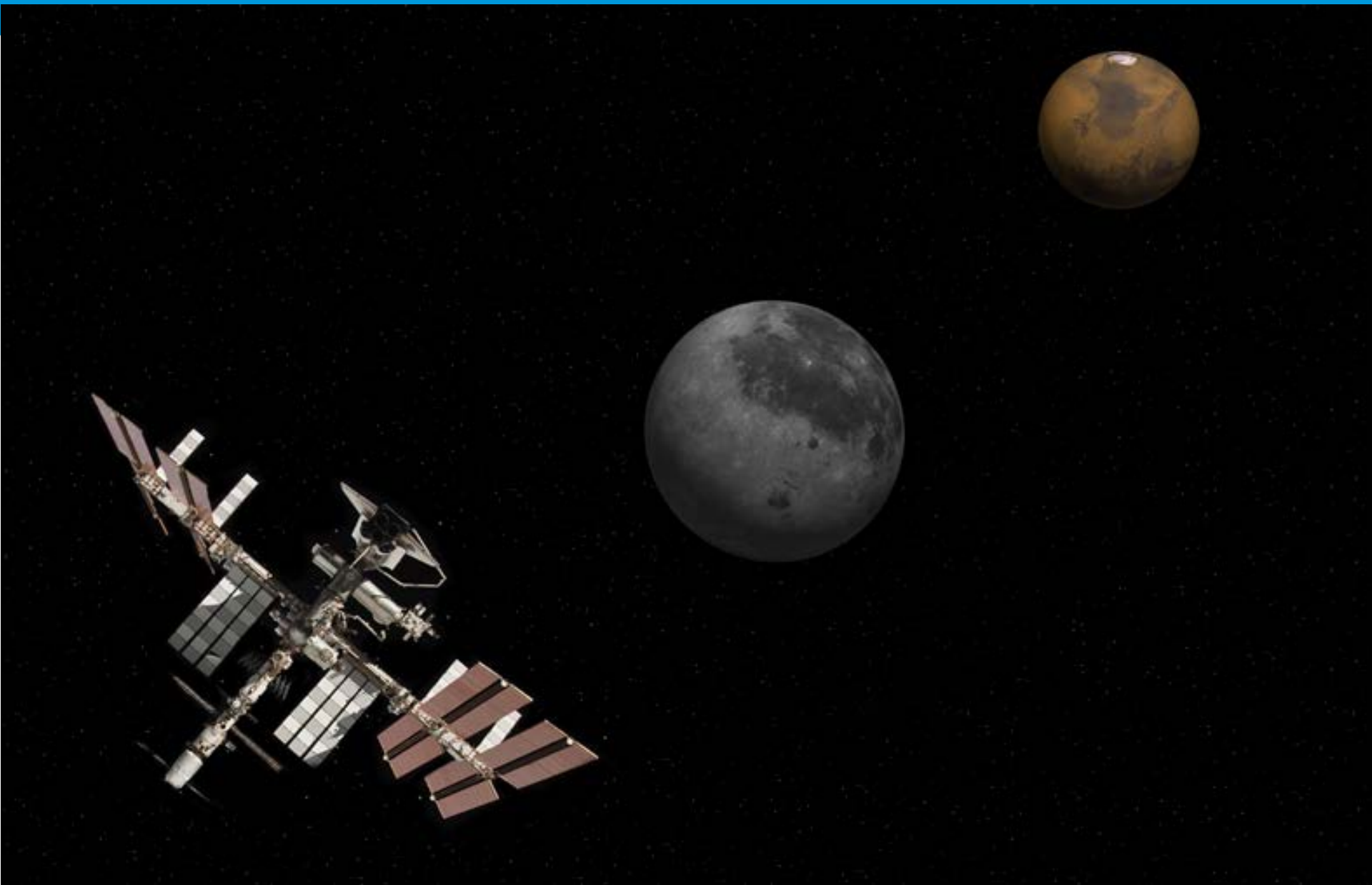
ESA’s plans for Lunar Exploration

On behalf of the ESA Lunar Exploration Team
Directorate of Human Spaceflight and Operations

