European Space Agency
human spaceflight

ESA Exploration Programmes from ISS to Lunar Lander

8th International Planetary Workshop
Portsmouth, 6-10 June 2011

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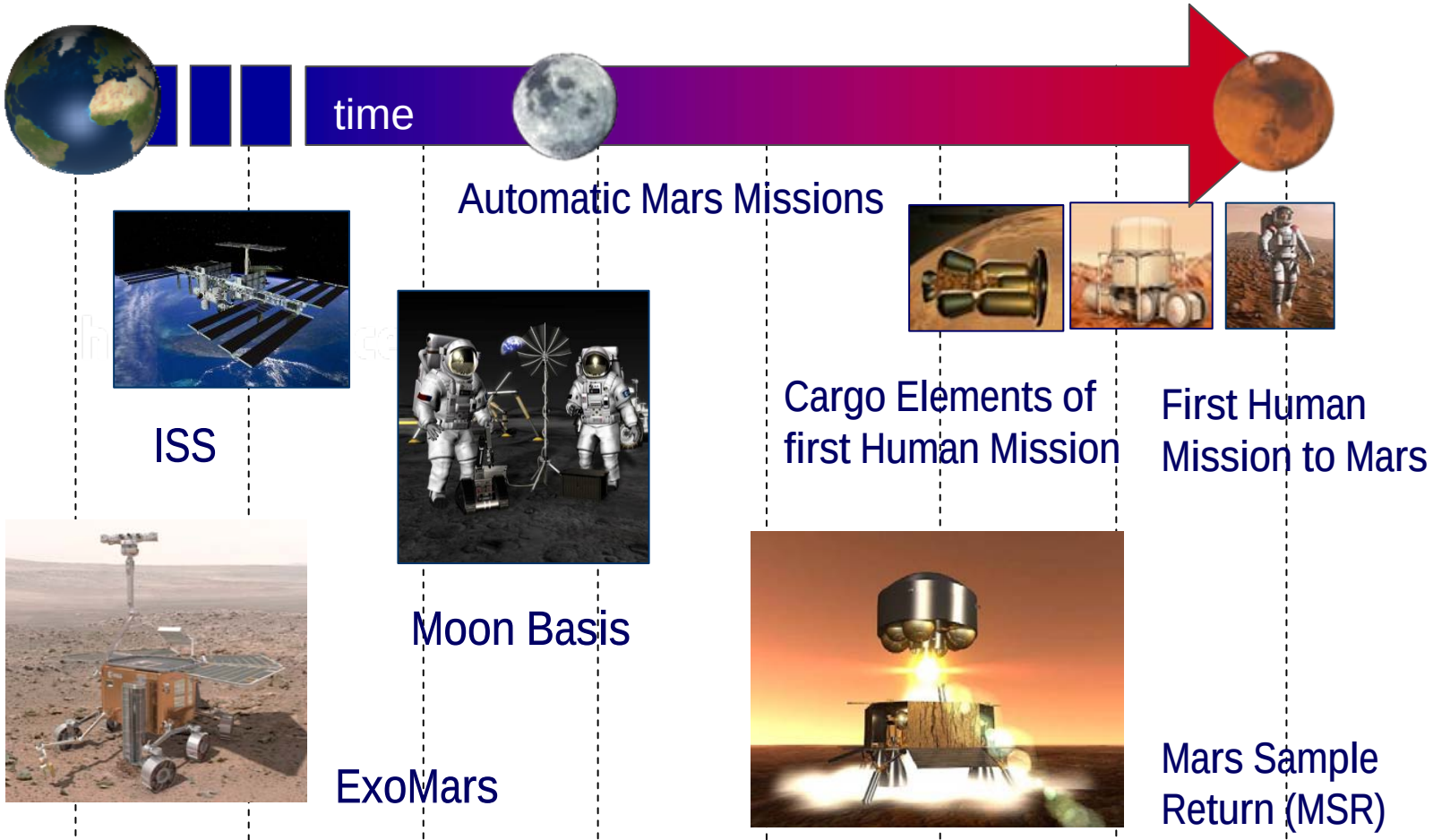
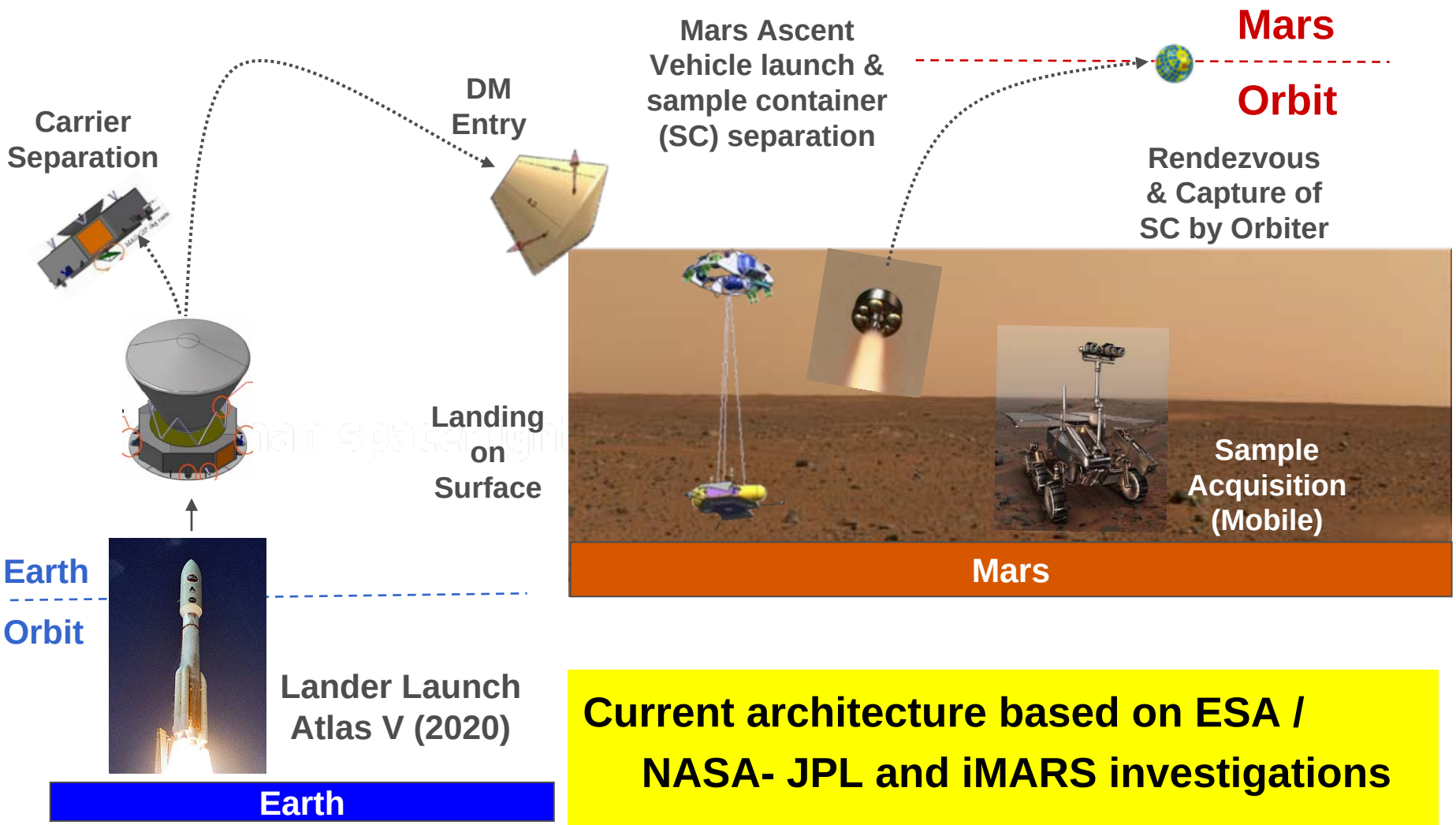
ESA - D/HSO

