ESA/Russia cooperation on ExoMars
Сотрудничество ESA / России на ExoMars

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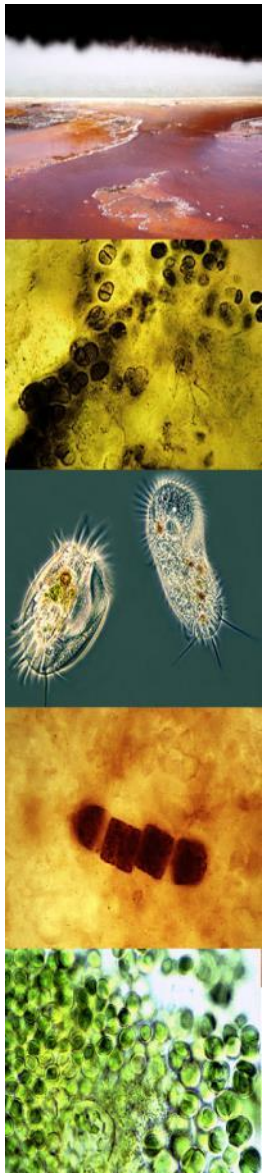
ESA ExoMars Project

Moscow - IKI
19 October 2016

Programme Objectives
Цели программы (1/2)

- **Technology Demonstration Objectives / Цели демонстрации технологии**
  1. Entry, Descent, and Landing (EDL) of a payload on the surface of Mars (2016 & 2020)
  2. Surface mobility with a Rover (2020)
  3. Access to the Mars subsurface to acquire samples (2020)
  4. Sample acquisition, preparation, distribution and analysis (2020)
  5. Qualification of Russian ground-based means for deep-space communication in cooperation with ESA's ESTRACK (2020)
  6. Development and qualification of Russian throttleable braking engines for prospective planetary landing missions (2020)

Programme Objectives
Цели программы (2/2)



❑ Scientific Objectives / Научные цели

1. Search for signs of past and present life on Mars (2020)
2. Investigate water/geochemical environment as a function of depth in the shallow subsurface (2020)
3. Investigate Martian atmospheric trace gases and their sources (2016 and 2020)
4. Characterise Mars surface environment (2016 and 2020)

❑ Programmatic Objective / Программный цель

1. Support Mars proximity communications of international surface assets until end 2022 (2016)

Programme Overview

Two missions with launches in 2016 and 2020

- The 2016 mission consists of a Trace Gas Orbiter (TGO) and an EDL Demonstrator Module (EDM)
- The 2020 mission consists of a Carrier Module (CM) and a Descent Module (DM) with a Rover and a stationary Surface Platform
- Large-scale International ESA-Roscosmos Cooperation with some contributions from NASA

Обзор программы

Две миссии с запуском в 2016 и 2020 гг.

- Миссия 2016 г. включает в себя Орбитальный аппарат (TGO) и модуль для демонстрации входа в атмосферу, спуска и посадки
- Миссия 2020 г. включает перелетный модуль и десантный модуль с размещаемым внутри него марсоходом и стационарной посадочной платформой
- Проект реализуется в рамках масштабной международной кооперации Роскосмос-ЕКА, некоторый вклад предоставляется НАСА

2016 Mission
Миссия 2016 г.

Proton M
Протон-М

Trace Gas Orbiter (TGO)
Орбитальный аппарат

Schiaparelli
EDL Demonstrator Module (EDM)
Демонстрационный десантный модуль
Скиапарелли

ESA ESTRACK
Станции ЕКА

NASA DSN
Станции НАСА

ROS Antennas
Станции Роскосмоса

MOCC @ ESOC Spacecraft Operations
ЦУП в ESOC

Science Operations Centre ESAC
ННК в ESAC

Science Archive Back-up Centre IKI
ННК (архив) ИКИ РАН

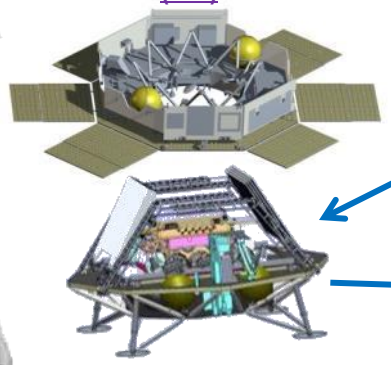
2020 Mission
Миссия 2020 г.

Proton M
Протон-М

Use

Carrier Module (CM)
Перелетный модуль (ПМ)

Descent Module (DM)
Десантный Модуль (ДМ)



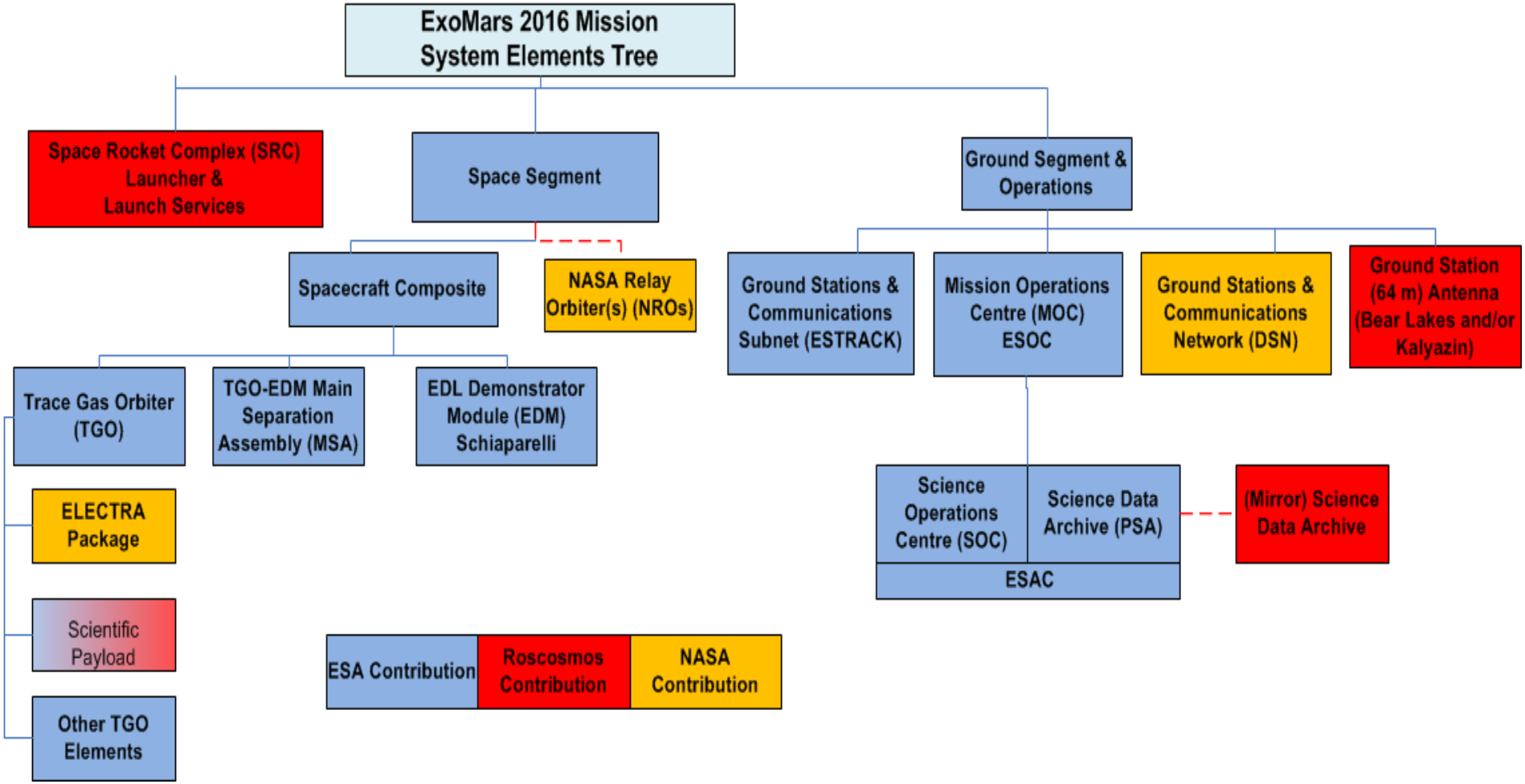
Landing Platform
Посад. платформа (ПП)

Rover
Марсоход (МХ)

