ExoMars Rover Vehicle

Development of the ExoMars Rover for Mars Planetary exploration

Seminário “ESPAÇO: A Contribuição Portuguesa em Investigação e Desenvolvimento”

IST, Lisboa, 12 de Abril 2011

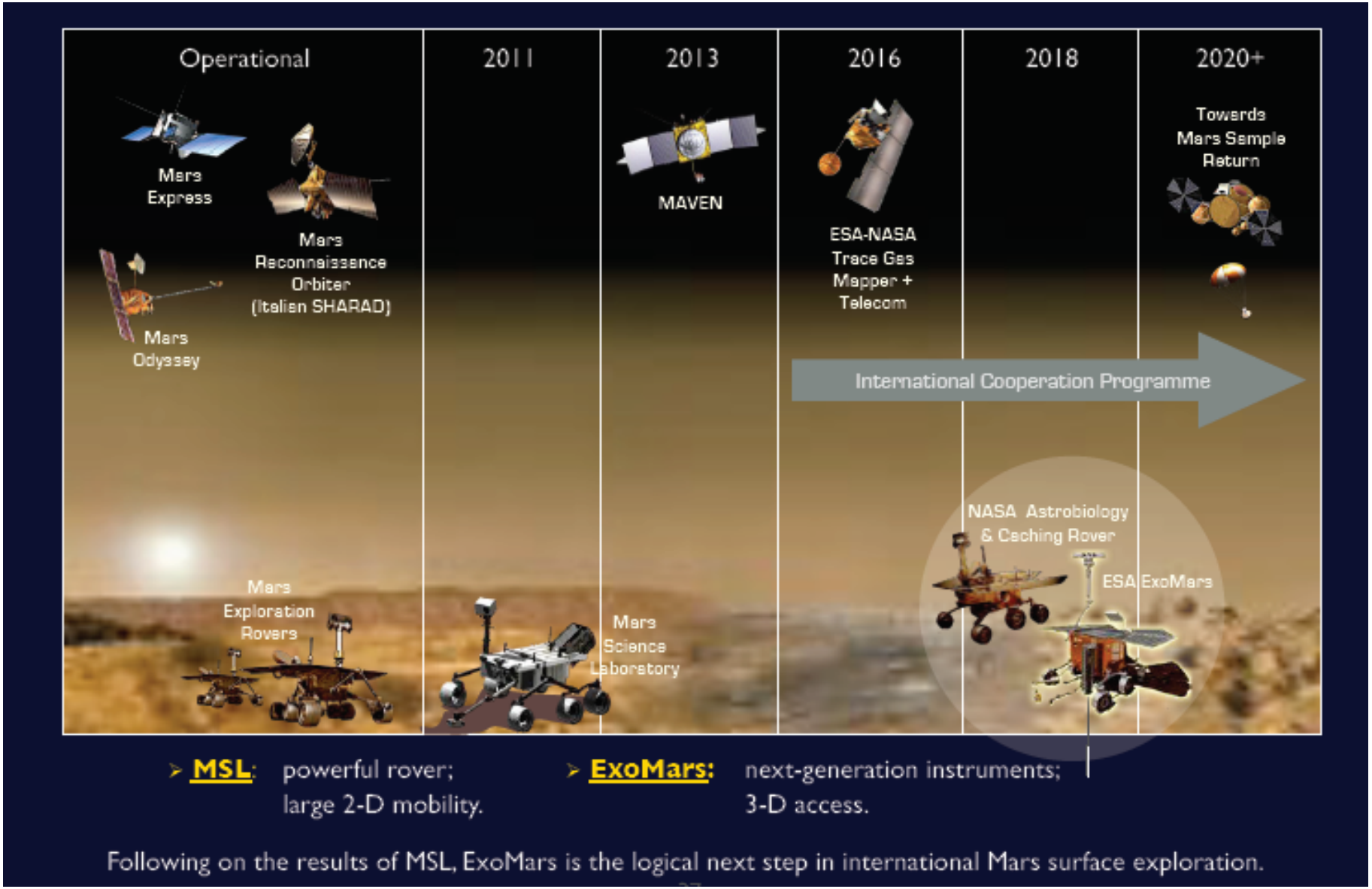
Nuno Silva

Mas antes de Marte: *Automated Transfer Vehicle*
A maior contribuição Europeia para vôos habitados

ATV1: Jules Verne

ATV2: Johannes Kepler

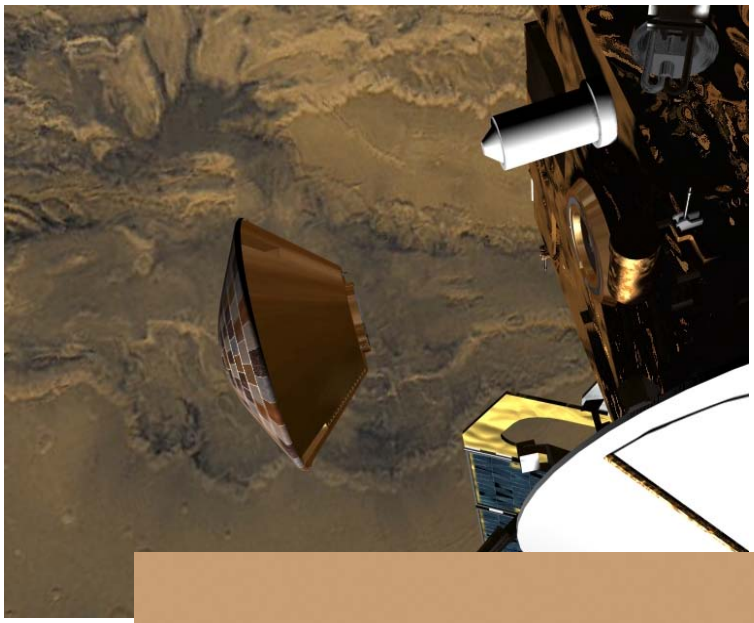
Exploration Road-map

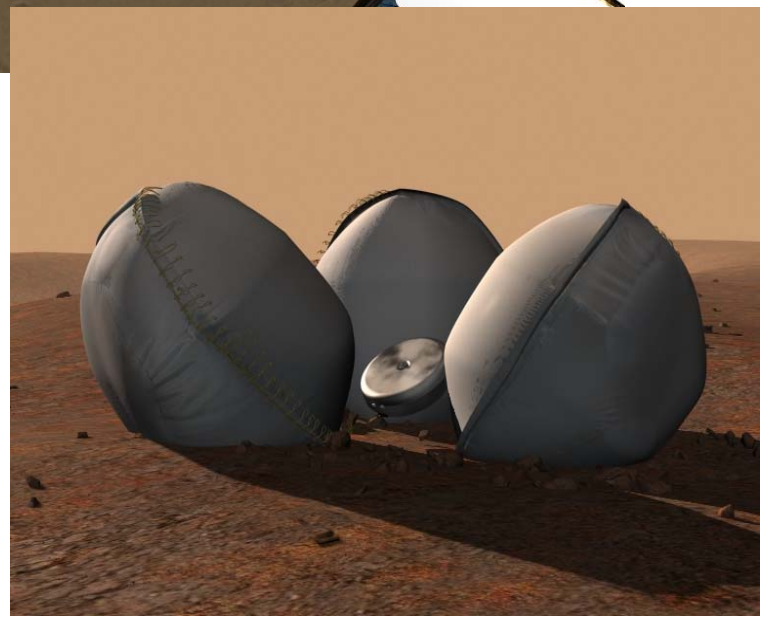


The Beagle2 Mission

Mission Goals:

- Chemical traces of Life
- Subsurface sampling (mole)
- Environment (meteorological) monitoring
- Stereo cameras
- Surface UV Flux
- 180sols design lifetime





ExoMars – An European Mission

First mission of the ESA Exploration Programme

Mission Goals

- **Science**
  - Search for signs of life (past and Present)
  - Investigate water/Geological environment
  - Investigate Martian Atmospheric gas traces and sources

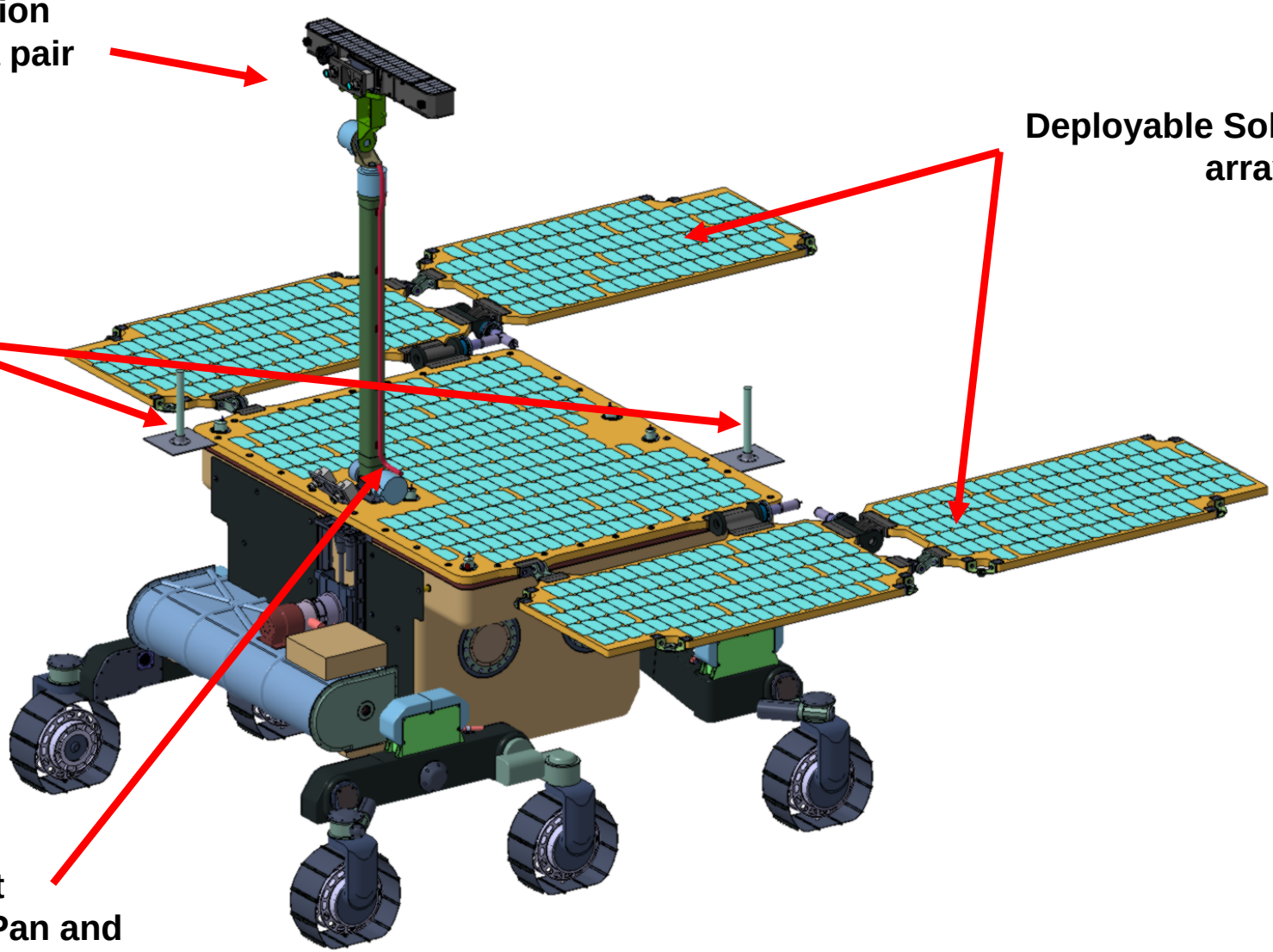
- **Technical**
  - Entry Descent and Landing of a payload on Mars
  - Surface Mobility with a rover
  - Access to sub-surface to acquire samples
  - Sample acquisition, preparation and analysis

