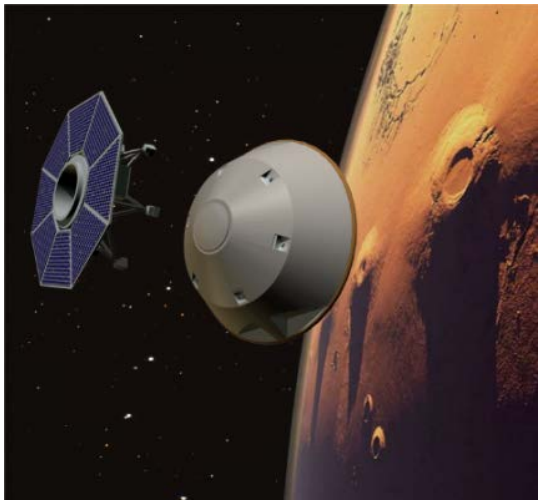
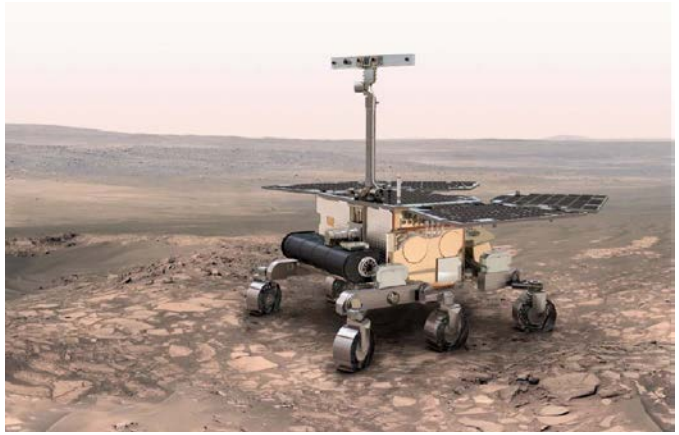
2018 ExoMars Mission
Rover Development Status
ASTRA 2015

ESA/ESTEC – 11 May 2015

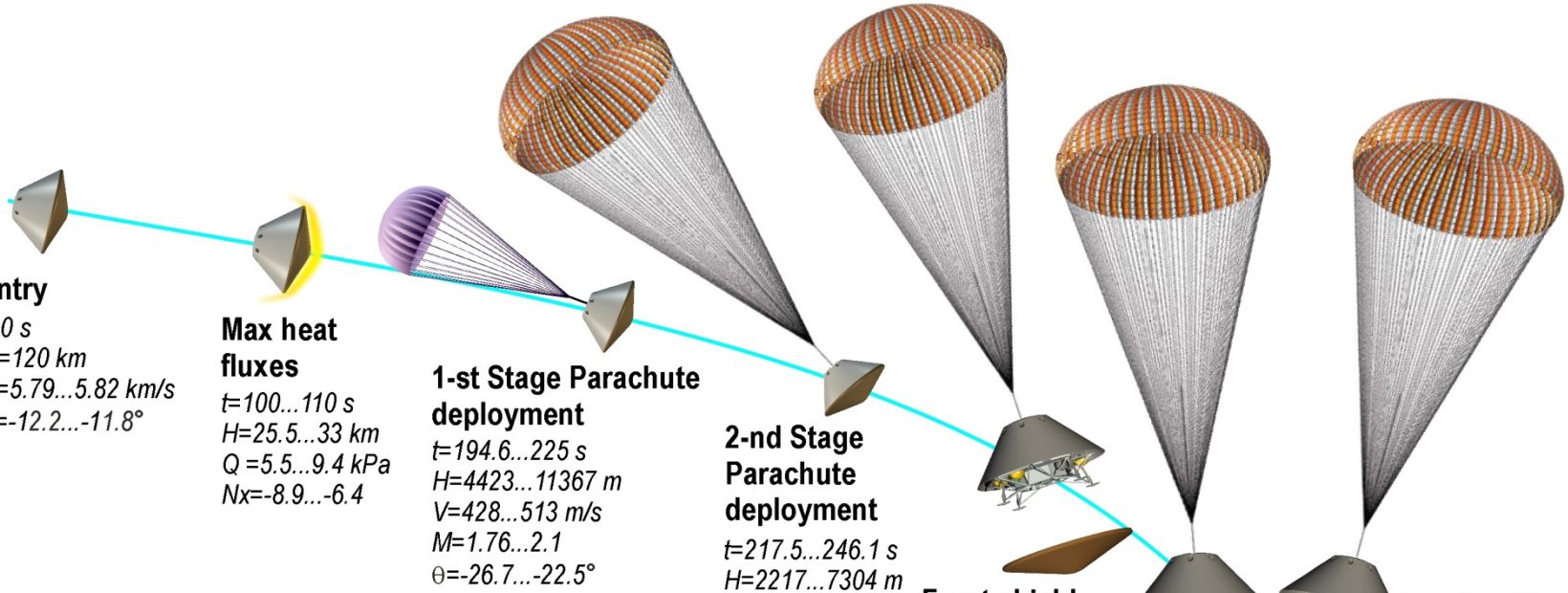
P. Baglioni
EXM Rover manager
European Space Agency





ESA UNCLASSIFIED – For Official Use

2018 Mission – EDL Overview and Timeline



Entry
t=0 s
H=120 km
V=5.79...5.82 km/s
θ=-12.2...-11.8°

Max heat fluxes
t=100...110 s
H=25.5...33 km
Q =5.5...9.4 kPa
Nx=-8.9...-6.4

1-st Stage Parachute deployment
t=194.6...225 s
H=4423...11367 m
V=428...513 m/s
M=1.76...2.1
θ=-26.7...-22.5°

2-nd Stage Parachute deployment
t=217.5...246.1 s
H=2217...7304 m
V=128...204 m/s
M=0.57...0.82
θ=-48.9...-37.3°

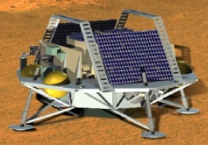
Front shield separation. Landing legs deployment
t=218.5...247.1 s
H=2131...8600 m
V=102...165 m/s

Radar activation
t=228.5...257.1 s
H=1664...8014 m
V=40..72 m/s
θ=-70.4...-55°

Landing Module separation. Start of power descent
t=273.9...429.2 s
H=497...500 m
V=27...35 m/s
θ=-90...-89.3°

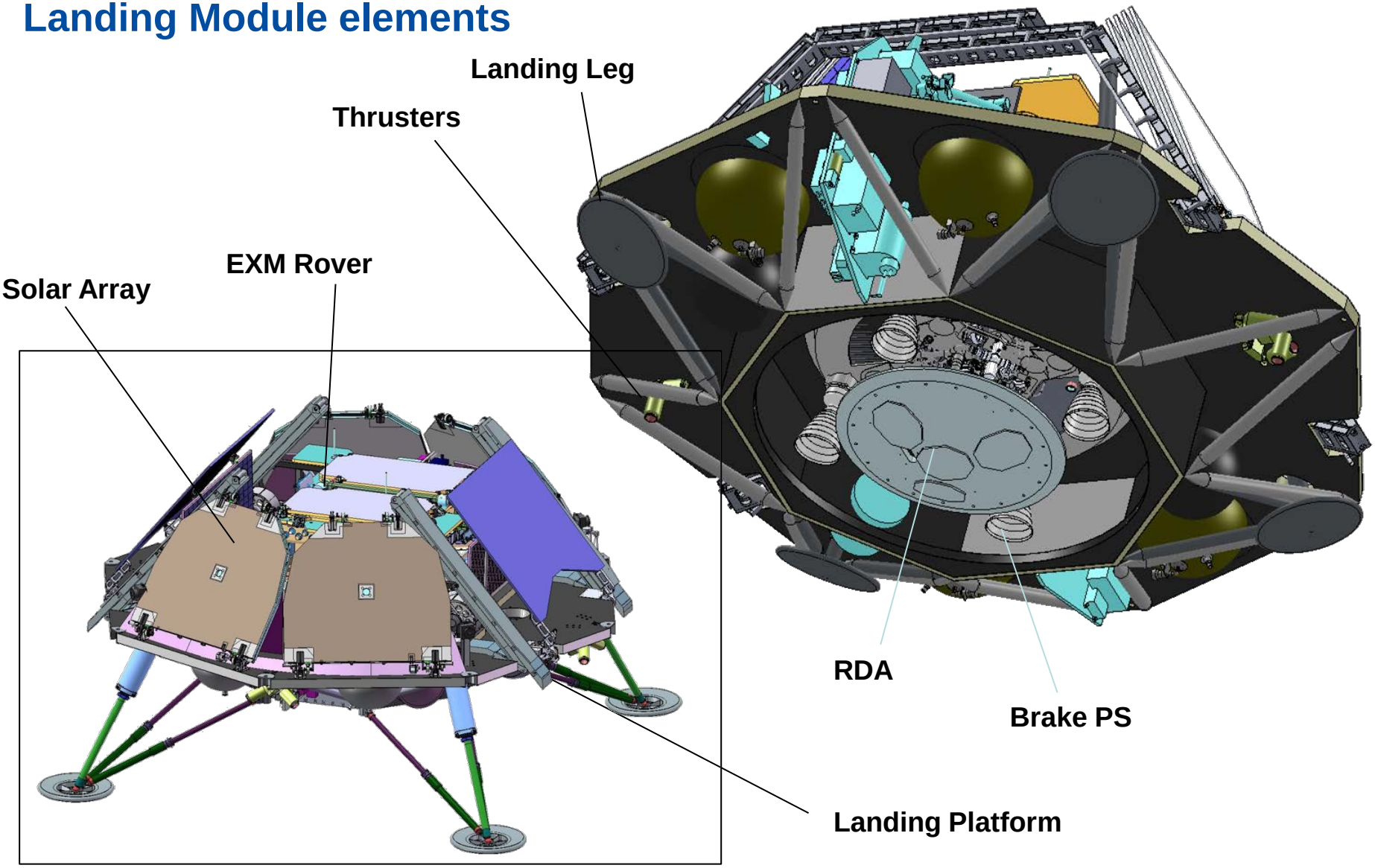
- Ls 324 deg, at the end of the Global Dust Storm Season
- Landing Site TBD based on engineering and science constraints >> 4 sites still possible, 2 have been now pre-selected
- EDL, Rover and Landing Platform Surface Ops data upload via UHF proximity link with TGO (and MEX TBC)

