

# Human and Robotic Exploration – an update for ESSC

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David Parker,  
Director of Human and  
Robotic Exploration  
26 November 2020

# Benefits driven exploration programme



Initiatives

Benefits

Strategic Objectives

Mission





# ESA funded and co-funded experiments 1972-2020



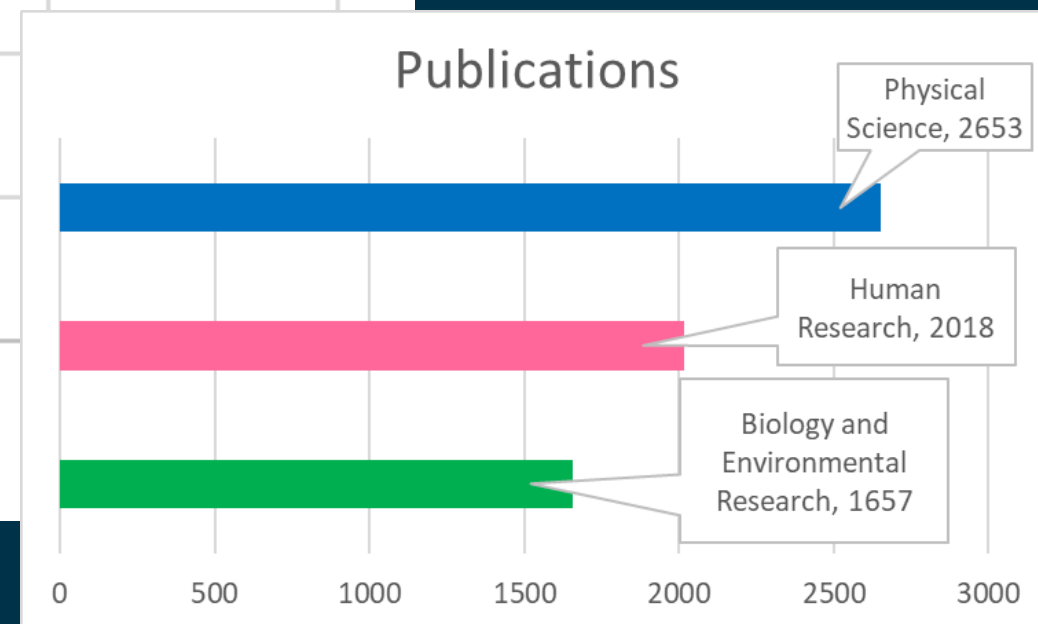
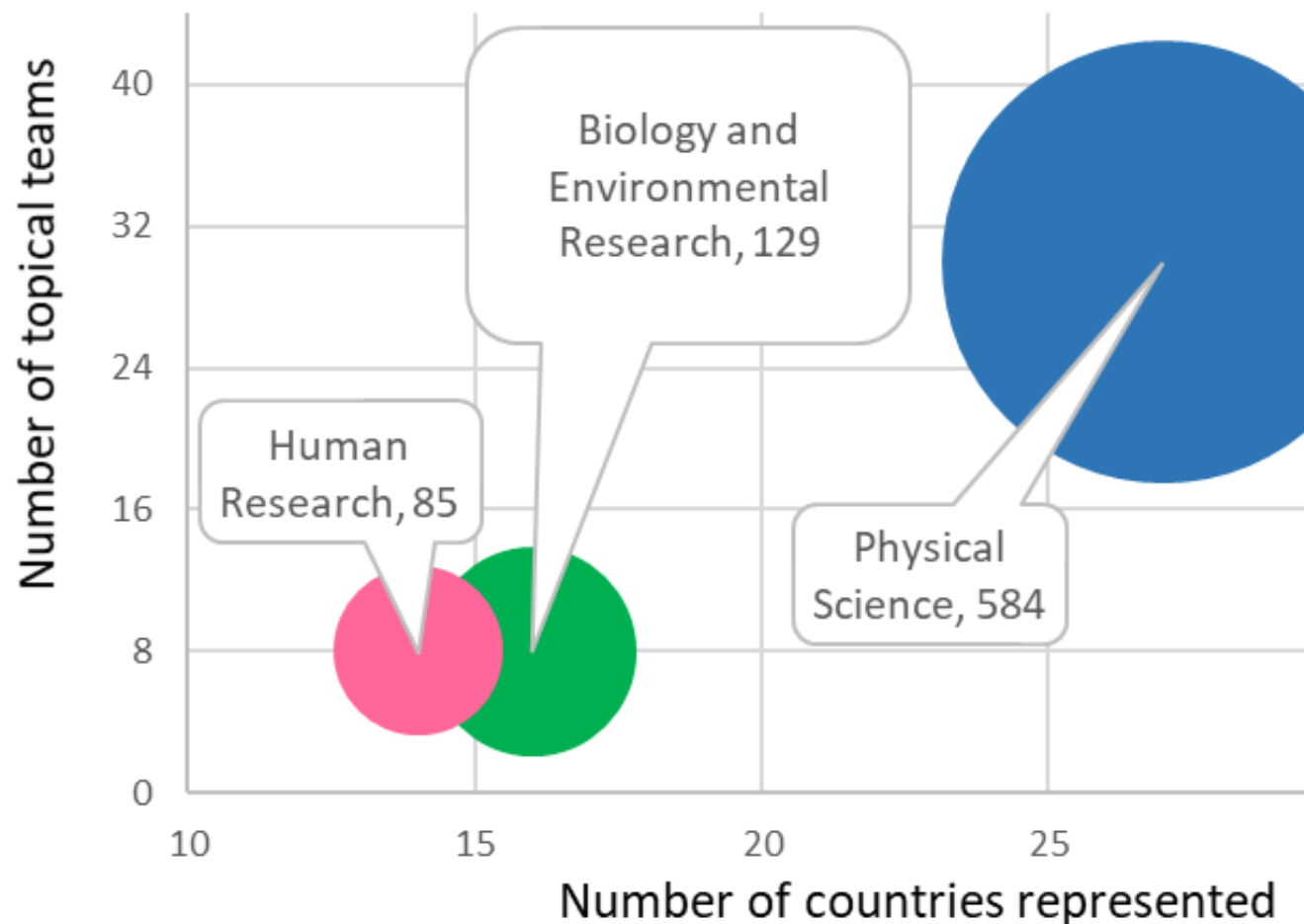
	Space Stations	Shuttle	Retrievable Capsules	Sounding Rockets	Parabolic Flights	Ground Facilities
Missions	85	30	18	87	91	49
Research Areas	59	42	35	50	71	43
Experiments	1661	416	171	394	1171	291