Total Program (2016+2018) value of ~1Bn€…

Austria
Belgium
Germany
France
Italy
Netherlands
Norway
Portugal
Spain
Sweden
Switzerland
United Kingdon
Canada

Partilha/Cooperação ESA/NASA: em mudança

Rover Vehicle Configuration

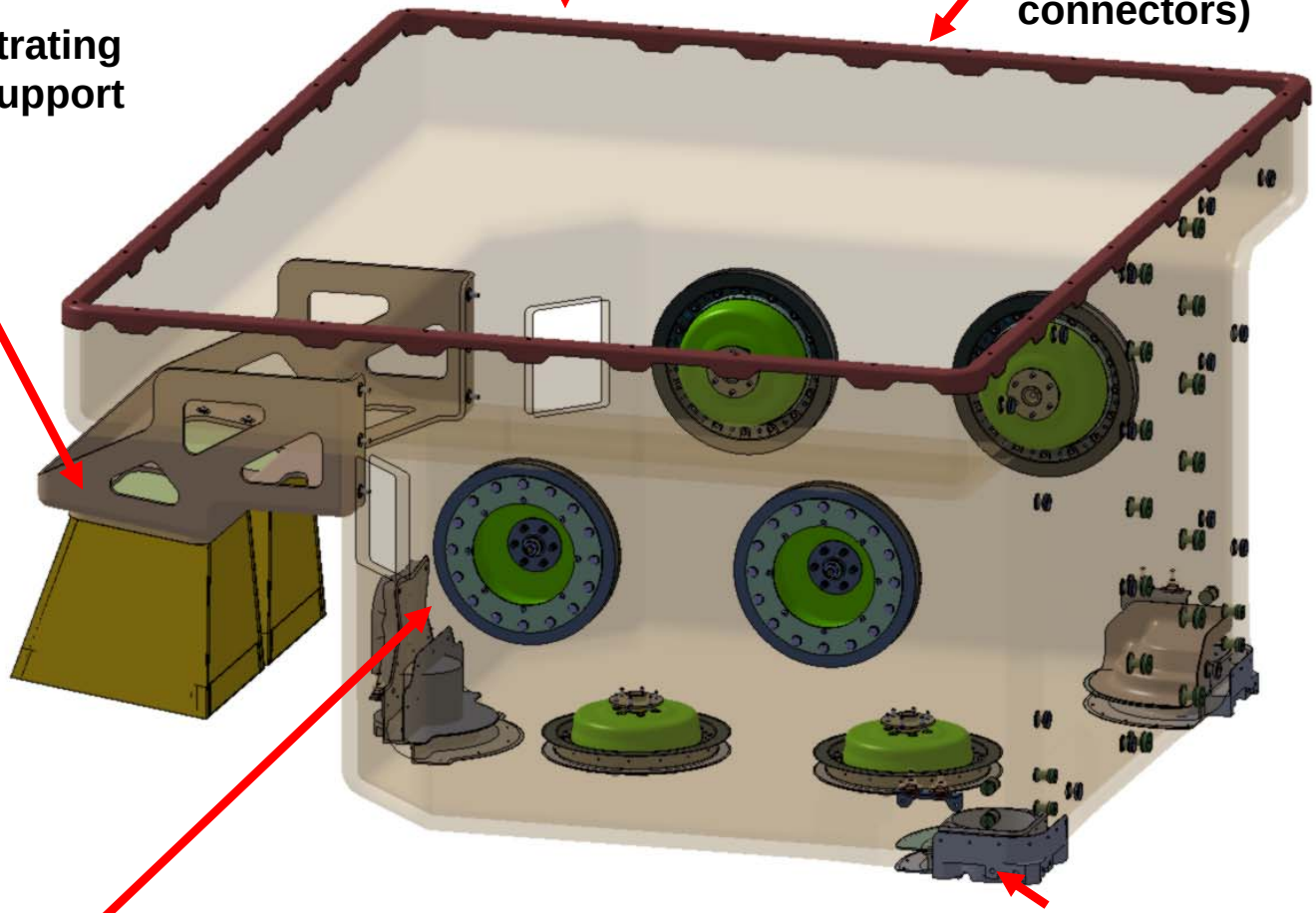


Body Structure

Edge capping – solar array & bio-seal interface

Potted inserts (e.g. for bulkhead electrical connectors)

Ground Penetrating Radar Horn support bracket

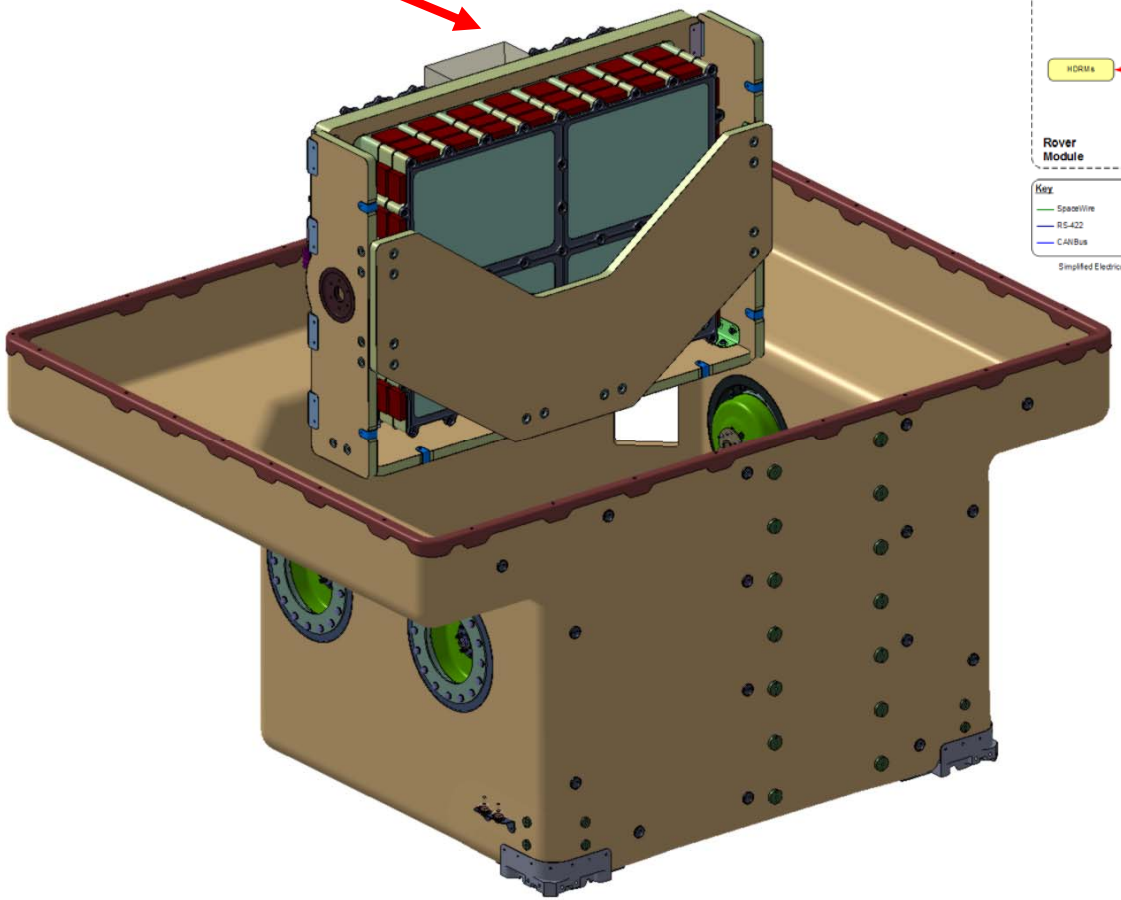


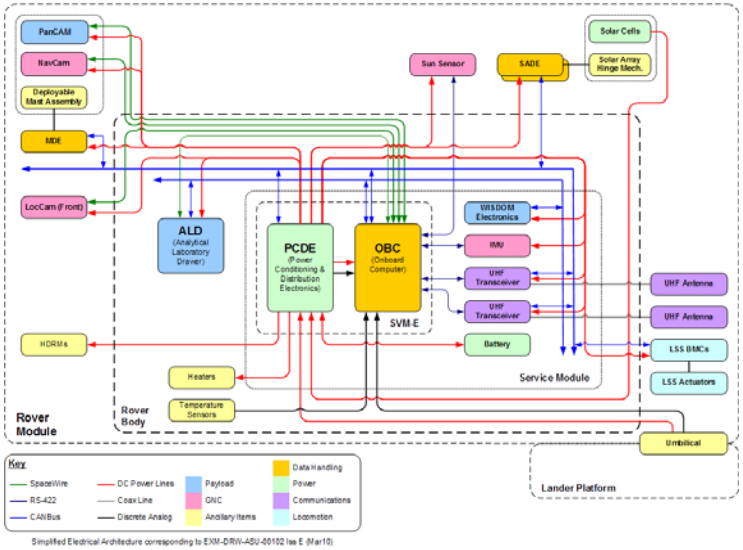
Iso-static mounts (6)

Bonded titanium alloy fittings for hold-down mechanisms / locomotion bogie attachment