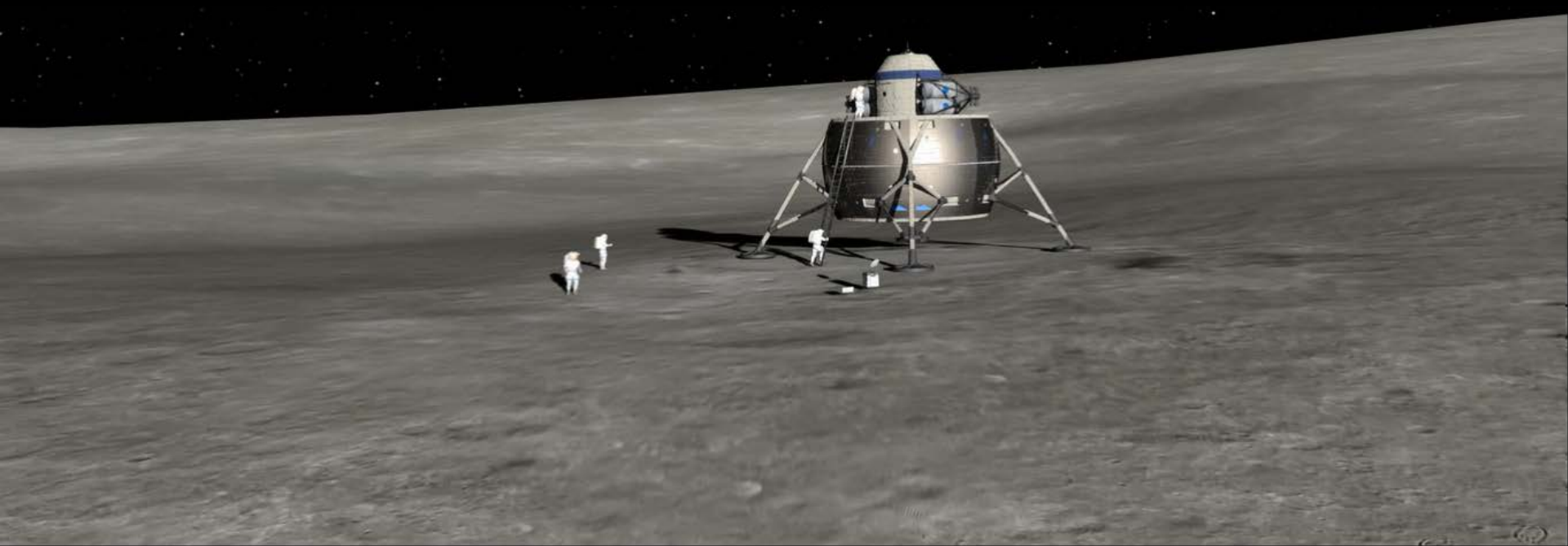
ESA's Exploration Destinations



Destination Moon

ESA Vision for Lunar Exploration:

“Provide access to the Moon’s surface to drive European discovery, innovation and inspiration.”



