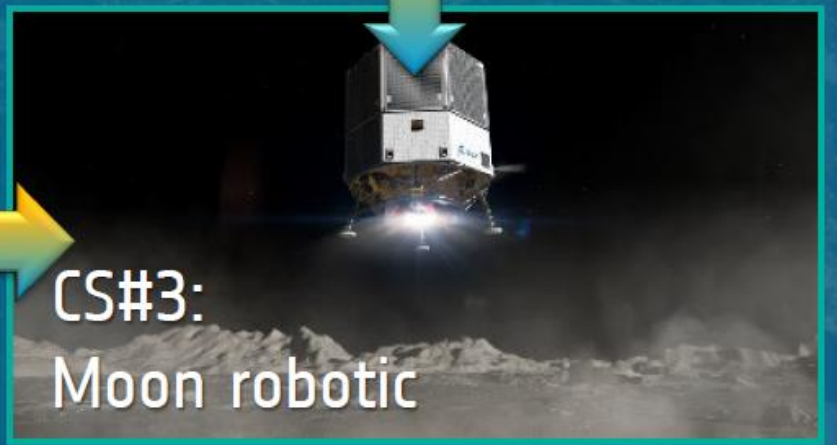
ESA lunar exploration and science from the Moon

SciSpace team

ESA's European Exploration Envelope Programme "E3P"