Landing Platform deployment

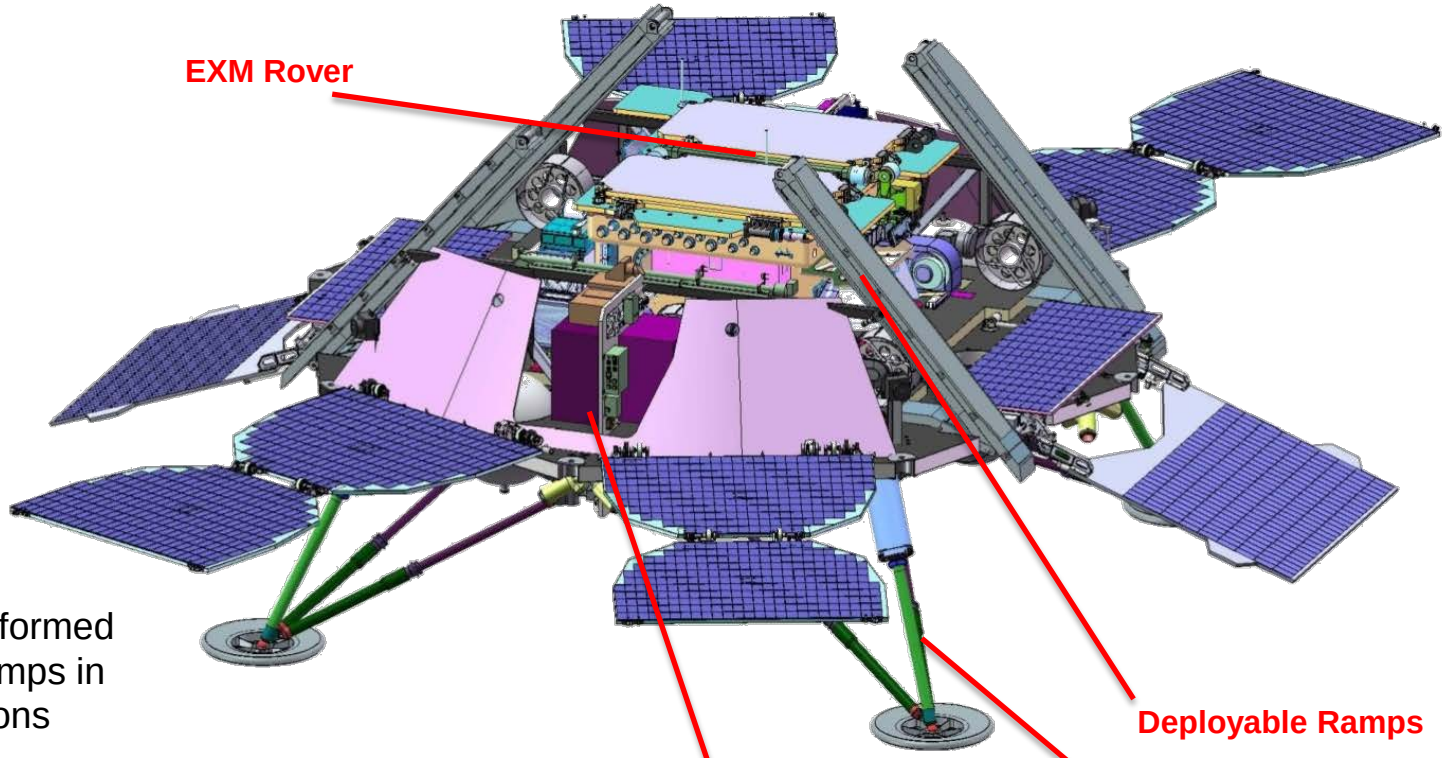


Propulsion cut-off Landing
t=321.7...484.8 s
H=0 m
Ve<2 m/s
Va<1 m/s

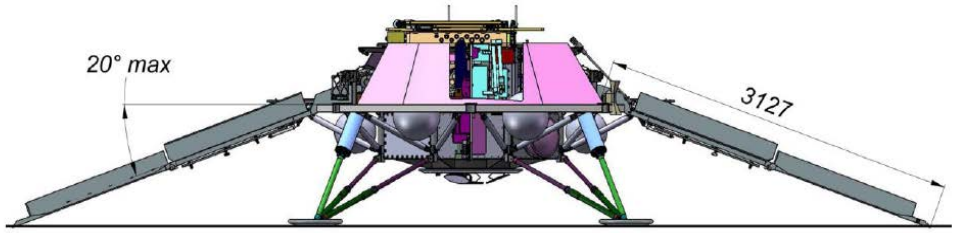
Landing Module elements



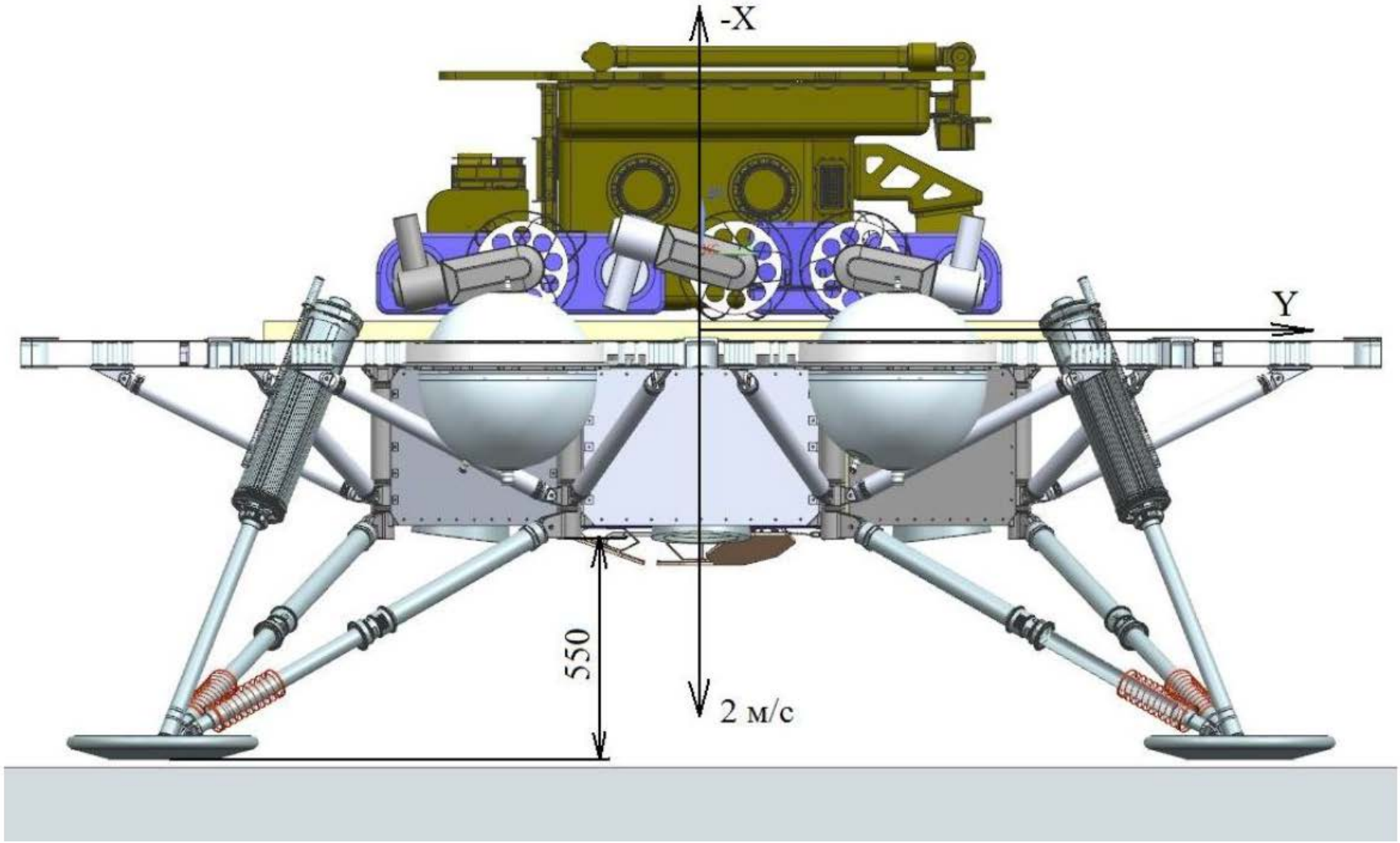
2018 Lander Configuration (S-PDR close-out – May 2015)



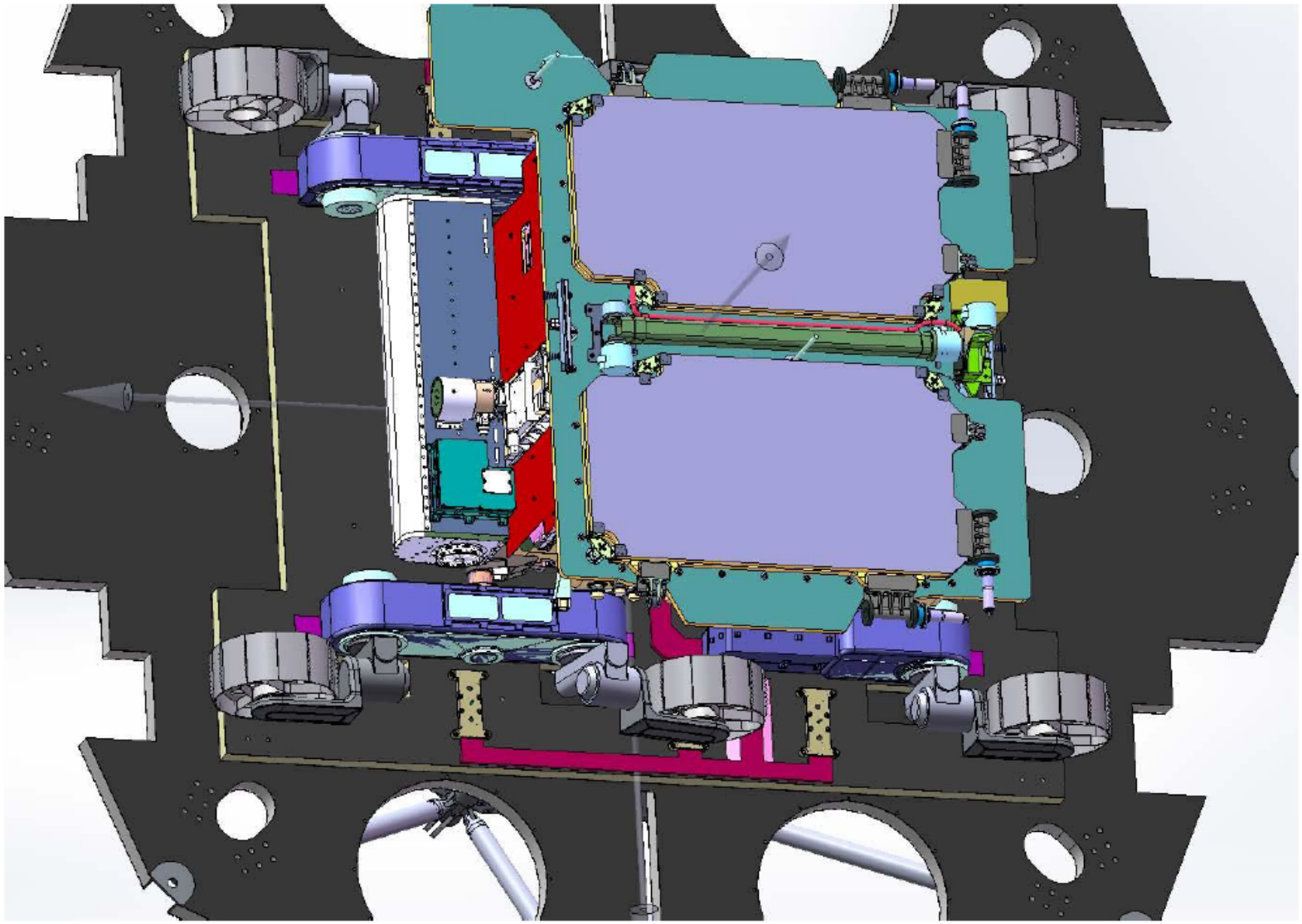
Rover Egress is performed along deployable ramps in two opposite directions



Rover accommodation on the Landing Platform



Rover Pallet Accommodation



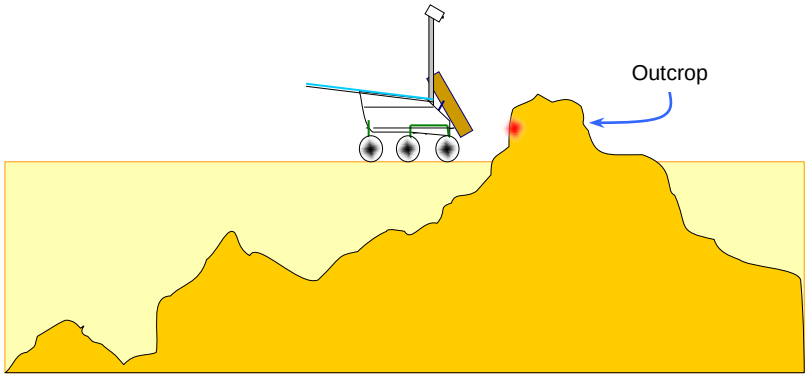
Rover top requirements

➢ Landing latitude at Mars:	5°S to 25°N
➢ Nominal mission:	218 sols
➢ Nominal science:	6 Experiment Cycles + 2 Vertical Surveys
➢ Experiment Cycles durations (EC,VS):	17÷25 sols
➢ Travelling:	up to a 70m target within 1 Sol
➢ Rover mass allocation:	310 kg mobile / 350 kg launch
➢ Payload:	Pasteur Payload Set
➢ Data Volume :	> 150 Mbits/sol

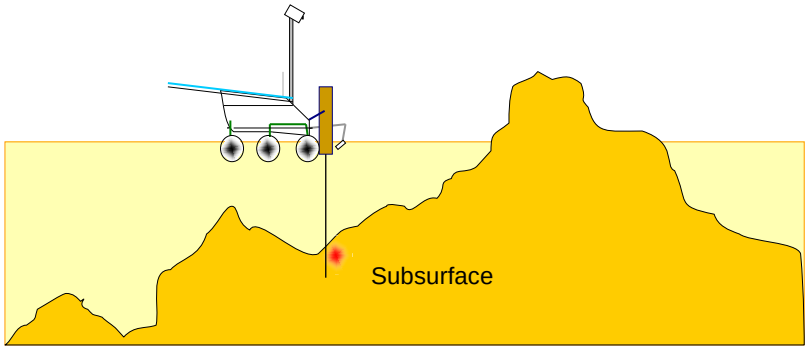
Reference Surface Mission

To complete 6 Experiment Cycles & 2 Vertical Surveys within 218 sols.

Experiment Cycle (EC):
Include driving to an site selected for good Science potential , drilling to acquire a sample preserved from radiations at least 1.5m below the surface. Process and analyse the sample with the SPDS and the full set of analytical instruments.



Vertical Survey (VS):
Acquire & analyse a sample every 50 cm from 0m to - 2m below the surface.



