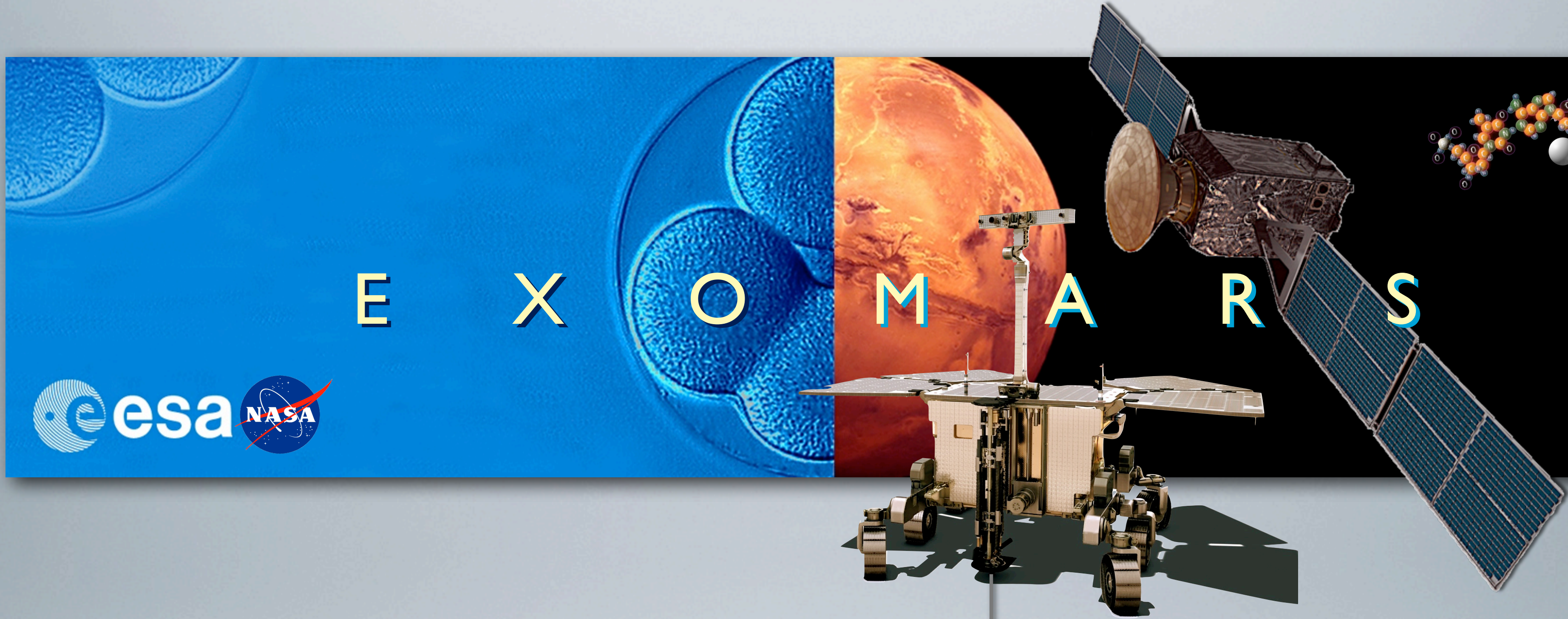


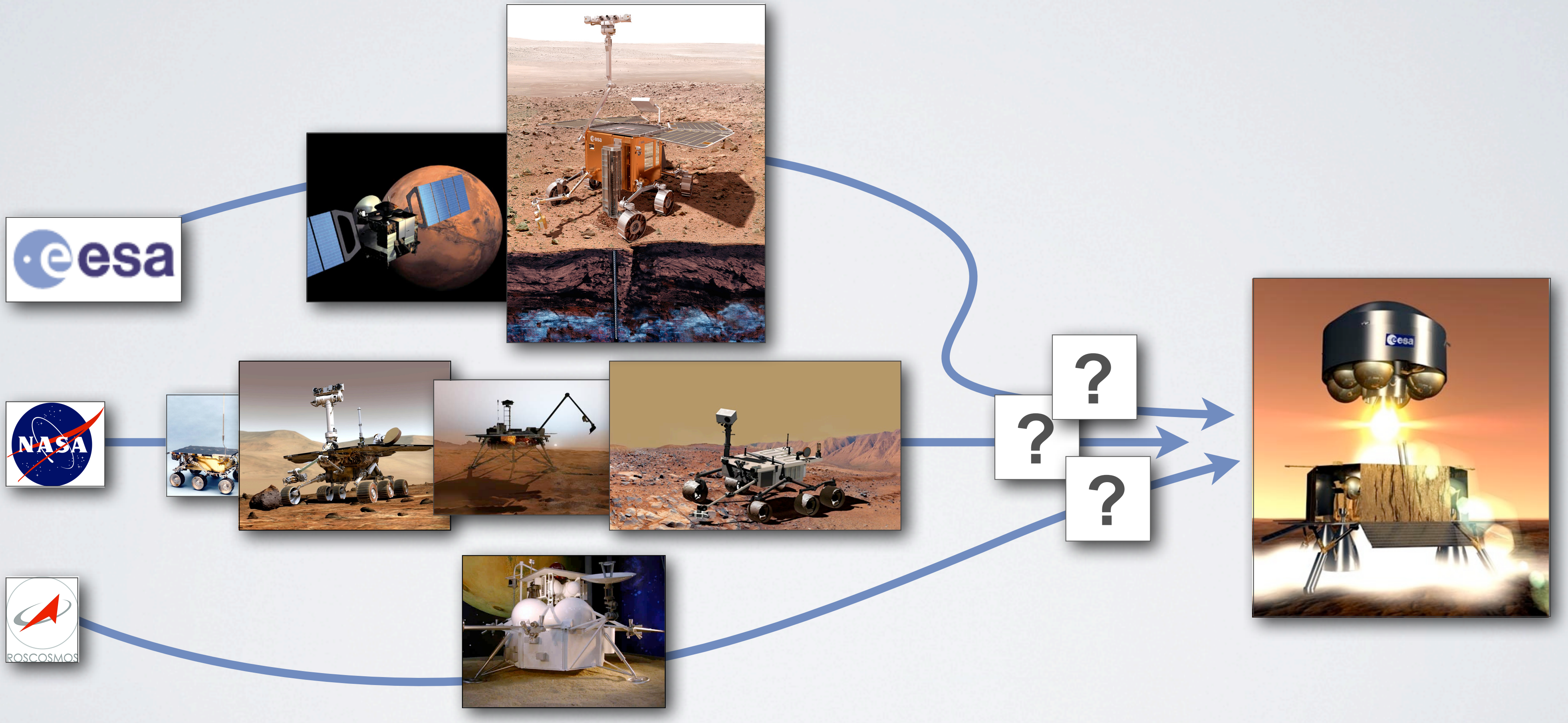
ESA's Mars Exploration Programme

J. L. Vago and the ExoMars and MREP Teams

MEPAG
30 September 2010, Monrovia CA (USA)

International Scene

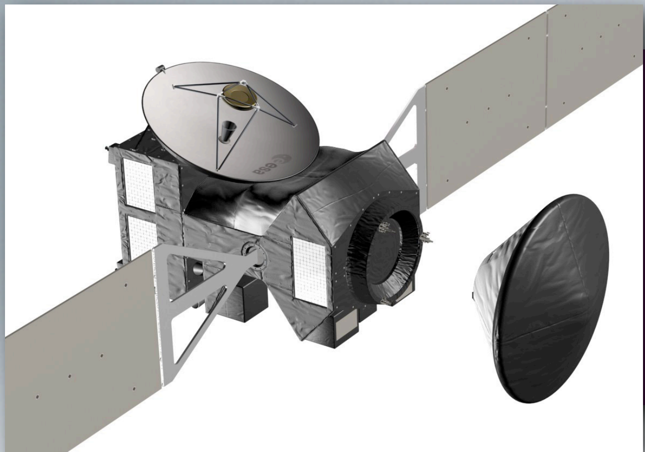
- Recognising that a Mars Sample Return (MSR) mission is very challenging, and that its undertaking will likely exceed the financial capabilities of any one agency,



Programme Building Blocks

E X O M A R S

- ESA and NASA have agreed to embark on a joint Mars robotic exploration programme:
  - ➡ Initial missions have been defined for the 2016 and 2018 launch opportunities;
  - ➡ Missions for 2020 and beyond are in a planning stage;
  - ➡ The joint programme’s ultimate objective is an international Mars Sample Return (MSR) mission.