Aurora Exploration Programme

ESA Programme (2001) for the human and robotic exploration of the Solar System



Reference MSR Architecture

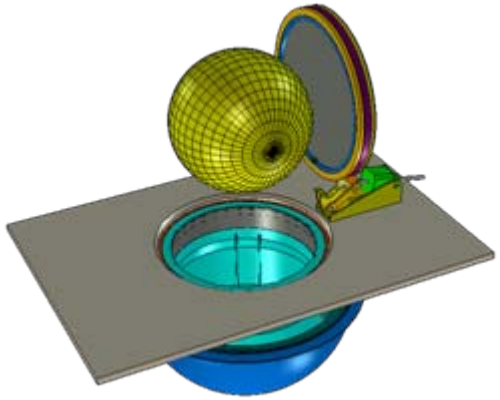


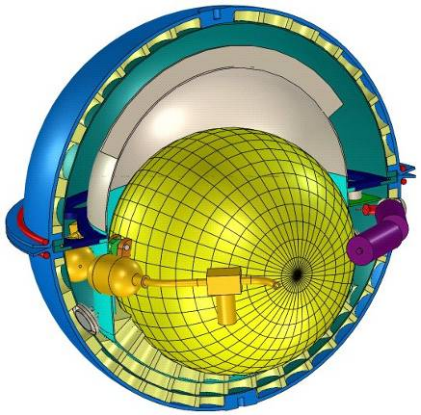
Current architecture based on ESA / NASA- JPL and iMARS investigations

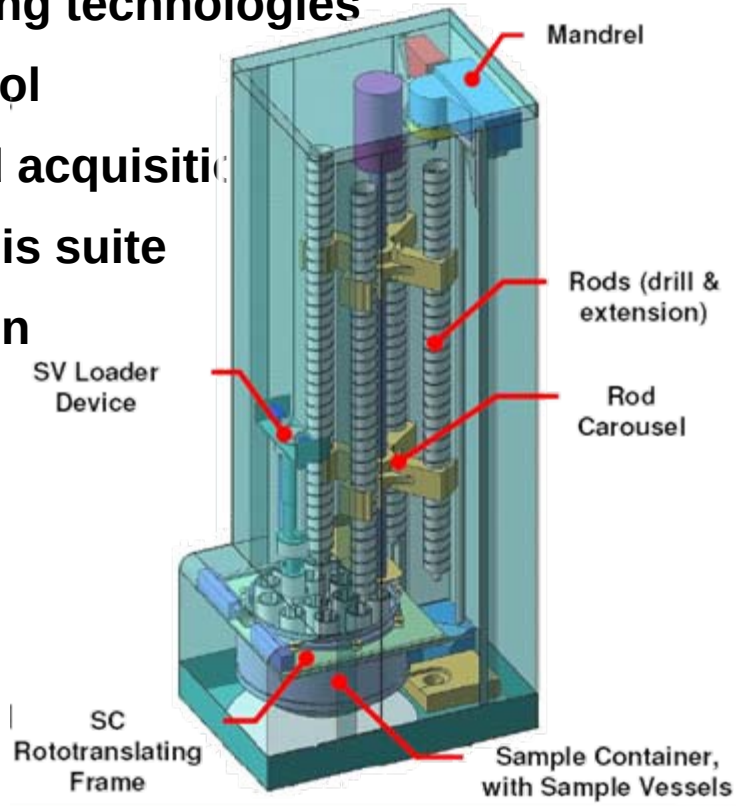
http://www.nasa.gov/home/hqnews/2007/dec/

Aurora - MSR Technology

- **Key mission elements under study will be supported by specific technology development efforts**
- **Major areas already identified include:**
  - **Bio containment – sealing and monitoring technologies**
  - **Planetary Protection – bio-burden control**
  - **Surface Sampling Systems – drill based acquisiti**
  - **In-Situ Instrumentation – sample analysis suite**
  - **Propulsion – targeted at MAV application**



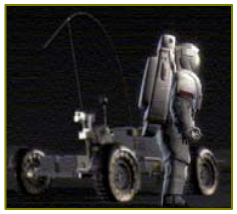




Human Moon Mission

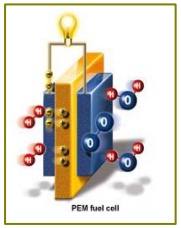
Moon: Next destination of international human missions beyond ISS and forwards to Mars.

