BASTET – A MASCOT-style Nanolander
Investigating the Subsurface of Apophis, Seismicity, and Tidal Forces during Earth Encounter

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9th IAA Planetary Defense Conference – PDC 2025 – IAA-PDC-25-07-214

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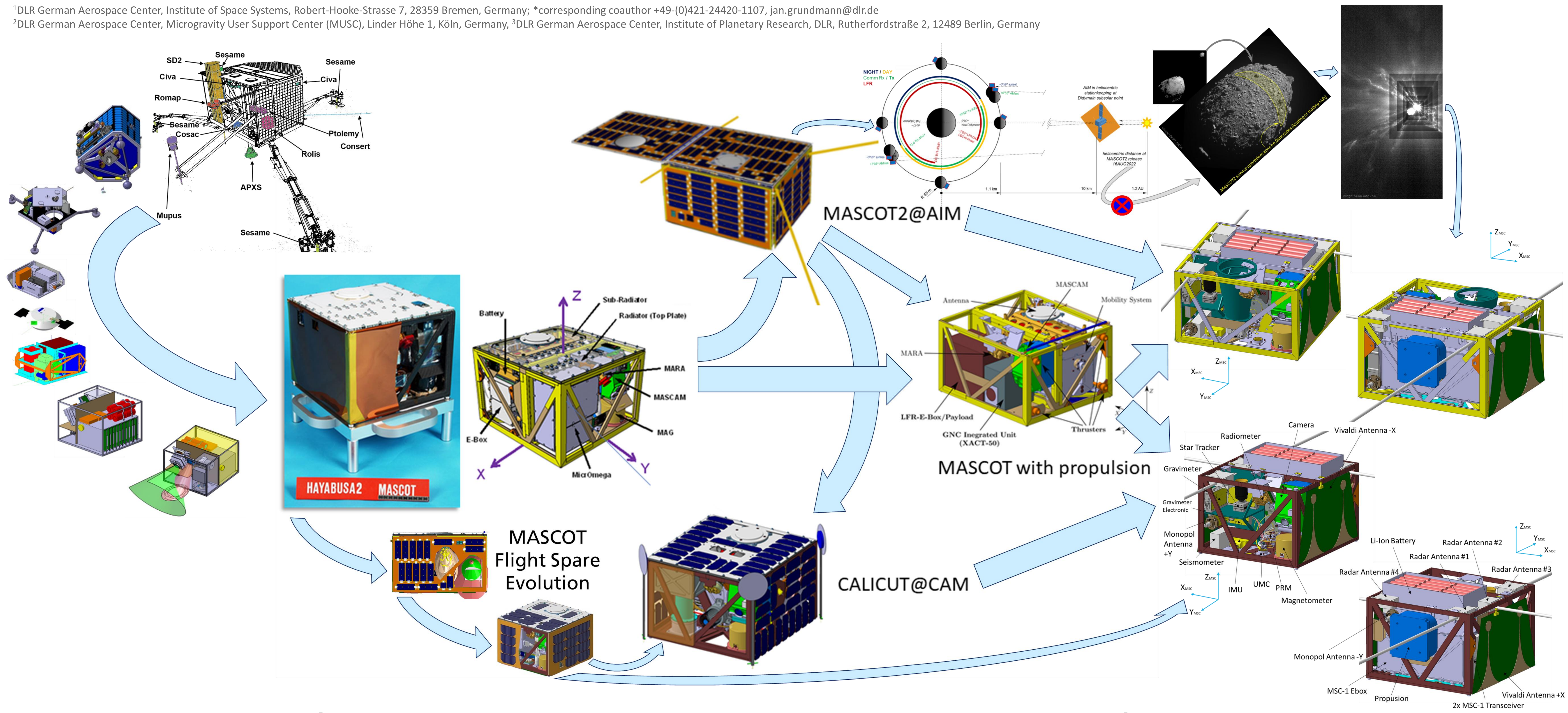
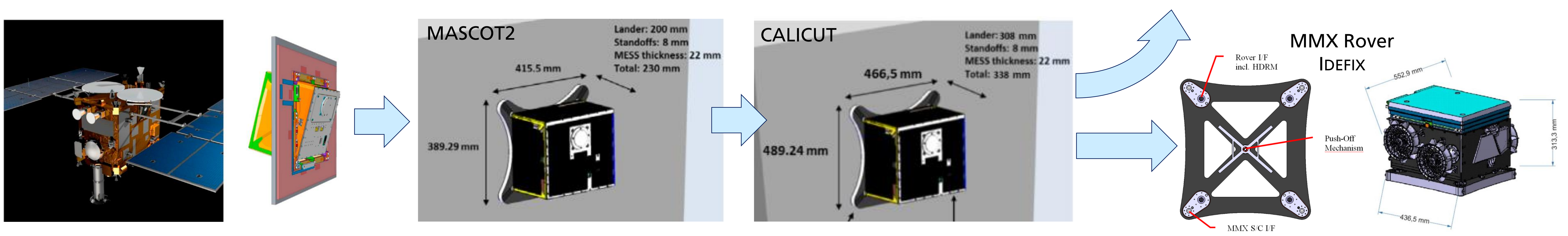