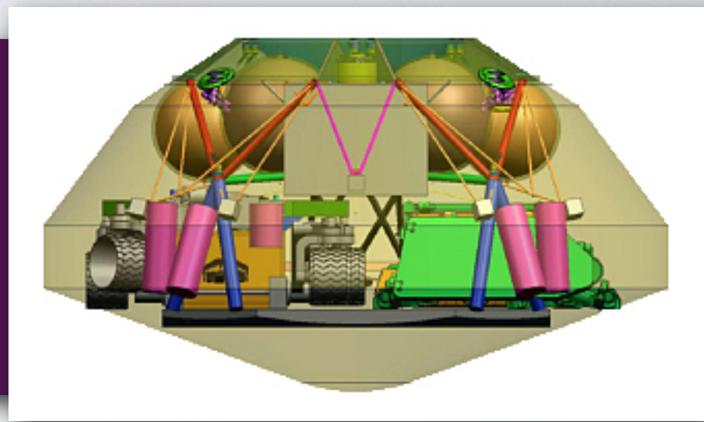


2016 — ESA-led mission

Launcher:	NASA – Atlas V 421
Orbiter:	ESA
Payload:	ESA-NASA
EDL Demo:	ESA

2018 — NASA-led mission

Launcher:	NASA – Atlas V 531
Cruise & EDL:	NASA
Rover 1:	ESA
Rover 2:	NASA



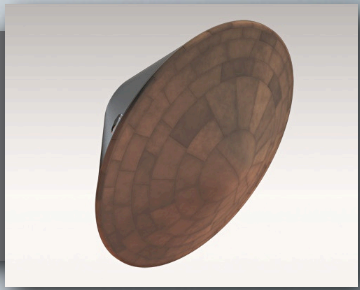
Mission Objectives

E X O M A R S

2016

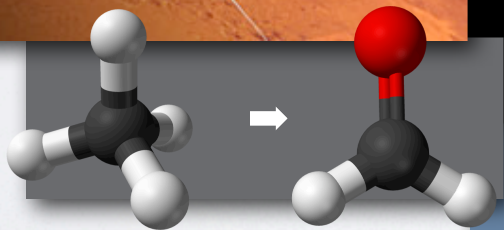
TECHNOLOGY OBJECTIVE

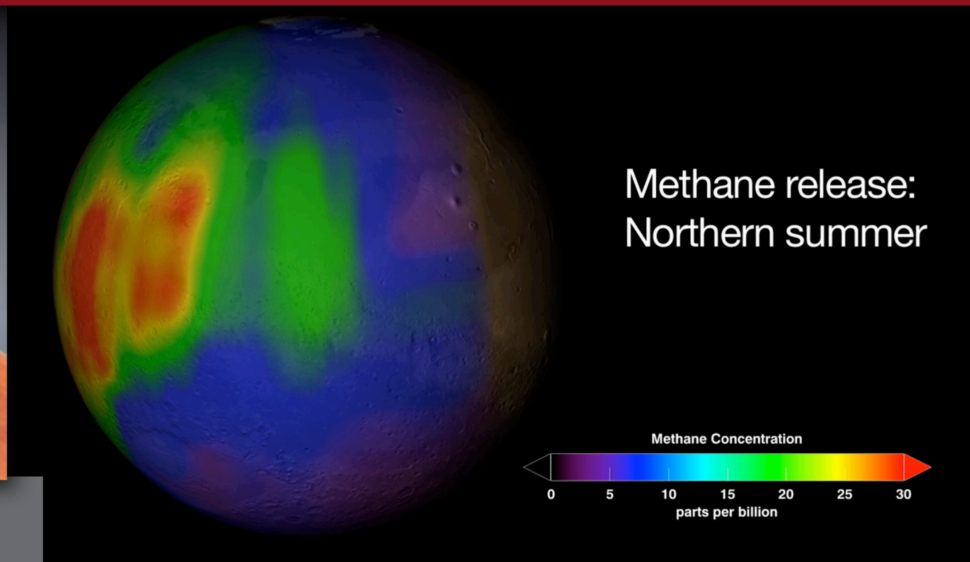
- Entry, Descent, and Landing (EDL) of a payload on the surface of Mars.



SCIENTIFIC OBJECTIVE

- To study Martian atmospheric trace gases and their sources.





- Data relay services for landed missions until 2022.

ExoMars TGO Payload

E X O M A R S

PRIORITISED GOALS

INSTRUMENTS

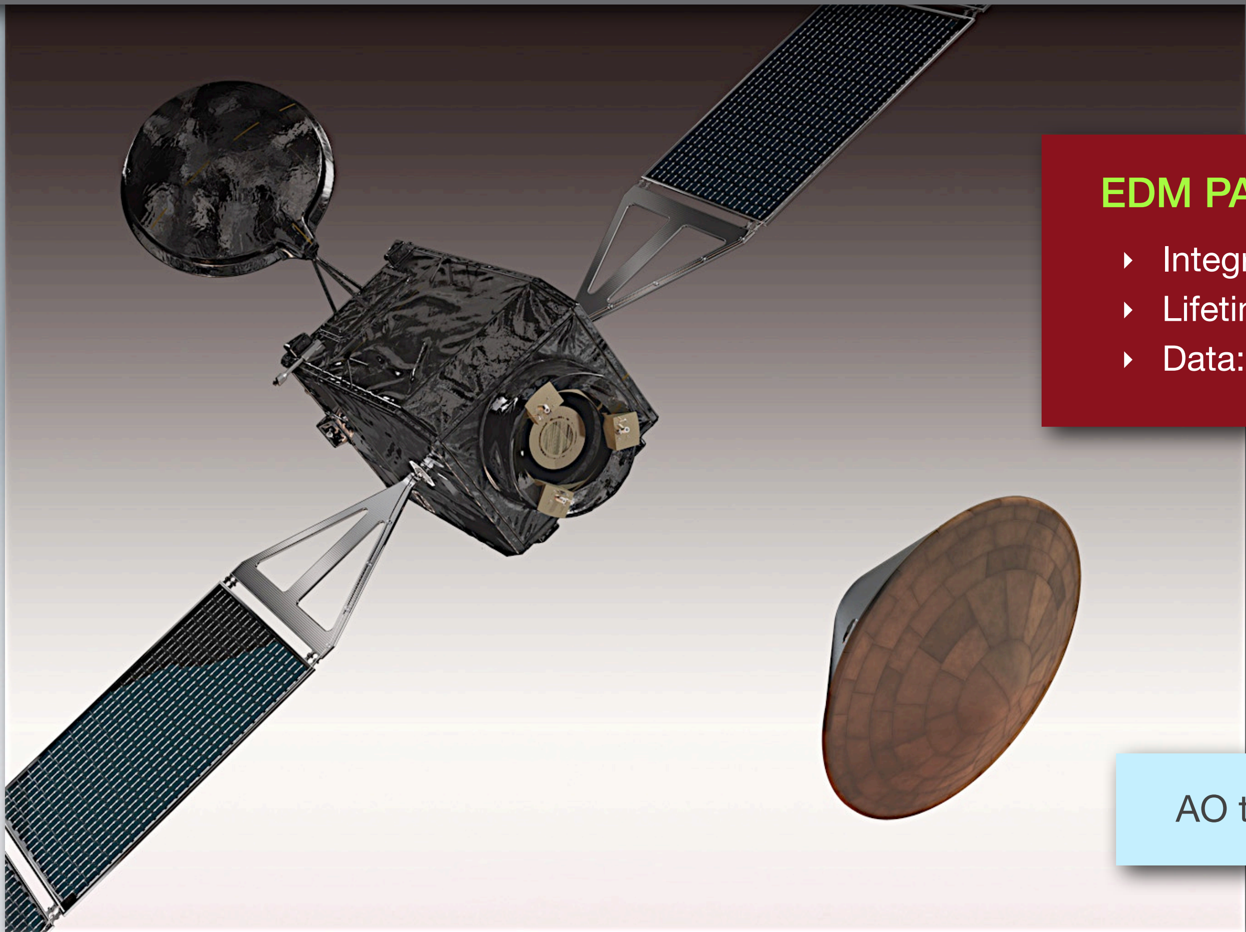
1. **Detect a broad suit of atmospheric trace gases** and key isotopes with high sensitivity:	**MATMOS** **(ppt)**	**USA**, CAN F	H/W Science
2. **Map their spatial and temporal variability** with high sensitivity:	**NOMAD** **(10^{-1} ppb)**	**B**, E, I, UK USA, CAN	
3. **Determine basic atmospheric state** by characterising P, T, winds, dust and water aerosol circulation patterns	**EMCS** **(P, T, dust, ices, H_2O)**	**USA**, UK F	
	MAGIE **(Full hemisphere WAC)**	**USA**, UK B, F, RUS	
4. **Map their spatial and temporal variability** with high sensitivity (≤ ppb):	**HiSCI** **(HRC 2 m/pixel)**	**USA**, CH UK, I, D, F	

Excellent coverage of high-priority objectives.

EDL Demonstration Module

EDM

- A European technology demonstrator for landing medium-large payloads on Mars;
- Provides a limited, but useful means to conduct scientific measurements during the dust storm season.

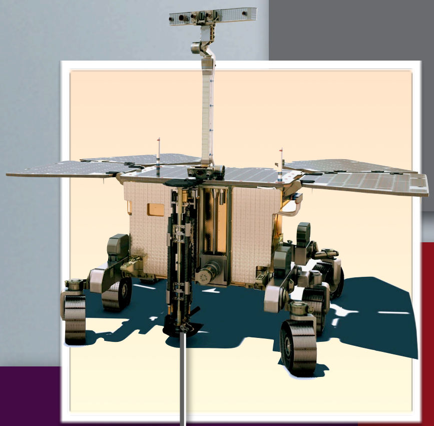


EDM PAYLOAD

- Integrated payload mass estimate: 3 kg;
- Lifetime: 8 sols;
- Data: Single pass of 50 Mbits.

AO to be released in November 2010

Mission Objectives



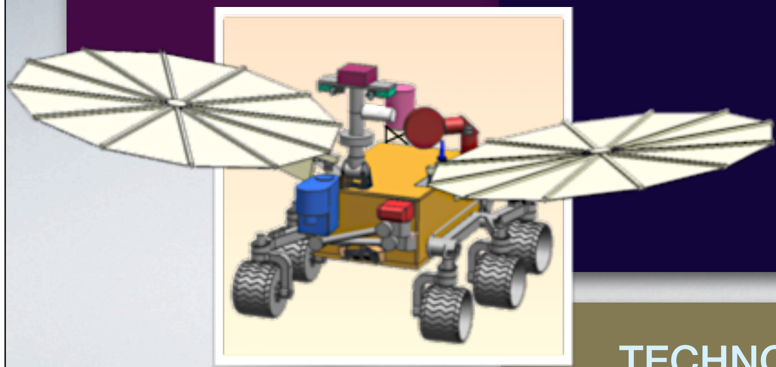
TECHNOLOGY OBJECTIVES

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

SCIENTIFIC OBJECTIVES

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

2018



SCIENTIFIC OBJECTIVES

- To identify, acquire, document, and cache “outstanding” samples in a manner suitable for collection by a future Mars Sample Return mission;
- To characterise sequences of geological units of a few km extent, documenting geological and geochemical variations at various scales.