Rover Vehicle E-SVM Configuration

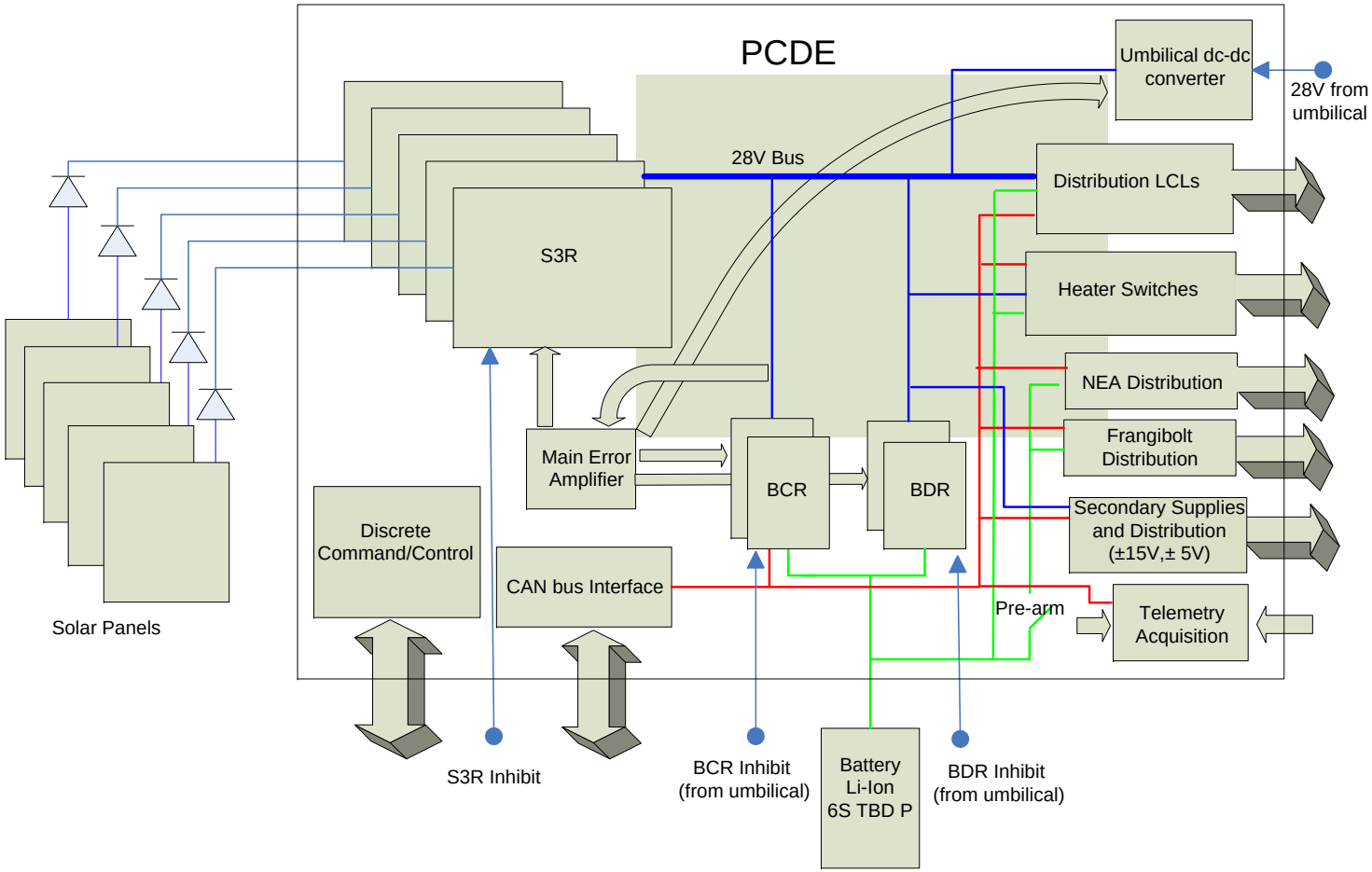
Electrical Service Module





Simplified Electrical Architecture corresponding to EXM-DRW-ASU-00102 Iss E (Mar10)

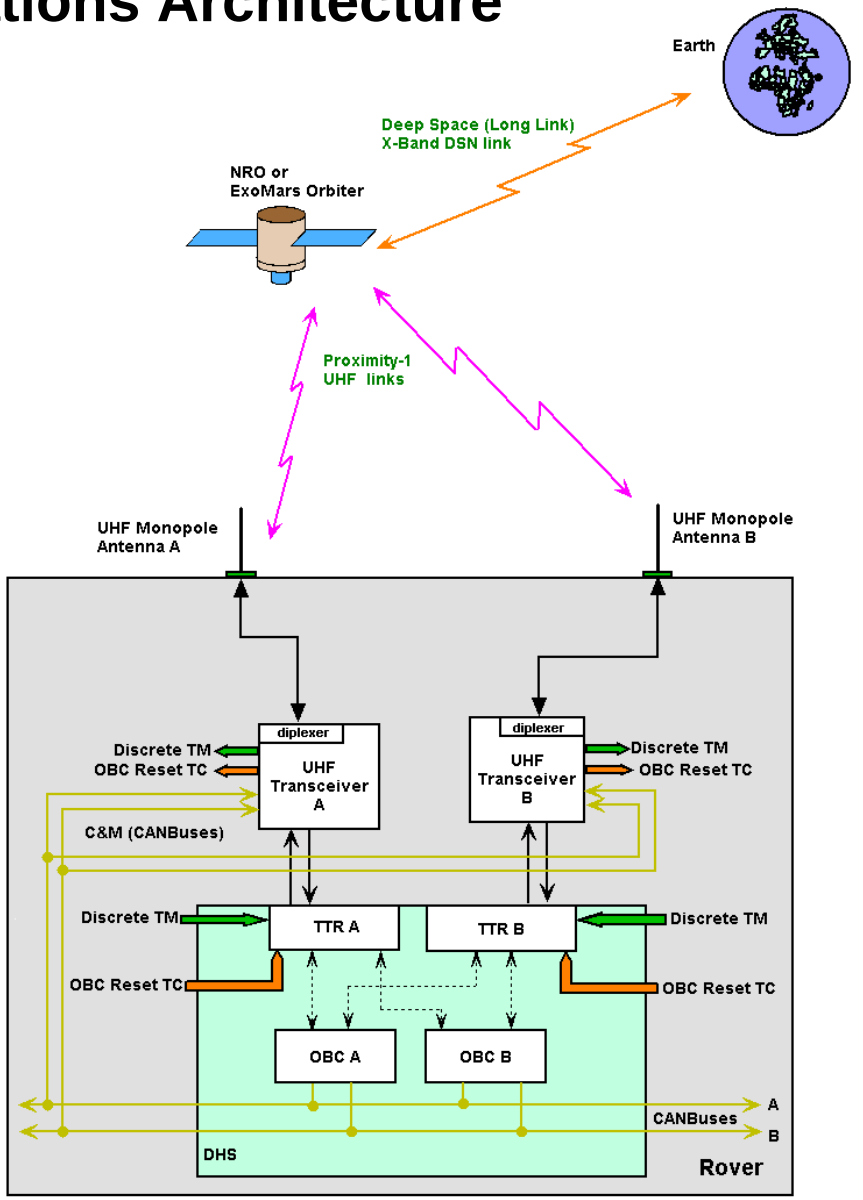
Power Sub-system Architecture



- **Battery**
  - li-Ion
  - Isolator Switch
  - Direct Negotiation
- **Solar Panels**
  - 2.5m^2 total area
  - Total of 5 panels
  - ~ 300watts
- **PCDE**
  - Direct Energy Transfer
  - LCL's 20+20

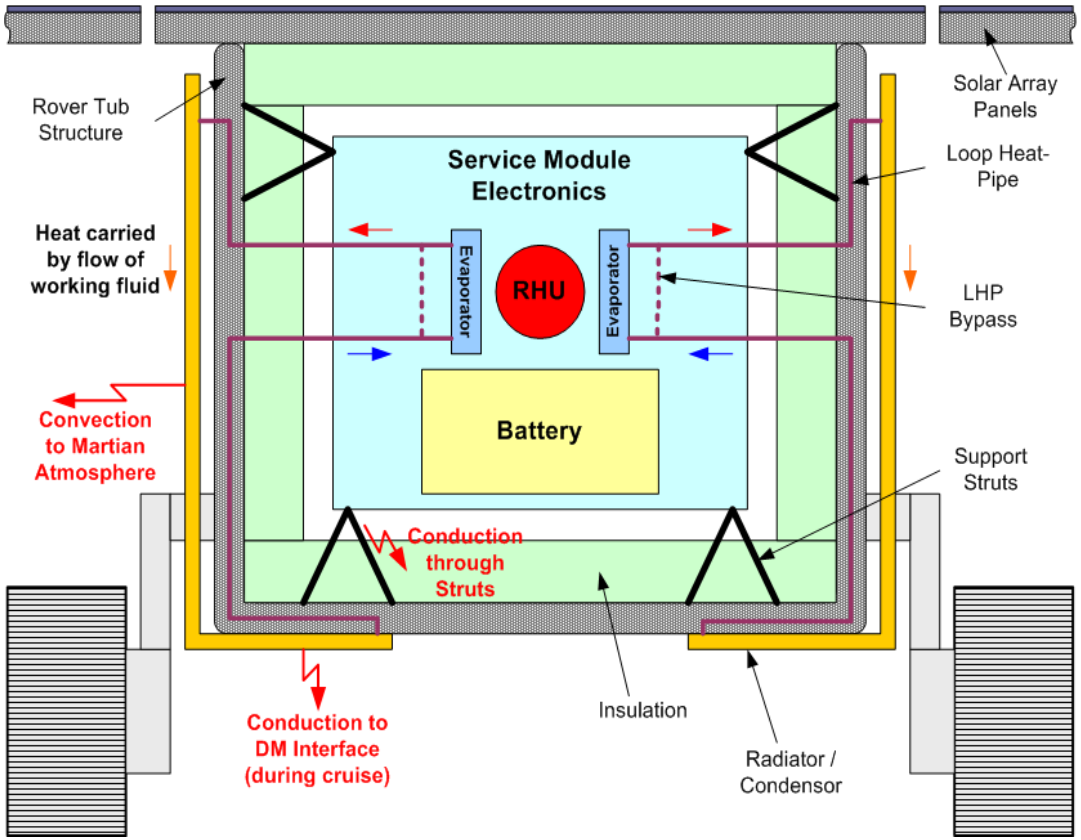
Communications Architecture

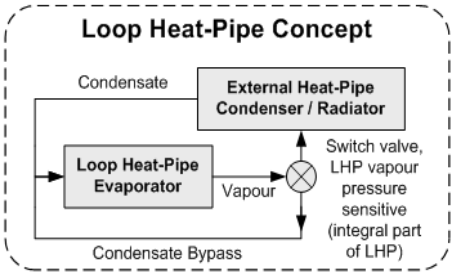
- **UHF**
  - Redundant UHF Transceiver
  - Redundant RF Path
  - Proximity-1 standard
  - 2 Monopole UHF antennae
- **Status**
  - UHF Transceiver Supplier selected