Test-bed for demonstration of innovative technologies & capabilities for sustaining human life on planetary surfaces.

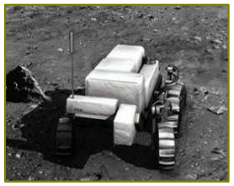


Surface Mobility

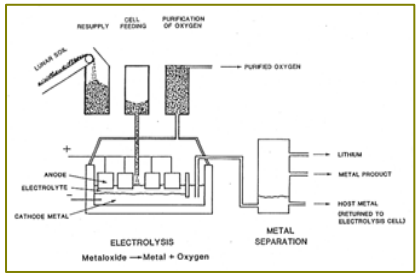
Sustainable Life Support



Energy Provision & Management



Robotic Support



In-Situ Resource Utilisation

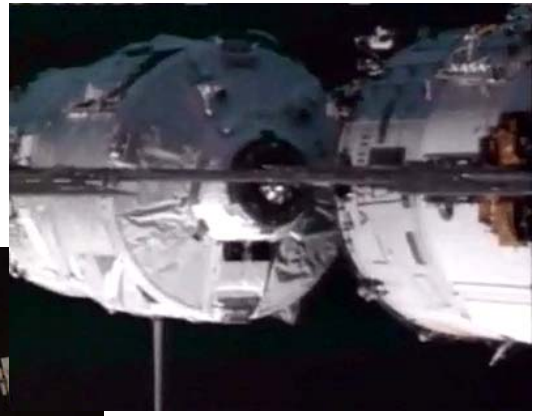
Columbus Laboratory - ISS

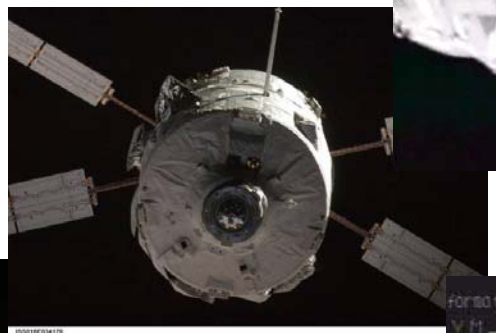
Launched 7 Feb. 2008, with Hans Schlegel and Leopold Eyharts after the mission of Paolo Nespoli (Node2).
D: 4.5 m - L: 6.8 m – W: 12 t

Automated Transfer Vehicle (ATV)

Europe's Space Supply Vehicle (20t)
Launched by an Ariane 5 carries:

- **H2O: 270 kg**
- **O2: 20**
- **Food: 500**
- **ISS fuel: 860**
- **ATV fuel: 5800**





ATV1- Jules Verne

- **Docked to ISS: 3 April 2008**
- **First ISS Re-boost: 25 April 2008**
- **De-orbit: 30 September 2008**

