# Once Explorers, Always Explorers

## *Europe's Space Exploration Vision*

David Parker
Director - Human and Robotic Exploration

Space19+

# Space19

# Exploration @ESA is Strategy-Driven

***"focused on solar system destinations where humans will someday live and work."***

Global Exploration Strategy Framework Document, 2007

## *ESA Scientific Programme*

'bottom-up' + mandatory

➢ **competitive mission selection** among proposals from science community

## *ESA Exploration Programme*

'top-down' + optional

➢ **step-wise** with goal of extending human reach to Mars surface


# European Human and Robotic Exploration in 2018

# Four Programmatic Pillars

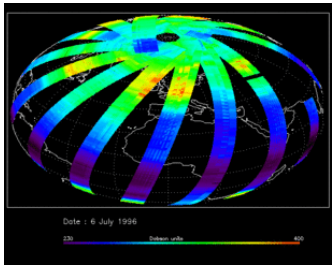
Science and Exploration

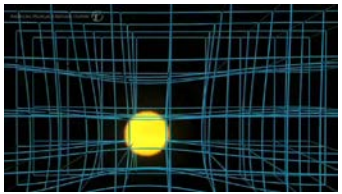
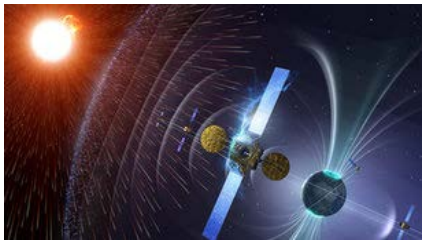
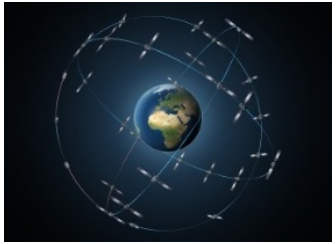
Safety and Security

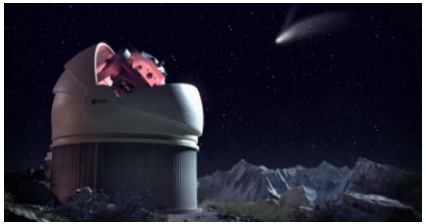
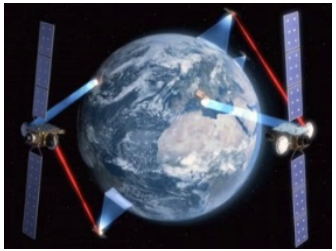
Applications

Enabling and Support (transp., tech, & ops)





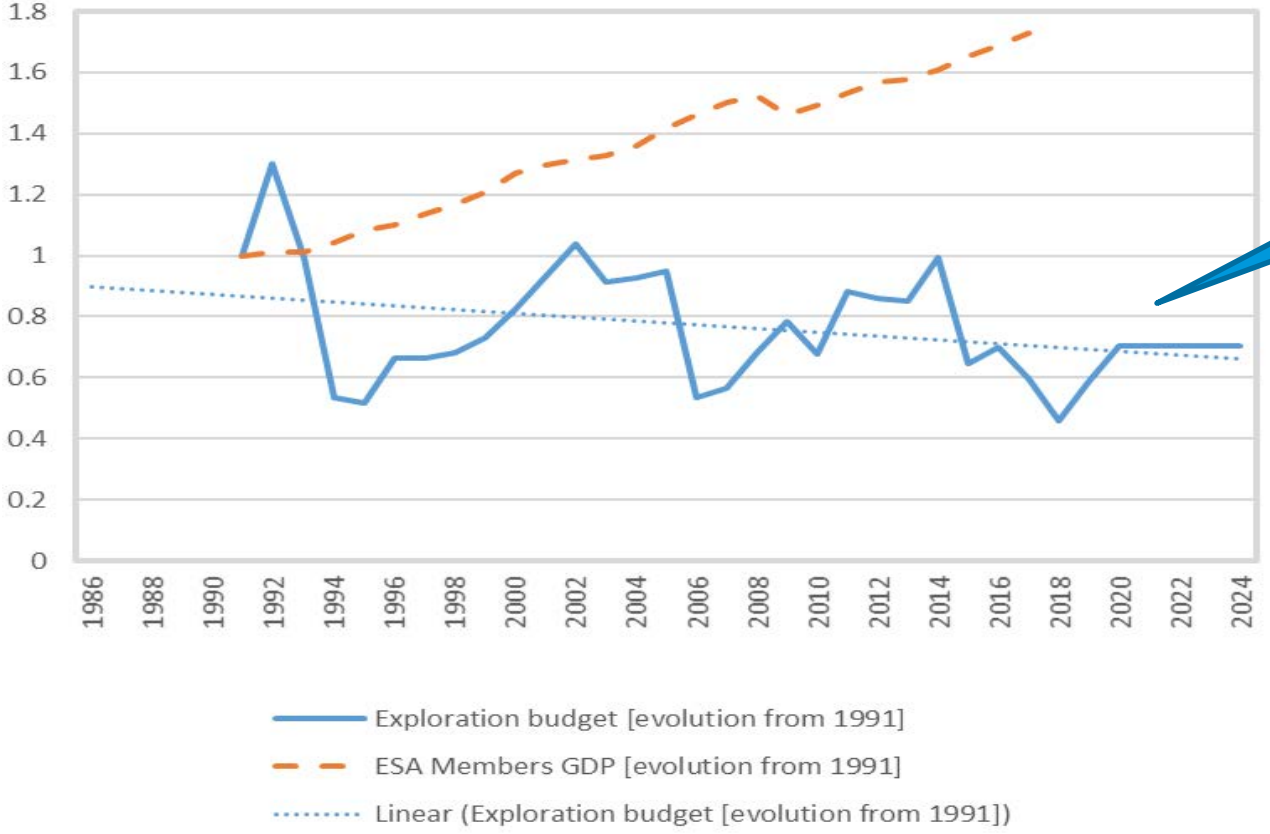





# 2019 ESA Ministerial Meeting – *Space19+*

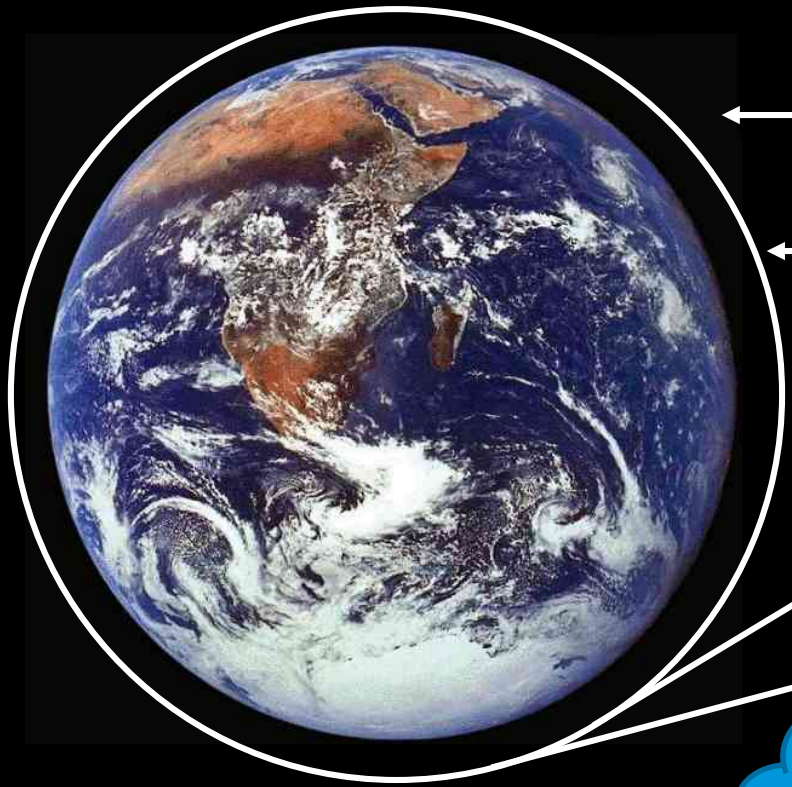
- New era of global exploration is happening *NOW*
- What role for Europe ?