Human Transportation

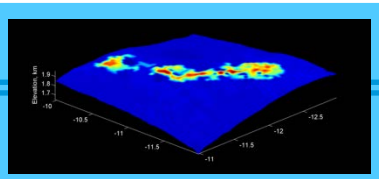

esa

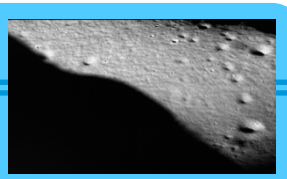
Core European Products and Services

PILOT

1. Characterise landing sites

Landing Sites Analyses

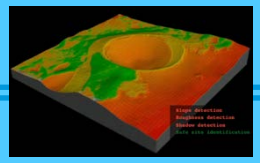


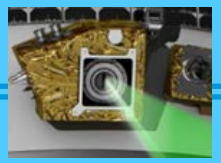


2. Access landing sites precisely and safely

Relative & Absolute Navigation

Hazard Detection

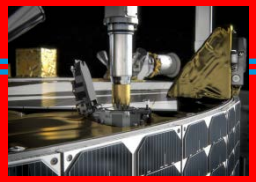




PROSPECT

3. Acquire samples of interest for exploration

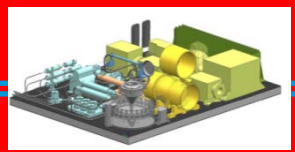
Lunar Drill



4. Analyse samples

Volatile Extraction & processing

Analysis

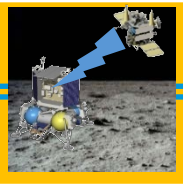


SPECTRUM

5. Communicate & Operate

Ground Support

UHF Proximity Link



Prepare future missions

PRECISE

INTELLIGENT

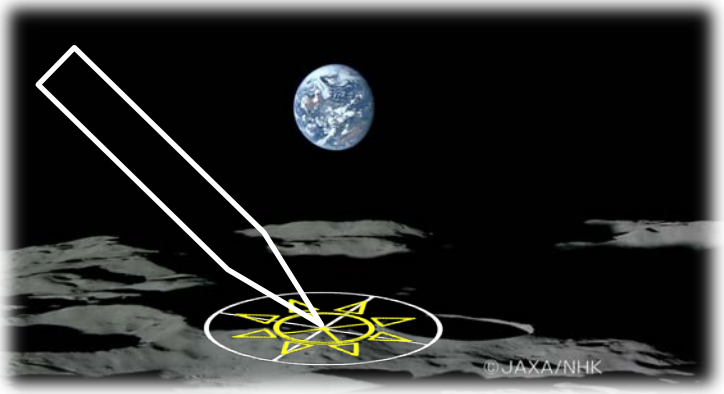
LANDING USING

ON-BOARD

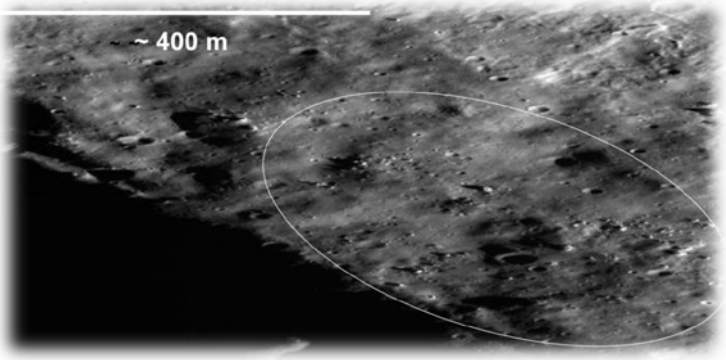
TECHNOLOGY

Access the surface

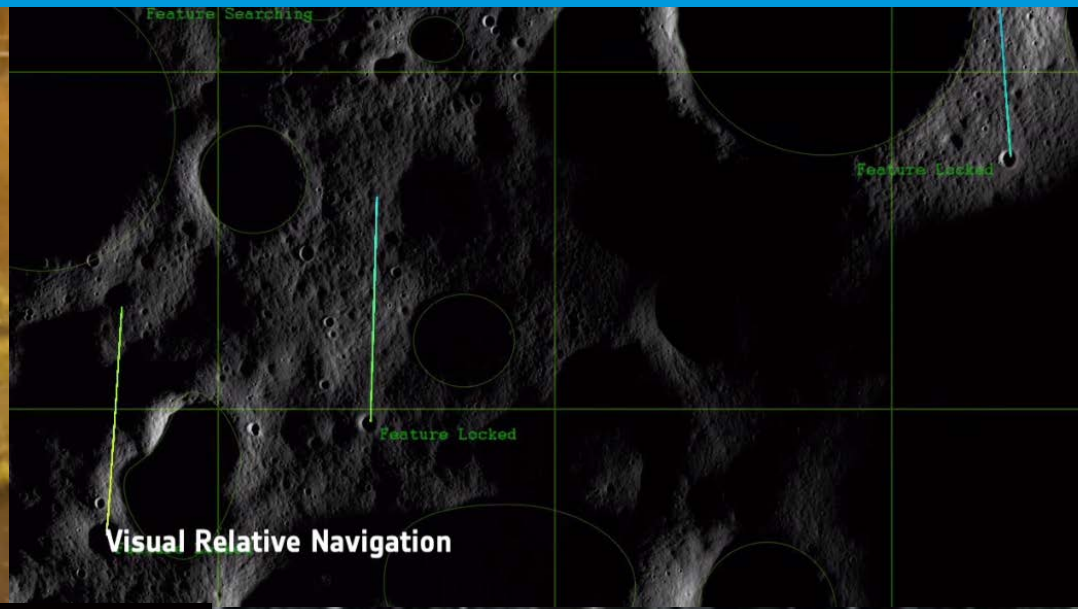
PRECISELY



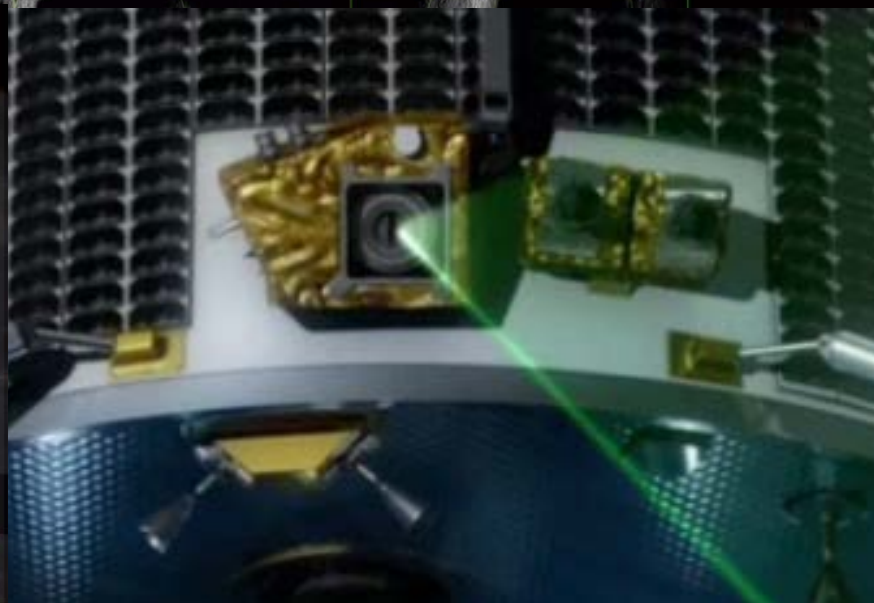
SAFELY



PILOT

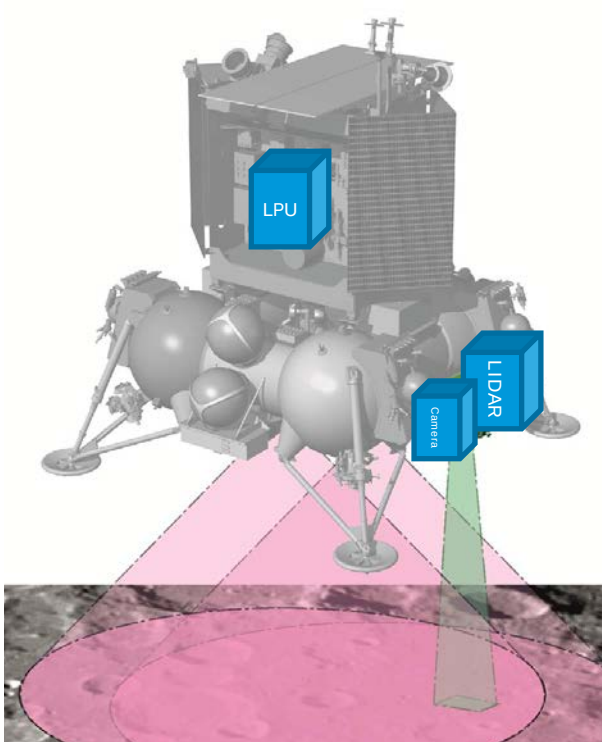

Feature Searching
Feature Locked
Feature Locked
Visual Relative Navigation


Landmarks Detection



PILOT for Precise and Safe Landing
Key development challenges

- Design for autonomy and reliability
- Real-time Software and IP Core development for highly computationally demanding applications (e.g. Image Processing) on space-grade processors and FPGA/ASIC
- Development of dedicated Processing Unit
- Development of high performance sensors (LIDAR and Camera)
- Integration of highly complex units and functions
- Integration onto platform, with on-board computer and into mission
- Validation in representative environment

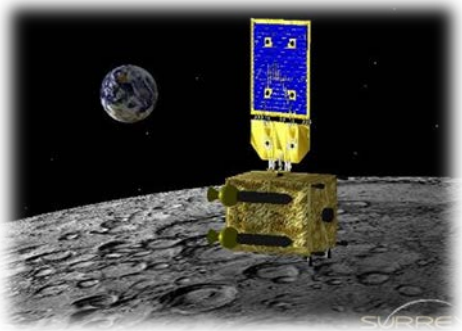


SPACE
EXPLORATION
COMMUNICATIONS
TECHNOLOGY FOR
ROBUSTNESS AND
USABILITY BETWEEN
MISSIONS

Phone home

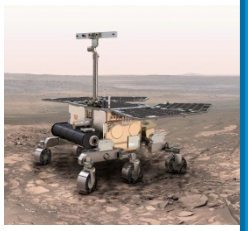
DIRECTLY

VIA A COMMS NODE



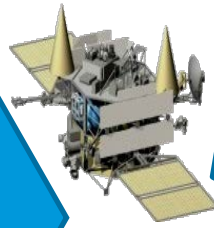
SPECTRUM Interspacecraft Link

- Realisation of an Orbiter-Lander UHF link to augment X-band direct-to-Earth
- Key component: lunar transceiver
- Heritage: Proximity-1 for Mars Express, ExoMars surface unit
- Proposed enhancements in terms of data rate, functionalities etc.