TECHNOLOGY OBJECTIVES

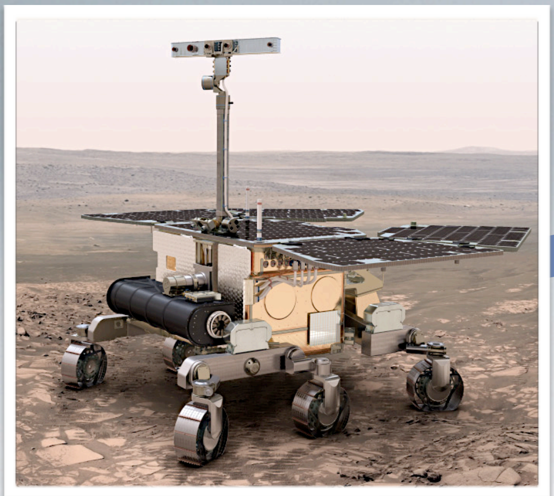
- Sample coring, acquisition, and encapsulation.

Preparing the Future

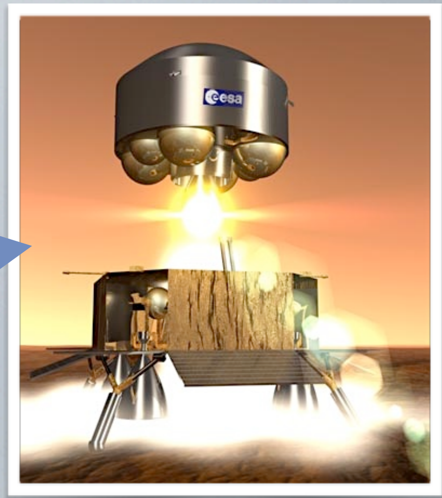
Mars Robotic
Exploration Preparation

Mission studies

Technologies



- 2018: ExoMars Rover



- Mars Sample Return

Preparing the Future

- Ongoing discussions with NASA to define a post-ExoMars mission scenario:
  - The objective is to converge to a common understanding of the Mars robotic exploration programme.

- ESA has defined the following mission studies in preparation for C-MIN 2012:
  1. Network science mission (4–6 probes), possibly with a high-precision landing demonstrator;
  2. Sample return from a moon of Mars (Deimos or Phobos);
  3. Mars atmospheric sample return;
  4. Precision lander (≤ 10 km) including sampling/fetching rover;
  5. MSR orbiter.

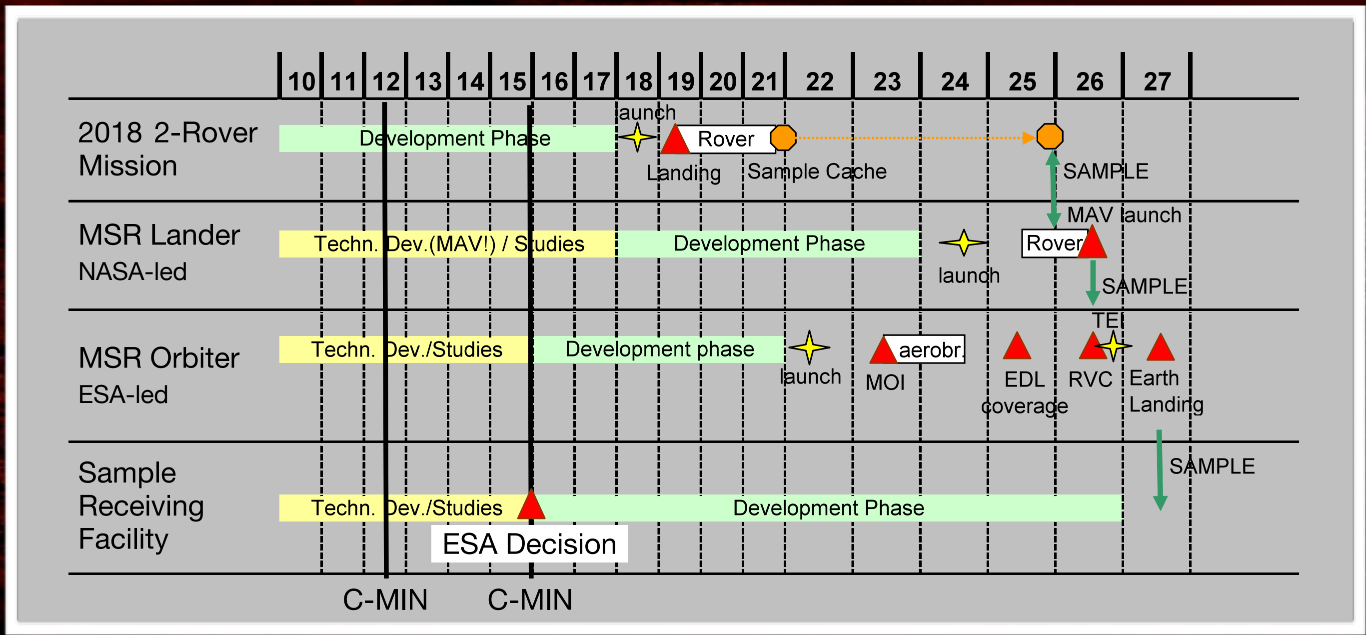
  Missions 1 through 4 are alternatives to cope with a possible MSR delay;
  Missions 4 and 5 constitute potential European-led contributions to MSR;
  The intention is to select 2–3 candidate missions by C-MIN 2012.

Programmatic Status

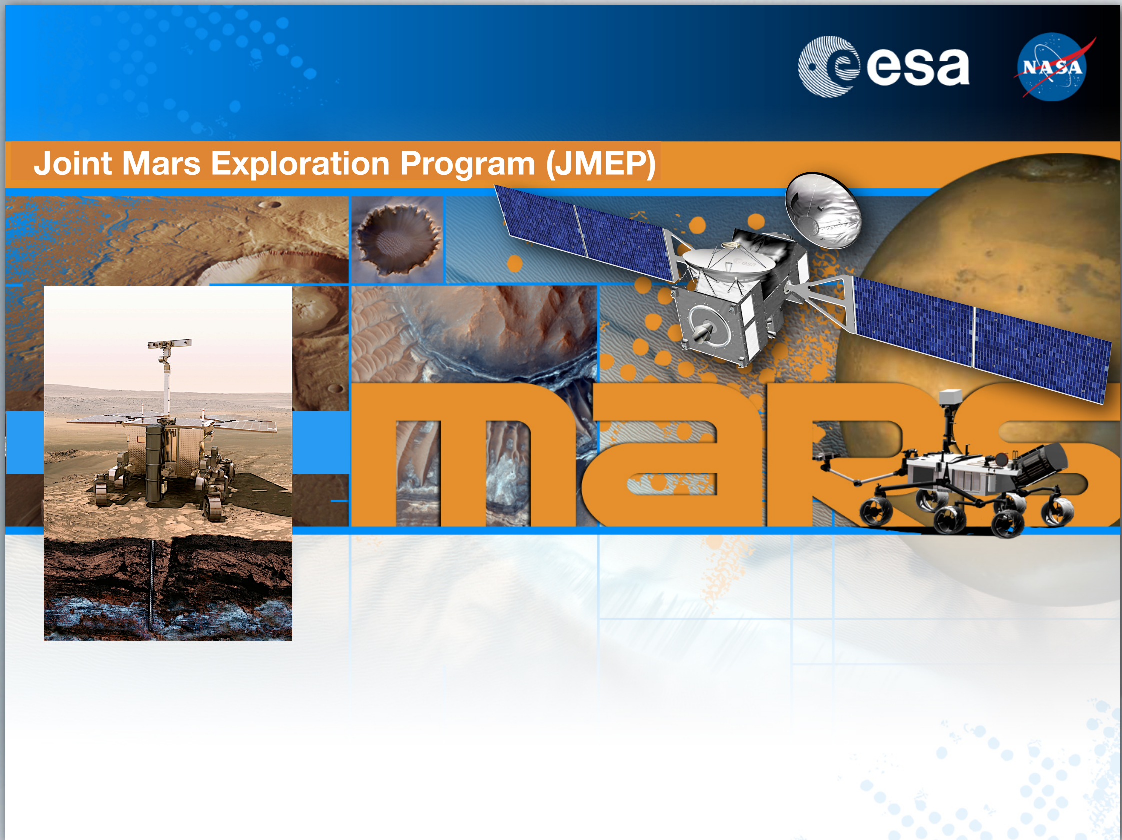
EXOMARS

- ExoMars Programme: 1 B€ approved at C-2009;
  - 850 M€ already available;
  - 150 M€ will be confirmed at 2012 C-MIN.
- MREP Programme: 35 M€ for technologies and future mission studies;

  Combined for MREP + General Studies Programme (GSP) + Technology Research Programme (TRP)



