Search for Life on Mars

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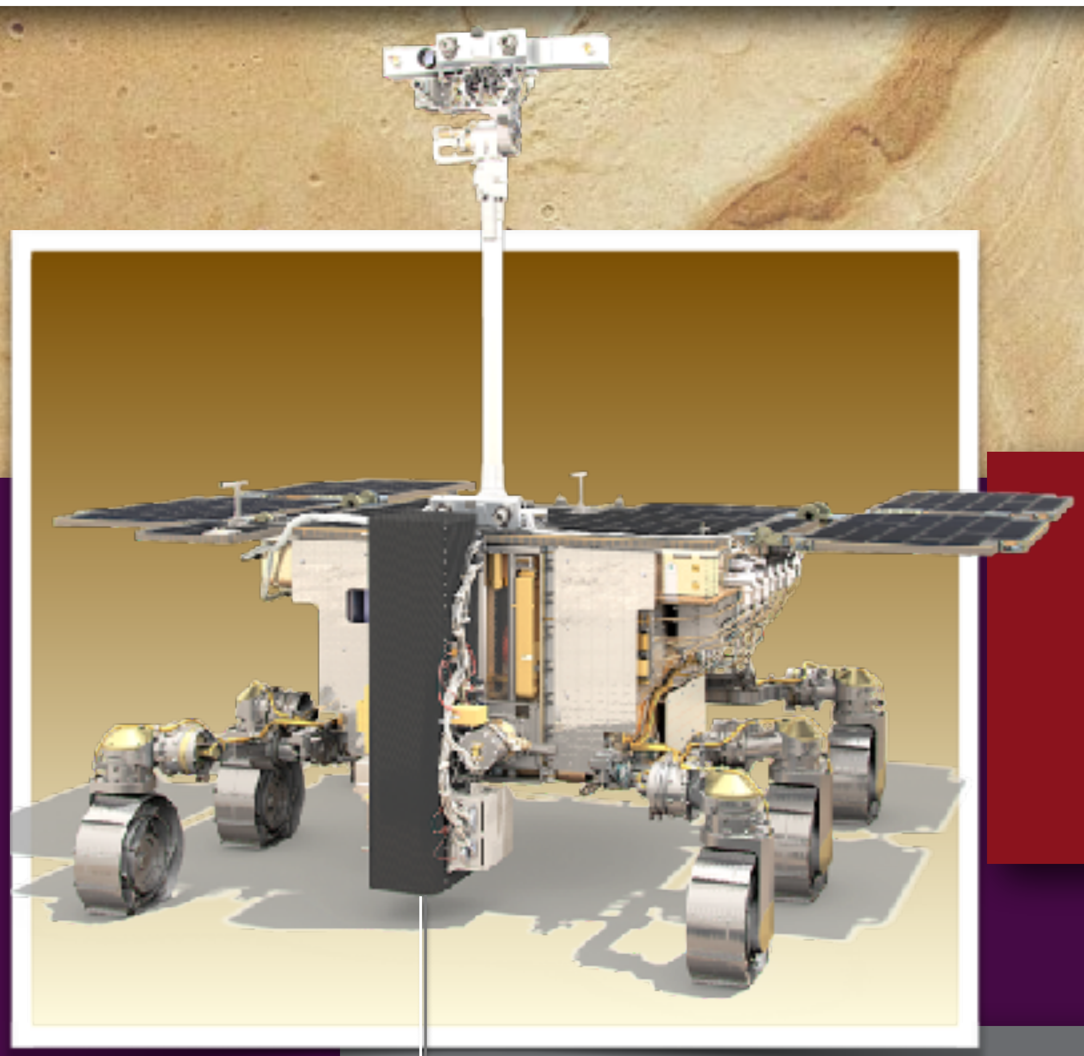
2020 Mission Objectives

E X O M A R S

2020



SCIENTIFIC OBJECTIVES

- To search for signs of past and present life on Mars;
- To investigate the water/subsurface environment as a function of depth.

TECHNOLOGY OBJECTIVES

- Surface mobility with a rover (having several kilometres range);
- Access to the subsurface to collect samples (with a drill, down to 2-m depth);
- Sample acquisition, preparation, distribution, and analysis.

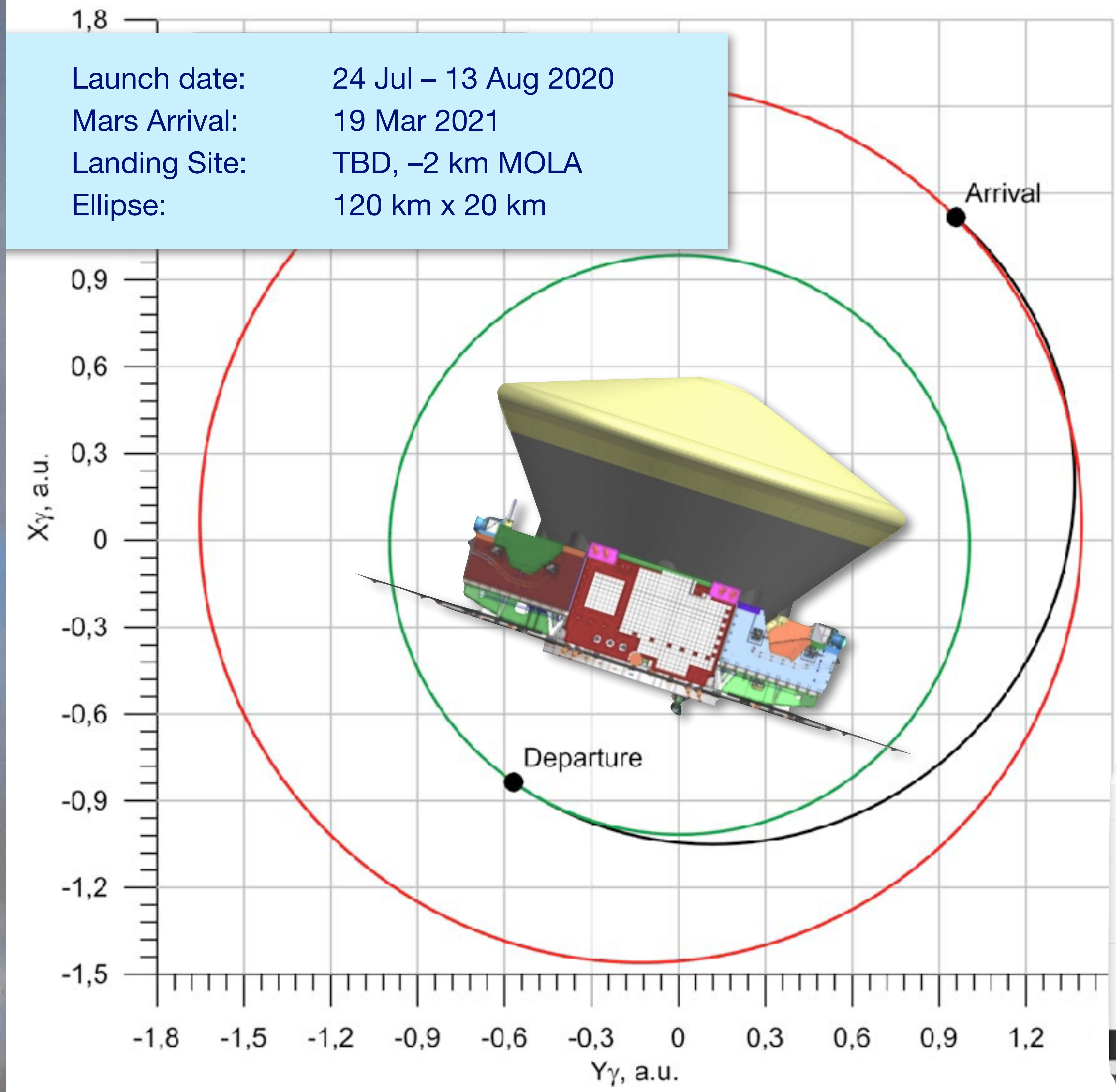
- To characterise the surface environment.

- Throttleable braking engines for planetary landing.
- Russian deep-space communications stations working in combination with ESA's ESTRACK.

Credit: Mamers Valles, MEX/HRSC

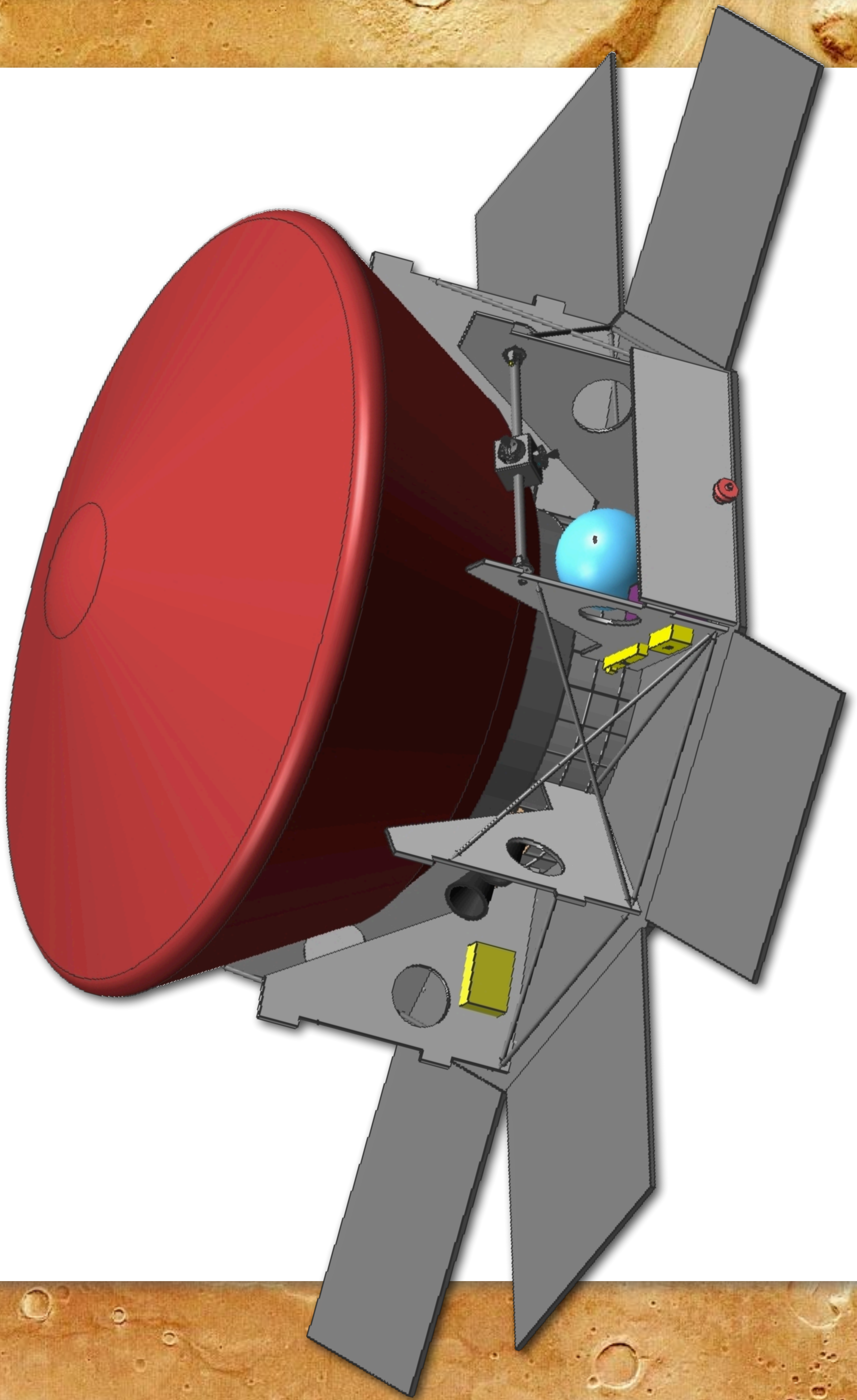
Launch

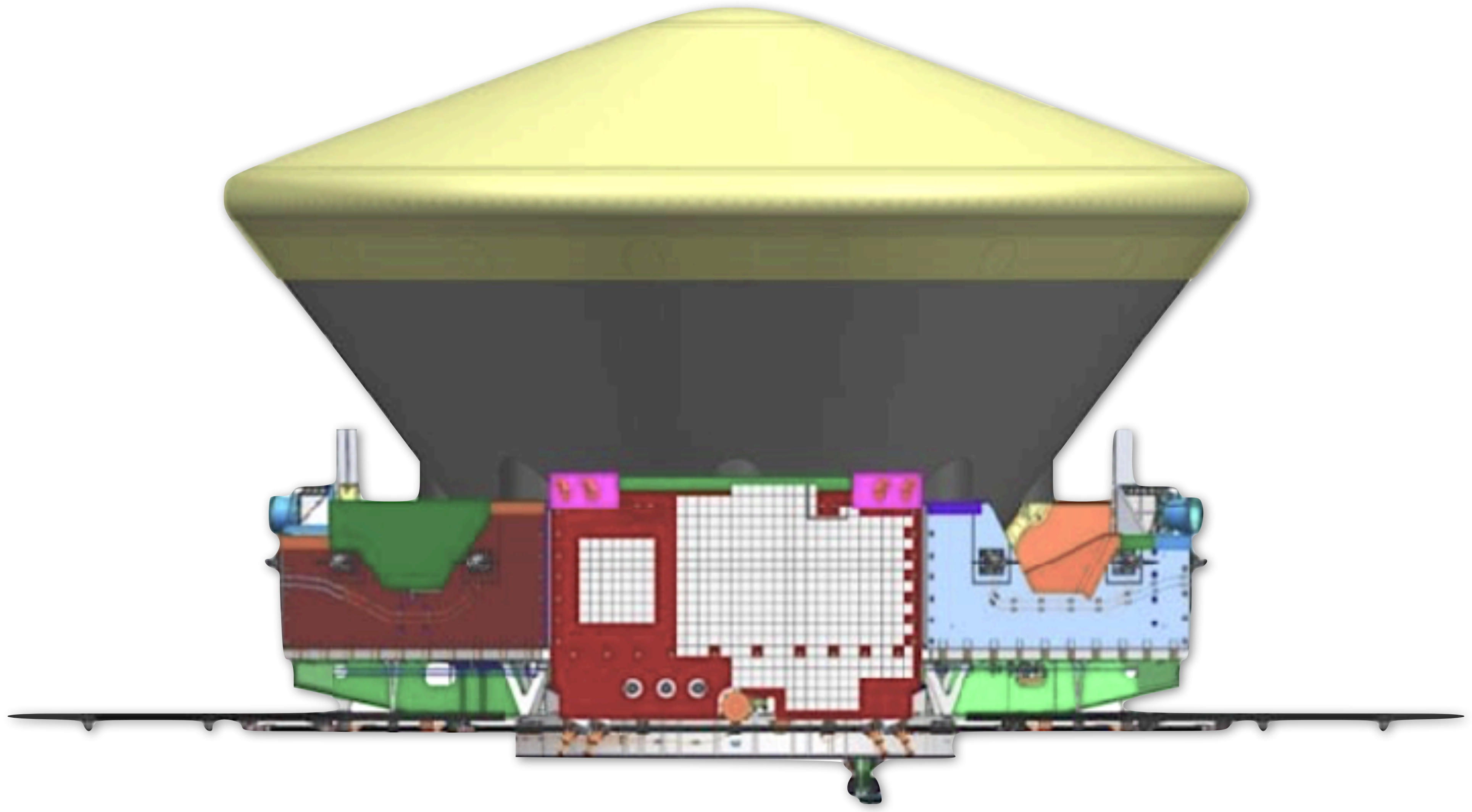
Launch date: 24 Jul – 13 Aug 2020
Mars Arrival: 19 Mar 2021
Landing Site: TBD, –2 km MOLA
Ellipse: 120 km x 20 km