# Why Europe doesn't have an independent exploration programme




Space19+

Proposal



1-2 years

~ 1 week

The Moon helps de-risk these challenges

Human Mars challenges:

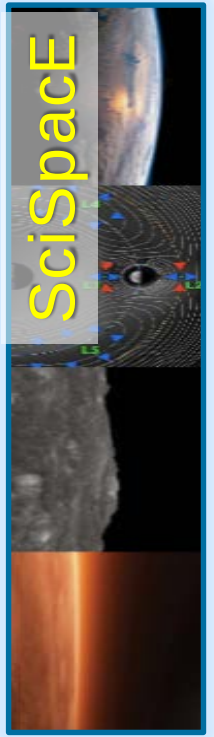
- propulsion
- safety/security
- physical health
- psychology
- radiation
- communication

# Our Future programme

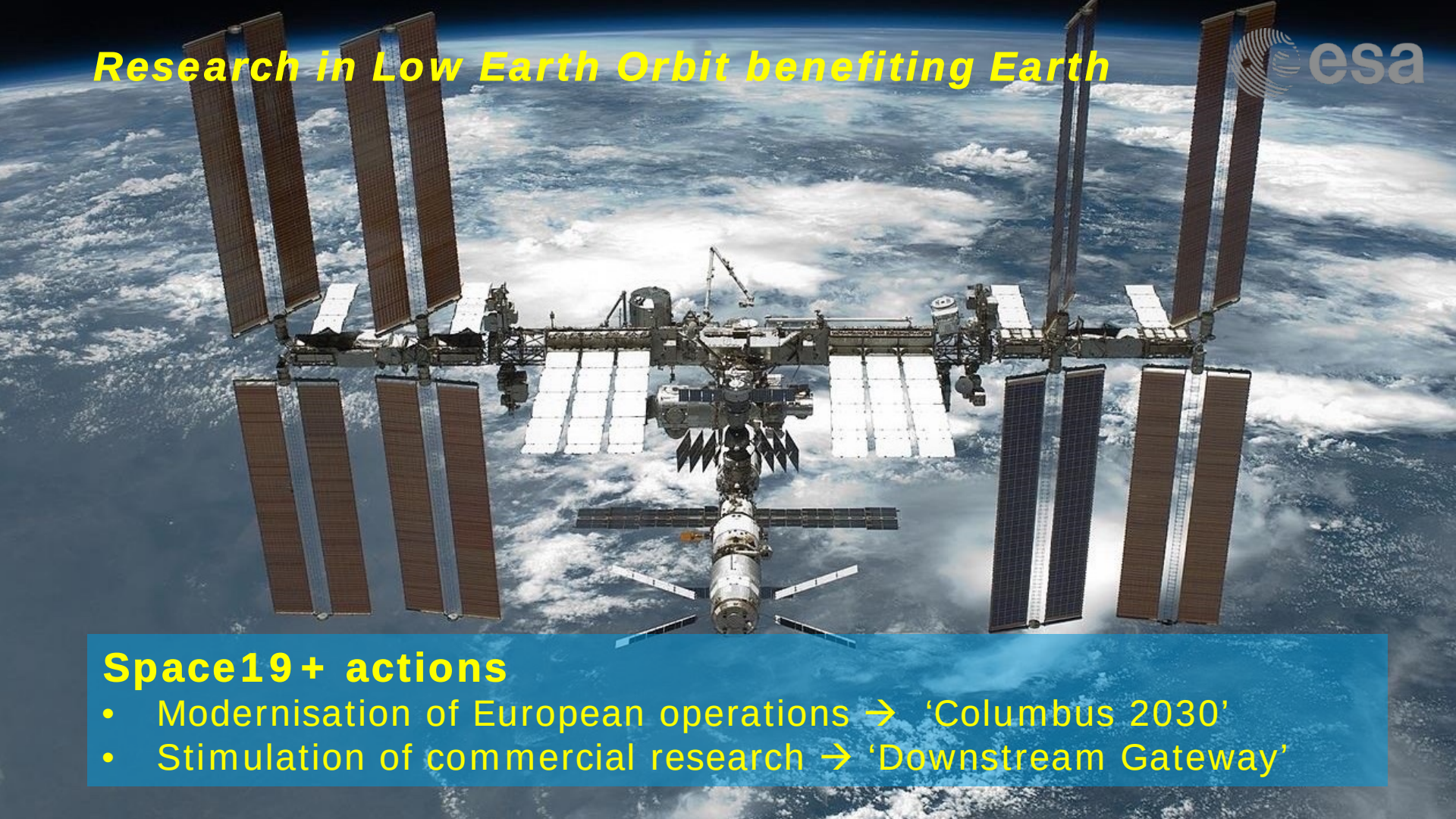
## *6 Activities; 4 Cornerstone campaigns; 1 Programme*





# *Research in Low Earth Orbit benefiting Earth*



## Space19+ actions

- Modernisation of European operations → ‘Columbus 2030’
- Stimulation of commercial research → ‘Downstream Gateway’

# → INTERNATIONAL SPACE STATION BENEFITS FOR EUROPE

## BETTER TOGETHER

1998: ESA meets International Space Station

strong partnership and international cooperation

- 15 international partners
- 230 individuals from 18 countries visited the ISS

## PROFITABLE SPACE

each euro spent on the Space Station produces €1.8 added value to European economies

1€ = 1€ 1€

**€7B** government revenues from ESA spending

**90%** spent in ESA participating countries

every 100 jobs in the space sector linked to the Space Station creates 90 additional jobs

## INSPIRATION

43K teachers trained per year

educational kits for schools

university lectures

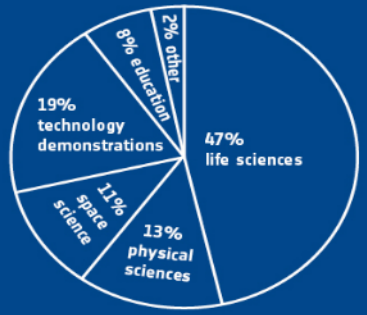
student nano-satellites and hands-on projects

**4M** friends **Facebook**

**6M** followers **Twitter**

**85M** views **YouTube**

## KNOWLEDGE FOR SOCIETY




**1850+** european researchers

**800+** experiments

## COMPETITIVE INDUSTRY

the partnership established Europe as a reliable international partner

Source: PricewaterhouseCoopers, ESA

European Space Agency

# International Space Station research

- Soyuz 59S successfully launched March 14, 2019
- Released in February:
  - Short-duration mission Announcement of Opportunity
  - Pre-/post-flight Announcement of Opportunity
    → AO Workshop on April 1 and 2, 2019 at ESTEC
  - EML Batch 4 Announcement of Opportunity
    → AO Workshop on May 23, 2019 in Friedrichshafen