UHF Transponder for ExoMars (currently EQM)

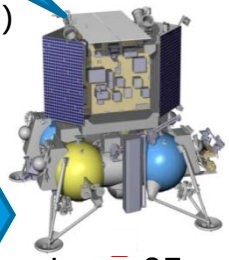
Upgrade for Orbiter to support 'Master' function: link robustness



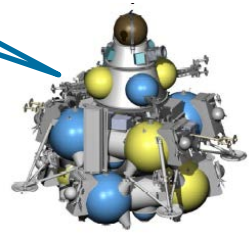
Luna-26 (Luna-Resurs O)

UHF

Use 'as-is' on lander side as 'Slave', with only delta-qualification and tailoring of interfaces



Luna-27 (Luna-Resurs 1)



Luna-28 (Luna-Resurs 2)

PROSPECT

PLATFORM FOR

RESOURCE

OBSERVATION AND IN-

SITU

PROSPECTING IN SUPPORT OF

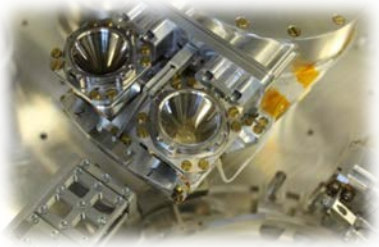
EXPLORATION,

COMMERCIAL EXPLOITATION &

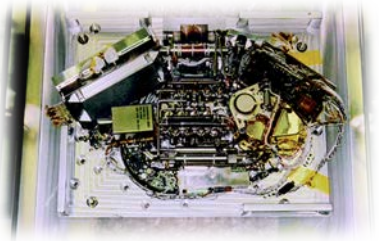
TRANSPORTATION

DRILL

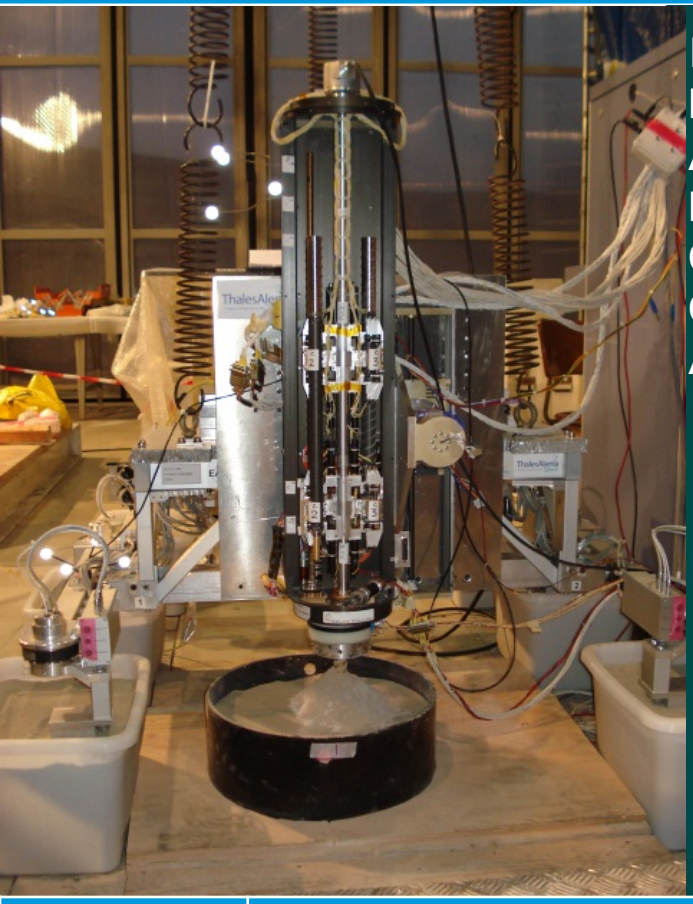
EXTRACT



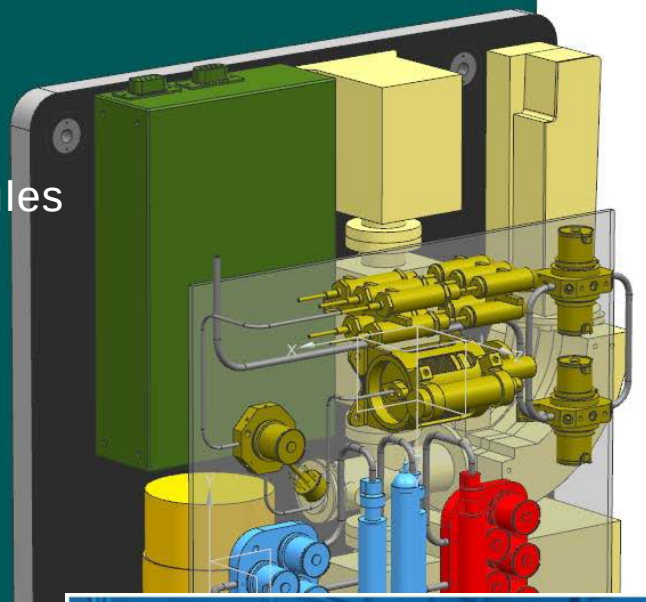
ANALYSE

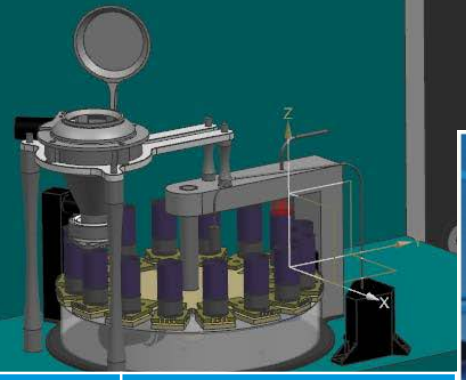


PROSPECT



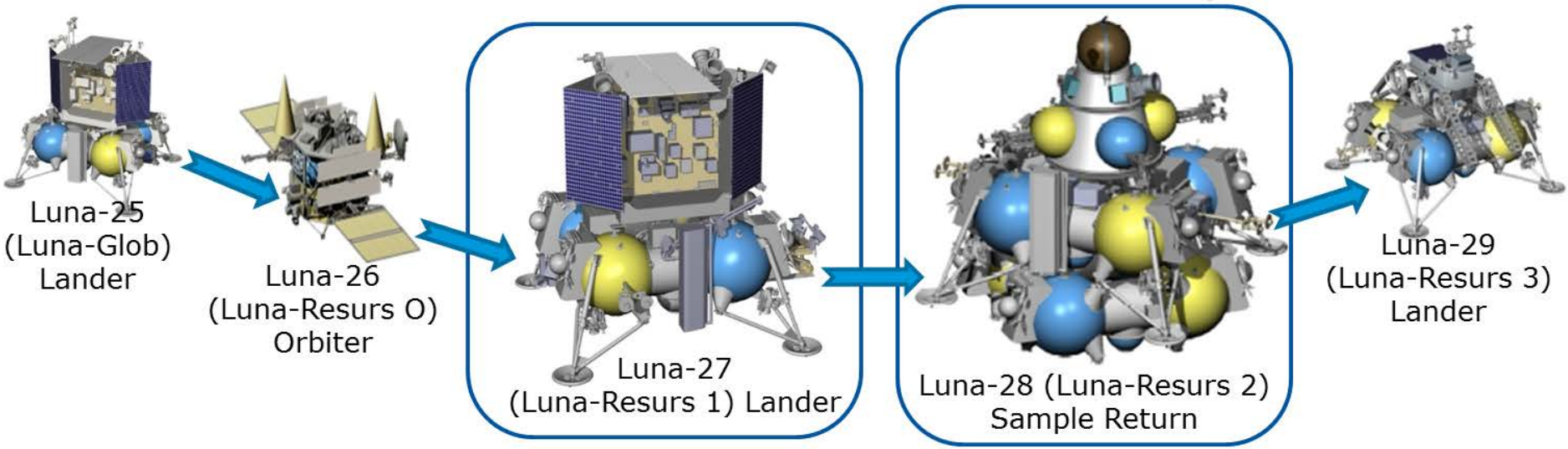
Drill and sample to 2m
Extract volatiles
Analyse composition
Establish yield