MASCOT concept evolution
For MarcoPolo from Philae @ Rosetta (*top*) via shrinking pocket-book editions and paddle-mobile XS packages towards internal mobility & organic integration, insensitive to target surface properties.

MASCOT nanolander mission-specific design milestones in the evolution towards a seamless portfolio
left: MASCOT nanolander aboard the JAXA mission Hayabusa2, launched Dec. 4th 2014, landed Oct. 3rd, 2018.
top: MASCOT2 nanolander design for the AIM mission of ESA, for deployment to Dimorphos before DART impact.
bottom: CALICUT nanolander concept for the Chinese Asteroid Mission/CNSA to an active asteroid in the main belt.
right: self-propelled MASCOT nanolander for small body observation missions similar to the Hera mission of ESA.
Studies have been performed for targets representing properties and orbits of all types of periodic NEOs & PHOs.

BASTET – tailored with strategic & ad-hoc re-use
A multi-messenger, multi-band interior structure investigation and longterm surface science package for Apophis' close Earth encounter as well as the *inevitable* close encounters of planetary defense targets, balancing evolution (*top*) with maximum Flight Spare re-use (*bottom*)

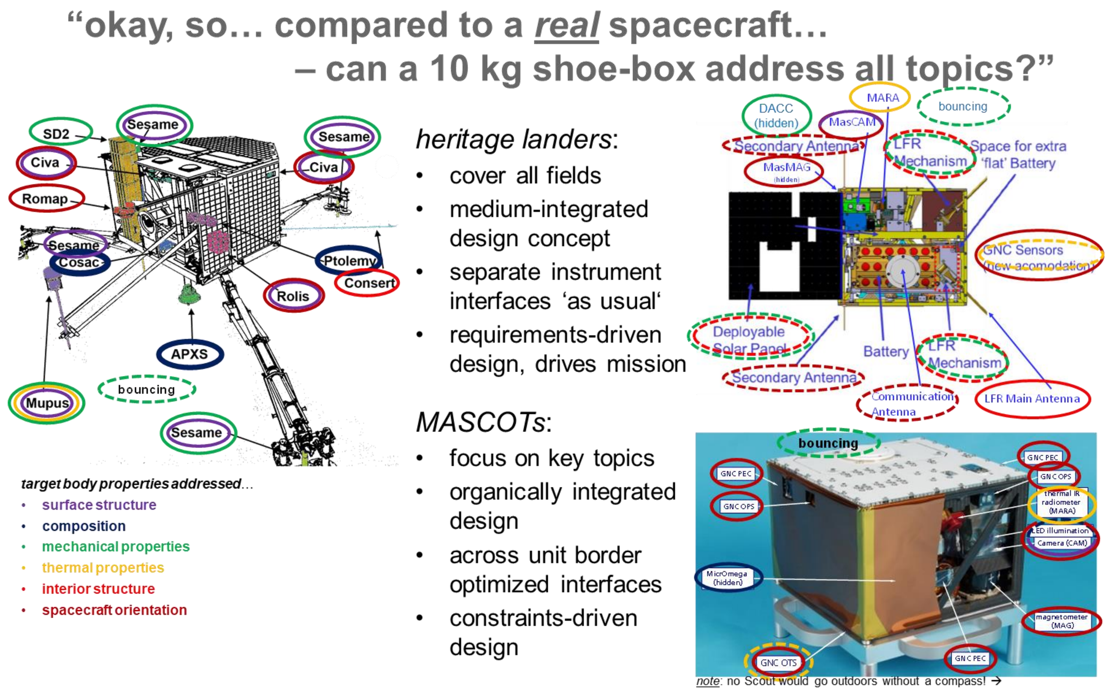


MASCOT under the Falcon's wings
Hayabusa2 required a deeply recessed integration into the spacecraft, enabled by a basket-like MESS (Mechanical and Electrical Support System) design.

