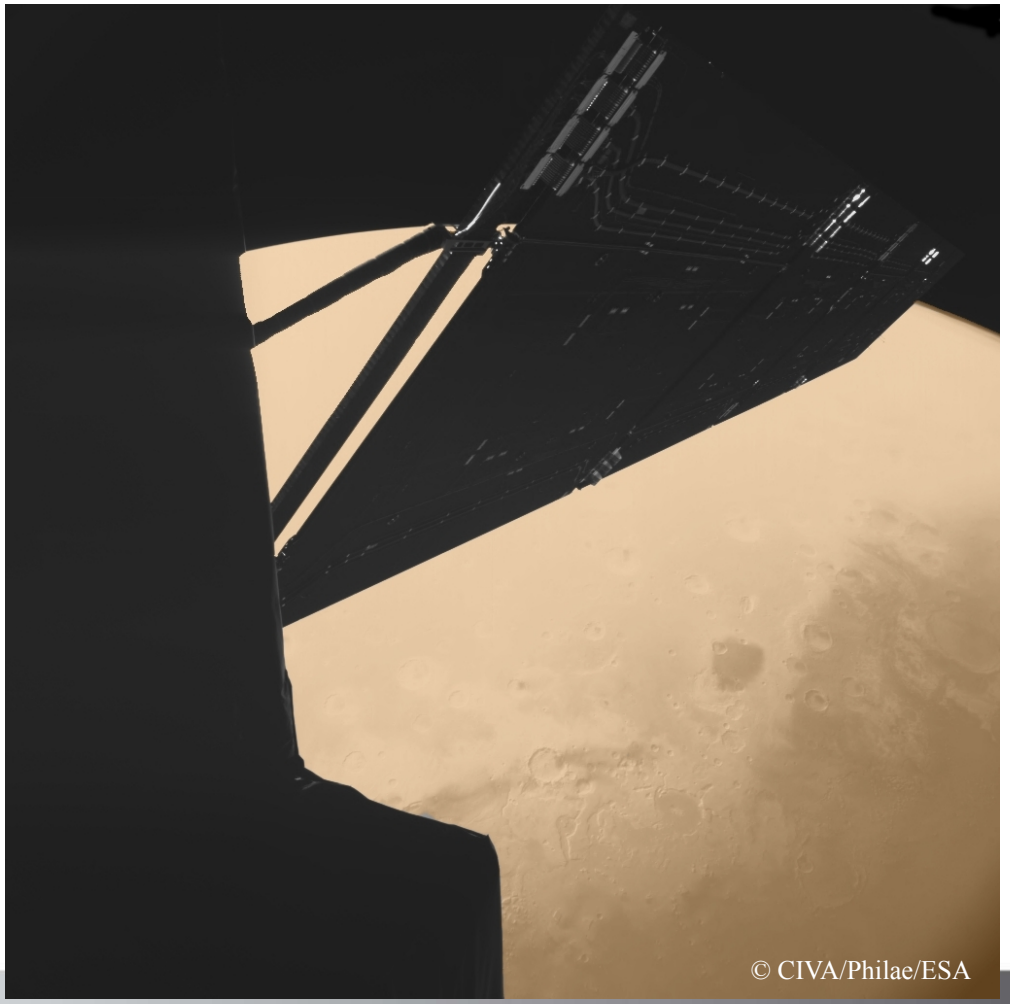



Lander FM
Thermal-Vacuum
Test at IABG,
October 2001

Mars Swingby: Results

- Autonomous Operations of the Lander via Battery
- Closest Approach: 250.6 km
- CIVA takes spectacular images
- ROMAP detects bow shock





Rosetta Results; 2014 and beyond

- Rosetta will provide a detailed characterization of 67P/ Churyumov-Gerasimenko after arrival in spring 2014
- Scientific results will soon be published (and openly accessible after 6 months)
- Landing foreseen for November 2014; Instruments will provide data on surface properties (incl. strength, porosity, thermal inertia, etc…)
- Lander and Orbiter system data and results (lessons learned) will enhance dramatically our knowledge on Comets

Hayabusa 2 – Introduction

- Japanese (JAXA) mission to…

  …a near Earth Object (NEO), 1999 JU3

- HY-2 is the successor of HY-1,
  - Launch Dec 2014
  - Arrival 2018, stays until 2019
  - Sample return by 2022
- Uses
  - Observations
  - Sample return
  - Penetrators
  - Landing module: Minerva, MASCOT