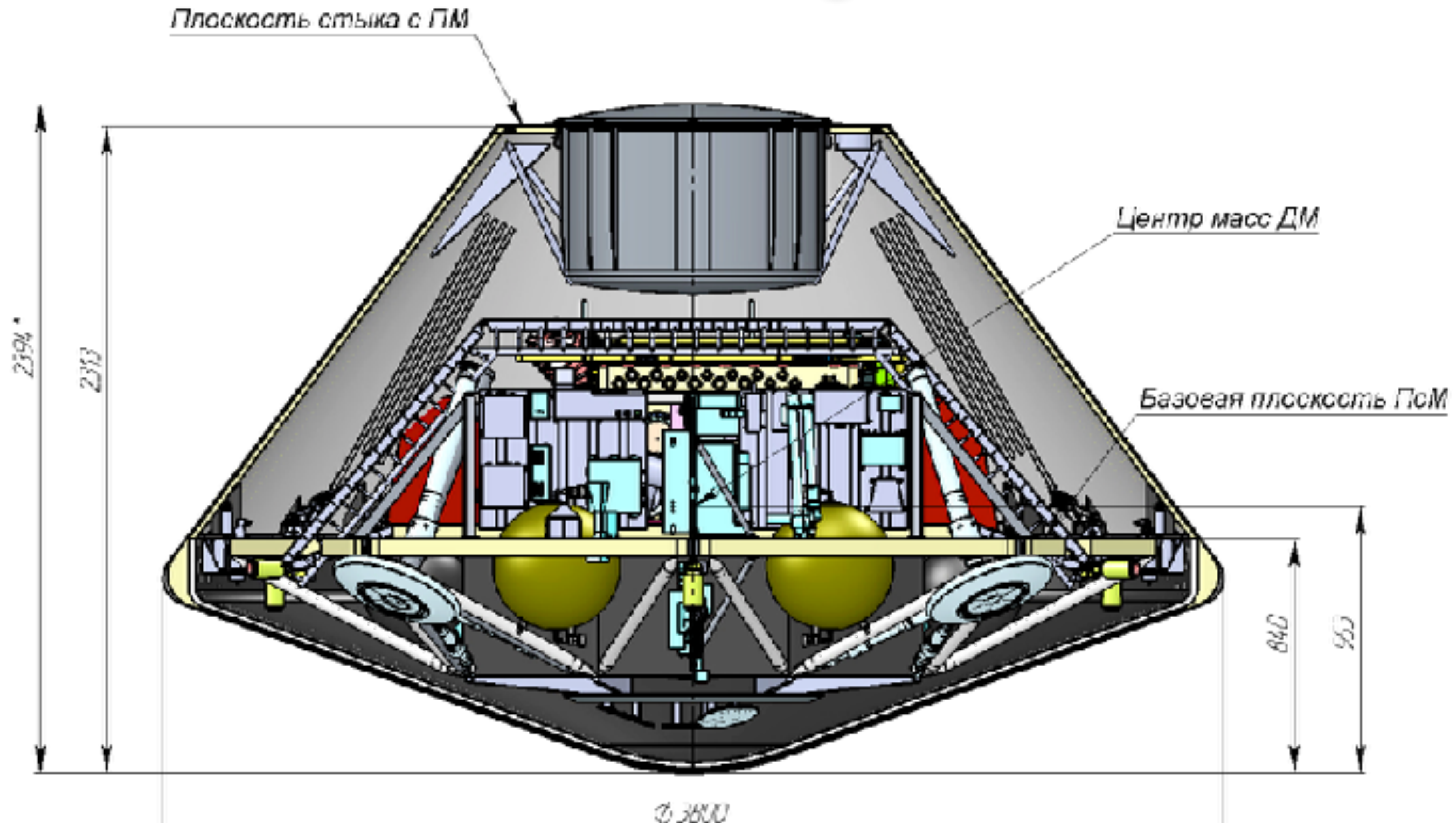


Credit: Mamers Valles, MEX/HRSC

Carrier and Descent Module

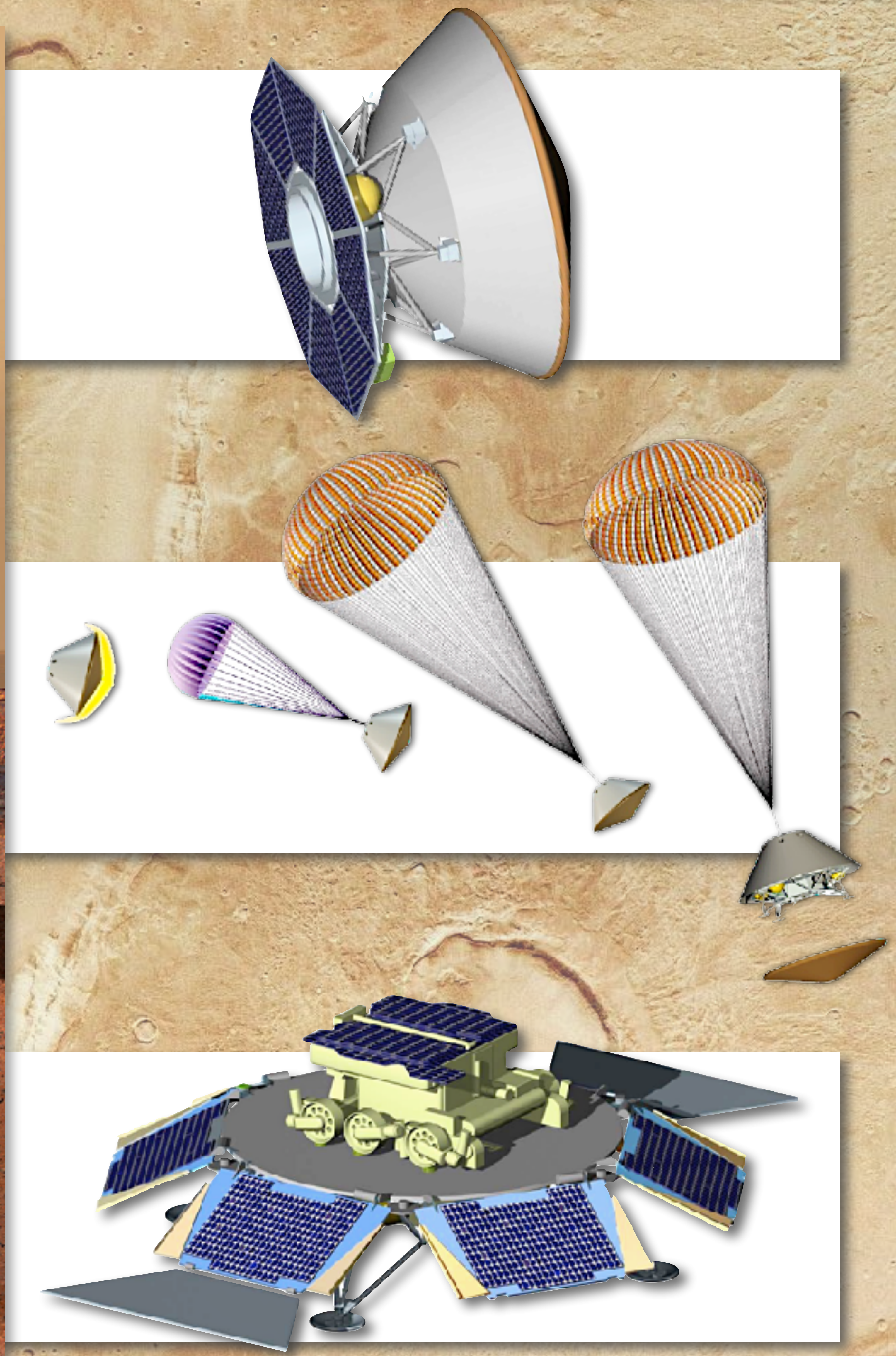






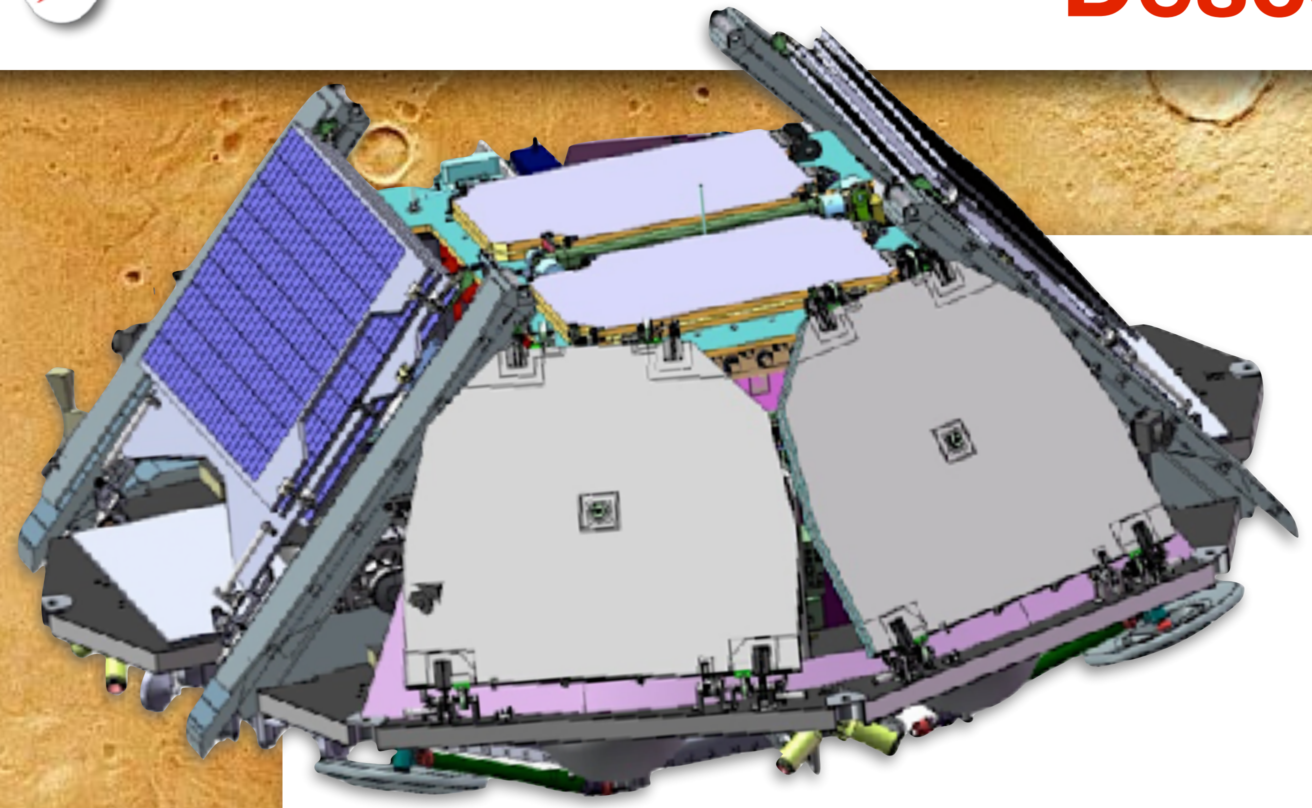
Credit: Mamers Valles, MEX/HRSC

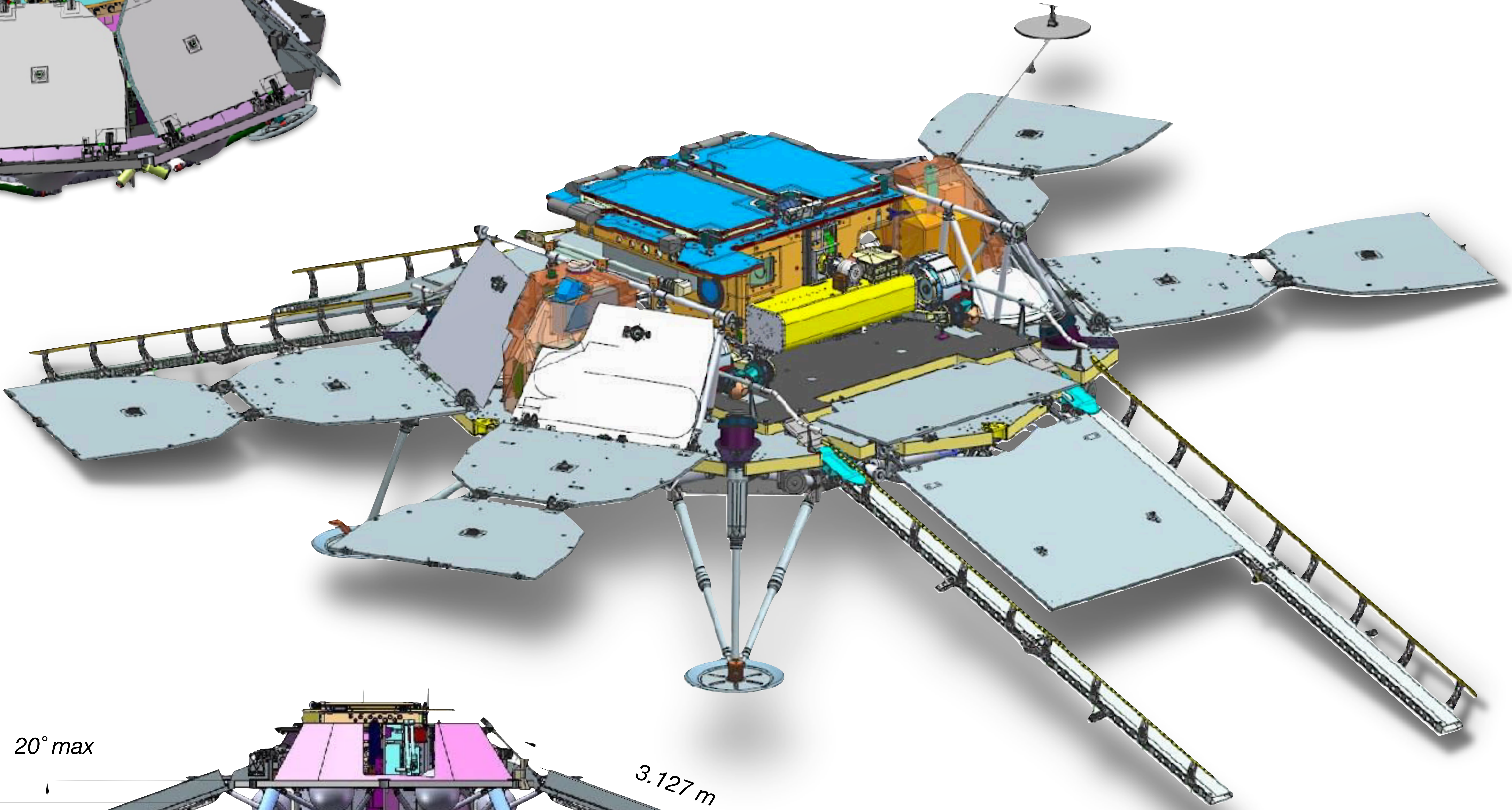
Entry, Descent, and Landing

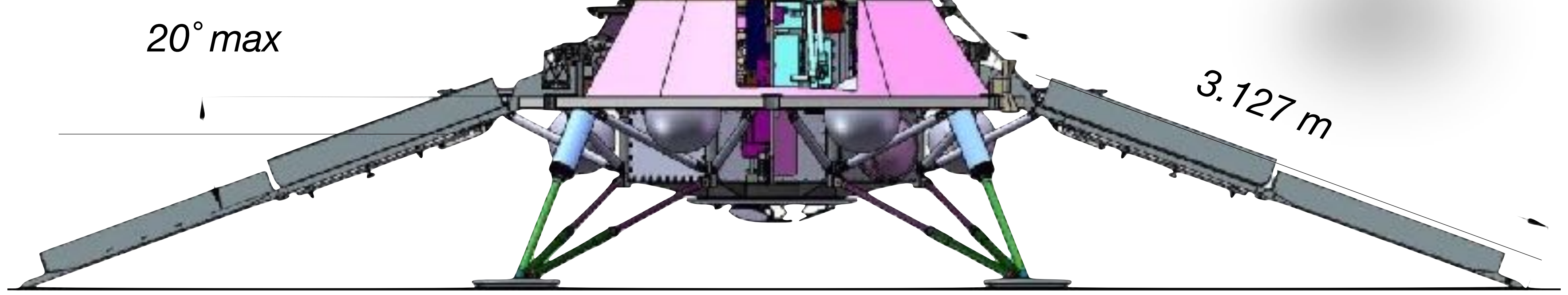


Credit: Mamers Valles, MEX/HRSC

Descent Module

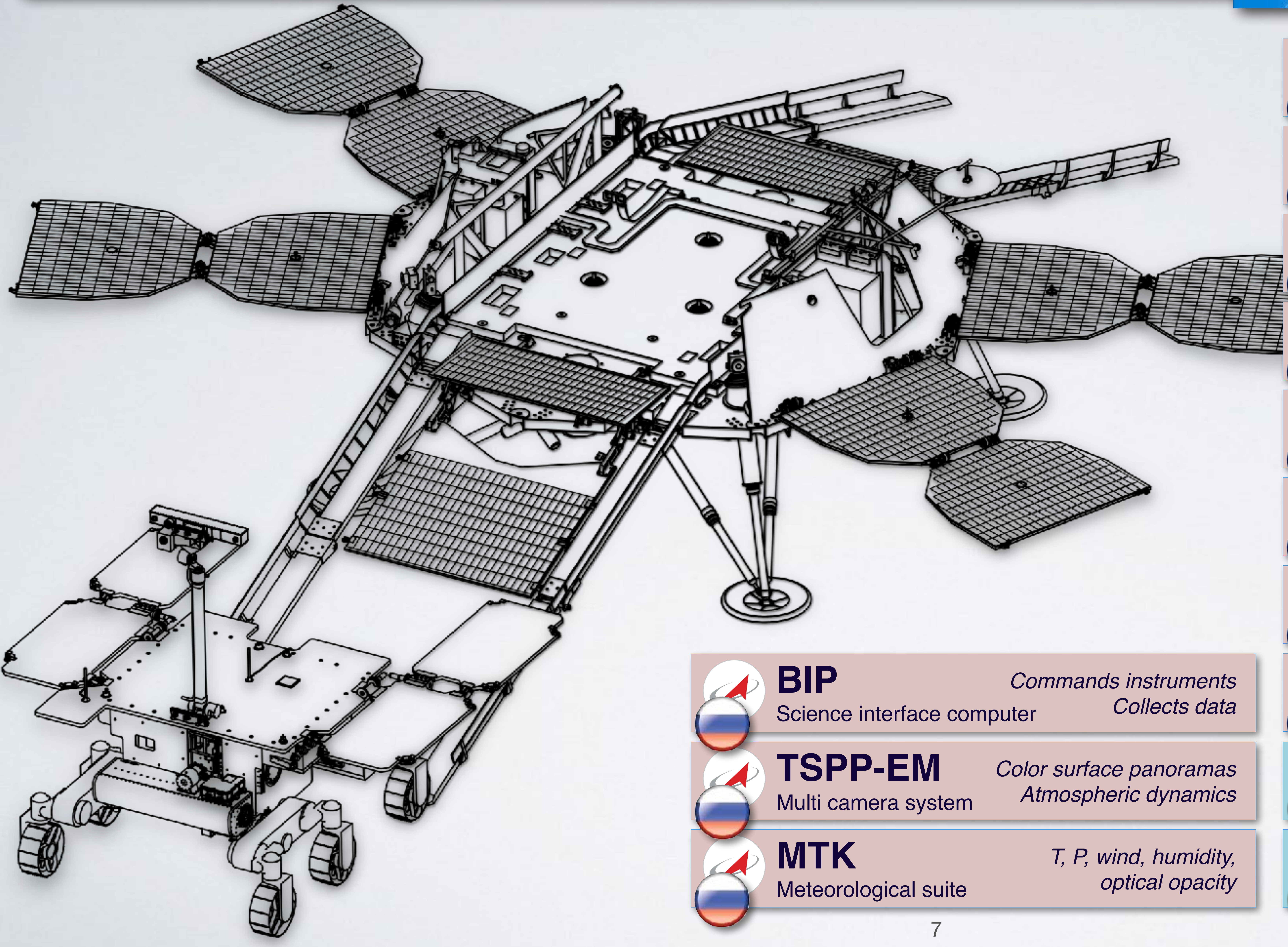






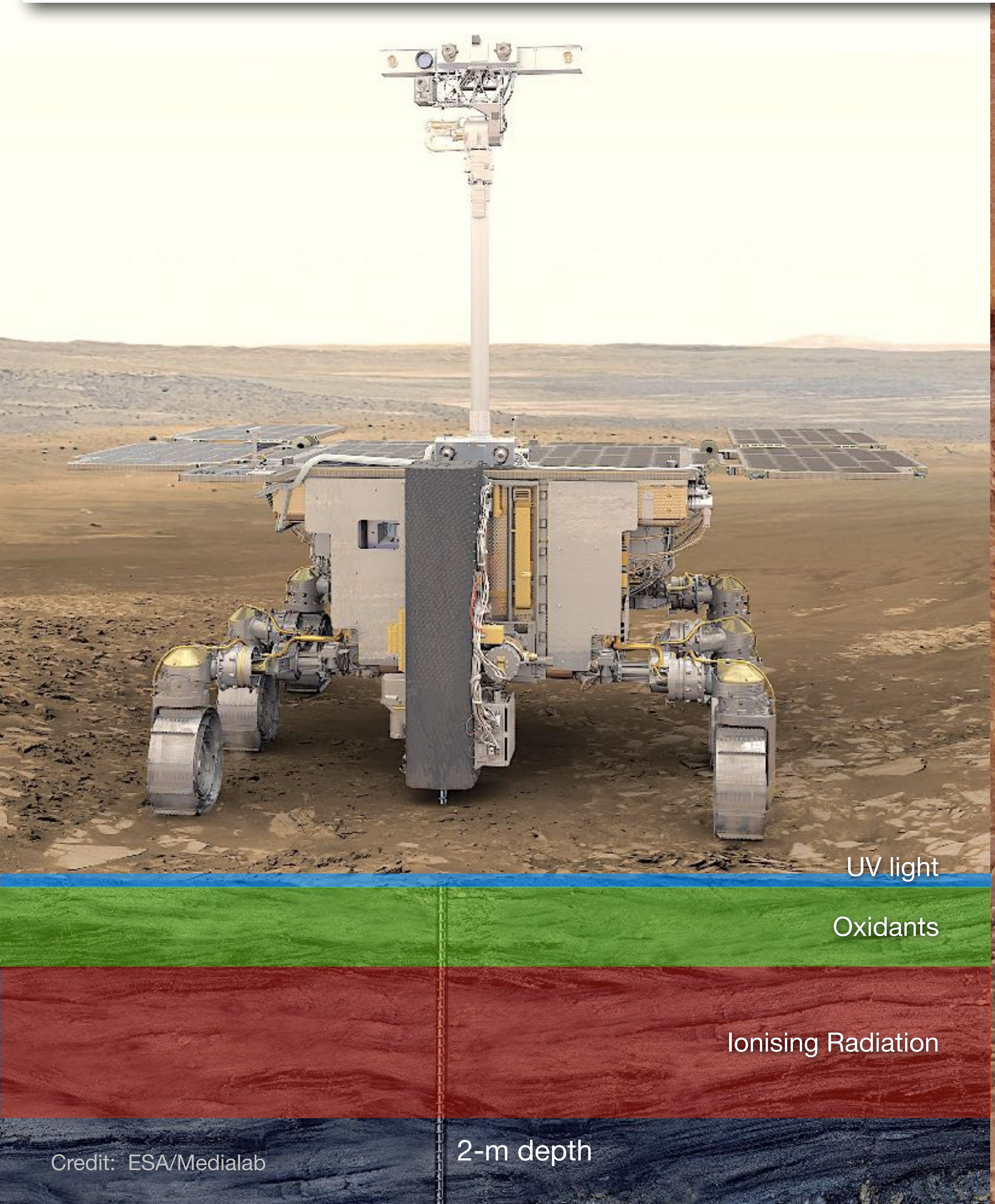
Credit: Mamers Valles, MEX/HRSC

Surface Platform



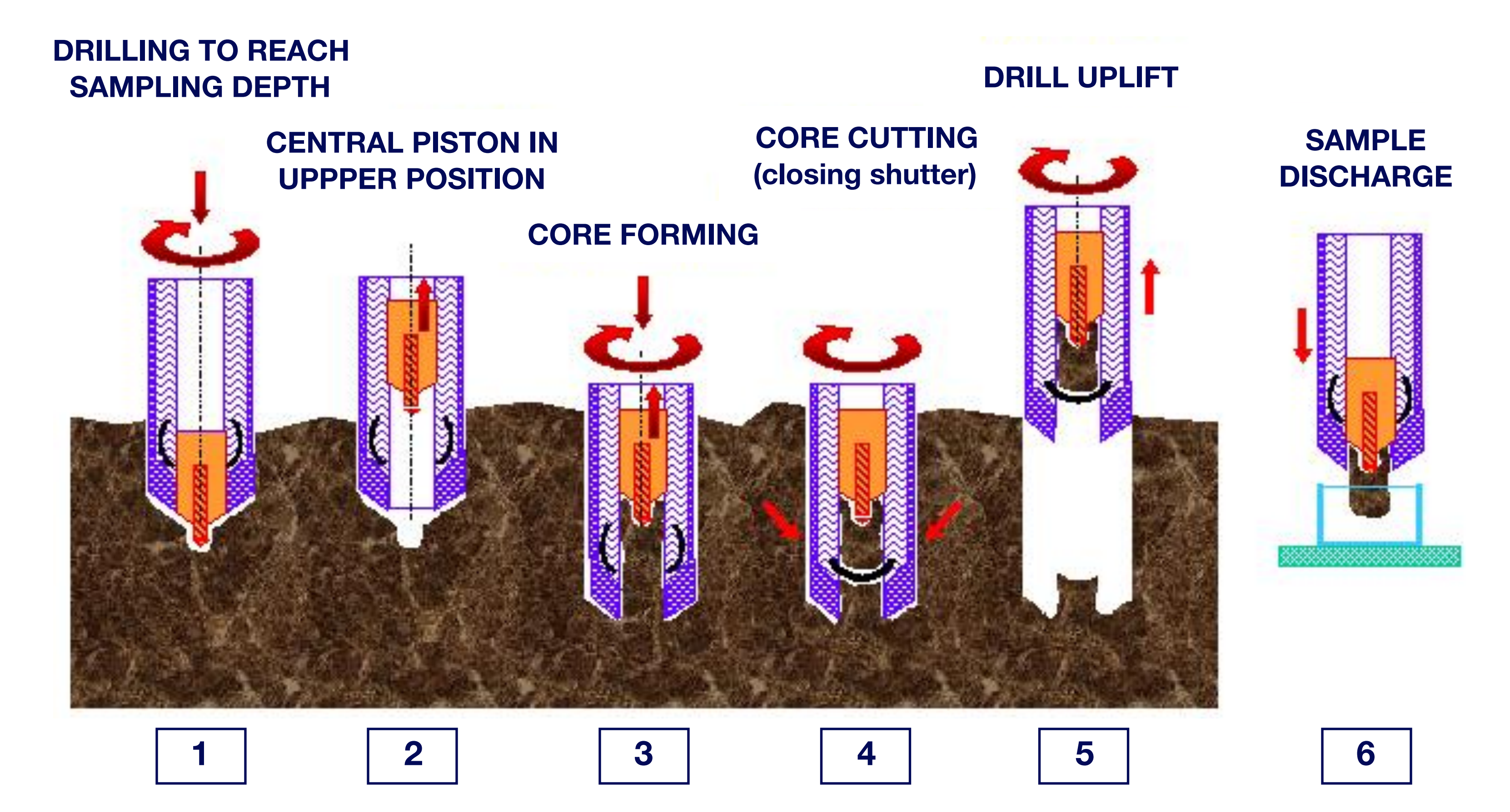
Instrument	Description	Measurement
PK	Dust suite	*Dust properties and E field monitoring*
FAST	IR Fourier spectrometer	*Trace gases T and aerosol monitoring*
RAT-M	Microwave radiometer	*Surface and atmospheric T monitoring*
ADRON-EM	Neutron detector	*Subsurface water content Radiation dosimetry*
MAIGRET	Magnetometer	*Magnetic field measurements*
MGAK	GCMS	*Atmospheric Analysis*
SEM	Seismometer	*Internal Mars structure investigations*
M-DLS	Diode laser spectrometer	*Atmospheric chemical and isotopic composition*