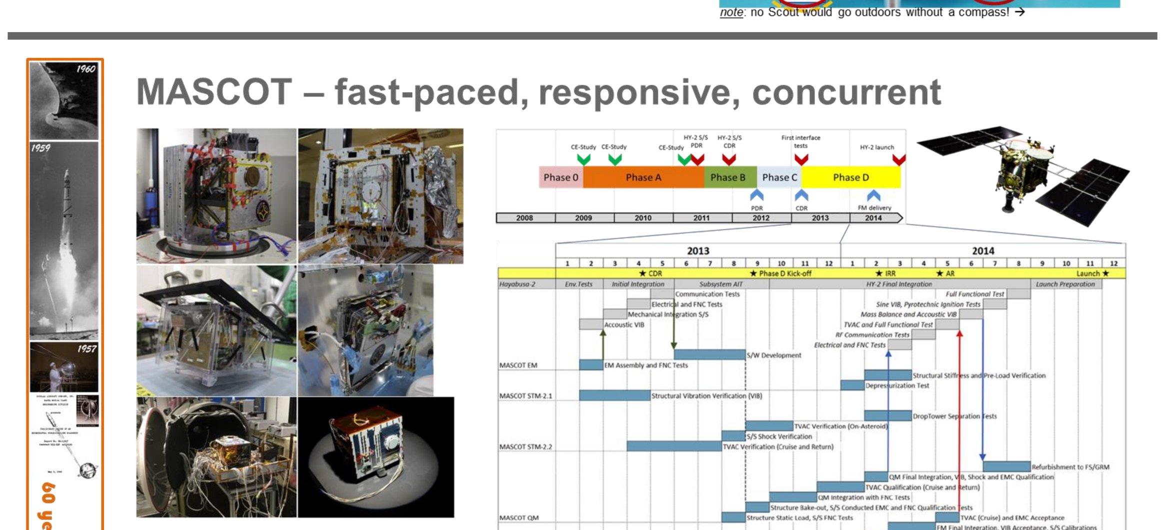
MASCOT MESS & DRSS – a scalable nanolander separation mechanism & support subsystem concept
For MASCOT2, a flat MESS design was developed to enable a more active participation in the cruise phase of the AIM mission of ESA, with open fields of view for the instruments (cf. Philae's ÇIVA) and local power supply by the nanolander's own photovoltaics. Communication, ranging and electrical interfaces pass through existing Inter-Satellite Links (e.g. MASCOT2@AIM) or a tailored DRSS (Data Relay Sub-System) which can be shared with others.

Small solar system body missions lateral re-use
The single hold-down release mechanism (HDRM) design of the MASCOT2 MESS was adapted for the MMX Rover, Idefix, into a 4 corner HDRM design using the same push-off mechanism and umbilical technology as MASCOT.