# ESA Research using bedrest model

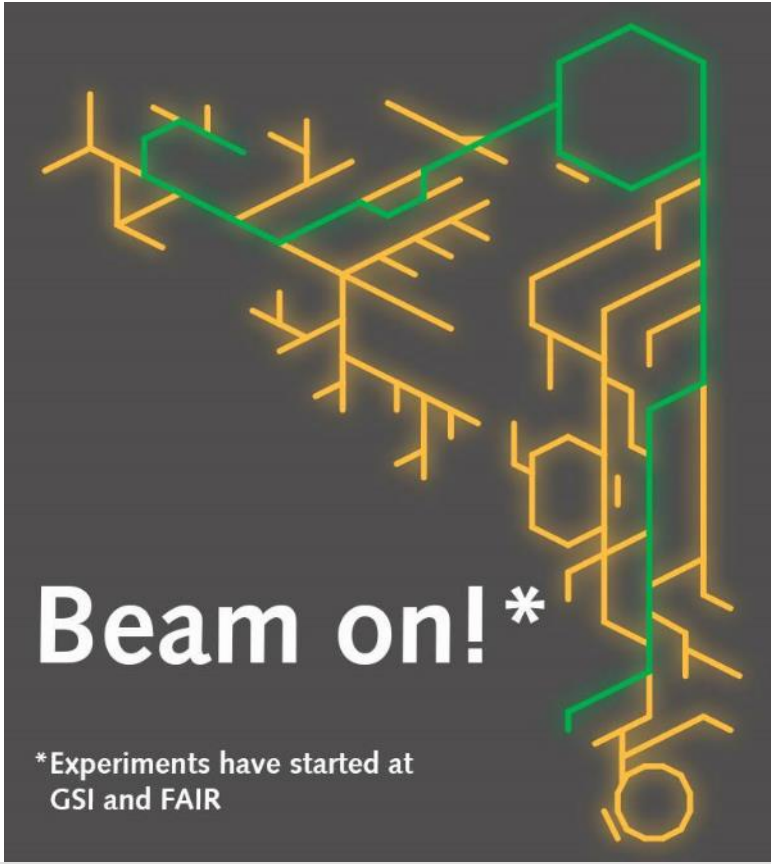
- Start of joint ESA/NASA Bedrest study on March 25, 2019.
- Preparations for future ESA-sponsored bedrest studies have started.
- Validation of dry-immersion model.

# ESA Research on Antarctic Research Stations

- Concordia WO2019 season with 4 ESA and 1 Italian experiment has started.
- Preparations for Concordia WO2020 are continuing.
- Recruitment of WO2020 Research MD under finalization.

# ESA Radiation Research Programme

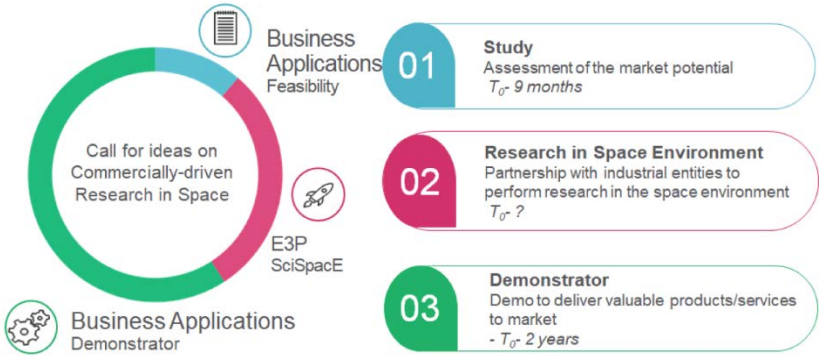
- Resumption of science activities through traditional IBER programme.
- Start of ESA/FAIR Radiation Summer School in September 2019.



# CFI Commercially-driven Research in Space

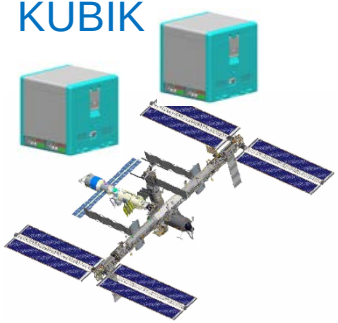
*Joint initiative between E3P and ESA Business Applications to boost application-driven utilisation of the ISS and other space environment facilities.*

Innovative 3 Phase Approach

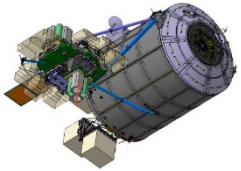



3 + 2 out of 38 proposals suggested for implementation


KUBIK



Bartolomeo



**14-16 Sept 2016**
ESA
Space for Inspiration

**8 Nov 2016**
ESA Inn Ex
*Health*

**4 Jun 2018**
ESA Inn Ex
Open CFI

**4 Sept 2018**
Close CFI
38 proposals

**Q1 2019**
CFI
Implementation


Forward to
the Moon

# ESA Lunar Strategies Developed

Working with the Community, and endorsed by HESAC, two key strategies have been produced:

✓ Lunar Science Strategy

✓ Space Resources strategy (in which Moon is identified as the first destination for using space resources to support exploration)

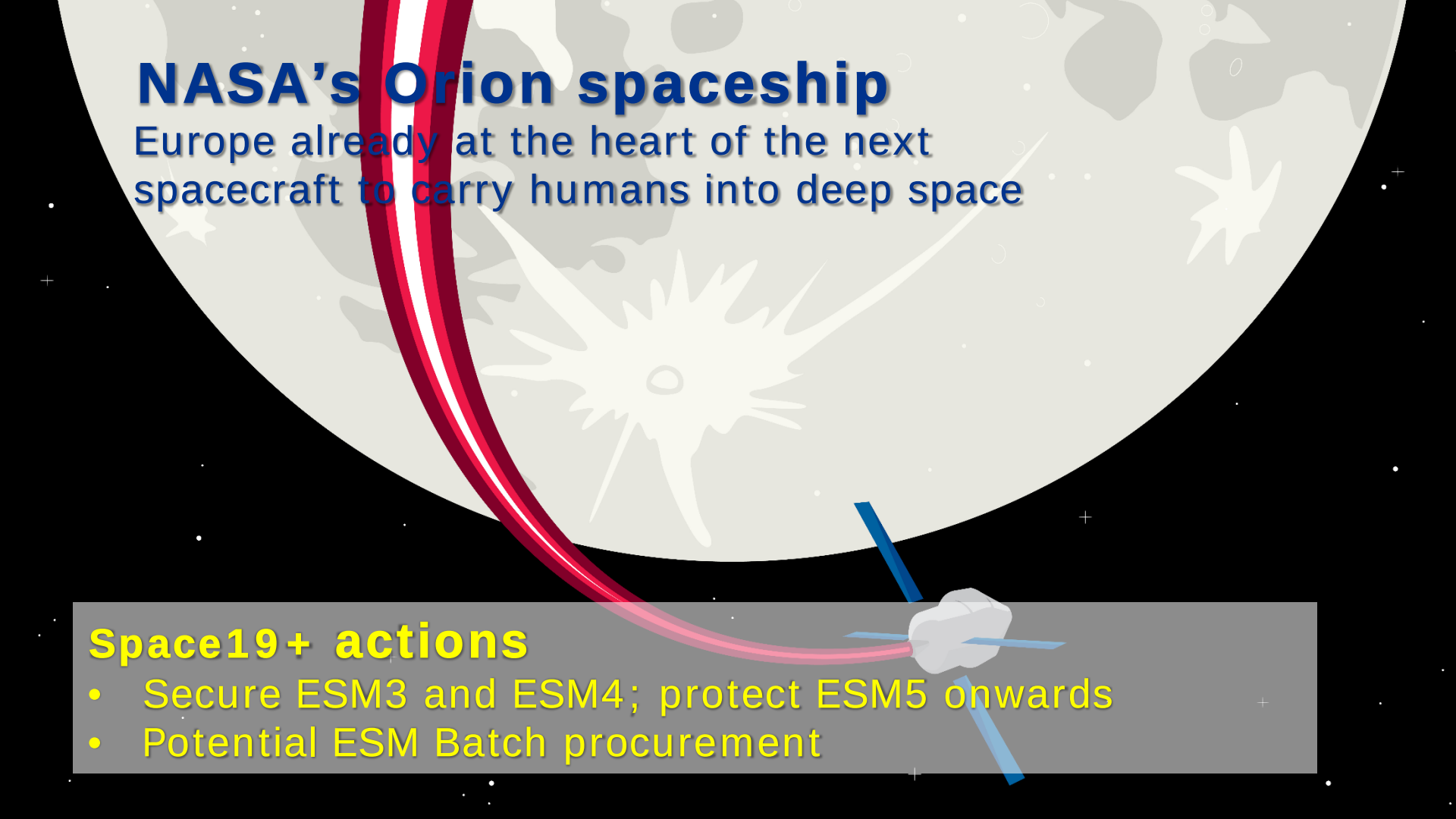
✓ Following RFI in 2018, a group of lunar science and technology payloads have been selected for implementation via the missions of opportunity element of Cornerstone 3.

