Misiones de Ciencia y Exploración Planetaria de la ESA

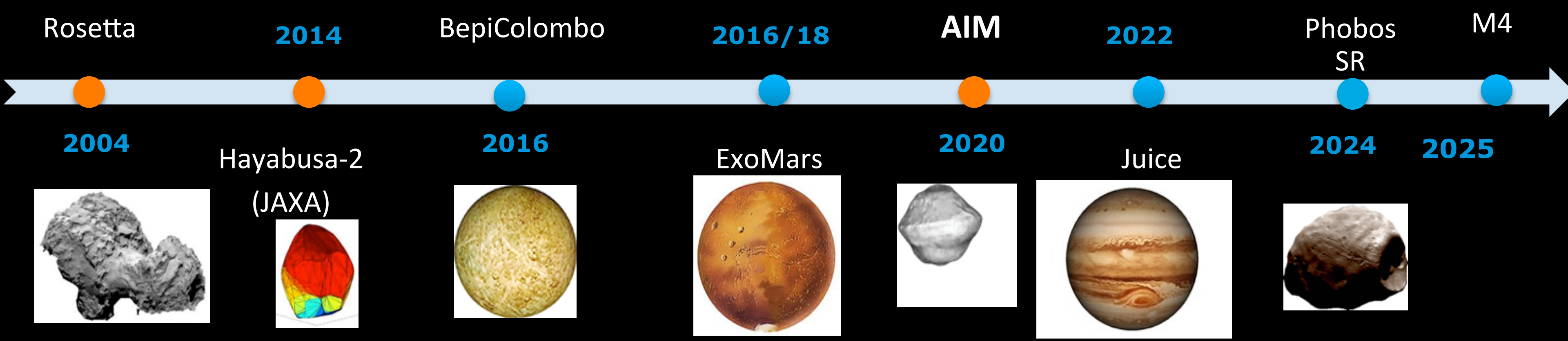
Andrés Gálvez

Science System Support Unit. ESA HQ, Paris

European Space Agency

IV Reunión de Ciencias Planetarias Y Exploración del Sistema Solar,
Alicante, 09 Junio 2015

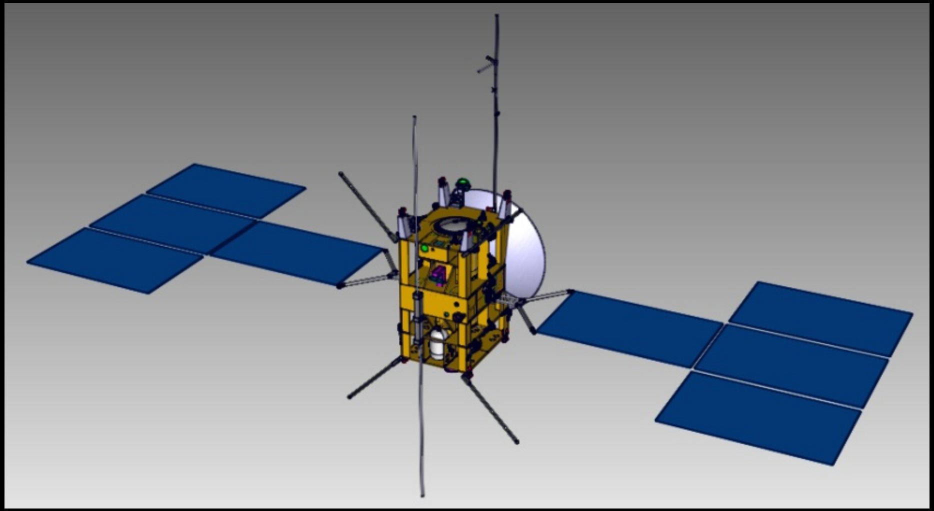
ESA future missions



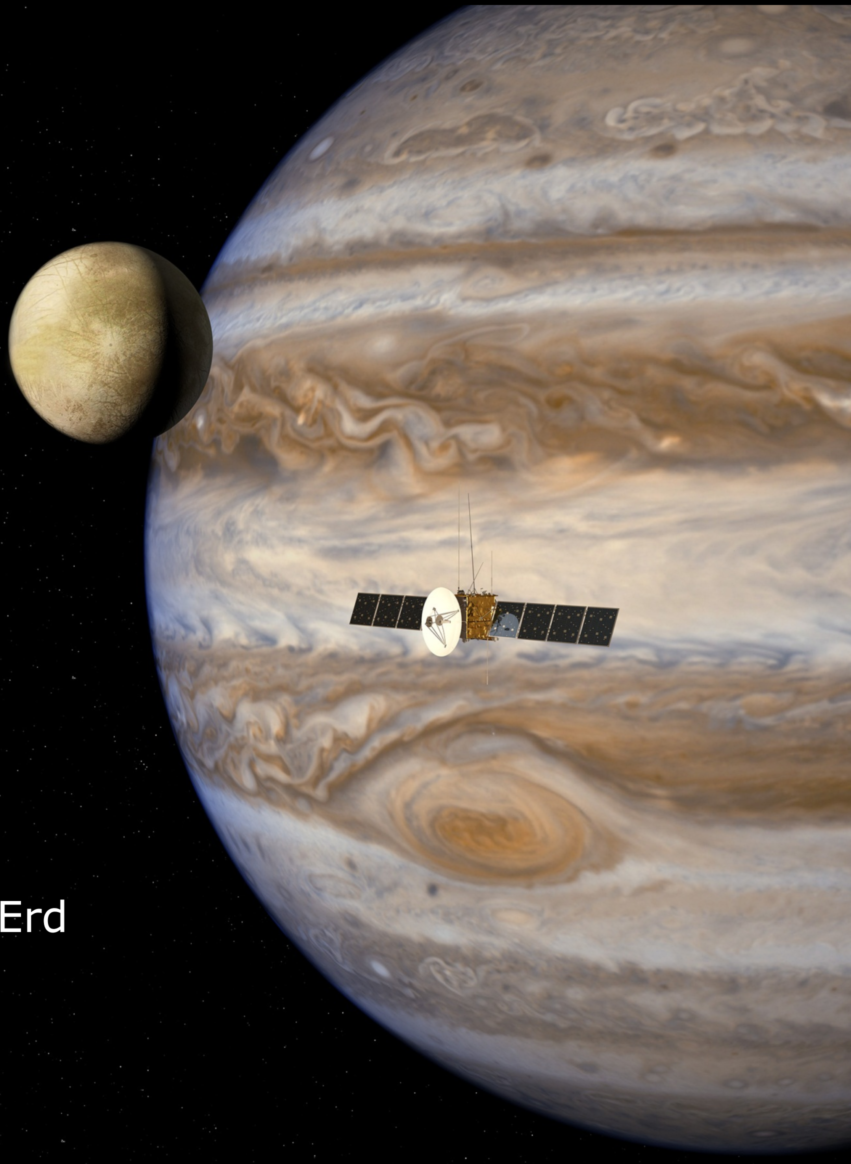
- Cosmic Vision, ESA´s Scientific Programme
  - Bepi Colombo is in implementation
  - JUICE in definition
- Mars Robotic Exploration
  - ExoMars
  - Phobos Sample Return
- Lunar mission activities are managed in Human Spaceflight.
- In technology demonstration
  - Asteroid Impact Mission (AIM) will be the first ESA mission to a small body (since 2004 launch of Rosetta and the only opportunity in the next 20 years

Missions in definition or implementation phase

- ExoMars 2016
- ExoMars 2018
- **JUICE**
- Bepi Colombo



JUICE overview



D. Titov, O. Witasse, G. Sarri, Ph .Gare, C. Erd
JUICE Science Team
ESA Study Team

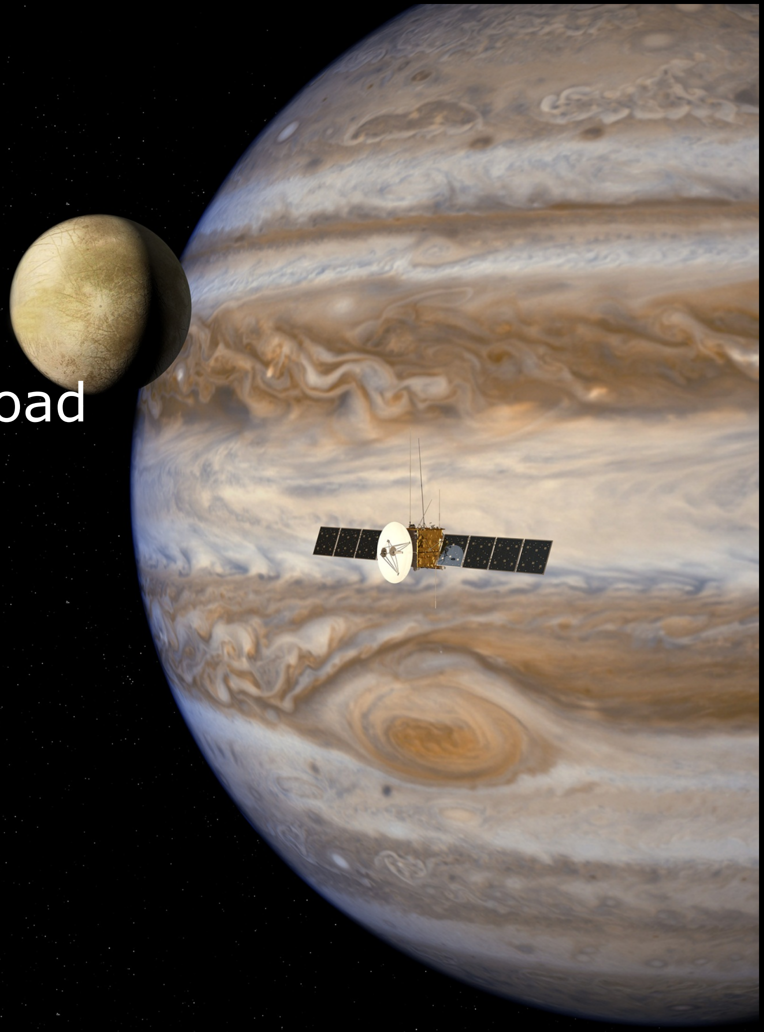
JUpiter Icy moons Explorer

JUICE concept

- Mission to the Jovian system
- Investigations from orbit and flyby trajectories
- Synergistic and multi-disciplinary payload
- European mission with international participation

JUICE Science Themes

- Emergence of habitable worlds around gas giants
- Jupiter system as an archetype for gas giants



JUICE Payload

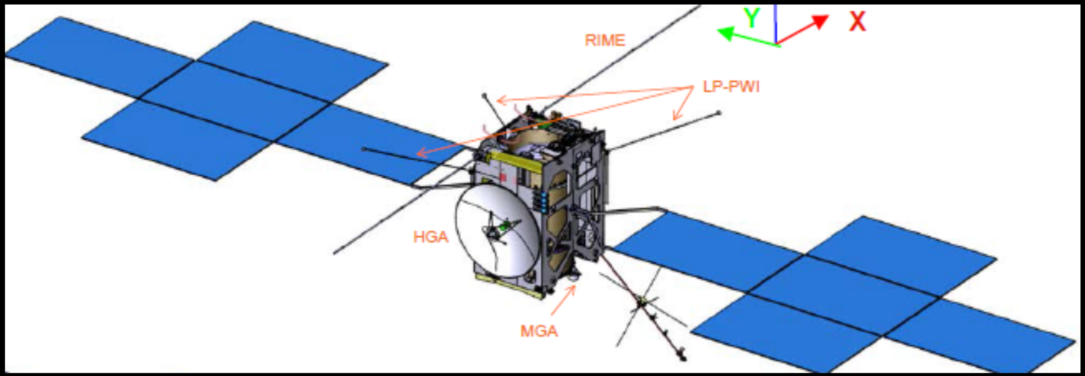
Acronym	PI	LFA	Instrument type
	Remote Sensing Suite		
JANUS	P. Palumbo	Italy	Narrow Angle Camera
MAJIS	Y. Langevin	France	Vis-near-IR imaging spectrometer
UVS	R. Gladstone	USA	UV spectrograph
SWI	P. Hartogh	Germany	Sub-mm wave instrument
	Geophysical Experiments		
GALA	H. Hussmann	Germany	Laser Altimeter
RIME	L. Bruzzone	Italy	Ice Penetrating Radar
3GM	L. Iess	Italy	Radio science experiment
PRIDE	L. Gurvits	Netherlands	VLBI experiment
	Particles and Fields Investigations		
PEP	S. Barabash	Sweden	Plasma Environmental Package
RPWI	J.-E. Wahlund	Sweden	Radio & plasma Wave Instrument
J-MAG	M. Dougherty	UK	Magnetometer

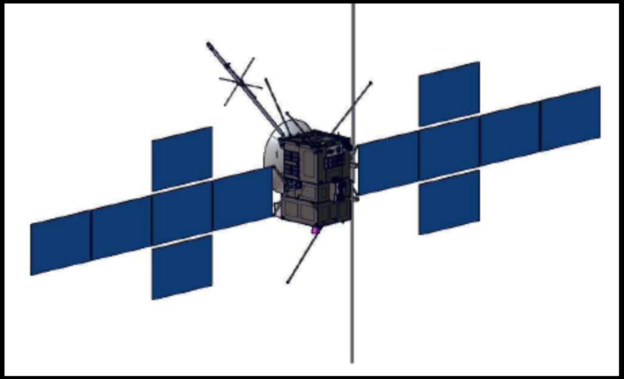
JUICE Current Baseline Scenario

- Launch: June 2022 (Ariane 5, Kourou)
- Cruise
- Jupiter Orbit Insertion: January 2030
- Jupiter Tour
  - 2 Europa and 6 Callisto flybys
  - Inclined orbit (up to 22 degrees)
  - Transfer to Ganymede
- Ganymede Orbit Insertion September 2032
- Ganymede Tour
  - High/elliptical altitude orbit (5000 km)
  - Low altitude orbit (500 km)
- End of nominal mission: June 2033

