Outlook for Probe and Lander Missions in ESA's Programmes

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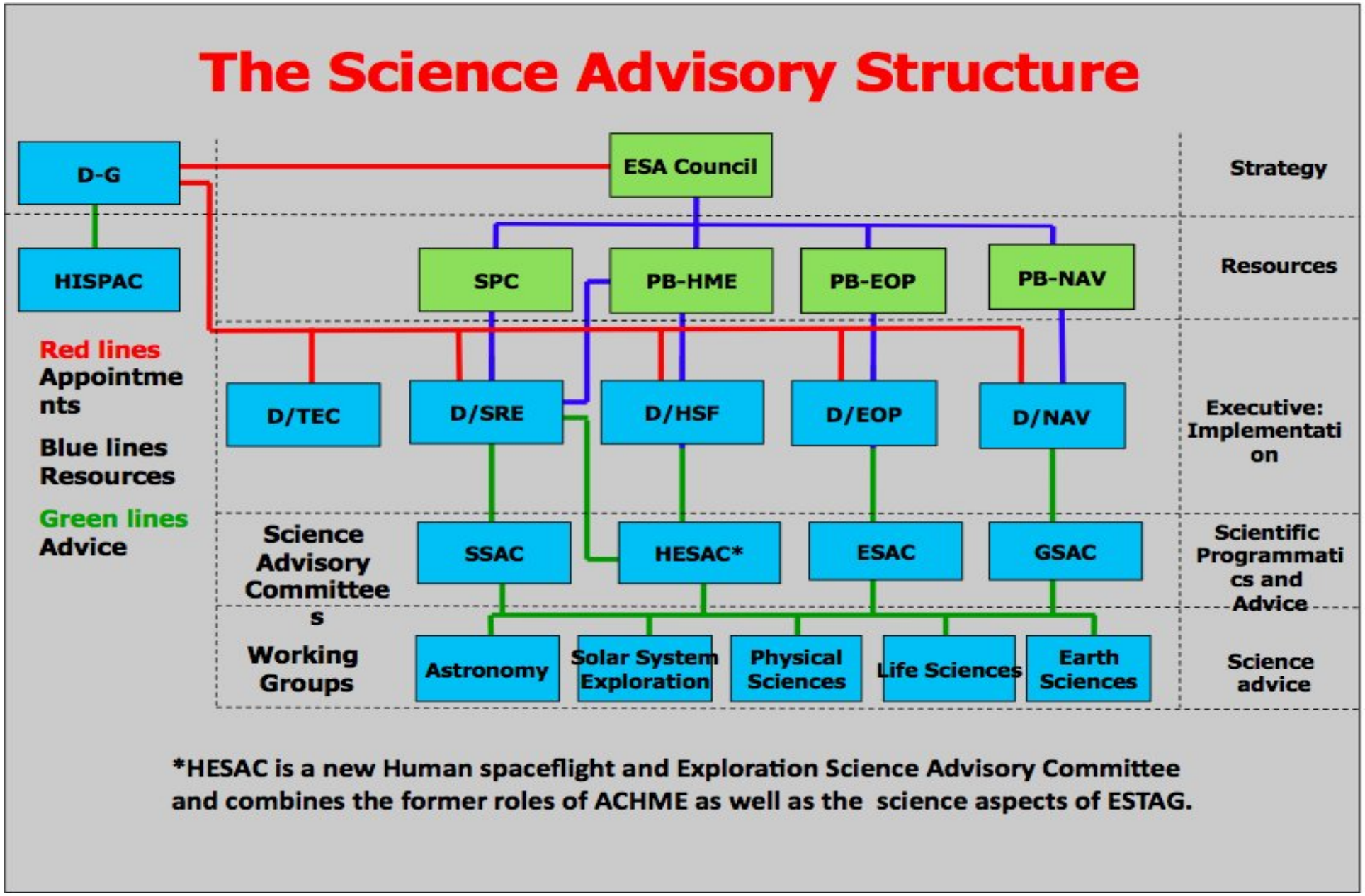
Solar System Missions Division
ESA/ESTEC, Noordwijk, Netherlands

7th International Planetary Probe Workshop
Barcelona, 4-18 June 2010

ESA Structure through the science eye



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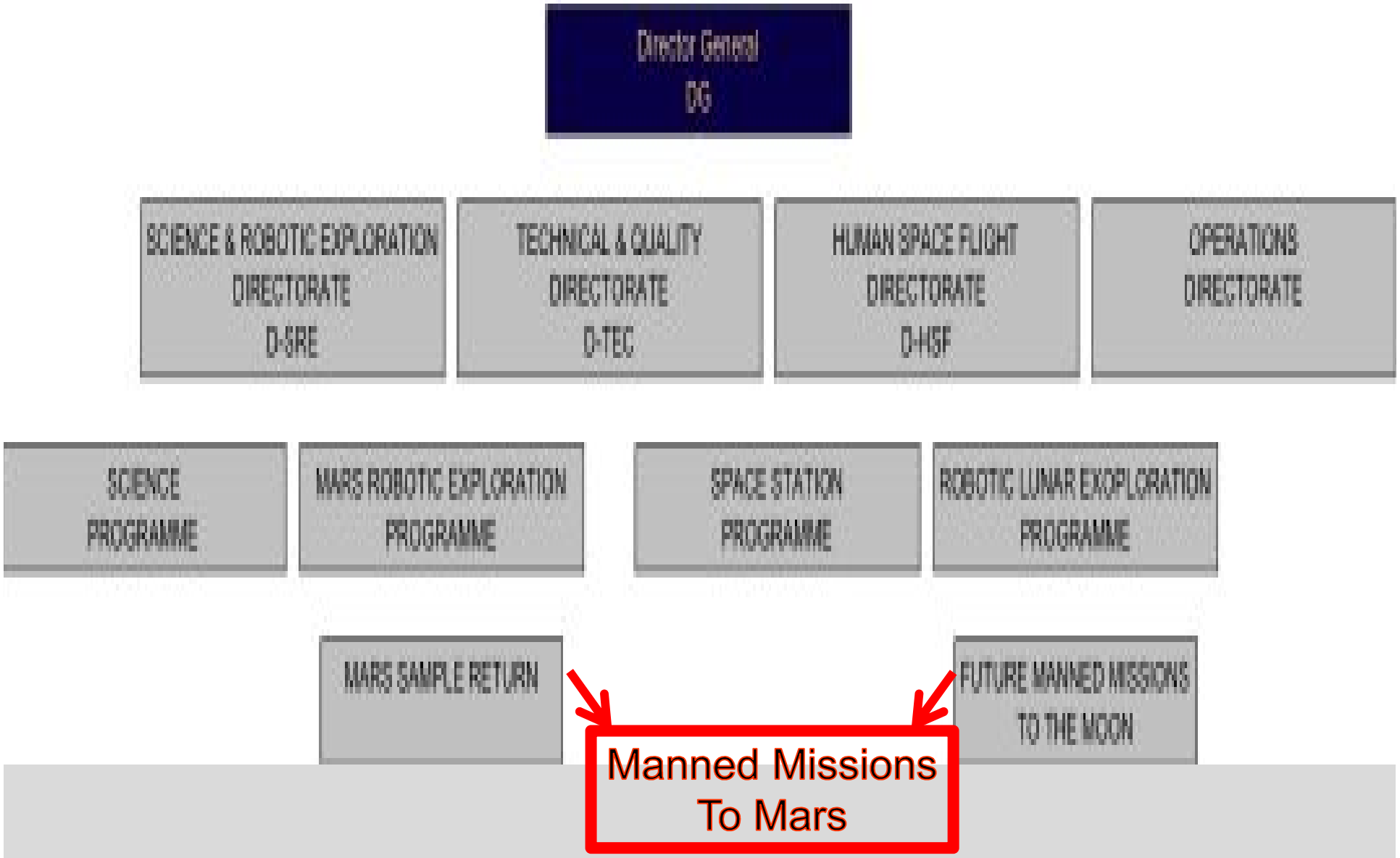
TECHNICAL & QUALITY DIRECTORATE
D-TEC
HUMAN SPACE FLIGHT DIRECTORATE
D-HSF
OPERATIONS DIRECTORATE
SCIENCE PROGRAMME
MARS ROBOTIC EXPLORATION PROGRAMME
SPACE STATION PROGRAMME
ROBOTIC LUNAR EXPLORATION PROGRAMME
MARS SAMPLE RETURN
FUTURE MANNED MISSIONS TO THE MOON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Manned Missions To Mars