Concentrate target molecules
Chemical conversion
Accurate isotopes





Isotopic ratio	Associated molecular species	Expected Precision
δD	H_2, H_2O, -OH, hydrocarbons	10 ‰
$\delta^{13}C$	CO, CO_2, hydrocarbons	0.1-1 ‰
$\delta^{15}N$	N_2, NH_3, nitrogen oxides	0.1-1 ‰
$\delta^{18}O$	H_2O, CO and CO_2	0.1 ‰

Robotic surface access
Cooperation with Russia under discussion



Main focus of proposed ESA-ROSCOSMOS Lunar cooperation

Current Mapping of Possible ESA Contributions to Russian missions

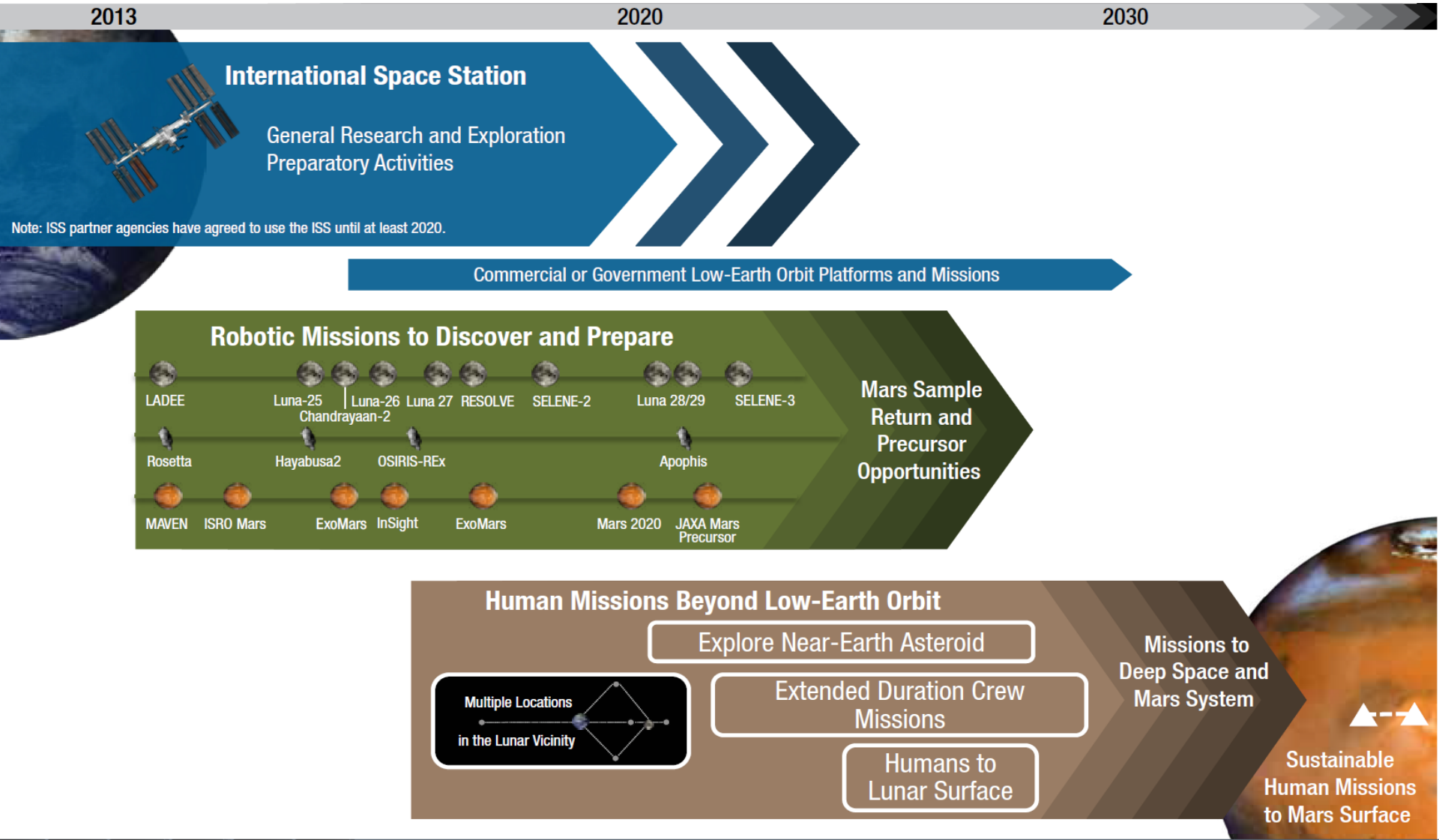
		Luna-Glob Lander	Luna-Resurs Orbiter	Luna-Resurs Lander	LPSR
SPECTRUM	Ground Support	X	X	X	X
	Interspacecraft Link		X	X	X
PILOT	Landing Sites Characterisation			X	X
	Navigation for Precision Landing			X	X
	Hazard Avoidance			X	X
PROSPECT	Drilling & Sampling			X	X
	Sample Processing & Analysis			X	X
FUTURE PRODUCTS	Major Systems				X