JMEP



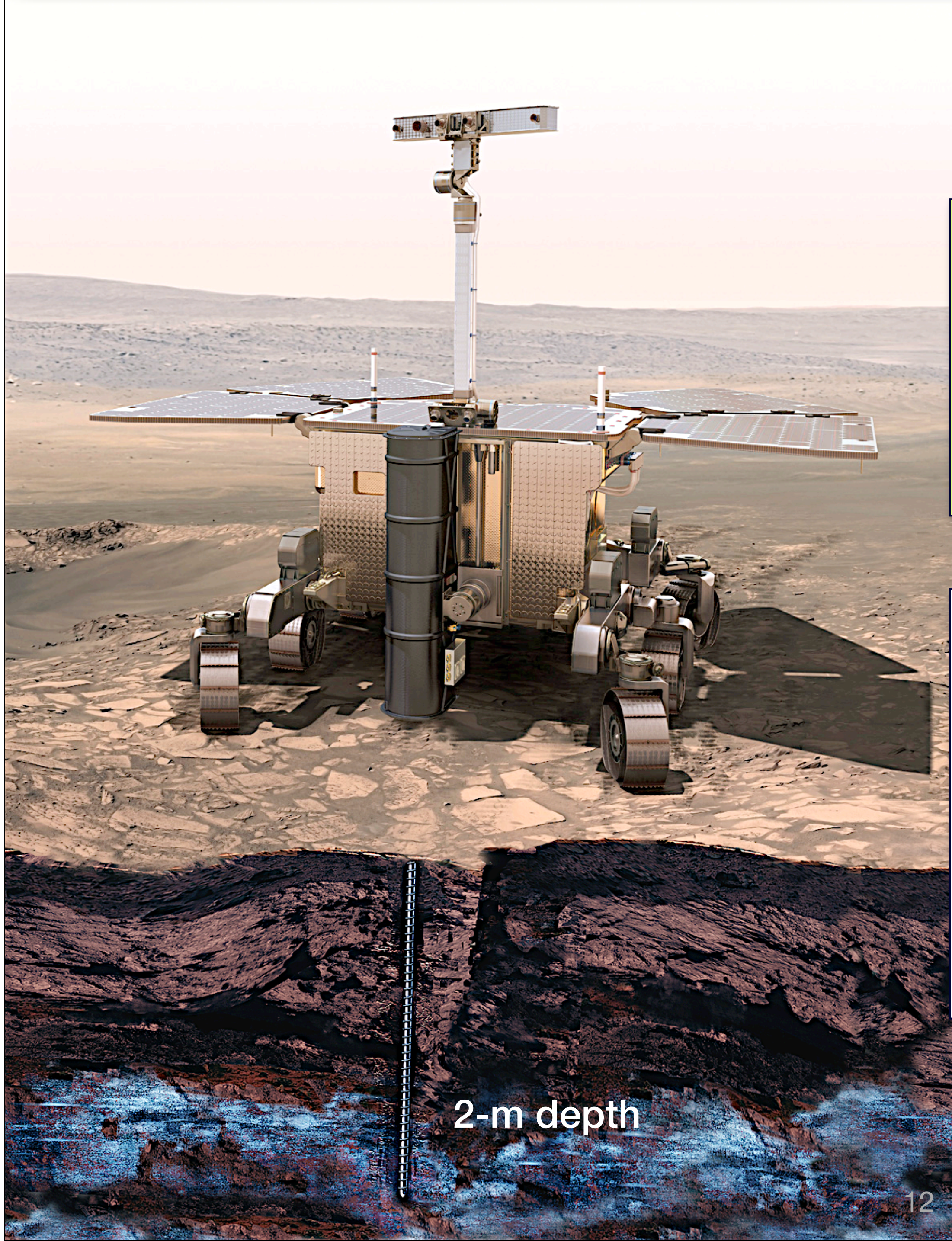
At programme level (standing)

- Joint Mars Executive Board (JMEB):
  - Steering of the joint programme, guidance for formulating missions, requirements, and programme architecture;
  - Oversight on implementation of missions.
- Joint Mars Architecture Review Team (JMART):
  - Independent review team to assess/critique programme level architecture, programmatic risk, national priorities, etc.
  - Oversight on implementation of missions.

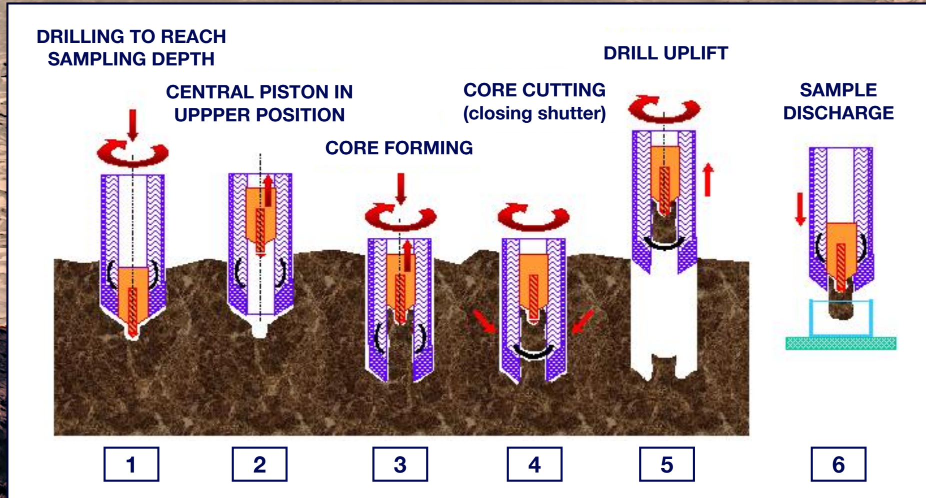
At project level (ad-hoc)

- Joint Engineering Working Group (JEWG):
  - Advanced engineering planning group; standing organisation at ESTEC & JPL.
  - Develop cooperative architecture options for shared mission responsibilities.
  - Complete for 2016 ExoMars TGO, starting for 2018 Two-Rover mission, soon for Mars Sample Return.
- Joint Instrument and other Study Teams:
  - Established by the JMEB. For example, Joint Instrument Definition Team (JIDT) established the investigation capabilities for the 2016 orbiter mission.
  - 2R-iSAG two-rover science analysis group explored science cooperation possibilities for the 2018 rovers. E2E-iSAG to carry out an end-to-end MSR science analysis.

Mobility + Subsurface Access



Nominal mission :	180 sols
Nominal science :	6 Experiment Cycles + 2 Vertical Surveys
EC length :	16 – 18 sols
Rover mass :	300 kg
Mobility range :	Several km

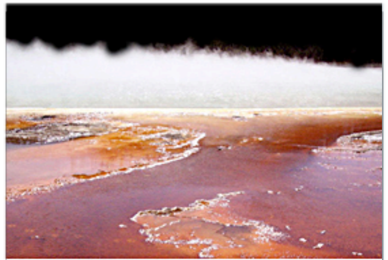


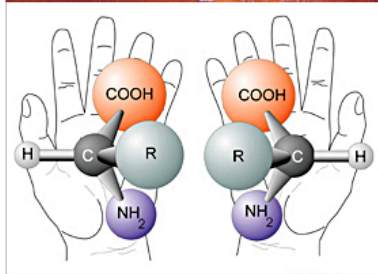
Credit: ESA/Medialab

Science Objectives (expanded)

ExoMars Rover: Search for signs of life;
Establish the scientific importance of subsurface samples for MSR.

- Conduct a thorough characterisation of surface outcrops (geology and biosignatures);
- Explore the shallow subsurface stratigraphy and identify candidate sites for drilling;
- Search for biomarkers;
- How do the distribution and preservation of organics vary with depth ?
- Study any geochemical variations in the geological record with depth.
- Progressively learn form the surface, radar, subsurface sample study cycle to inform the selection of drilling sites.

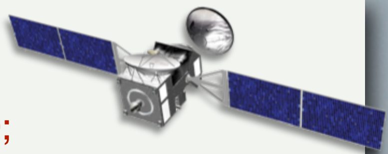




ExoMars Project Status

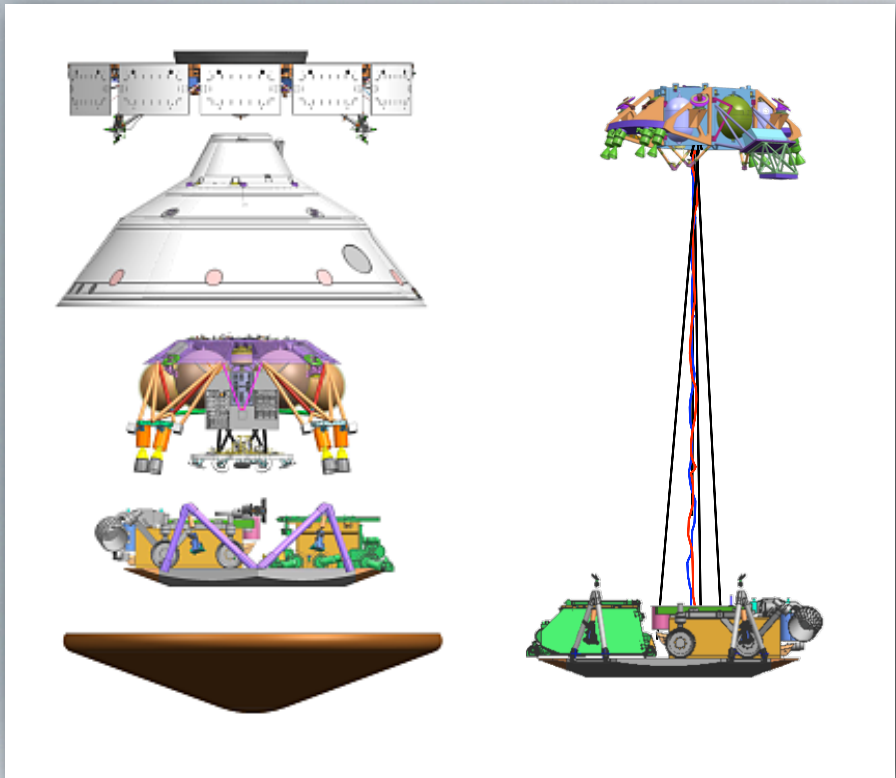
- Industrial negotiations completed for present stage of programme (B2X2 + Advanced CD2):
  - ➡ ESA documentation defined and applied to the new contractual baseline;
  - ➡ System PDR for 2016 and 2018 missions to run from 25 October – 13 December 2010;
  - ➡ Statement of Intent (SOI) and Letter of Agreement (LOA) signed; good progress on Memorandum of Understanding (MOU).