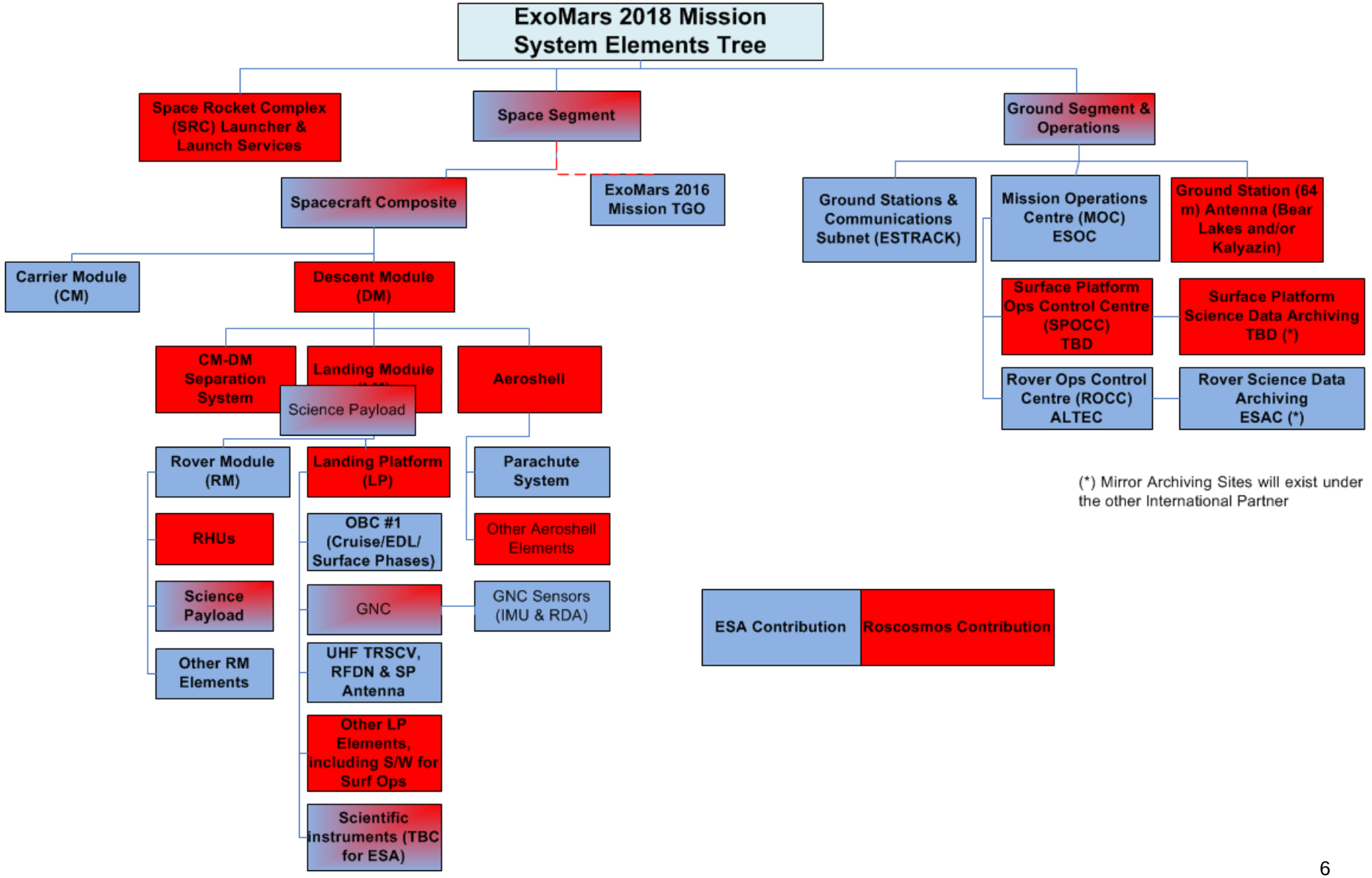
LPOCC
ЦУП ПП

ROCC
ЦУП МХ

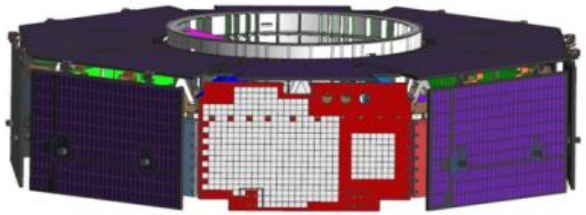
2016 Mission System Elements Tree



2020 Mission System Elements Tree

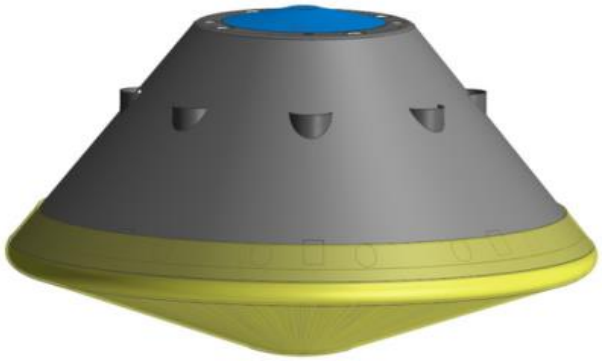


EXM 2020 S/C Composite configuration



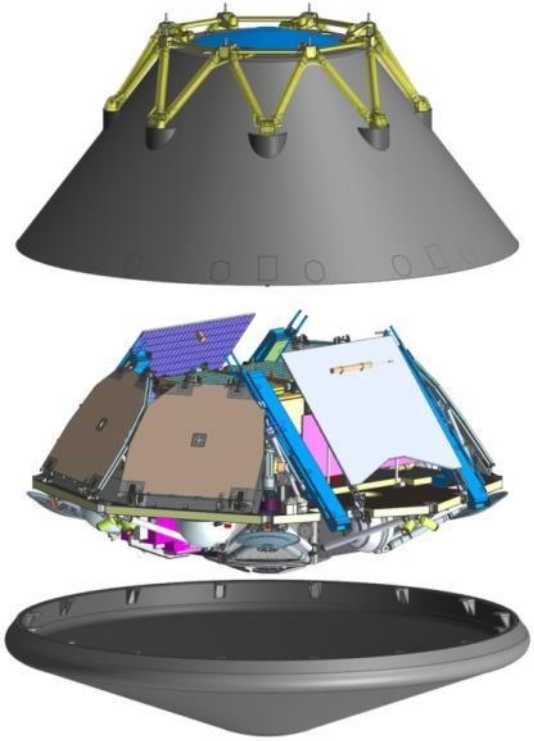
Carrier Module (ESA)

Separation system (Roscosmos)



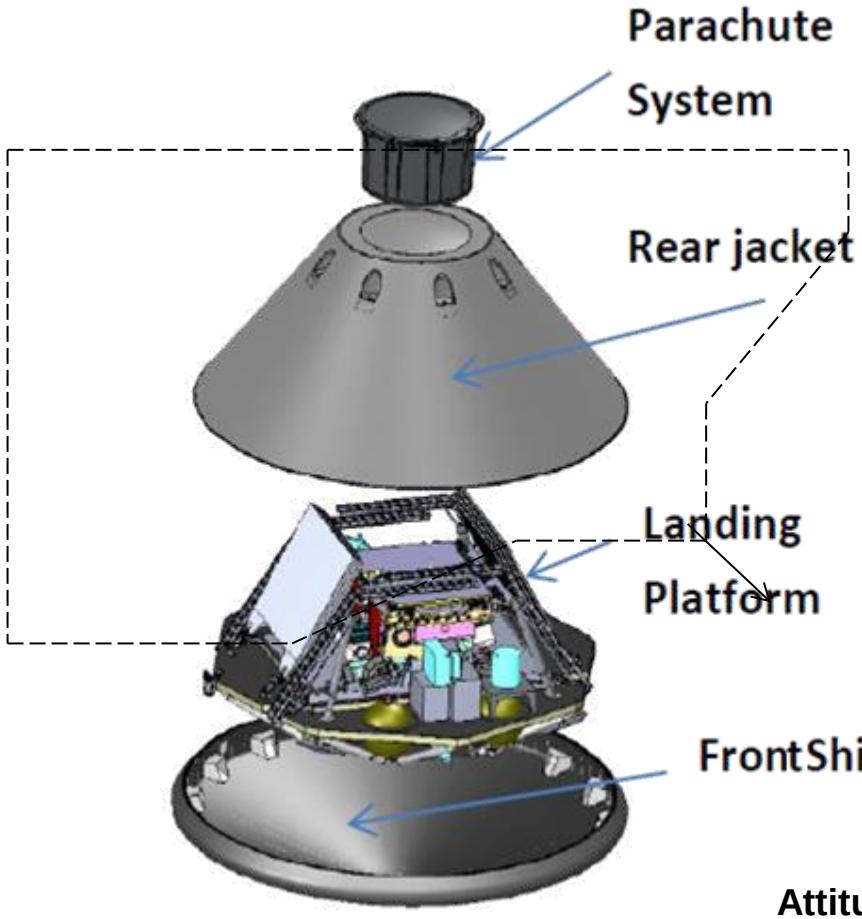
Descent Module (Roscosmos with ESA equipment)