BIP	Science interface computer	*Commands instruments Collects data*
TSPP-EM	Multi camera system	*Color surface panoramas Atmospheric dynamics*
MTK	Meteorological suite	*T, P, wind, humidity, optical opacity*
LaRa	Coherent transponder	*Radio science for internal structure investigations*
HABIT	Habitability studies	*T, UV dose, humidity, salt deliquescence*

Mobility + Subsurface Access



Credit: ESA/Medialab

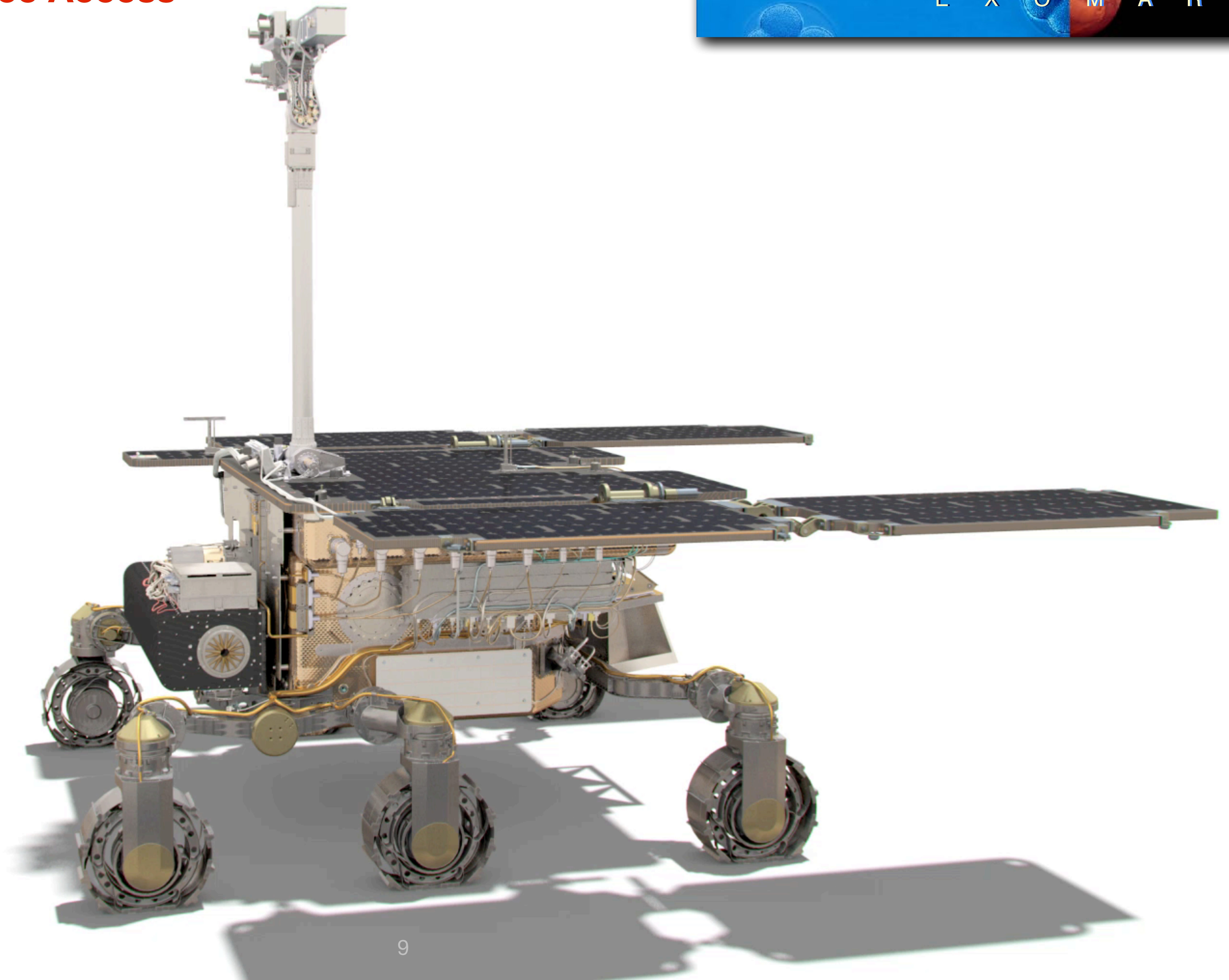
Nominal mission :	218 sols
Nominal science :	6 Experiment Cycles + 2 Vertical Surveys
EC length :	16–20 sols
Rover mass :	300-kg class
Mobility range :	Several km



Credit: Argyre, MEX/HRSC

Mobility + Subsurface Access

E X O M A R S

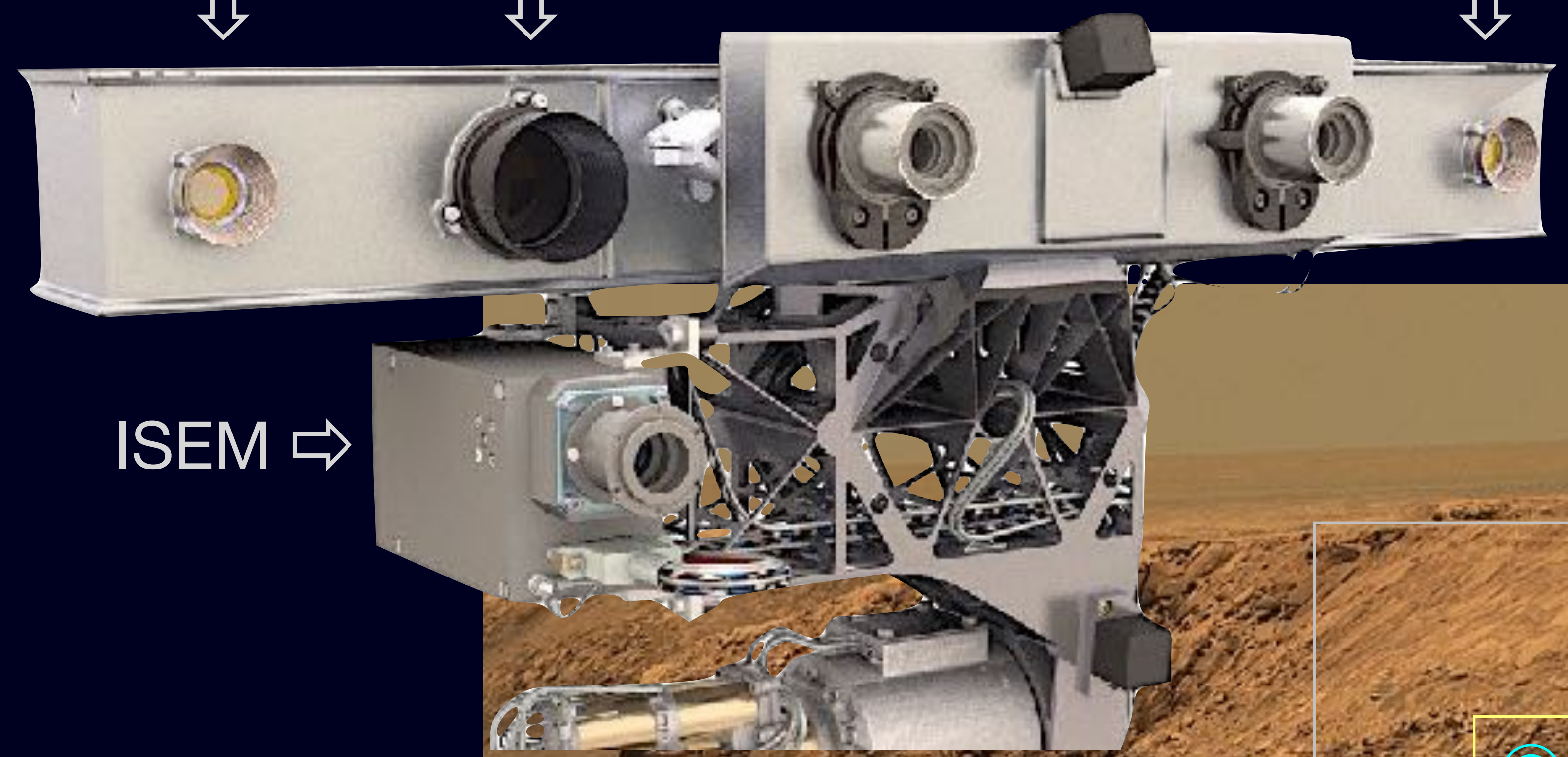


Site Characterisation

E X O M A R S

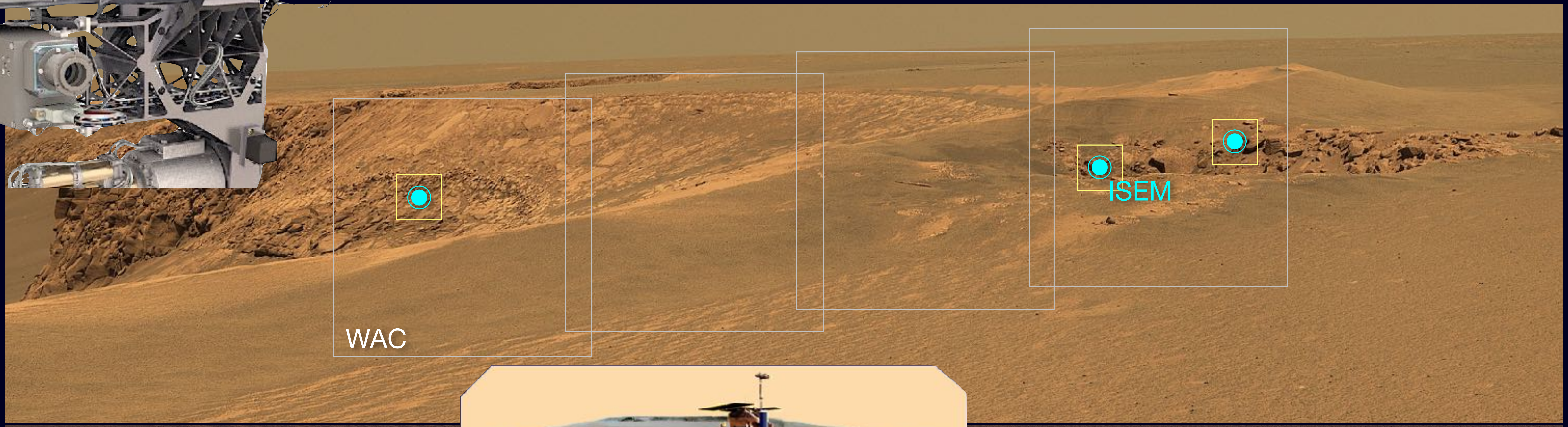
WAC ⇩ HRC ⇩ WAC ⇩

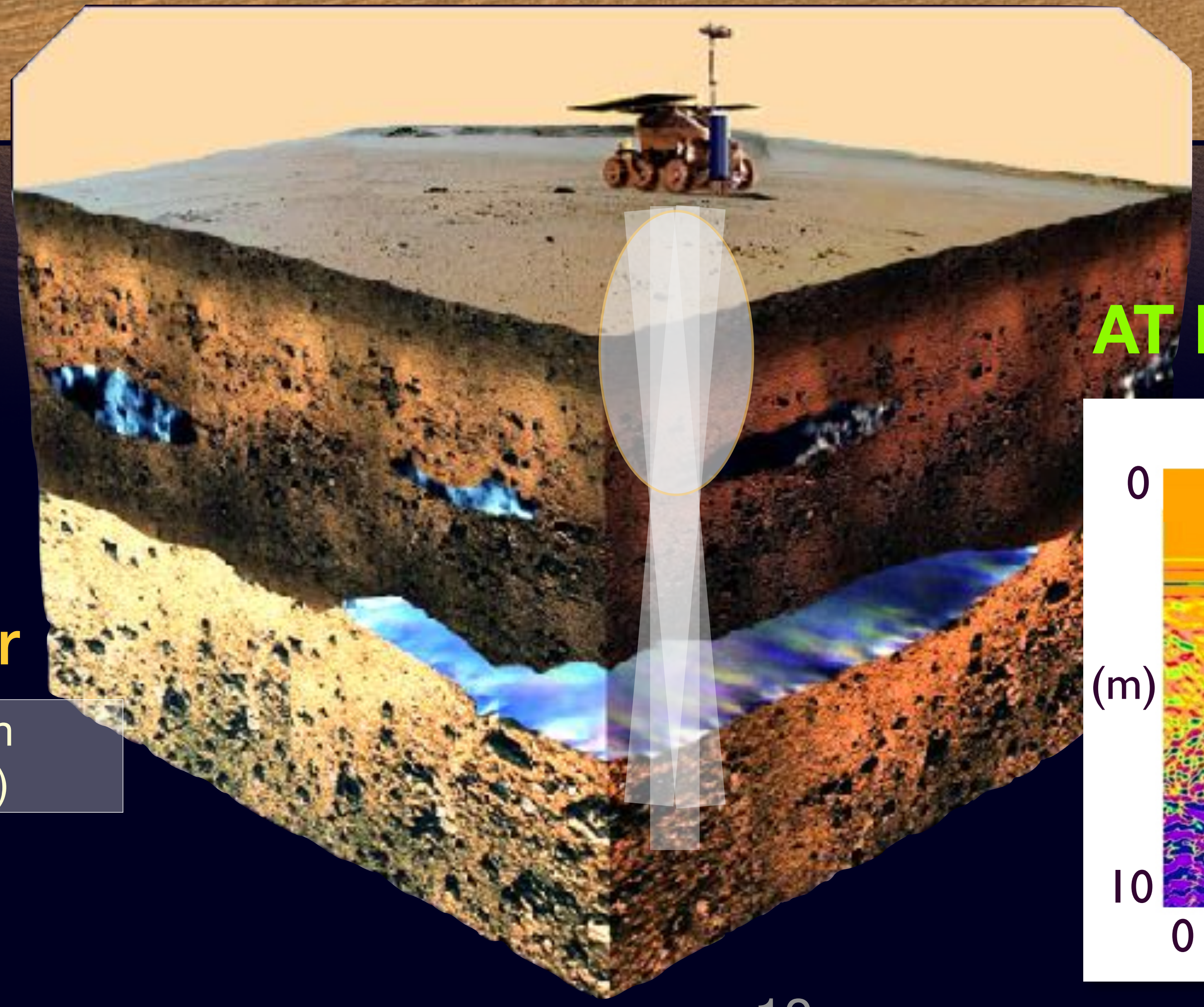
ISEM ⇨



AT PANORAMIC SCALE: To establish the geological context

Two Wide Angle Cameras (WAC): Colour, stereo, 35° FOV;
One High-Resolution Camera (HRC): Colour, 5° FOV
One IR spectrometer (ISEM): 1° FOV.