# Lunar research identified by the community

- The bombardment history of the inner solar system
- The structure and composition of the lunar interior
- The diversity of lunar crustal rocks
- Volatiles at the lunar poles
- Volcanism, impact and regolith processes
- Atmospheric and dust environment
- Life sciences and astrobiology
- Fundamental physics
- Low frequency Radio Astronomy
- **Space resource utilisation**

# NASA’s Orion spaceship

## Europe already at the heart of the next spacecraft to carry humans into deep space



**Space19+ actions**

- Secure ESM3 and ESM4; protect ESM5 onwards
- Potential ESM Batch procurement

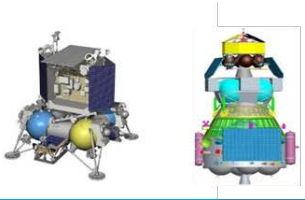
# *The Gateway: a sustainable spaceport for the Moon*

A permanent basecamp to support robots and humans on the lunar surface (and a research infrastructure by itself !)

# Preparing for the Gateway

- Possible design of ESPRIT's interior was tested underwater in Marseille in March by JF Clervoy and Astronaut trainer H. Stevenin.
- Test's main objectives were to evaluate requirements for payload operations and determine the best positioning for two cameras that will allow operations to be viewed from Earth.
- Credit: Airbus Defence & Space


# Moon Robotic exploration (CS#3) and link to human exploration



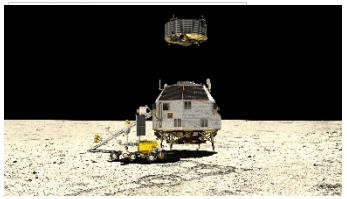
Link with Cornerstone 2 Gateway

Opportunity missions with third parties

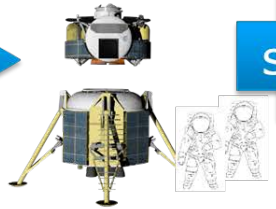
Commercial solicited dedicated to ISRU

OR

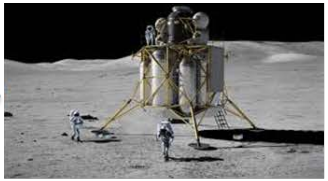
ESA-led robotic (HERACLES)



Role in Human Architecture



subsequent



Period 2 (2020-22) Period 3 (2023-25) Period 4 (2026-28)

# Moon Robotic exploration (CS#3) (2/2)

- Step 1: Missions of Opportunity
  - ✓ PILOT and PROSPECT (Luna-27)
  - ✓ New possibilities: e.g. Chang'e series, US missions, JAXA, commercial
- Step 2: Preparation of an ESA-led robotic mission
  - ✓ Robotic Precursor to human exploration (HERACLES) enabled by IPs
  - ✓ Demonstration of end-to-end ISRU enabled by commercial partnership

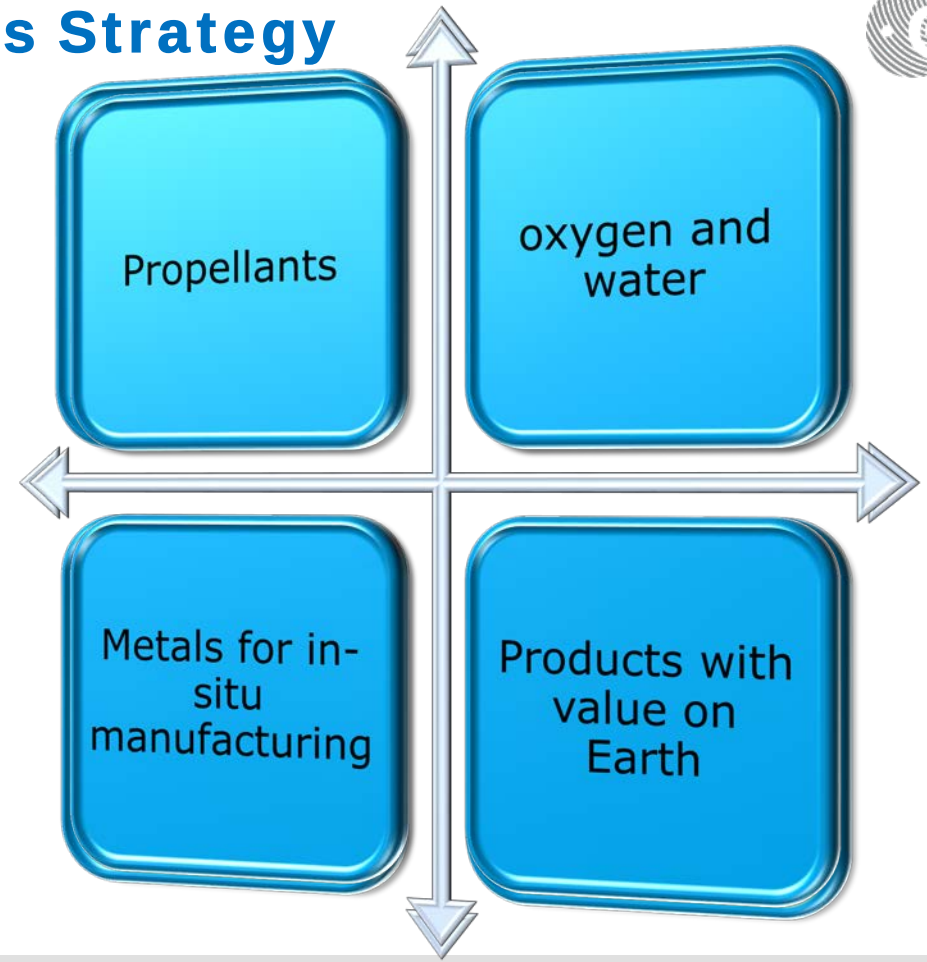
| 2020 | 2021 | 2022 | >2023 (E3P3) |
|---|---|---|---|
| HERACLES Phase B1<br>ISRU Phase B1 | Down selection | → Phase B2 | → Phase C/D |

- Step 3: Role in Human architecture (Phase A/B studies within ExPeRT)
  - ✓ Roles in US-led ascender/descender or Moon tug transfer vehicle considered
  - ✓ Both elements based on Orion/ESM experience