- MASCOT (and MESS) are a contribution by DLR and CNES to HY-2

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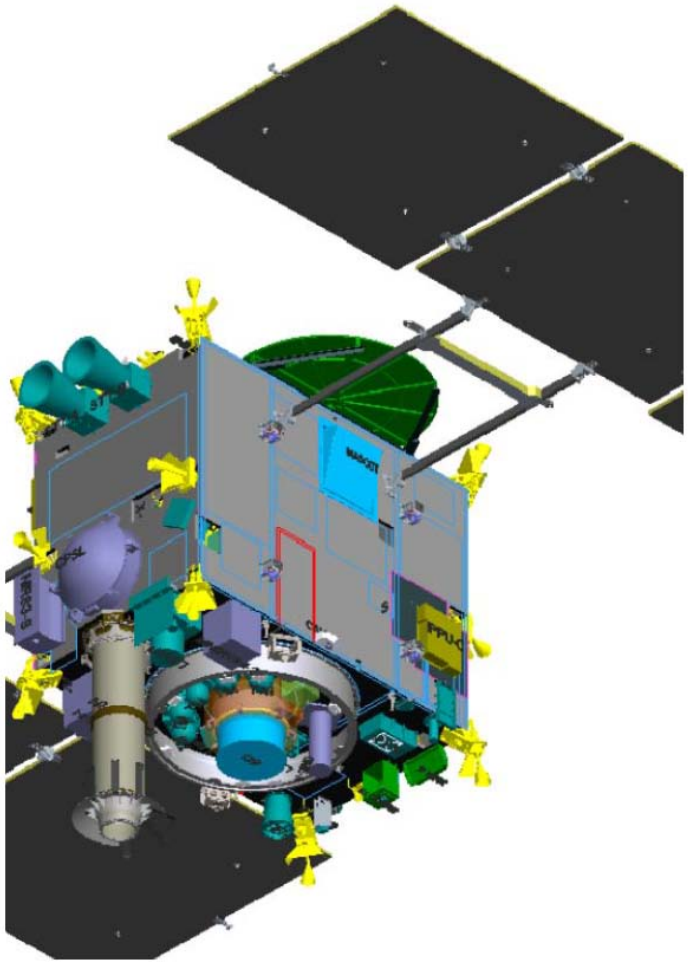
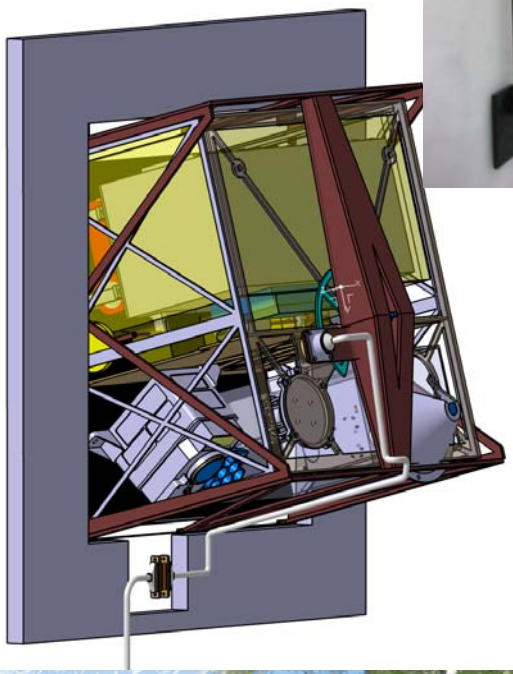
MASCOT Location and Configuration





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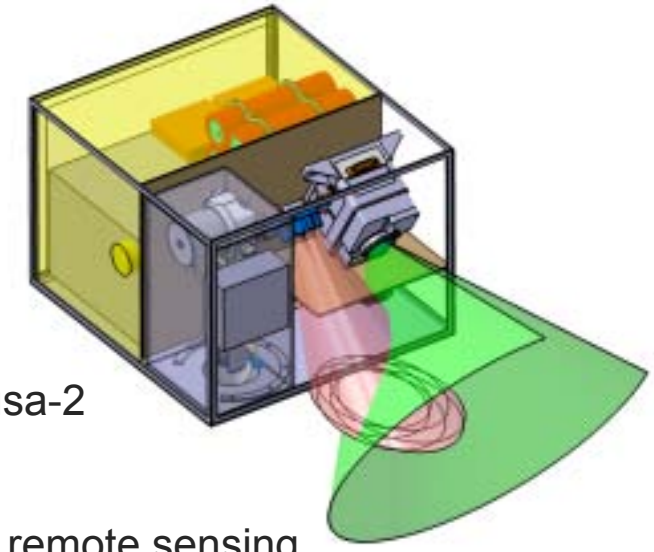
MASCOT Science Objectives