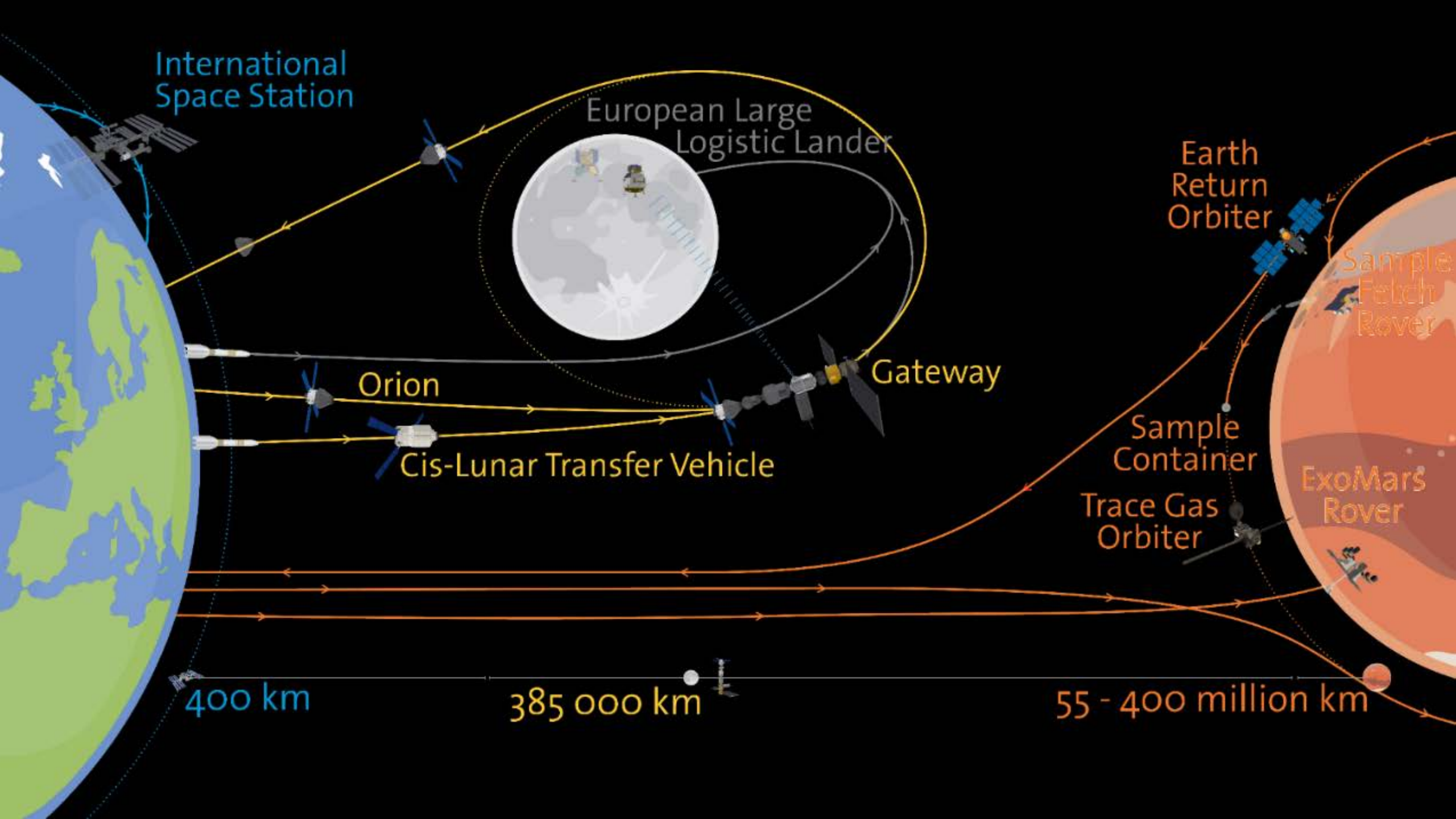
<https://eea.spaceflight.esa.int/portal/>