Conclusions

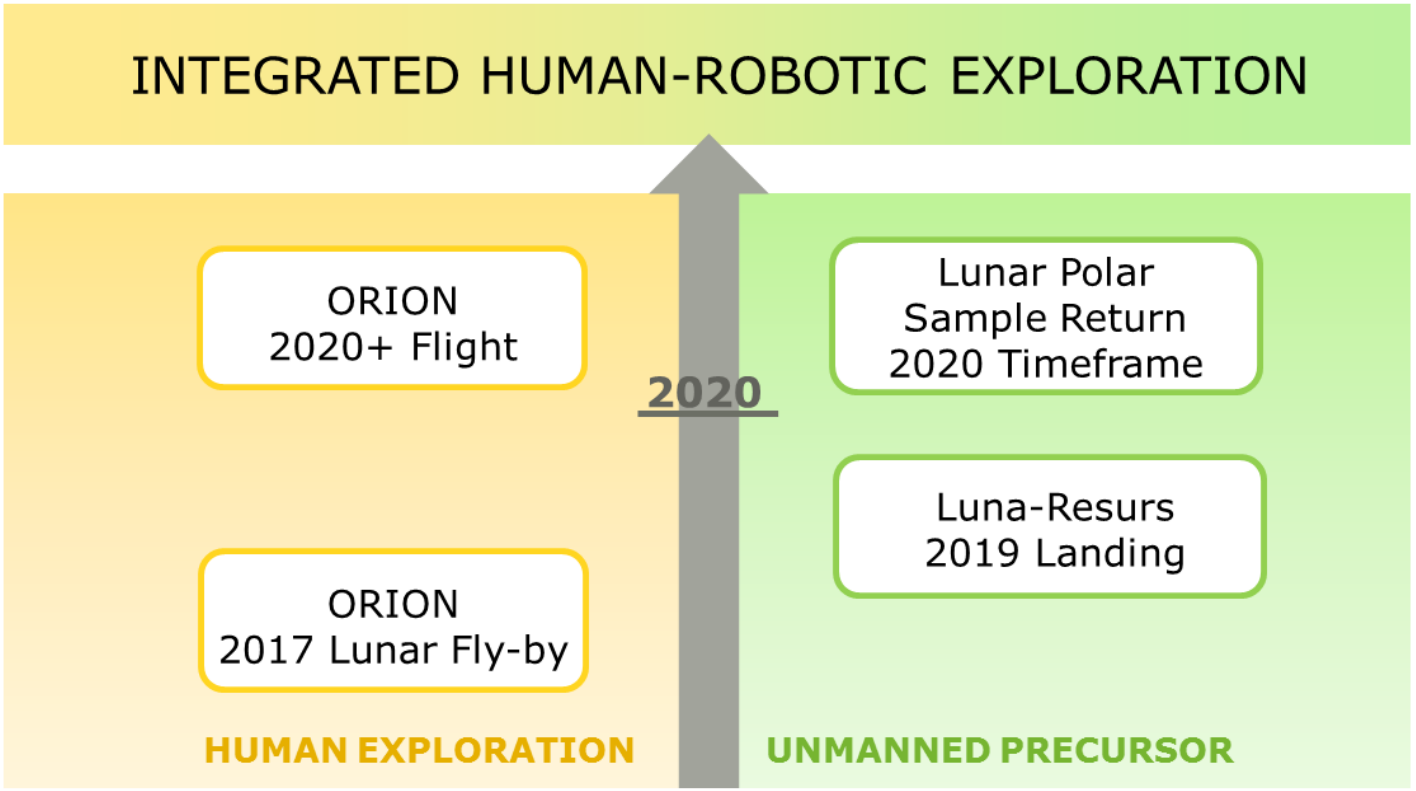
- Moon is ESA's the next destination for human exploration after ISS
- This can only be realised through international cooperation
- ESA is developing core exploration products based on previous investments, as contributions to international missions:
    - PILOT
    - SPECTRUM
    - PROSPECT
- ESA is in discussion with Russia with a view to establishing a joint Lunar exploration programme, building on the existing Exomars cooperation.
- Key budget decision point for ESA is CMin 2014 December 2014.
- ESA is open to explore new cooperations that can lead to access to and exploitation of the lunar surface.