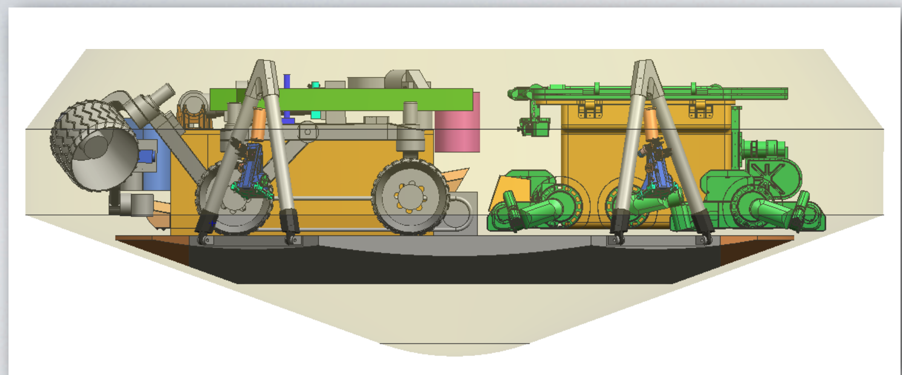
- 2016 ExoMars Trace Gas Orbiter:
  - ➡ Payload kickoff meeting (ESA, NASA, JPL) took place on 1–2 September 2010;
  - ➡ First Orbiter Science Working Team (OSWT#1) to take place at JPL on 13–14 October 2010.

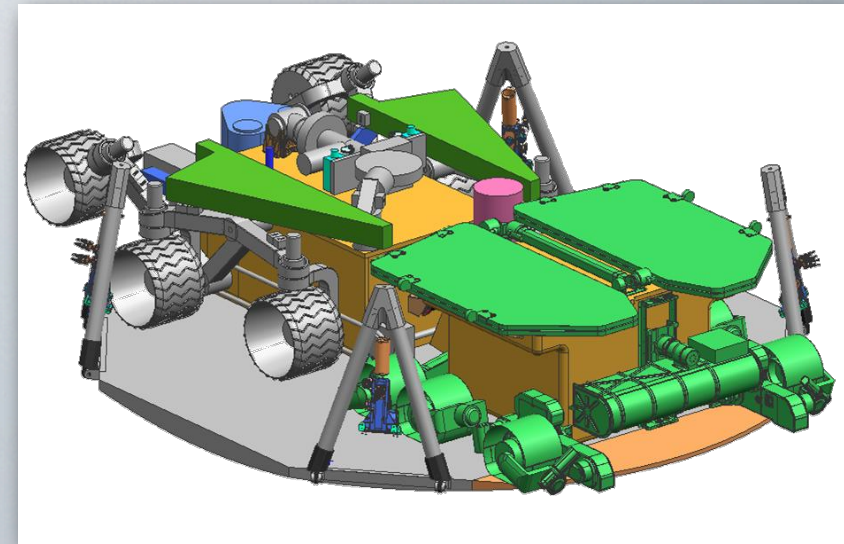


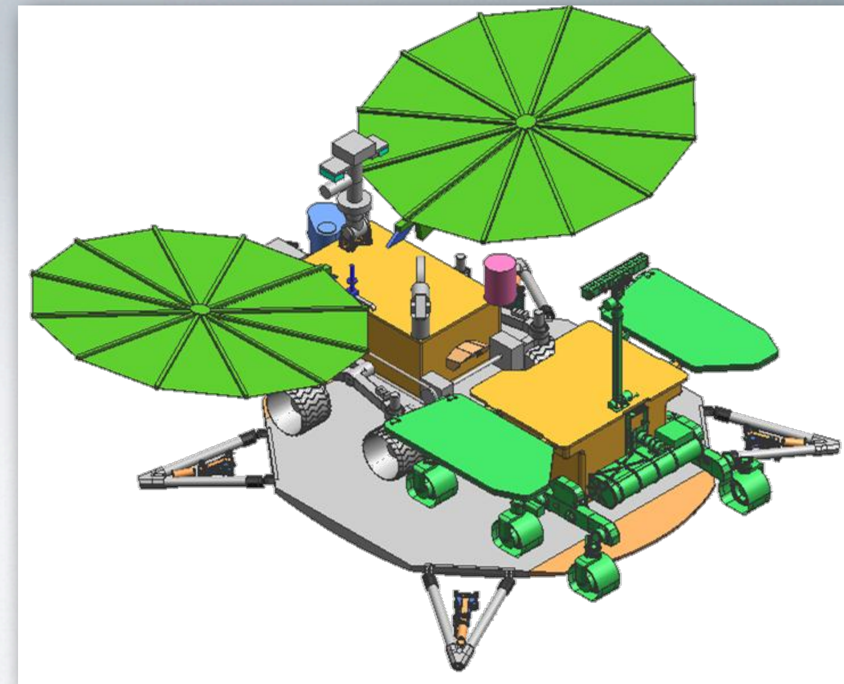
- 2018 ExoMars Rover:
  - ➡ First lander accommodation workshop took place in JPL during June 2010;
  - ➡ Rover design work progresses; medium-term activities to centre around prototype testing;
  - ➡ Reformation of MOMA-LDMS team;
  - ➡ Procurement of rover equipment and software for Phase C/D.