Main features of spacecraft design

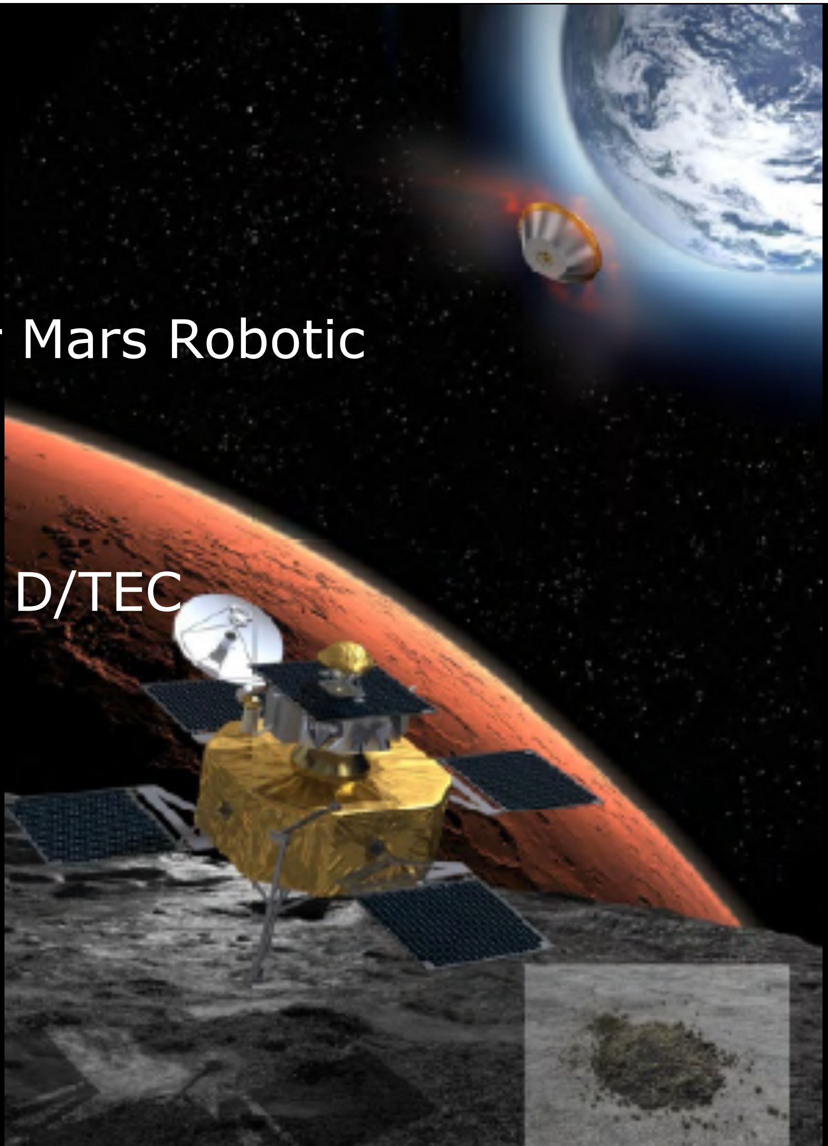
- Dry mass ~2200 kg, propellant mass ~2900 kg
- High Δv required: 2700 m/s
- Payload ~218 kg, ~ 180 W
- 3-axis stabilized s/c
- Power: <1000 W
- HGA: ~3 m, fixed to body, X & Ka-band
- Steerable MGA, X & Ka-band
- Data return 1.4 Gb per day





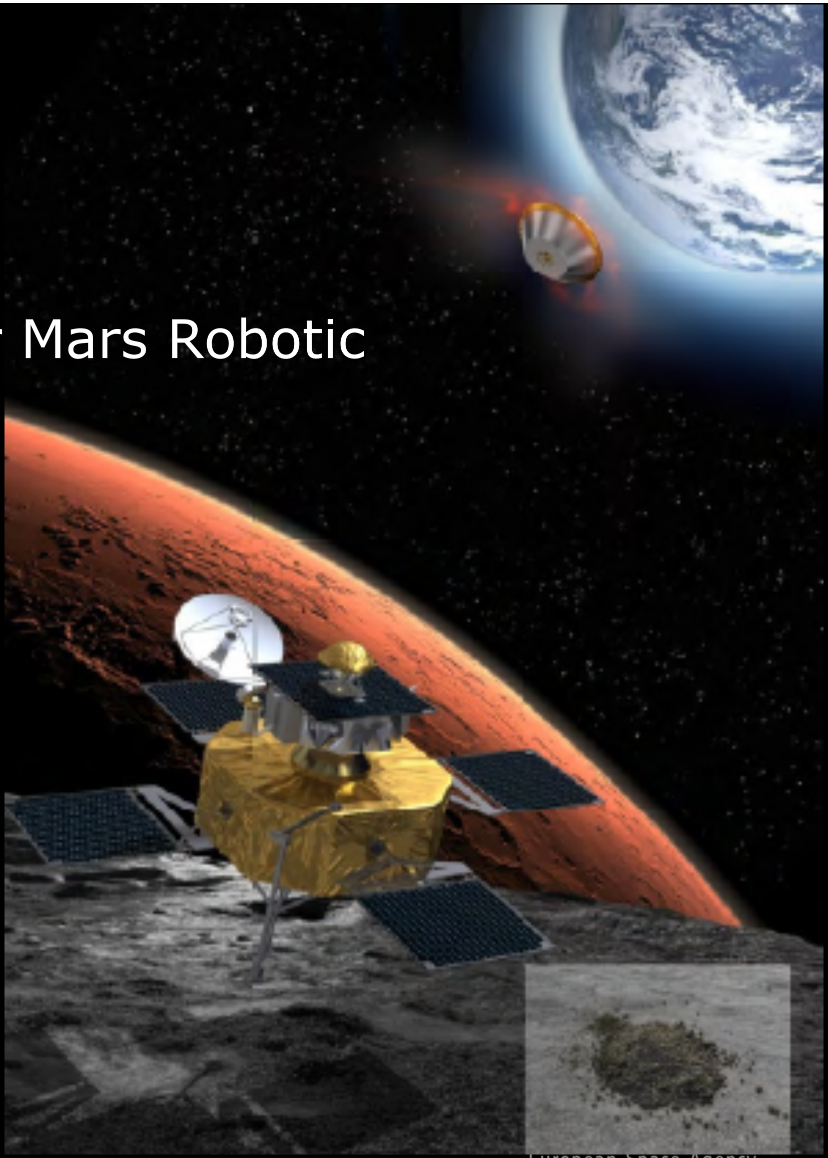
New Missions in assessment phase

- Phobos Sample Return and other Mars Robotic Exploration Missions in D/SRE
- Lunar activities in D/HSO
- Asteroid Impact Mission (AIM) in D/TEC



New Missions in assessment phase

- Phobos Sample Return and other Mars Robotic Exploration Missions in D/SRE

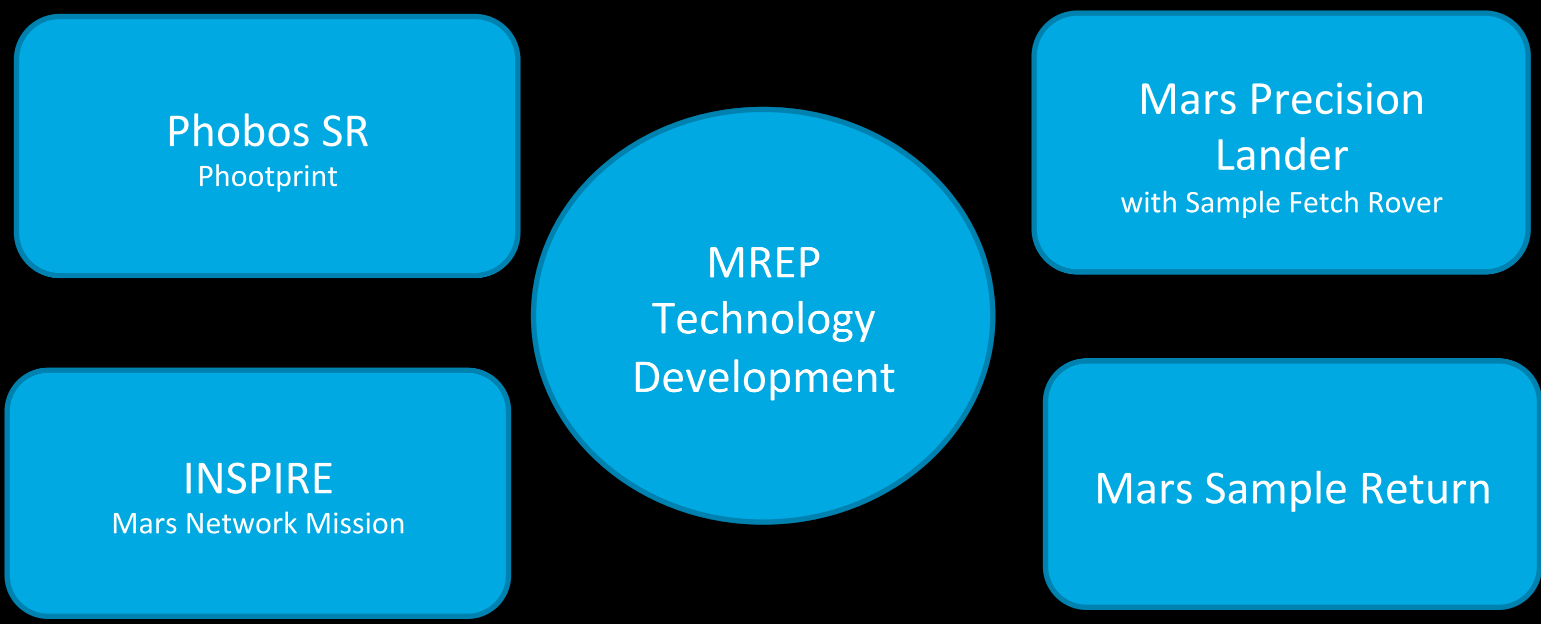


P. Falkner, D. Rebuffat Future Missions Office
Science & Robotic Exploration (SRE), ESA

MREP-2 Overview

esa

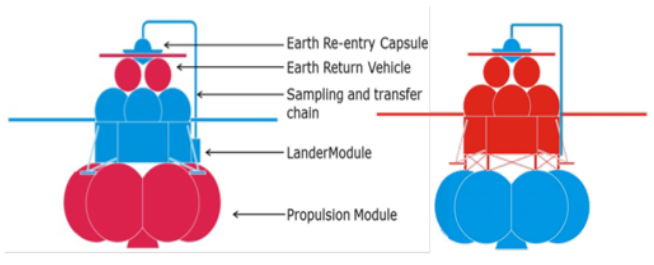
- Optional programme following MREP-1 and ExoMars
- Subscribed at C-Min 2012 and enable decisions at next C-Min (2016)
- Initiation of PB-HME working group on future robotic exploration missions
- Initiated co-operation with ROSCOSMOS ⇨ joint Phobos SR

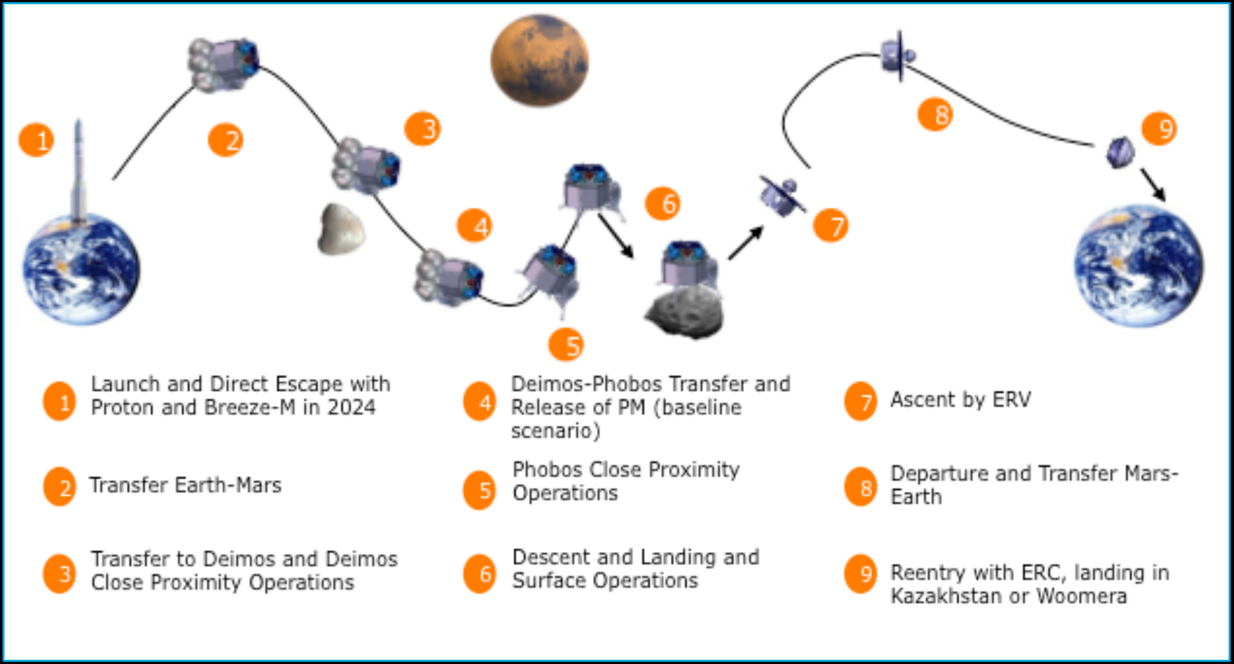


Phobos Sample Return Phase-A

- Phobos Sample Return Phase A 12-month will start in June 2015, results for ESA´s C-MIN 16 decision
- Study to address two joint Roscosmos / ESA scenarios as well as an ESA standalone scenario
- Study will assume a modular architecture (4 elements : Propulsion Module, Landing Module, Earth Return Vehicle, Earth Reentry Capsule) as in previous joint internal ESA-Roscomos study