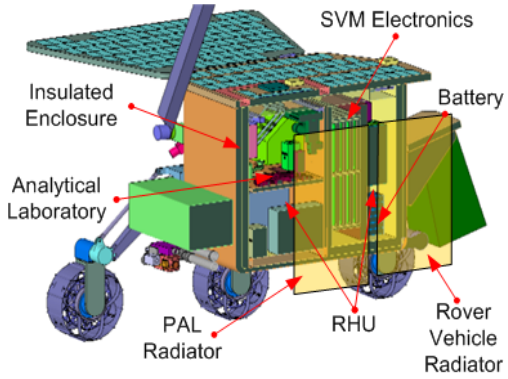


Communication System Architecture Block Diagram

Thermal Subsystem







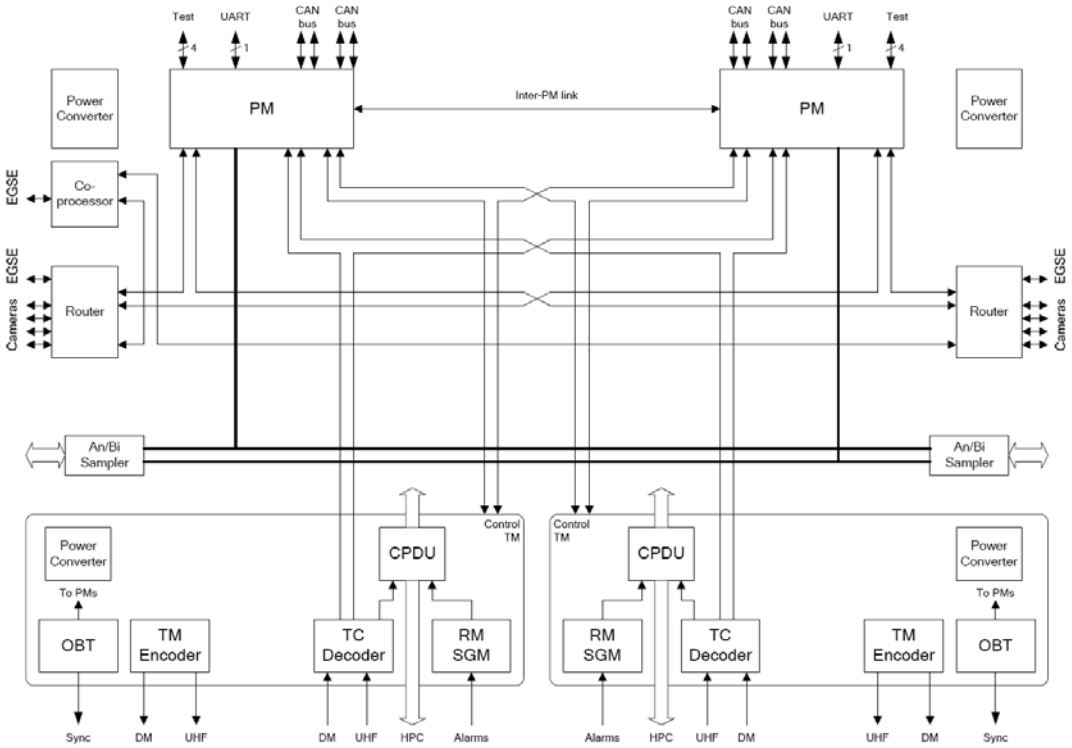
- **Loop Heat Pipe system (~15watt)**
- **Standard Heater elements (mats, etc) supporting electronic control loops**

Onboard computer

- **Core Module**
  - LEON based processor
  - 512MB SDRAM
  - CAN databus, RS 422 I/F
  - RTEMS O/S
  - OBC reconfiguration
  - On Board Time

- **Navigation Computer & Mass Memory**
  - LEON based algorithm co-processo
  - 16GB of Flash Memory
  - 512MB SDRAM
  - EDAC protection
  - SpW for high speed instruments
  - SpW routing network

- **Power supply and Interface module**
  - High priority telecommand to PCDE
  - HKTM acquisition
  - Internal secondary voltages



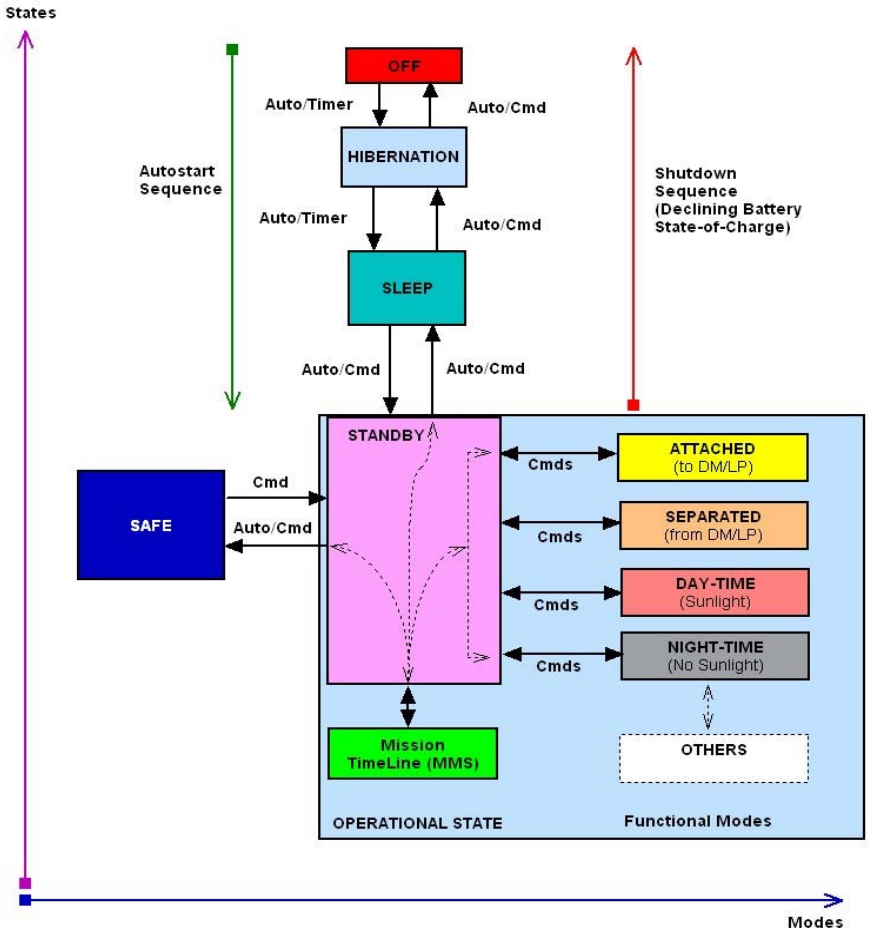
Development Model delivered to Astrium

Onboard SW and Operations

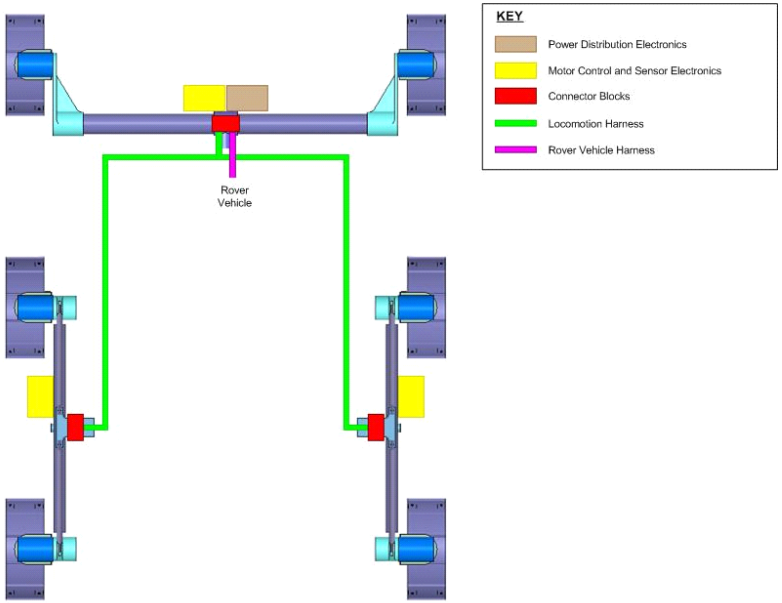
- **Software Requirement for Version 1 complete**
  - V1 Implementation about to commence
- **Architecture and Requirements Definition for V2**

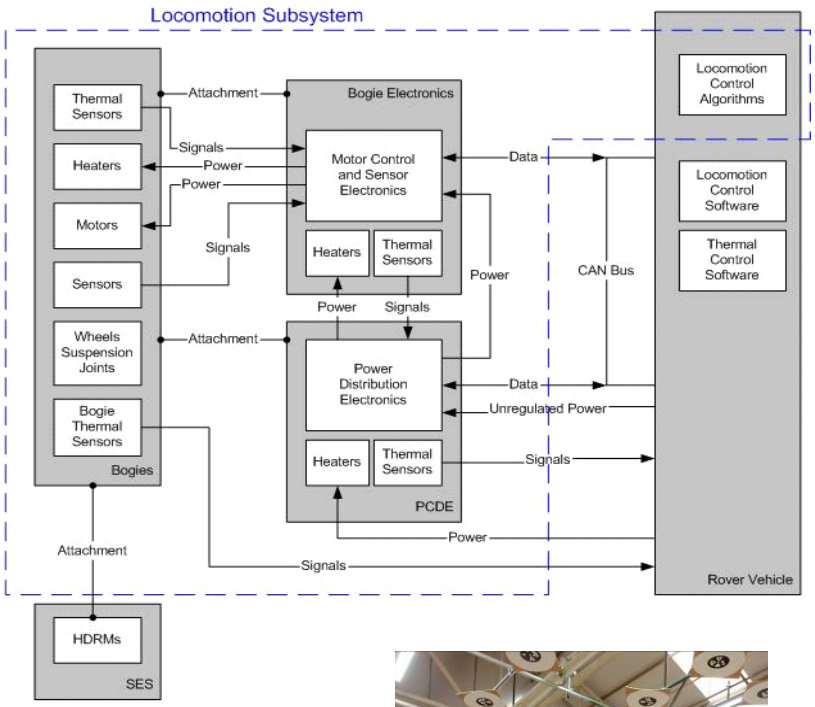
- **Rover Vehicle Software Features:**
  - RTEMS OS
  - Data Handling Software (providing PUS TC/TM service functionality and some architectural services)
  - On-Board 'File Management' (image storage & retrieval etc)
  - OBCP Interpreter
  - Vehicle Application SW to perform vehicle locomotion control, localisation data processing, 'platform level' management (thermal, power etc)
  - 4 SW versions expected developed using the C language