Flying Two Rovers

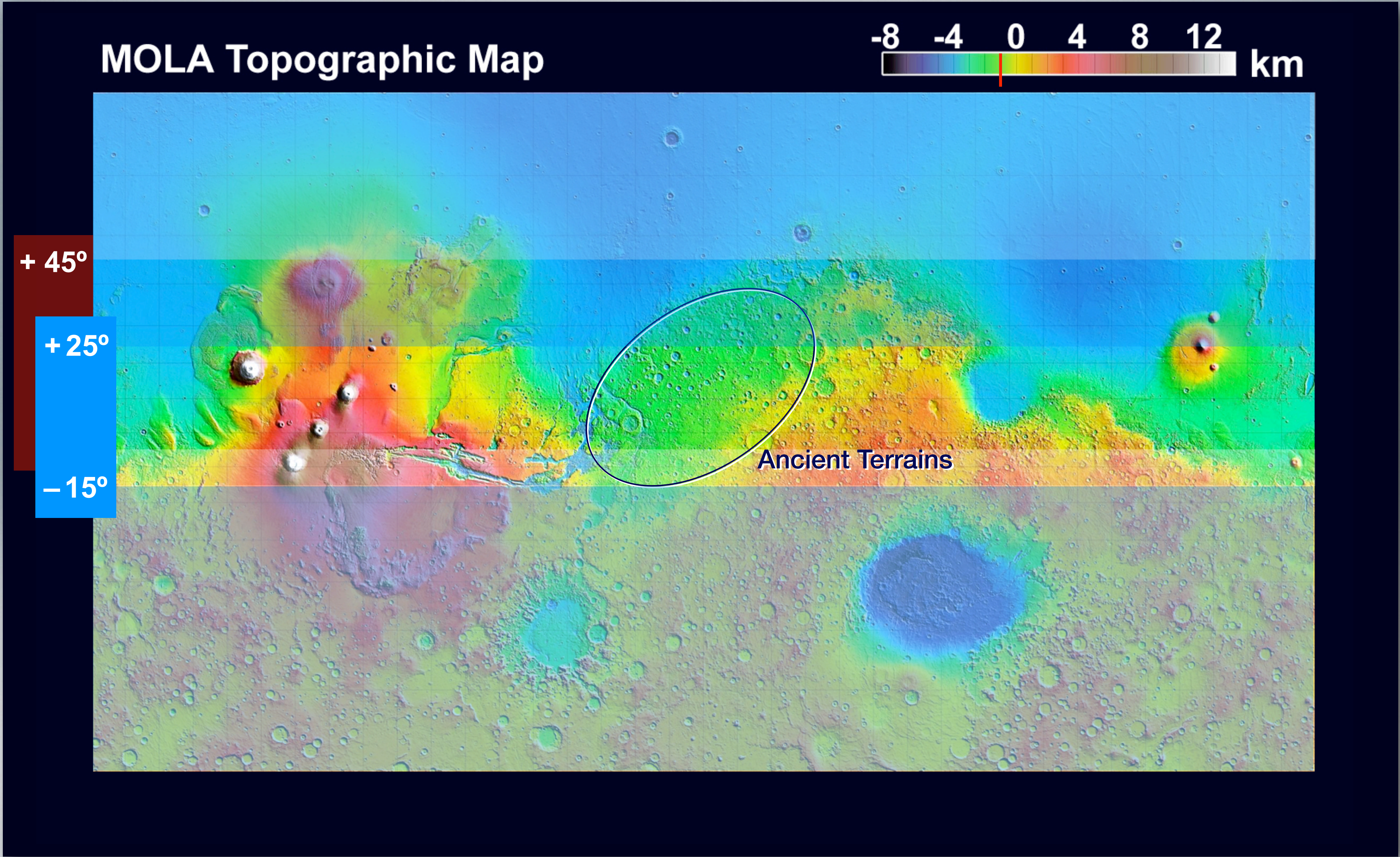








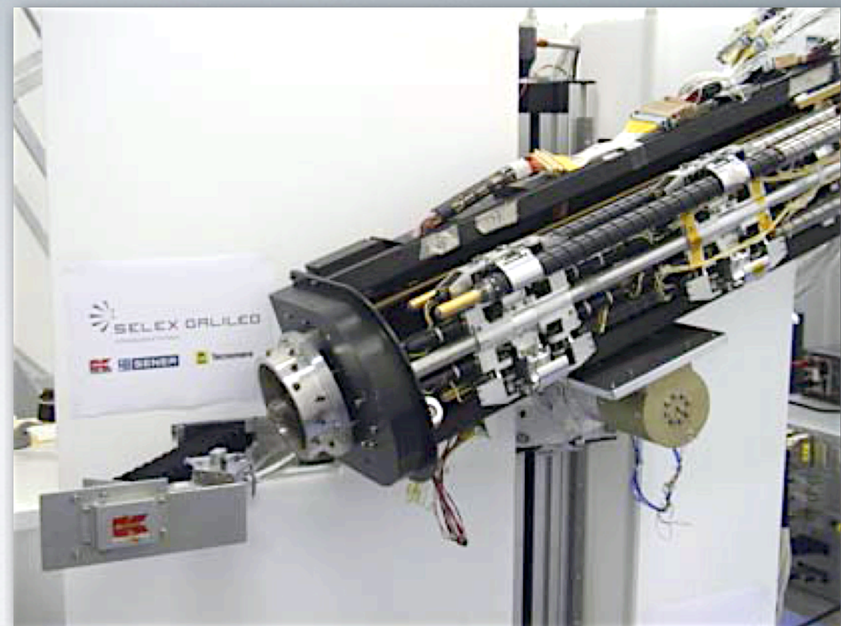
Landing Latitudes



Rover Breadboard Activities

E X O M A R S

- Locomotion and navigation subsystems:
  - Two chassis breadboards, wheels, GNC.
- Sample Preparation and Distribution System (SPDS) mechanisms:
  - Tested in laboratory and under Mars simulated conditions.
- Drill and positioner:
  - Extensively tested in laboratory and under Mars simulated conditions;
  - Stand alone and on rover chassis breadboard;
  - Down to 2 m depth.
- Thermal control system elements.
- Electronics;
- Next are further tests of the drill with more realistic geological strata configurations, including ice lenses.
  - Dedicated science team has defined the sequences and procured suitable rocks.



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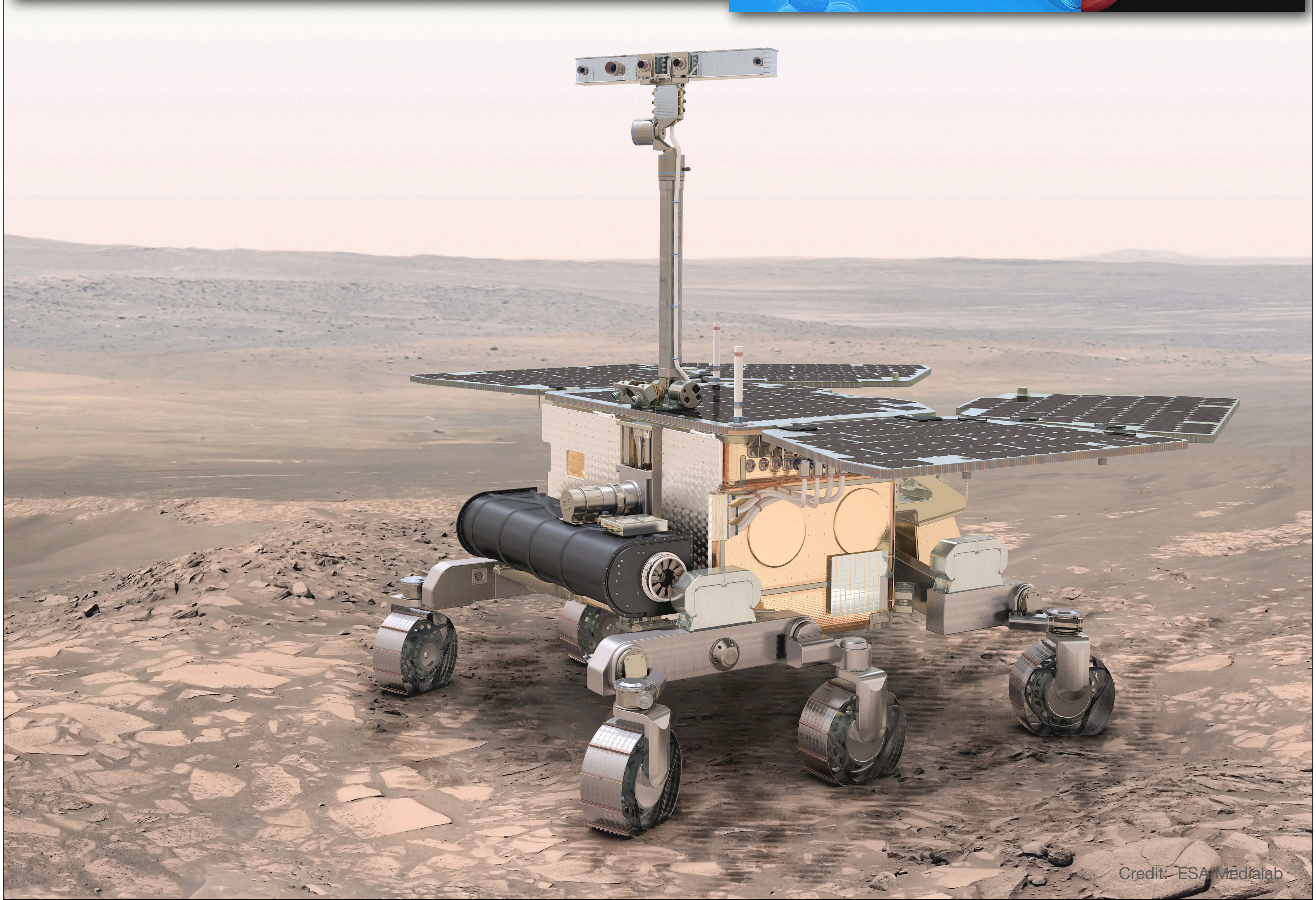
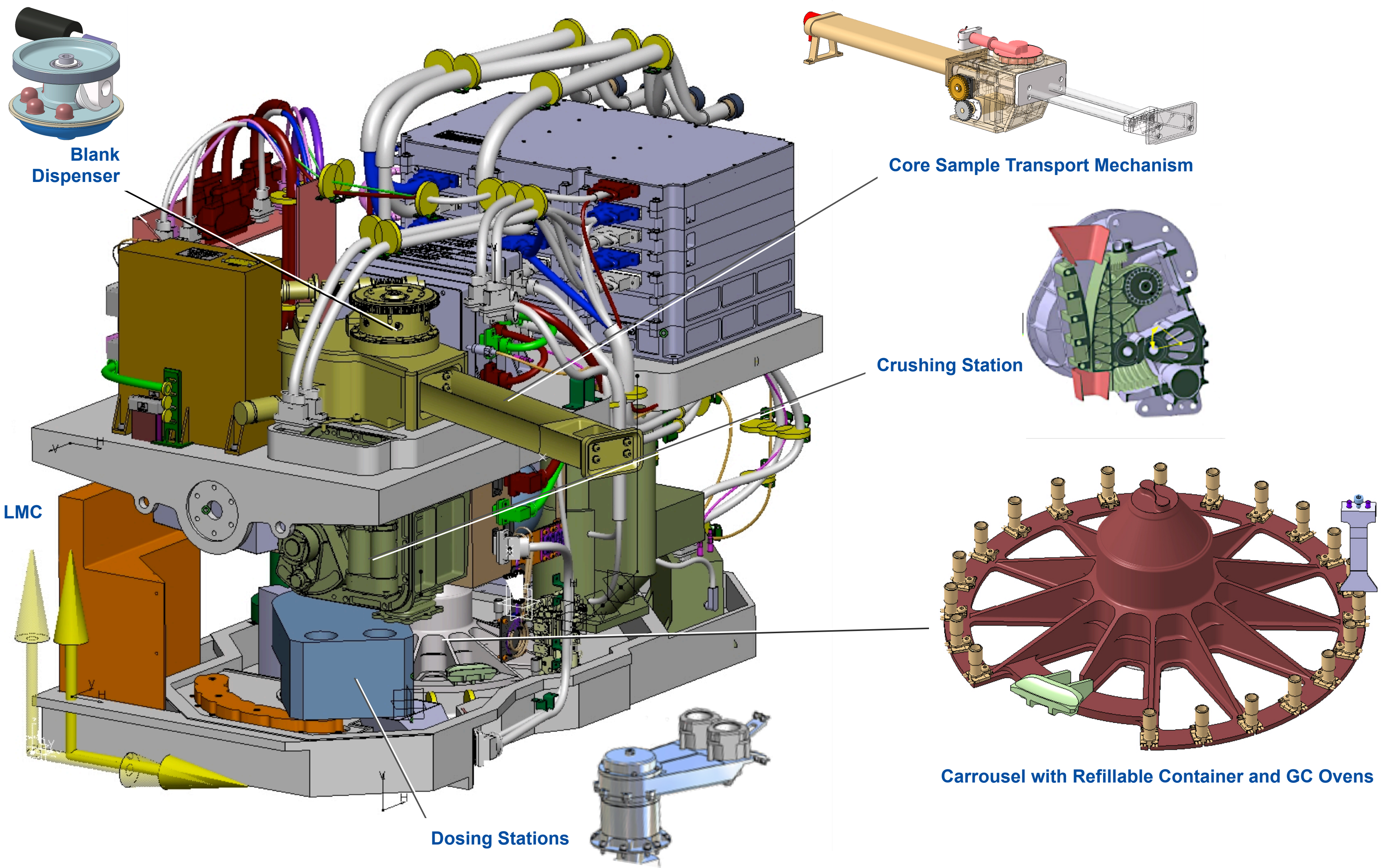
Rover Deployment