# ESA's Space Resources Strategy

## What ?

***An end to end demonstration of feasibility of using lunar resources***

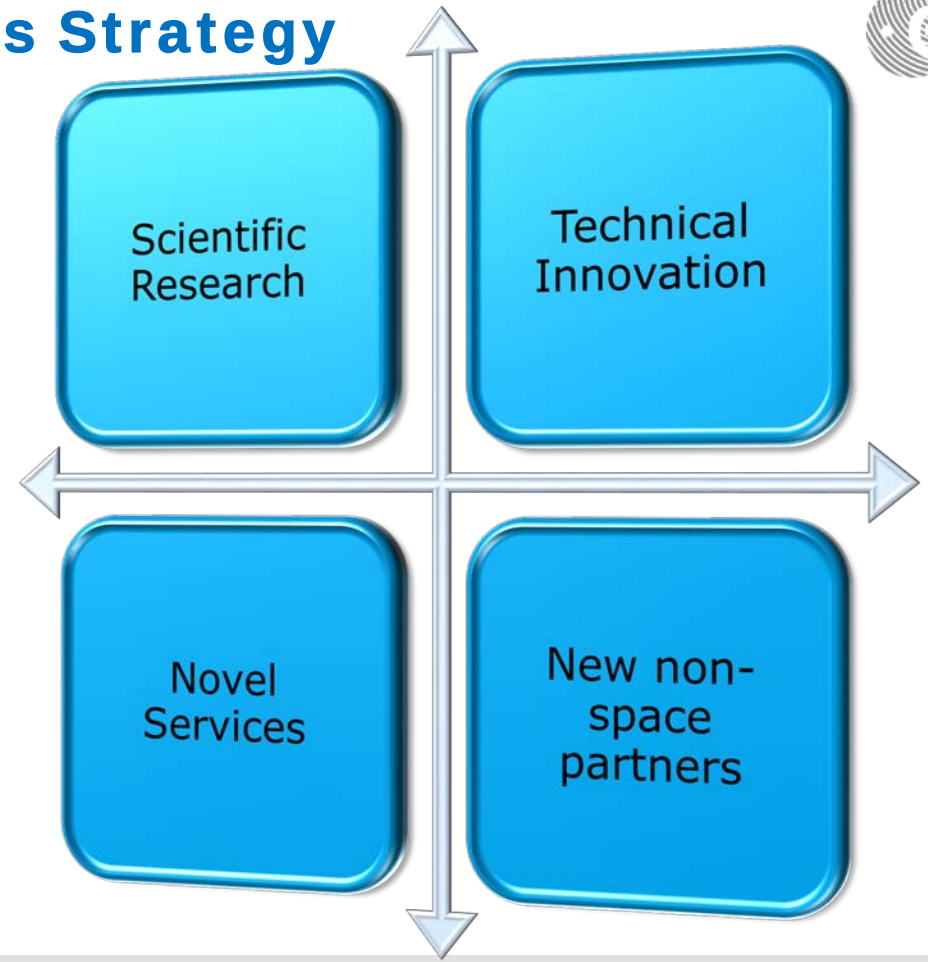


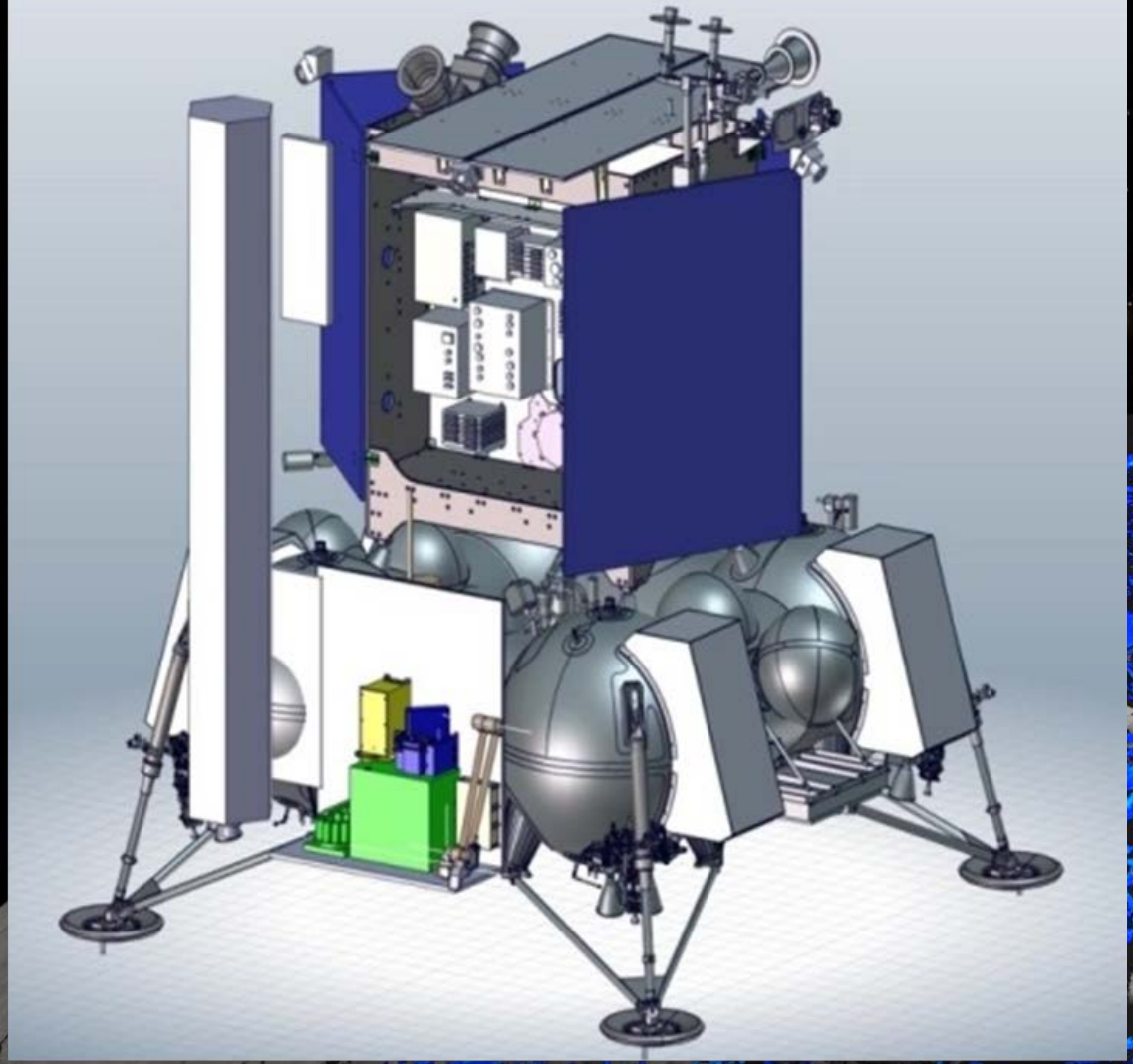
# ESA's Space Resources Strategy

**What ?**

***An end to end demonstration of feasibility of using lunar resources***

**And How ?**





# Lunar Resource Lander (ESA+Russia) 2023

Permanently shadowed regions at Moon's South pole.