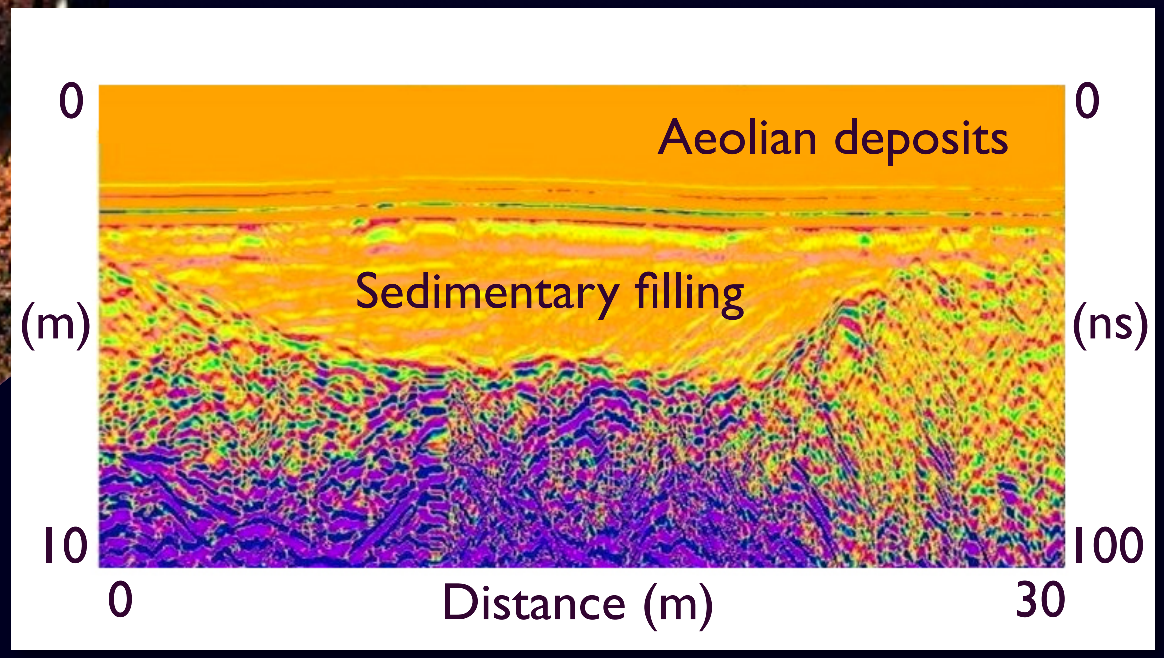


Neutron Detector

Ground Penetrating Radar

~3-m penetration, with ~2-cm resolution
(depends on subsurface EM properties)

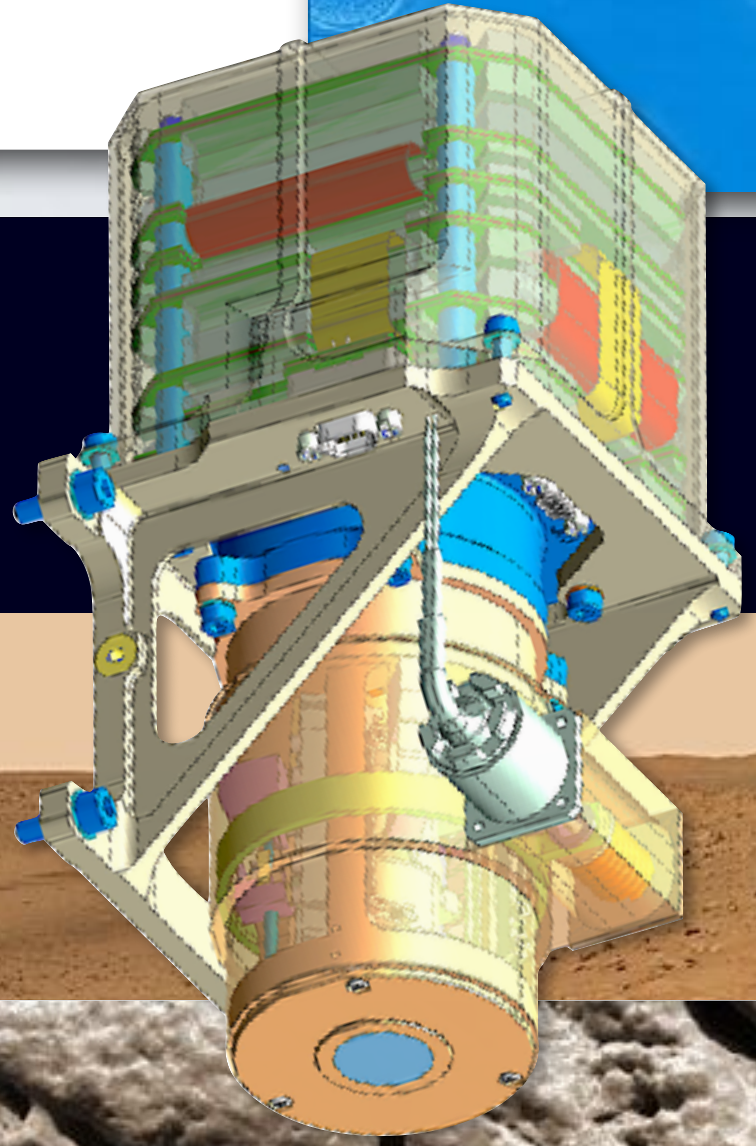
AT DEPTH: To study the stratigraphy for drilling



Heggy et al. 2007

Outcrop Characterisation

AT ROCK SCALE: To ascertain the past presence of water
For a more detailed morphological examination



High-Resolution Camera

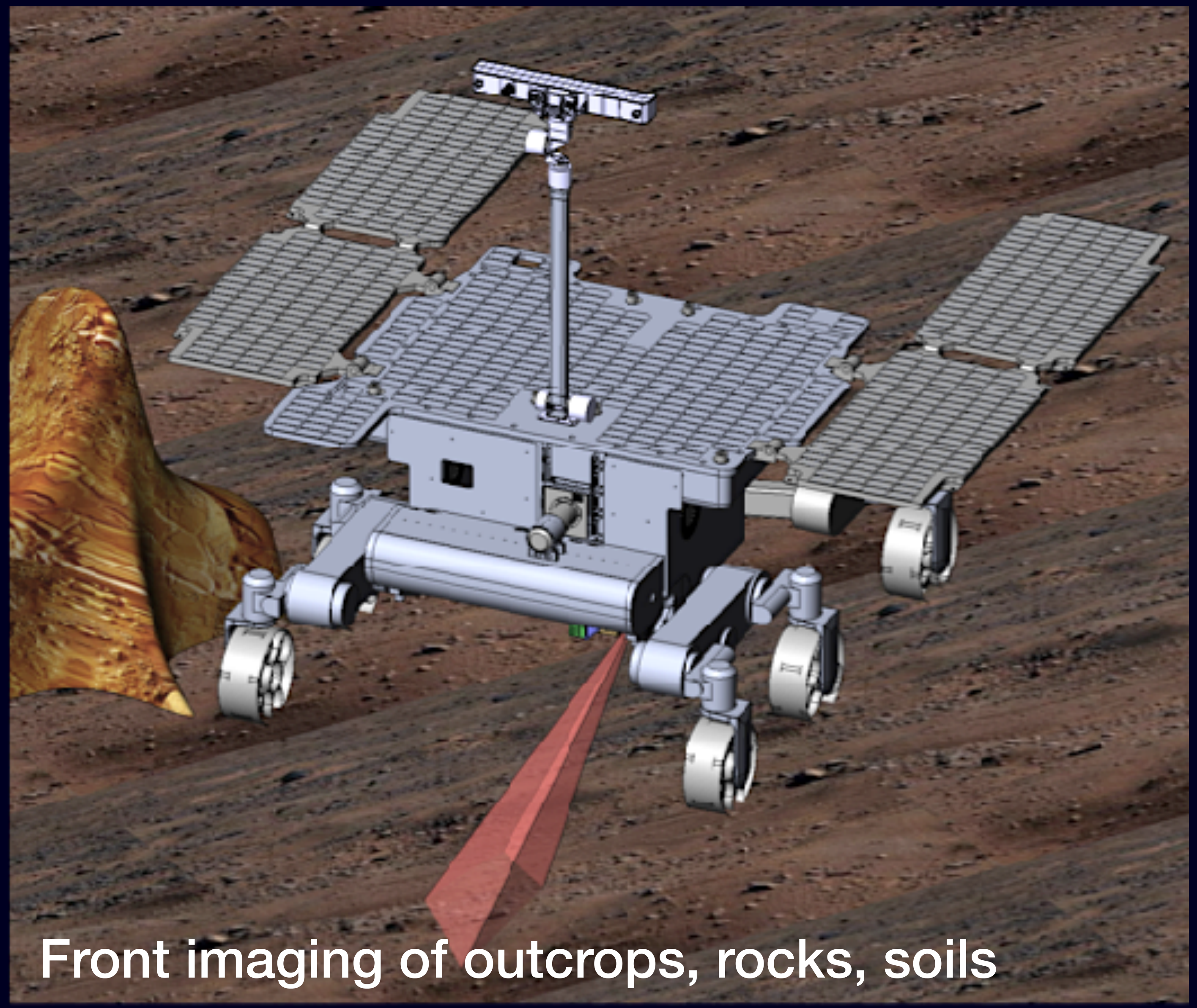
Close-Up Imager

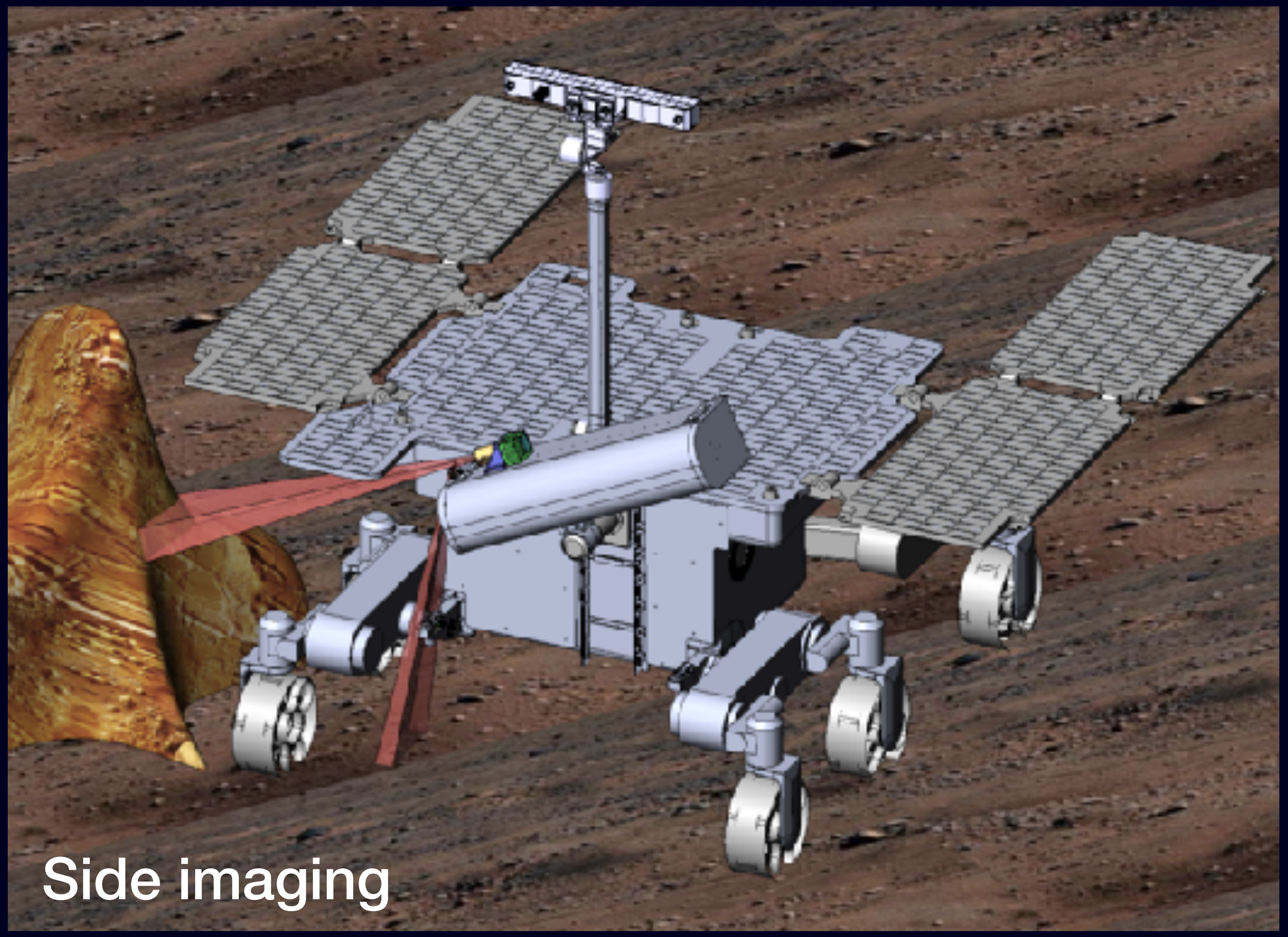
Colour, 20–100-µm/pixel resolution, 19° FOV,
Focusing range: 10 cm to ∞

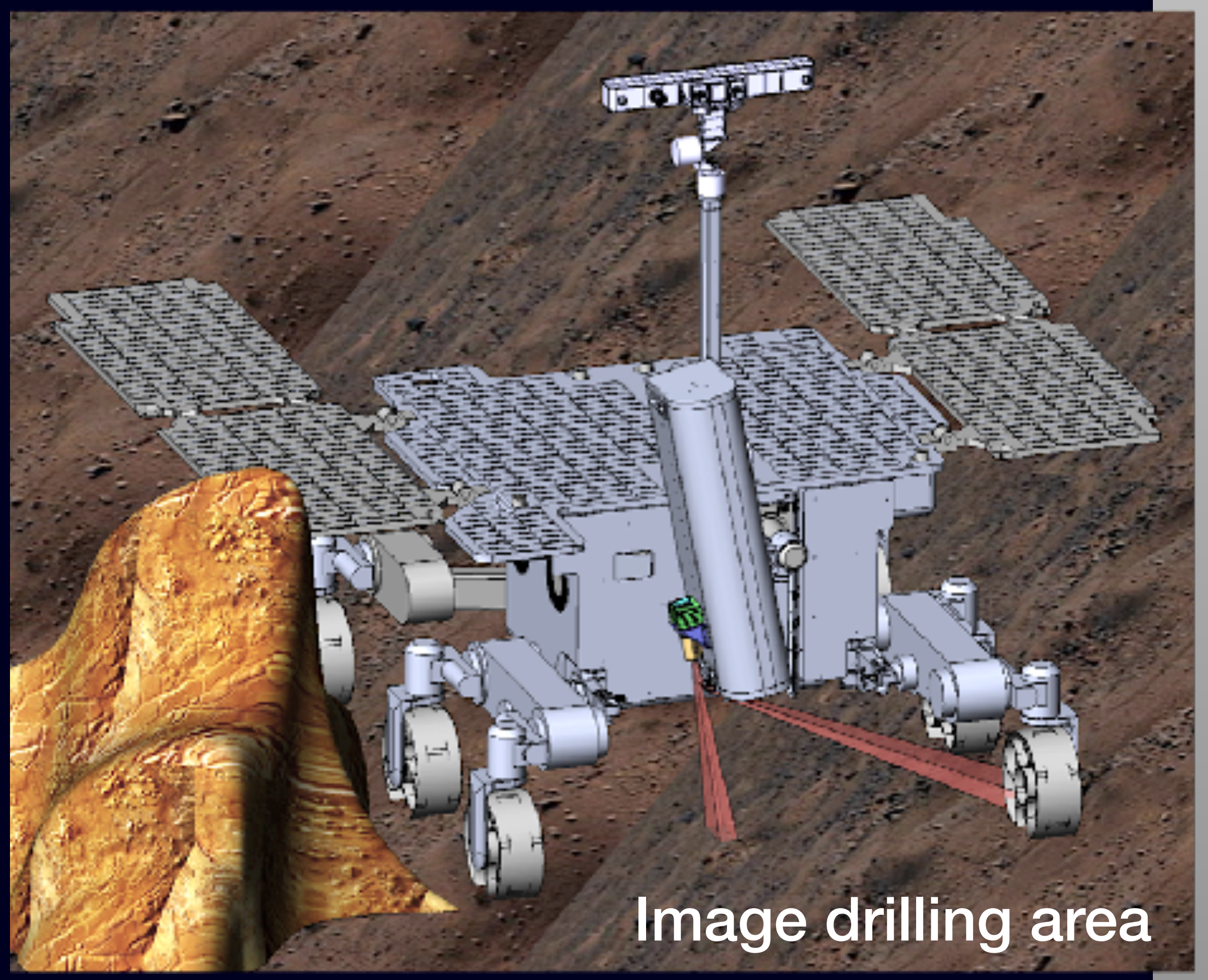
Next step: **ANALYSIS**

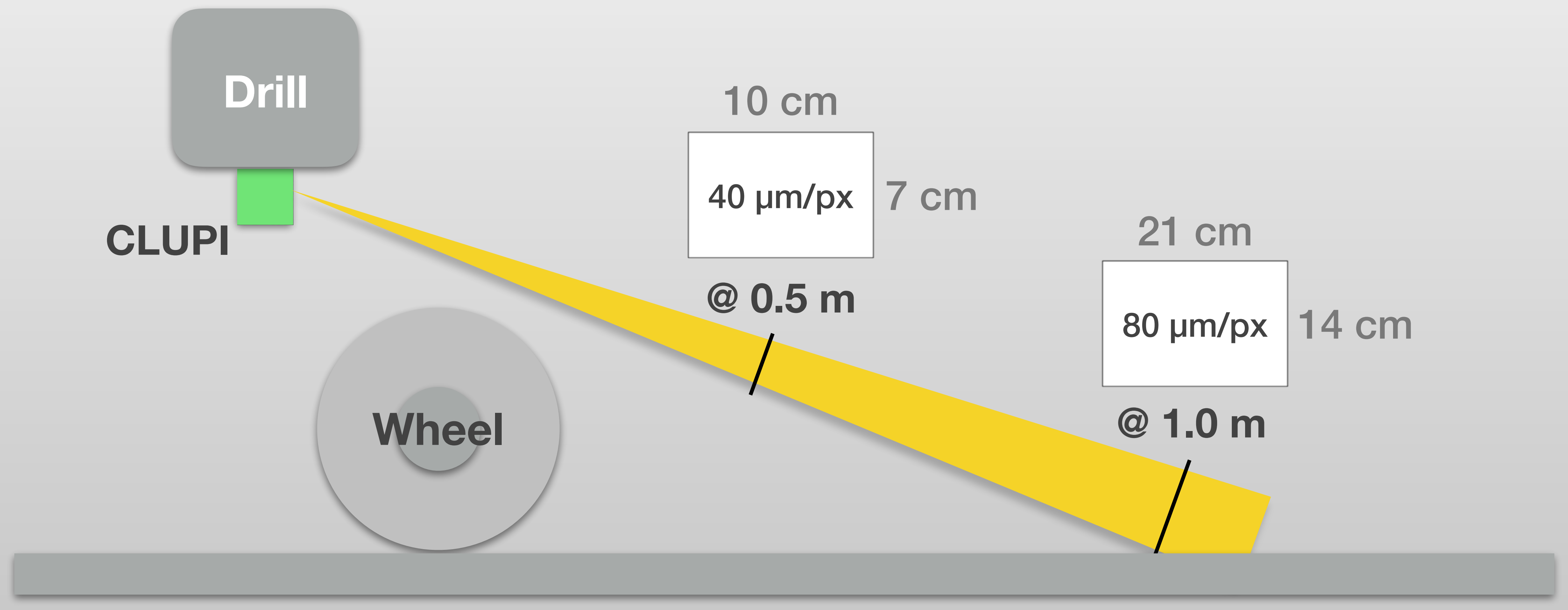
Use the drill to collect a sample
- From an outcrop
- From the subsurface