Baseline joint scenario | Back-up joint scenario

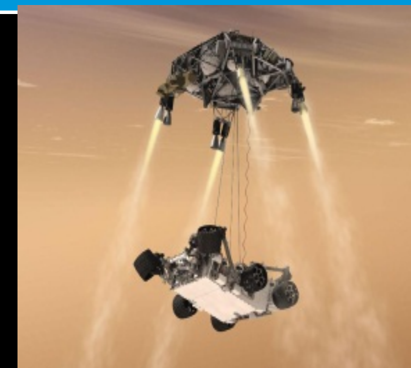




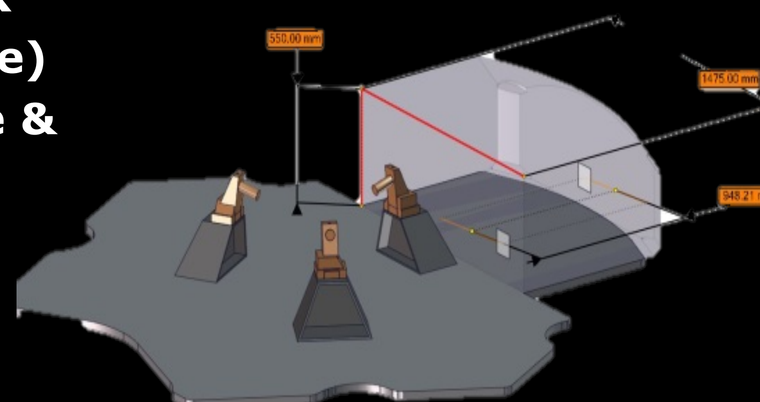
- Proton launch (joint scenarios) or Ariane 5 or 6 (ESA-standalone)
- Direct escape in 2024
- Transfer to Mars (11 months)
- 9 months around Deimos / Phobos
- Departure from Mars in 2026
- Return to Earth (8 months)
- Return Capsule release and recovery in 2027 in Kazakhstan or Australia
- Mission lifetime ~ 3 years

MarsFAST: ESA/NASA joint mission study

- **Joint mission based on the NASA Skycrane and ESA rover technologies**
  - **NASA: EDL System and static platform**
  - **ESA: Fast mobility rover & egress system**
- **Main requirements for ESA rover:**
  - **Mass allocation (rover + egress) 200 kg**
  - **Fast mobility demonstration for MSR Fetching Rover (~290 m/sol average)**
  - **Science payload allowing for remote & in situ science, sample acquisition/ transfer/analysis (no life detection)**
  - **Minimum 180 sols life time**
- **ESA internal CDF study on the rover** in Sept-Oct 2014



MSL Skycrane concept (credit NASA)

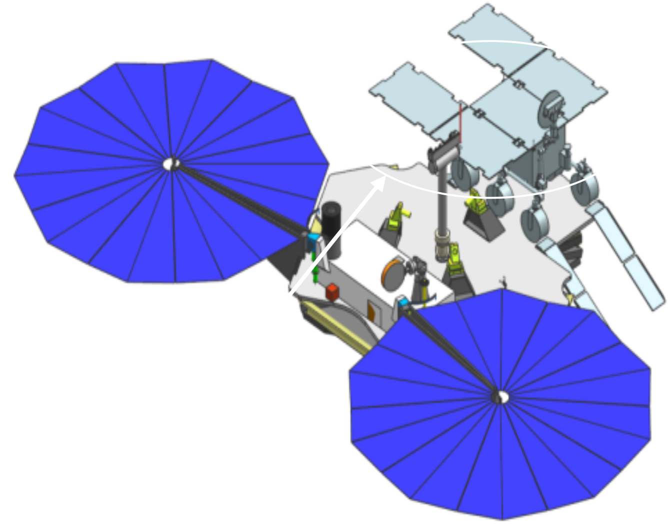


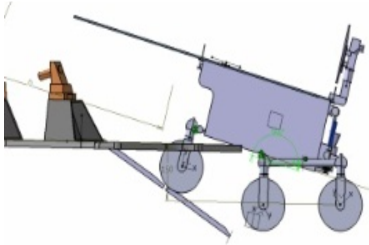
Volume allocation for the stowed rover (from JPL)

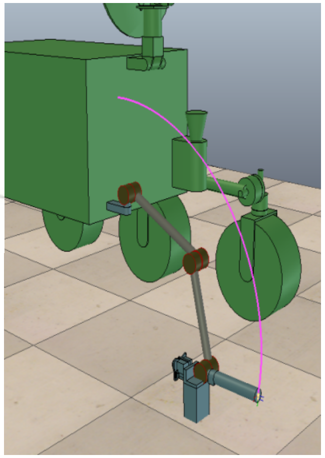
MarsFAST: ESA/NASA joint mission study

MarsFAST rover main features

- Strawman payload: stereo camera, meteo package, Mössbauer spectrometer, close-up imager, luminescence dating (requires sample acquisition)
- Robotic arm & sampling tool for in situ analyses and sampling operations
- Total rover mass: 156 kg
- Fast mobility using vision based navigation
- Communications: UHF relay to Orbiter, and X-band Direct to Earth (low data rate)
- Hibernation capability for 14 sols during a local dust storm
- Egress system sized to cope with hazards and platform attitude after landing

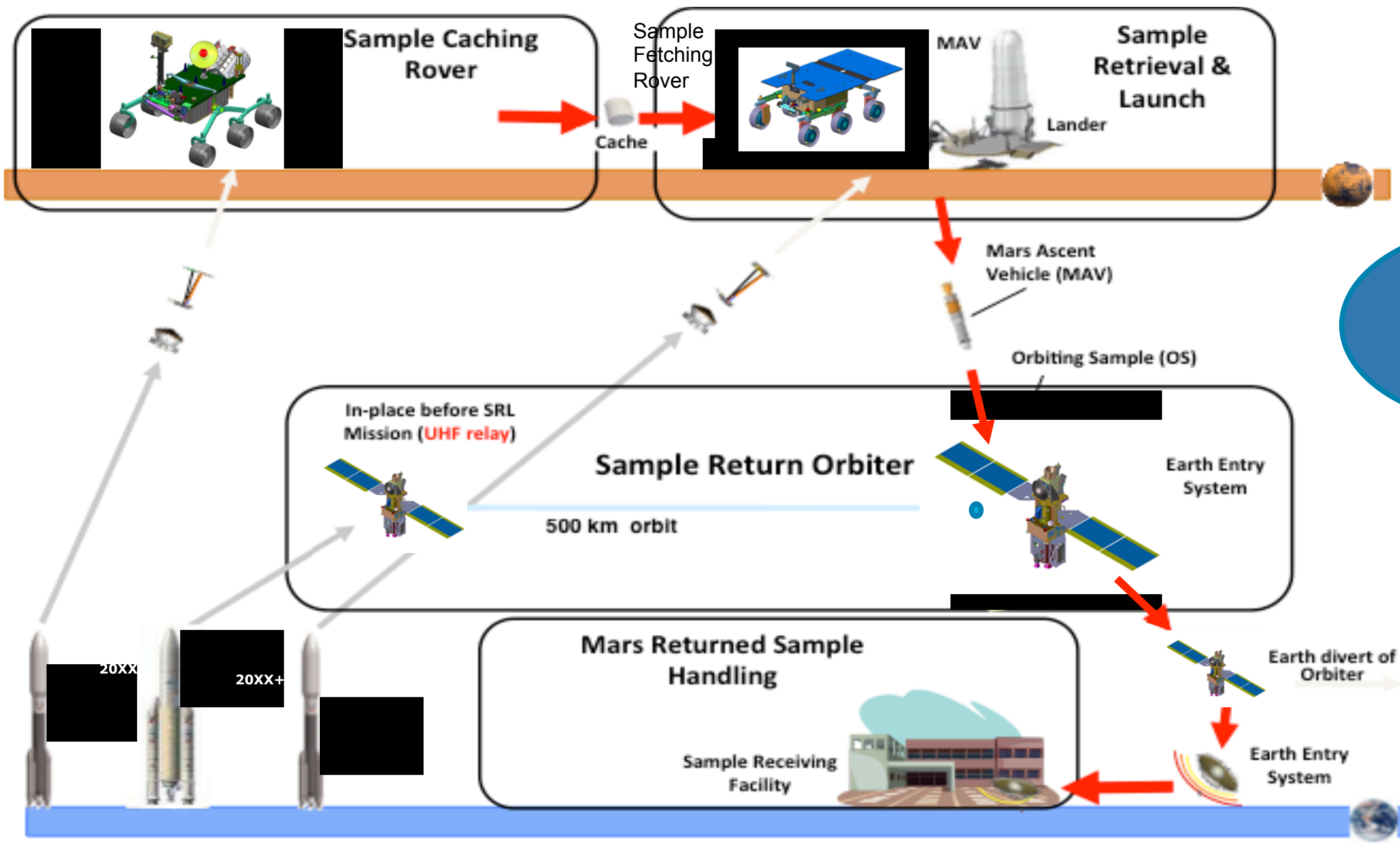






Egress & sampling analyses

Mars Sample Return ⇨ iMARS II



New iMARS II

- The Caching Rover mission (SCR) selects and puts the samples in a Cache waiting for retrieval (could be 2020)
- The Sample Retrieval and Launch mission (SRL) retrieves the samples and launches them into Mars orbit
- The MSR Orbiter mission (SRO) rendezvouses and captures the Orbiting Sample (OS) then returns it to the Earth
- The Returned Sample Handling element (MSR-H) performs all the ground-based operations up to samples delivery to laboratories

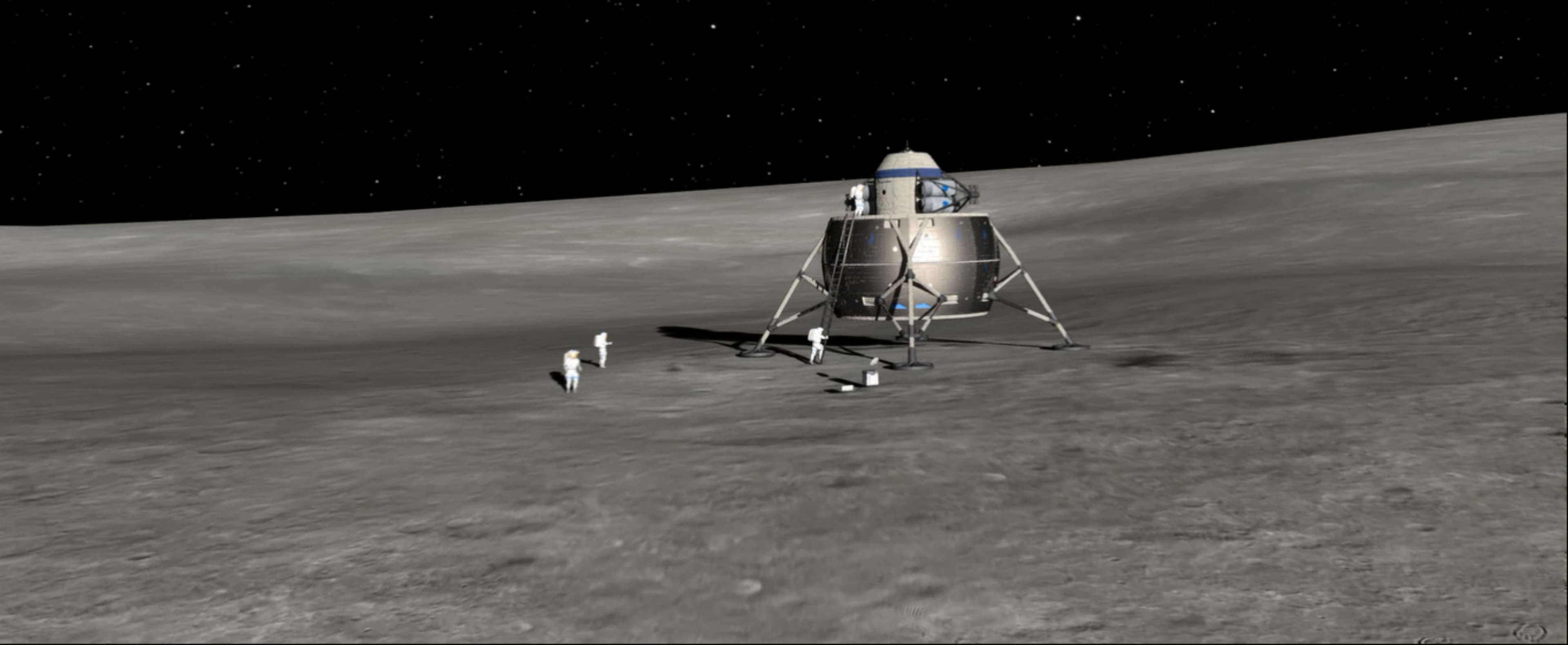
ESA's plans for Lunar Exploration

B Houdou, J Carpenter, R Fizakerley
Lunar Exploration proiject team (HSO), ESA

Destination Moon

ESA Vision for Lunar Exploration:

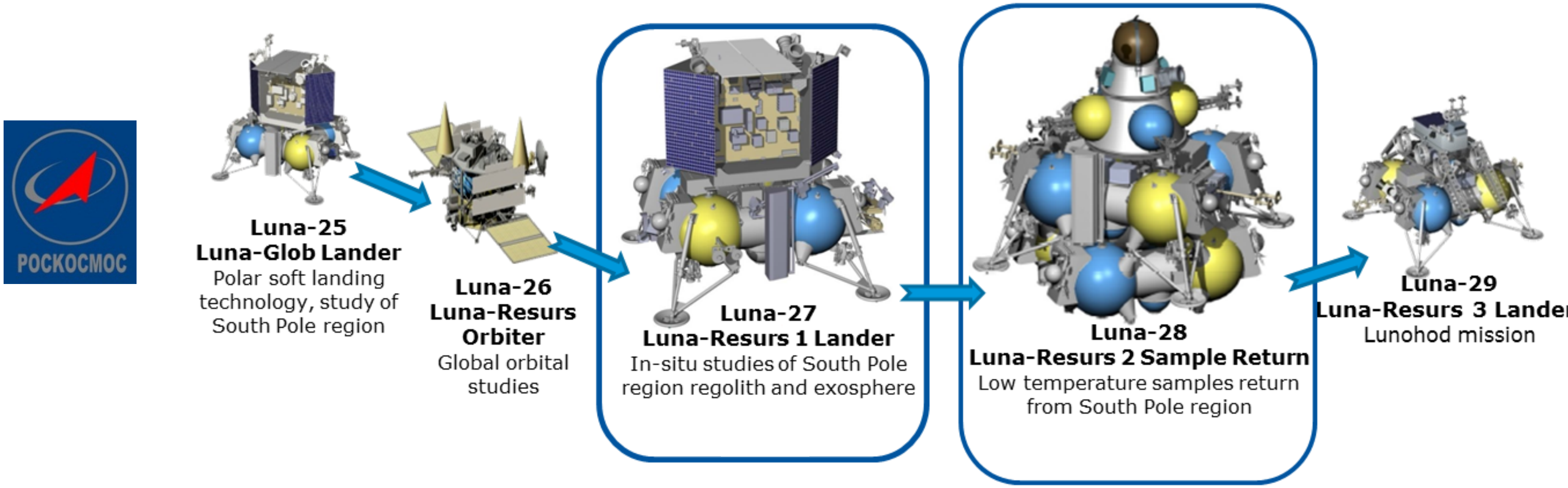
“Provide access to the Moon’s surface
to drive European discovery, innovation and inspiration.”



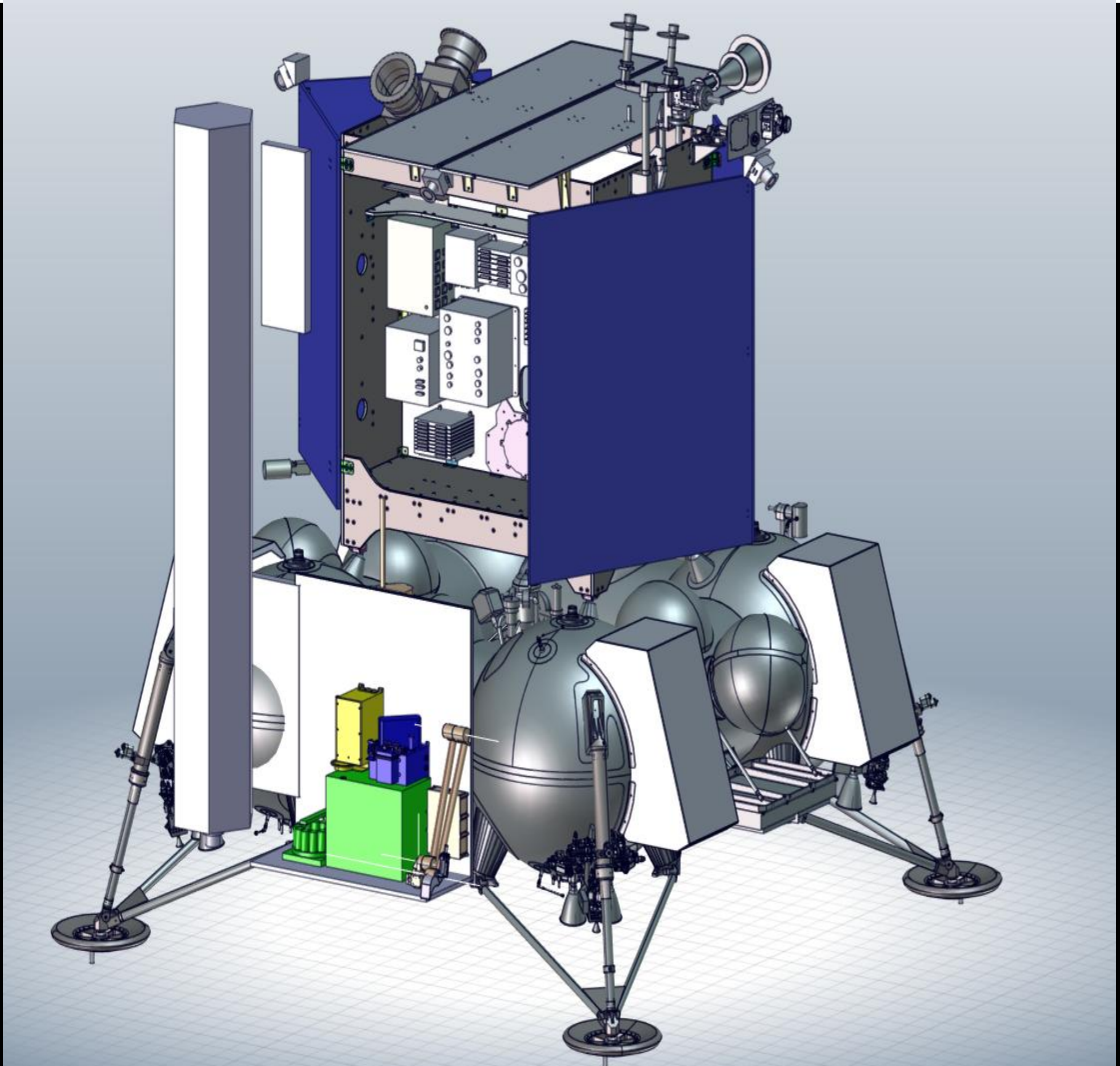
ESA lunar exploration products: cooperation with Russia

- **Phase B+ for ESA products I.e. PROSPECT (drill) and PILOT (landing system) to start in 2015**
- **Cooperation with Russia as first flight opportunity: ESA products to be embarked on Russian Luna-Resource Lander (Luna-27)**
- **Feasibility study on Lunar Polar Sample Return (Luna-28), in 2015/2016**
- **In preparation of future human missions in the lunar vicinity**

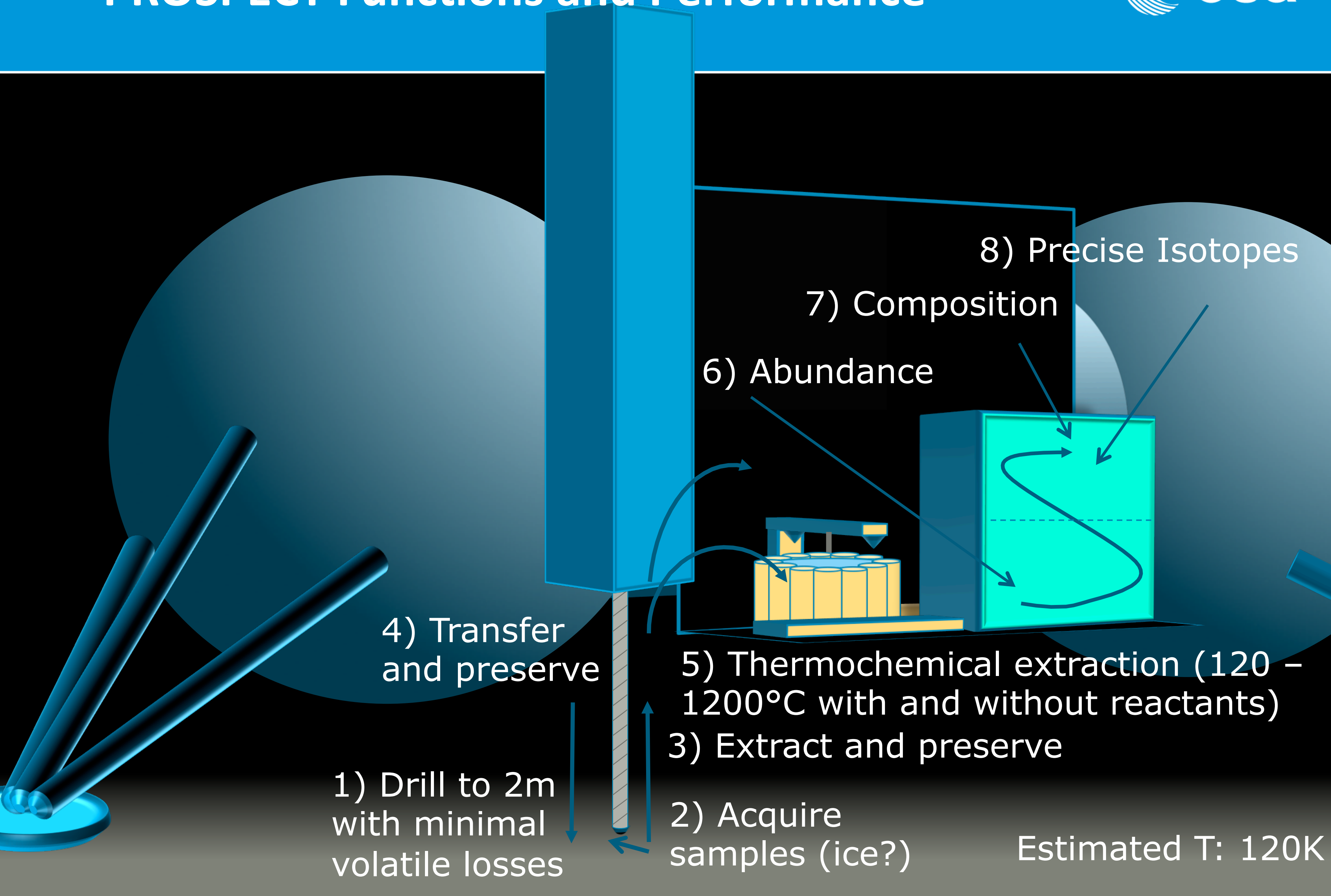
Main focus of ROSCOSMOS-ESA Lunar Cooperation



PROSPECT Overview



PROSPECT Functions and Performance



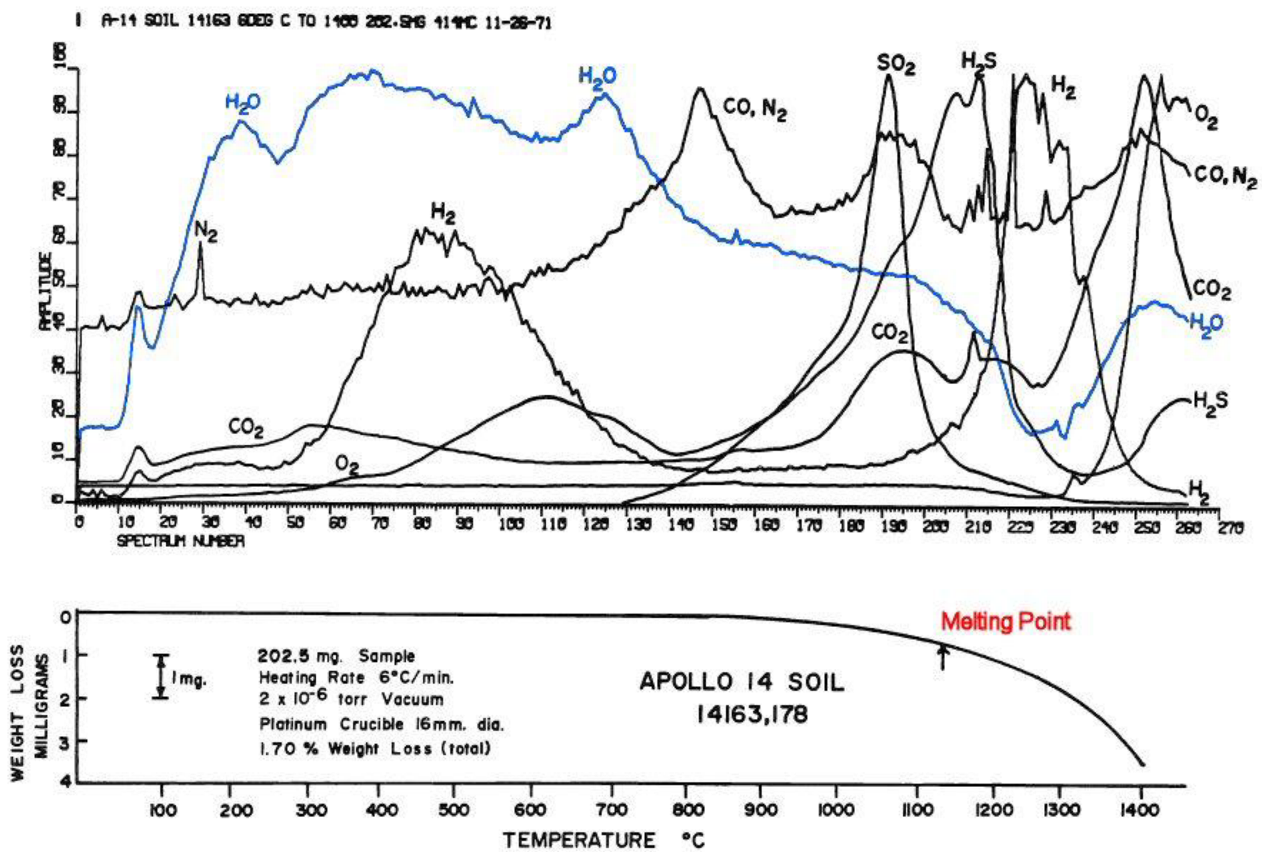
Questions addressed by PROSPECT

1. **Are Lunar volatiles and regolith a potential resource for future exploration?**
2. **what can resource orientated measurements tell us that's of fundamental scientific value?**

   a. What is there?
   b. How much is there?
   c. What does it take to release the resource relevant species?
   d. What are the sources of volatiles?
   e. What were the processes that put them there?
   f. How can we use this knowledge to understand the wider distribution?