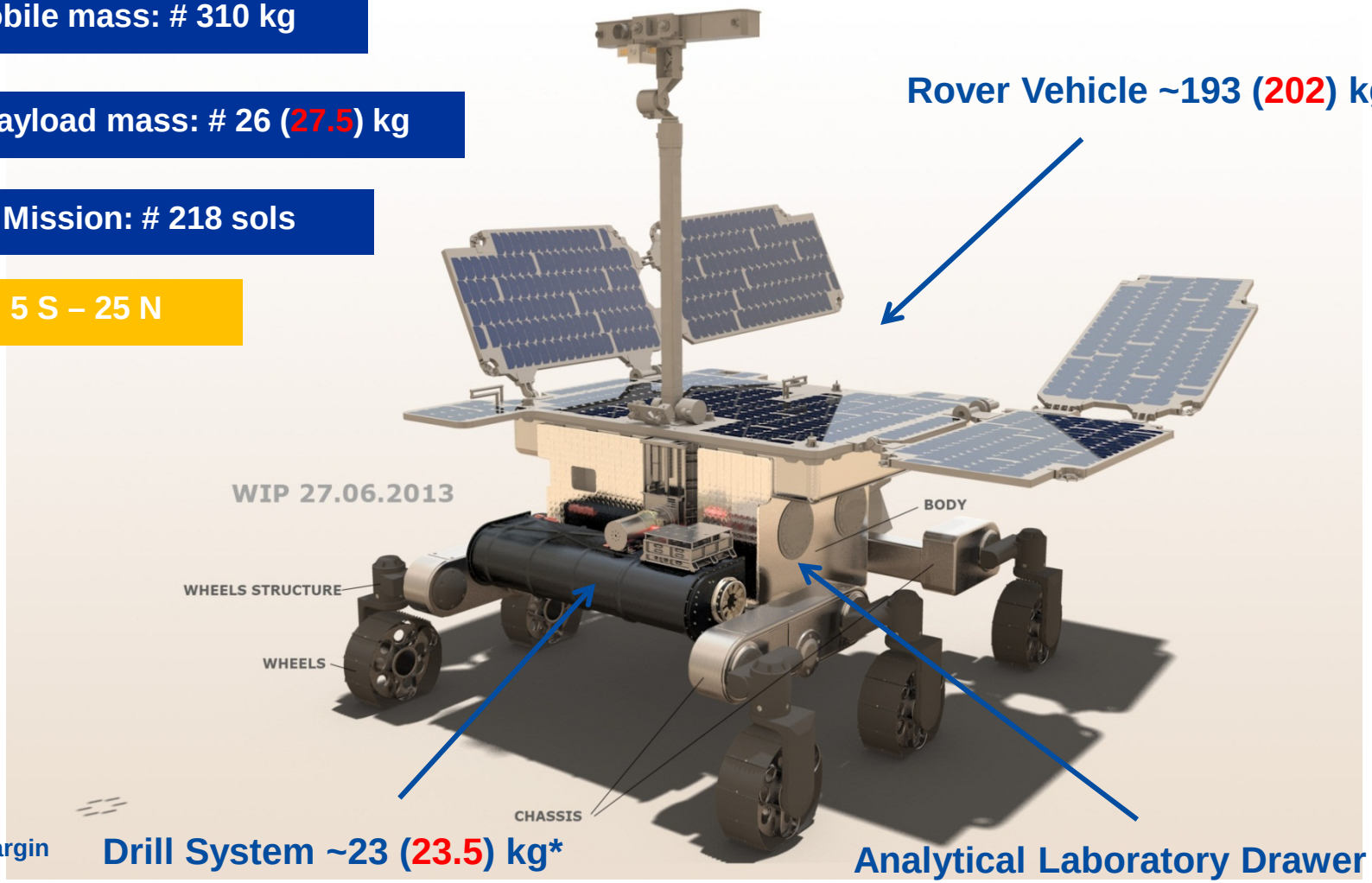
ExoMars Rover

Rover mobile mass: # 310 kg

Science Payload mass: # 26 (27.5) kg

Nominal Mission: # 218 sols

Latitude: 5 S – 25 N



Rover Vehicle ~193 (202) kg*

Drill System ~23 (23.5) kg*

Analytical Laboratory Drawer Incl. Payloads ~55 (58.5) kg*

(*) excl. System Margin

Rover Budget Status

Mass Budget

Mass remain critical, S-PDR agreement have reduced Rover Launch Mass allocation of 5kg => 345Kg , Mobile Mass unchanged at 310Kg

- Current Predicted (rounded) mass are 296Kg Mobile / 312Kg Launch
- System margin is low => Strict Mass control is implemented at all levels, mass reductions exercises on going, possible de-scoping are being evaluated

Power/Energy Budget

- Energy budget is under revision due to limitation in Battery performances and uncertain rate of Battery degradation during ground ops and cruise
- Pre-selected landing sites are anyway favorable for power generation

Data Volume budget :

- Rover capabilities are well in excess of the required average 150Mbits/sol , ranging in the area between 370 to 420 Mbits/sol depending on TGO Orbit/Antenna used and Landing Site Considered. It is anyway to be underlined that the available visibility time will have to be shared with the Lander Science.

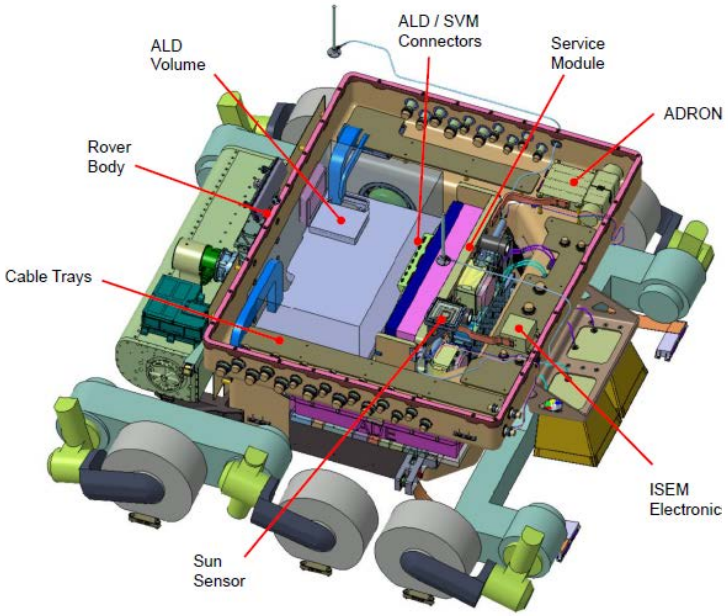
Contamination Budget :

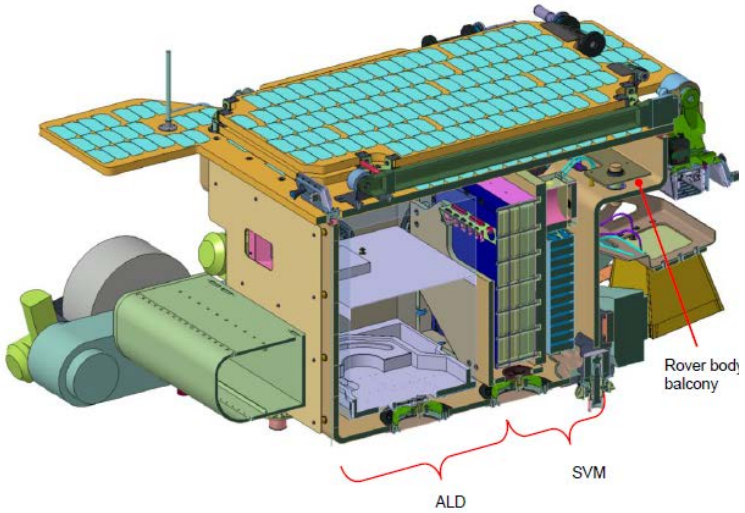
- Budget presented at S-PDR represent an improvement with respect to the previous one presented at ALD PDR , depending on the considered model of adsorption from atmosphere. UCZ Integration already foreseen in a dedicated ISO3/AMC-9 facility (AMC-9 is at the edge of technical feasibility).