The past: heritage to built upon

- Atmospheric Reentry Demonstrator (ARD, 1998) http://www.esa.int/esapub/bulletin/bullet109/chapter6_bul109.pdf ➔
- (Cassini)-Huygens (1997-2005… 2017) (next slides)
- MEX-Beagle2 (2003) http://www.beagle2.com/index.htm

Cassini-Huygens:

NASA-ESA-ASI mission to the Saturn System

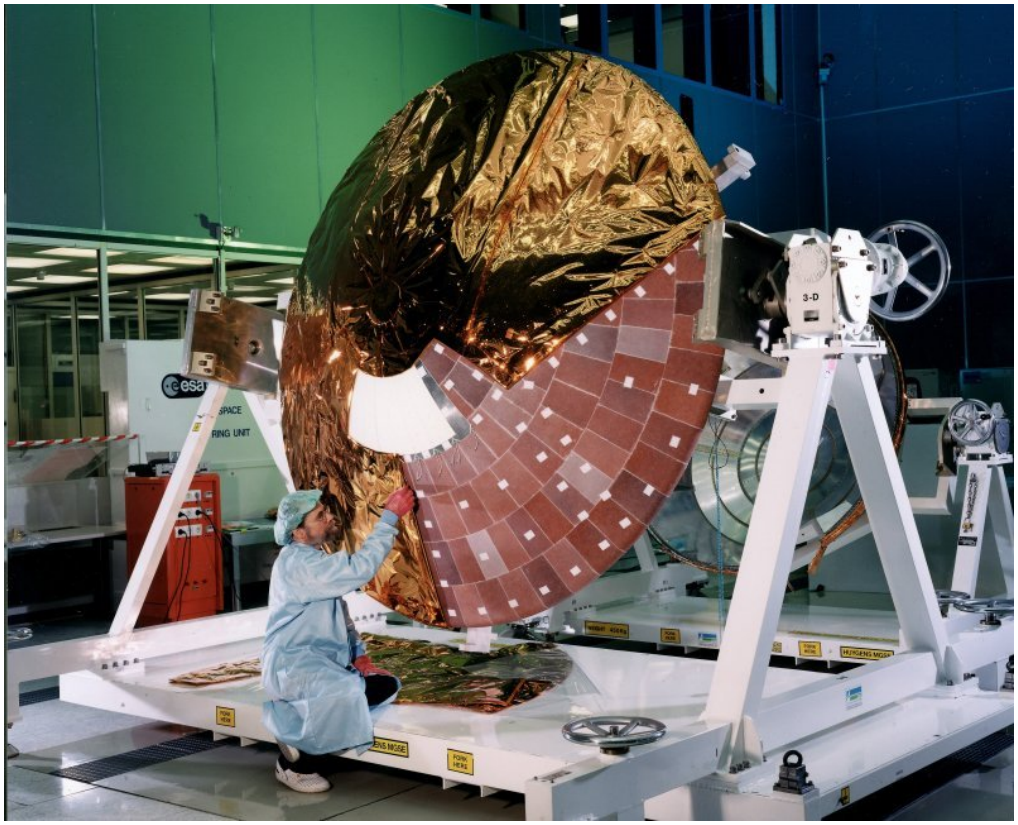
Huygens:

- First landing on a moon other than Earth's
- Most distant landing in Solar System
- First ESA Planetary landing

Huygens Fifth Anniversary Meeting; Barcelona, Spain,13–15 January 2010 Report to appear in EOS this week ?
Video presentations:
http://www.vimeo.com/channels/huygens2titan1