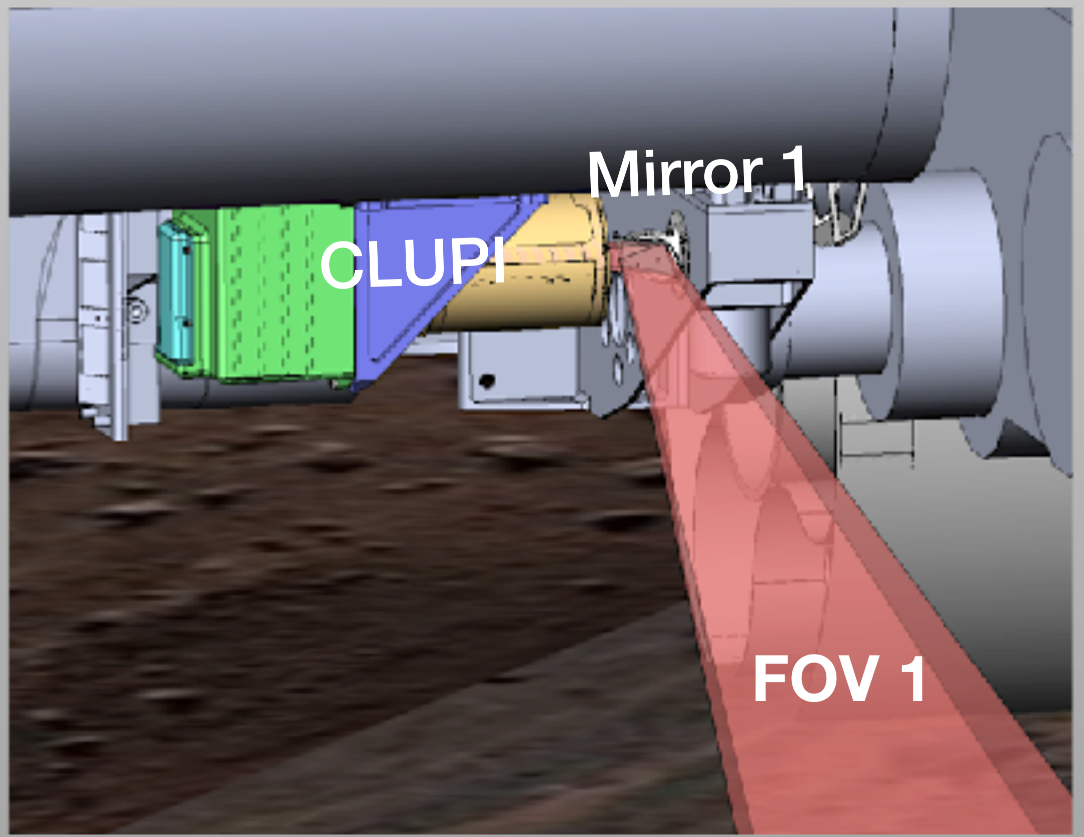
Close-Up Imager

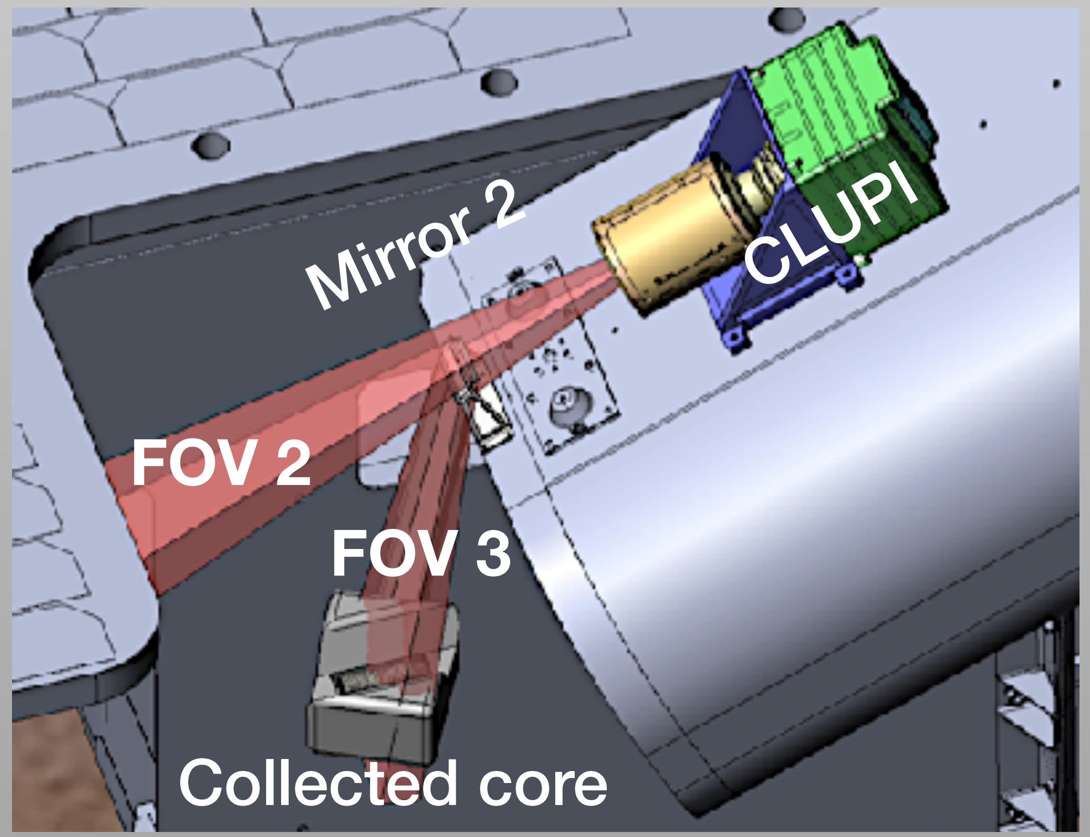








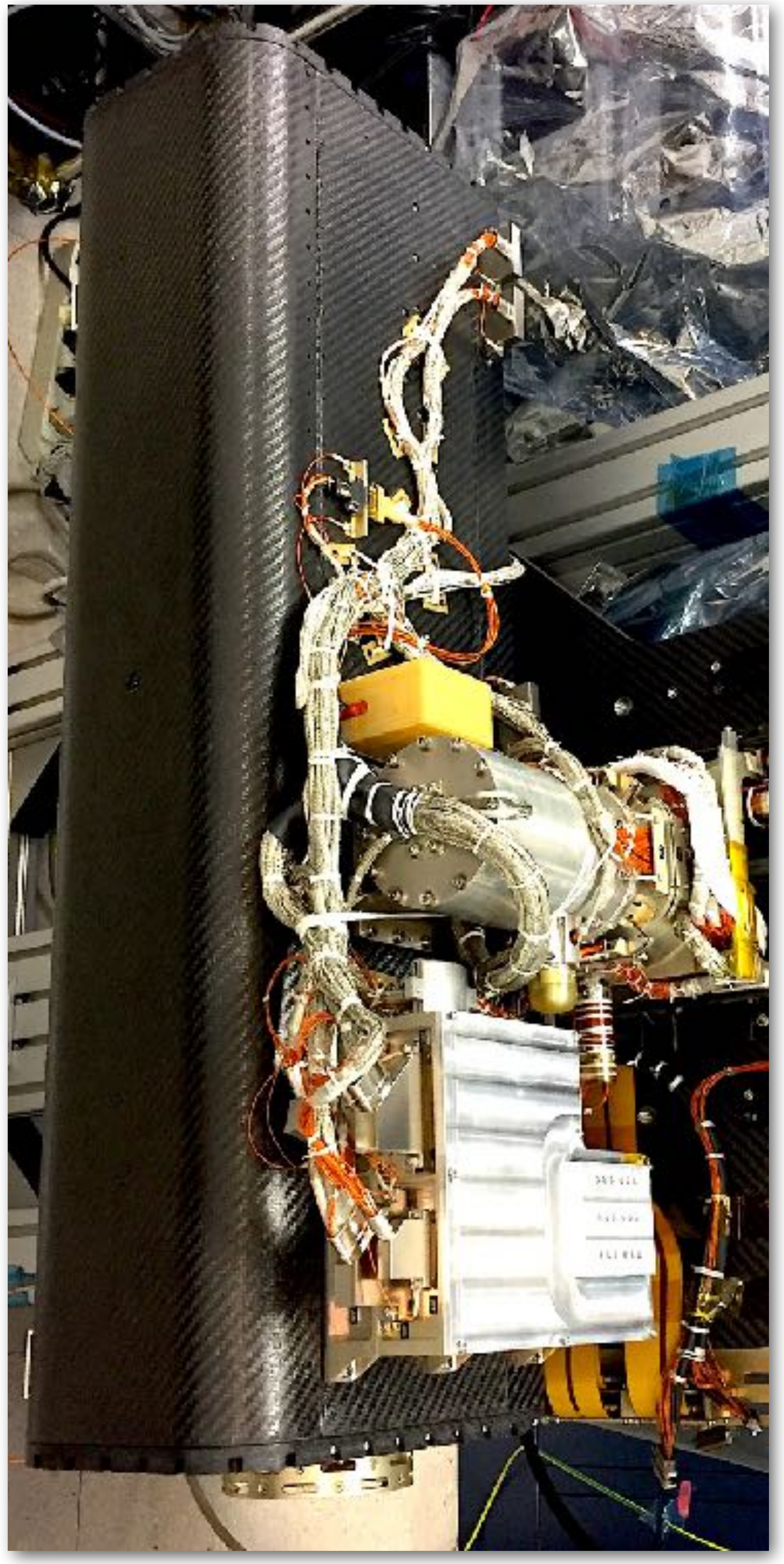


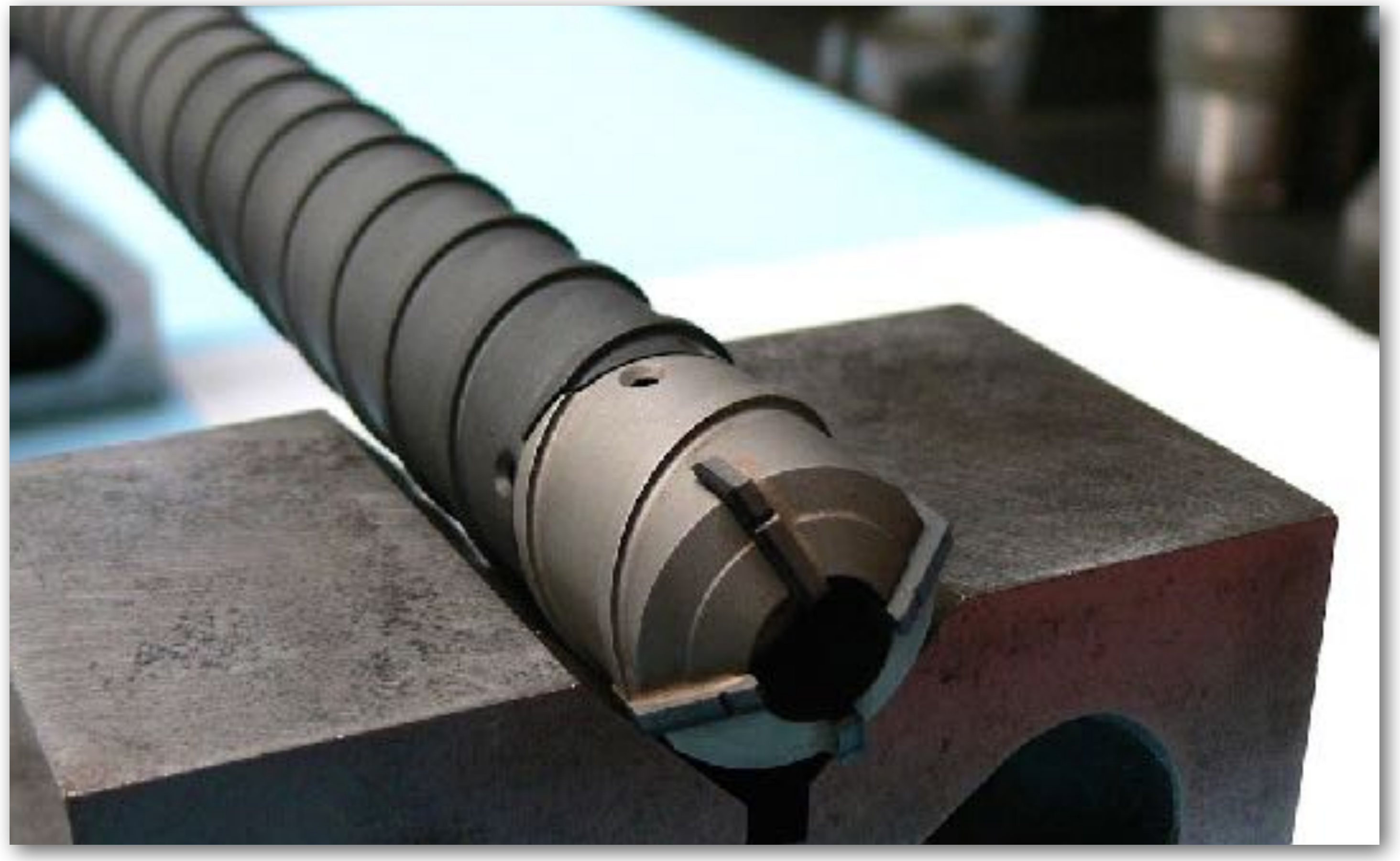


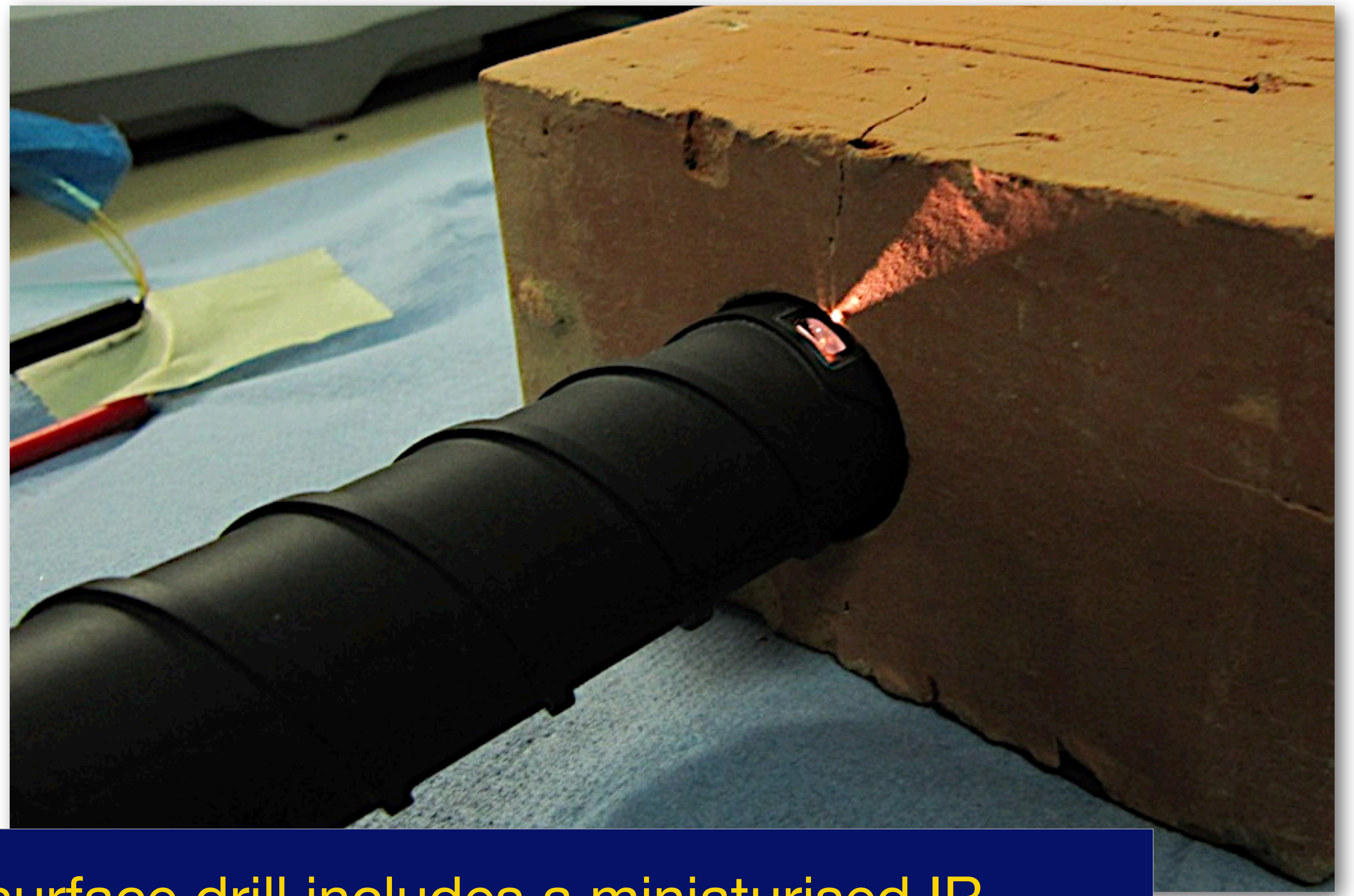
Credit: Space Exploration Institute

Subsurface Drill

OBTAIN SAMPLES FOR ANALYSIS: From 0 down to 2-m depth





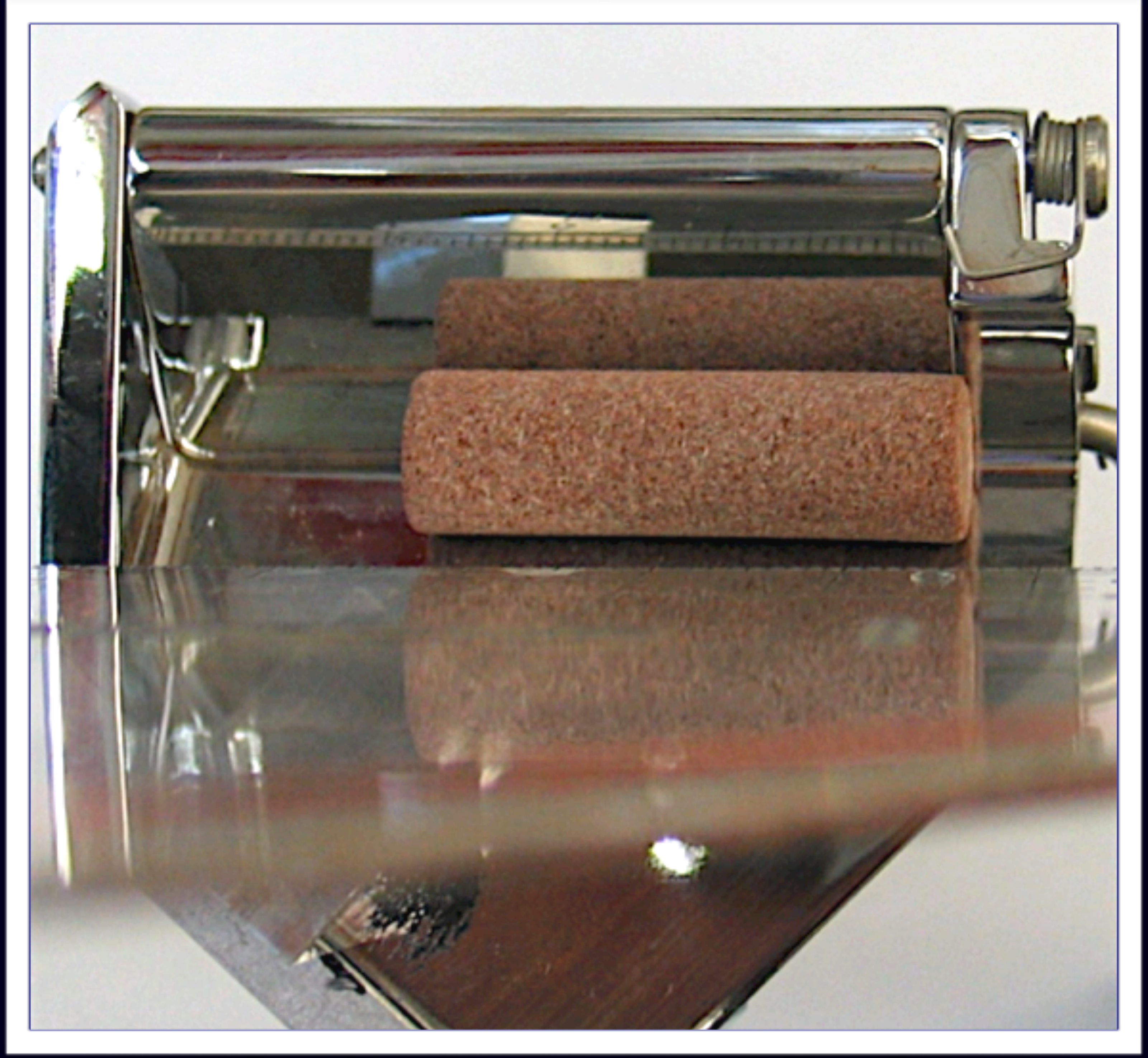


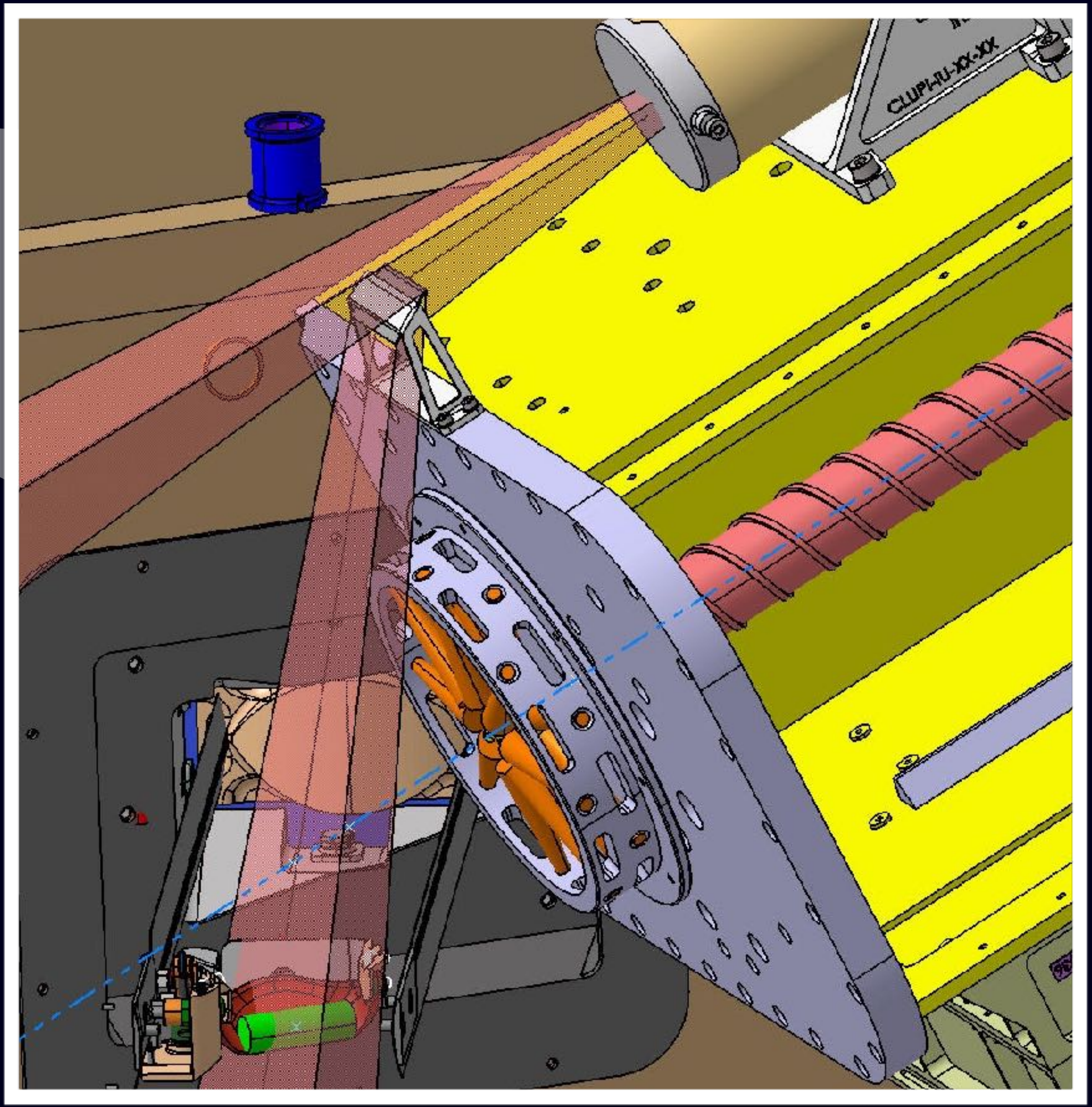
Subsurface drill includes a miniaturised IR spectrometer for borehole investigations.

Subsurface Drill

Sample Delivery

DRILL discharges sample into Core Sample Transport Mechanism (CSTM).
PanCam HRC and CLUPI image the sample.
Sample is delivered to Analytical Laboratory Drawer (ALD) — 15 min.