**"okay, so… compared to a *real* spacecraft…
– can a 10 kg shoe-box address all topics?"**



MASCOT – fast-paced, responsive, concurrent

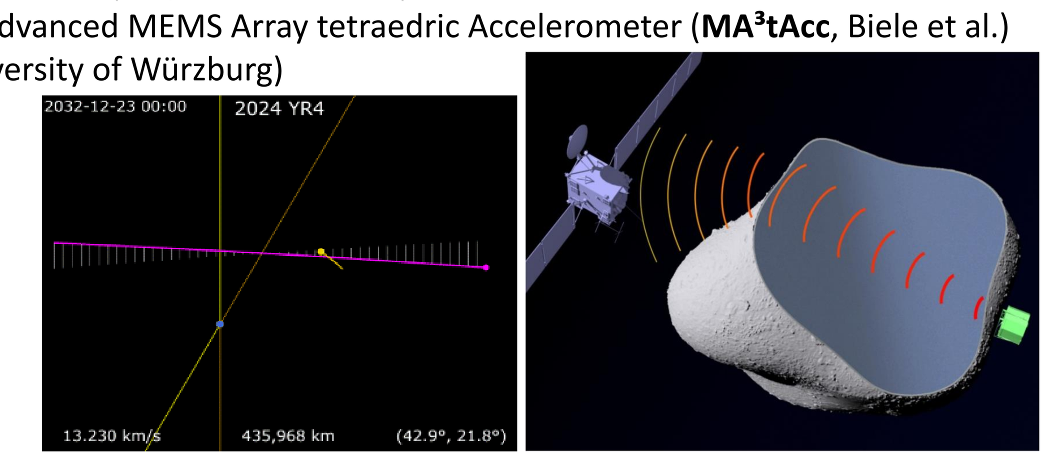


- 4 years of precursor studies
- 2 years from funding release to FM delivery
- 11 models of MASCOT built
- concurrent AIV with focus on earliest possible testing

Science on BASTET - mo*B*ile *A*pophis *S*cout for *T*omographic *E*xploration in *T*idal encounter.

BASTET is developed to complement & augment the observations of Apophis that rendezvous spacecraft can provide from a distance with occasional close slow fly-bys. It adds an on-asteroid segment which investigates the interior of Apophis; takes close-up high-resolution observations of a small area of the surface before, during & after close Earth encounter on Friday, April 13th, 2029; and provides longterm science & tracking with a direct link to Earth. Any NEO concerning planetary defense has at least one close encounter with Earth. The same tasks & capabilities are required for rendezvous characterization & shepherding through close encounters, before & after deflection, or before impact.

- ***Mission Main Instrument (MMI)*: Apophis Interior Structure Exploration (ApoISE) a**steroid **p**roperties **o**bservation multi-sensor package & teams:
  - *Radar / radio waves frequency spectrum section*:
    - Wideband Ground-Penetrating Radar & Altimeter (**WGPR/A**, Plettemeier et al.)
      - synergetic support from the communication subsystem (DLR GSDR in BASTET & DRSS aboard host spacecraft)
  - *Seismic / tidal / gravity forces frequency spectrum section*:
    - *Low frequency and gravity component sensor*: GRAvimeter for Small Solar system bodies (**GRASS**, Karatekin et al.)
    - *Medium frequency and seismic range sensor*: Seismic Instrument for Asteroids (**SIA**, Murdoch et al.)
    - *High frequency and accelerations range sensors*: MASCOT Multi-channel Advanced MEMS Array tetraedric Accelerometer (**MA³tAcc**, Biele et al.)
      - synergetic support from the GNC subsystem's IMU & Star Trackers (University of Würzburg)
      - excitation source support from the MASCOT Mobility Subsystem (DLR)
- ***Surface and Context Science Instruments (SCSI)*** set & teams:
  - MASCOT Magnetometer (**MasMag**, Plaschke et al.)
  - MASCOT Radiometer (**MARA**, Grott et al.) with improved sensor head
  - MASCOT Camera (**MasCam**, Schmitz et al.) with enhanced LED illumination
    - synergetic support and imaging from the GNC subsystem's Star Trackers
    - shared use of MA³tAcc acceleration sensors & GNC IMU while bouncing
    - shared use of GNC orientation and proximity sensors for ambient data



Designed for a long and intense science phase around the close Earth encounter and with provisions for autonomous escape from a 'cold dark hole' trap, BASTET has a very large battery for a spacecraft of its size and average power level. Managed through the DRSS, it is possible to share battery and photovoltaic power, sensors and other resources, in particular if small or extremely lightweight spacecraft are required for a target.

	BASTET	MASCOT FM (weighed)	MASCOT2	CALICUT
Lander (separating mass), kg	≈16.6	9.66	12.12	9.80
Lander power & battery, kg	≈5.0	1.82	3.43	3.50
MESS (remaining mass), kg	≈0.83	1.23 – with MasCam & MARA CalTarget & ISL Antenna	0.82	1.21
DRSS (remaining mass), kg	≤1.0	mission-specific ISL provided by & budgeted on host spacecraft		
total integrated mass, kg	≈18.5	11.02	12.94	11.01

DLR