# SciSpacE Topical Teams

Bubble area represents number of individual scientists active in the research area



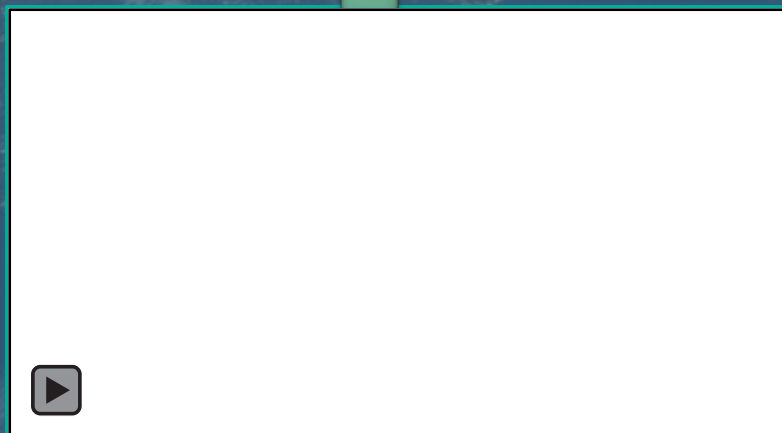


# E3P following Space19+ 4 Cornerstone campaigns + 2 transversal activities

**EXPERT** space robotics



**SciSpaceE**



## INTERNATIONAL COOPERATION

- ❑ Gateway MoU and MSR international agreement signed by DG
- ❑ Pesquet + Maurer flight agreements signed with NASA
- ❑ Further lunar science opportunities with NASA/India/Japan

## PROCUREMENT

- ❑ 1.3 B€ contracts approved and signed by October 2020
- ❑ 1.6 B€ additional contracts to be signed during 2021

## EVOLVED ORGANISATION

- ❑ HRE 2.0 operational to align organisation with mandate at Space19+



To reflect 33% programme growth following Space19+

- Programme Manager for integration and support to Director
- 3 **development/operations** groups corresponding to 3 E3P destinations
- **Research and Payloads** group for science including ISS/Gateway payloads
- ExPeRT team for **studies and technology**
- **Commercialisation & Innovation**
- **Strategy and Coordination**
- **Programme Management Support**

# CS#1: Humans in LEO

## Research in Low Earth Orbit benefiting Earth





# Expedition 1 crew: December 2000



# Expedition 64 crew: December 2020

# Operations at the time of Covid...

All pre-flight Baseline Data Collections (BDCs) with Crew-1 astronauts (V.Glover, M.Hopkins, S.Walker, S.Noguchi) for ESA experiments (Myotones, GRIP, GRASP, TIME and DNAmAge) were successfully completed

BDCs were performed at JSC in cooperation with NASA to account for current Covid-19 restrictions