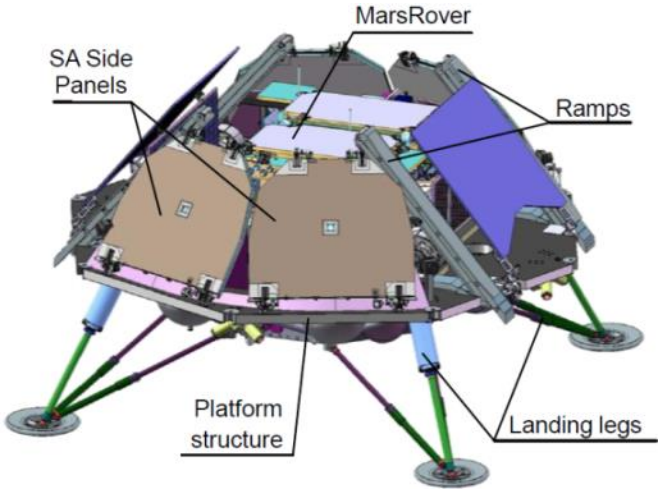
Spacecraft Composite

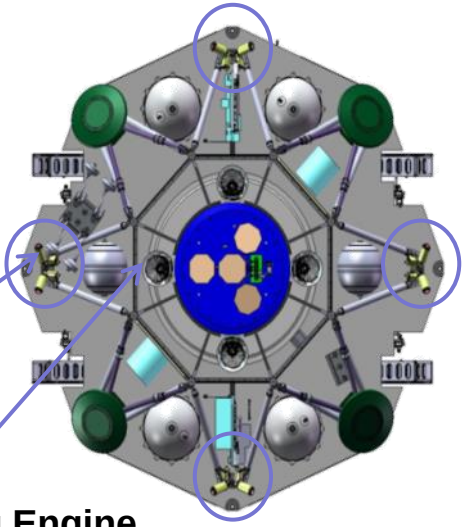


Descent Module including Rover Module (ESA)