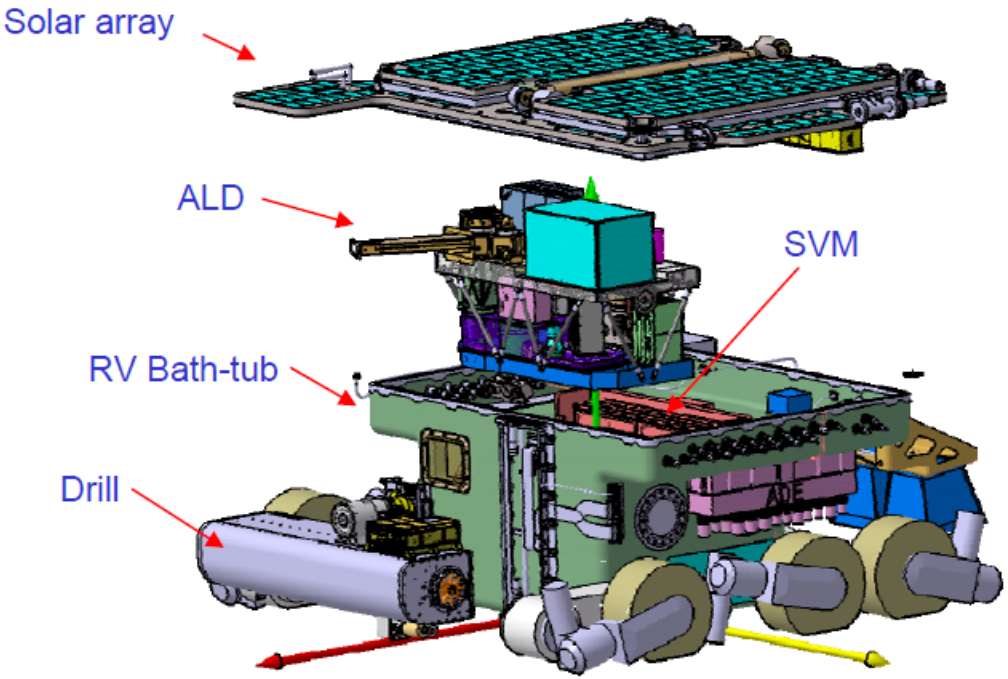
Rover deployed configuration

ESA UNCLASSIFIED – For Official Use

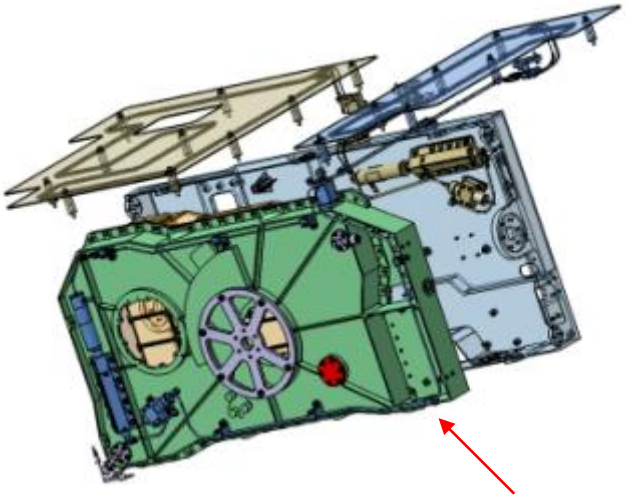
Rover internal lay-out



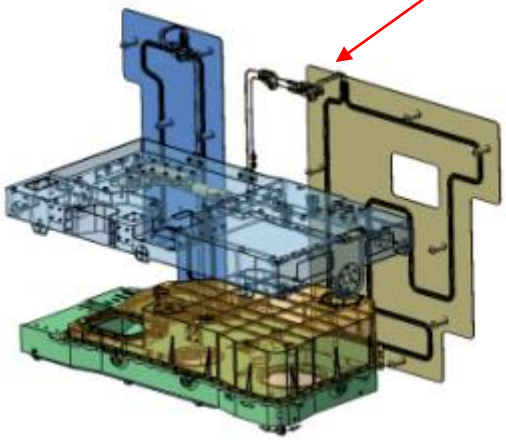


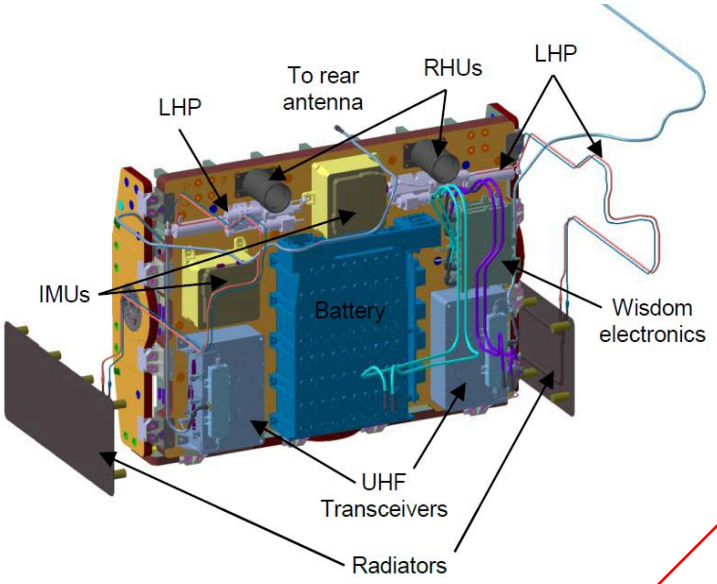


Structures and Thermal Control

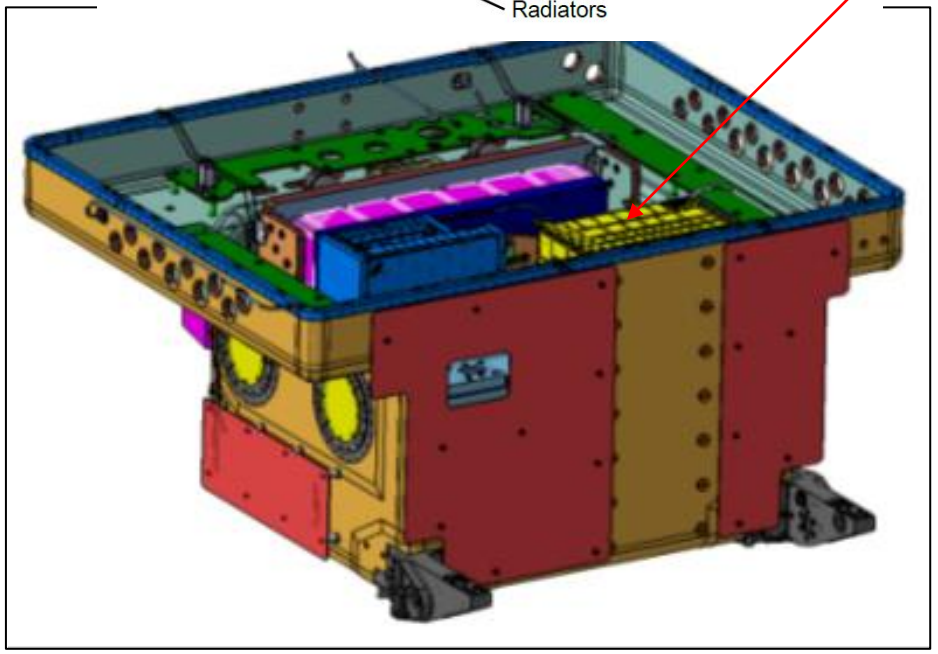


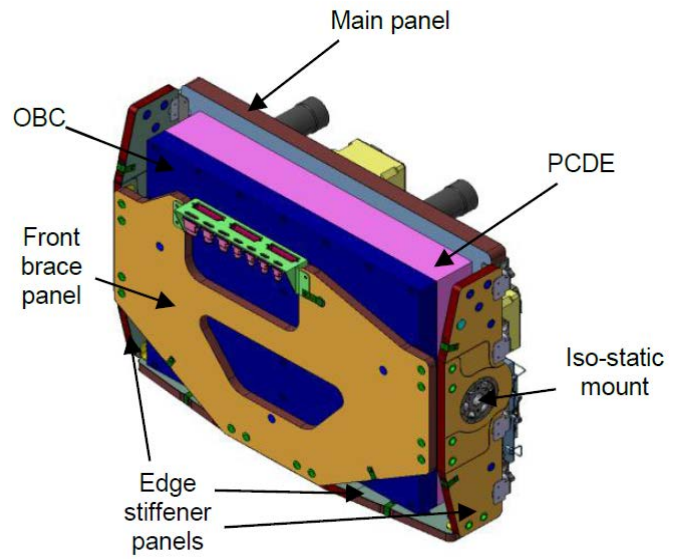
ALD

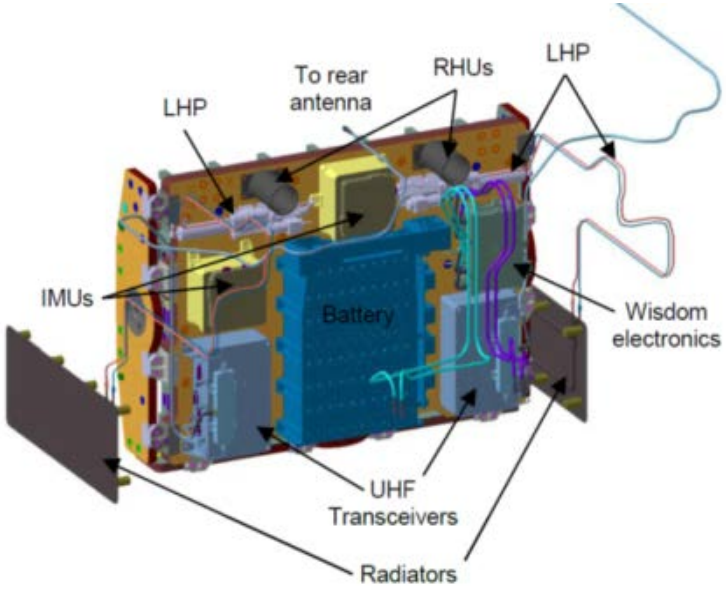




SVM







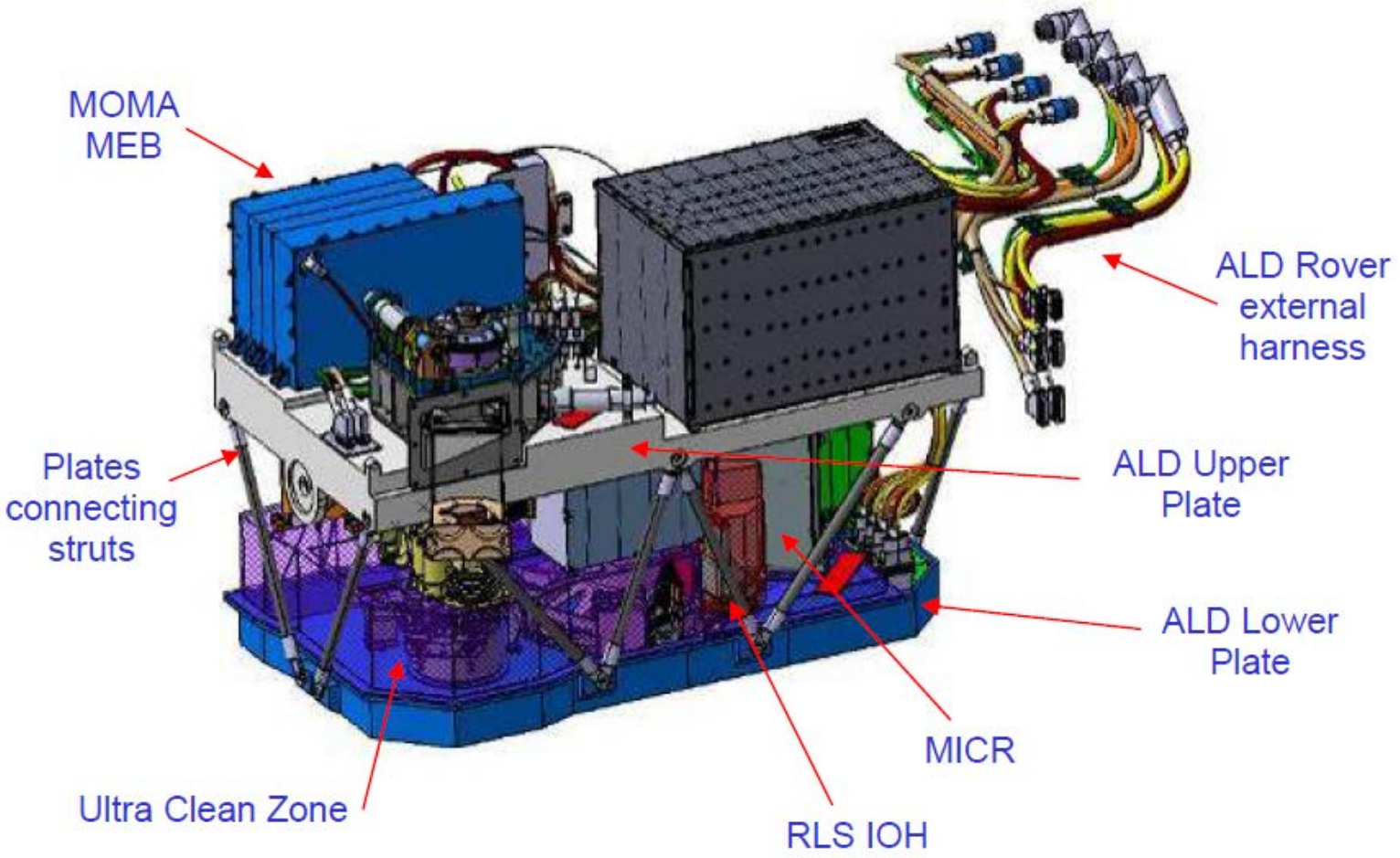
Service Module

The Service Module (SVM) is a sub-assembly of Rover Vehicle service equipment mounted to an independent sub-structure in the aft part of the rover body

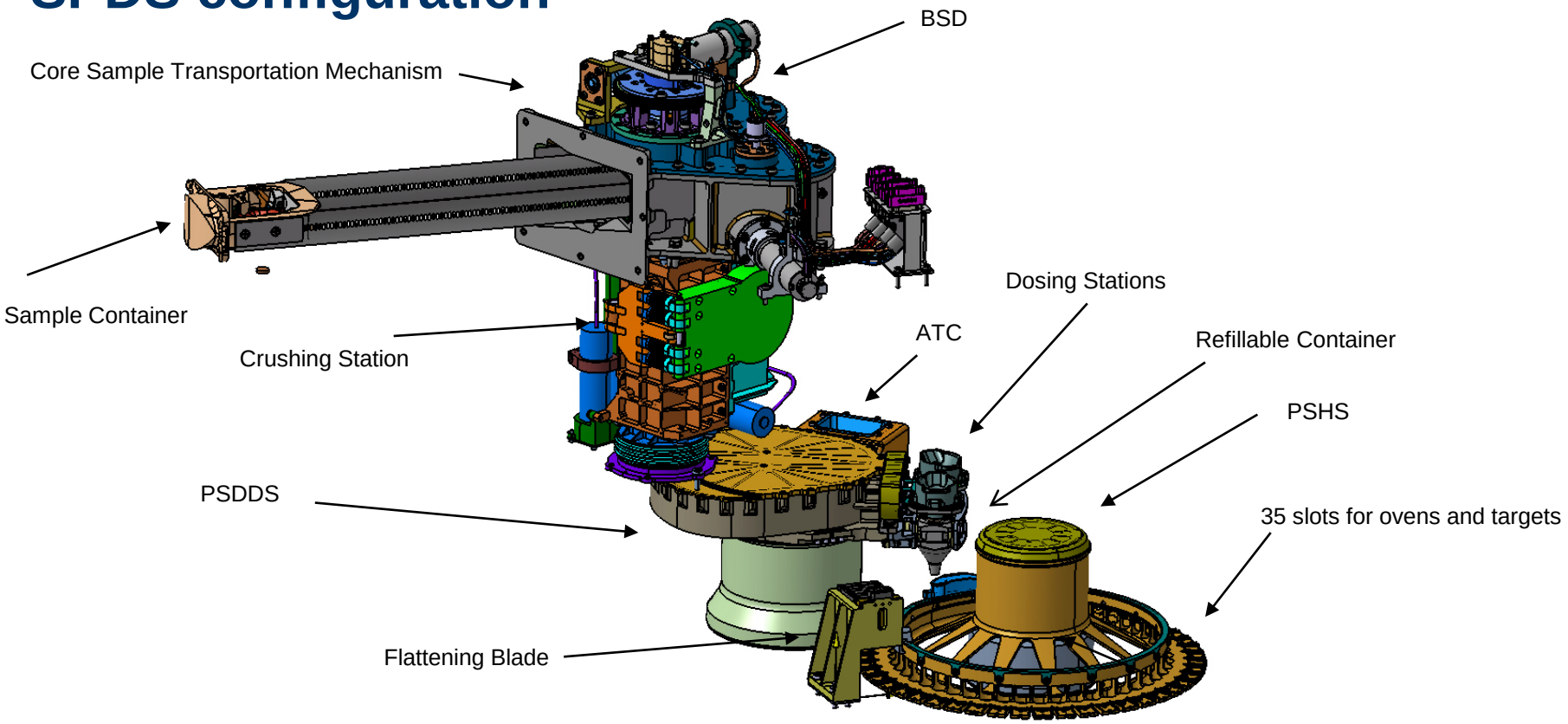
The following equipments are incorporated in this module:

- Battery
- Power Conditioning & Distribution Electronics (PCDE)
- On-Board Computer (OBC)
- 2 x UHF Transceivers (including diplexers)
- 2 x Inertial Measurement Unit (IMU)
- WISDOM Electronics Unit
- Electrical Harness (including ALD interface connectors)
- 2 x ‘Angel’ 8.5W RHUs with canisters
- 2 x Loop Heat Pipe Circuits (evaporators, condensers, by-pass valves and pipes) and associated radiators

Analytical Laboratory Drawer

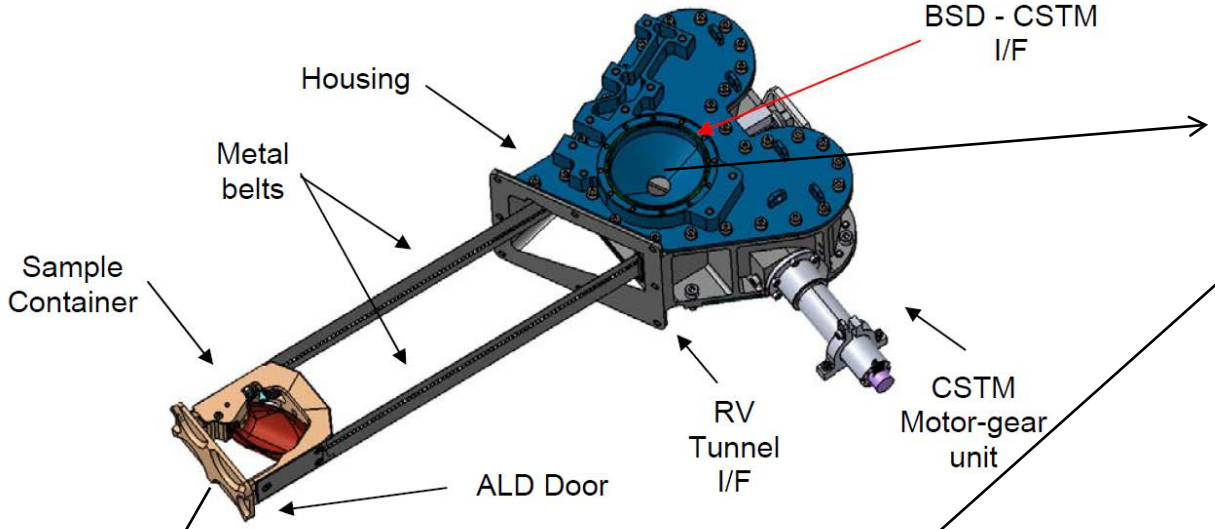


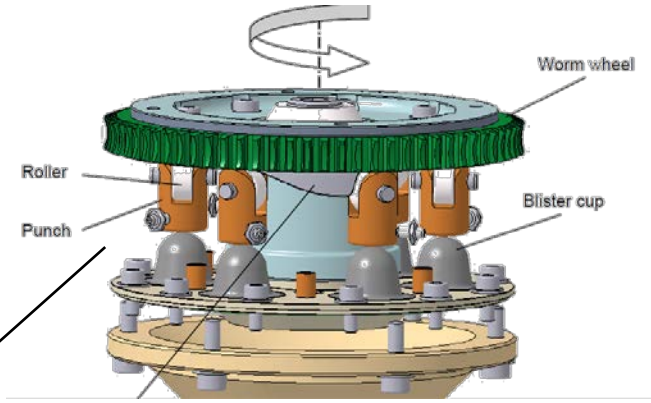
SPDS configuration

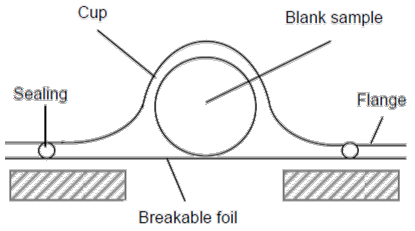


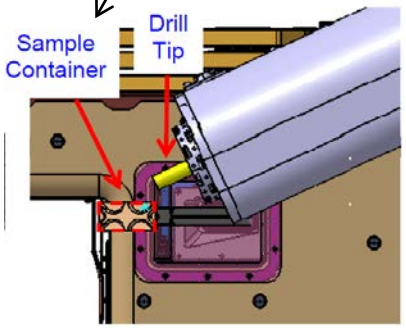
- **Core Sample Handling System (CSTM)**
  - **Including a Blank Sample Dispenser (BSD) mechanism for dispensing blank samples, one sample at a time.**
- **Crushing Station (CS)**
  - **Including a commandable hammering system for powder release**
- **Powdered Sample Dosing and Distribution System (PSDDS)**
  - **including of two Dosing Station (DS) units, a Positioner, and an Alternative Transport Container**
- **Powdered Sample Handling System (PSHS)**
  - **Including carrousel with GC ovens, Tapping Station, refillable container**