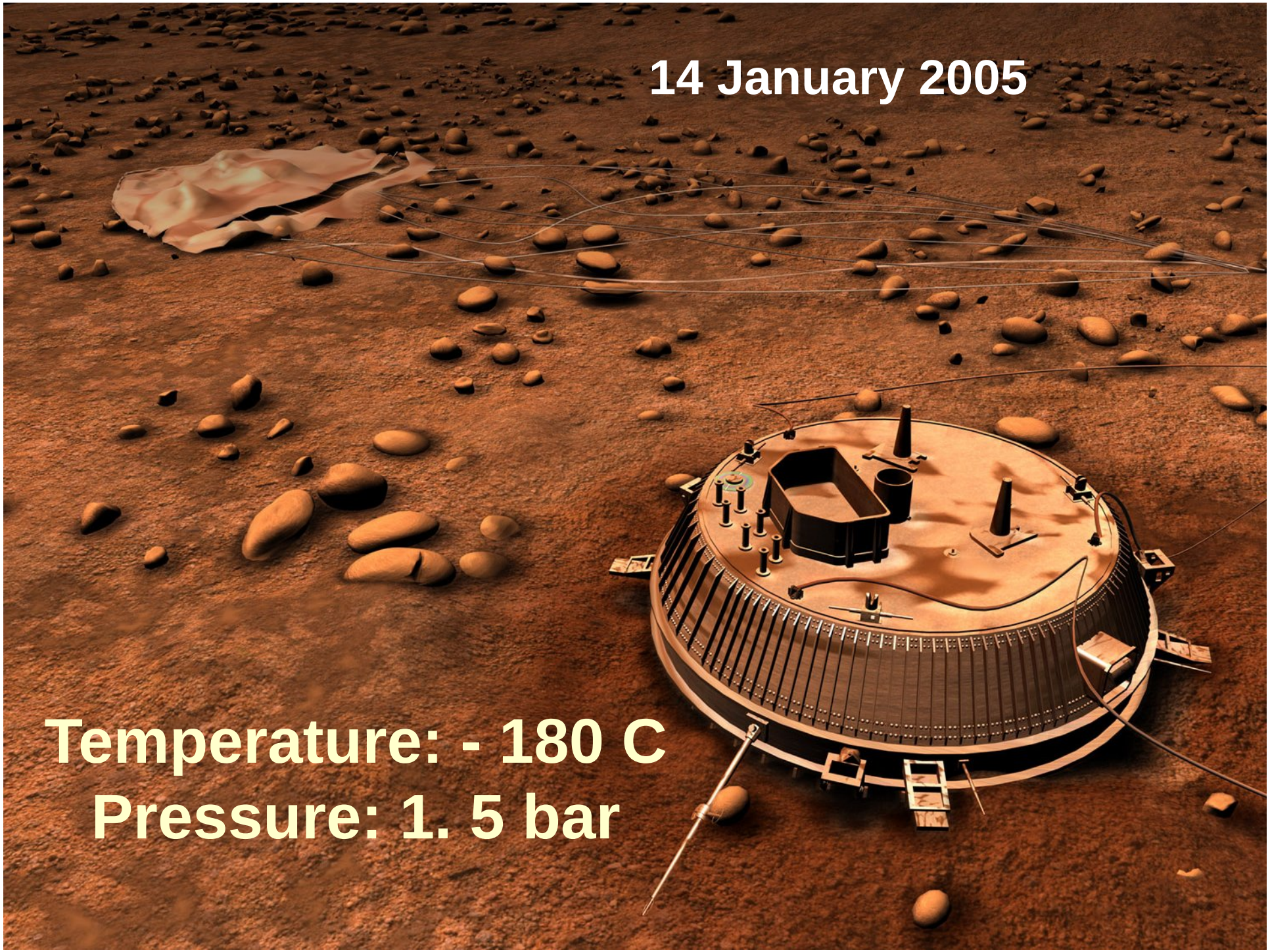
NASA/ESA/ASI Cassini Huygens

NASA- Cassini Orbiter; ESA –Huygens Probe

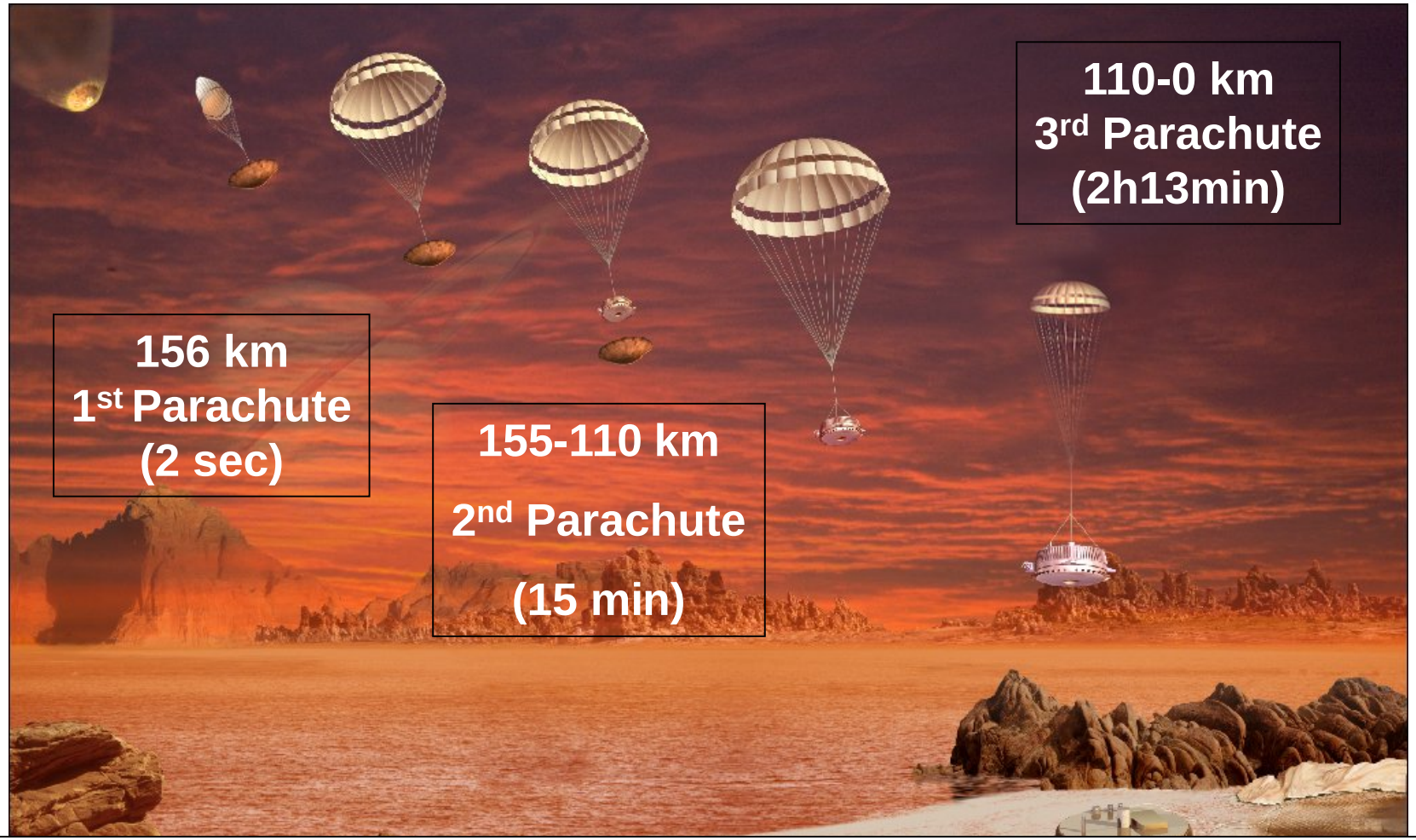


Huygens Industrial Consortium

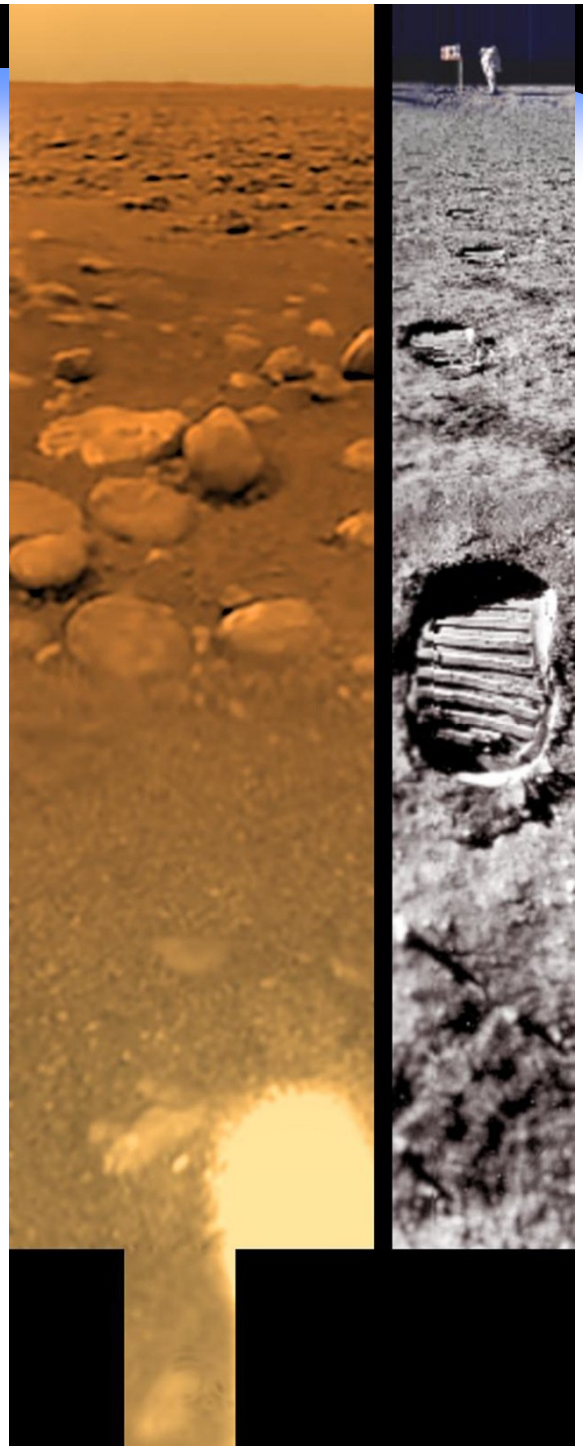
Huygens entry and descent


14 January 2005
Temperature: - 180 C
Pressure: 1. 5 bar

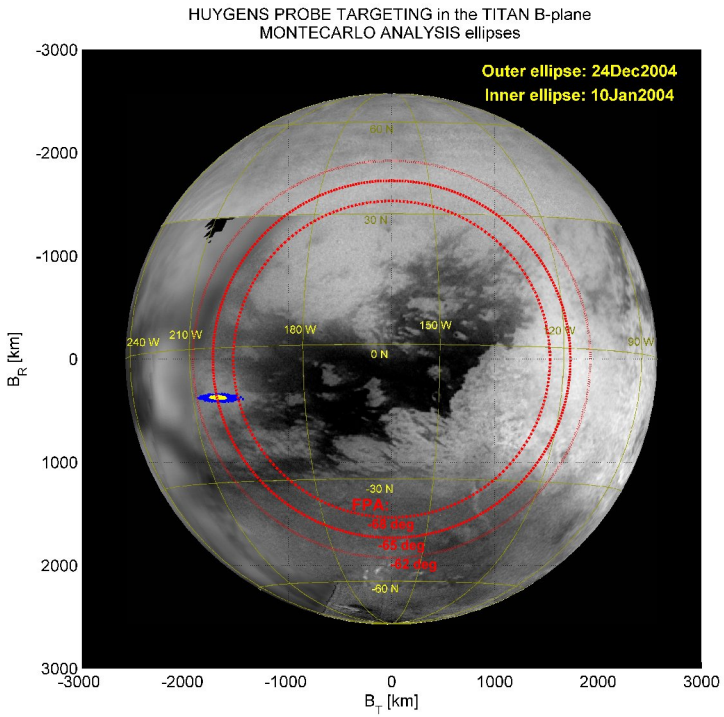
Huygens Mission scenario

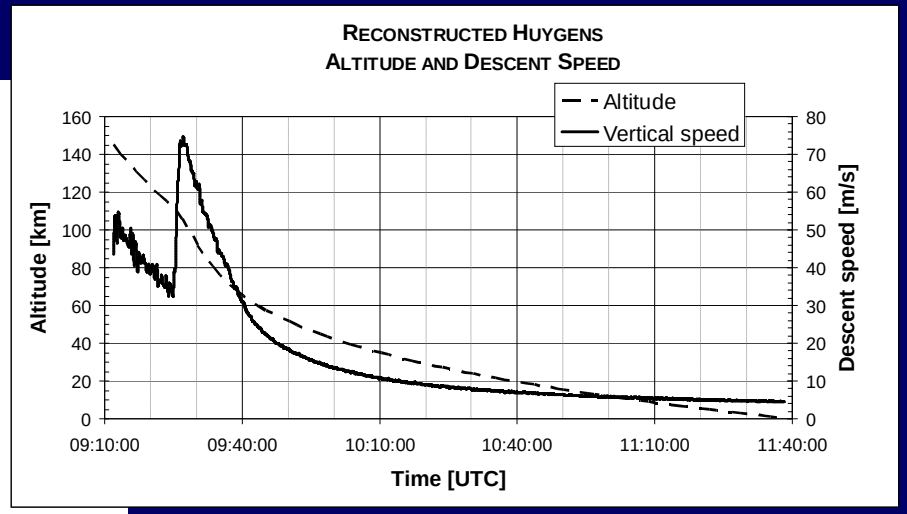


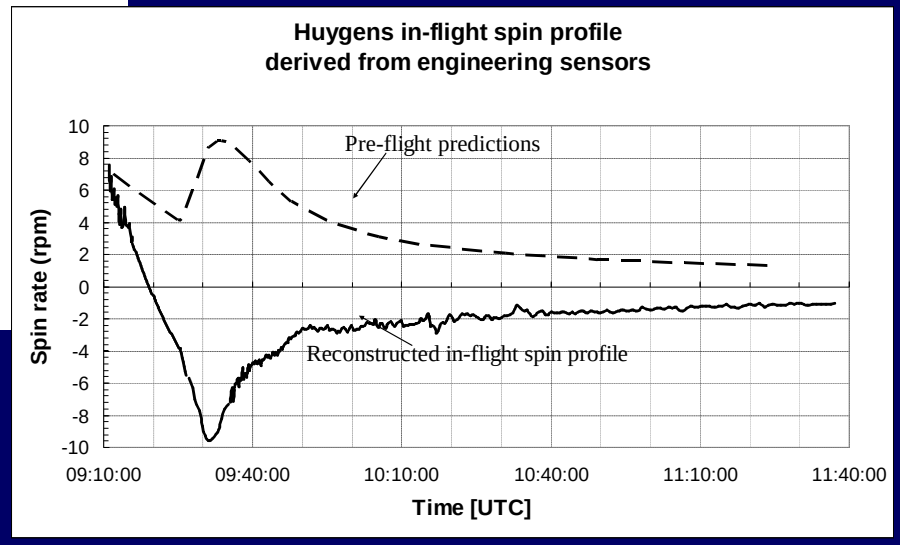
Data via Cassini: 2h28min (descent) and 1h12min (surface)
Signal via radio telescopes: 5h42min, including 3h14min on surface