- **Software subcontracting**
  - To be released as 3 separate Subcontracts (Tranches)
  - Sub-Contracting at System level and Code level
  - Subcontractor will be responsible for the code and unit test activities Integration support to Astrium
  - Co-Engineering development approach to maintain efficient risk managed process



Locomotion Subsystem





- **6 wheel, 21 DOF system**
- **Includes Electronics Drive system**
- **Flexible wheels baselined**
- **Building on existing BB activities**

GNC Equipment

NavCam

Sun Sensor

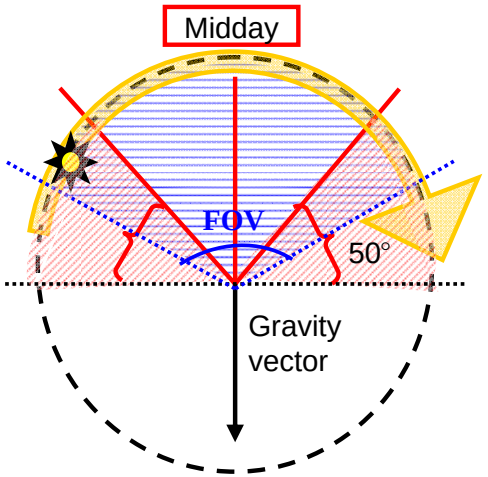
LocCam

IMU

GNC Functions - Localisation

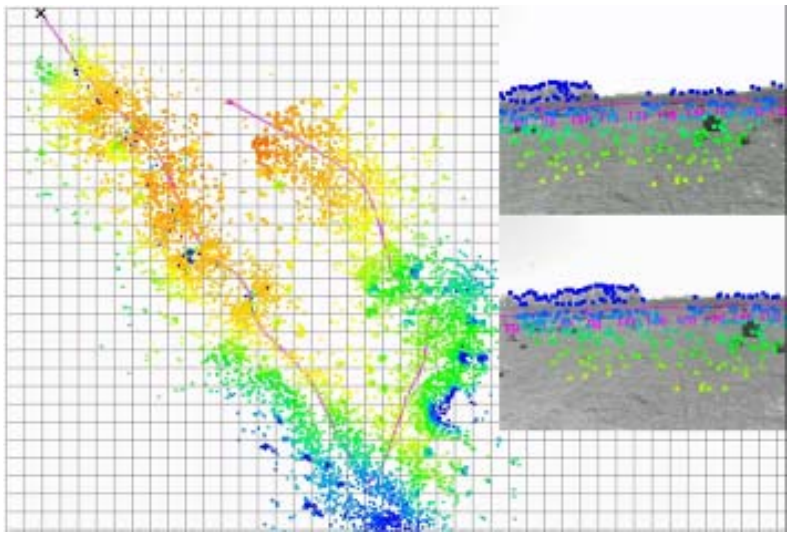
How is the Rover oriented?

- Sun and gravity direction measurements are compared against a reference
- This allows knowing the heading (where is North) and the tilt (angle with vertical) of the Rover
- Performed when the Sun elevation is low (Rover static)

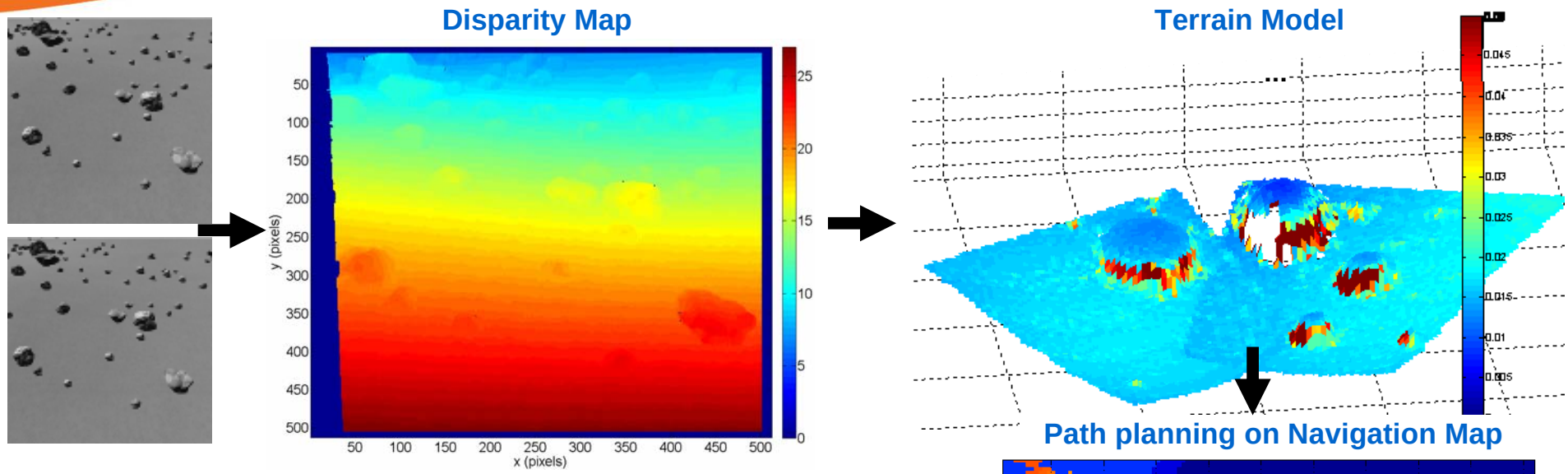


Where is the Rover?

- LocCam stereo images used to identify and track features as the Rover moves
- The way the features appear to move is used to deduce how the position and orientation of the Rover changed
- Wheel odometry and rate information used between visual frames



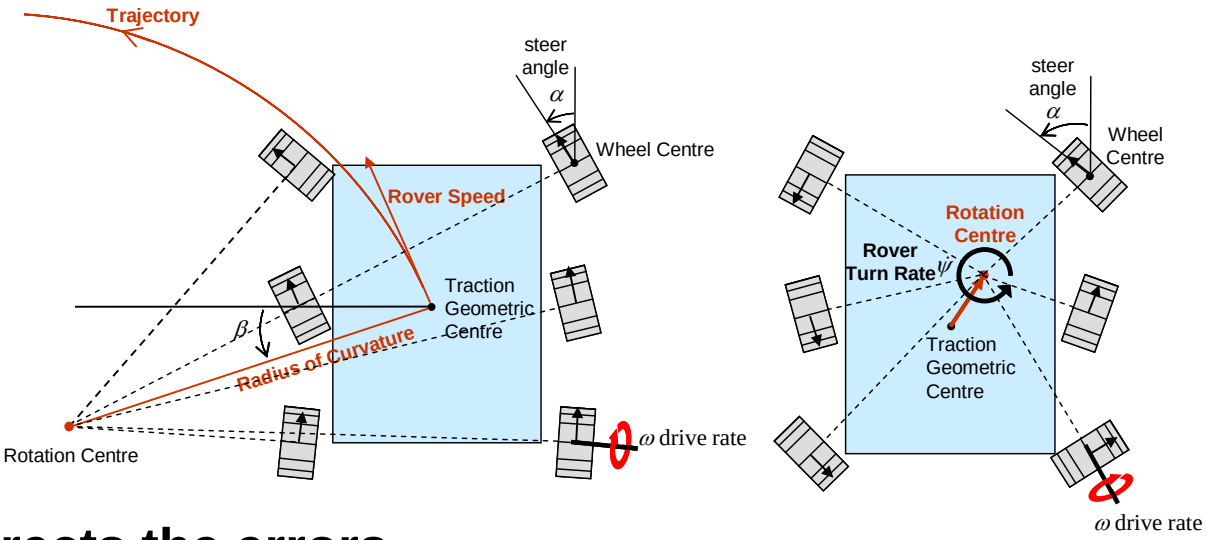
GNC Functions - Navigation



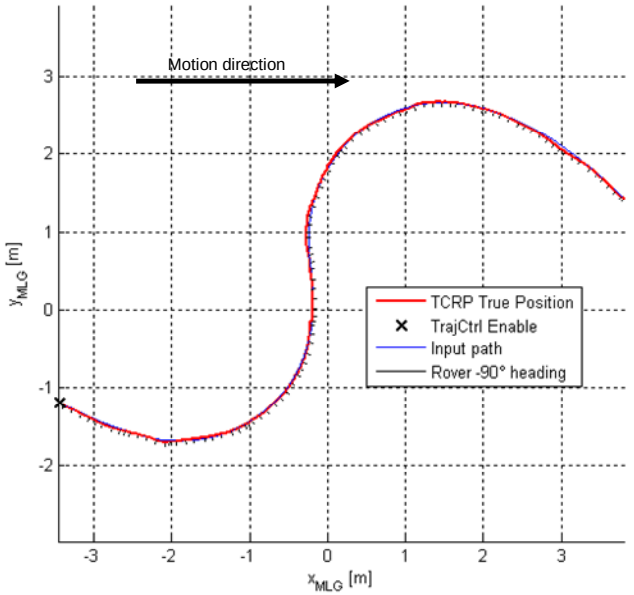
1. **Perception: produces a disparity map from NavCam Stereo Images**
2. **A 3D terrain model is built with estimation of uncertainties**
3. **A Navigation Map including forbidden areas and driving cost is produced**
4. **A path to the target is planned through the navigable areas with minimum cost**

GNC Functions – Trajectory Control

- **Makes the Rover follow a path by:**
  - Correcting lateral and heading errors