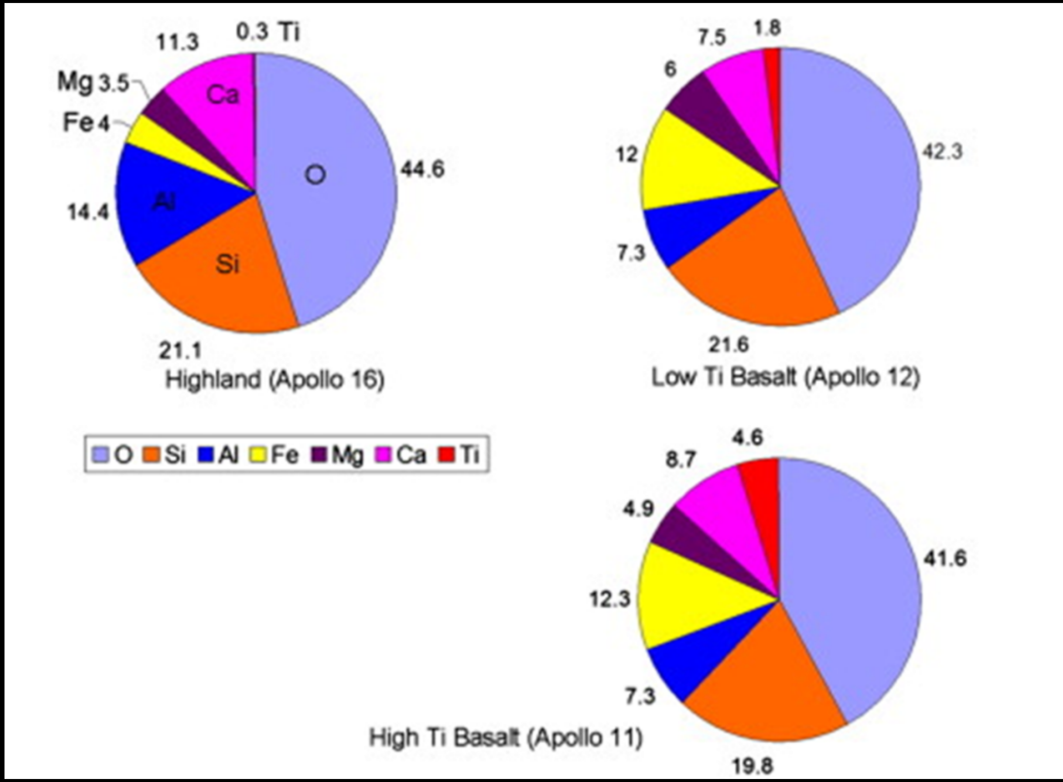
Volatiles in the regolith as potential resources

1. **Phase**
2. **Composition**
3. **Abundance**
4. **Distribution**
5. **Metrics for O2**
6. **Feasibility of ISRU**



Sampling a new kunar site

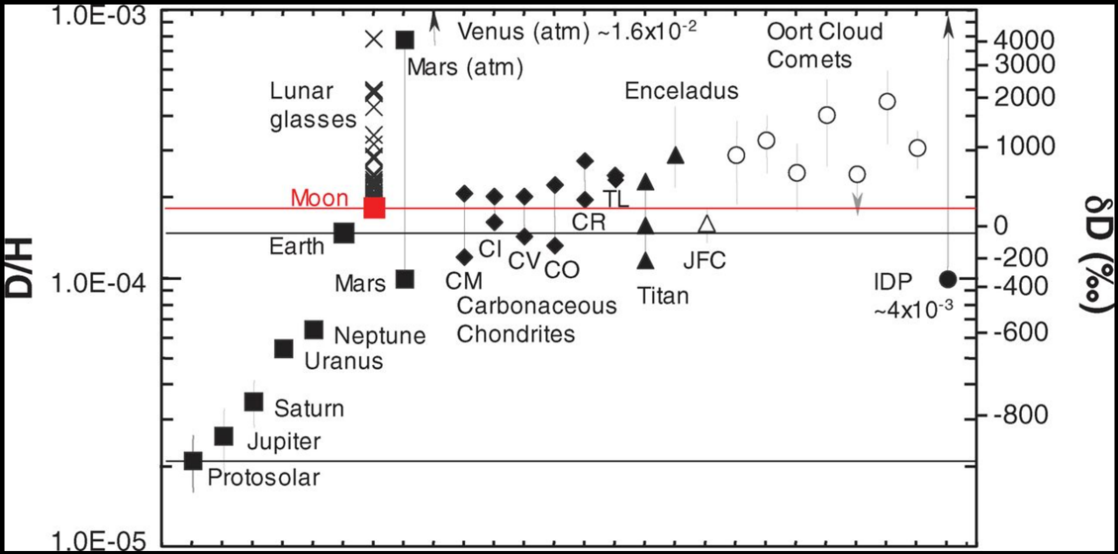
1. **Composition of regolith at a new and unexplored location**
2. **Regolith mechanical properties**



From Schwandt et al. 2012

Origins of volatiles in Earth-Moon System

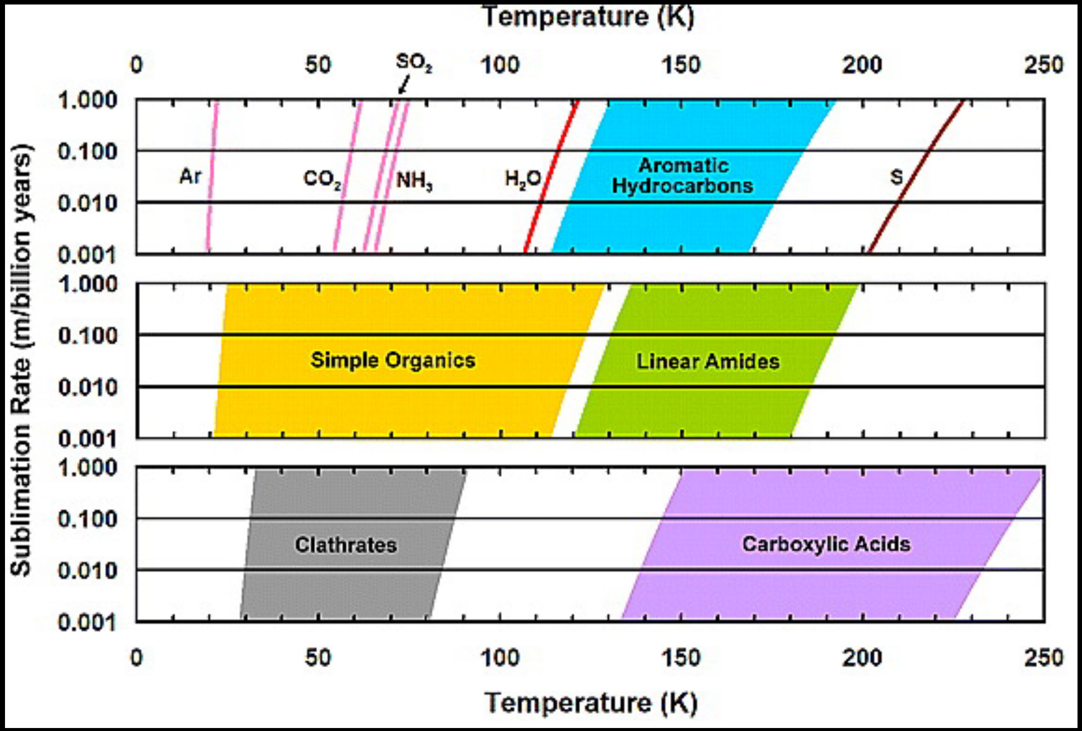
1. **Constrain volatiles delivery to the Earth-Moon system e.g.**
   a. **Asteroids**
   b. **Comets**
   c. **Solar Wind**
2. **Time averaged volatile inventory to the Earth-Moon system.**
3. **Relationships between molecules associated with the building blocks of life and those occurring in lunar ices and their sources.**



From Saal et al. 2013

Prebiotic chemistry

1. **Delivery by impactors**
2. **Products of organic synthesis reactions in lunar ices**
3. **Composition, chemistry and isotopic nature of any prebiotic organic molecules which are present and compare them with their terrestrial counterparts.**



PROSPECT User Group Call: Why Join Us

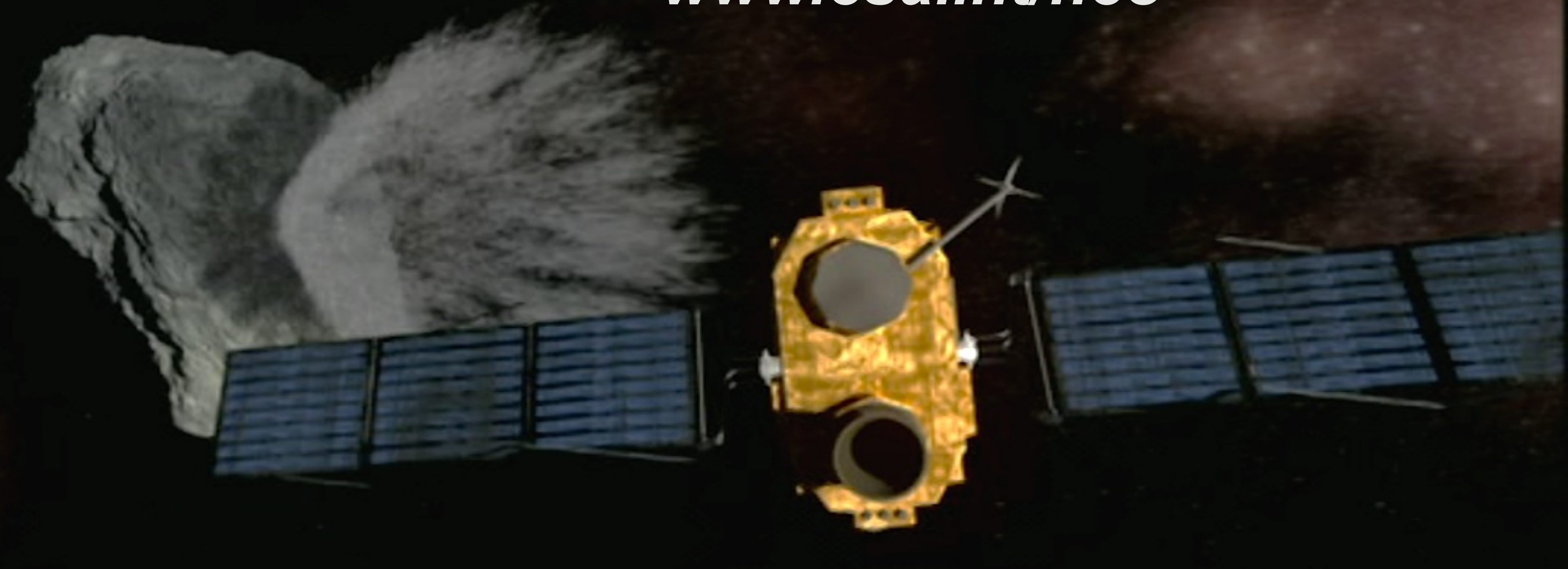
1. Play a role in the first steps of a new era in lunar exploration
2. Develop skills and experience in lunar exploration
3. Generate new research and collaborations along the way
4. Be involved as operations at the surface of the Moon unfold
5. Lead the way in exploiting the data

http://www.esa.int/Our_Activities/Human_Spaceflight/Research/Research_Announcements

Open until June 30th.