Science and Challenges of Lunar Sample Return

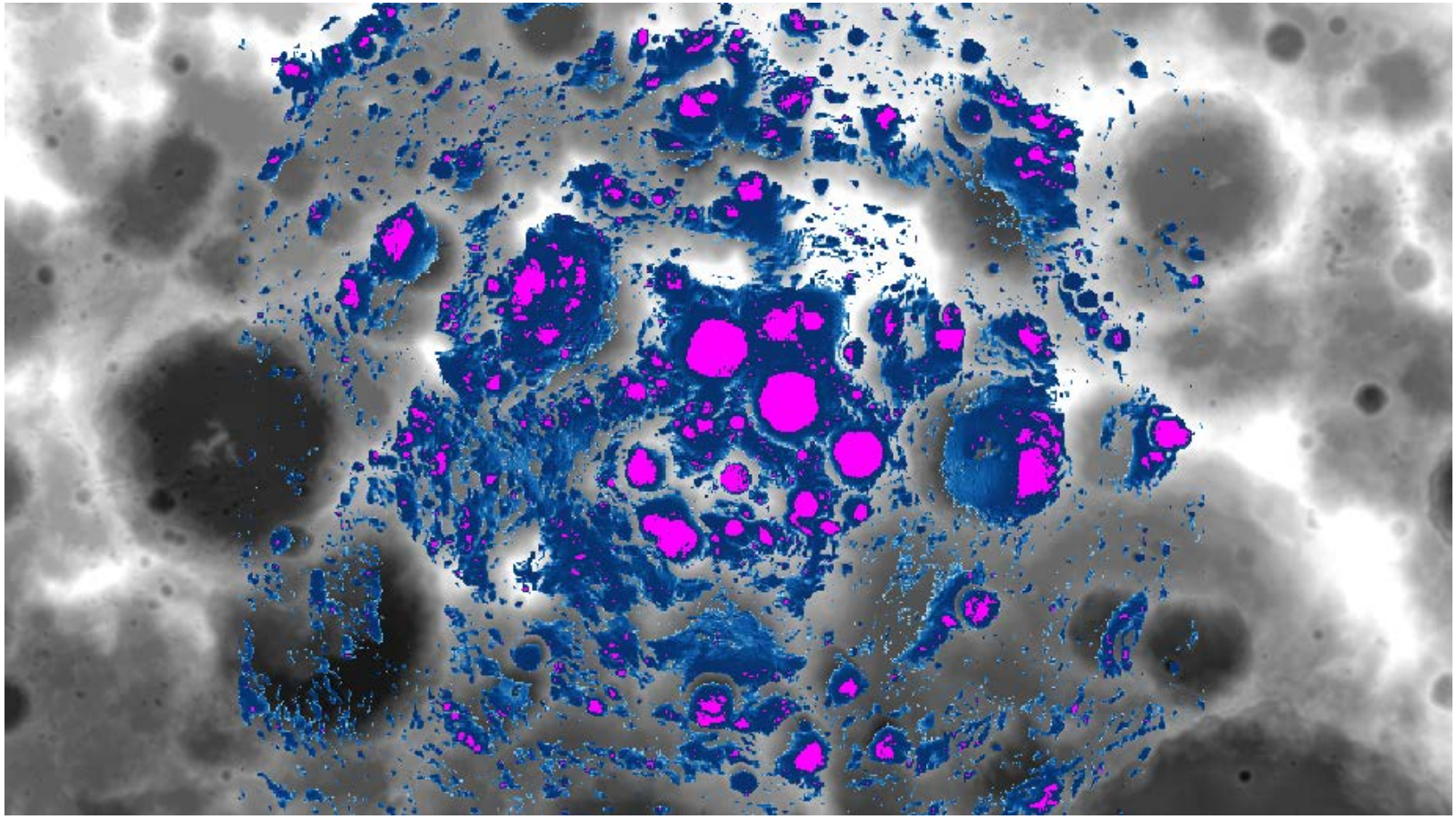
International Cooperation and the Global Exploration Roadmap