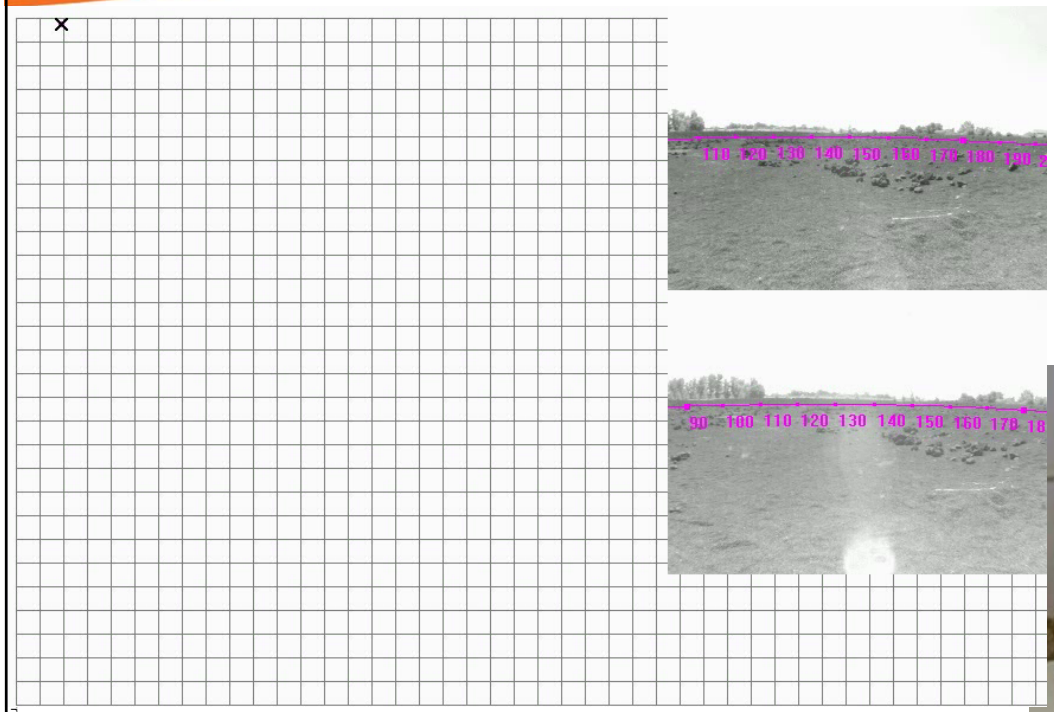


- **Using control laws it corrects the errors by sending corrective manoeuvres to the locomotion**
  - Generic Ackermann to accurately follow path
  - Generic Point Turn to accurately rotate around itself



- **It has a goal of minimising wearing of actuators**

Vídeos e perguntas



Visual Localisation

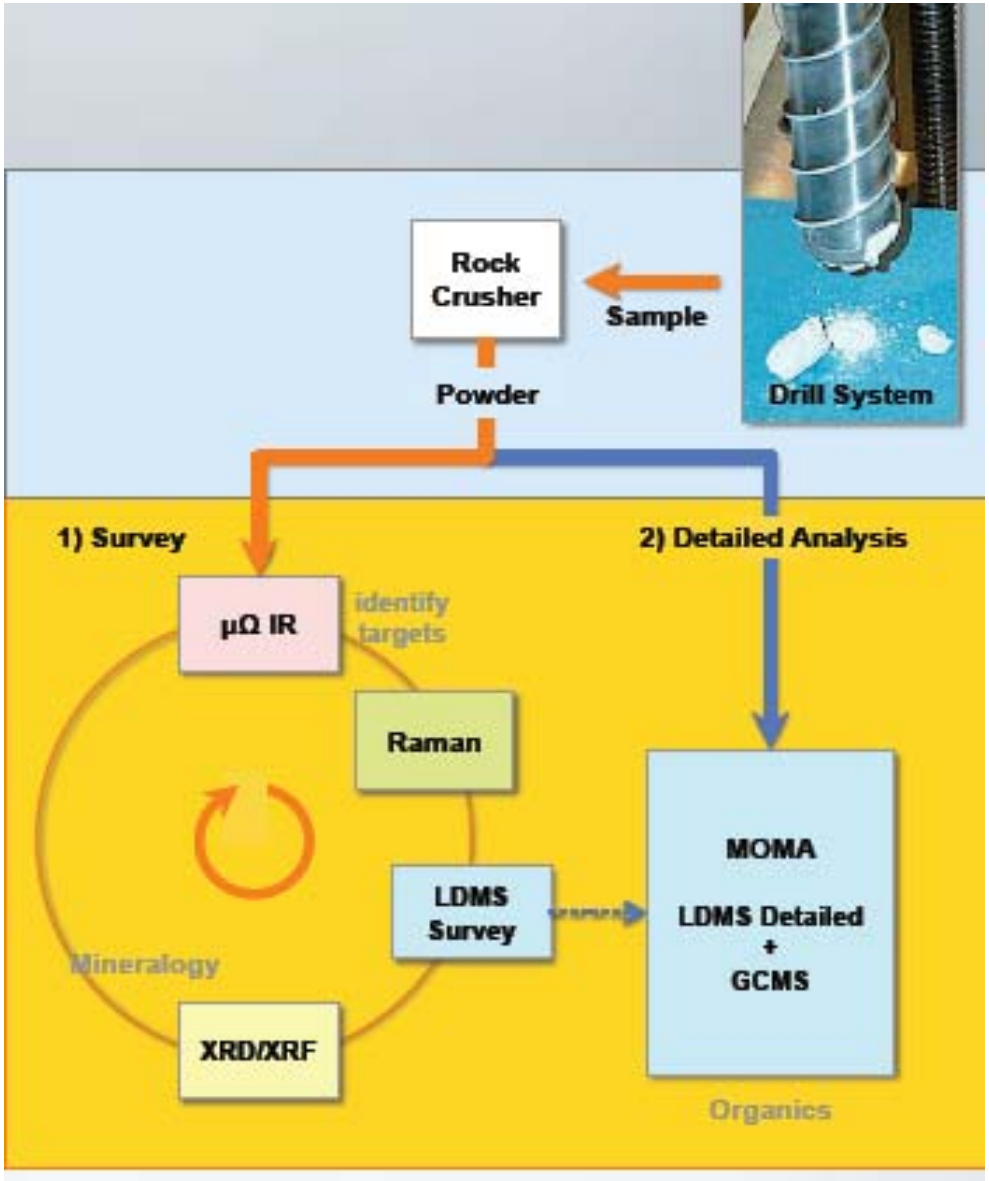
Trajectory Control

nuno.silva@astrium.eads.net

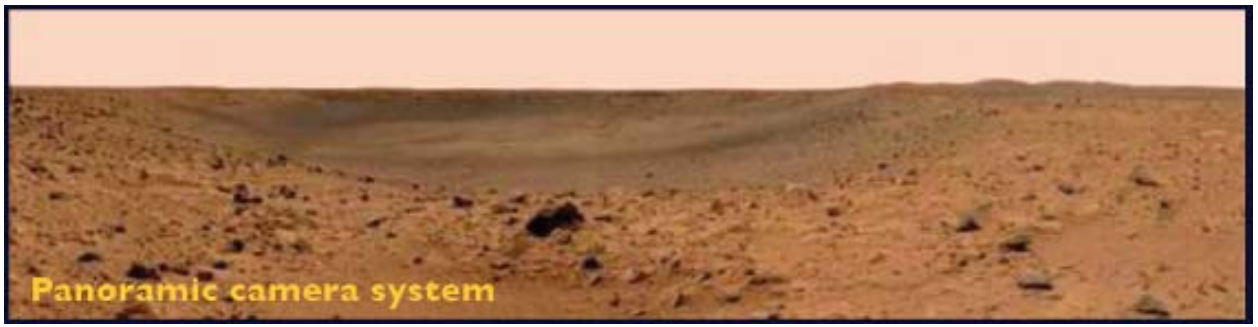
BACKUP SLIDES

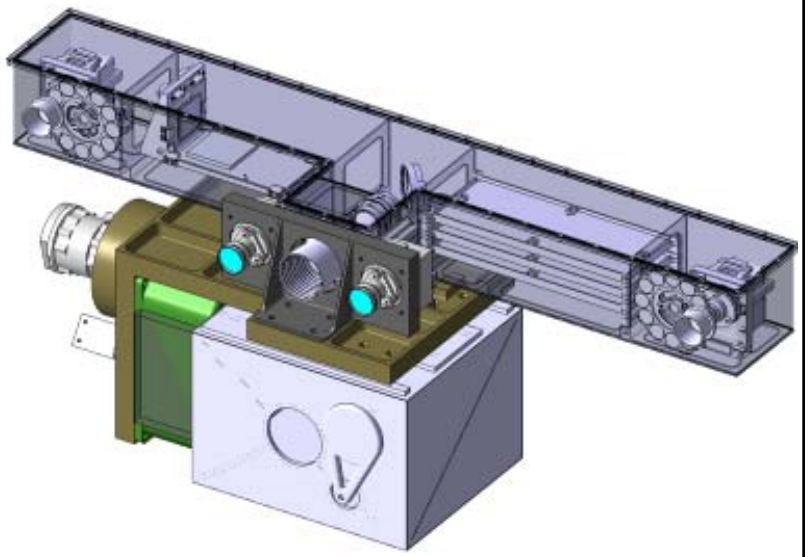
Science Payloads

- **ExoMars Mission flying 7 instruments within Rover**
  - PanCam
  - MOMA MicrOmega
  - Mars-XRD
  - Raman
  - Wisdom
  - Ma_Miss
- **Instruments (and teams) funded directly by each National Space agencies.**



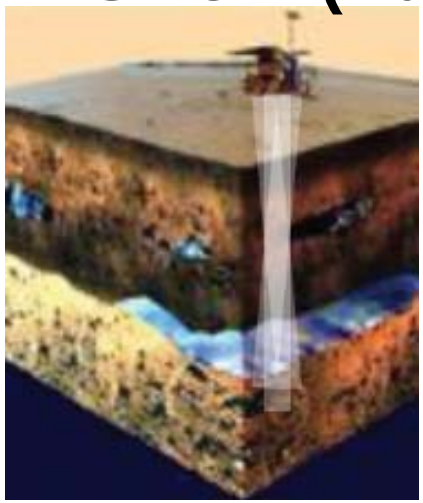
PanCam (Panoramic Cameras)





Led by Mullard Space Science Lab (UK)