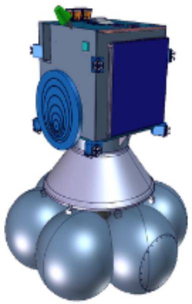
Asteroid Impact Mission

www.esa.int/neo



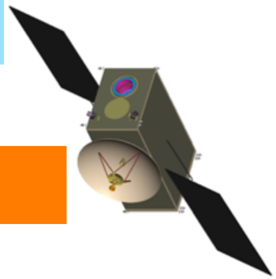
I Carnelli, K Mellan, A. Gálvez (D/TEC), M Kueppers (D/SRE)
& the international AIDA team

AIDA = AIM + DART



AIM: Physical characterization

DART: kinetic impact



Test validation by AIM + ground-based optical/radar

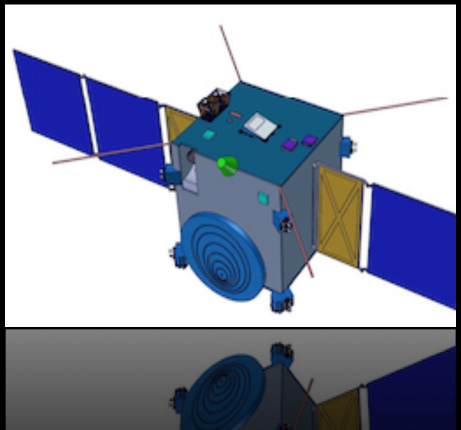
Missions are independent, but results boosted if flown together

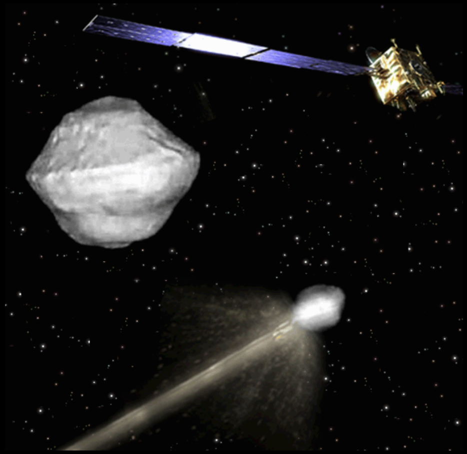
Impact date (October 2022) and target (Didymos) are fixed.

Asteroid Impact Mission (AIM)

Small mission of opportunity to demonstrate technologies for future missions & asteroid scientific investigations

Technology demonstration	Asteroid impact test	Science





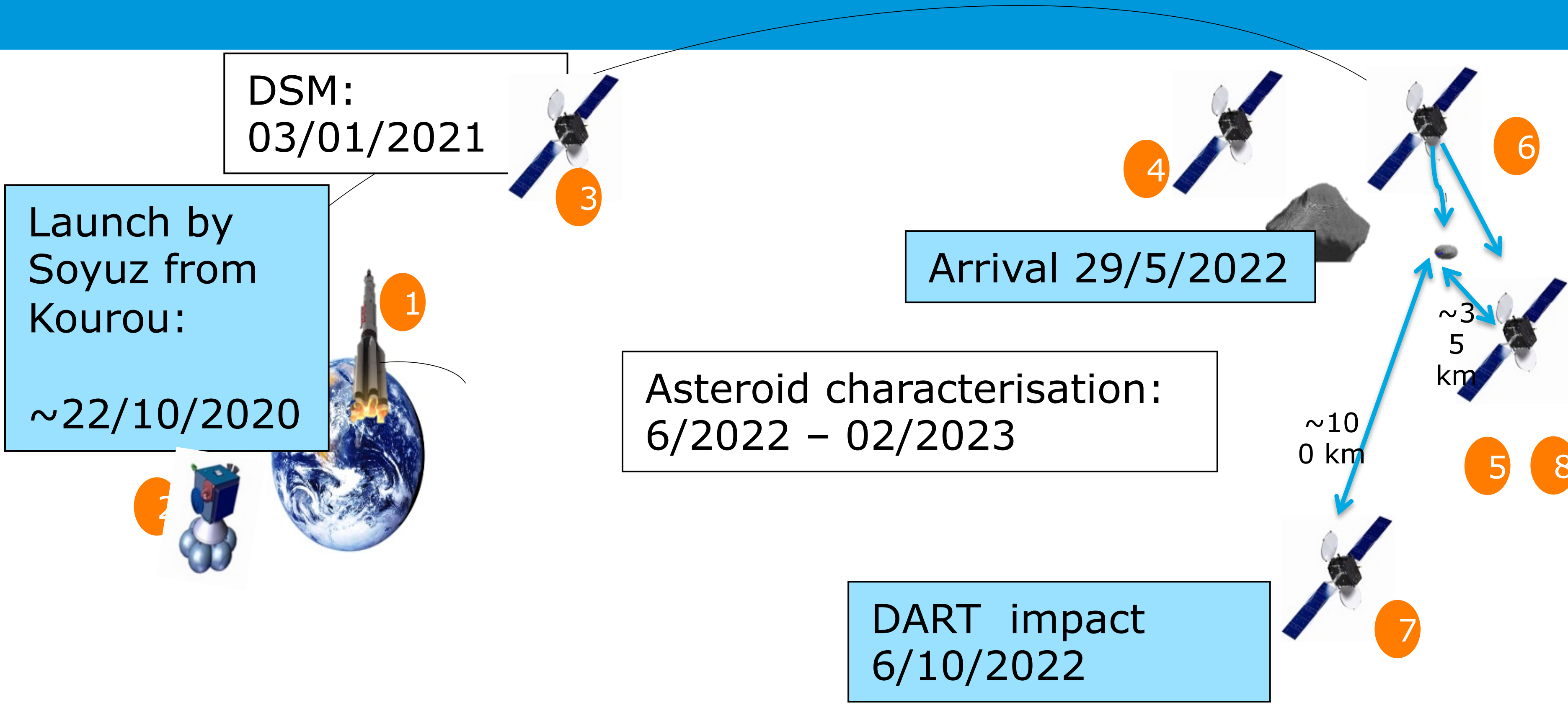
AIM Asteroid Research Objectives

P#	Parameter	Relevance to goal	Supporting instrument(s)
S#1	Didymoon size, mass, shape, density	Mass key to momentum, size to shape, volume, gravity and density to internal structure, operations	• Mass from binary orbit, spacecraft tracking (RSE, Optel-D) • Shape model from Visual Imaging System (VIS), laser altimetry (Optel-D)
S#2	Dynamical state of Didymoon (period, orbital plane axis, spin rate and spin-axis)	Key to determine momentum, indirect constraints on the internal structure	• VIS
S#3	Geophysical surface properties, topology, shallow subsurface	Bulk composition, material mechanical properties, and surface thermal inertia, key to determine momentum as shallow subsurface drives the efficiency of the impact shock wave propagation, data point to validate kinetic impact simulations	• VIS for surface features • Thermal InfraRed Imager (TIRI) for surface roughness • Hi-frequency radar HFR for shallow subsurface structure • Accelerometer on lander
S#4	Deep internal structure of Didymoon	Interior can affect absorption of impact energy, "data point" to validate asteroid mitigation models. Key to distinguish between scenarios of binary origin	• Low-frequency radar LFR • Drift-bys to estimate gravity field

AIM Technology Research Objectives

P#	Goal	Comment
T#1	Qualify an end-to-end 2-way deep-space optical communications system for small missions	• Primary goal transmit full asteroid 1m resolution map before DART arrival (goal, transmit images of the impact) • Components and operations representative of terminal developed for commercial applications. • Maximum platform independence: inertial pseudo-star pointing, mirror-stabilization, power-limited modes 135 W nominal @ 0.11 AU and 50 w power limited mode @ 3.3 AU max distance
T#2	Demonstrate deep-space inter-satellite communication network for independent CubeSat-based sensors (COPINS)	• Deploy up to two 3U cubesats (or any combination of units) • Demonstrate inter-satellite link network between AIM, COPINS and MASCOT-2 lander
T#3	Demonstrate asteroid landing and extended operations in the secondary component of a binary system	• Demonstrate landing on small (170 m) asteroid and inter-satellite link in deep-space • Test long-lived payload operation i.e. transmission radar and surface imaging, possibly other if resource allow.