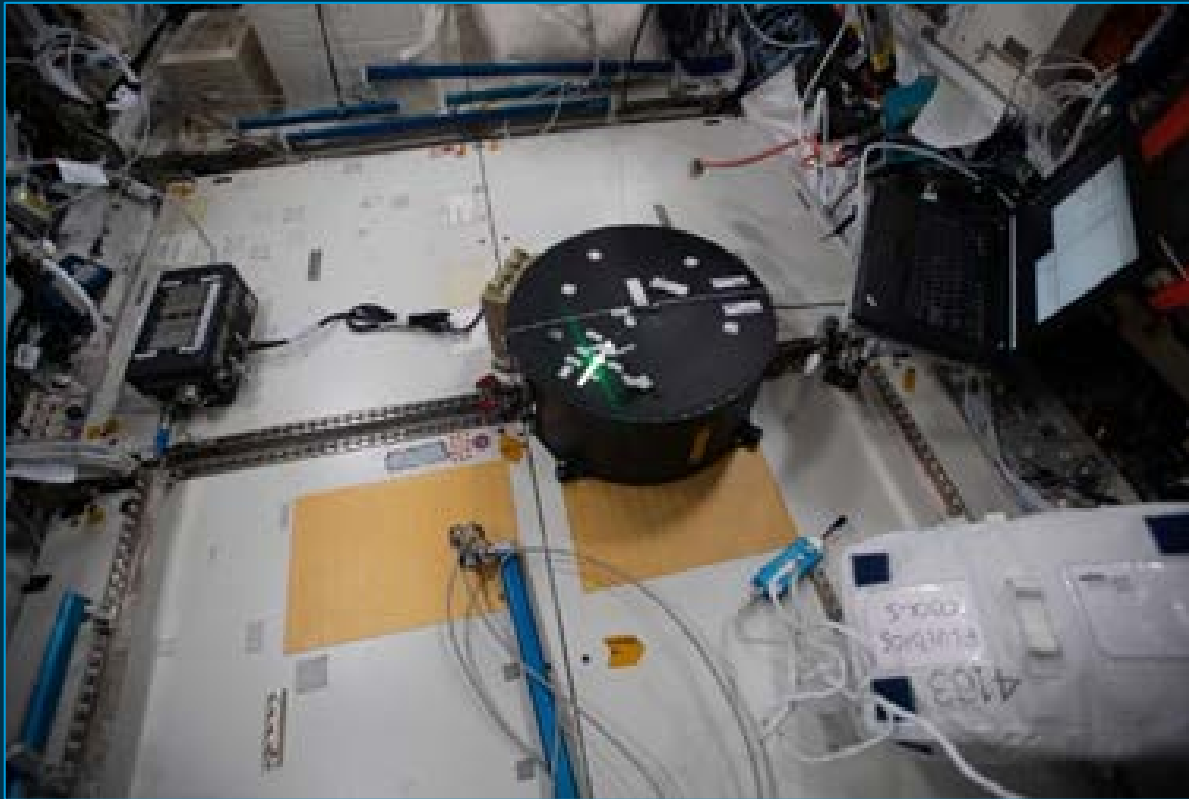


# ISS Research: EDR2 installation on-board



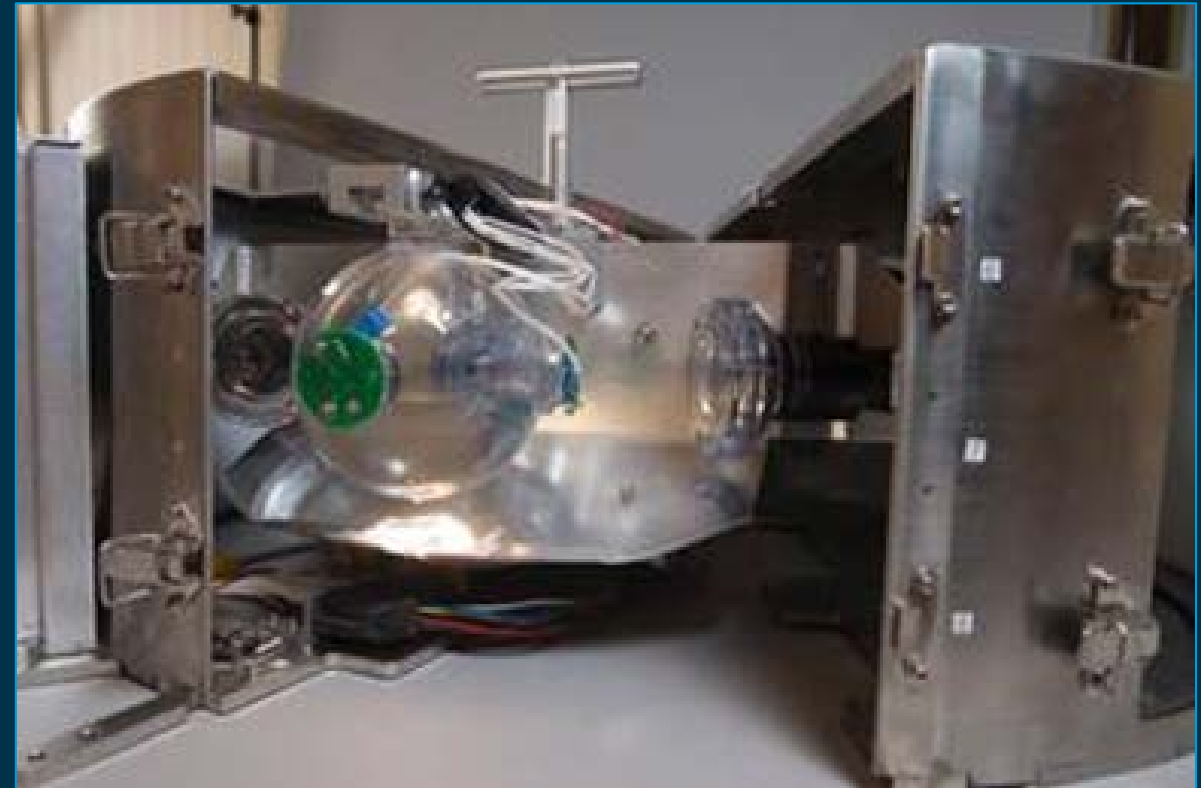
Credits: ESA





Fluidics installed on the deck racks in the Columbus laboratory  
(Credits: NASA)

The Fluidics experiment equipment featuring one of the three transparent spheres  
(Credits: CNES)



# ISS Research: PK-4 Science Campaign #10

PK-4 Science campaign #10 was conducted by Russian crew member Anatoly Ivanishin with remote support from TSUP/Russia and COL-CC/Germany

Credits: ESA MK



# ISS Research: Transparent Alloys SETA completed



Transparent Alloys SETA experiment was completed with good science results and near real-time data downlink