Perhaps hosting water ice

*(false colour)*

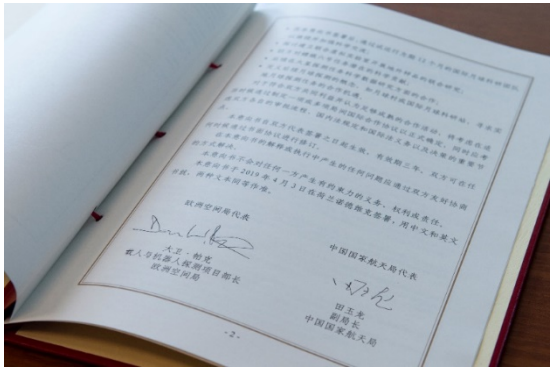
# Lunar science Statement of Intent signed with NASA SMD

- Coordinate science on early robotic missions
- E.g. NASA CLPS
- European Lunar Pathfinder
- Joint WG set up

# Letter of Intent with CNSA

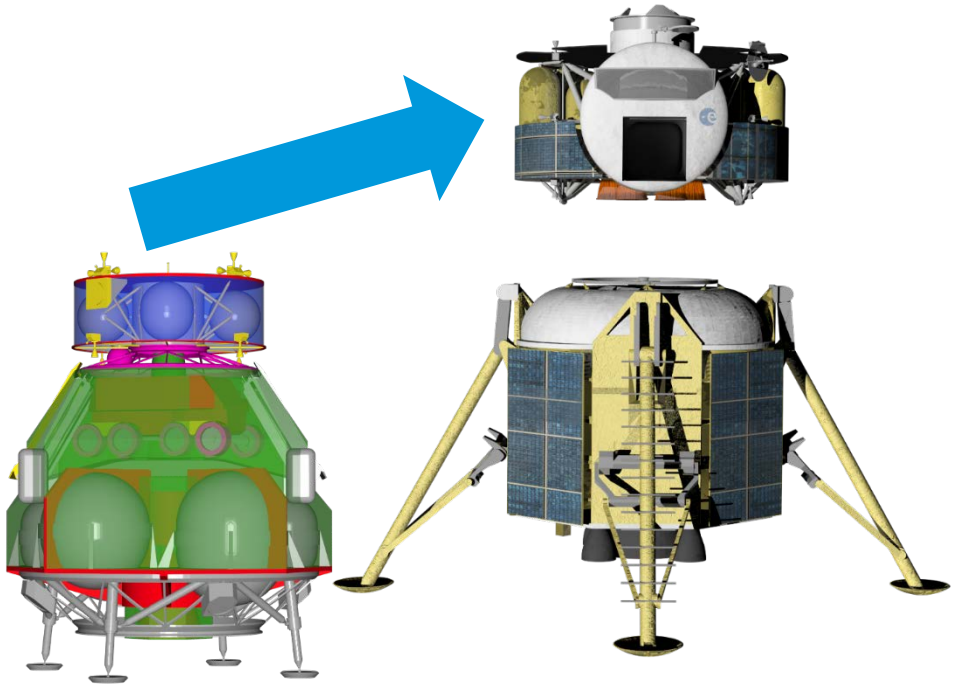
Cooperation opportunities in the following areas:

- 12 months pilot phase aimed at establishing an International Lunar Research Team.
- Joint Virtual Laboratory on extra-terrestrial samples.
- Potential European contributions to the Chang'E 6 mission.
- Future scientific Mars cooperation.
- Future architecture work on an International Lunar Research Station.



# Towards a Human Return to the Moon

- Not just a re-run of Apollo !
- Balance “Science” and “Mars forward” objectives
- Sustainable - re-usable elements
- Plan for an “Exit Strategy”
  - ✓ Transition to sustained presence - a Moon base
  - ✓ Forward to Mars




Gateway + robotic missions
= sustainable human exploration

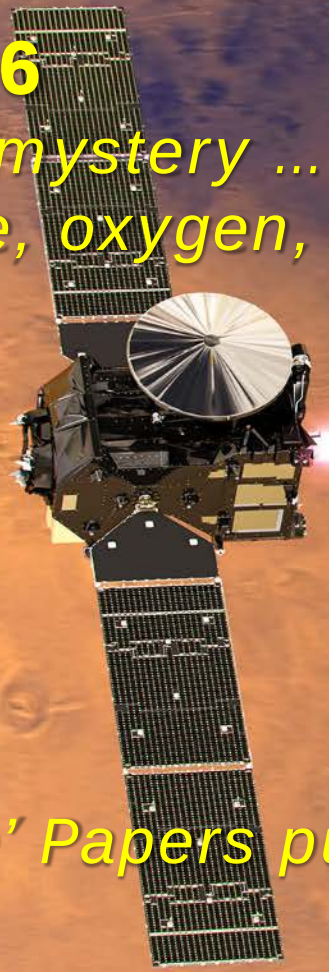
# And on to the Red Planet …

Martian north pole & northern Tempe Terra, 2 May 2014 / ESA Mars Express HRSC / ESA, DLR, FU Berlin, Justin Cowart, CC BY-SA 3.0 IGO

# ExoMars 2016

*On the trail of a mystery …*

*Is there methane, oxygen, water in the atmosphere?*



*→ First 3 'Nature' Papers published in April 2019*

ExoMars 2016 Trace Gas Orbiter Mars orbit insertion, 19 October 2016 / ESA, Roscosmos

# ExoMars 2020

## *The Rosalind Franklin Rover*

A robotic scientist in search of life

ExoMars 2020 rover / ESA, Roscosmos

ESA, Roscosmos

# What are we aiming for with the rover ?

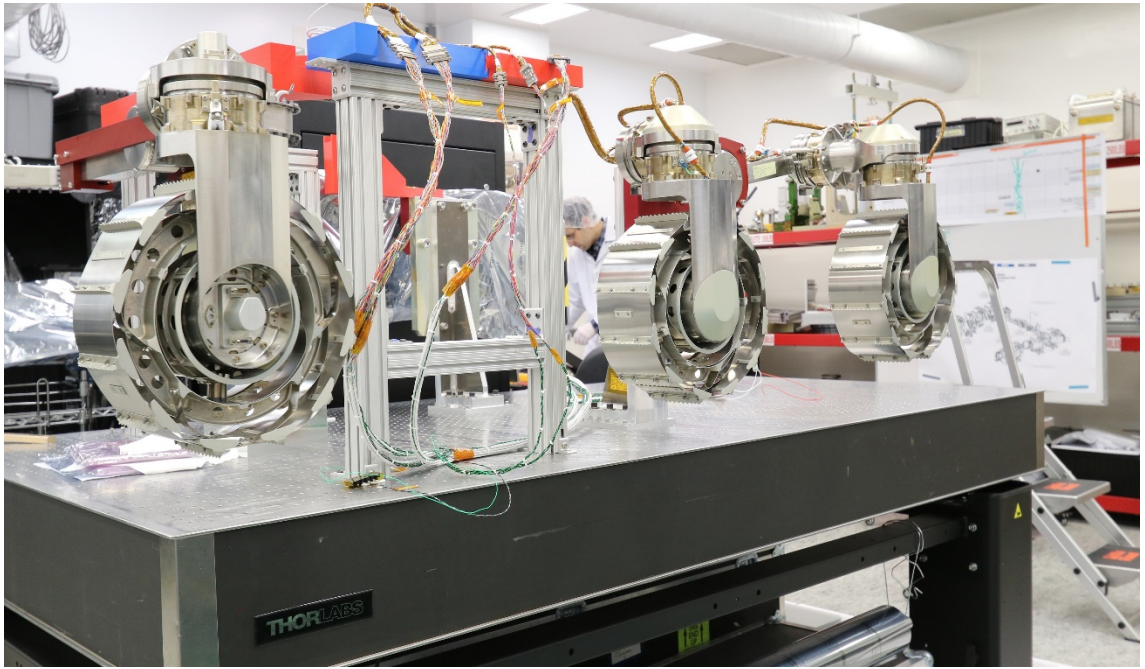
## 2020: ExoMars Rover and Surface Platform