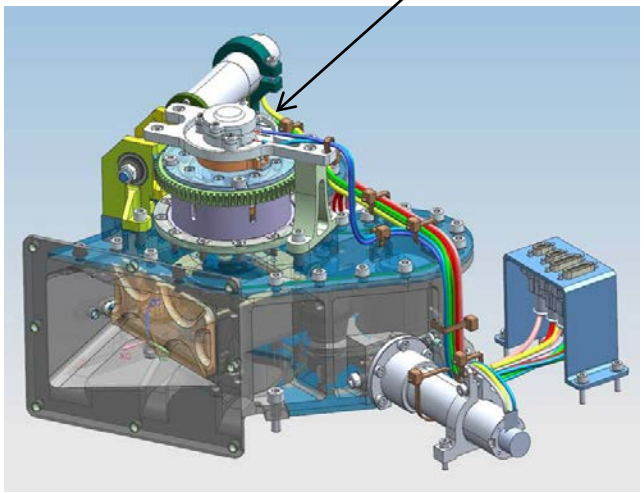
Core Sample Handling System (CSHS = CSTM + BSD)

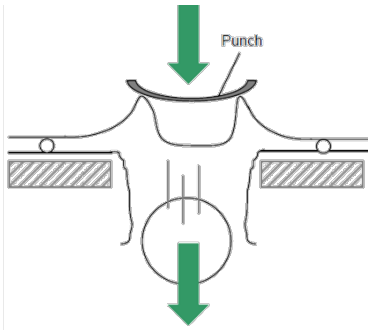




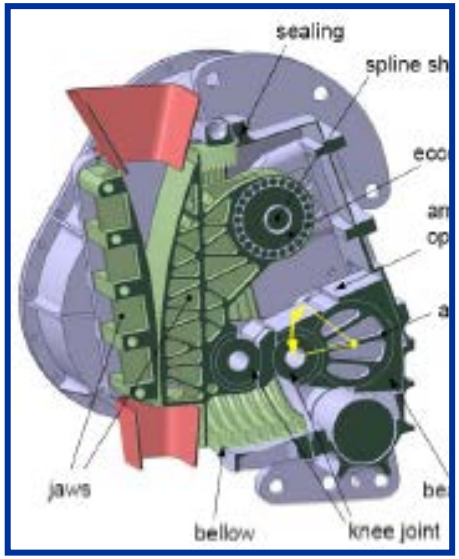


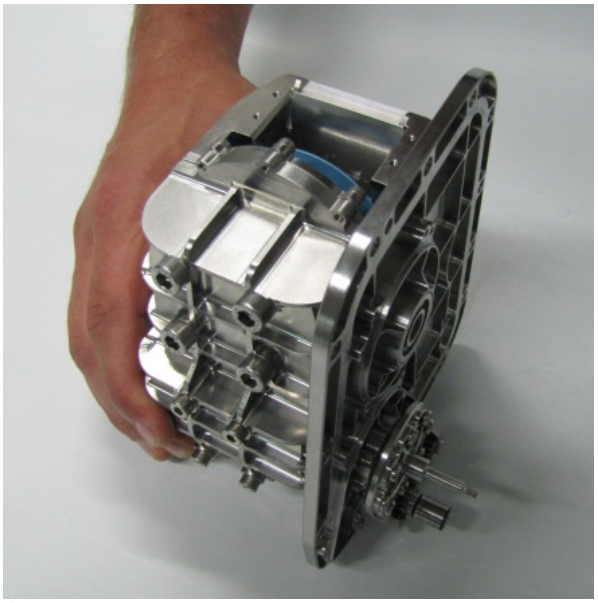


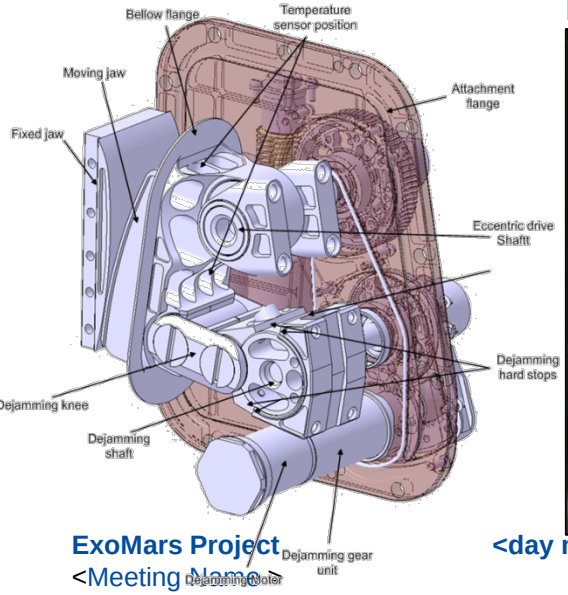


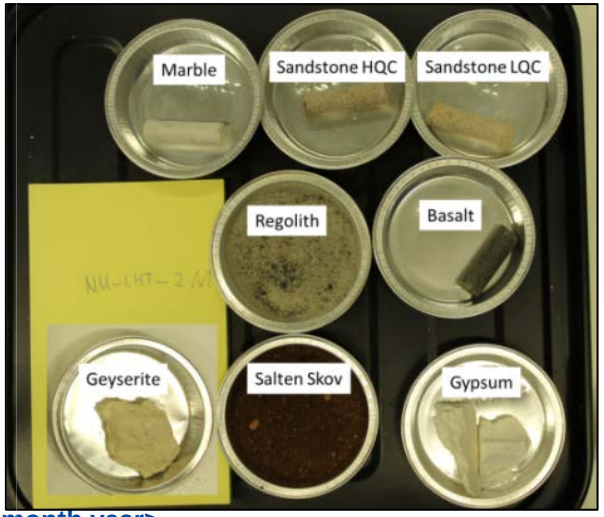


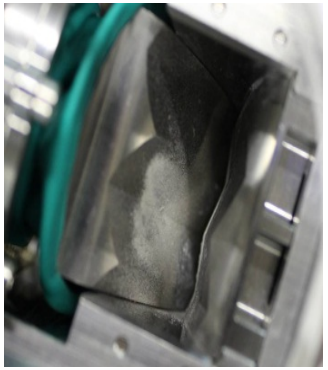
Crushing Station (CS)

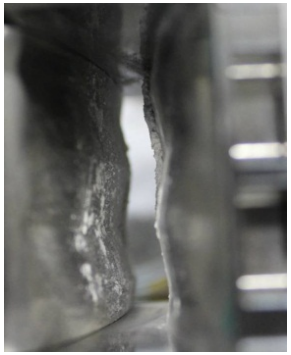




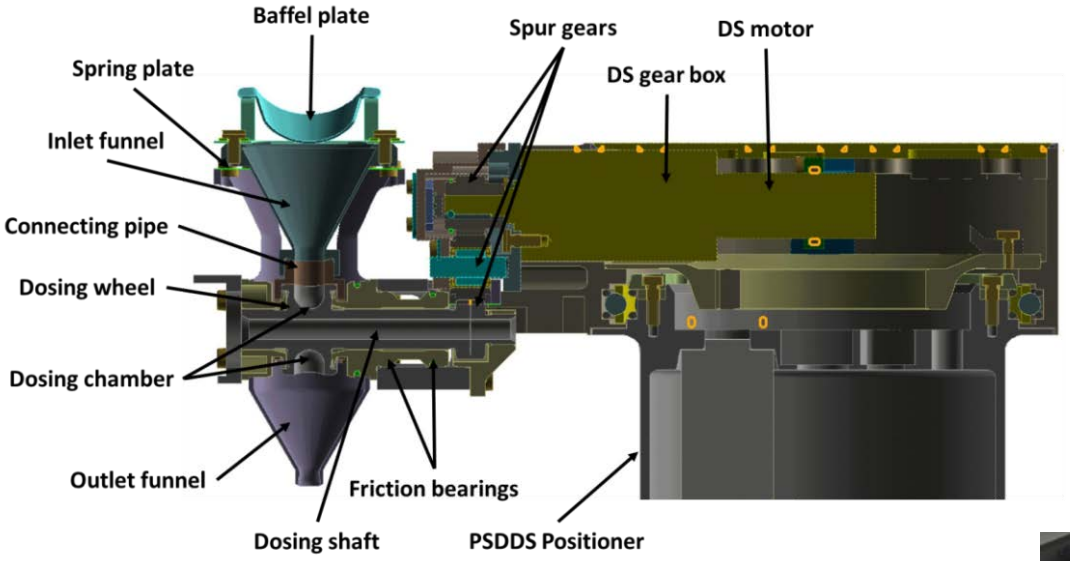


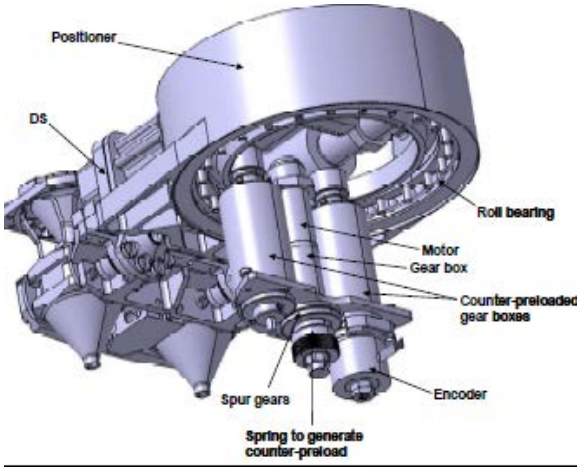


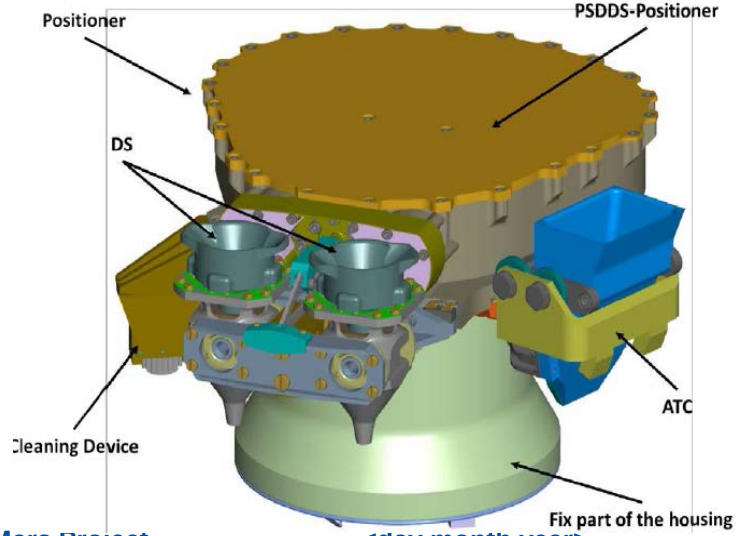


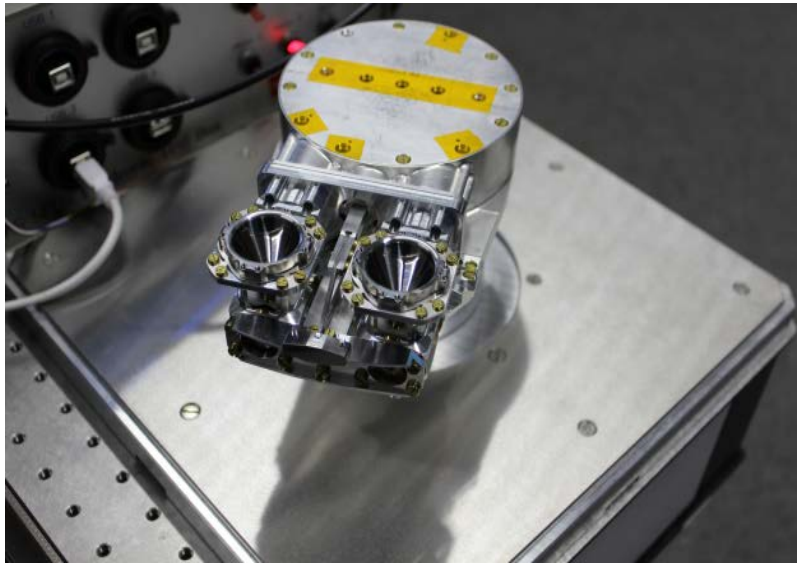


Powder Sample Dosing & Distribution System (PSDDS)