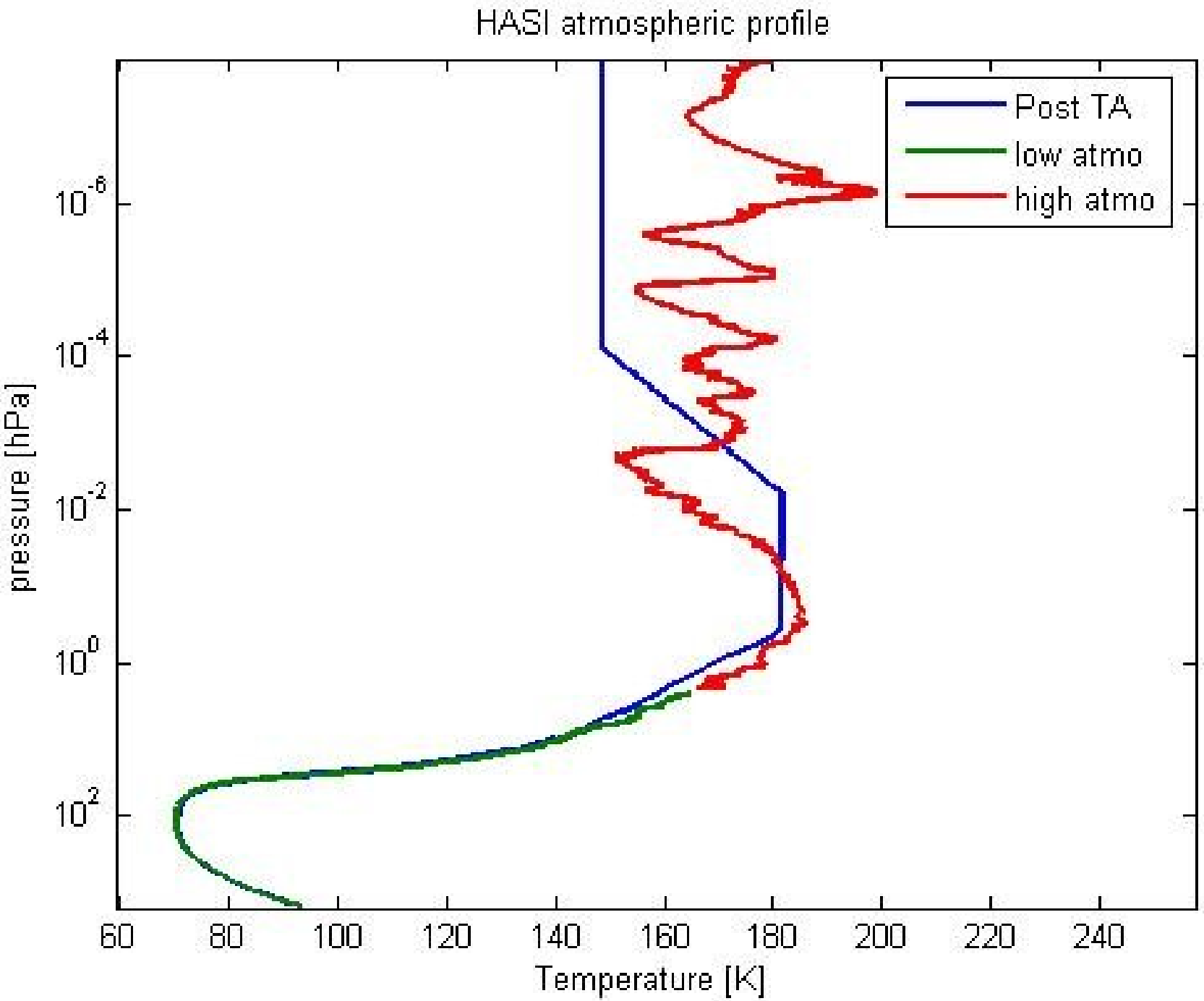
Entry and Descent Trajectory





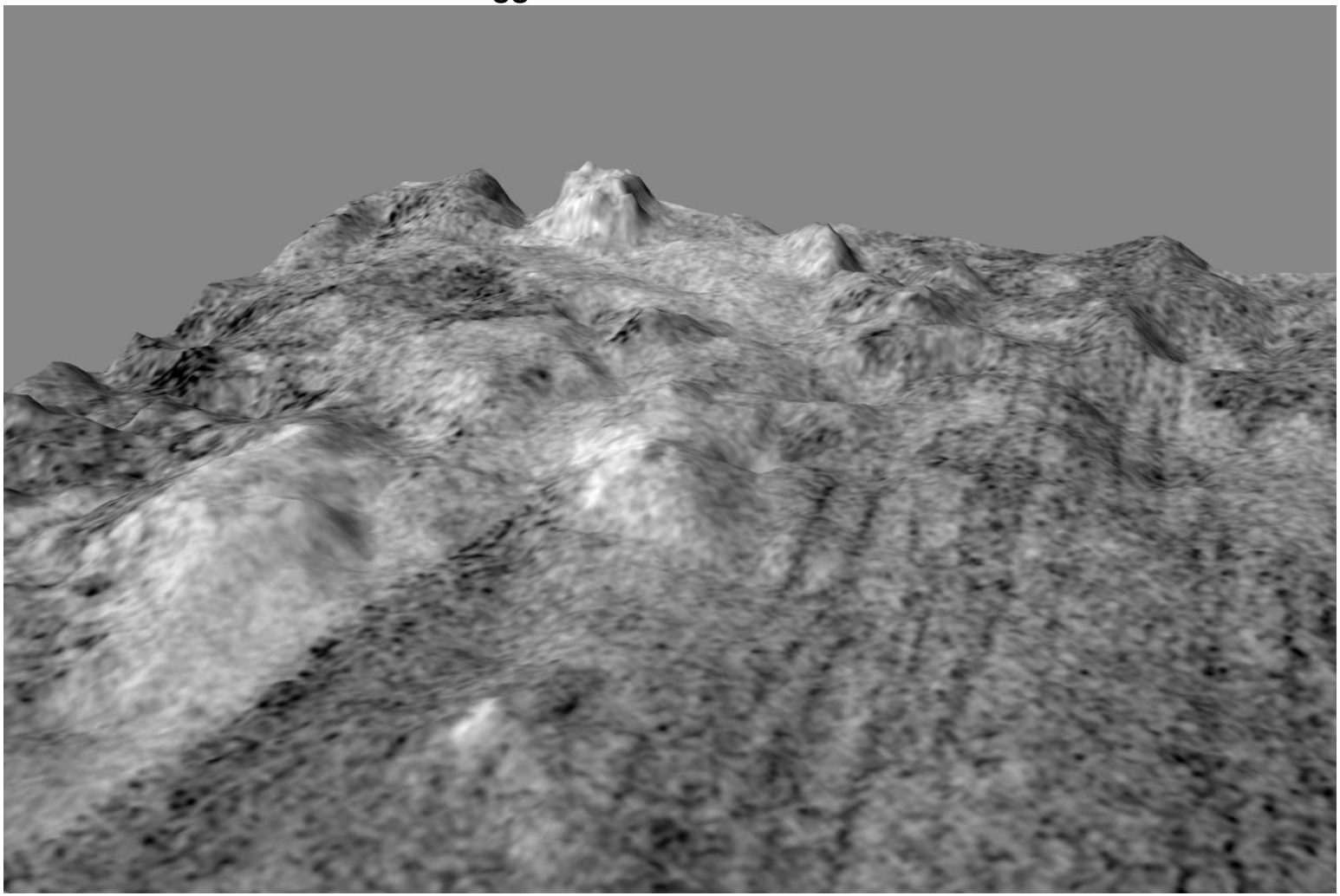


Landing site: 192.2º W; 10.25º S


HASI atmospheric profile
Post TA
low atmo
high atmo
pressure [hPa]
10^{-6}
10^{-4}
10^{-2}
10^{0}
10^{2}
60
80
100
120
140
160
180
200
220
240
Temperature [K]

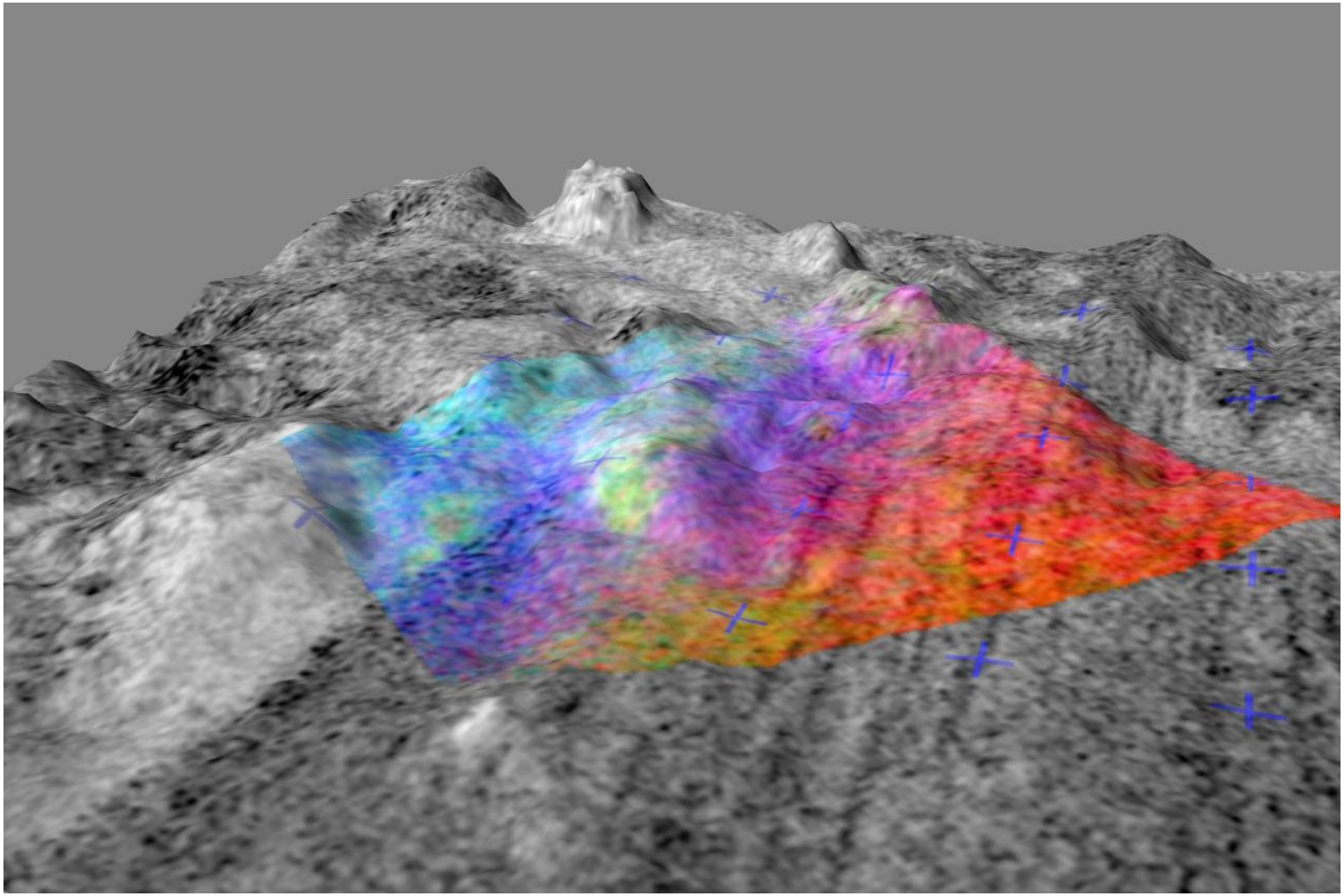
Huygens Site Perspective with RADAR

20x vertical exaggeration



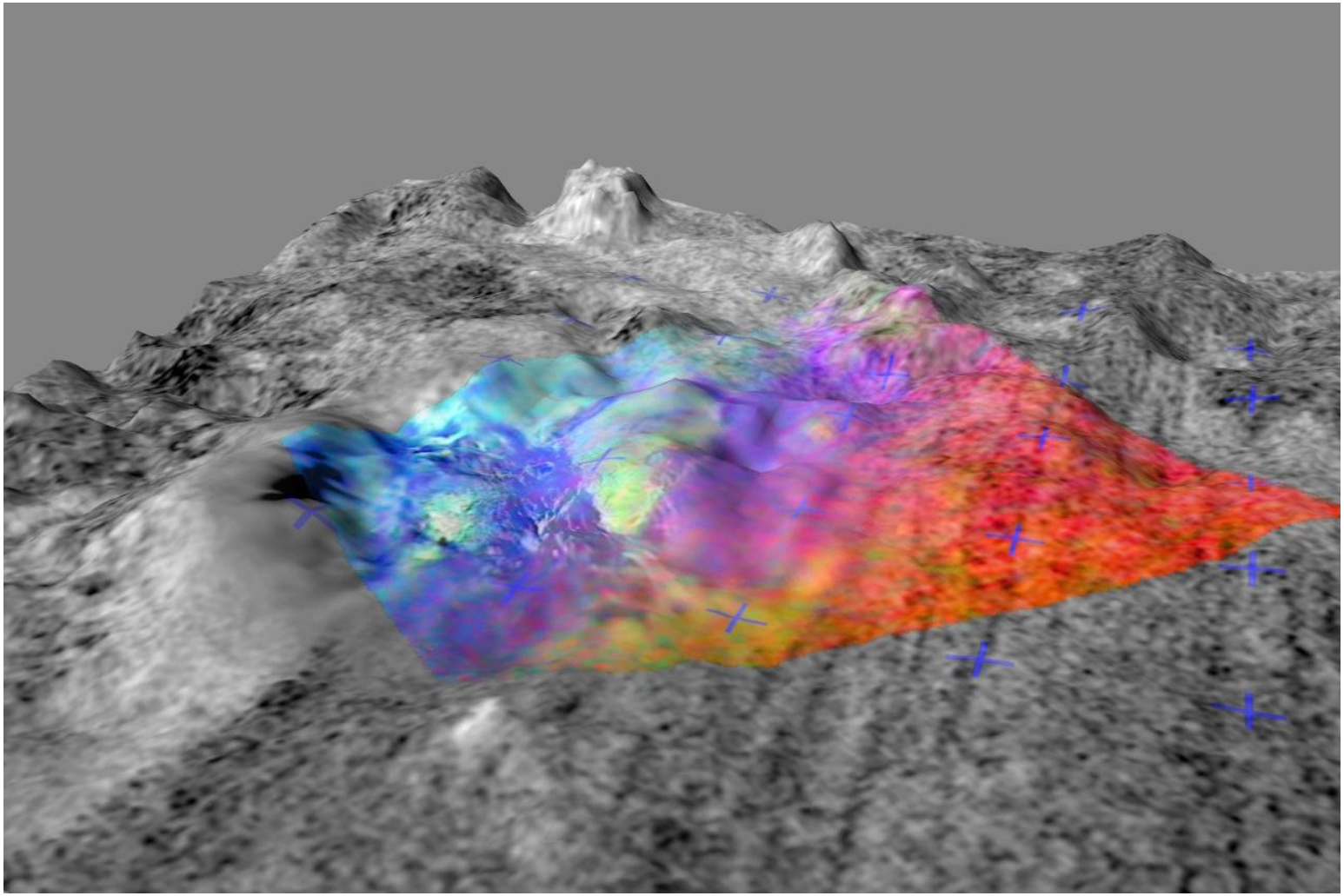
Huygens Site Perspective with RADAR+VIMS

Credit: C. Sotin, VIMS Team



Huygens Site Perspective with RADAR+VIMS+DISR

Credit: E. Karkoschka, DISR Team



The Present or near future

- Science Programme
  - Rosetta-Philae (comet nucleus lander, 2004-2014)
  - VEX aerobraking at Venus; under study, planned towards end of mission (2005- 2012 ?)
- D-HSF and D-TEC

EXPERT (European Experimental Re-entry Test Bed, see presentation F. Ratti et al., session 6A). 2011 ?