E X O M A R S



Analytical Laboratory

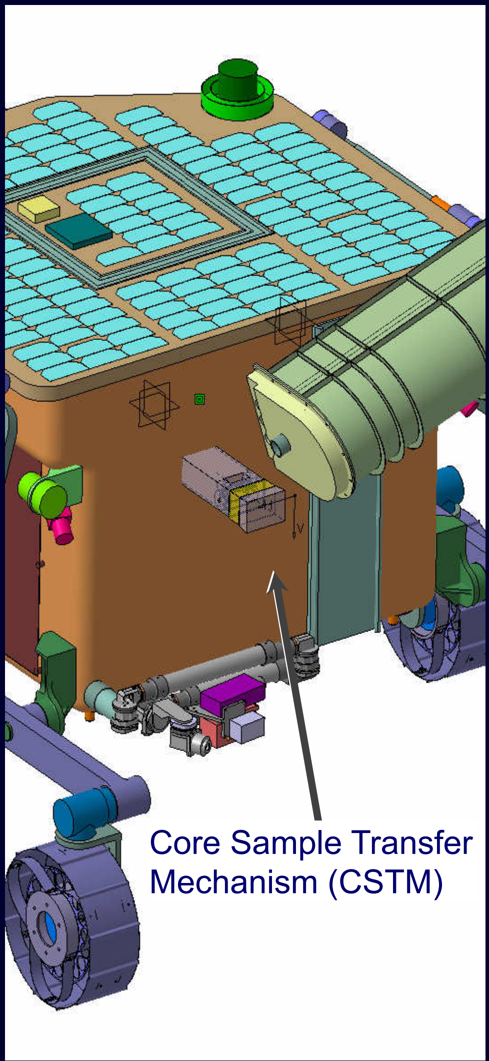


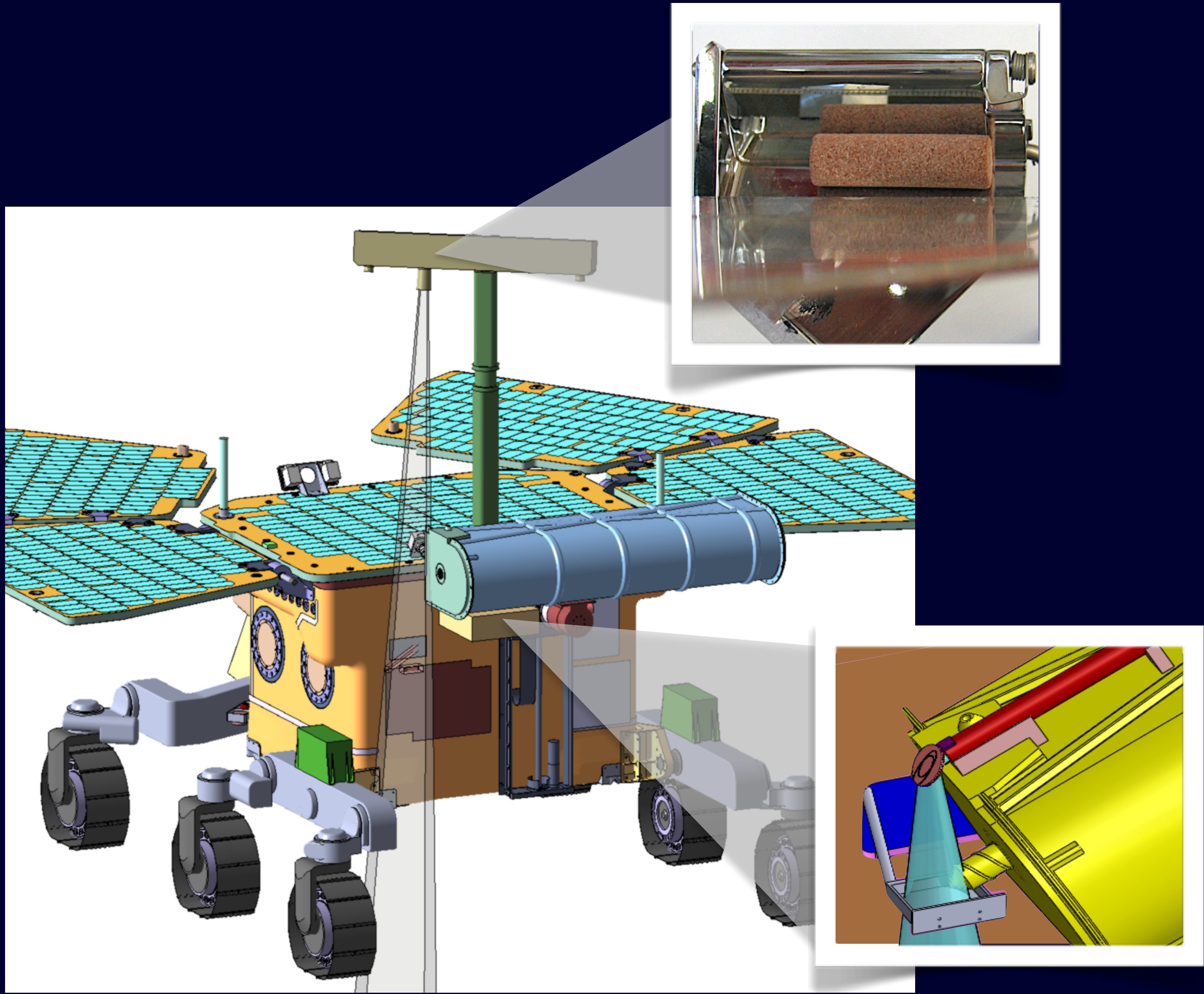
Credit: ESA/Astrium

Sample Delivery

DRILL discharges sample into Core Sample Transport Mechanism (CTSM). **CLUPI** images sample.

PanCam **HRC** provides a backup sample imaging capability.