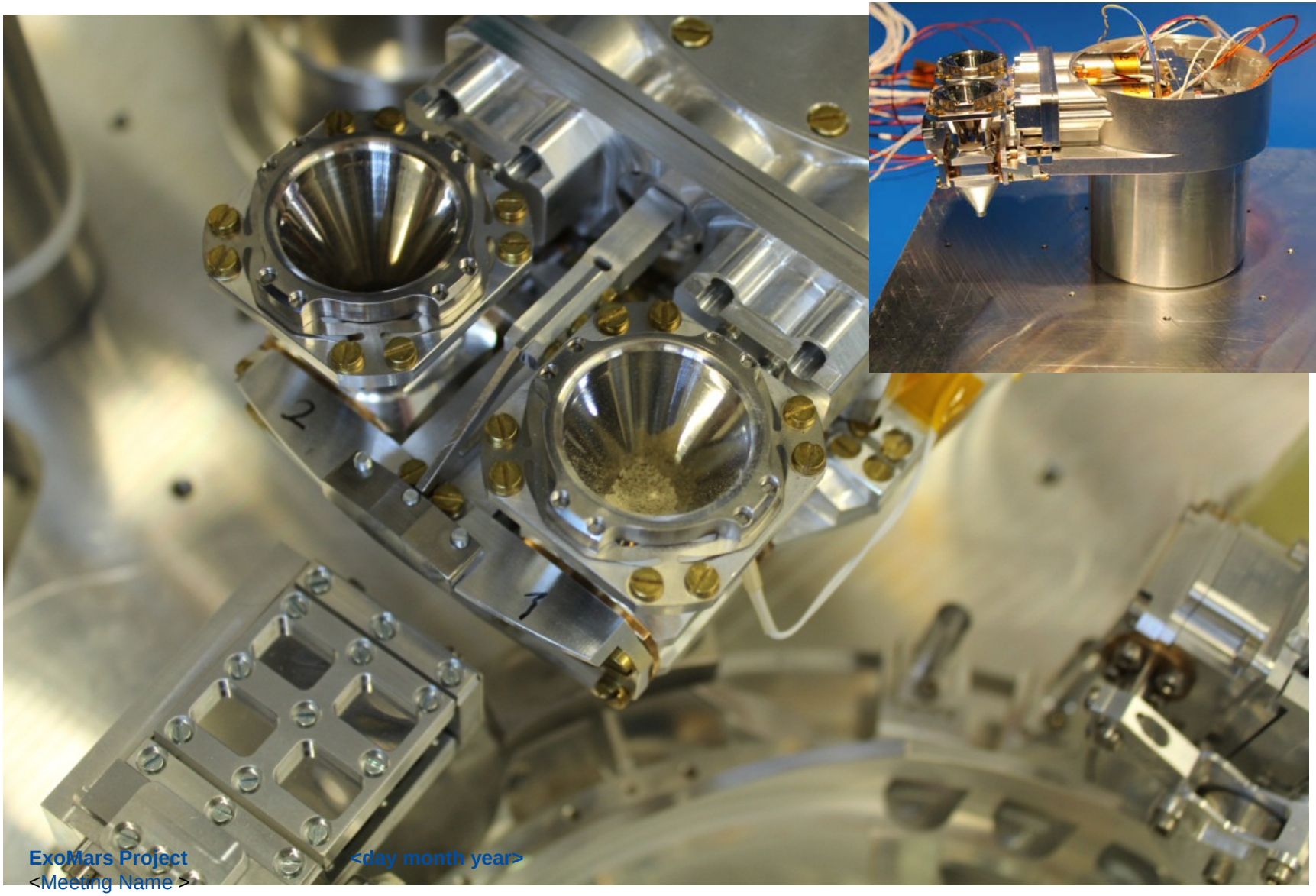




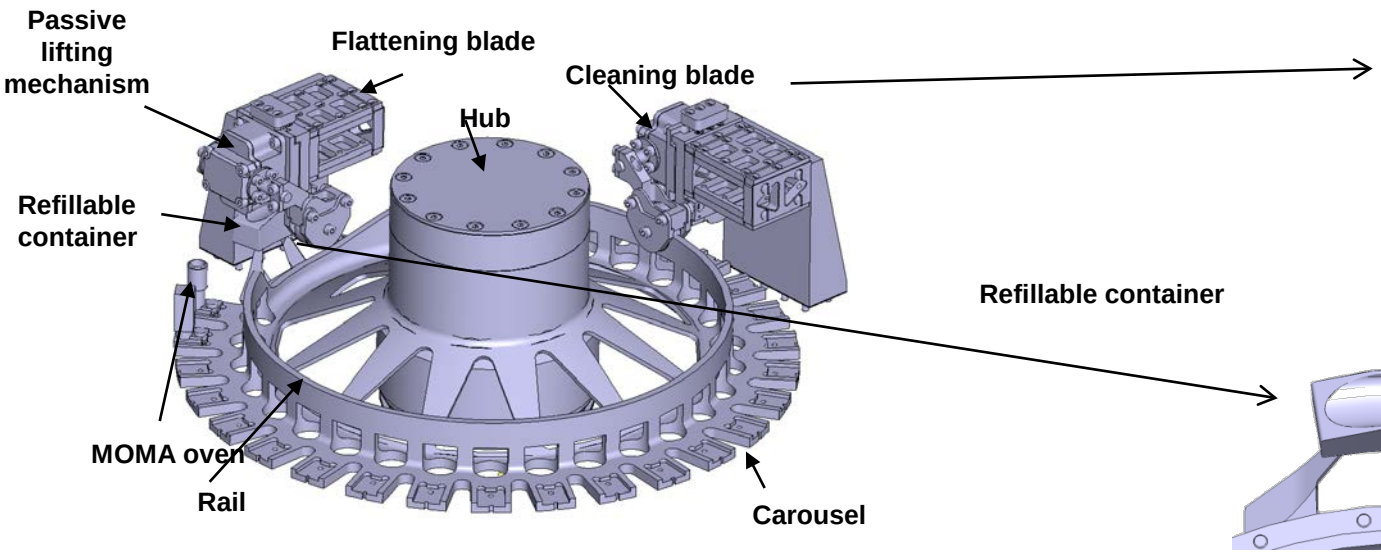


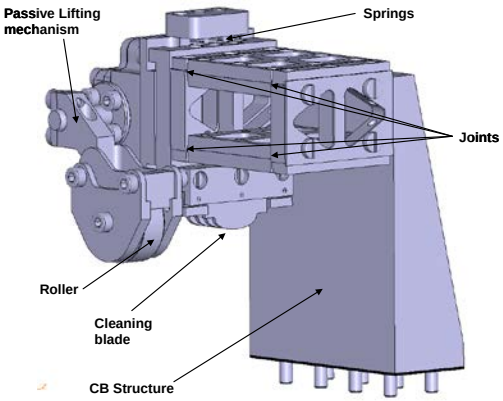


PSDDS Engineering Model



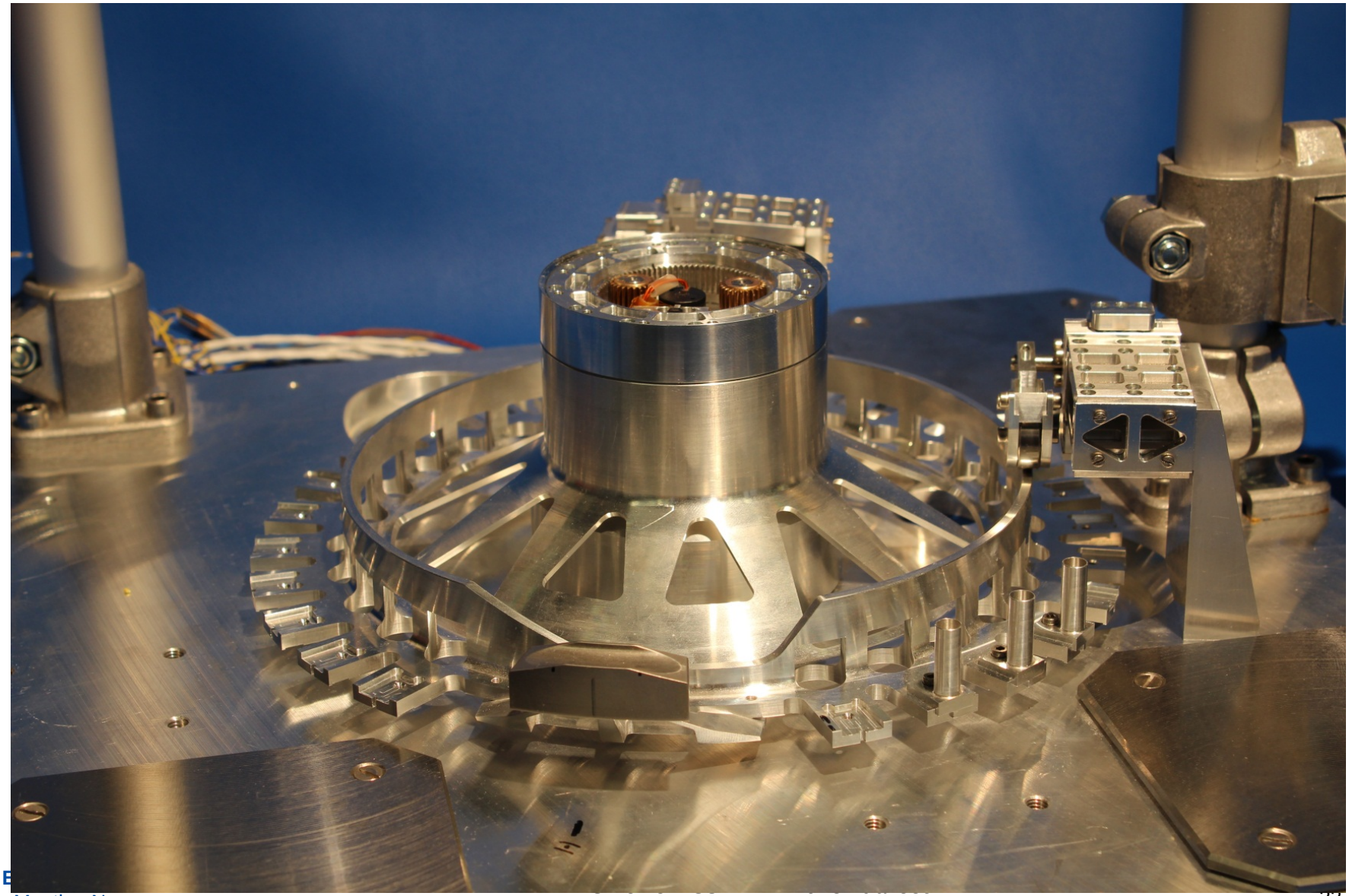
Powder Sample Handling System (PSHS)





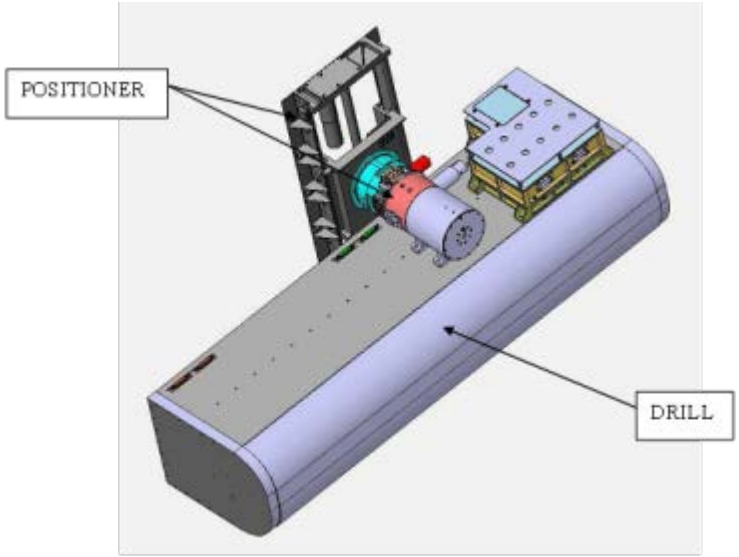
Refillable container

Powder Sample Handling System (PSHS) EM

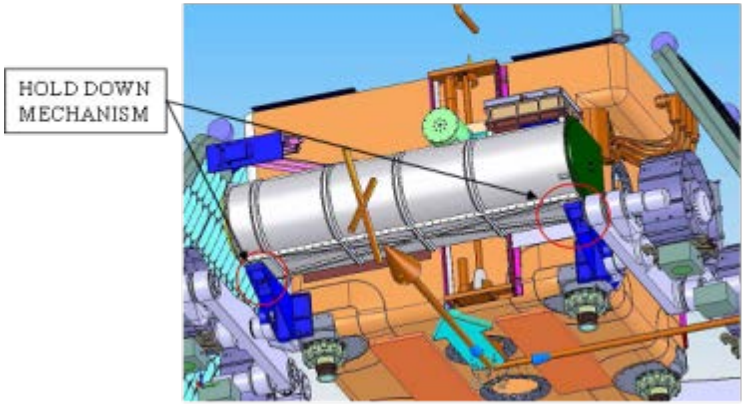


Drill System

- **The Drill system is composed of three sub-systems:**
  - **Drill Unit**, which includes all the components needed to drill and to collect samples
  - **Positioner mechanism**, which allows all the necessary movements of the Drill box, and include the **jettison mechanism**
  - **Hold Down system,** which provides to the Drill/Positioner additional connection to the Rover vehicle during launch



- **The Drill accommodates two instruments:**
  - **Ma_Miss** (Mars Multispectral Imager for Sub-surface Science): miniaturized near-infrared imaging spectrometer to conduct mineralogical investigations.
  - **CLUPI**: CLose UP Imager for the observation of Cored Sample, drill hole and drill fines