IXV (Interim Experimental Vehicle, Vega, 2012-2013 ?)

ATV reentry Capsule study

The Present or near future
(Robotic Mars Exploration Programme)

Exomars

The future (1)

- Science Cosmic Vision Programme

  Past studies:

  TSSM: Orbiter, Balloon and Landers (K. Rey, C. Erd, Session 2, R. Jaumann, session 3 b, A. Coustenis Session 1 poster)

  Current studies:

  EJSM: Ganymede penetrator; Europa Surface Element (EJSM presentation, Grasset et al., JGO penetrator study, S. Vijendran, session 7B)

The future (2)

- Science Cosmic Vision Programme
  - Technology preparation studies in preparation for planned call for (M)edium mission proposal this summer; proposal deadline 3 December (next slide)
  - Mars Robotic Exploration Preparation

    Technology developments (second next slide)

Technology preparation studies for future planetary probe missions

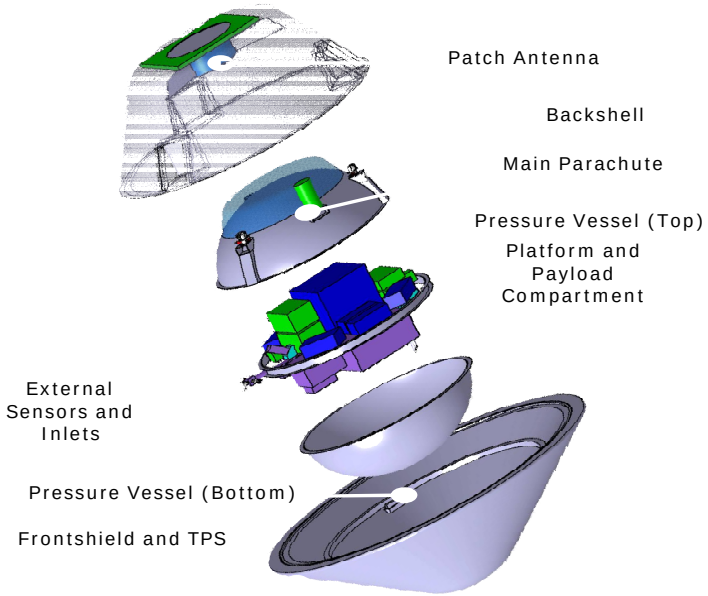
Studies done at ESA on: Earth re-entry, Mercury (MSE), Venus SR, Venus Balloon, Lunar Lander, various Mars probes (Netlander, Demo-lander, Sample return lander, inflatable ED-landers, penetrators, etc.), Jupiter entry probes, Titan probe, Titan balloon

New CDF Study on: Planetary Entry Probes(1): Venus Entry and Descent to surface, Saturn, Uranus and Neptune deep probes.

- Aim: understand atmospheric entry conditions at all solar system bodies and required technologies
- Focus: on ED(L)S part and probe design, TPS sizing, probe delivery conditions and data relay scenario

Property	Venus	Saturn	Uranus	Neptune
Orbital				
Distance to Sun	0.72 AU	9.54 AU	19.22 Au	30.06 AU
Axial Tilt	177.3 deg	26.73 deg	97.77 deg	28.32 deg
Entry Conditions				
Atmosphere Composition (Main Constituents)	CO_2, N_2	H_2, He, CH_4	H_2, He, CH_4	H_2, He, CH_4
Entry Flight Path Angle	-25 deg	-25 deg	Shallow (5-25 deg)	Shallow (5-25 deg)
Inertial Entry Velocity	~11.8 km/s	~36 km/s (expected)	~25 km/s (expected)	~25-28 km/s (expected)
Height of Entry Interface	200 km	700 km	513 km	~500 km
Peak Heat Flux	60 MW/m^2	70 MW/m^2	295 MW/m^2	68 MW/m^2
Heat Load	~220 MJ/m^2	~1100 MJ/m^2	390 MJ/m^2	375 MJ/m^2
Ballistic Coefficient	190 (iterating)	220 (iterating)	125	125
TPS Design	Front: Sepcore High Density Carbon-Phenolic Back: PICA-like	Front: Sepcore High Density Carbon-Phenolic Back: PICA-like	Front: Sepcore High Density Carbon-Phenolic Back: PICA-like	Front: Sepcore High Density Carbon-Phenolic Back: PICA-like

Entry Characteristics: work in progress some values subject to iterations



(1) See Planetary Entry Probes Poster session 1 (K. Geelen)

Technology preparation studies for future planetary probe missions

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Technology preparation studies for future planetary probe missions

Focus Mars: Mars Robotic Exploration Preparation (MREP)

- follow on to ExoMars 2016 Orbiter/DemoLander and 2018 Dual Rover (ExoMars/Max-C)
- in agreed collaboration with NASA

Studies on:

1) Mars Sample Return mission with (NASA) MSL like landing of Mars Ascent Vehicle.
Eventually complemented with precisions lander for delivery of sample fetching rover

⇨ Mars Precision lander (<10 km) industrial study will be conducted in 2010 / 11

⇨ Mars Sample Return Orbiter industrial study will be conducted in 2010 / 11

2) Alternative mission scenarios will be studies too:

⇨ Mars (deep) atmospheric sample return will be assessed by CDF in Aug-Sep 2010, potentially followed by industrial study

⇨ Deimos or Phobos sample return have study heritage (no further industrial study for the moment)

⇨ Netlander has extended study heritage (no further industrial study for the moment)

Ongoing dedicated technology Development(2) on:

1) MSR technology (Rendezvous, Planetary Protection, robust aerobraking,Earth re-entry capsule, GNC aspects, sampling, etc…)
2) Intermediate (alternative) missions like: NetLander technology (airbags, parachute, EDLS GNC optimisation, low temperature batteries, etc…)
3) Long term technology (e.g. nuclear power sources based on $Am_{241,}$, High thrust engine,…)

(2) See MREP Technology Preparation Poster session 1 (Sanjay Vijendran)

The future (3)

Robotic Lunar Exploration Programme

Objectives

esa human spaceflight

Programme Objective

PREPARATION FOR FUTURE HUMAN EXPLORATION

Lunar Lander Mission Objective

ENABLE SUSTAINABLE EXPLORATION

- **Soft Precision Landing with hazard avoidance**

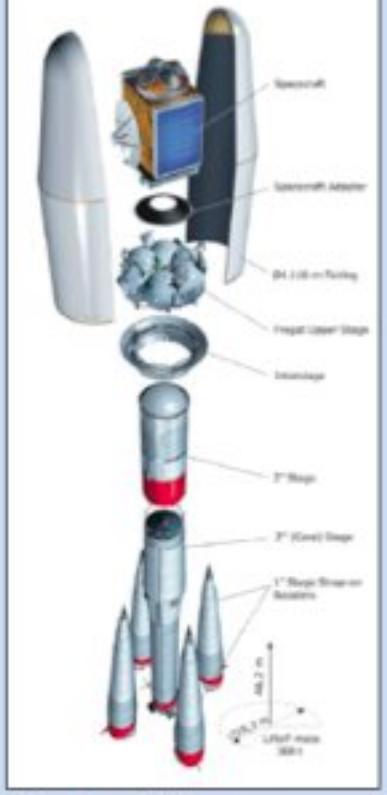
- **Crew health**
- **Habitation**
- **Resources**
- **Preparations for human activities**