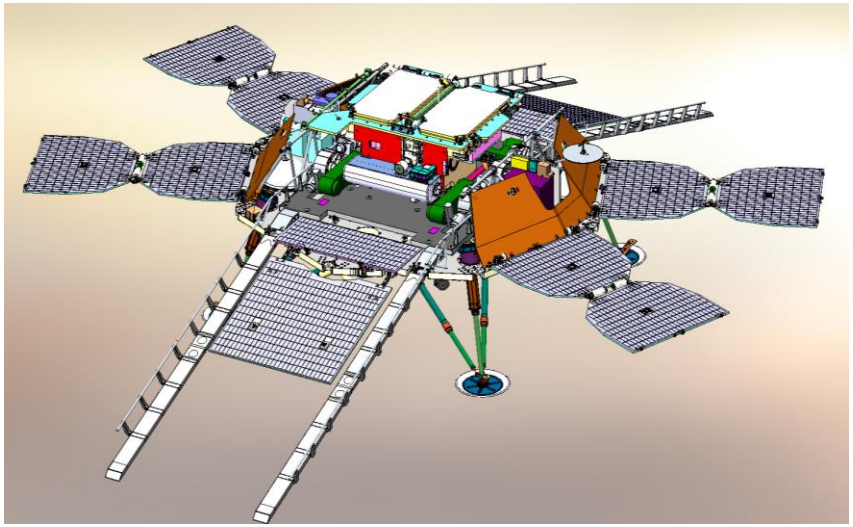
2020 Descent Module Overview

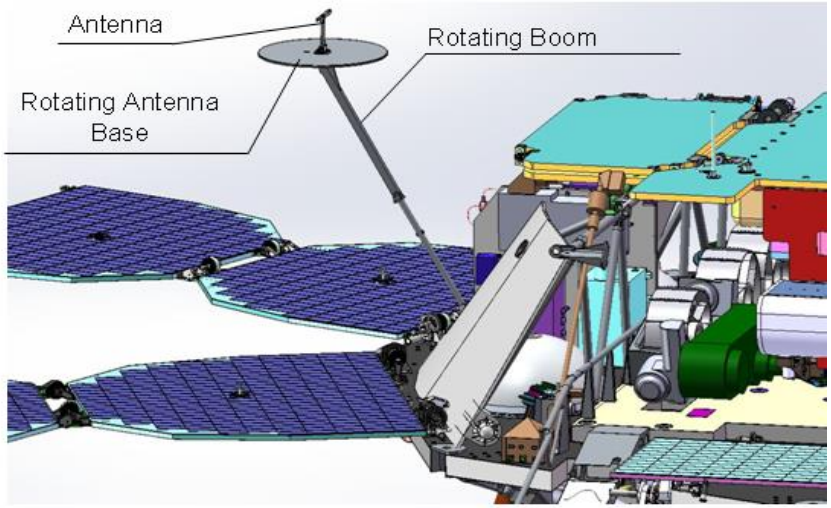


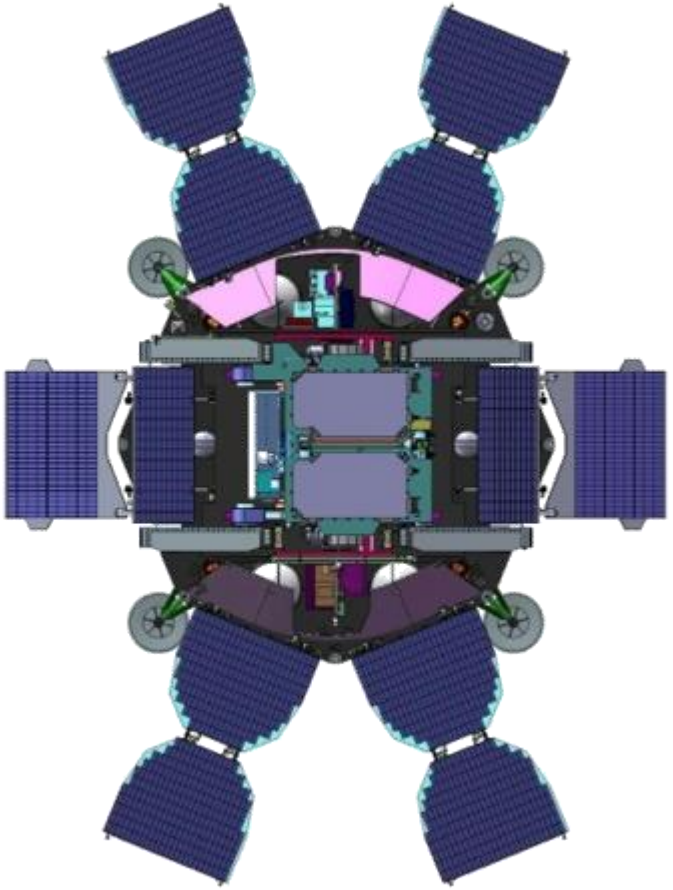




Surface Platform after landing







ExoMars Rover

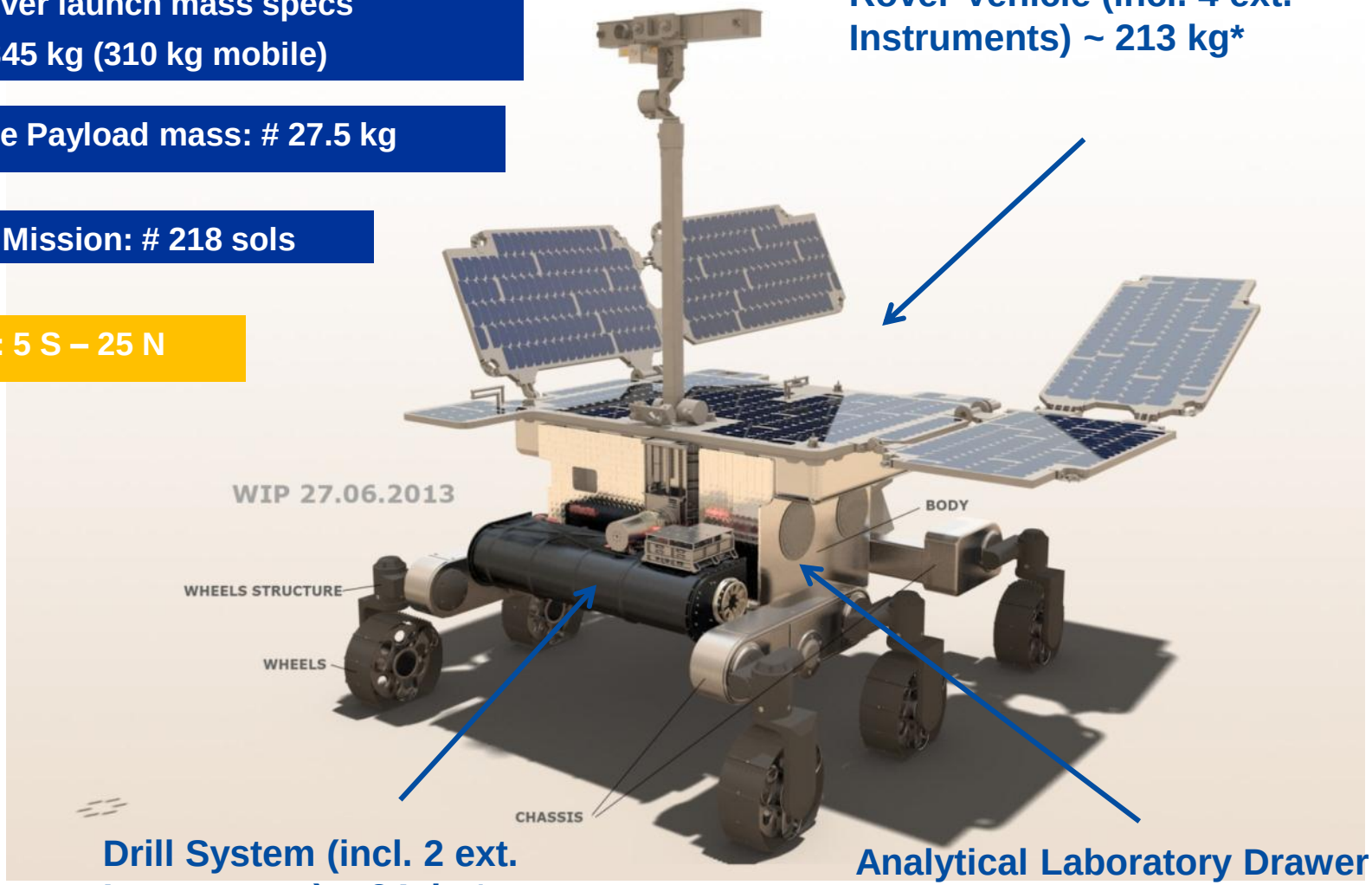
Rover launch mass specs
345 kg (310 kg mobile)

Science Payload mass: # 27.5 kg

Nominal Mission: # 218 sols

Latitude: 5 S – 25 N

Rover Vehicle (incl. 4 ext. Instruments) ~ 213 kg*



Drill System (incl. 2 ext. Instruments) ~ 24 kg*

Analytical Laboratory Drawer (incl. 3 Instruments) ~ 60 kg*

(*) Predicted Mass

2020 Mission Programmatic Status

- **Phase C/D development underway / Развитие Фаза C/D в стадии реализации**

  - ESA / Industry negotiations completed for a July 2020 launch / ESA / Промышленность переговоры завершены к запуску июля 2020
  - ESA Council of Ministers meeting 1-2 December for final approval of programme / Совет Министров ЕКА заседания 1-2 декабря для окончательного утверждения программы.
  - Joint Key Point Review of the 2020 mission underway with European and Russian partners / Совместный обзор ключевых точек 2020 миссии в стадии реализации с европейскими и российскими партнерами.
  - European Hardware deliveries started / Европейские HW поставки начали.

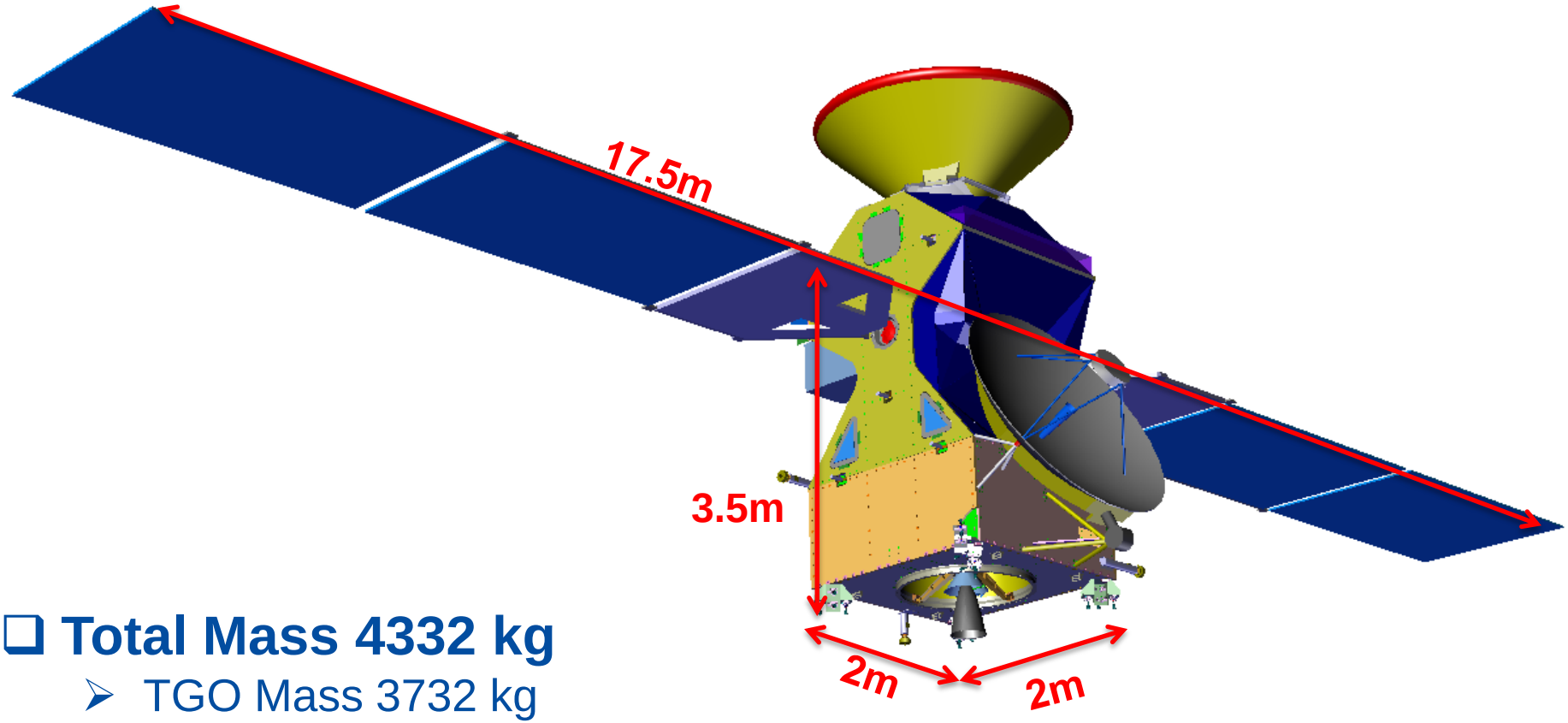
2016 Mission

Trace Gas Orbiter

&

Schiaparelli

2016 Mission – SCC Overview



- **Total Mass 4332 kg**
  - TGO Mass 3732 kg
  - EDM Mass 600 kg

2016 TGO (1/2)

TGO integrated (HGA view)