Credits: ESA





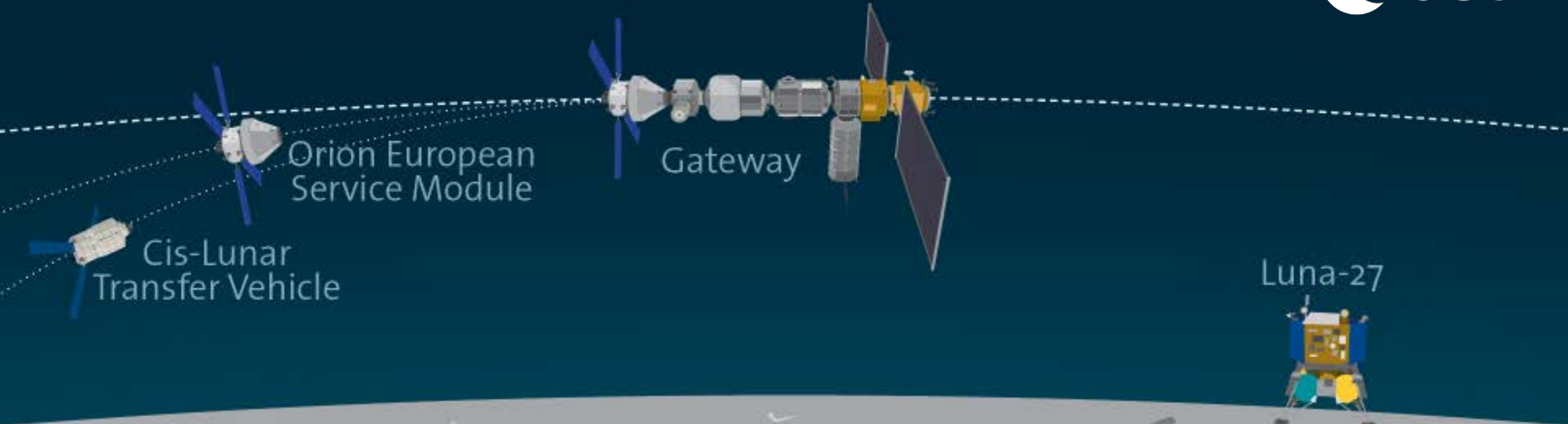
- ESA Astro-Pi 2019/2020 Challenge performed successfully
- 6350 teams contributed to Mission Zero
- 208 teams in Phase 4 of Mission Space Lab

# Analogue Research: Parabolic flights

ESA Parabolic Flight Campaign 73 completed with three successful flights out of Paderborn Lippstadt