Directorate of Human and Robotic Exploration Programmes

Commercialisation as a cross-cutting theme

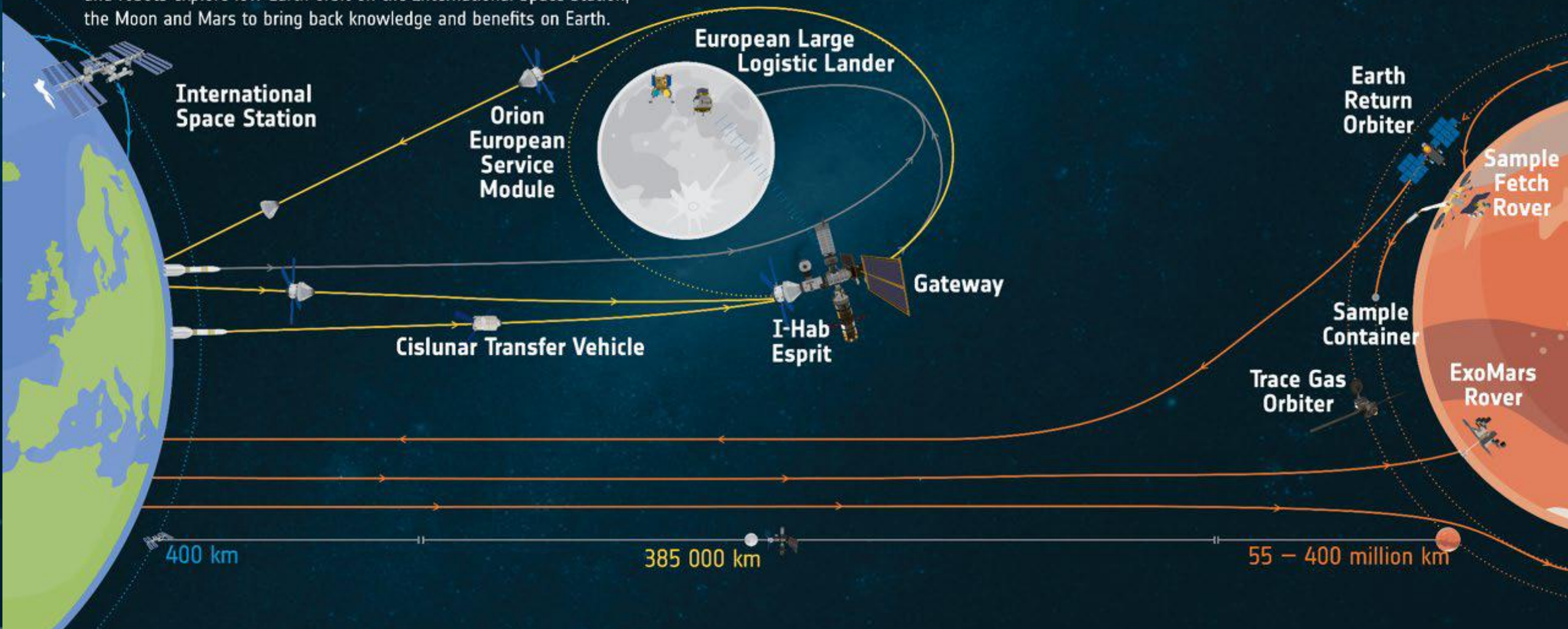


ExPeRT = Mission studies and mid-TRL technology

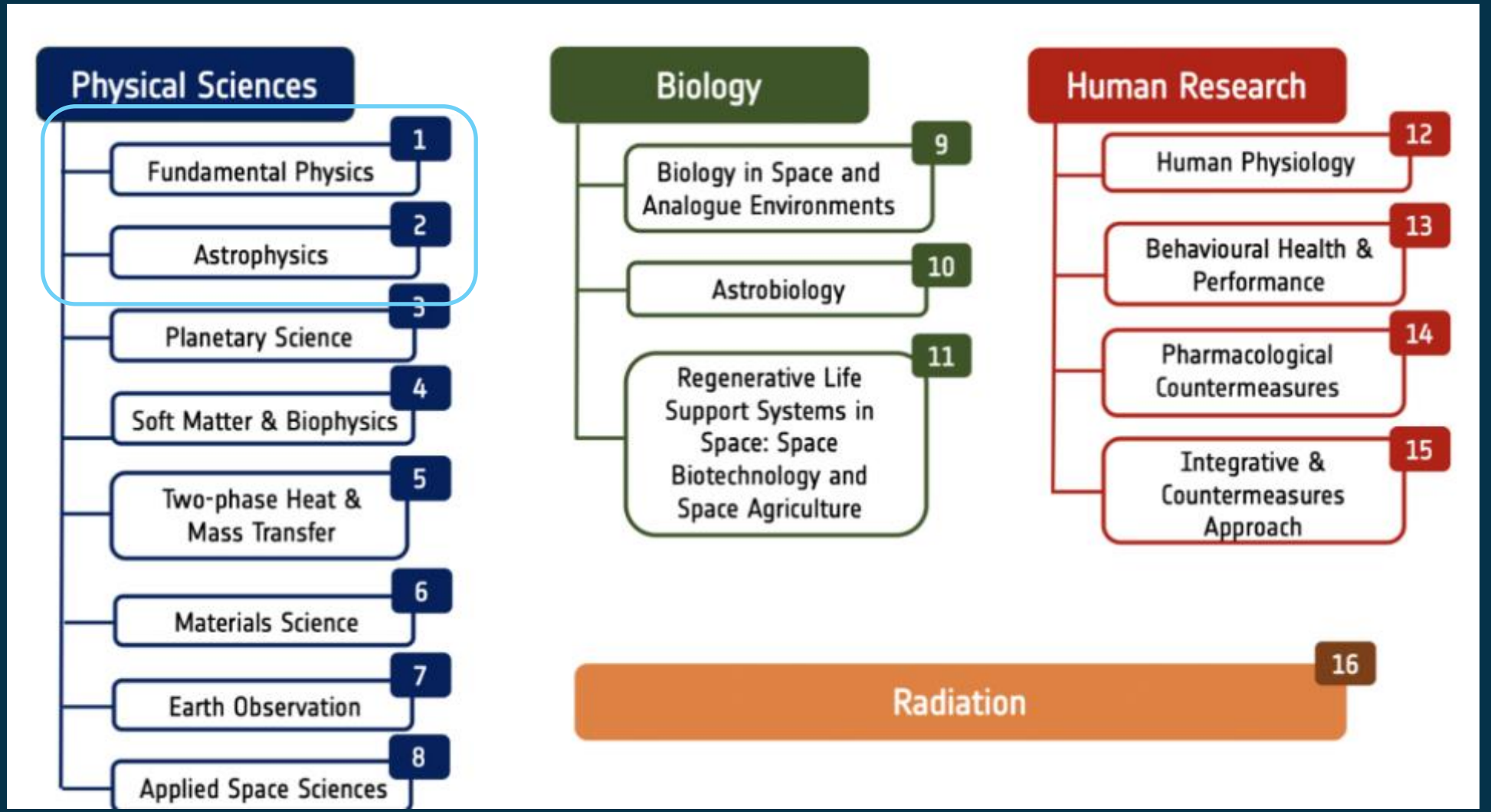
SciSpacE = Science in the Space Environment