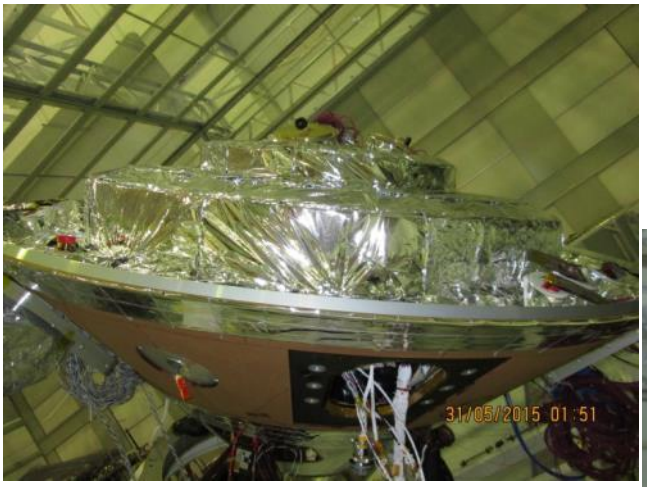
TGO integrated (Instrument's Deck view)

2016 TGO (2/2)

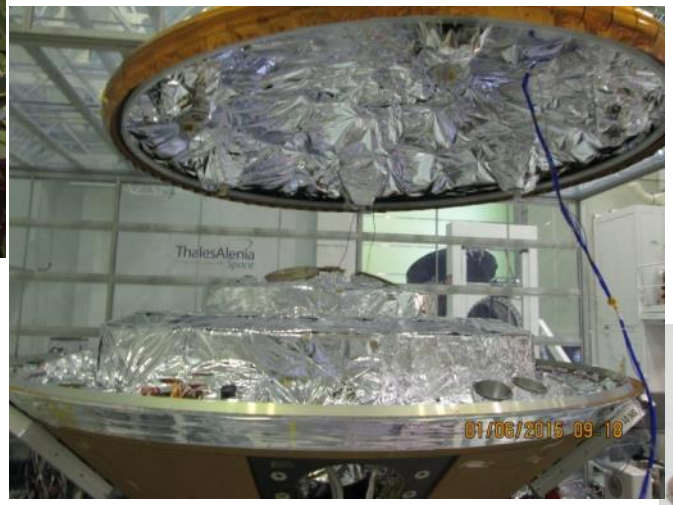
TGO with Solar Arrays deployed

2016 EDM – FM Front and Back Shield

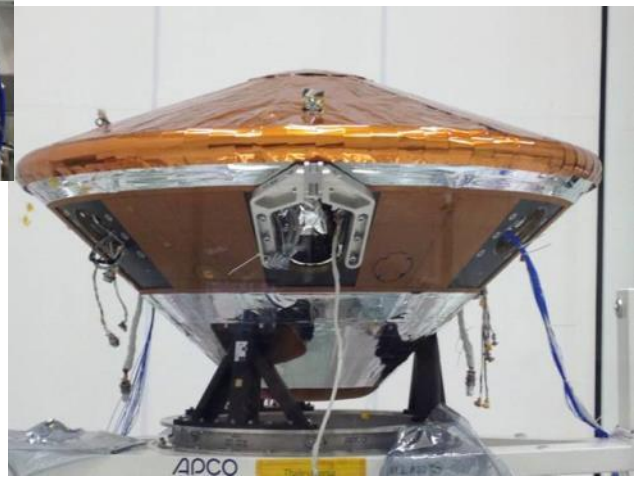
2016 EDM – PFM Integration Steps



EDM Surface Platform Integrated with Backshell



Mating of Front Shield to Back Shield



EDM PFM integrated

2016 TGO Science Instruments

NOMAD

High-resolution occultation and nadir spectrometers

Atmospheric composition (CH_4, O_3, trace species, isotopes) dust, clouds, P&T profiles

UVIS (0.20 – 0.65 μm) λ/Δλ ~250	SO	Limb	Nadir
IR (2.3 – 3.8 μm) λ/Δλ ~10,000	SO	Limb	Nadir
IR (2.3 – 4.3 μm) λ/Δλ ~20,000	SO		

CaSSIS

High-resolution, stereo camera

Mapping of sources Landing site selection

ACS

Suite of 3 high-resolution spectrometers

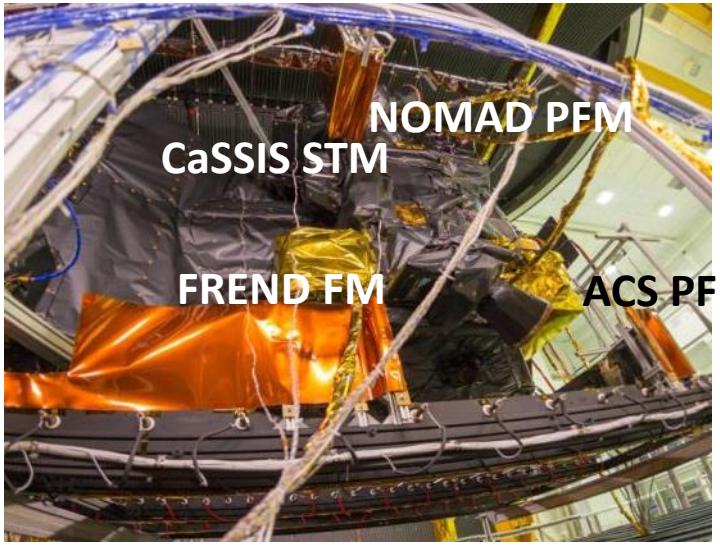
Atmospheric chemistry, aerosols, surface T, structure

Near IR (0.7 – 1.7 μm) λ/Δλ ~20,000	SO	Limb	Nadir
IR (Fourier, 2 – 25 μm) λ/Δλ ~4000 (SO)/500 (N)	SO		Nadir
Mid IR (2.2 – 4.5 μm) λ/Δλ ~50,000	SO		

FREND

Collimated neutron detector

Mapping of subsurface water And hydrated minerals

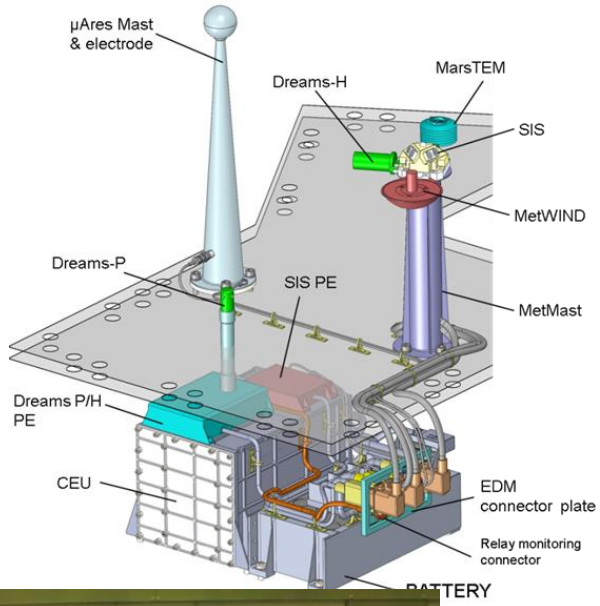


TGO Instruments onto S/C in TV Chamber

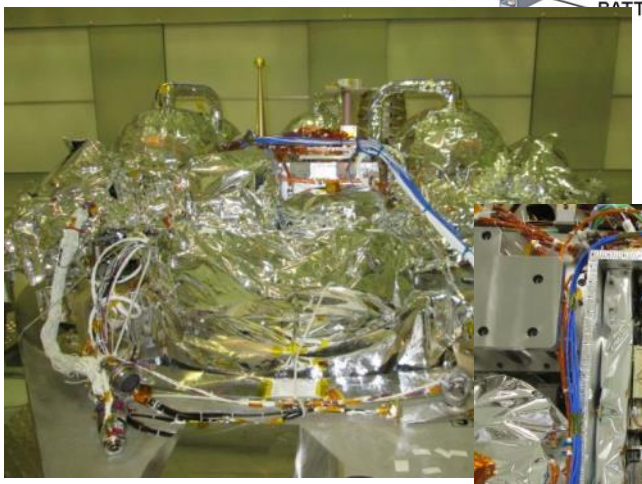
CaSSIS FM telescope

2016 EDM Science Measurements

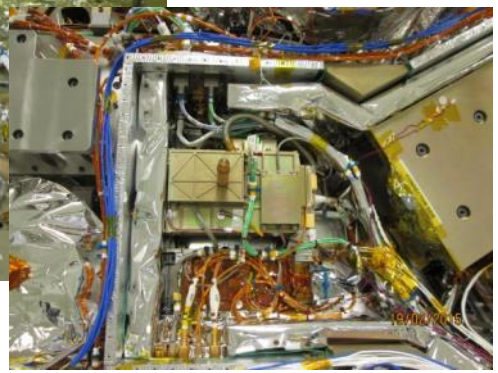
- **Improve our knowledge of Mars atmosphere with in-situ observations (Entry-Descent-Landing phase)**
  - **AMELIA experiment**