# Forward to the Moon



✓ TIA-led LCNS study procurement ongoing

European Large Logistic Lander

**Awaiting any effects of change of US administration**

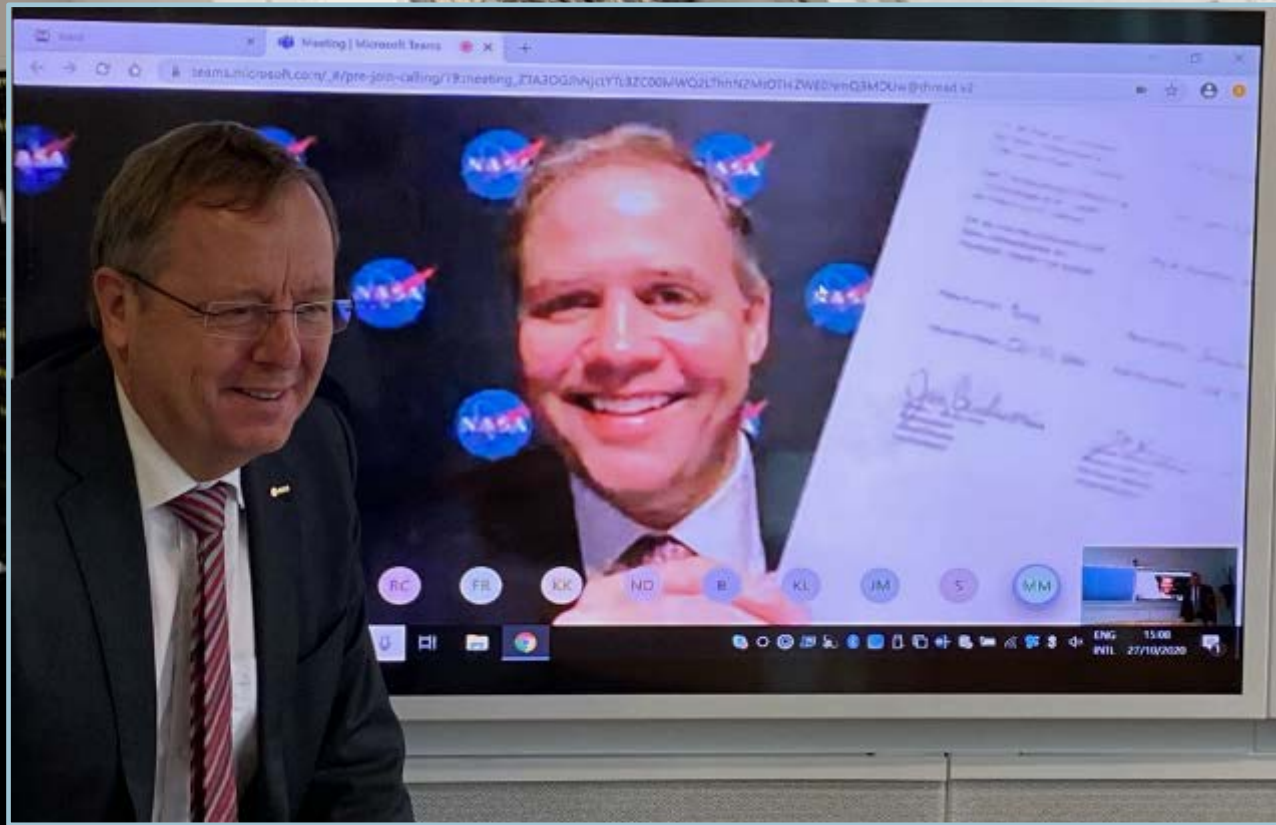
ESA UNCLASSIFIED - For Official Use



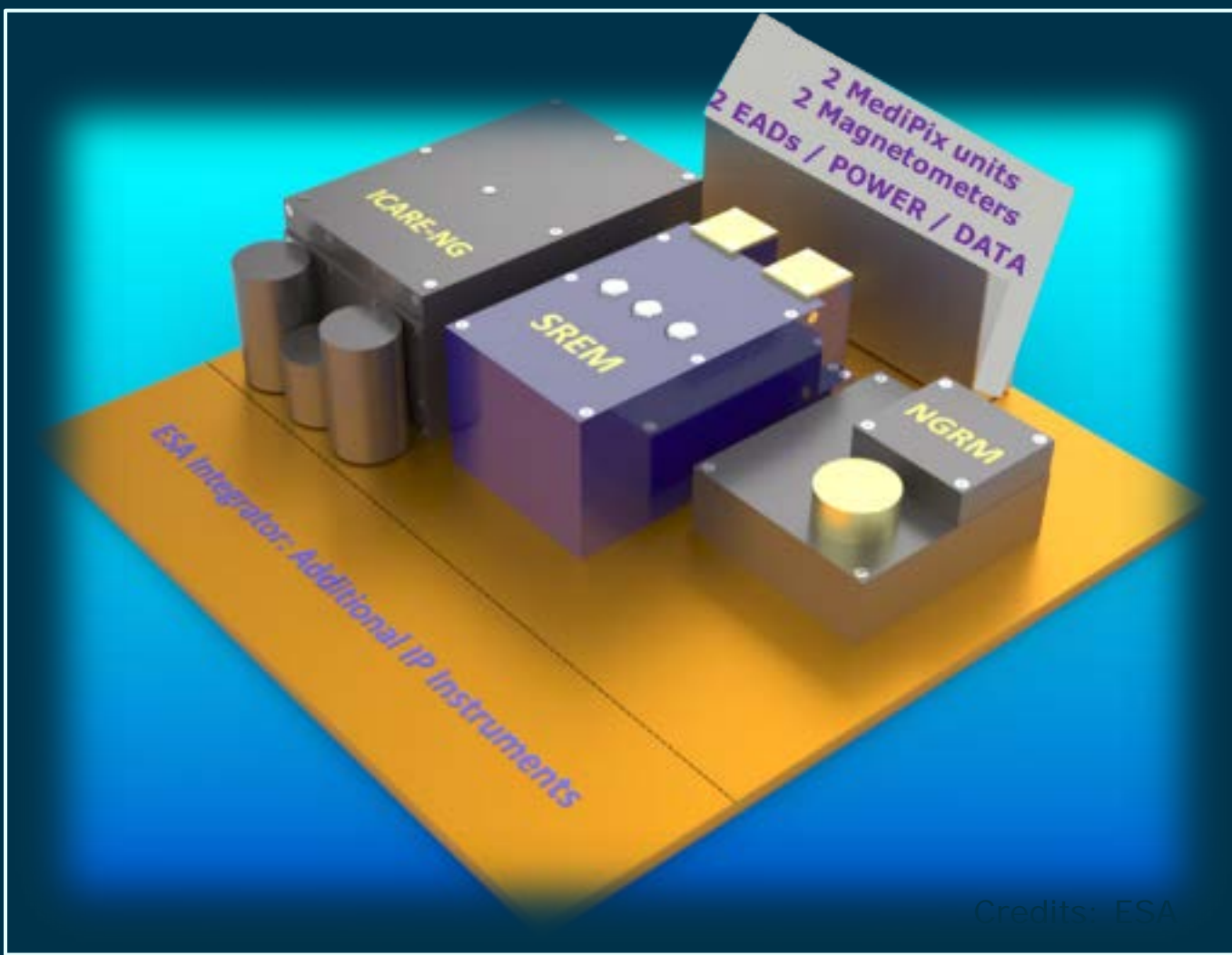
- ESM1 activities at KSC concluded, formal handover to NASA in 12/2020
- ESM2 shipment to KSC in 2021
- ESM 3 starting assembly in Bremen
- Contract for ESM 4-6 being finalised