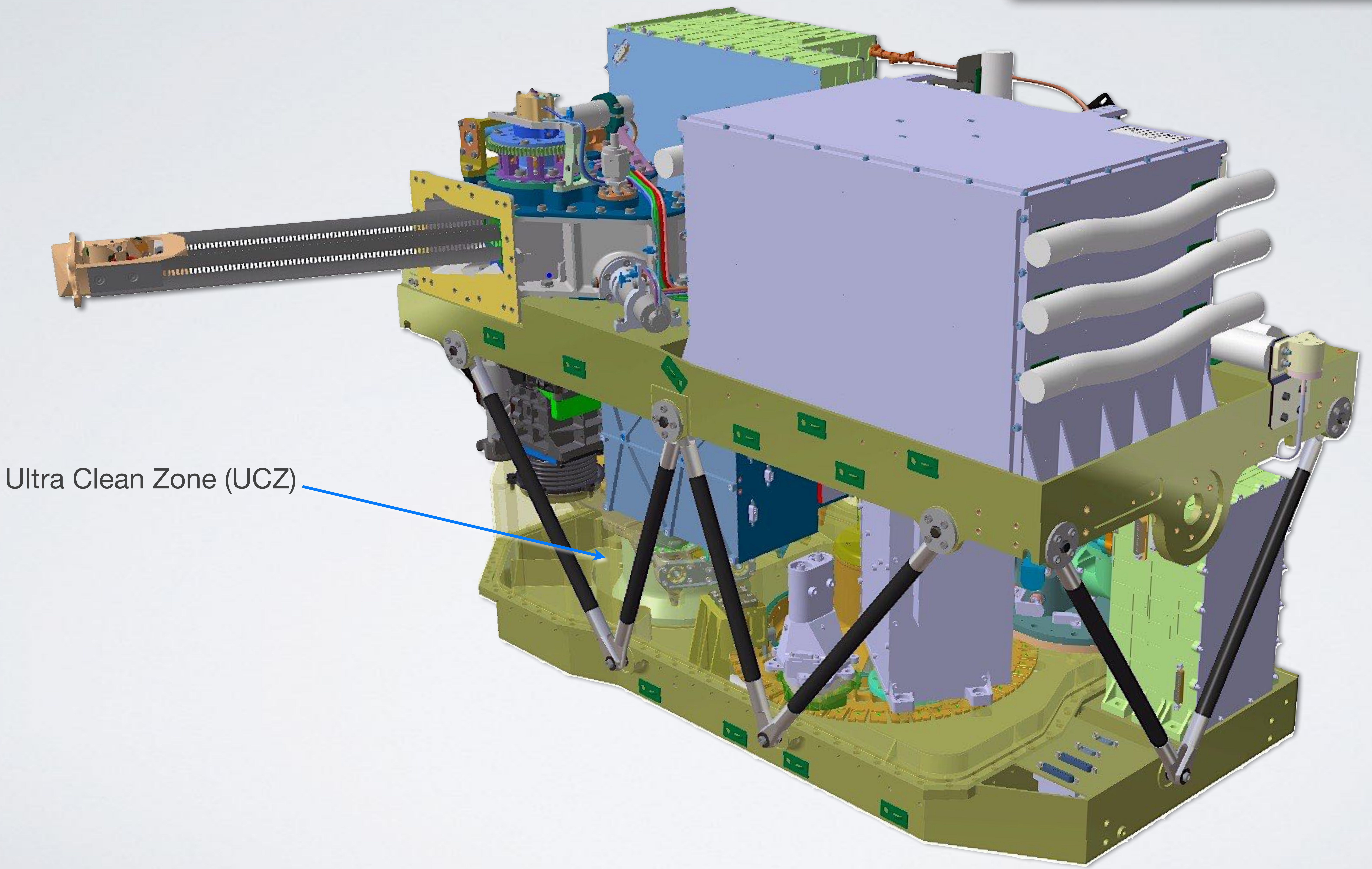


Analytical Laboratory Drawer

E X O M A R S

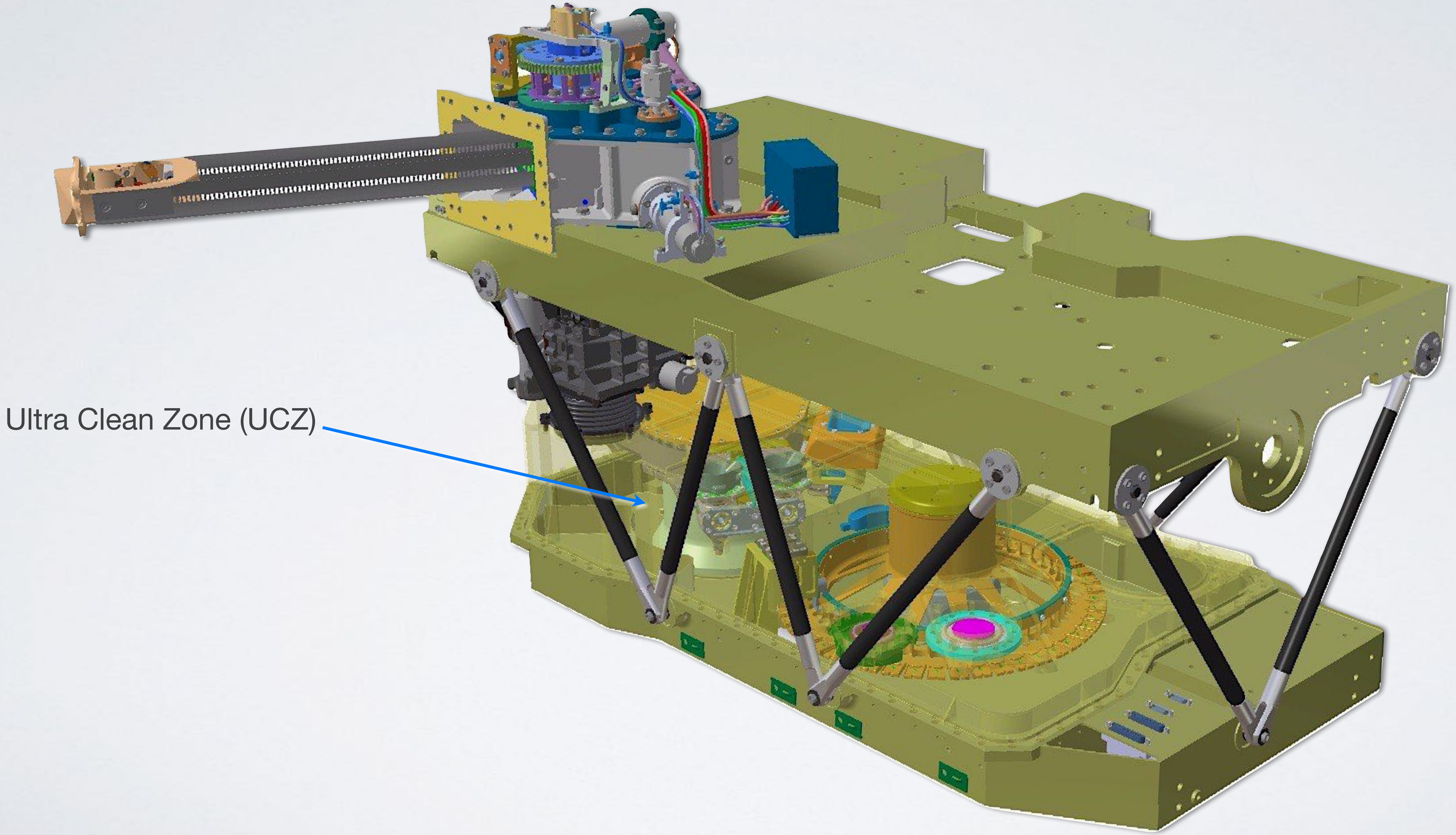
Credit: TAS-I

Analytical Laboratory Drawer



Credit: TAS-I

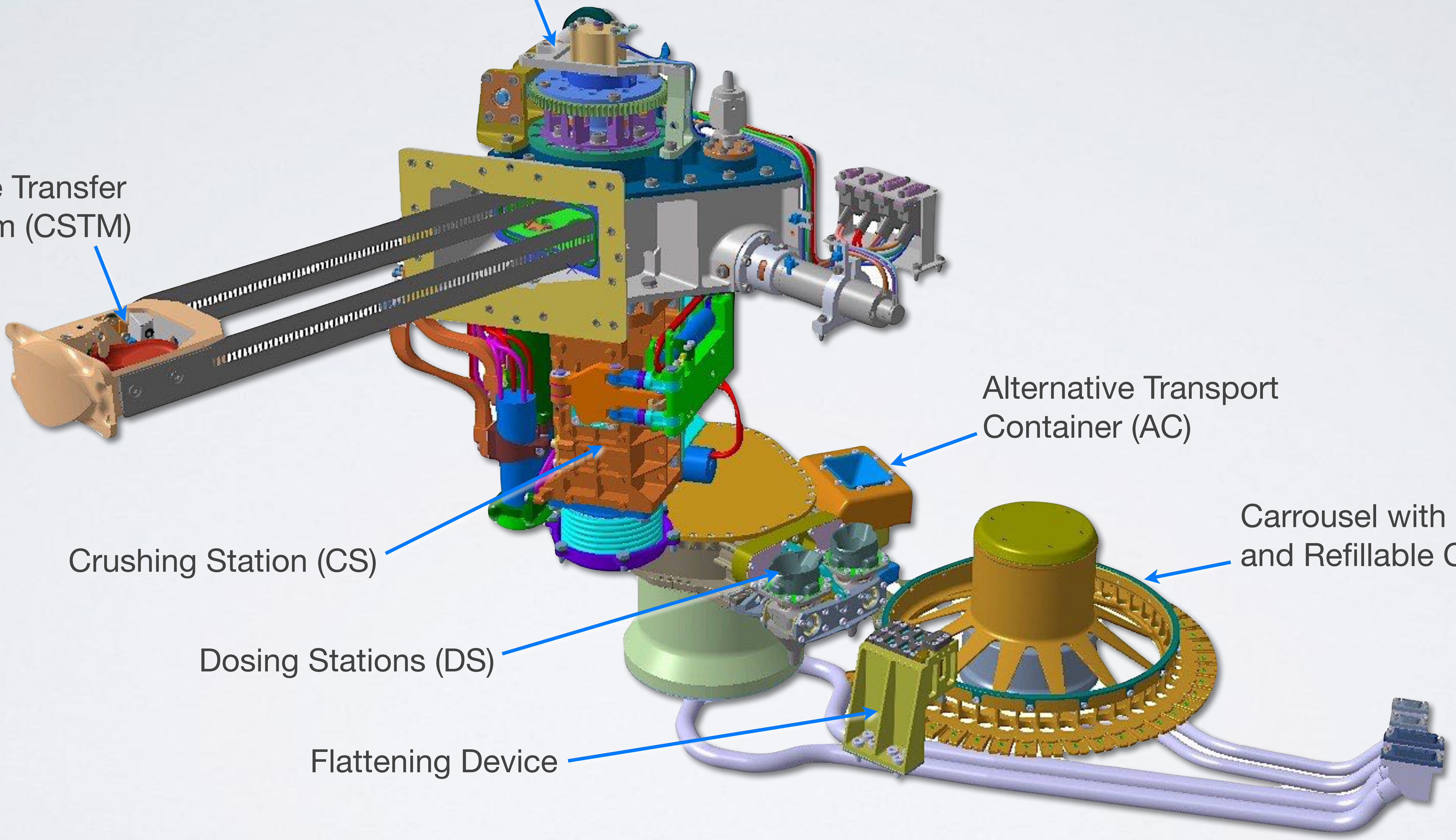
Analytical Laboratory Drawer



Credit: TAS-I

Analytical Laboratory Drawer

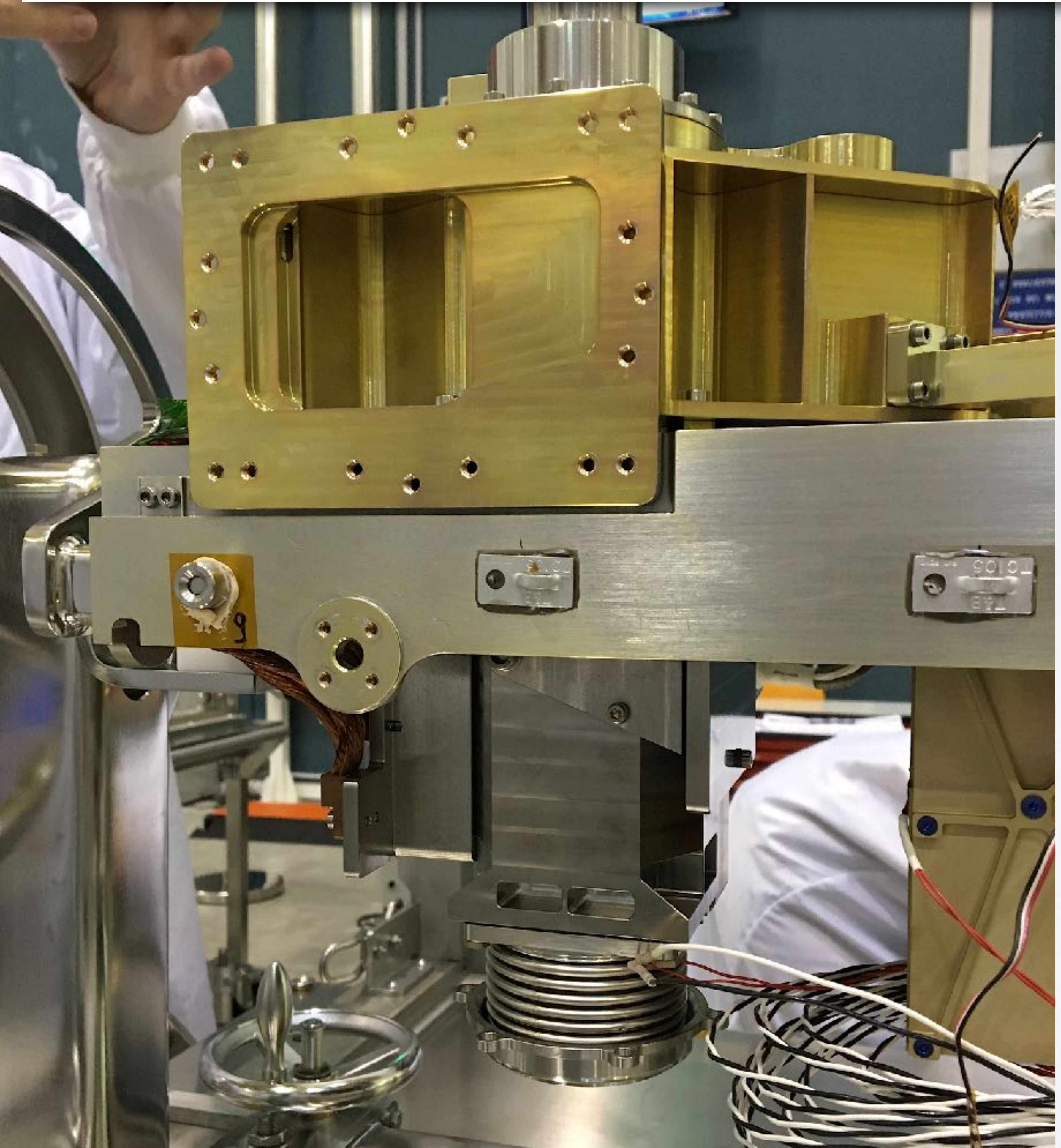
E X O M A R S

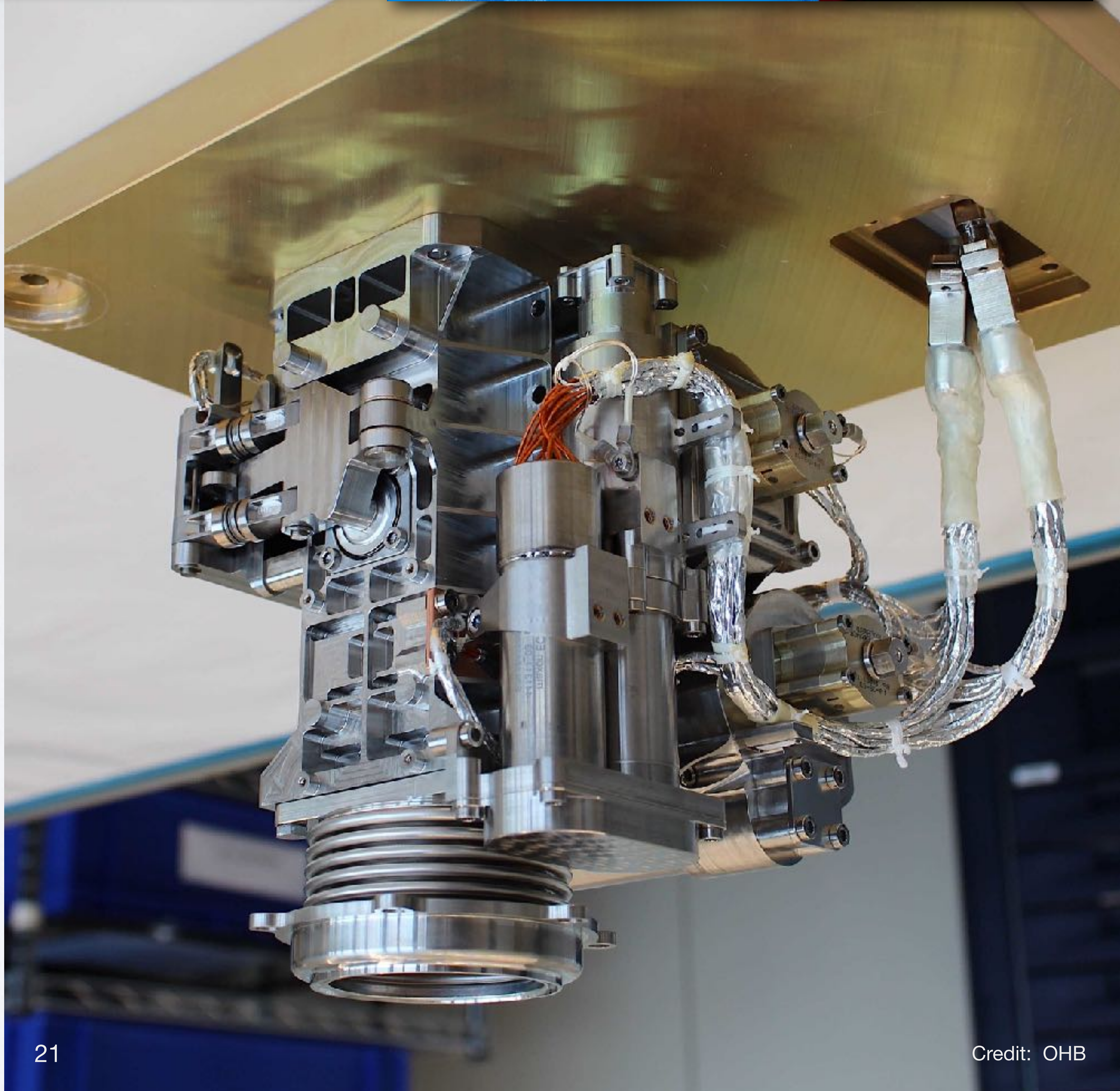


Credit: TAS-I