Lunar Lander –Baseline & Status

esa human spaceflight

LAUNCHER

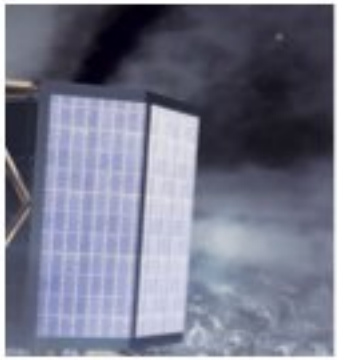
Soyuz



Courtesy of Arianespace

THERMAL

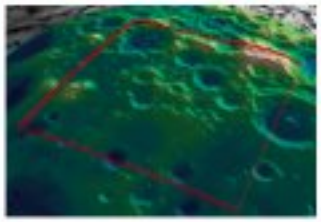
No RHUs



Reliant on Solar Power generation + conventional thermal control

LANDING SITE

South Polar



- **Phase B1 activities shall be initiated in July for a duration of 18months**

Conclusions

- Outlook for Planetary Probes and Landers look good within ESA's Programmes.
- Probes and Landers are well suited for (are enabling) international cooperation on planetary missions.
- Significant technology developments are required to get ready for the future.
- Exciting science opportunities offered by Probes and Landers at all planets and their moons. Except Titan, all other moons and Small Bodies require penetrators or retro-rockets for active descent control

Cassini VIMS: 1.6 – 5.O µm

2016 Mission Objectives

E X O M A R S

2016

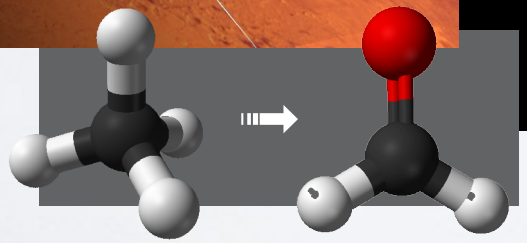
TECHNOLOGY OBJECTIVES

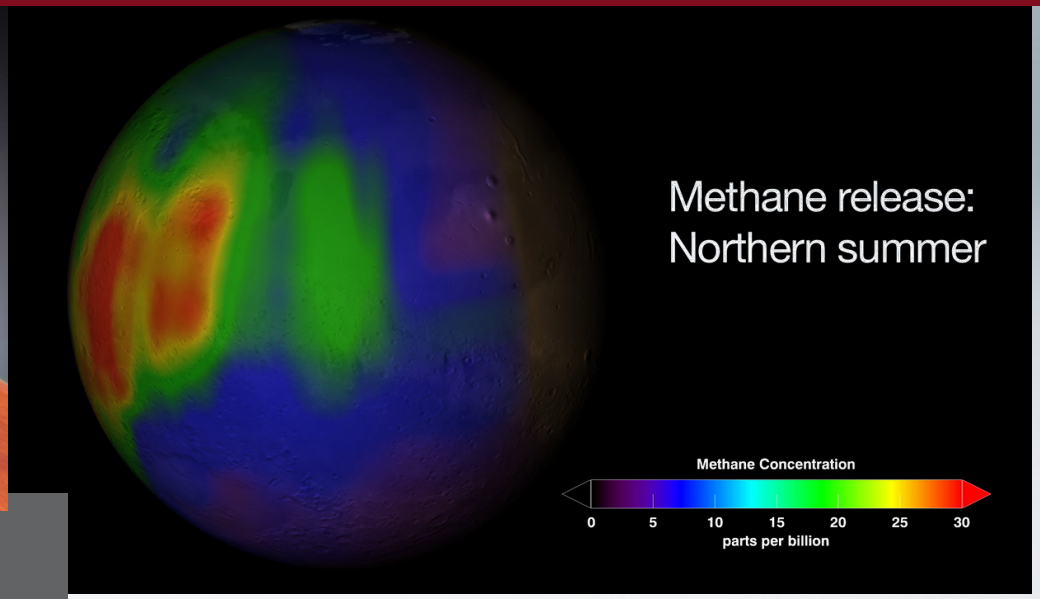
➟Entry, Descent, and Landing (EDL) of a payload on the surface of Mars;

➟Provide data relay services for all landed missions until 2022.

SCIENTIFIC OBJECTIVE

➟To study Martian atmospheric trace gases and their sources.





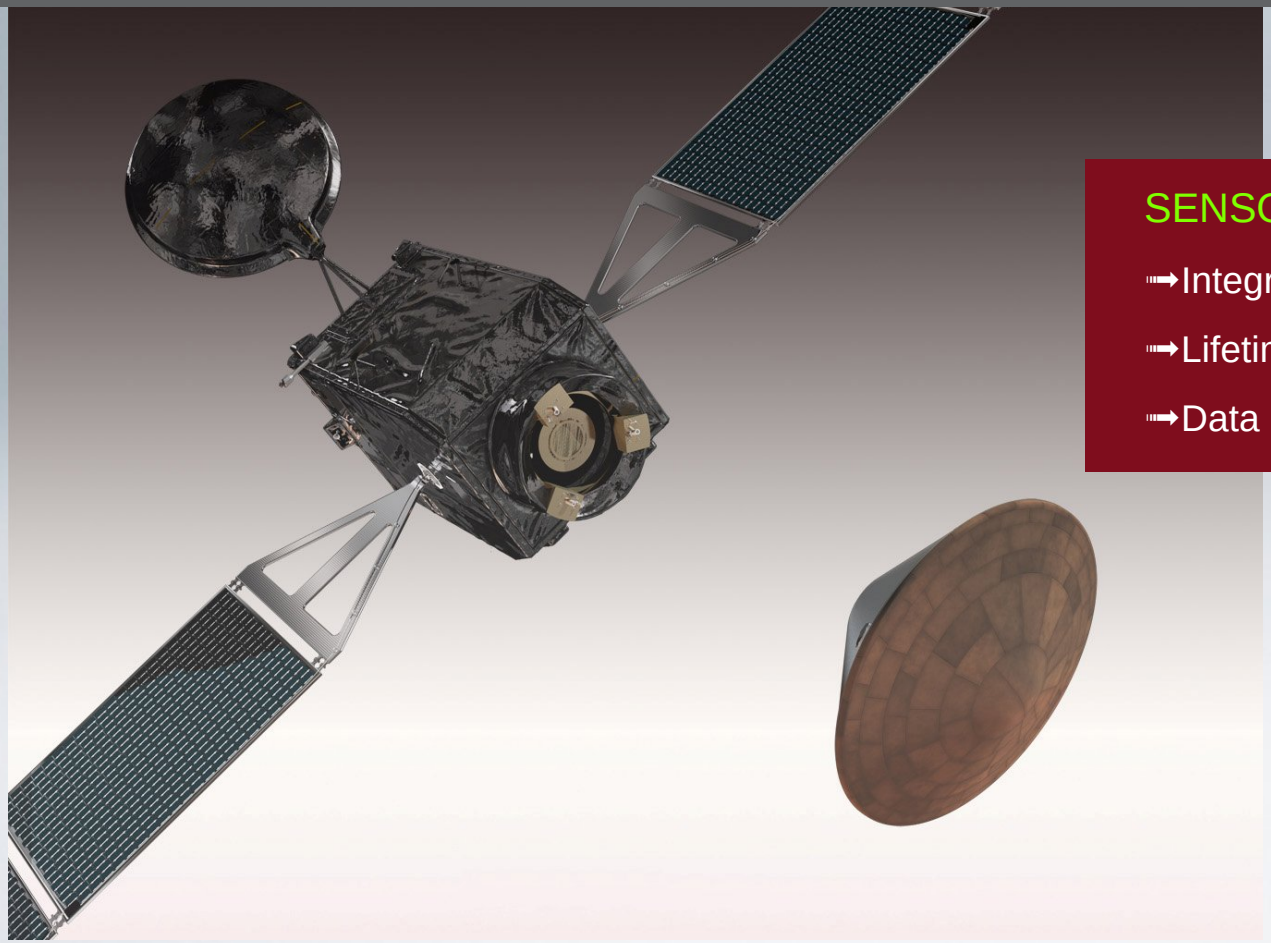
2016 Entry & Descent Module

EXOMARS

EDM

➟A European technology demonstrator for landing medium-large payloads on Mars;

➟Provides a limited, but nevertheless useful, means to conduct measurements during the dust storm season.



SENSOR SUITE

➟Integrated payload mass estimate: 3 kg;

➟Lifetime: 8 sols;

➟Data : 2 passes of 50 Mbits each.