- **Improve our knowledge of Mars environment at times of high dust loading (Surface Operations phase)**
  - **DREAMS experiment**



DREAMS FM in the (still open) EDM Central Bay



2020 Mission

Rover and Surface Platform

2020 Mission – SCC Overview

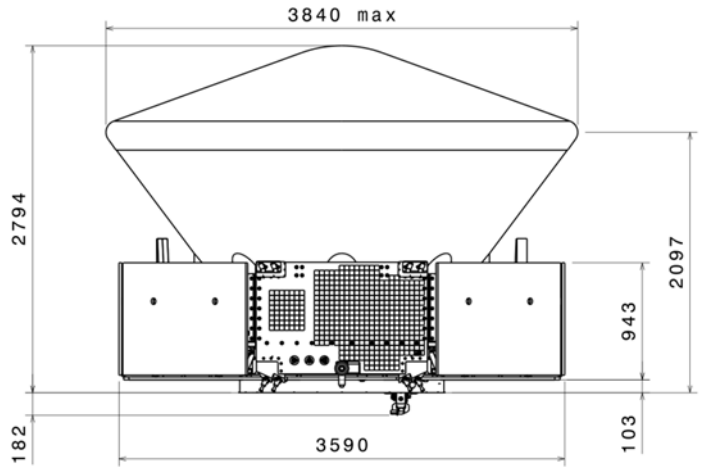
Total Mass: 2900 kg

CM Mass: 900 kg NTE [1]

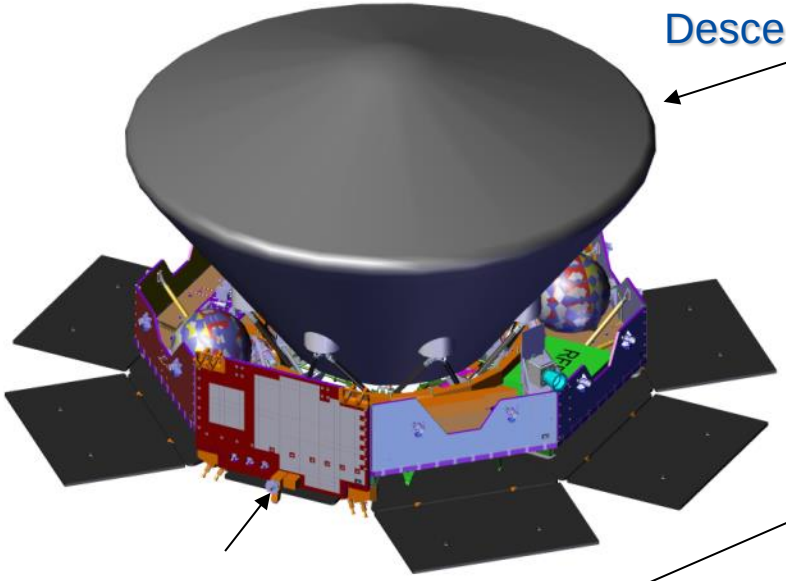
DM Mass: 2000 kg NTE [2]

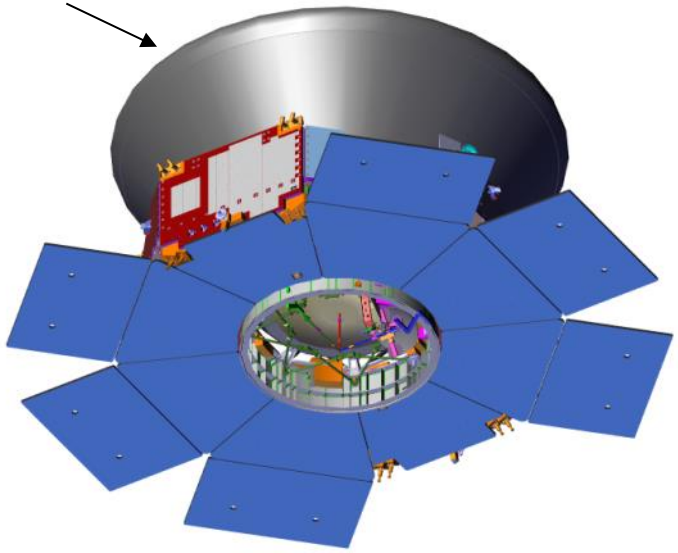
[1] includes CM consumables and CM-DM Separation Mechanism (parts left on CM)

[2] includes CM-DM Separation Mechanism (parts left on DM), DM consumables, Rover and Surface Platform Science Instruments



Descent Module – DM

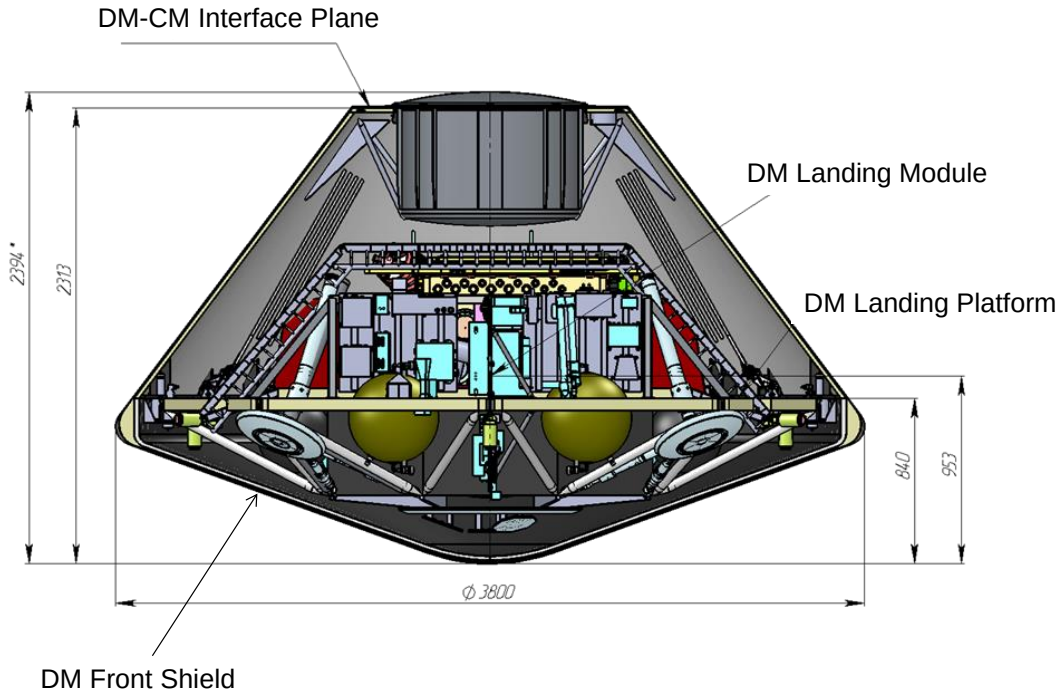




Carrier Module – CM with deployed Solar Arrays

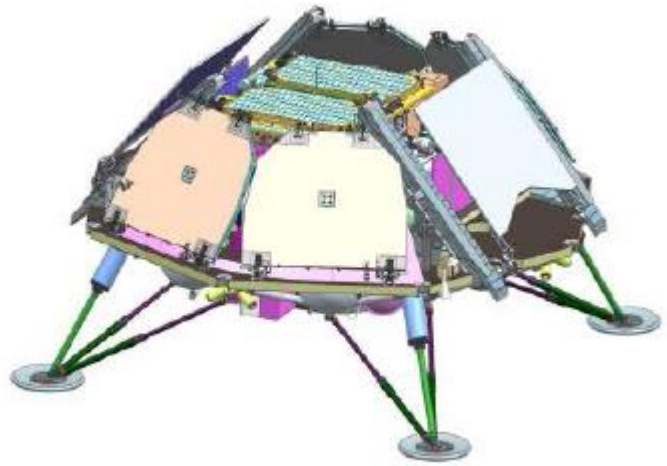
2020 Descent Module Overview

- Interfaces to CM via CM-DM Separation Mechanism
- Accommodates, and distributes power to RM
- Performs EDL and soft landing
- Communications with orbital assets during EDL via rear jacket antenna