Analytical Laboratory Drawer

Rock Crushing Station





Credit: OHB

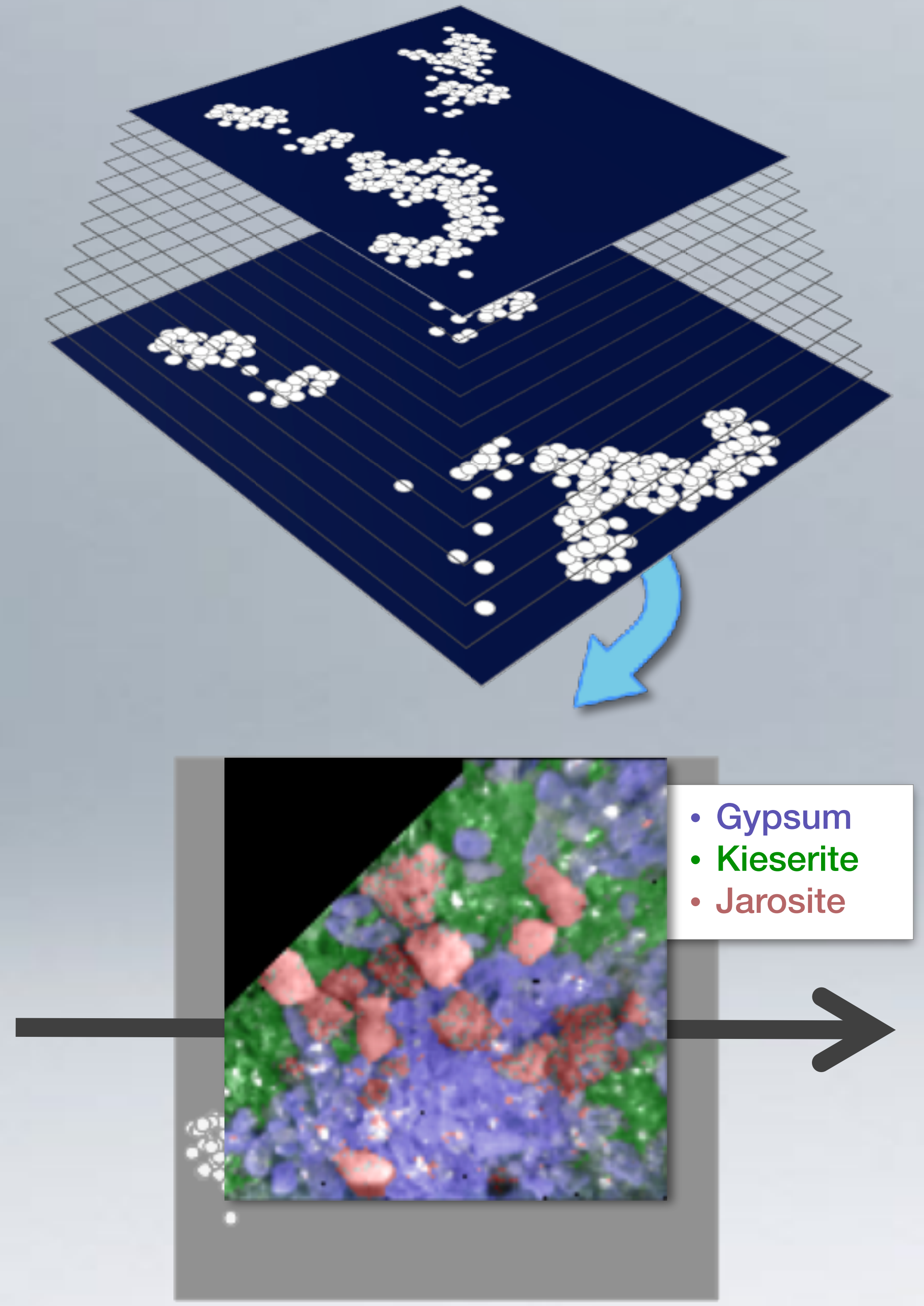
Powder Sample Dosing

Credit: OHB

Sample Analysis

Use mineralogical + image information from μΩ to identify targets for Raman and MOMA-LDMS.

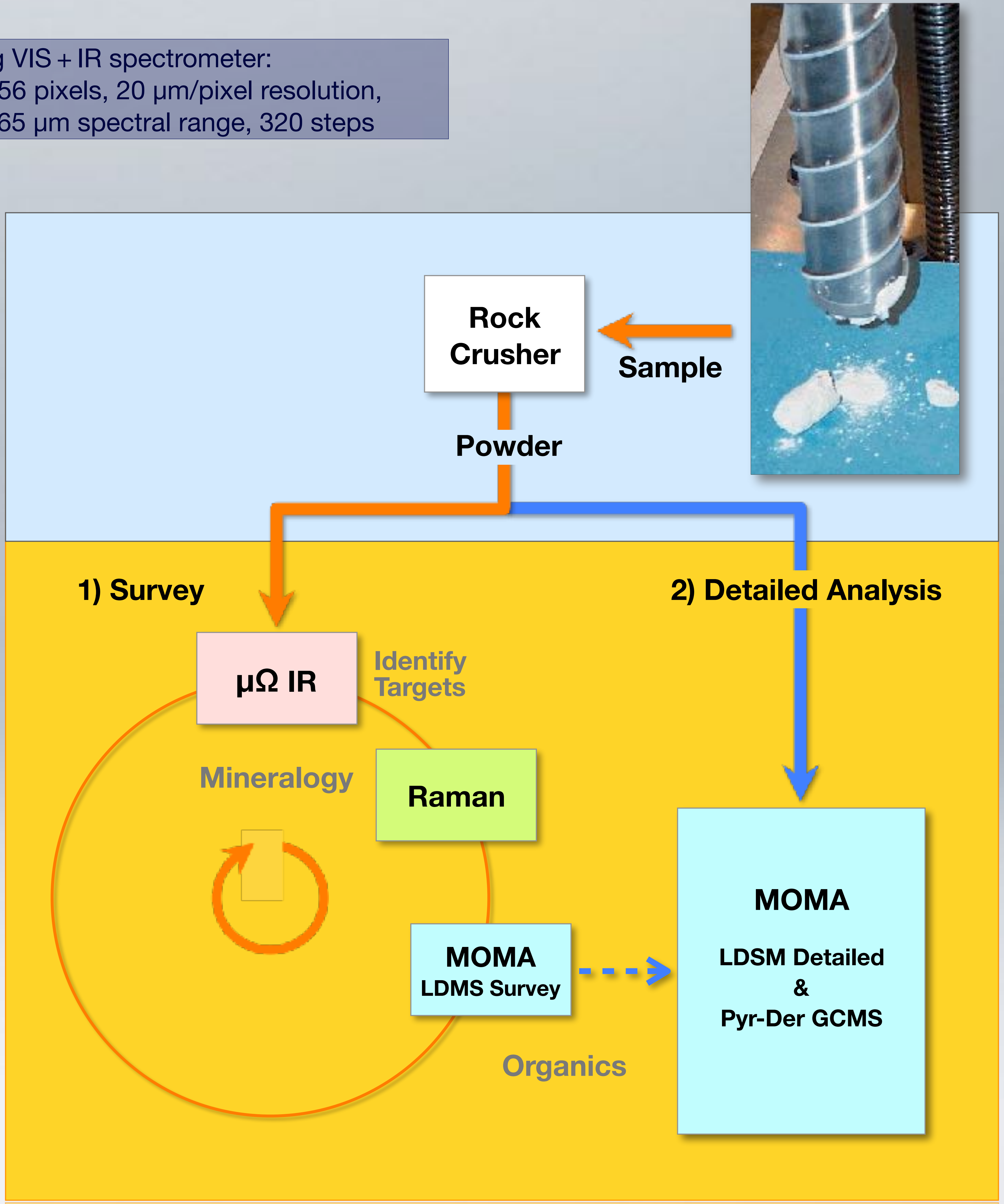
Imaging VIS + IR spectrometer:
256 x 256 pixels, 20 μm/pixel resolution,
0.95–3.65 μm spectral range, 320 steps