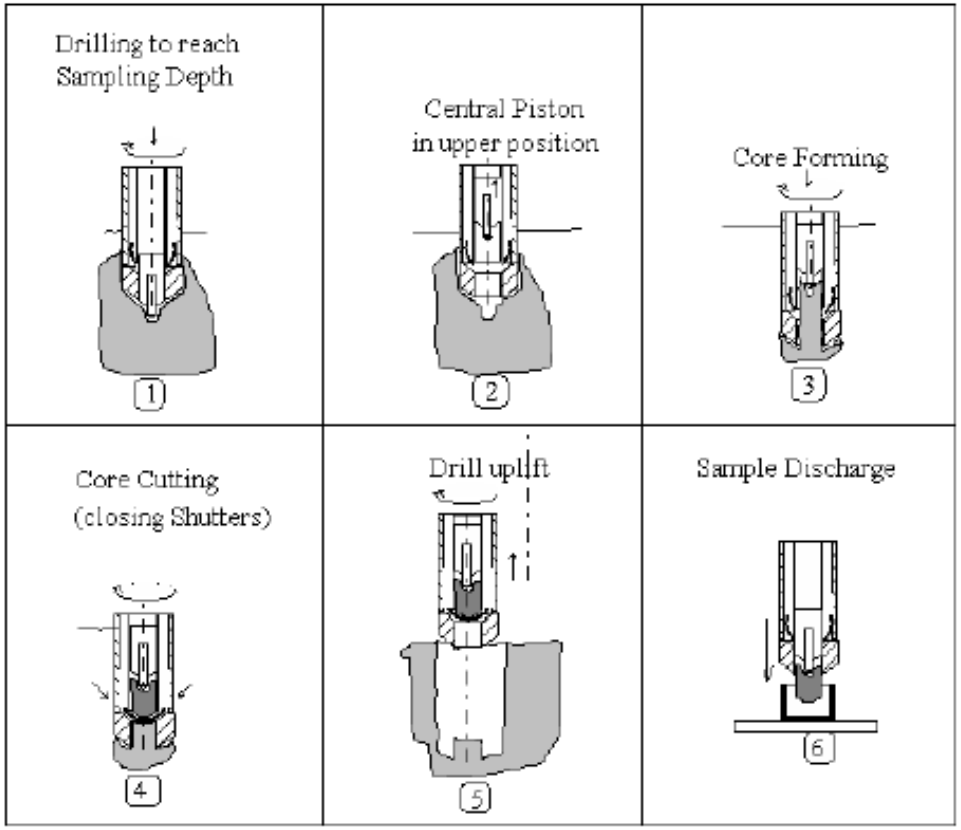
Exomars Drill Unit - Basic Sampling Procedure

Drill Tool with
Central piston in "Drill Mode"

Drill Tool with
Central piston in "Core Mode"

Drill Tool with
Central piston partly closed

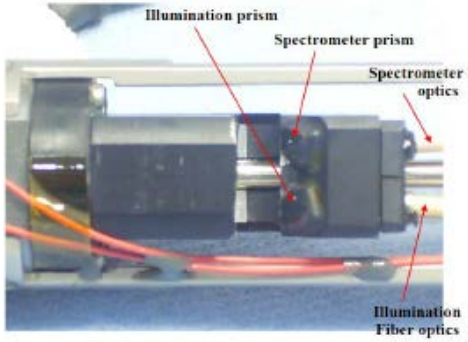
Drill Tool with
Central piston fully closed



Complete Drill EQM model

Drill tool front
(drill mode)

Drill tool front
(core mode)



Details on Spectrometer optical ports
(image prism and illumination prism)

Lamp lit and the light conveyed via optical fibre and optical prism through the sapphire window (taken over a dark background)

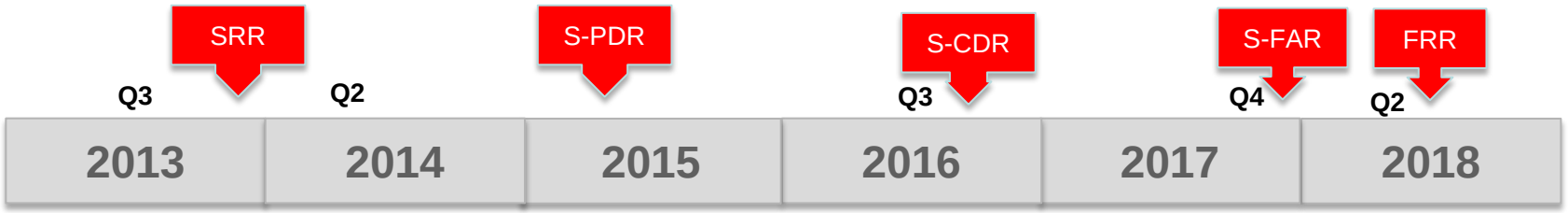
Lamp switched off (taken in normal laboratory illumination conditions)

2018 Mission Development Status

The Rover design activities are proceeding with Adv. CD funding, in parallel with the 2018 mission and system design consolidation. In particular:

- TAS-I/ASU are progressing in the Rover development: **PDRs** at subsystem level have been completed and **EM/QMs** of key elements are being built and tested.
- **All the equipment has been procured with fully assigned CD contracts**

- **System Requirements Review successfully closed in Dec. 2013**
  - LAV is progressing in the design of the Descent Module and its Landing Platform, with the existing Rover design as driving requirement
- **S-PDR** (incl. PDRs of CM and DM & GS Req. Rev) **successfully closed on 6 of May 2015**



Rover development status >> design progress

- **Main systems design reviews:**
  - RV PDR completed in Q4 2013;
  - ALD PDR completed in Q2 2014
  - Drill Detailed Design Review completed in December 2014
- **RV & ALD Subsystems design reviews:**
  - PDRs completed:
    - OBC, SPDS, NavCams/LocCams, BEMA (mobility), HDRMs (hold downs), DMA (mast)
    - DSEU (warm electronics), ADE (cold electronics)
    - Structures for the RV & ALD
    - IMU, VisLoc SW, Simulators (RVIS) & GSEs
  - PDRs on going:
    - PCDE (Board planned), SA (Solar Arrays), Harness, MMS (SW)
  - CDRs completed
    - Drill (DDR), BEMA, LHP (Loop Heat Pipes), RVIS

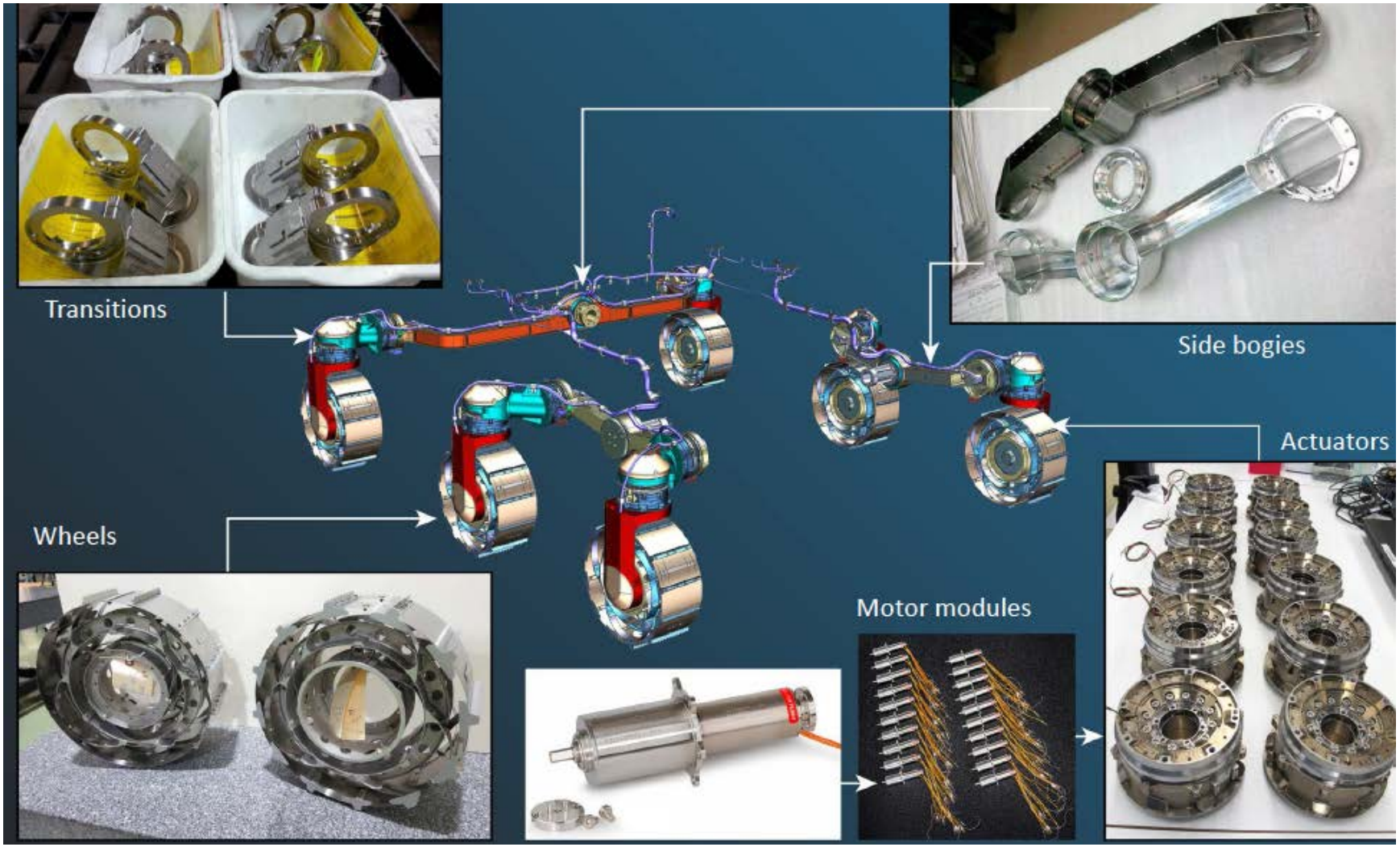
  - **SPDS QM MAI to be completed by Q2 2015**
  - **ALD EQM I&T scheduled in Q3 2015**

Rover development status >> test & technology progress

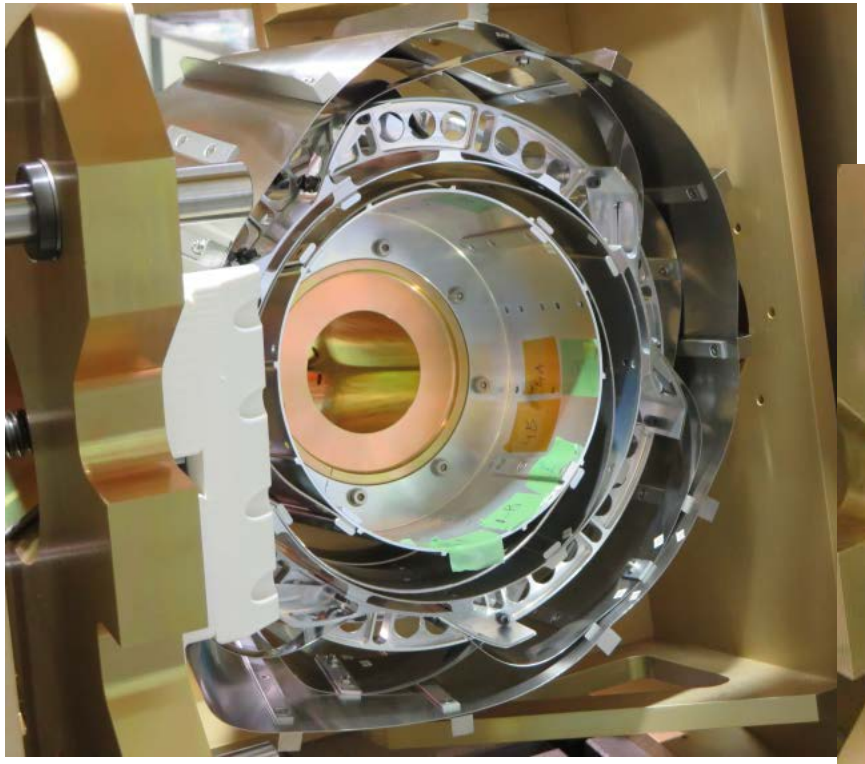
- Rover Vehicle:
  - Mobility and GNC validation tests continue at MDA (Can) and at ADS Mars Yard (UK) with latest Rover Breadboard (BB2), with use of NavCam & BEMA EMs and with VisLoc SW (SciSys)
  - Wheels test completed at MDA. BEMA characterization test foreseen in November 2015
  - TCS validation tests successfully completed (Gas Gap, LHP > STM being manufactured)
  - Rover Cold Electronics (ADE) development on going
    - PDR completed. Validation tests on going, to be completed by June 2015.
- Drill:
  - Drill pre-EQM test campaign (2 m depth in Mars like conditions and with selected Mars-type materials) test campaign in May-June 2014 successfully completed.
  - Additional tests performed Q3 2014, including test with DSEU EM & SW v0.1.
  - Drill EQM modifications of Drill clamps and on Drill tip completed and proven through additional vibration test.
- ALD:
  - SPDS QMs manufacturing almost completed (DRBs June 2015)
  - Testing with ALD DSEU EM (electronics & SW) successfully performed.
  - UCZ Structures/sealing & valves tests completed; PDR successfully completed.
  - ALD STM Structure under manufacture.