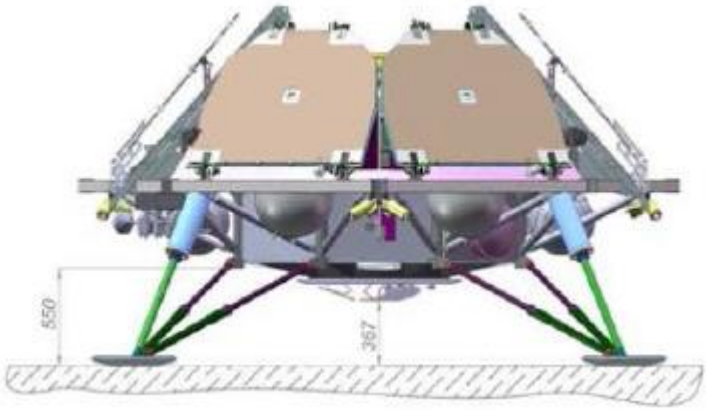


- Total mass 2000 kg NTE
- 1850 kg dry mass
  - 345 kg RM NTE
  - 45 kg science payload NTE
- 150 kg fuel

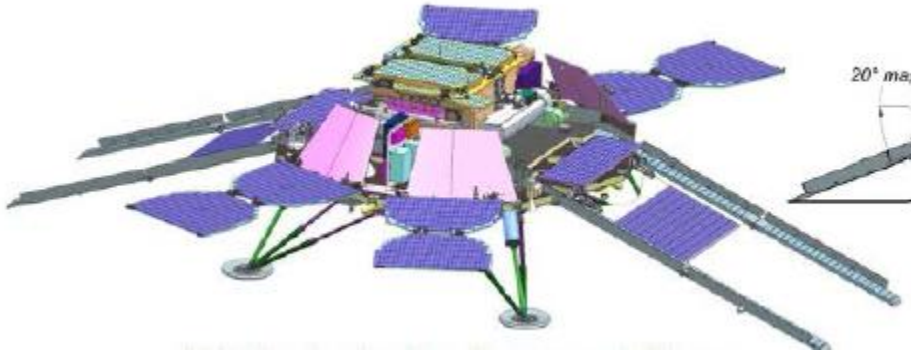
2020 Surface Platform Overview



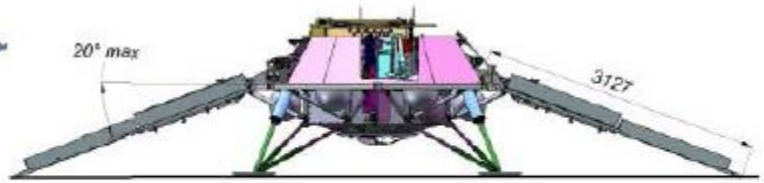
SP in pre-landing configuration after release of front shield



SP at the moment of touchdown



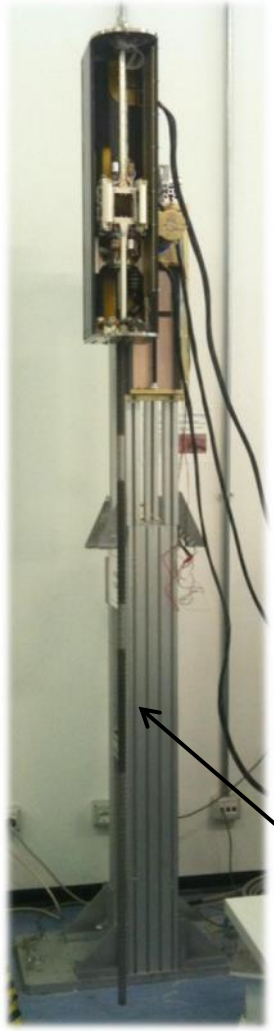
SP after landing, ramps and solar arrays are deployed

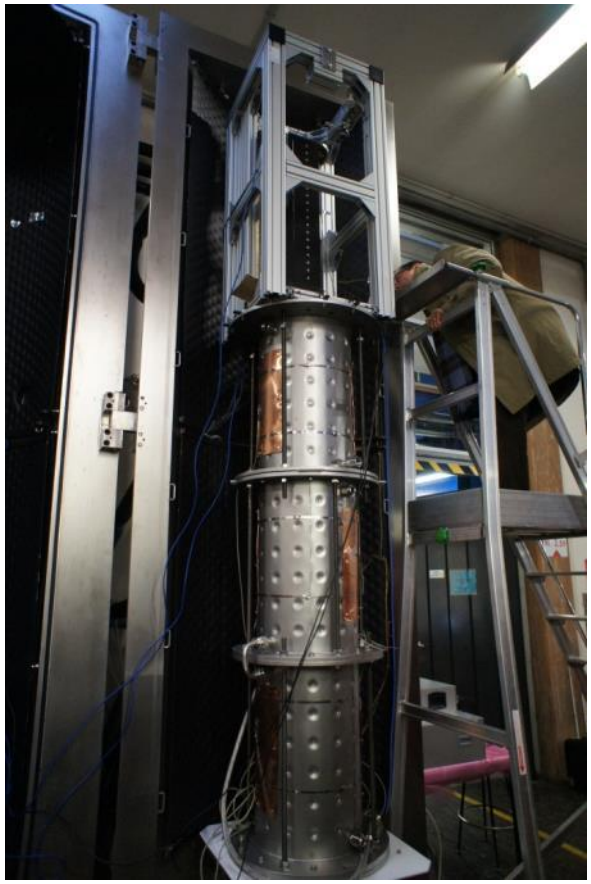


Ramp's inclination

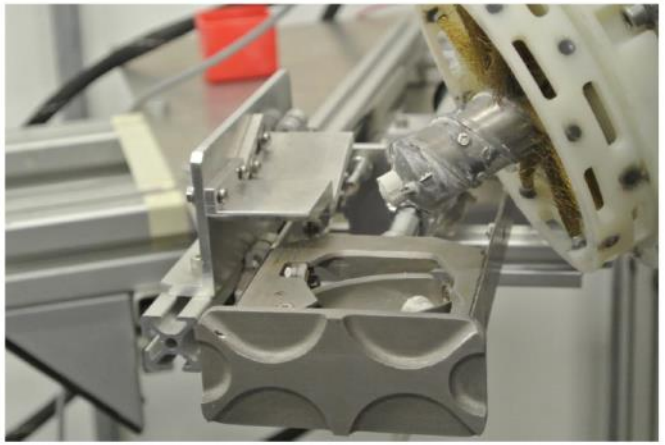
2020 Rover Drill

- EQM fully functional during tests in Mars representative environment and materials





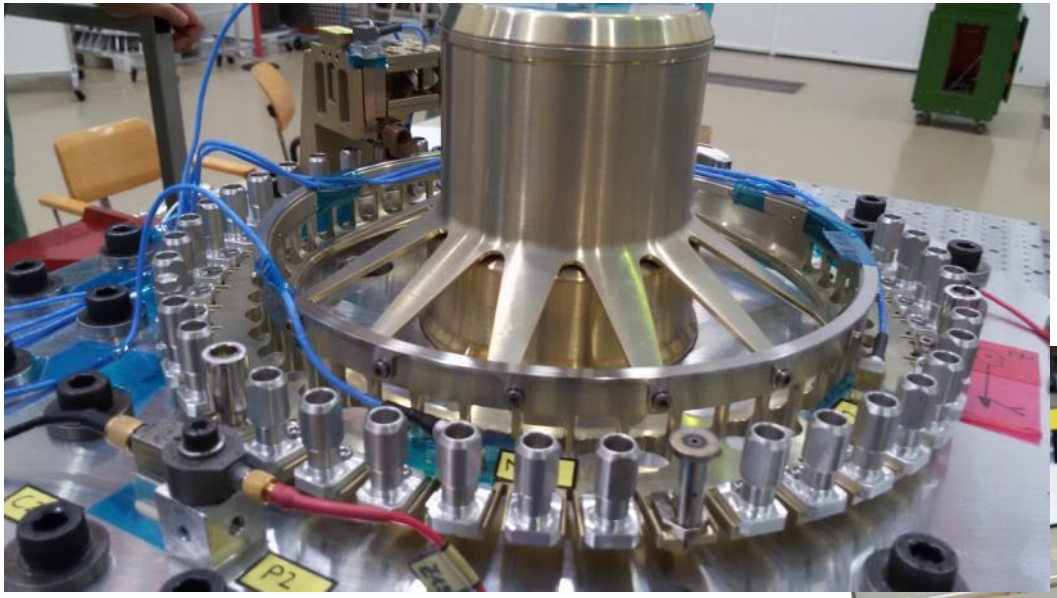
Drill pre-EQM
Drill tool + 3 Extension rods deployed