ESA'S HUMAN AND ROBOTIC EXPLORATION DESTINATIONS

ESA's Human and Robotic Exploration programme will see astronauts and robots explore low Earth orbit on the International Space Station, the Moon and Mars to bring back knowledge and benefits on Earth.



“SciSpacE” Science consultation – defined by our research community



Some interests in Moon for Fundamental Sciences and Astrophysics

ESA consulted the scientific community in 2020, collecting research questions for ESA's Directorate of Human and Robotic Exploration (D/HRE).

Research questions are related to Standard Model of particle physics , General Relativity, de-cohences and collapse models in quantum mechanics. Also observation about the origin of our Universe : Gravitation waves, dark matter/energy, Cosmic rays, Solar and stellar physics …

Nature of the dark matter

Radio interferometer accessing to wavelengths shorter 30 MHz, that are distorted or completely absorbed by the Earth's ionosphere.

Existence of primordial black holes

Lunar reflector, Lunar-based gravitational wave (GW) interferometer

Some interests in Fundamental Sciences and Astrophysics

Measuring Cosmic Ray distribution

Cosmic Ray detectors to measure the variations of fluxes and spectra with both location and time.

Evolution of solar surface magnetic field

Lunar radio telescope long-wave radio emission

Radiation and energetic particle Environment: Multi-point measurements

magnetometer, plasma package (electrons and ions) and a radiation monitor/energetic particle detector

Weak Equivalence Principle (Moon composition dependent) and Strong Equivalence Principle

Lunar laser ranging experiments

Moon activities

Payloads in development for partner led missions

All payloads address objectives in the Strategy for Space Resources and Strategy for Science at the Moon

Payloads prepare for future missions in preparation

Payload	Topic	Status
EMS-CLPS	Exosphere and volatiles	Testing for flight December 2021
EMS-LUPEX	Resource exploration and volatiles	In preparation for mission in 2024
PROSPECT-Luna	Resource exploration and volatiles	Phase CD for flight 2025
PROSPECT-CLPS	Resource exploration and volatiles	Manifest for CLPS delivery 2024
Laser reflector	Geophysics and relativity	Manifest CLPS delivery 2023