- 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

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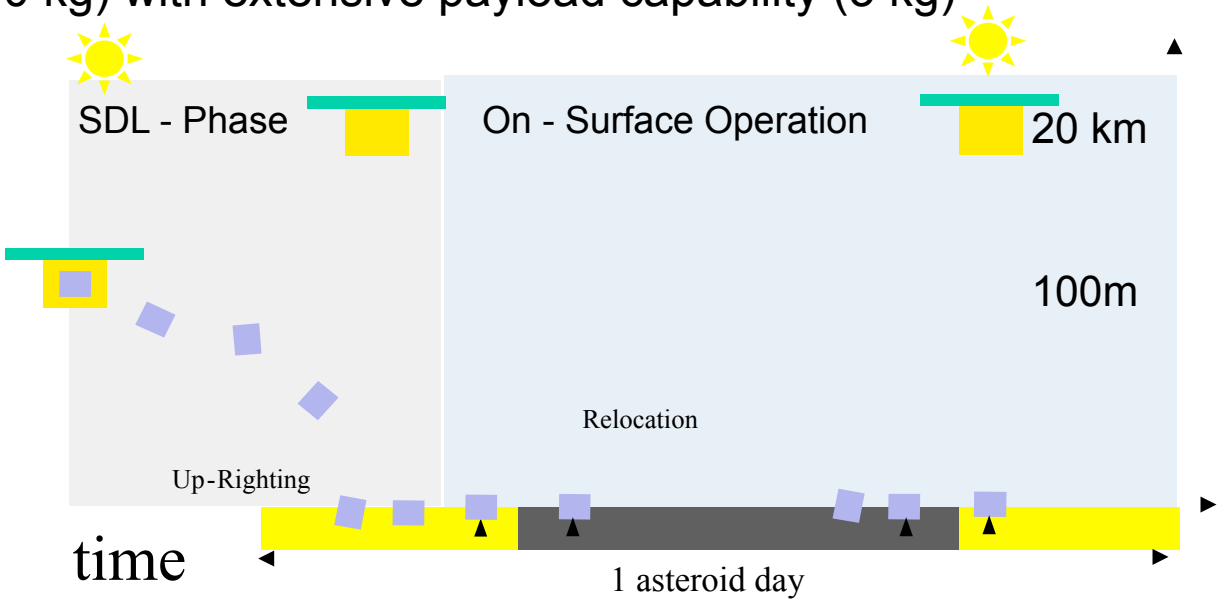
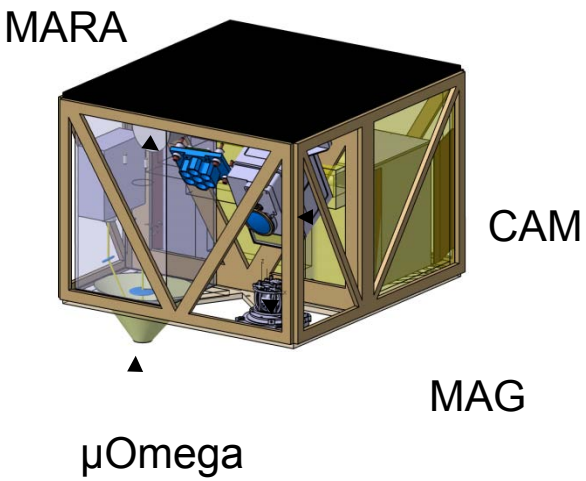
Mobile Asteroid Surface Scout (MASCOT)

- dedicated landing package for in-situ science on small bodies, currently part of the Hayabusa-2 payload (launch planned in 2014)
- Design can be modified regarding P/L and adapted to other missions
- E.g. proposed as for possible ESA mission Marco-Polo-R (FANTINA)
- low mass system (10 kg) with extensive payload capability (3 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

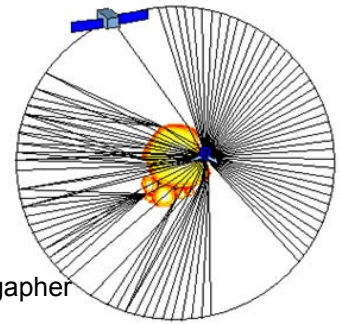
- LIBS,
- APX
-Thermal Mapper,
- Mößbauer Spectrometer,
I- R-spectrometer (MicrOmega),
- Camera,
- optional elements

LIBS for ExoMars
© DLR

MicrOmega
for MASCOT
© IAS

FANTINA

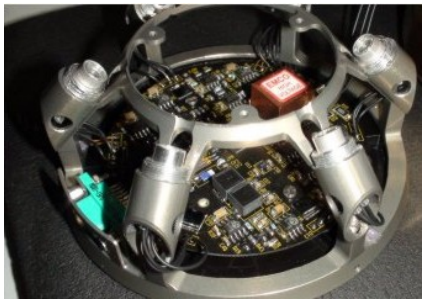
-Radar Tomographer
- Camera
- optional elements



Concept of
Radar Tomogapher
Image: IPAG

Technology and Space Situational Awareness

(*Decisions November 2012*)

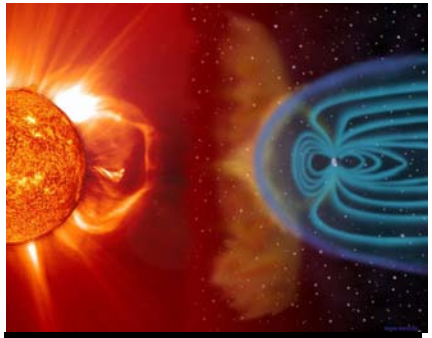


GSTP (2013-2017)

•German funding: 57 M€

Space Situational Awareness (SSA) (2013-2016)

(Mainly protection against space debris and space weather but also includes asteroid impact mitigation)



•Germany co-signed the respective ESA programs

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Summary

- DLR activities mainly coupled with ESA
- Ongoing missions in the frame of science programmes (Rosetta, Hayabusa 2, MarcoPolo-R)
- Human Exploration Activities embedded into ESA-NASA cooperation