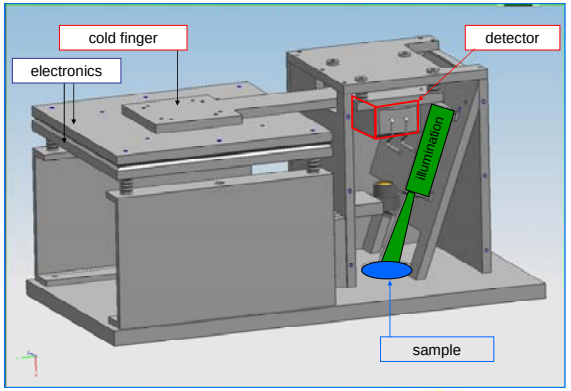
WISDOM (Radar)



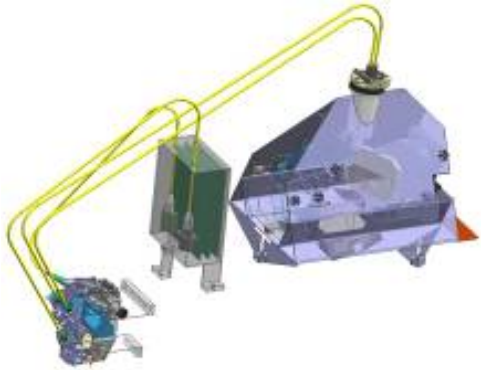
Led by LATMOS (F)

Instruments Internal

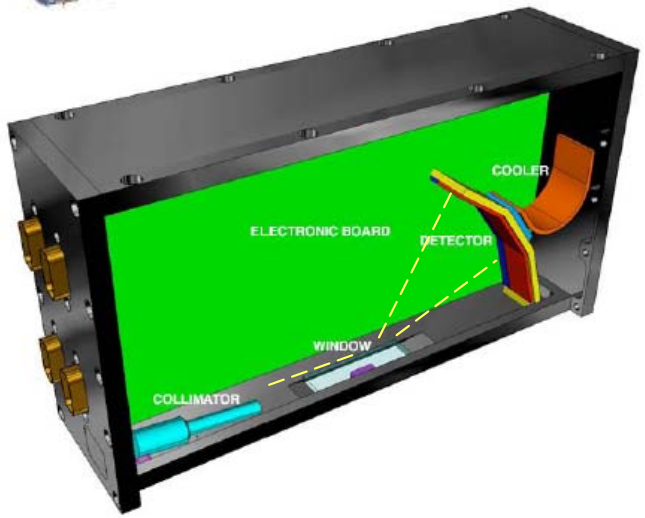
- **MicrOmega IR (Imaging instrument in IR)**
  - Analyses crushed samples
  - Mineral grain sizes =>for XRD/MOMA
  - Led by Institute of Astrophysics, Orsay (F)



- **Raman Spectrometer**
  - Laser based spectrometer
  - Provides geological and mineralogical context
  - Led by University Valladolid, (E)

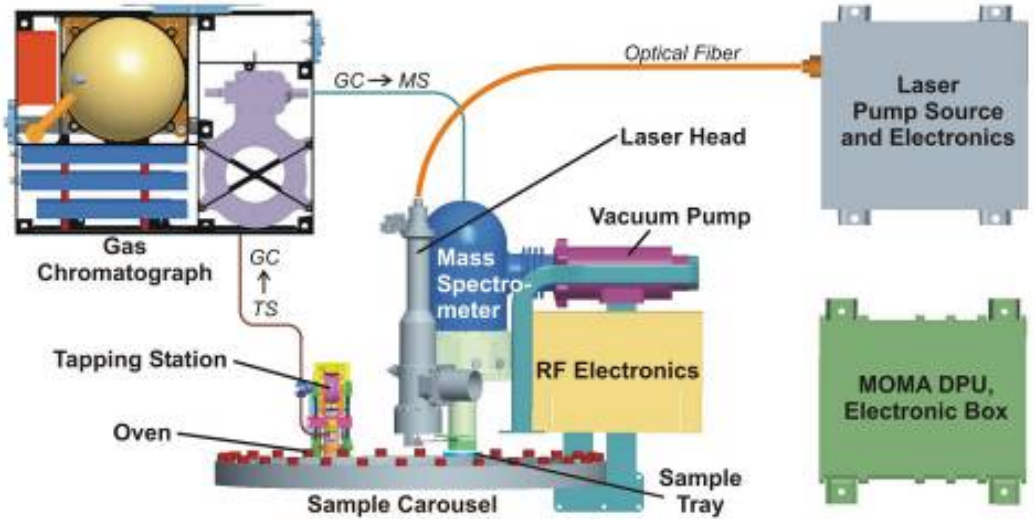


- **Mars-XRD (XRayDiffractometer)**
  - Focussed on silicate minerals such as clays and sulphates
  - Also contains an X-Ray fluorescence capability (useful atomic composition information).
  - Led by IRSPS (I)

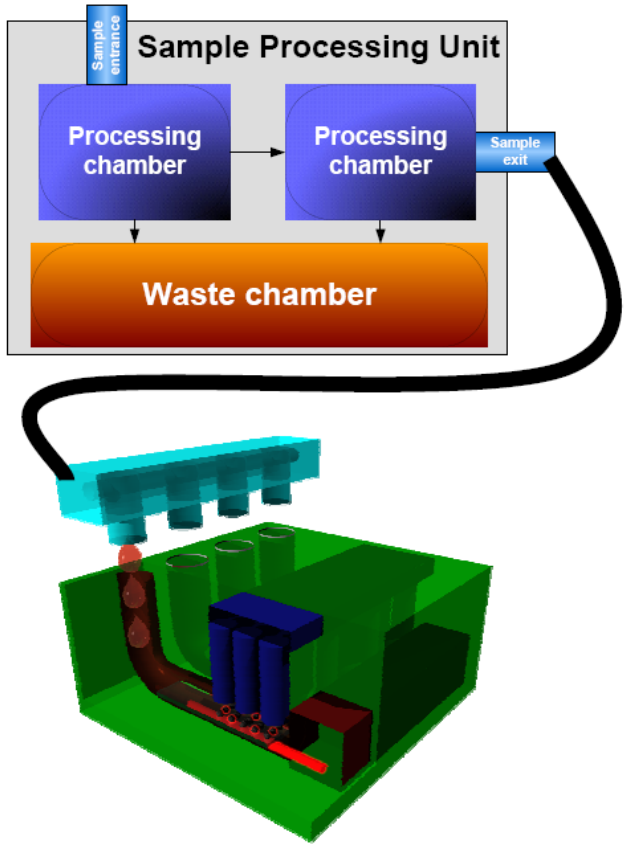


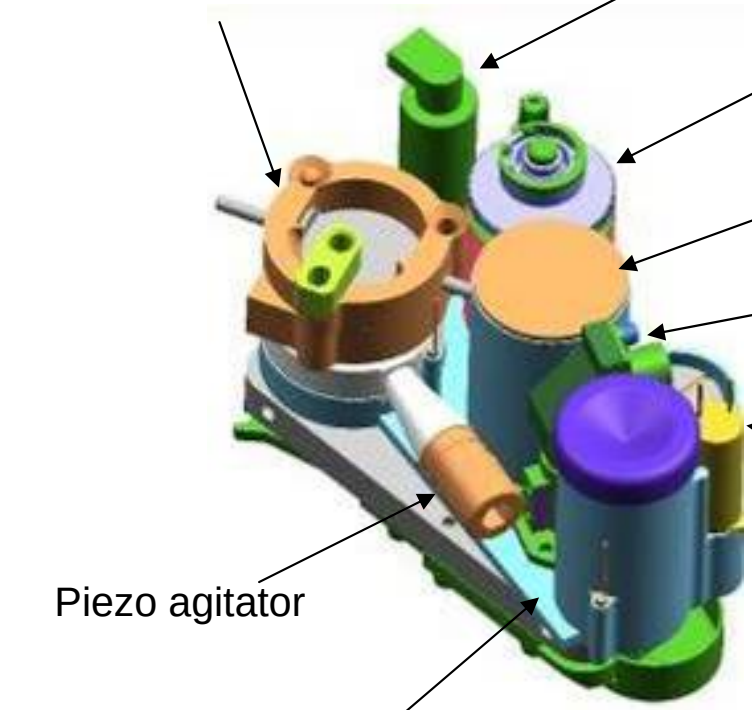
Internal Instruments

- **MOMA (Mars Organic Molecule Analyser)**
  - Largest Instrument in Rover
  - Directly targeting biomarkers
  - Both atmospheric gases, and subsurface samples
  - Led by John Hopkins University (USA)