- ✓ Travel back in time 4 billion years to explore the bottom of a Martian sea that no longer exists
- ✓ Drill deep to penetrate below the organics degradation horizon
- ✓ Look for traces of life beyond Earth
- ✓ Obtain knowledge for future sample return and human missions


# Analytical Laboratory – the heart of the rover science

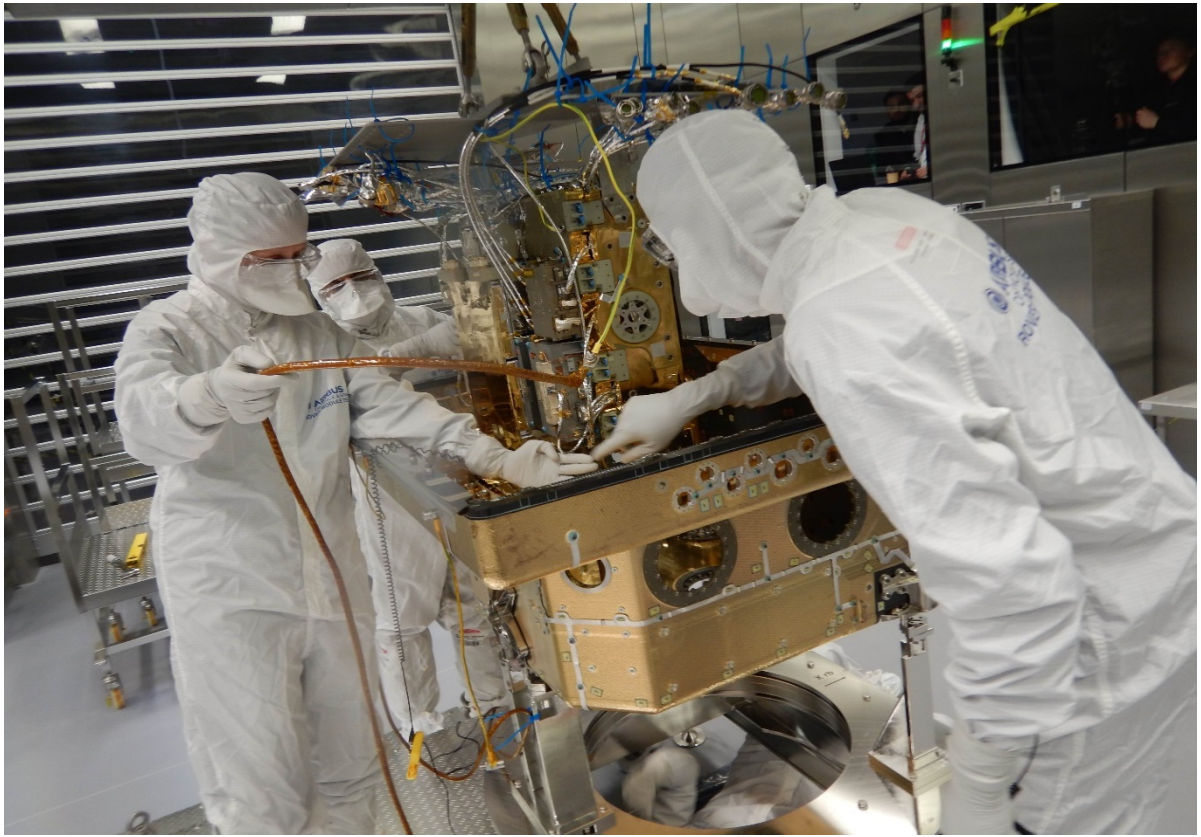
# Rover Chassis testing and the flight hardware


Rover chassis testing credit:
RUAG-CH facilities




Rover Chassis Flight Model
Credit: MDA-Canada

# Status of Rover Module



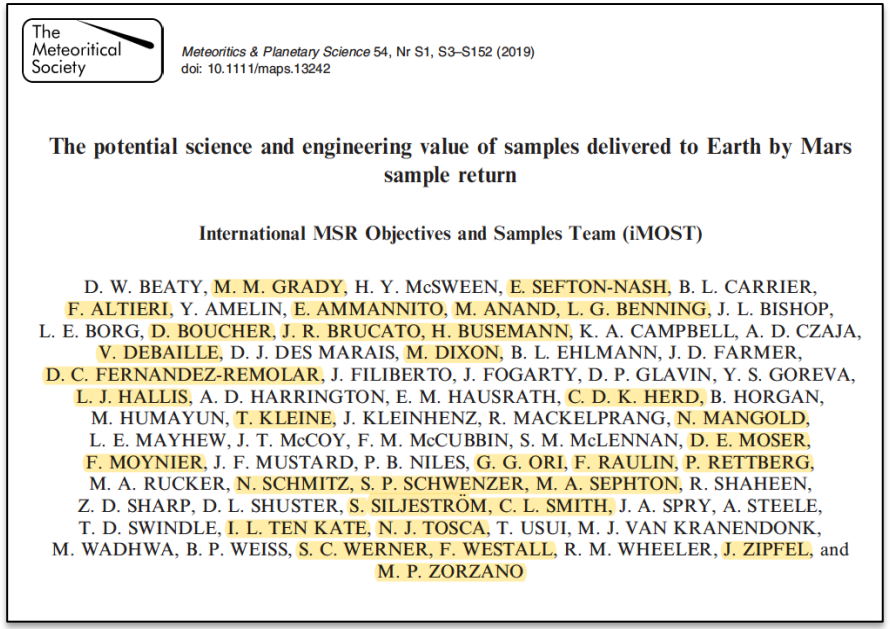
Rover service module integration within the flight model bathtub

Credit: Airbus Defence & Space

# The First Round Trip to the surface of Mars

*Robotic Mars Sample Return*

# International Science Case for MSR published



The Meteoritical Society

*Meteoritics & Planetary Science* 54, Nr S1, S3–S152 (2019)
doi: 10.1111/maps.13242

**The potential science and engineering value of samples delivered to Earth by Mars sample return**

**International MSR Objectives and Samples Team (iMOST)**

D. W. BEATY, M. M. GRADY, H. Y. McSWEEN, E. SEFTON-NASH, B. L. CARRIER, F. ALTIERI, Y. AMELIN, E. AMMANNITO, M. ANAND, L. G. BENNING, J. L. BISHOP, L. E. BORG, D. BOUCHER, J. R. BRUCATO, H. BUSEMANN, K. A. CAMPBELL, A. D. CZAJA, V. DEBAILLE, D. J. DES MARAIS, M. DIXON, B. L. EHLMANN, J. D. FARMER, D. C. FERNANDEZ-REMOLAR, J. FILIBERTO, J. FOGARTY, D. P. GLAVIN, Y. S. GOREVA, L. J. HALLIS, A. D. HARRINGTON, E. M. HAUSRATH, C. D. K. HERD, B. HORGAN, M. HUMAYUN, T. KLEINE, J. KLEINHENZ, R. MACKELPRANG, N. MANGOLD, L. E. MAYHEW, J. T. McCOY, F. M. McCUBBIN, S. M. McLENNAN, D. E. MOSER, F. MOYNIER, J. F. MUSTARD, P. B. NILES, G. G. ORI, F. RAULIN, P. RETTBERG, M. A. RUCKER, N. SCHMITZ, S. P. SCHWENZER, M. A. SEPHTON, R. SHAHEEN, Z. D. SHARP, D. L. SHUSTER, S. SILJESTRÖM, C. L. SMITH, J. A. SPRY, A. STEELE, T. D. SWINDLE, I. L. TEN KATE, N. J. TOSCA, T. USUI, M. J. VAN KRANENDONK, M. WADHWA, B. P. WEISS, S. C. WERNER, F. WESTALL, R. M. WHEELER, J. ZIPFEL, and M. P. ZORZANO

**Executive Summary:** https://doi.org/10.1111/maps.13232
**Full Report:** https://doi.org/10.1111/maps.13242

**iMOST co-chairs:** Monica Grady (Open University, UK), David Beaty (JPL), Hap McSween (U. of Tenessee), Elliot Sefton-Nash (ESA).