# ESA - NASA Gateway MoU Signature



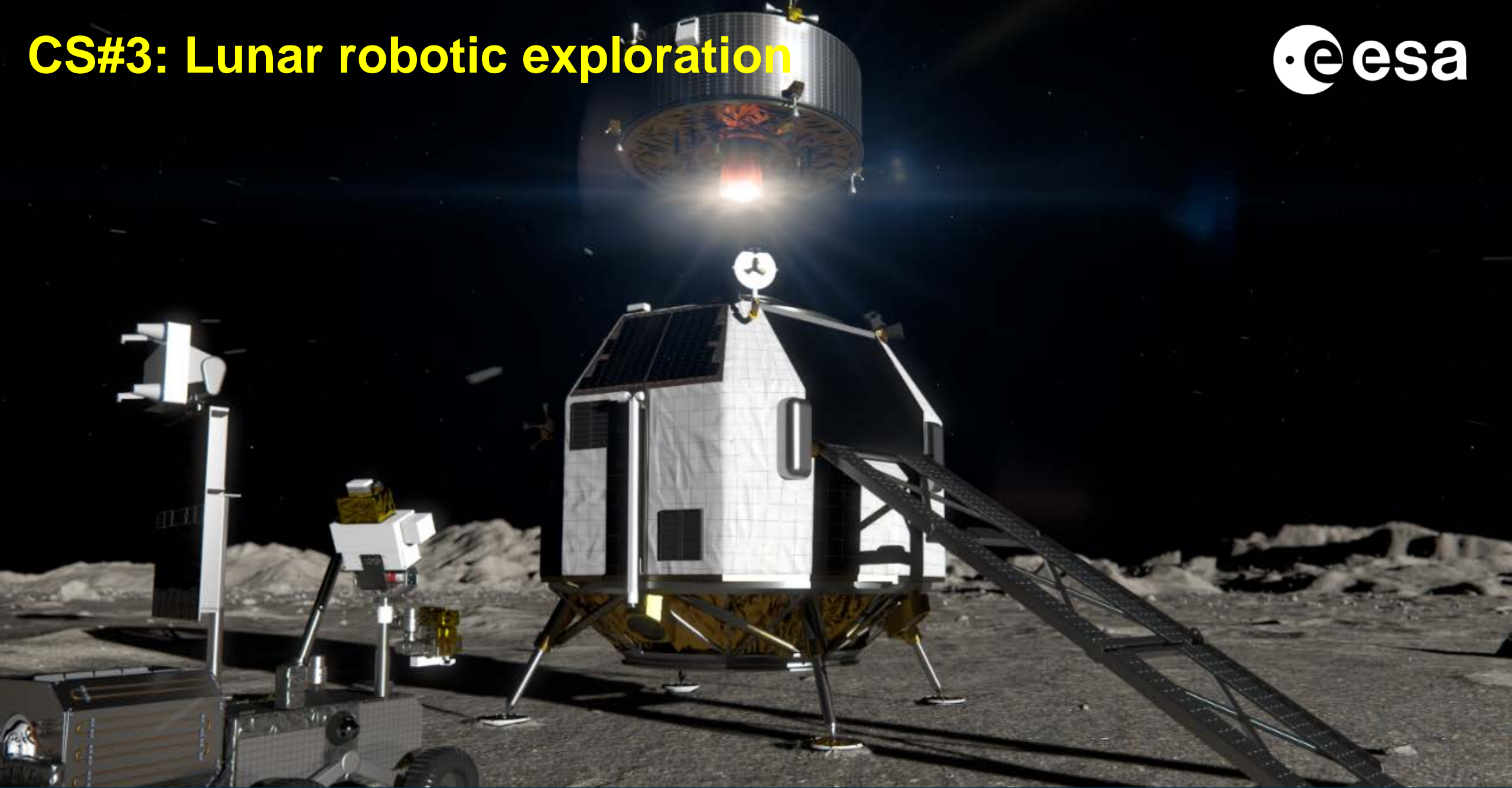
# Gateway science: European Radiation Sensors Array (ERSA)



- First Gateway science payload
- Will fly externally mounted on the Power and Propulsion Element (PPE) in 2024
- ESA/JAXA radiation payload inside I-Hab planned as second step

Credits: ESA

# CS#3: Lunar robotic exploration





# CS#3: Lunar robotic exploration



- PITMS payload for NASA 2021 CLPS mission successfully passed CDR
- An overall framework for lunar science cooperation with NASA in preparation
- Two parallel industry studies started for Phase A/B1 of the European Large Logistic Lander (EL3)
- 300+ responses from the community to the Call for Ideas for future Moon missions enabled by EL3



Two ESA-led special issues of *Planetary and Space Science* were released in 2020 on Lunar preparatory science:

- Science and Exploration of Lunar Resources with ESA's PROSPECT Package. Edited by Elliot Sefton Nash, Evelyn Füri, Neil Bowles.

<https://www.sciencedirect.com/journal/planetary-and-space-science/special-issue/10GPHNCMM4X>

- Space resources. Edited by Alexandre Meurisse, James Carpenter, Jessica Flahaut, Philipp Reiss.

<https://www.sciencedirect.com/journal/planetary-and-space-science/special-issue/10XZVBFP4CZ>

**ISRU-DM Phase A for Oxygen/Water extraction from regolith: completion in Nov 2020 (parallel contracts: SAS BE; OHB IT)**

- Three processes studied (Hydrogen Reduction, Carbothermal, Molten-Salt Electrolysis)

**ISRU-DM Phase B1 for Oxygen extraction from regolith in procurement from industry**

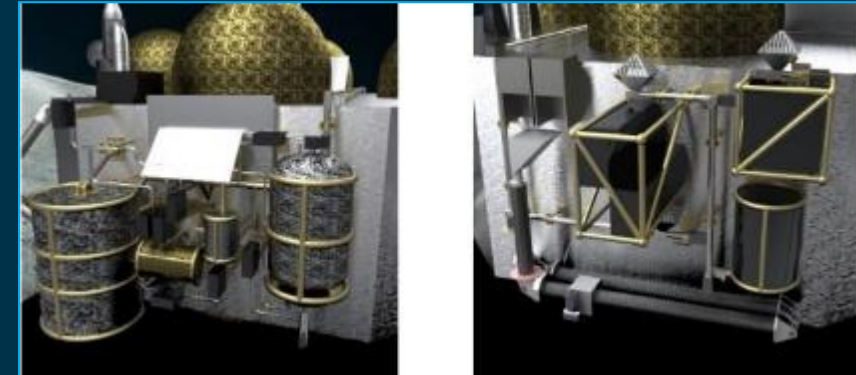


Image credit: SAS-BE (Phase 0)