μΩ = 20 μm

Raman = 50 μm

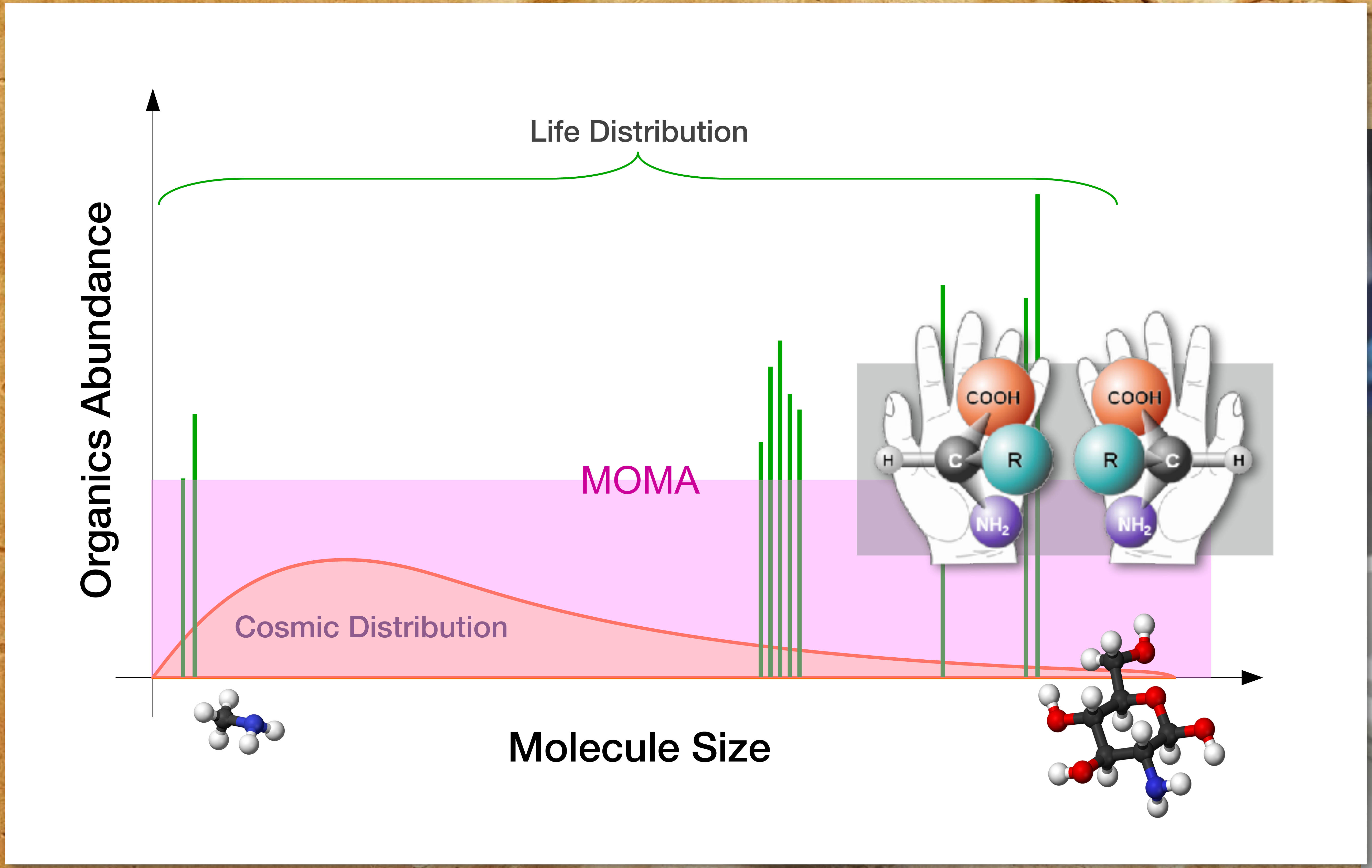
LDMS = 400 μm

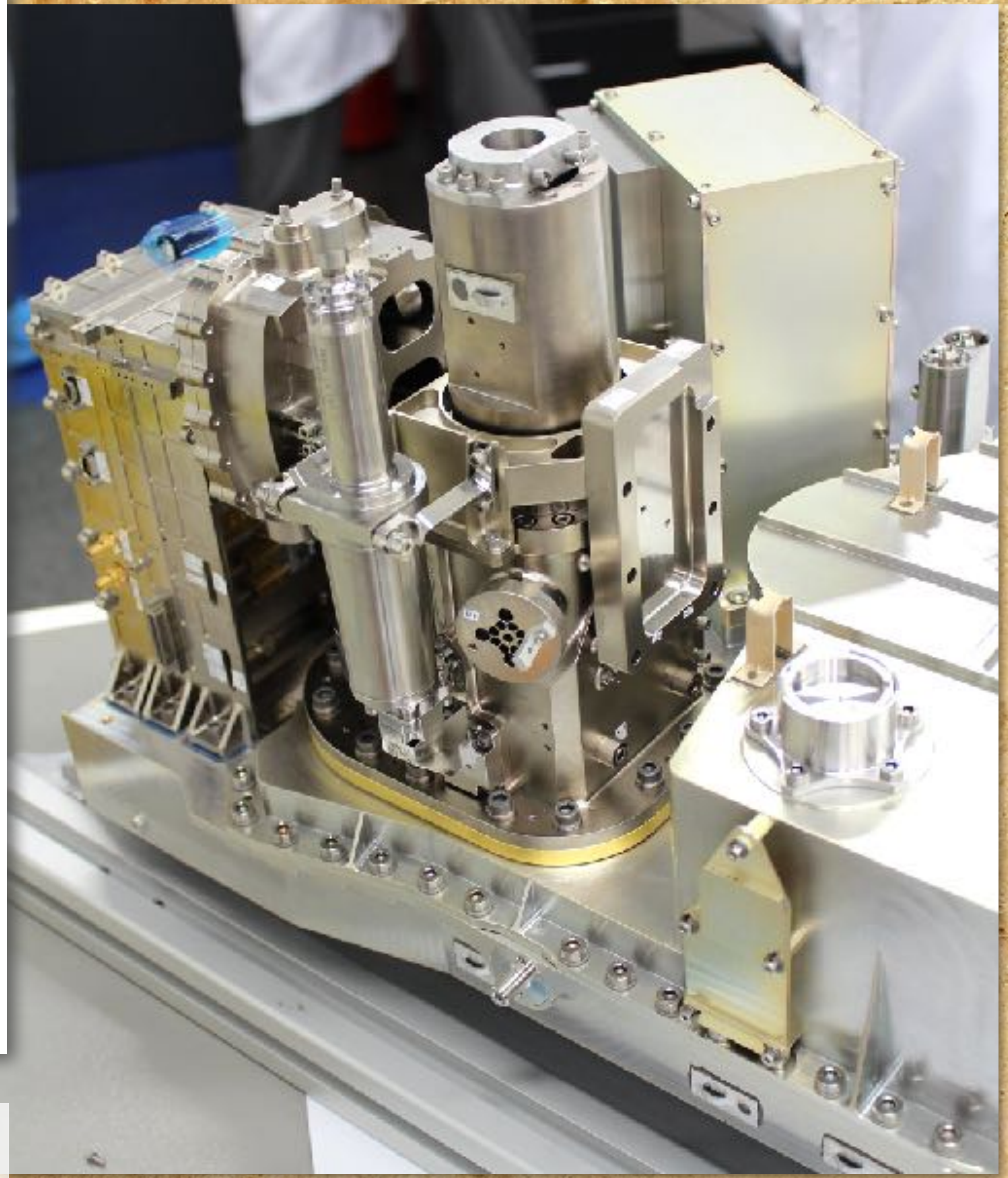


Raman: Spectral shift range 200–3800 cm^{-1}
Spectral resolution: 6 cm^{-1}

LDMS = Laser Desorption Mass Spectrometry
GCMS = Gas Chromatograph Mass Spectrometer

Characterisation of Organic Molecules





Broad identification range (50–1000 Da), including distribution, and chirality.
High sensitivity (≤ 1 pmol/mol in TV-CGMS, ≤ 1 pmol/mol/mm² in LDMS).
Resolution ≤ 1 Da over 50–500 Da range, ≤ 2 Da thereafter.
Ability to perform MS-MS analysis on trapped fragments.
LDMS mode appears not to be disturbed by perchlorates.

Credit: Mamers Valles, MEX/HRSC

ExoMars Biosignature Score

EXOMARS

Morphological biosignatures:	Σ points
Multilayer organosedimentary structures (*e.g.* stromatolites)	20
Other candidate biomediated textures (*e.g.* MISS)	10
Features suggestive of (fossil) microorganisms	20

Result of first blank chemical check: (prior to beginning sample analysis)	**Factor**
No organics, clean background	1.0–0.9
OR Few, well known spacecraft organics in background	0.8–0.5
OR Background heavily compromised by contamination	0.2–0.0

Chemical biosignatures:	Σ points
Detection of primary biomolecules or their degradation products	20
Enantiomeric excess (or other isomer selectivity)	30
Molecular weight clustering of organic compounds	20
Evidence of repeating constitutional subunits	20
Systematic isotopic ordering at molecular (group) level	20
Bulk isotopic fractionation	10

Geological context:	Σ points
Long-lived water or hydrothermal setting (morphology)	15–10
Long-lived water or hydrothermal setting (mineralogy)	15–10

× + Score

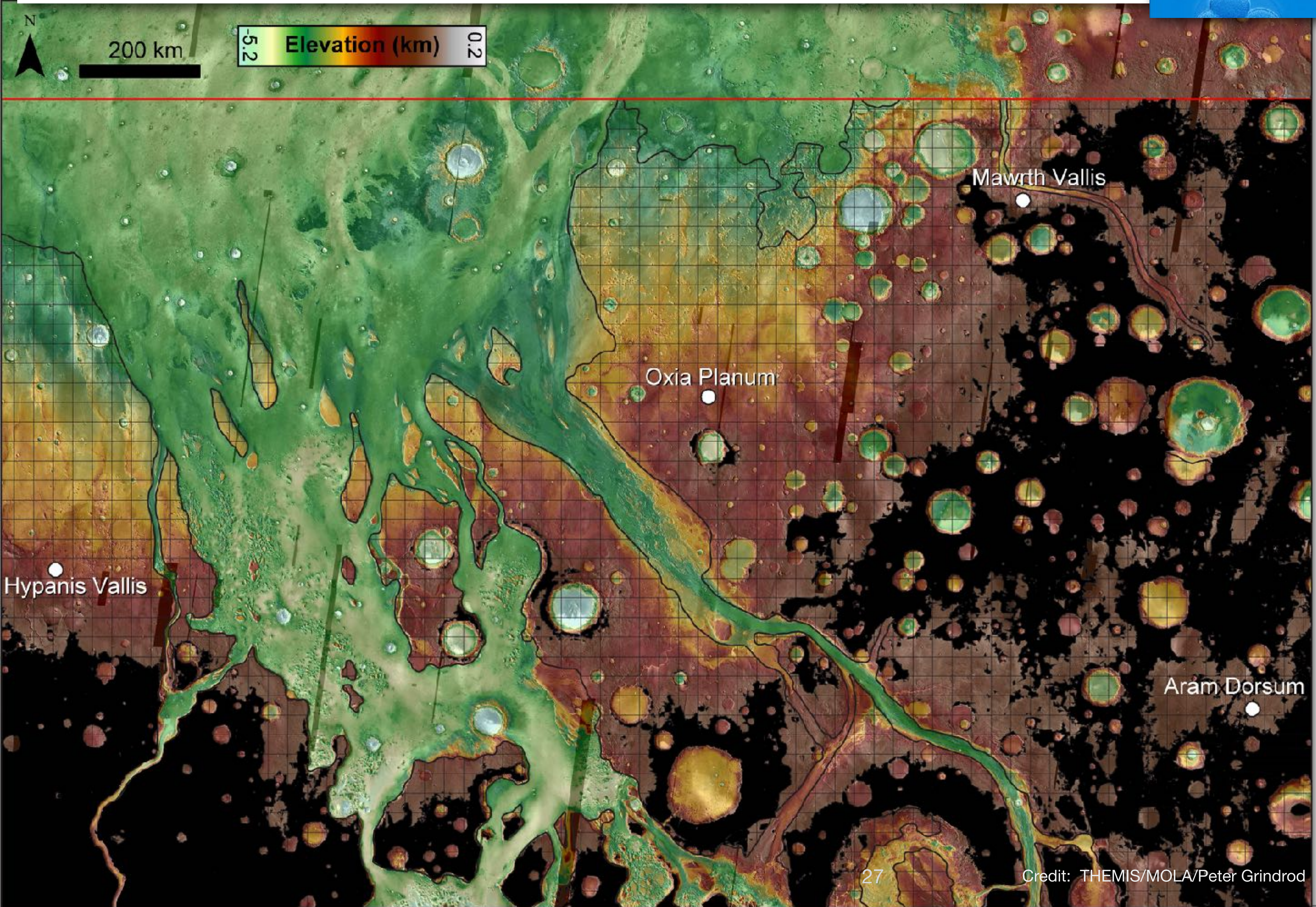
Credit: Mamers Valles, MEX/HRSC

ExoMars Rover Issue

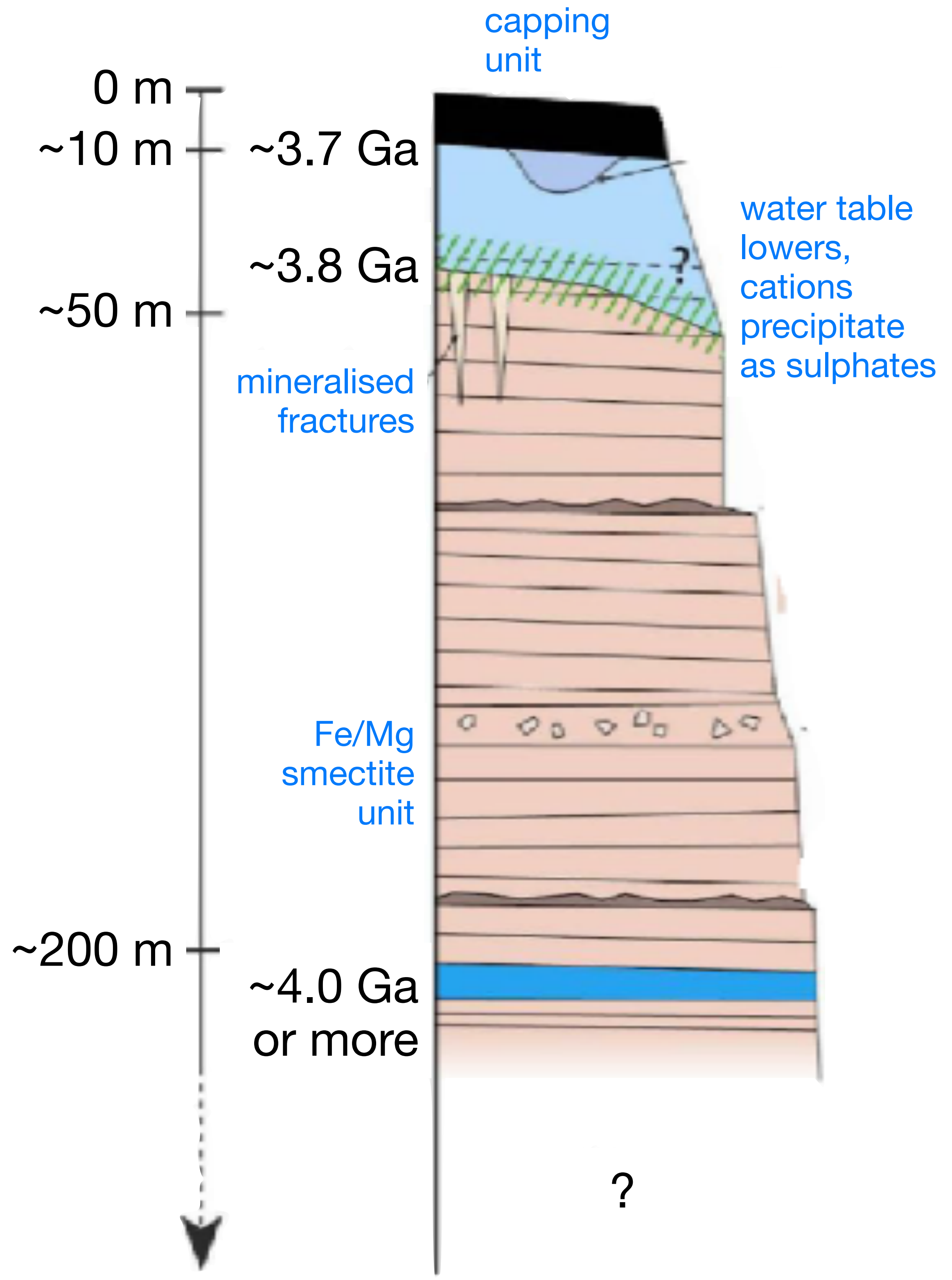
- *Astrobiology,* June–July 2017
- Introduction paper describing the ExoMars rover science and mission.
- A dedicated paper for each of the nine instruments.

Credit: Sand dunes near the north pole, MRO/HiRISE

Candidate Landing Sites

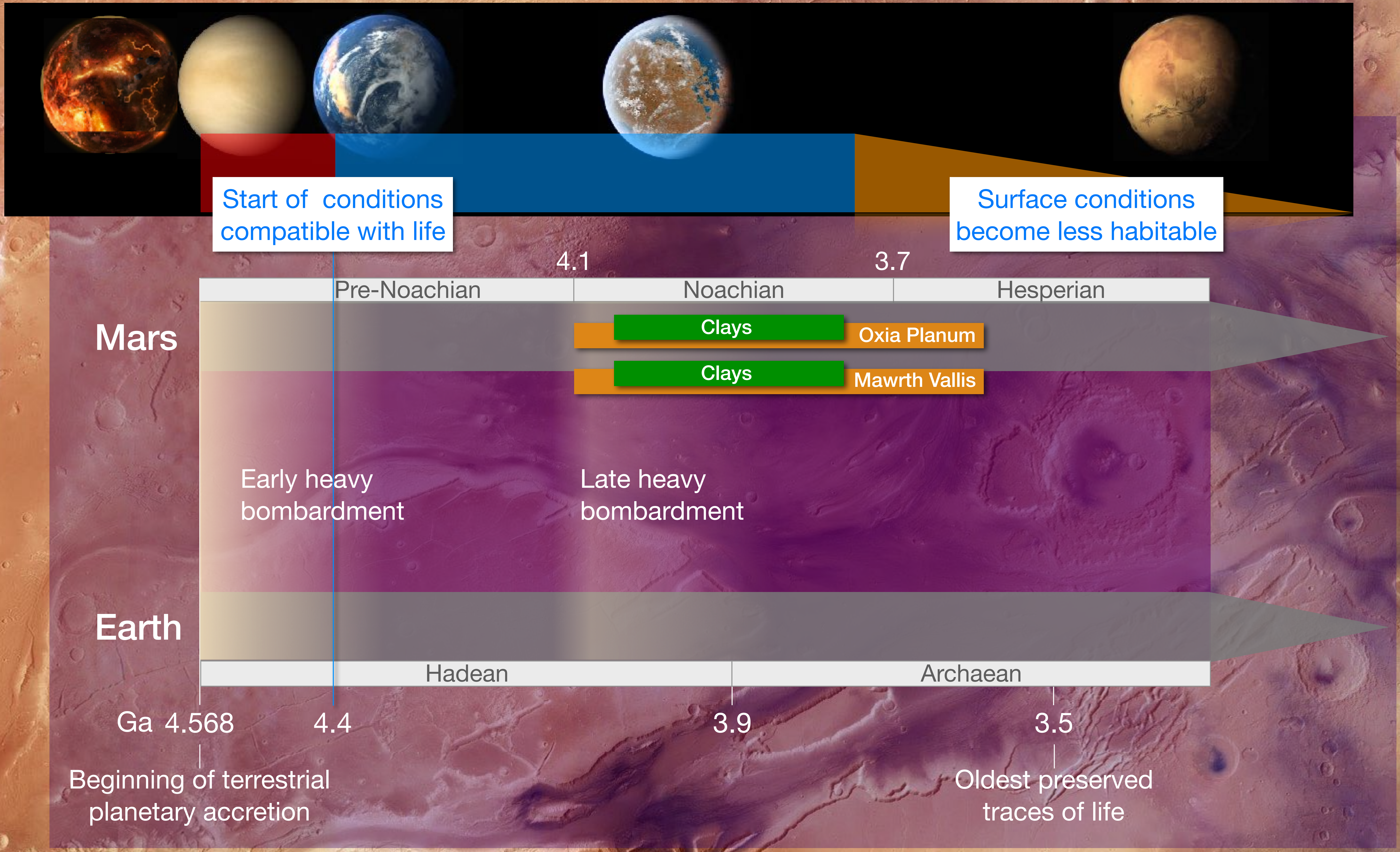


Candidate landing sites:
Oxia Planum
Mawrth Vallis



Oldest terrains to be targeted

Candidate Landing Sites



Credit: Kasei Valles, MEX/HRSC

Rover and Surface Platform

E X O M A R S

Credit: ESA/Medialab

Rover and Surface Platform

2020: ExoMars Rover and Surface Platform

- Travel back in time 4 billion years to explore the bottom of a Mars ocean.
- Drill deep to penetrate below the organics degradation horizon.
- Look for traces of life beyond Earth.
- Study the surface geology and environment.
- Obtain results that may make MSR and astronaut missions possible.

Credit: ESA/Medialab