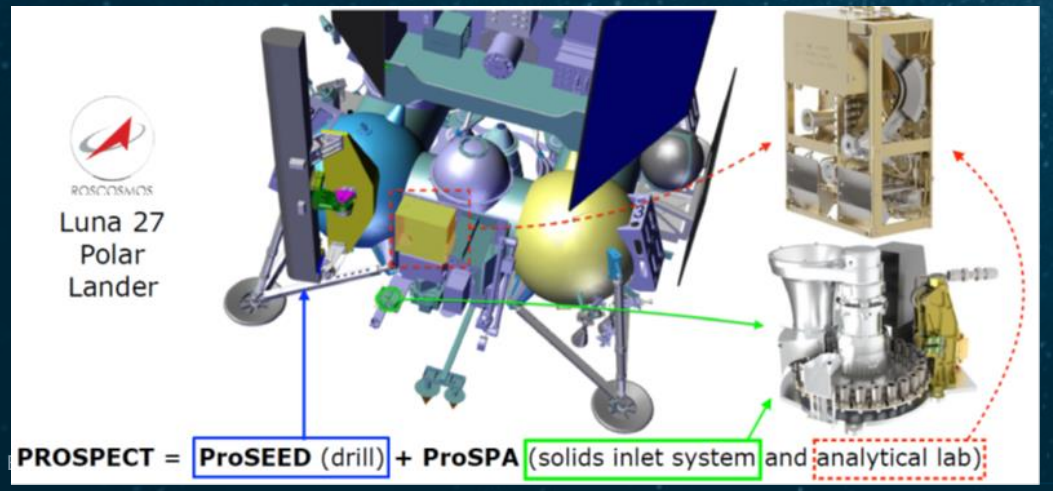
Mission studies

Mission concepts are being advanced with CDF and Pre-Phase A Industrial Study

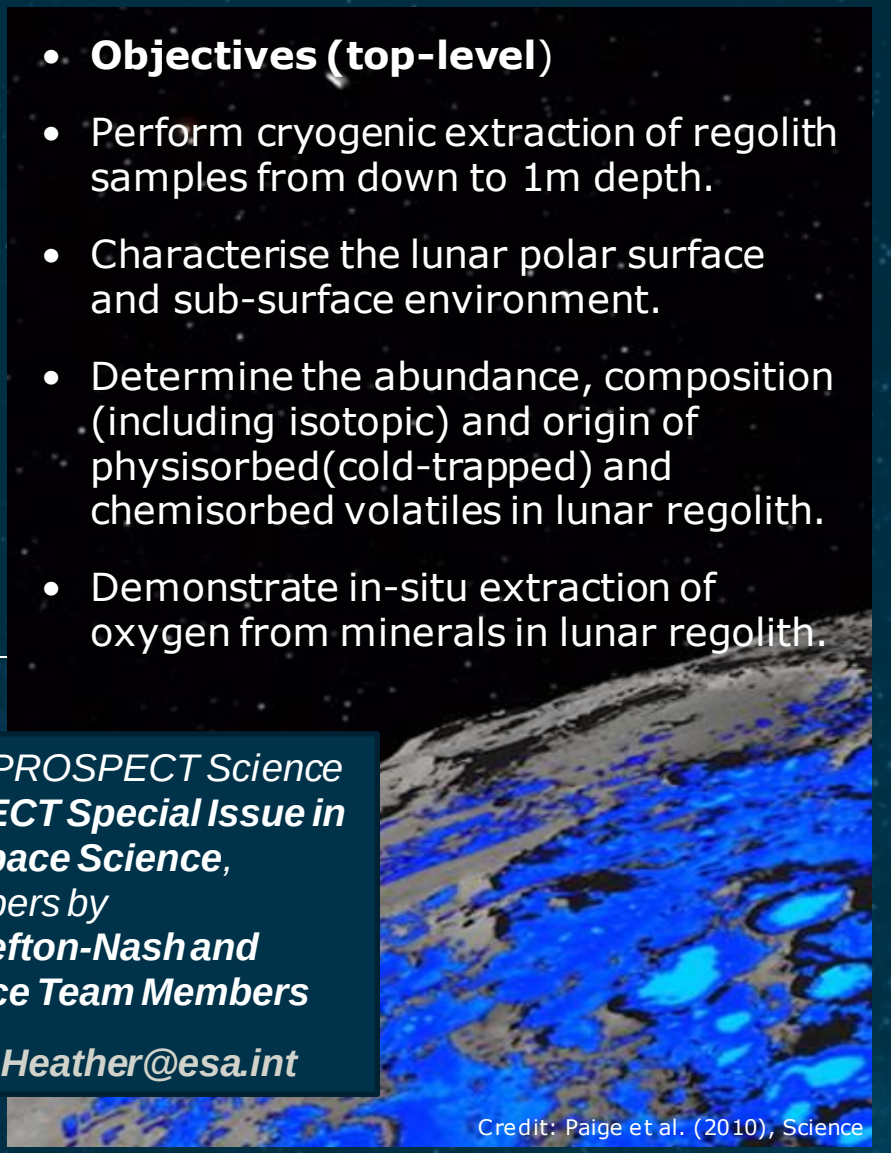
- Polar Explorer: Water, ice & volatile prospecting
- Astrophysical observatory
- European rover for science & exploration
- Biosciences mission exposing diverse biological samples
- Geological exploration of new terrains and lithologies