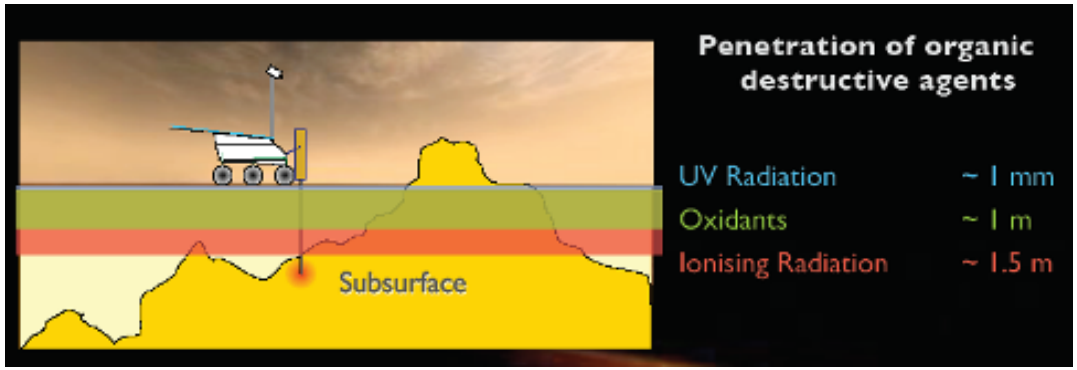
Internal Instruments – Life Marker Chip



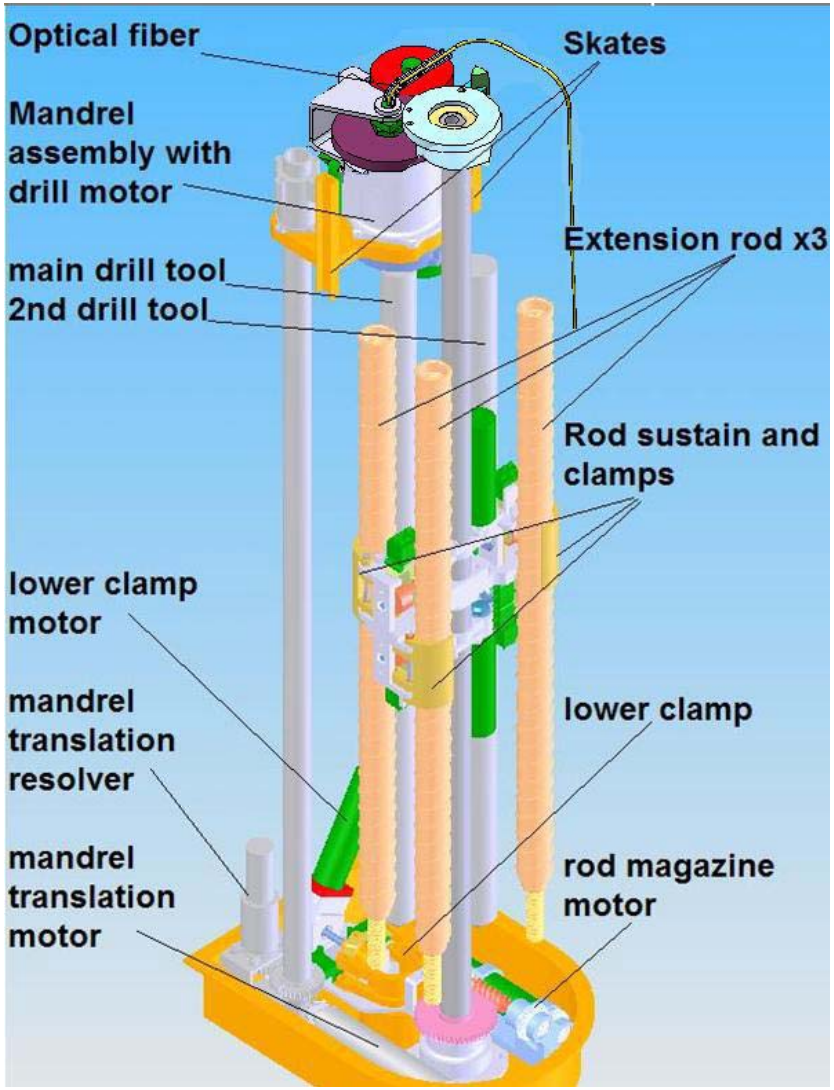


University of Leicester (UK)
Cranfield University (UK)
Magna Parva (UK)
Surrey Satellite Technology Ltd (UK).
Imperial College (UK)
Dutch Space (NL)
Lionix (NL)
DLR (D)
Kayser Italia (I)

Drill System

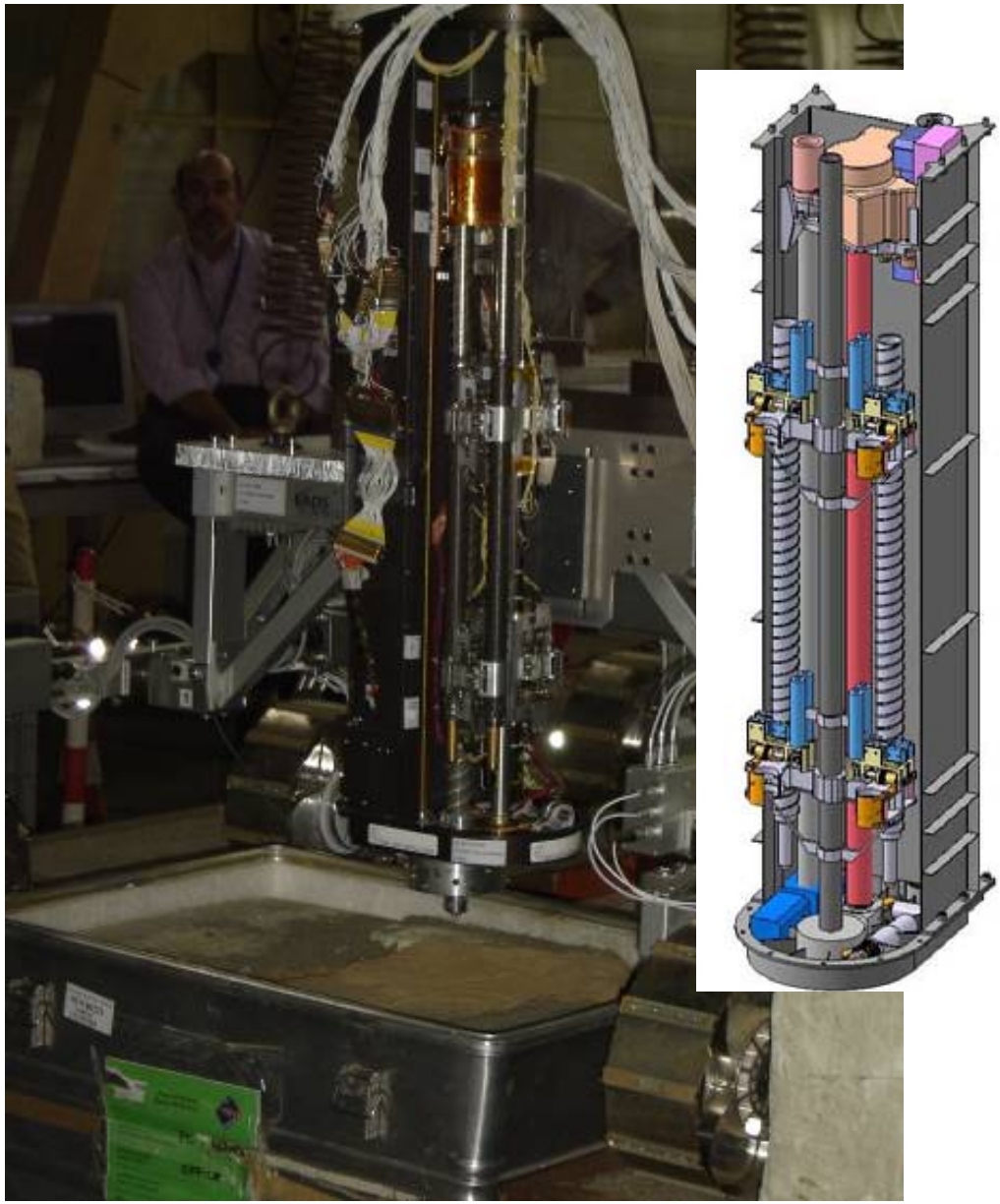


- **Bore-hole IR camera “Ma-Miss”**
  - Fibre-optic feed from Drill to in-board detector
  - Observing within drill hole <50cm depth
  - Imaging and spectra by reflectance in near-IR (0.8-2.8um)
  - Led by National Institute of Astrophysics, Rome (I)

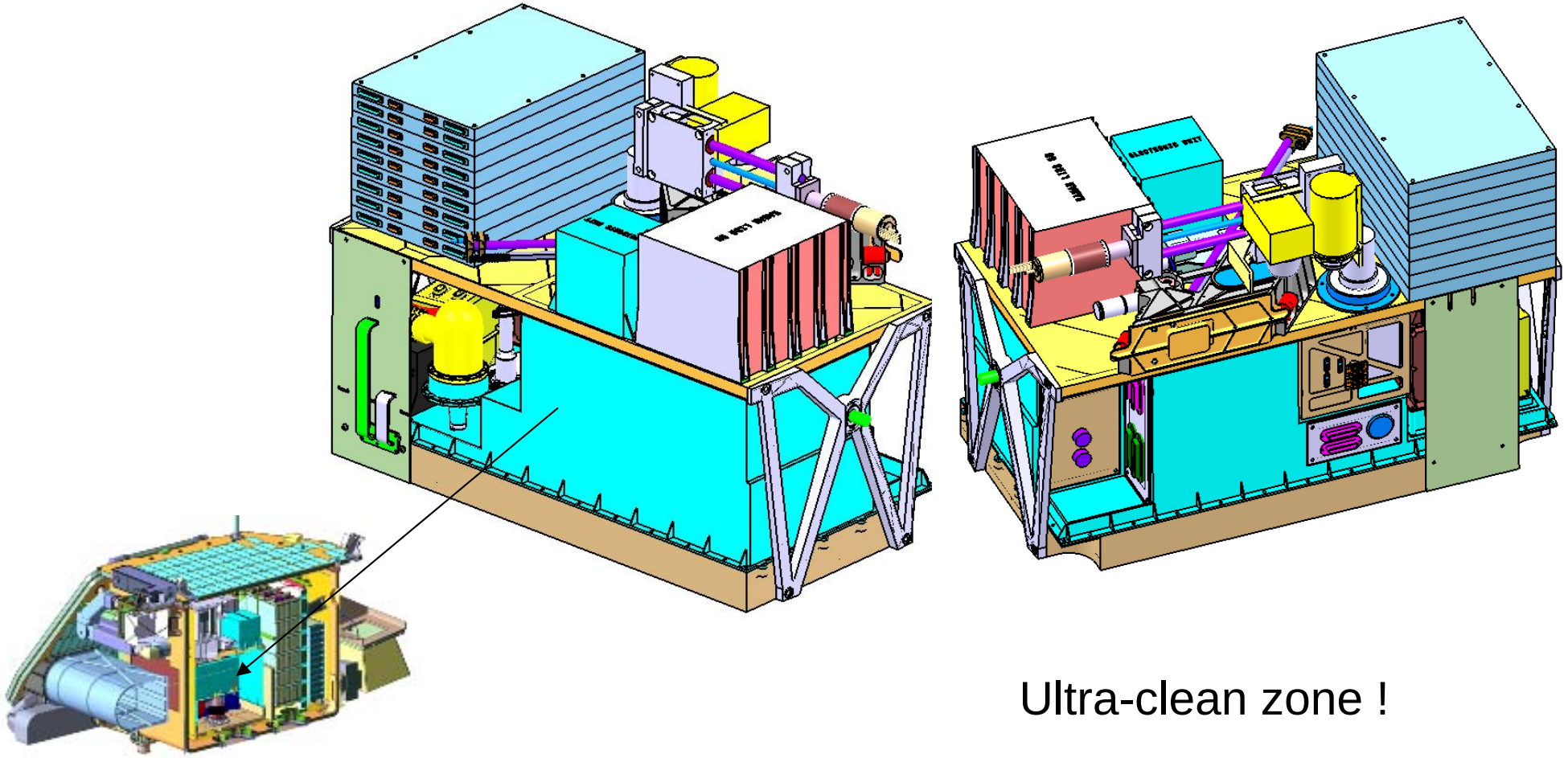


Drill System

2m drill



Analytical Laboratory Drawer (ALD)



Ultra-clean zone !

Inside the Analytical Laboratory Drawer