AIM mission scenario



1 Launch

2 Departure burn

3 Deep space manoeuvre

4 Rendez-vous burn

5 Co-flying / Characterisation

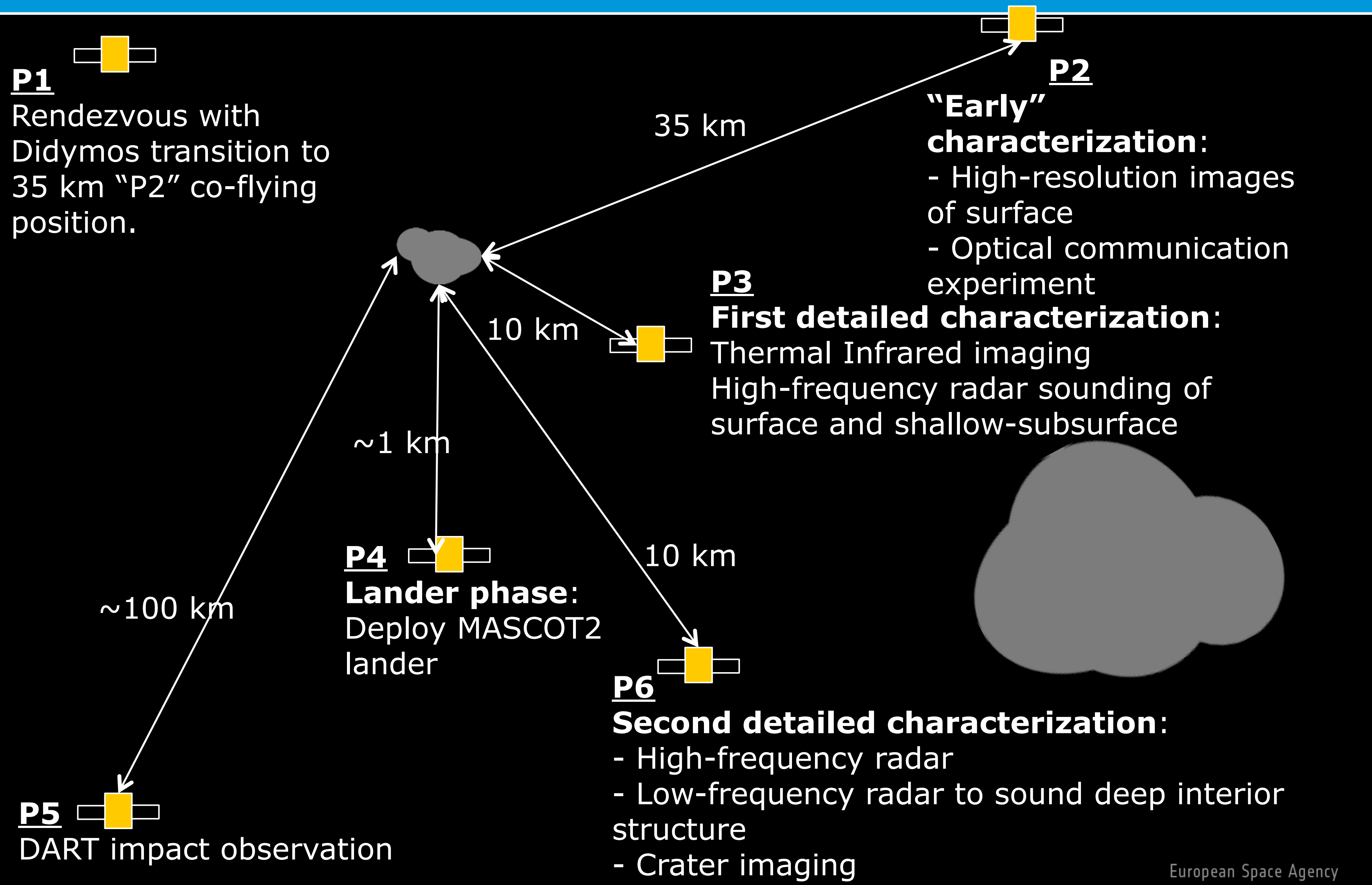
6 Lander deployment

7 DART impact observation

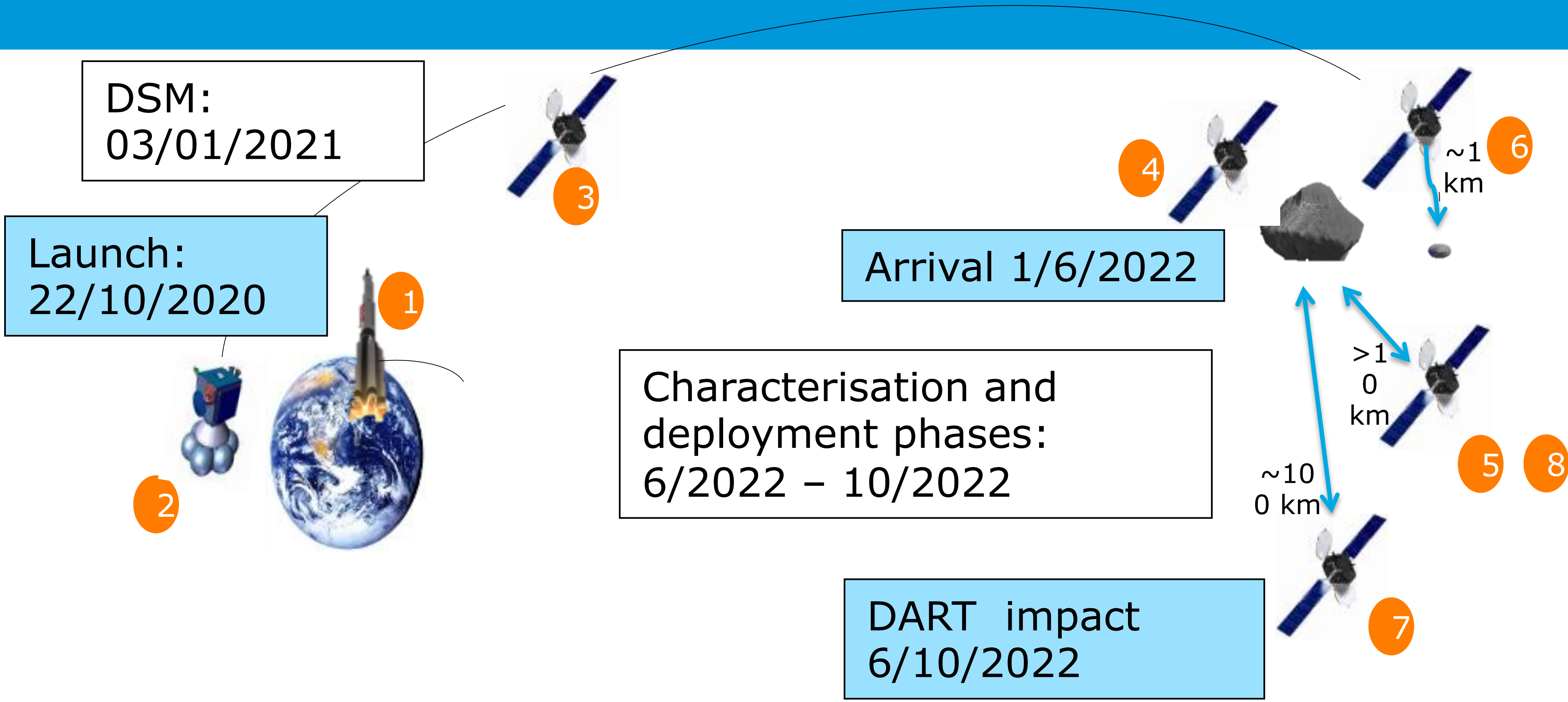
8 Co-flying / Characterisation

9 Post-impact characterisation

Close proximity Asteroid Operations: 29 May 2022 – 25 December 2022

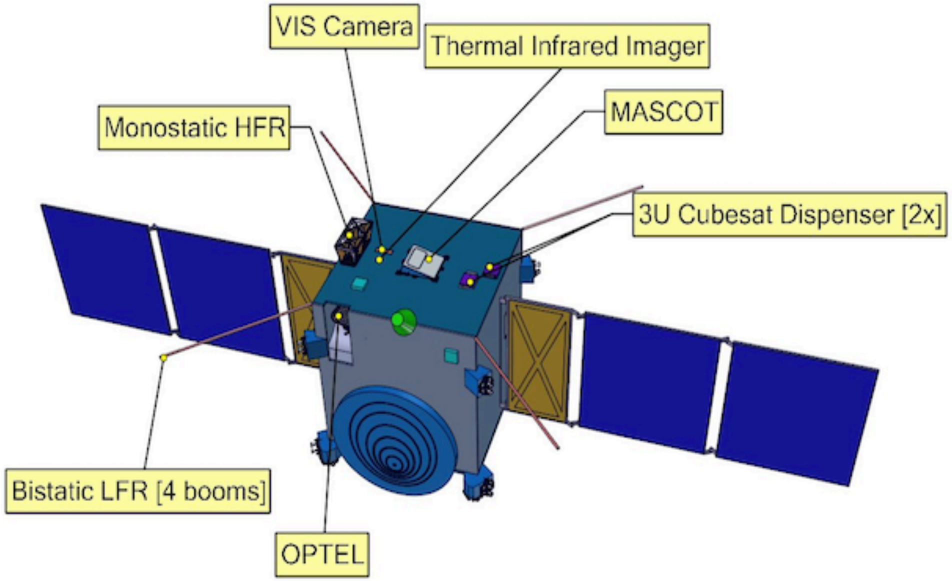


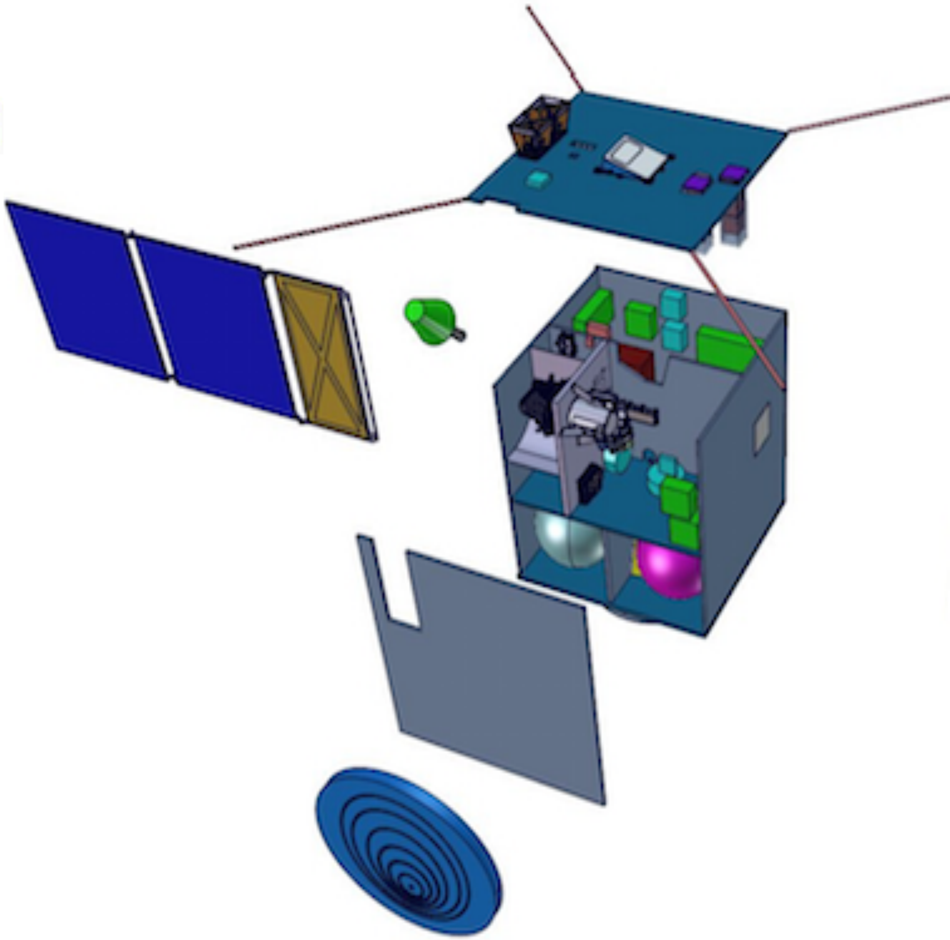
AIM Mission Scenario



1. Launch
2. Departure burn
3. Deep space manoeuvre
4. Rendez-vous burn(s)
5. Characterisation (ECP, DCP
6. Lander deployment
7. DART impact observation
8. Characterisation (post-impact)
9. End of mission

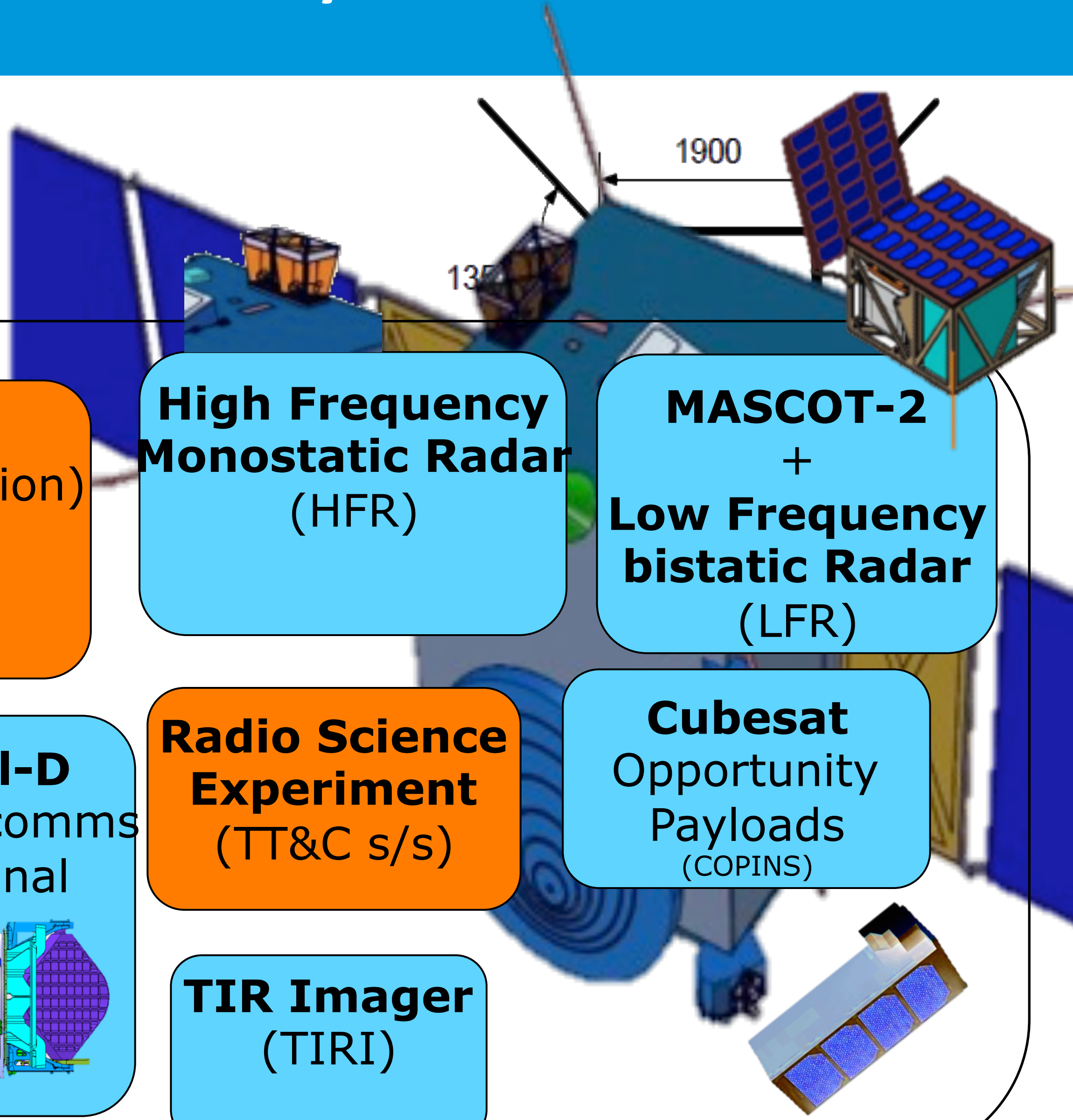
AIM main elements

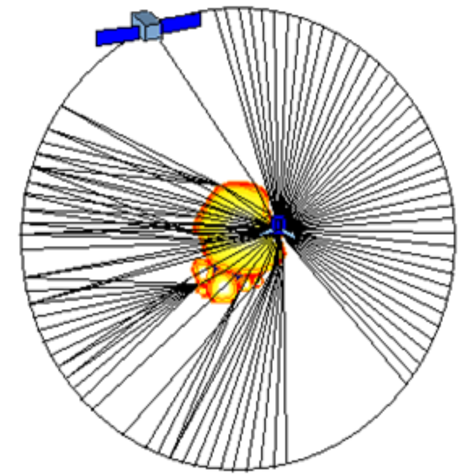




Technology Payload	Mass
OPTEL-D (Optical terminal)	39.3
MASCOT-2 (incl. low-frequency radar)	13
COPINS	13.2
Asteroid Research Payload	**Mass**
Thermal Infrared Imager	3.6
Monostatic High Frequency Radar	1.7
Bistatic Low Frequency Radar (Orbiter)	1.2
Visual Imaging Camera	2.4

AIM Model Payload



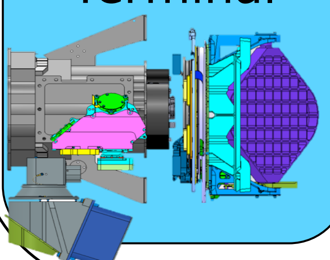


VIS
(Navigation)

High Frequency Monostatic Radar
(HFR)

MASCOT-2
+
Low Frequency bistatic Radar
(LFR)

Optel-D
Optical comms Terminal



Radio Science Experiment
(TT&C s/s)

Cubesat
Opportunity Payloads
(COPINS)

TIR Imager
(TIRI)

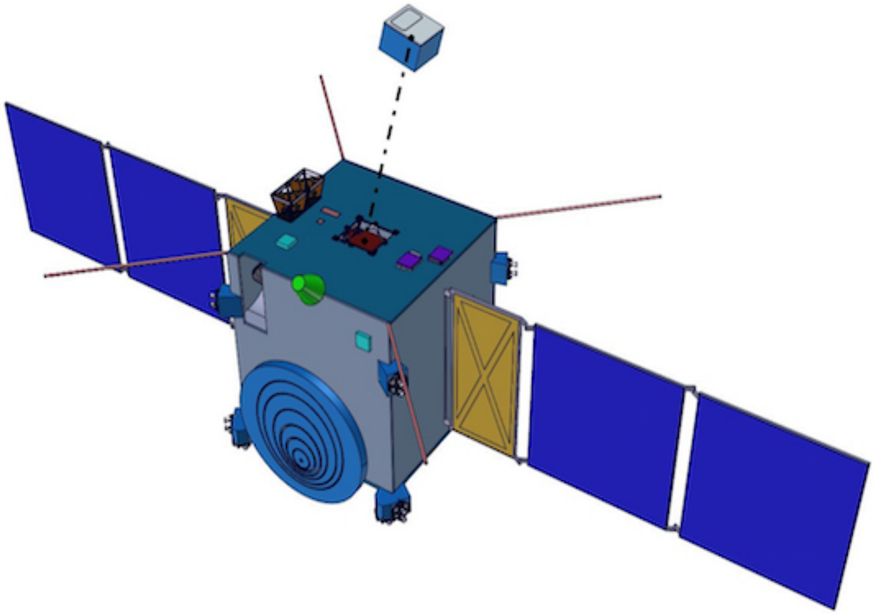
Built-in AIM S/C (subsystem)