Summary

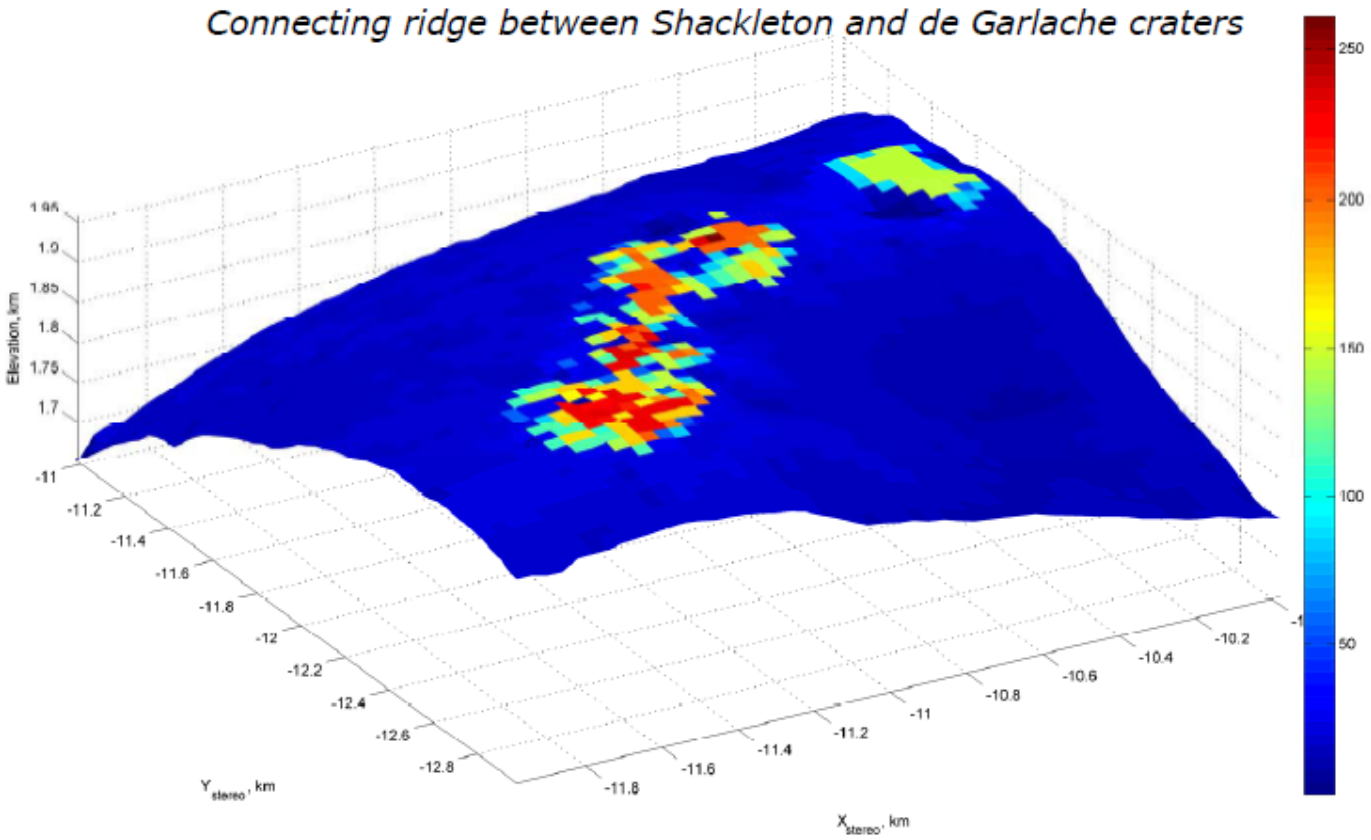

INTEGRATED HUMAN-ROBOTIC EXPLORATION
ORION
2020+ Flight
ORION
2017 Lunar Fly-by
2020
Lunar Polar
Sample Return
2020 Timeframe
Luna-Resurs
2019 Landing
HUMAN EXPLORATION
UNMANNED PRECURSOR

The Lunar South Polar Region



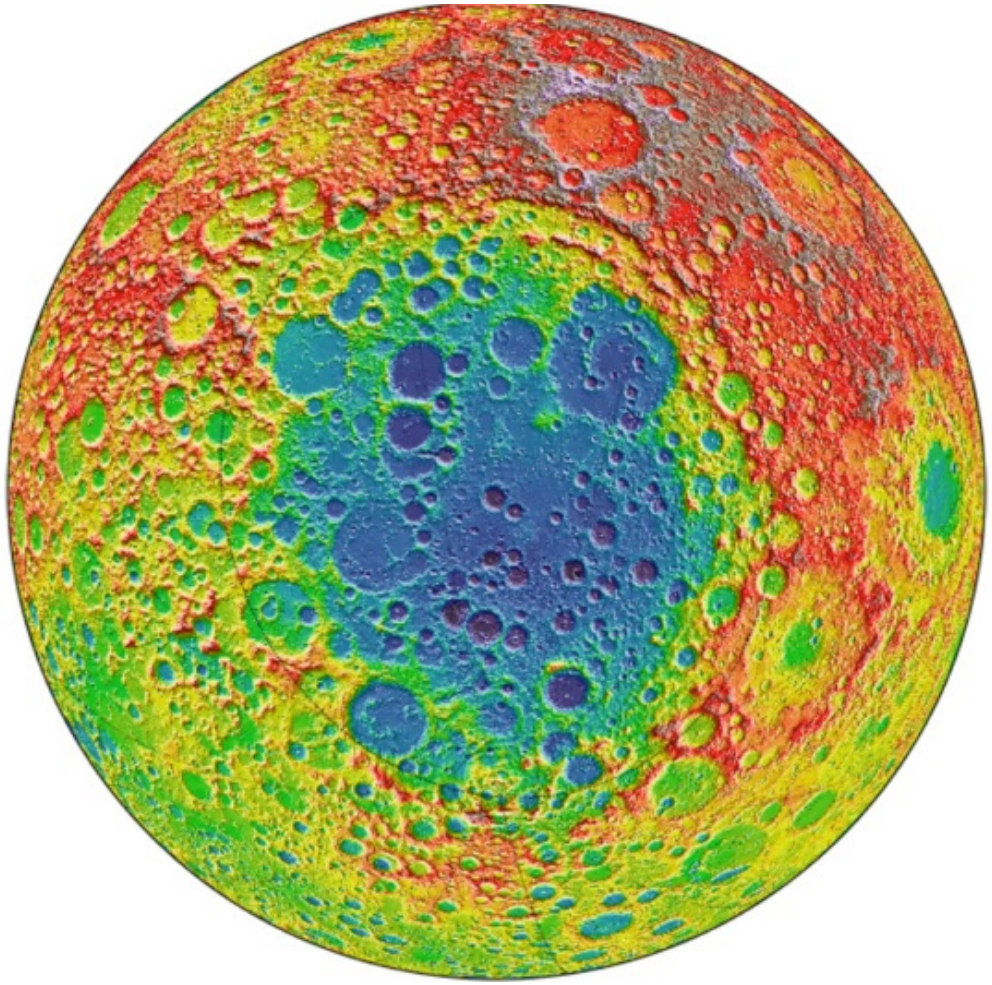
Data from Paige et al., 2010

The Lunar South Polar Region



European Space Agency

The Lunar South Polar Region



European Space Agency

Scientific Participation

1. **Long term access will bring future opportunities**
    a. Through international partnerships
    b. Building on strategic investments now
2. **Lunar Sample Return will bring new samples to Europe**
    a. LPSR with Russia
    b. Other potential opportunities
3. **Participation in Russian missions**
    a. Luna-Resurs lander
        – ESA contributions
        – Russian & European experiments
    b. Luna-Glob lander and Lunar Resurs Orbiter
        – Russian & European experiments