2018 Mission Objectives

E X O M A R S

2018

TECHNOLOGY OBJECTIVES

➟Surface mobility with a rover (having several kilometres range);

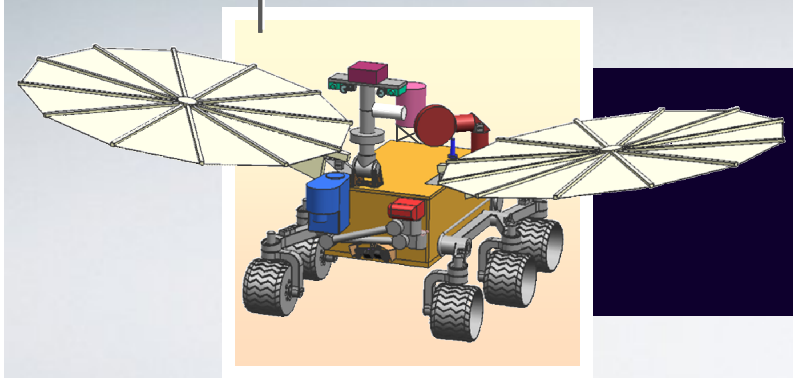
➟Access to the subsurface to acquire samples (with a drill, down to 2-m depth);

➟Sample acquisition, preparation, distribution, and analysis.

SCIENTIFIC OBJECTIVES

➟To search for signs of past and present life on Mars;

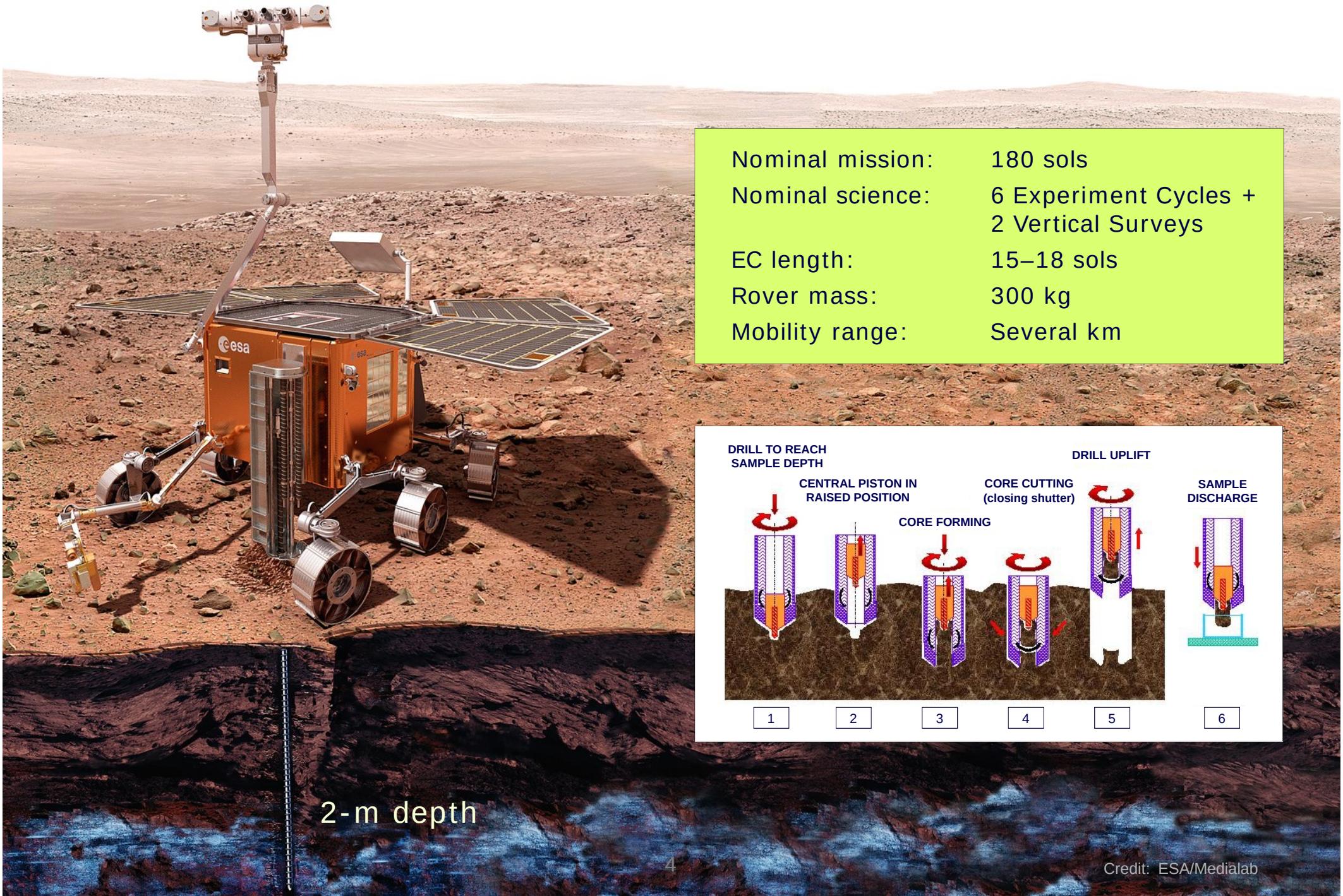
➟To characterise the water/subsurface environment as a function of depth in the shallow subsurface.



SCIENTIFIC OBJECTIVES

➟To identify, acquire, document, and cache “outstanding” samples in a manner suitable for collection by a future Mars Sample Return Mission.

Mobility + Subsurface Access



Nominal mission:	180 sols
Nominal science:	6 Experiment Cycles + 2 Vertical Surveys
EC length:	15–18 sols
Rover mass:	300 kg
Mobility range:	Several km

Credit: ESA/Medialab

Science Exploration Scenario

Determine the rover's geological context:

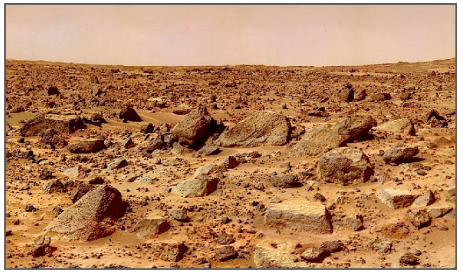
- Survey site at large scales — **Panoramic Instruments**
- Examine surface outcrops and soils at sub-mm scales — **Close-Up Instruments**

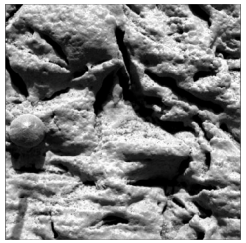
Collect a subsurface (or surface) sample

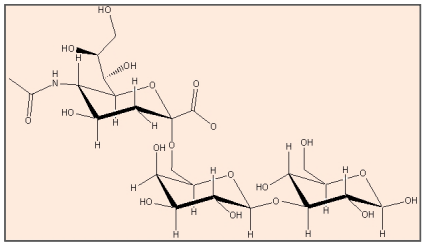
Study sample:

- Survey analysis
- Detailed analysis

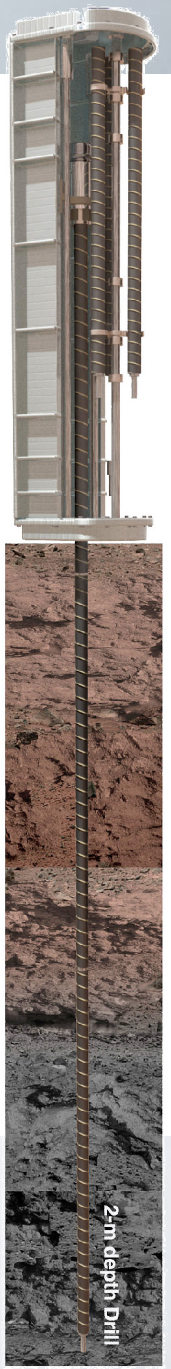
Analytical Laboratory





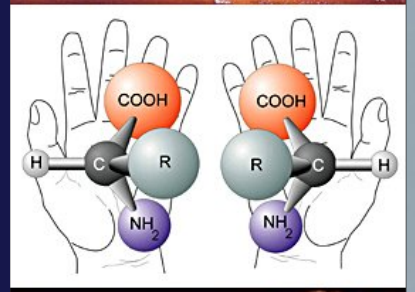


Scale



Science Objectives (expanded)

ExoMars Rover: Search for signs of life;

Establish the scientific importance of subsurface sampling 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 biomarkers vary with depth ?
- Study any geochemical variations in the geological record with depth.
- Progressively learn from the surface, radar, subsurface sample study cycle to inform the selection of drilling sites.