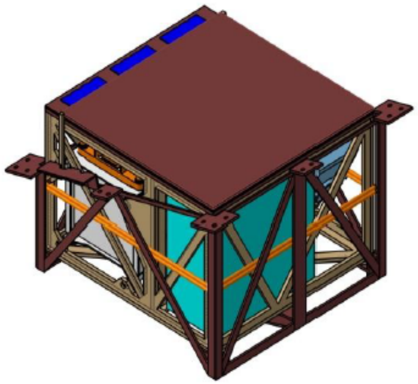
AIM payload

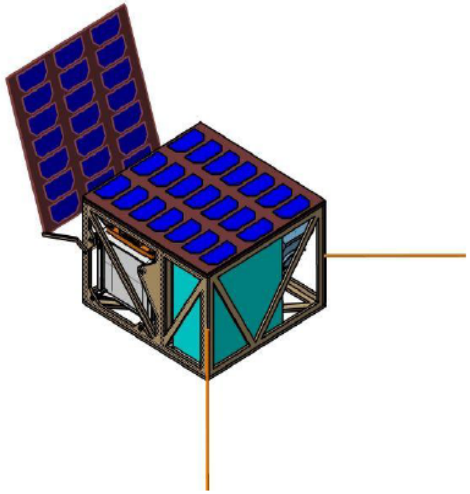
MASCOT-2 lander

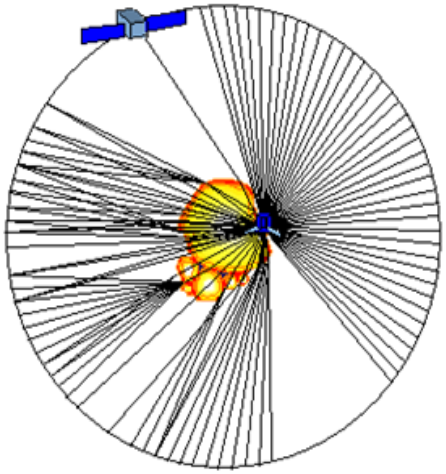
- Unfoldable solar generator cover
- Supports orientation and protects solar cells during touch-down
- Carries low-frequency radar transmitter.

Signal to be captured by the AIM spacecraft will enable understanding the interior structure of the asteroid

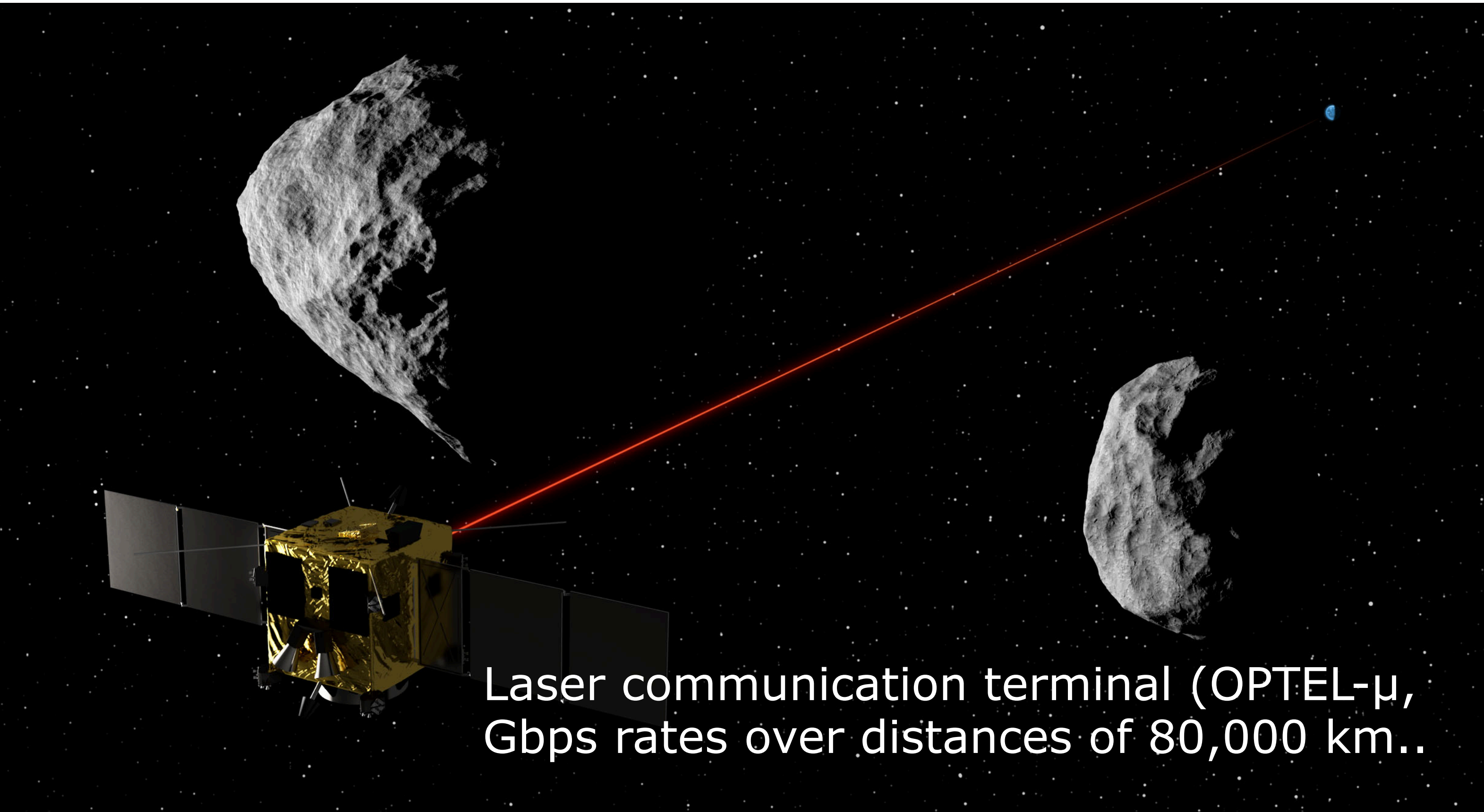








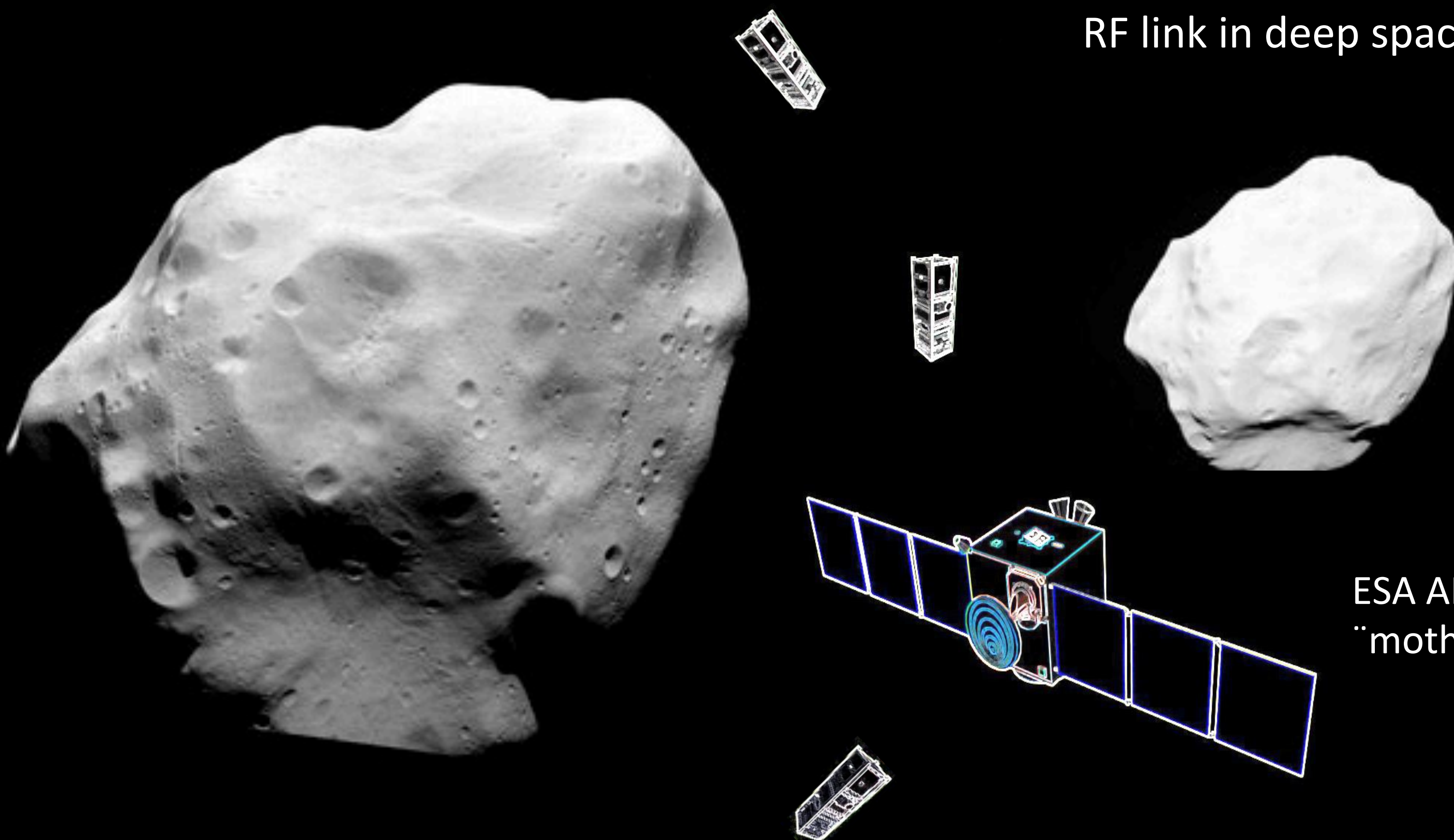
Optel-D



Background:
NASA´s LADEE LLCD (622 Mbps down/20 Mbps up from the Moon) was tested using ESA´s OGS

CubeSats Opportunity Payloads (COPINS)

Independent payloads and RF link in deep space



ESA AIM
¨mothercraft¨

AO in 2015 – 18 proposals under evaluation

Thermal IR Imager (TIRI)

TIRI strawman design

- Heritage: MERTIS
- Spectral resolution: 7 µm – 15 µm (TBD number of spectral bands)
- Sensor: 160 x 120 pixel microbolometer (uncooled)
- CCD bit depth: 8 bit

Instrument performance

- Spatial resolution: 14.2 m on secondary asteroid @ 10 km
- preliminary requirement: <20 m

- TIRI may be operated simultaneously to VIS
- Data volume for single measurement set: 2.8 Mbit (12 h imaging / 1200 s readout rate)
- Min data volume for mission goals: 16.8 Mbit
- (6 measurement sets - TBC)

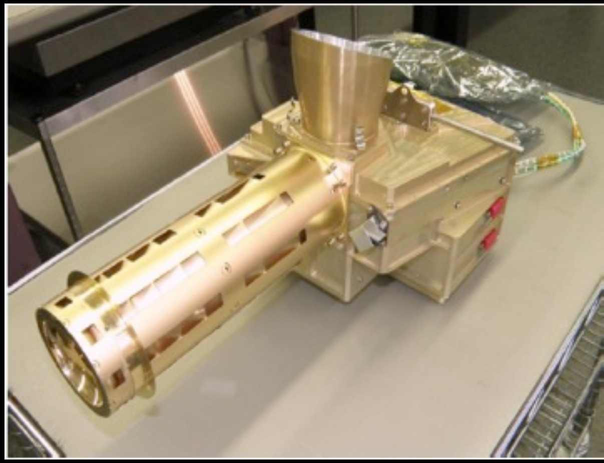


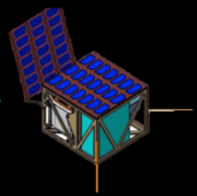
Figure: MERTIS

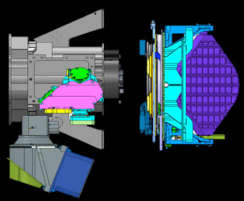
AIM & Payload activities 2015-2016

A (2015) — B1 (2016)

KO	PM1	PM2	PM3/PRC	PRR	PM4	ISRR
KO	KO+2	KO+4	KO+6	KO+9	PRR+3	PRR+6
ESTEC 19 March	8-13 May	3-6 July	21-22 Sept ESAC	19-29 Jan ESTEC	8-11 April	6-13 July ESTEC

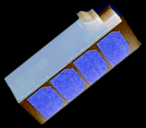
15 April — MASCOT-2





May — OPTEL-D

30 April — HFR



May — COPINS

July — TIRI

Summary & Conclusions

Several projects will offer opportunities to the community:

In MREP-2 (D/SRE)

- ESA/NASA/JPL MarsFast rover concept internal studies
- Phobos SR in industrial Phase-A
- iMars-2 MSR plan continues (report end June 2015)

In Lunar exploration (D/HSO)

- Studies on the PROSPECT drill for Roscosmos Luna-27 mission, and on Lunar Polar Sample Return Luna-28 in 2020s

In the technologyy Demonstration mission (D/TEC)

- Asteroid Impact Mission, in the context of the AIDA ESA-NASA cooperation, noe in industrial Phase A/B1
- AIM MASCOT-2 and radars started, studies on Optical Terminal and Cubesat Opportunity Payloads under evaluation
- ESA ITT for a study on the Thermal Infrared Imager planned after the summer


Thank you