PROSPECT: Overview & Objectives

- PROSPECT is composed of the ProSEED drill and the ProSPA analytical laboratory (see below)
- Will perform sub-surface sampling and analysis of lunar regolith to understand abundance, composition and distribution of lunar volatiles in the south polar region
- Developed for flight onboard Russian Luna-27 / Luna-Resours mission to be launched in 2025, as part of ESA-ROSCOSMOS cooperation
- Development for Luna-27 now in Phase C; additional flight opportunities also being pursued, e.g. NASA CLPS Astrobotics 1 (Peregrine), JAXA LUPEX, NASA CLPS 2024 (polar mission)



- **Objectives (top-level)**
- Perform cryogenic extraction of regolith samples from down to 1m depth.
- Characterise the lunar polar surface and sub-surface environment.
- Determine the abundance, composition (including isotopic) and origin of physisorbed(cold-trapped) and chemisorbed volatiles in lunar regolith.
- Demonstrate in-situ extraction of oxygen from minerals in lunar regolith.


Credit: Paige et al. (2010), Science

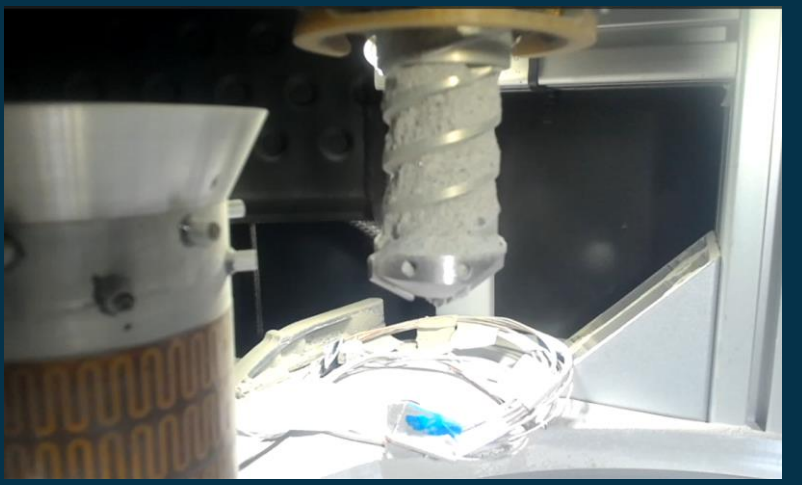
For further details on PROSPECT Science aspects, see ***PROSPECT Special Issue in Planetary & Space Science****,*
and papers by
D. Heather, E.Sefton-Nash and PROSPECT Science Team Members