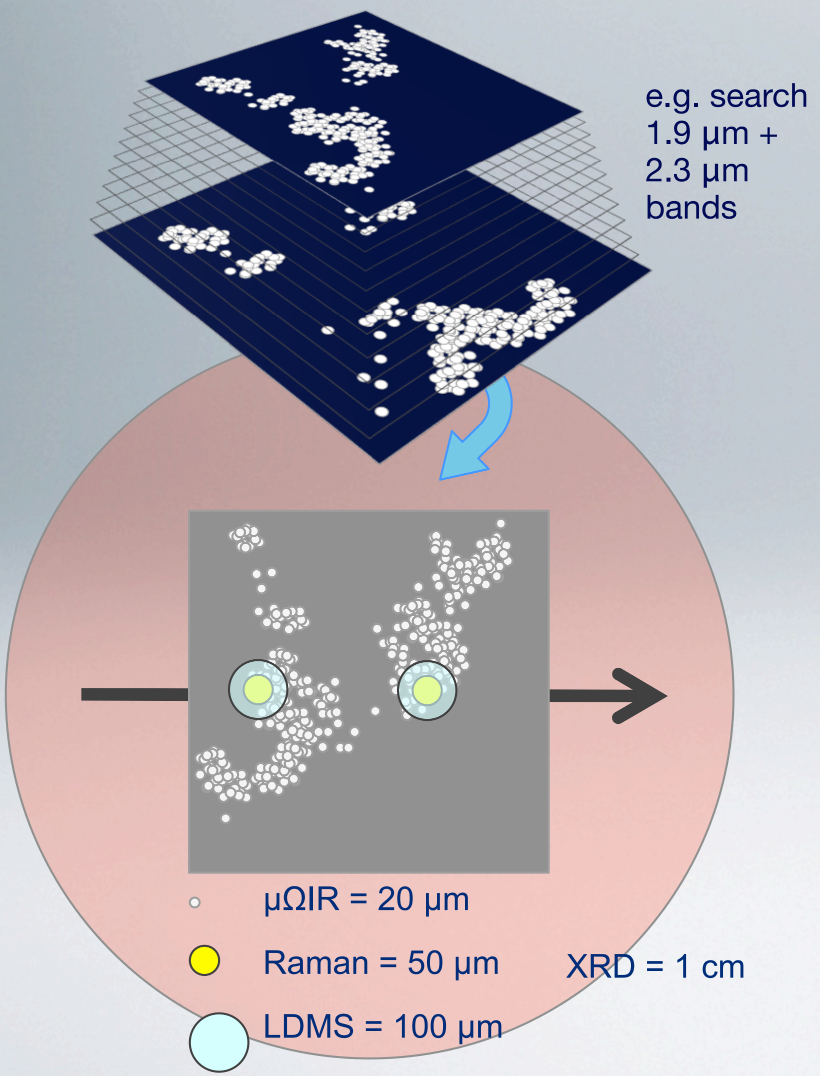


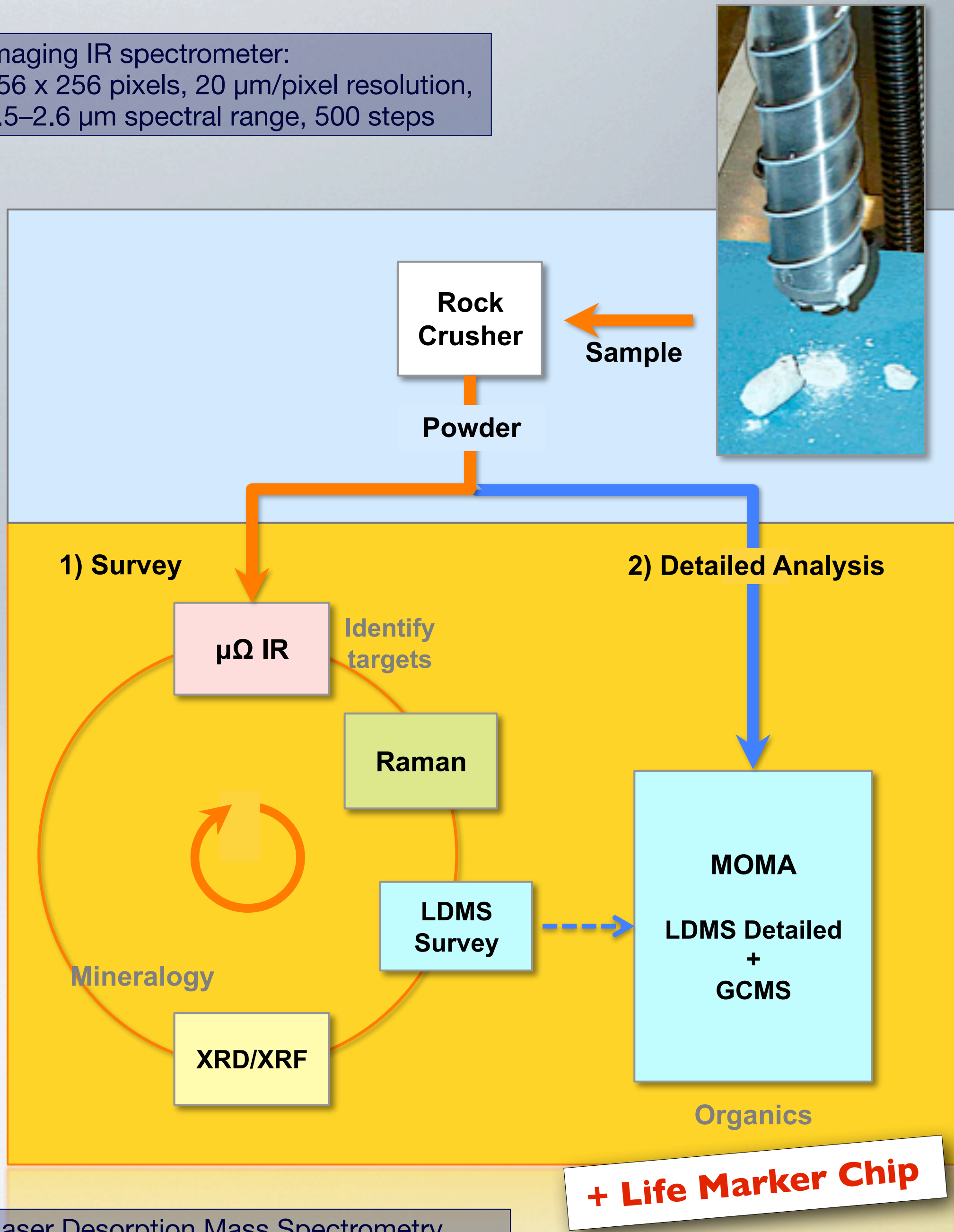


Sample Analysis

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

Imaging IR spectrometer:
256 x 256 pixels, 20 µm/pixel resolution,
0.5–2.6 µm spectral range, 500 steps





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

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

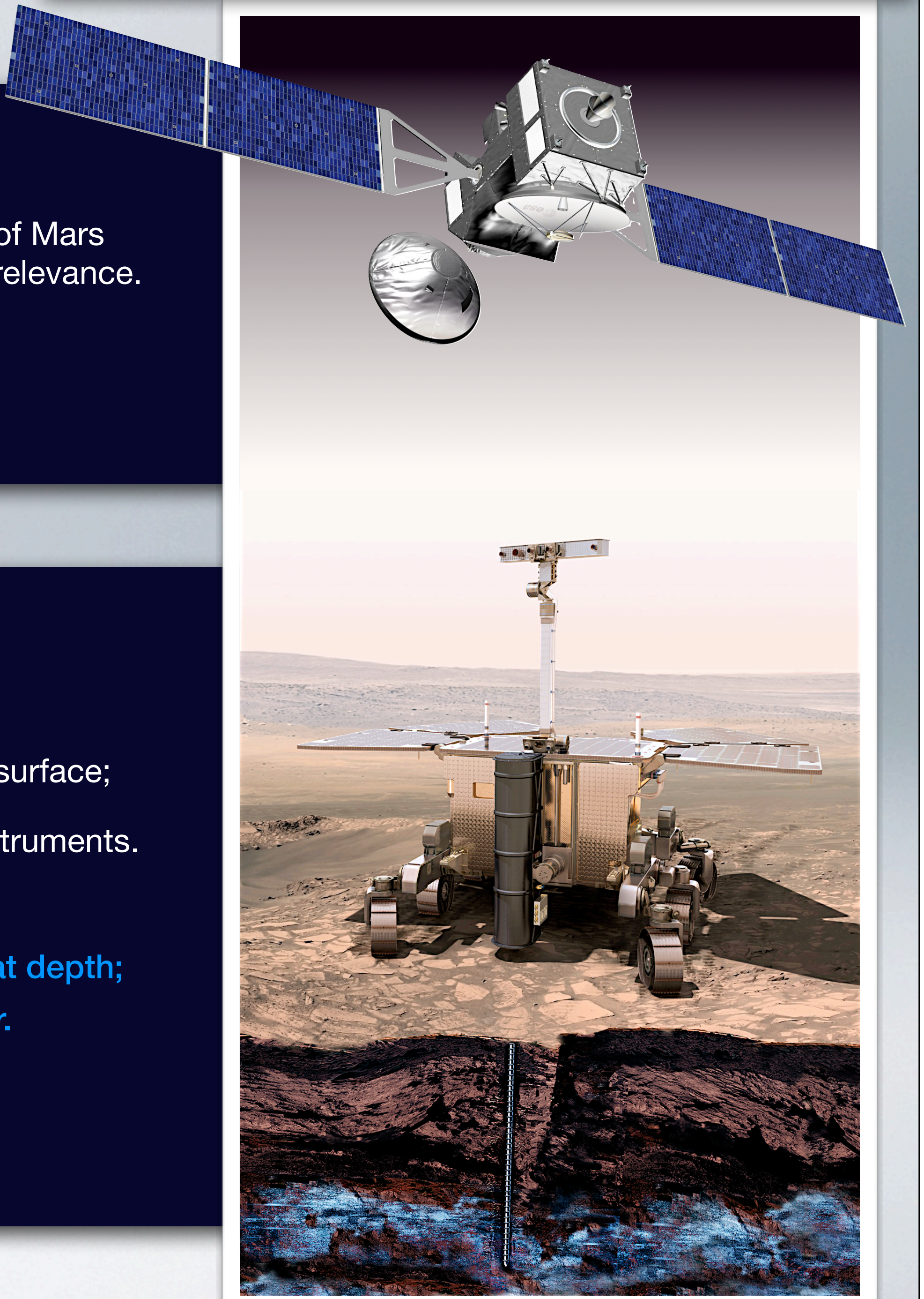
International

EXOMARS

Instrument Name	Description	Countries
PanCam (WAC + HRC)	Panoramic camera system	**UK**, D, CH H/W F, I, A, USA Science
WISDOM	Shallow ground penetrating radar	**F**, D N, USA, B, I, E, UK
CLUPI in drill box	Close-up imager	**CH**, F CAN, UK, D, I, B
Ma_MISS included in 2.0-m drill	IR borehole spectrometer	**I** P, PL
MicrOmega	IR imaging spectrometer	**F** CH, RUS, I, D, UK
RLS	Raman laser spectrometer	**E**, F, UK D, NL, USA
Mars-XRD	X-ray diffractometer + X-ray fluorescence	**I**, UK E, P, NL, D, F, RUS, USA, AUS
MOMA	LDMS + Pyr-Dev GCMS for characterisation of organics	**D**, F, USA NL, S
LMC	Life marker chip	**UK**, NL, I D, N, USA

Conclusions

E X O M A R S



2016: ExoMars Trace Gas Orbiter

- Its science will provide new insights into our understanding of Mars and key atmospheric processes of potential astrobiological relevance.
- An excellent base for international collaboration.
- Master landing technologies for future European missions.

2018: ExoMars Rover

- A great exobiology mission;
- The first ever to combine mobility with access to the subsurface;
- The rover's Pasteur payload contains next-generation instruments.
- The rover will study for the first time:
  - Organics and biomarkers for past and present life at depth;
  - Vertical characterisation of geochemistry and water.
- New sample handling and locomotion technologies.
- A step closer to Mars Sample Return.

Save this date !!!

Week of 13 June 2011: "Mars Week" in Europe

Lisbon, Portugal

- **Opportunity for pre-conference Mars science meetings**
  All day Sunday (June 12) and morning Monday (June 13): 1.5 days
- **International Conference on "The Exploration of Mars Habitability"**
  Monday afternoon (June 13) through end Wednesday (June 15): 2.5 days
- **1st International MEPAG Meeting**
  Thursday (June 16) through end Friday (June 17): 1.5 days

Field Trip: Río Tinto, Spain

- **Visit to unique geology and acidic environment**
  Saturday (June 18) to Monday/Tuesday (June 20/21): 3–4 days