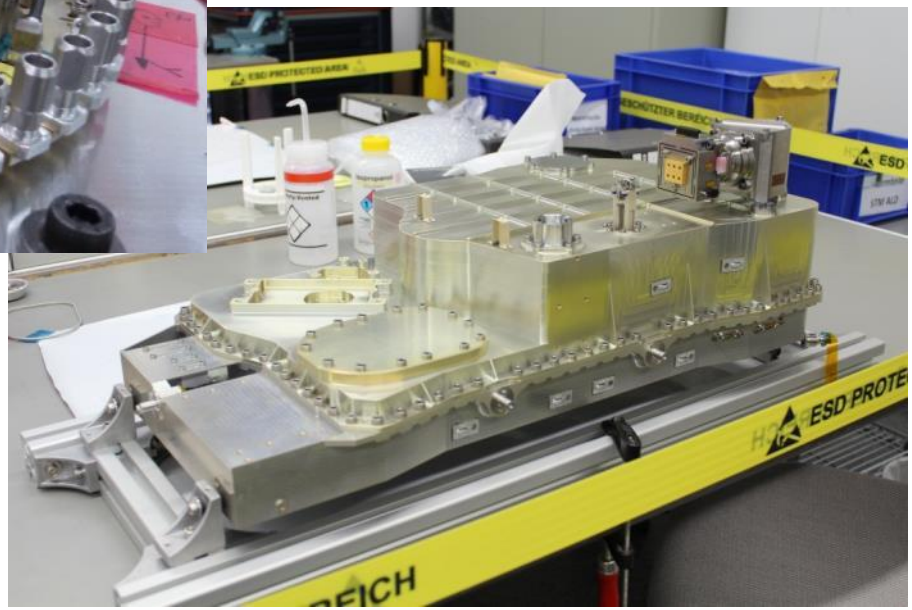
Sample Deposit into Core Sample Transportation Mechanism by Drill

Ma_Miss BB during Drill tool EM testing

2020 Rover Analytical Laboratory Drawer and Powdered Sample Handling System

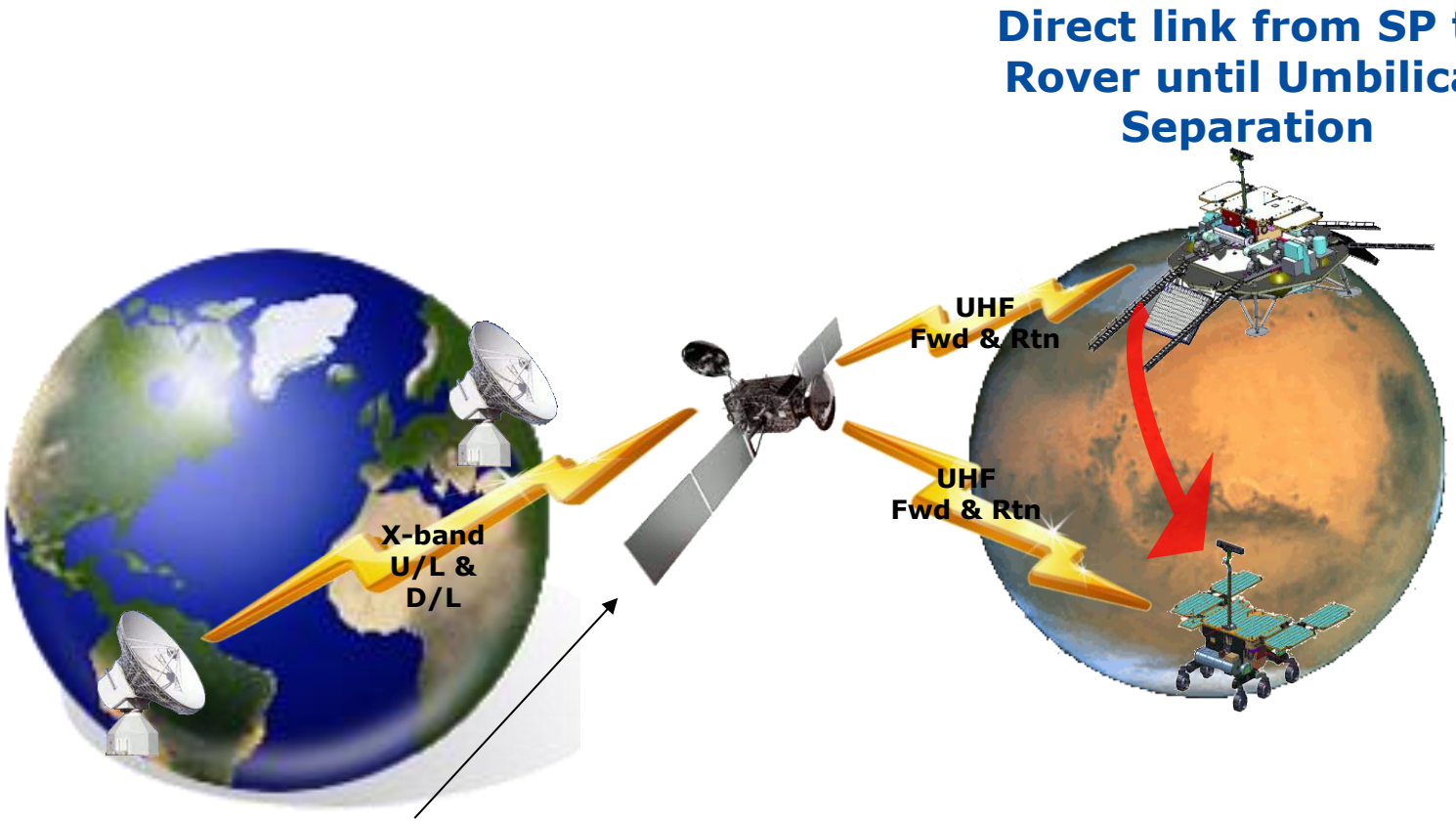


PSHS QM during Vibration Testing



ALD STM Lower Plate Assembly

2020 Mission Operations Overview



- ExoMars 2016 TGO provides data relay support to surface assets
- 2 communication windows per sol with Rover
- EDL will be monitored by largest available UHF radio telescope antenna

PanCam
Wide-angle stereo camera pair
High-resolution camera

Geological context
Rover traverse planning
Atmospheric studies

WAC: 35° FOV, HRC: 5° FOV

ISEM
IR spectrometer on mast

Bulk mineralogy of outcrops
Target selection

λ = 1.15 – 3.3 µm, 1° FOV

CLUPI
Close-up imager

Geological deposition environment
Microtexture of rocks
Morphological biomarkers

20-µm resolution at 50-cm distance, focus: 20 cm to ∞

WISDOM
Ground-penetrating radar

Mapping of subsurface stratigraphy

3 – 5-m penetration, 2-cm resolution

FREND
Passive neutron detector

Mapping of subsurface
Water and hydrated minerals

Drill + Ma_MISS
IR borehole spectrometer

In-situ mineralogy information

λ = 0.4 – 2.2 µm

Analytical Laboratory Drawer

MicrOmega
VIS + IR Spectrometer

Mineralogical characterization of crushed sample material
Pointing for other instruments

λ = 0.9 – 3.5 µm, 256 x 256, 20-µm/pixel, 500 steps

RLS
Raman spectrometer

Geochemical composition
Detection of organic pigments

spectral shift range 200–3800 cm^{-1}, resolution ≤ 6 cm^{-1}

MOMA
LDMS + Pyr-Dev GCMS

Broad-range organic molecules at high sensitivity (ppb)
Chirality determination

Laser-desorption extraction and mass spectroscopy

Pyrolisis extraction in the presence of derivatisation agents, coupled with chiral gas chromatography, and mass spectroscopy

SP Payload composition