Questions: David.Heather@esa.int

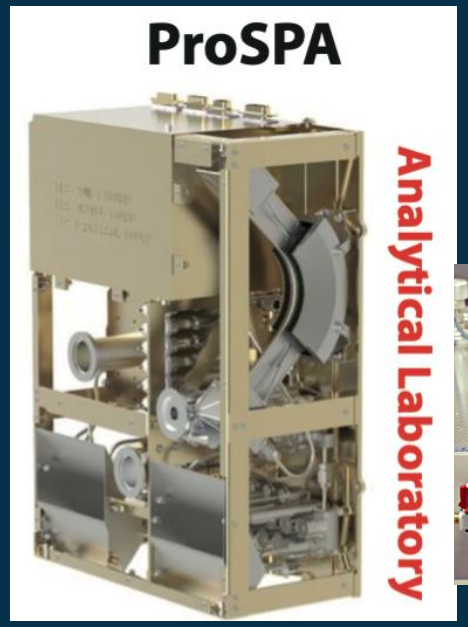
ProSEED / ProSPA Development Status for L27

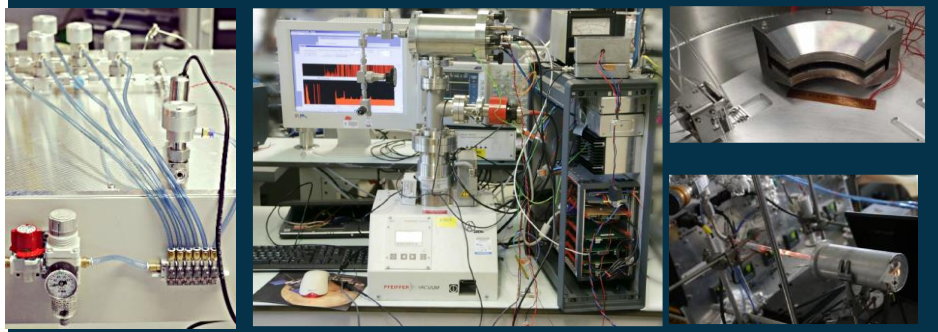
ProSEED Drill: *Successful demonstration of Drill Design capabilities completed; Imaging System Engineering Model testing completed by Science Team.*

ProSPA: *All key elements of the laboratory (GPS, ITMS, MSS), the Solid Inlets System and camera (SAMCAM) have been prototyped and tested individually*

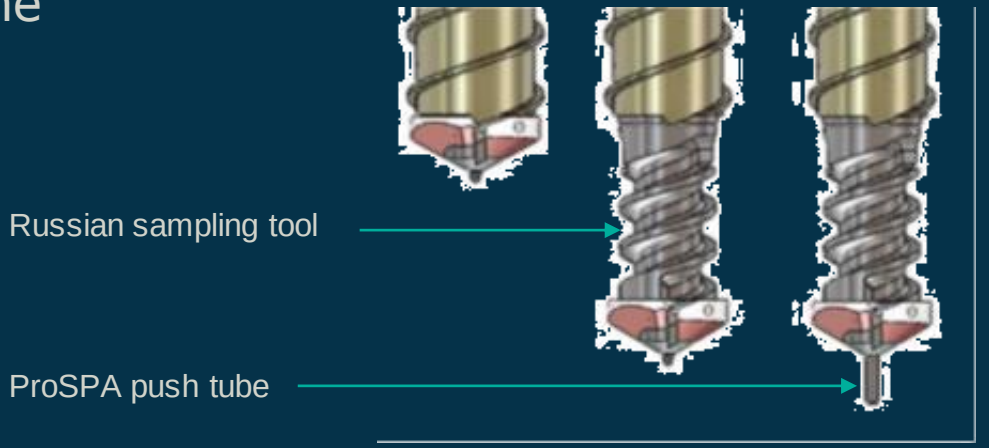


- Detailed Design ongoing with dedicated testing of units & components, e.g:
  - Extreme temperature survival testing
  - Environmental compatibility and lifetime testing
  - Dust compatibility testing





Credits: OU



Credits: Leonardo

Conclusions

The Moon platform is a unique platform for Fundamental physics and astrophysics.

ESA is developing missions on the Moon :

- PROSPECT mission on Luna 27
- EL3 cargo lander, Cis-Lunar Transfer Vehicle, …

The future depends on the support of the research community and of members states