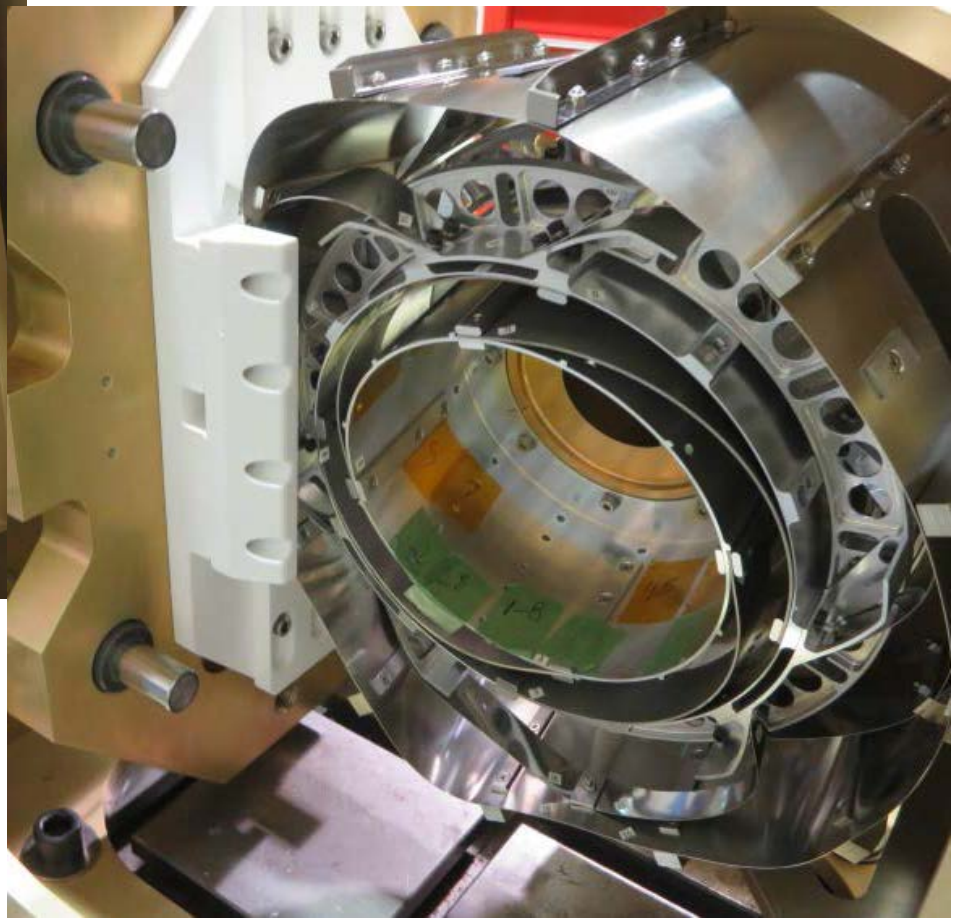
Rover Mobility/Autonomous Navigation test at ADS Mars Yard

Bogie Electro-Mechanical Assembly (BEMA)



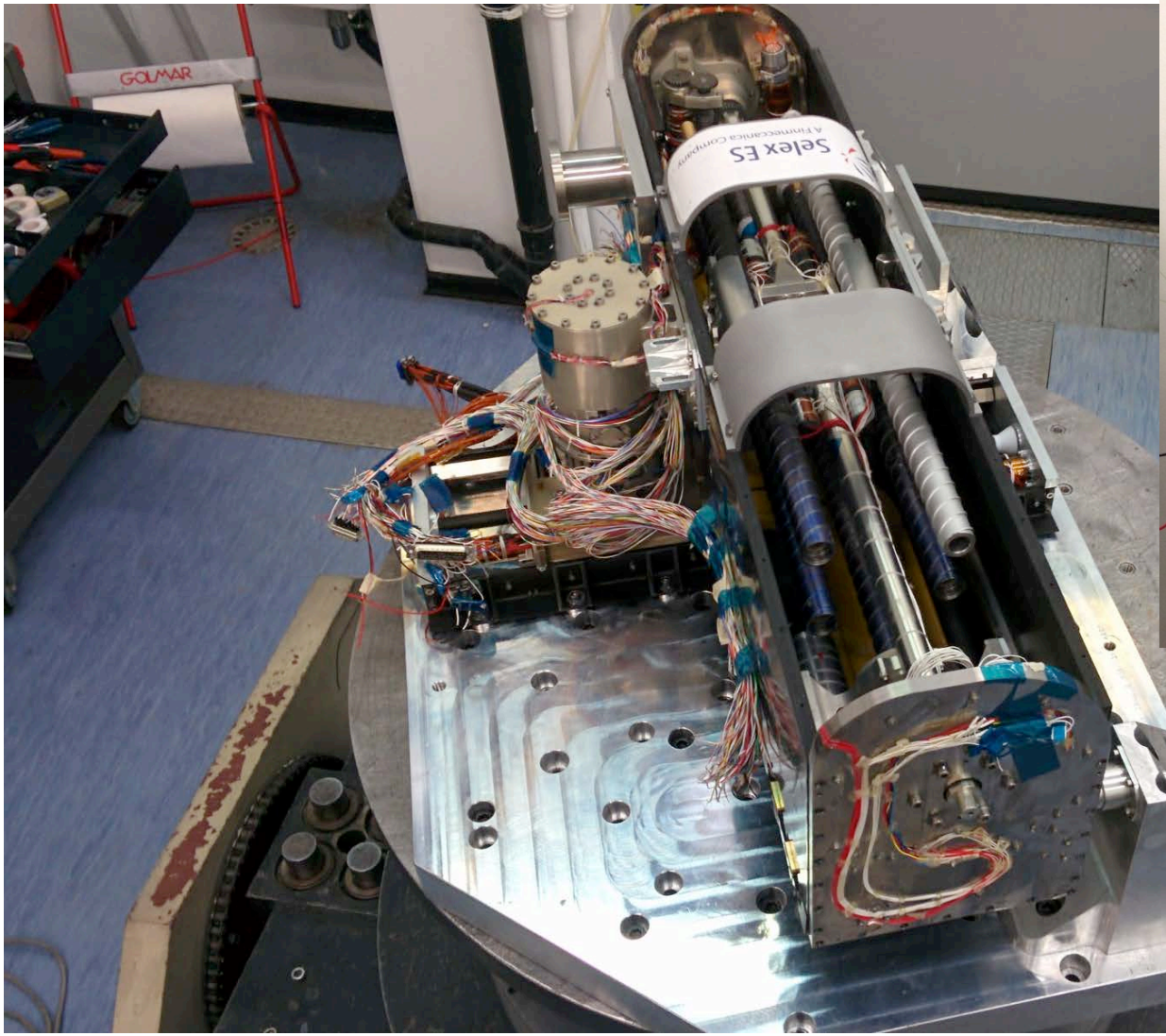
BEMA Wheels tests at MDA





ESA UNCLASSIFIED – For Official Use

Drill EQM on Vibration bench (April 2014)

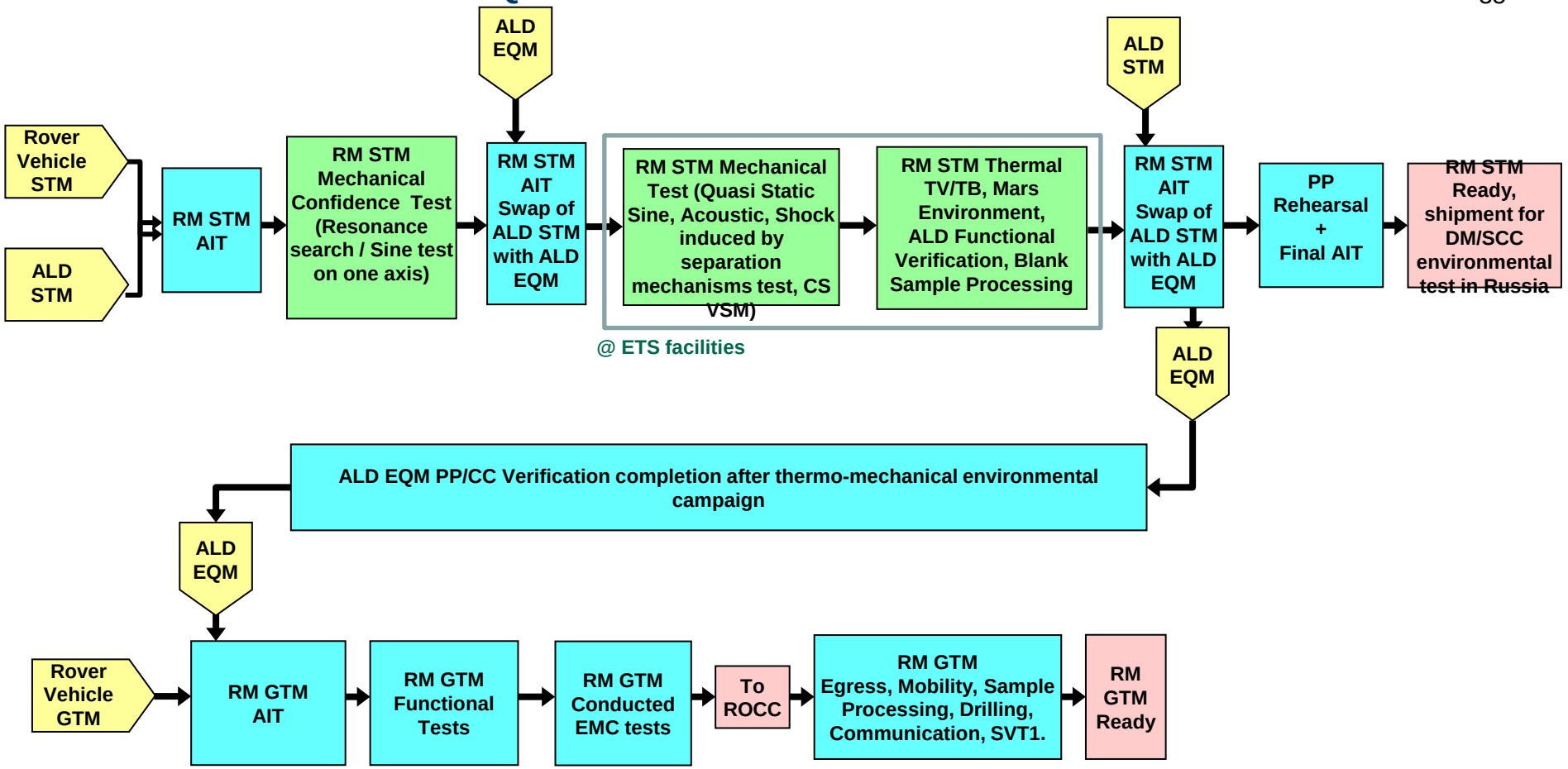


Major Rover development steps/events in last year

- **Progress in design & development**
  - PDR process almost completed
    - Rover subsystems level
    - Scientific Instruments
  - CDR performed for BEMA, LHP, RVIS, Drill (DDR)
  - Drill QM assembly and qualification process start
  - SPDS STMs & QMs MRRs > QM DRBs in Q2 2015
- **Technology and test**
  - Autonomous Navigation (VisLoc SW and cameras)
  - Cold electronics (ADE) technology validation (TRL-5)
  - TCS technology validation (LHP manufacture for STM)
- **Consolidation of Rover to Landing Platform interfaces (RM to DM IRD, to be signed end of May 2015 between TAS-I and LAV)**
- **2018 DM DR & 2018 S/C S-PDR successfully closed**
- **2018 C/D/E1 Industry Proposal**
  - **First Proposal in October 2014 not accepted**
  - **New Proposal expected by May 2015**

Back up Slides

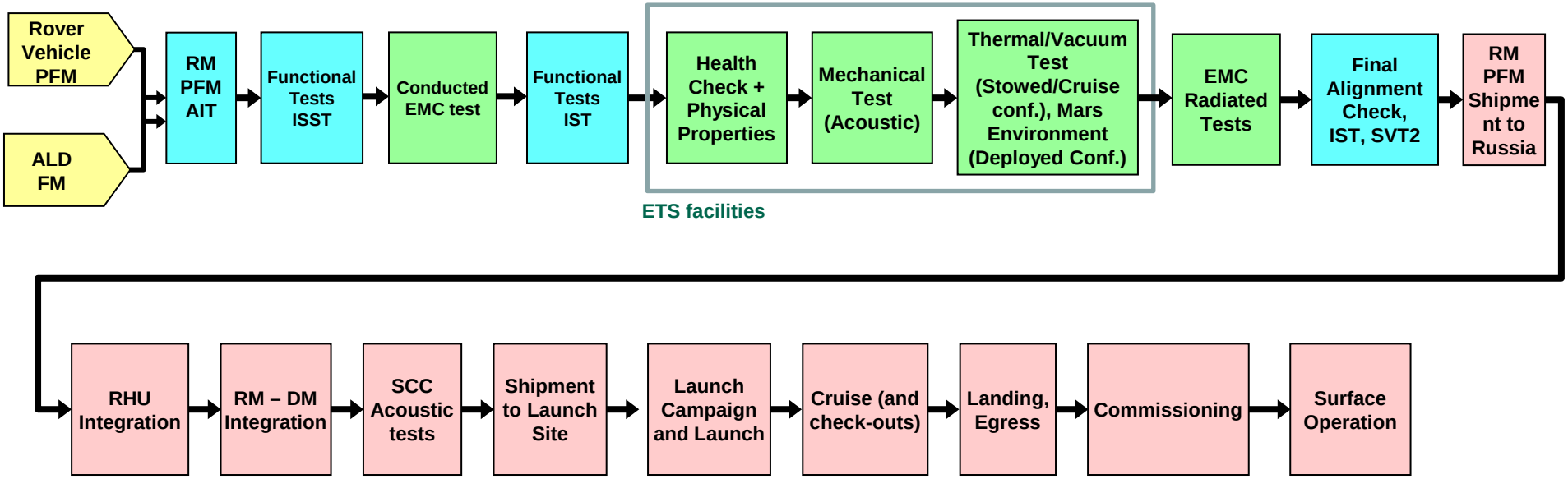
Rover STM – ALD QM - GTM AIT flow



Note: Health Checks between steps are included even if not specifically mentioned by this summary overview.

ESA UNCLASSIFIED – For Official Use

Rover PFM AIT flow



Note: Health Checks between steps are included even if not specifically mentioned by this summary overview.

ESA UNCLASSIFIED – For Official Use