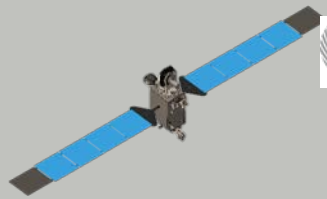
- Structure of MSR scientific objectives defined
  - 7 primary objectives
  - 2 have detailed sub-goals (geology, life)
- Major effort to validate with large community
  - 71 co-authors (32 in ESA states, yellow)
  - Presentation and community feedback at 4 major science conferences
  - 31 reviewers
- Massive effort to review all relevant published literature

# Mars Sample Return Campaign

Mars 2020 Rover

Sample Return Lander

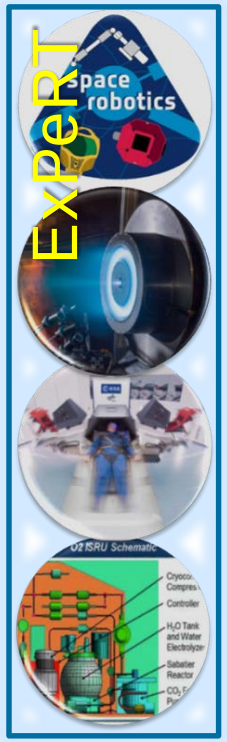
Earth Return Orbiter



Science Facilities

International

# ExPeRT Period 2 - Technology




## *Technology*

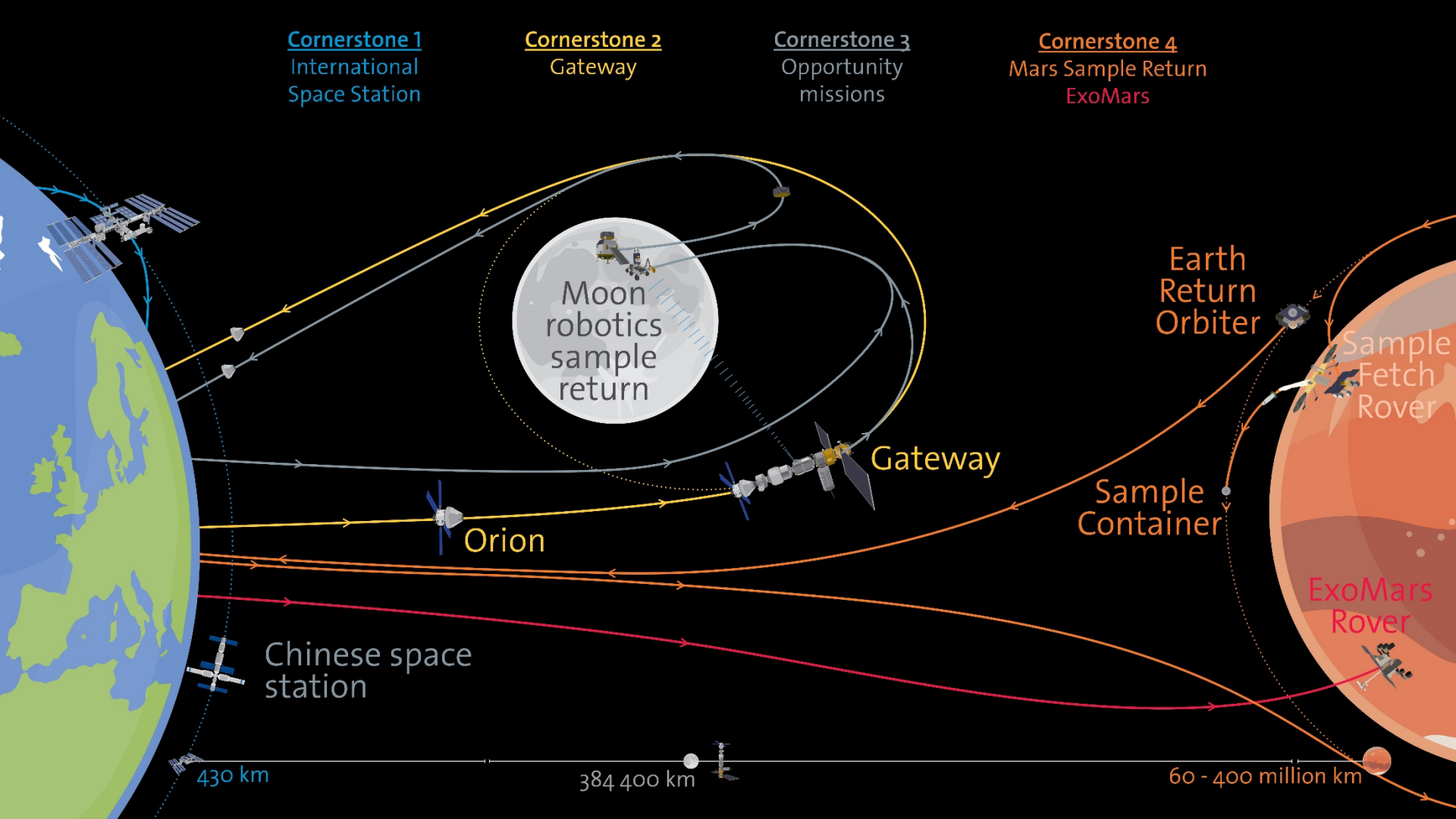
- ❑Propulsion
- ❑Energy
- ❑Life Support
- ❑Autonomy/Navigation/Artificial Intelligence
- ❑In Situ Resources
- ❑Radiation protection and mitigation

## *System Studies*

- ❑ Main focus: robotic + human lunar

# Main contents of E3P Period 2

| Activity | Main actions |
|---|---|
| SciSpacE | - ISS science; non-ISS science; start of Gateway science |
| CS#1 Humans in LEO | - Columbus 2030 (modernisation project)<br>- Astronaut missions in 2020/21/22<br>- Business in Space Growth Network |
| CS#2 Humans Beyond LEO | - ESM batch procurement (3+4; protect 5+6)<br>- ESPRIT (refuelling, telecoms and science module)<br>- I-Hab (crew module with JAXA/CSA/NASA) |
| CS#3 Lunar robotic | - Missions of Opportunity (tech/science on 3rd party international and commercial missions)<br>- Preparation for major European-led mission |
| CS#4 Mars robotic | - Completion of ExoMars<br>- MSR Sample Fetch Rover<br>- MSR Earth Return Orbiter |
| ExPeRT | - Mid-TRL exploration technology + mission studies |


Cornerstone 1
International Space Station
Cornerstone 2
Gateway
Cornerstone 3
Opportunity missions
Cornerstone 4
Mars Sample Return
ExoMars
Moon robotics sample return
Gateway
Orion
Earth Return Orbiter
Sample Fetch Rover
Sample Container
ExoMars Rover
Chinese space station
430 km
384 400 km
60 - 400 million km

# Tomorrow's headlines ?

*... First European en route to the Moon ...*

*... First lunar internet service operational ...*

*... First proof that explorers can 'live off the land' using off-world resources ...*

*... First round-trip mission to surface of Mars underway ...*


Space19
esa
esa
European Space Agency