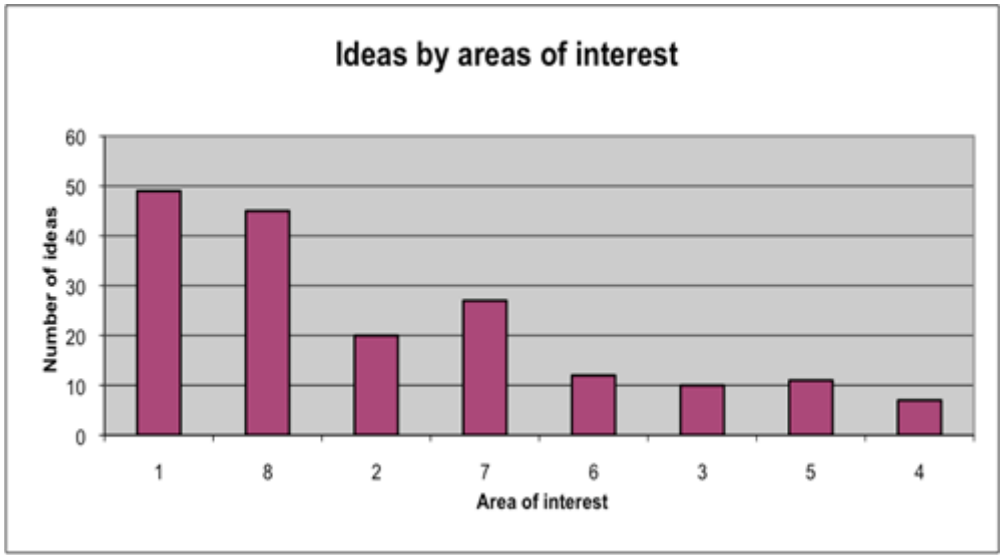
ISS for Exploration : Call for Ideas

- Issued October 2010 – due date 10 December 2010
- Potential areas of interest:

- Astronauts (health monitoring, countermeasures,…)
- Life Support Systems (waste treatment, water recycling, air monitoring, food production,…)
- Failures management and repair (improved trouble shooting and repair capability, multipurpose equipments and work tools, …)
- Habitation (inflatable modules…)
- Robotic systems (learning robots, voice commanded robotics systems, human-robot team work,…)
- Telecommunications and tele-operations (Human controls of on Earth robots (Moon / Mars surface robot precursor)
- Space Operations and Information Systems (expert systems to support decision making, …)
- Other

CFI ISS for Exploration - results

Proposals received: 181 (under evaluation)



Area of interest	Number of ideas
1 – Astronauts	49
8 – Other	45
2 - Life Support Systems and Monitoring Systems	20
7 - Space Operations and Information Systems	27
6 - Telecommunications and Tele-Operations	12
3 - Failure Management and Repair	10
5 - Robotic Systems	11
4 - Habitation	7

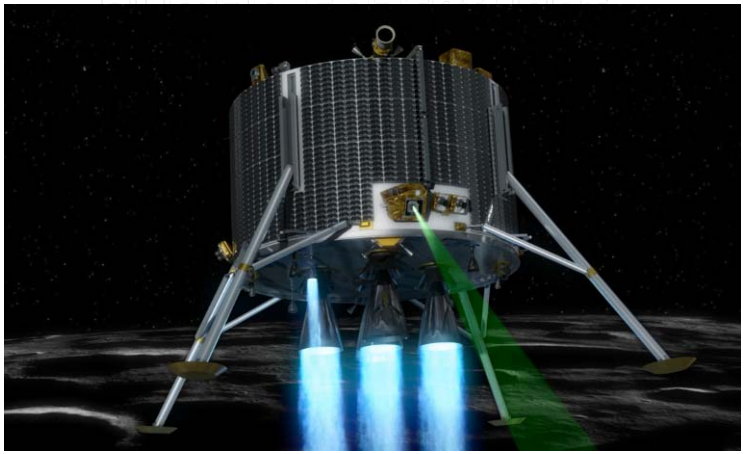
Lunar Lander

Lunar Lander Mission Objective

primary objective

opportunity for investigations

- **Soft Precision Landing with hazard avoidance**

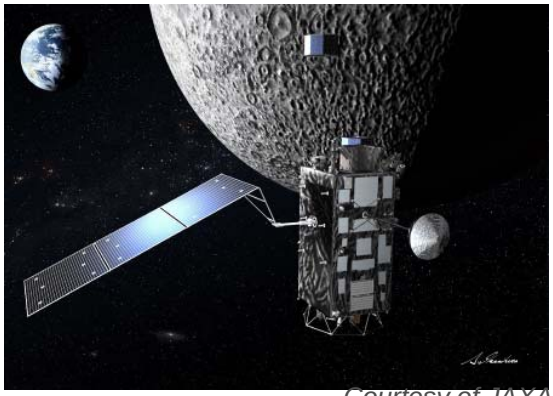


- **Crew health (radiation, dust) and Habitation**
- **Resources (HO, H2O, minerals)**
- **Robotic Mobility Payload Experiment (MPE–DLR)**
- **Preparations for human activities**

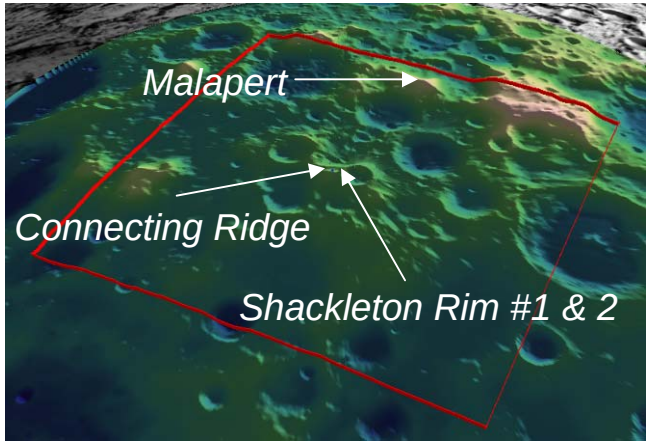
Note: Technology is applicable to other destinations

South Pole Landing Site

- Polar regions may experience extended periods of illumination (>14days)
- No RHU foreseen – design shall enable survival of short darkness periods (10's hours);
- Terrain in the polar regions requires very precise navigation and landing with hazard avoidance;
- JAXA's Kaguya orbiter surface mapping (~200m resolution in South Pole region)
- Analyses shall be repeated in Phase B1 using more accurate (0.5 m / pixel) data coming in from NASA's Lunar Reconnaissance Orbiter (LRO)



Courtesy of JAXA

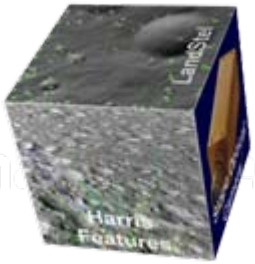


Courtesy of NASA

Precision Landing Technology

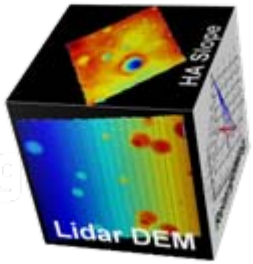
Technology activities developed since 2005 under ESA Aurora Core / TRP programmes and nationally funded R&D activities, are key building blocks in the mission development logic

TRN Sensors: Optical camera and Lidar



Optical Terrain Relative/Absolute+ Navigation

+: ANTARES



Reusable GNC and HDA Software

COTS Model-based Development & Validation Framework

Generic Avionics Platform

Terrestrial Dynamics Test Facilities

Industries across Europe are already developing the next generation of technologies needed to successfully land on the Lunar surface

Phase B1 Bread boarding

- **Relative / absolute navigation and HDA demonstration test:** test with hardware-in-the-loop on the TRON dynamic test bench (DLR Bremen), with a representative Lunar surface model

- **Absolute navigation rapid prototype:** specification and implementation for systematic performance analyses

- **Flow interaction and Pressure regulator test:** investigation of disturbances in the feed system and regulation at high mass flow (5x500N EAM - 6x220N ATV – 16x20N AOCS)

- **220N thruster hot firing test:** performance characterisation at 2.5 Hz command frequency (1 Hz qualified for ATV)

Conclusions

- The Lunar Lander is a key step in preparing exploration of the Moon and beyond
- The mission will bring together the results of Europe's technological investment and experience, to achieve a first in lunar exploration: landing at the Moon's south pole
- The Lunar Lander payload represents an important opportunity for the European research community

http://www.esa.int/esaHS/SEMJRY4DHNF_exploration_0.html