Image credit: SAS-BE (Phase 0)



- Signature of Implementation Agreement between ESA, LSA and LIST for establishment of ESRIC on 18 November
  - ✓ 10 vacancies published by ESRIC
  - ✓ Both research and business support functions

[www.esric.lu](http://www.esric.lu)



# Prototype oxygen plant at ESTEC





# CS#4: ROBOTIC MARS EXPLORATION



Trace Gas Orbiter



ExoMars Rover



Earth Return Orbiter



Sample Fetch Rover



Sample Transfer Arm



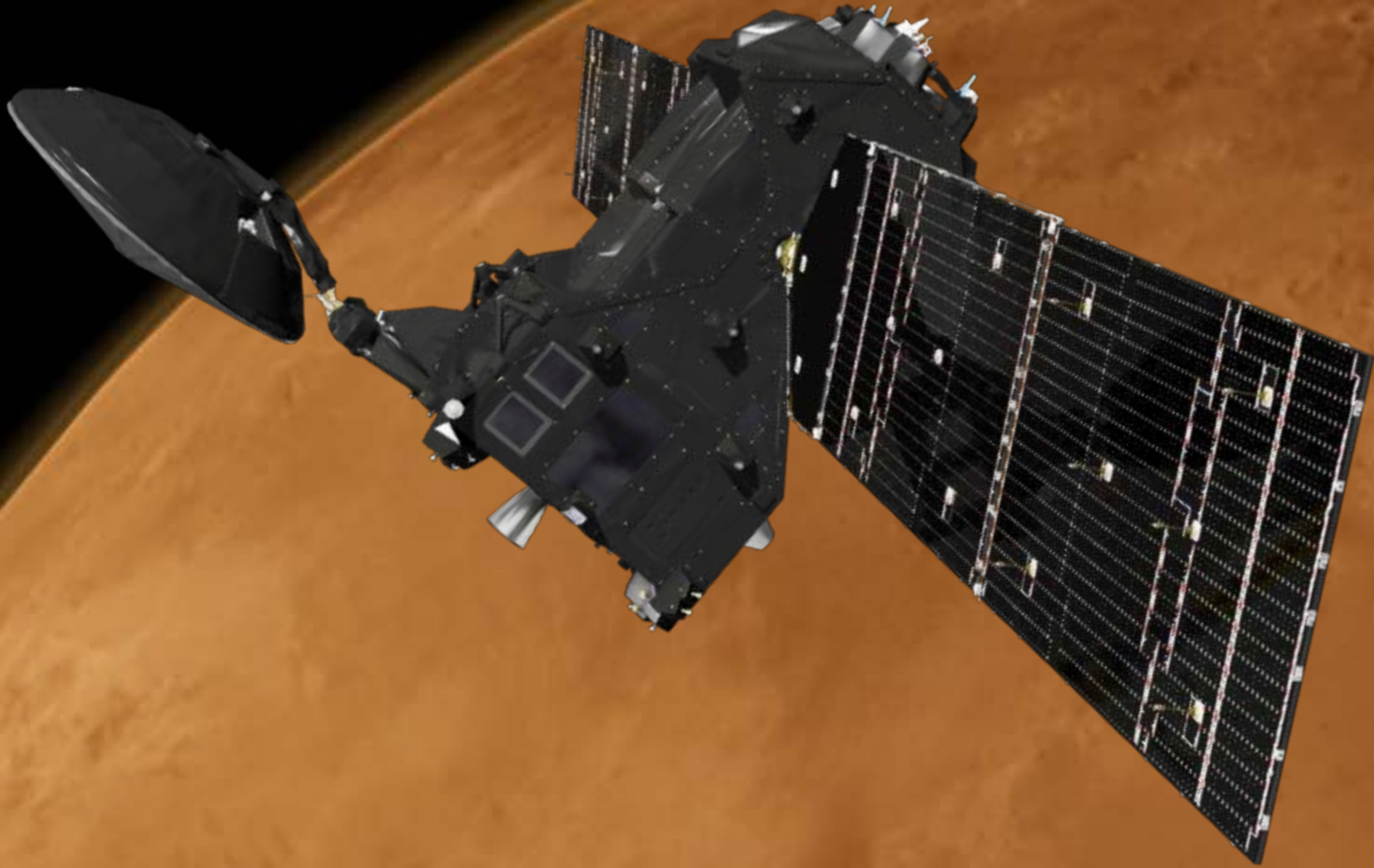
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D. Parker, 21 Oct 2020 | Slide 31



→ THE EUROPEAN SPACE AGENCY

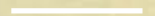
# Planetary science in action



ExoMars Trace Gas Orbiter, launched 2016 / ESA, Roscosmos







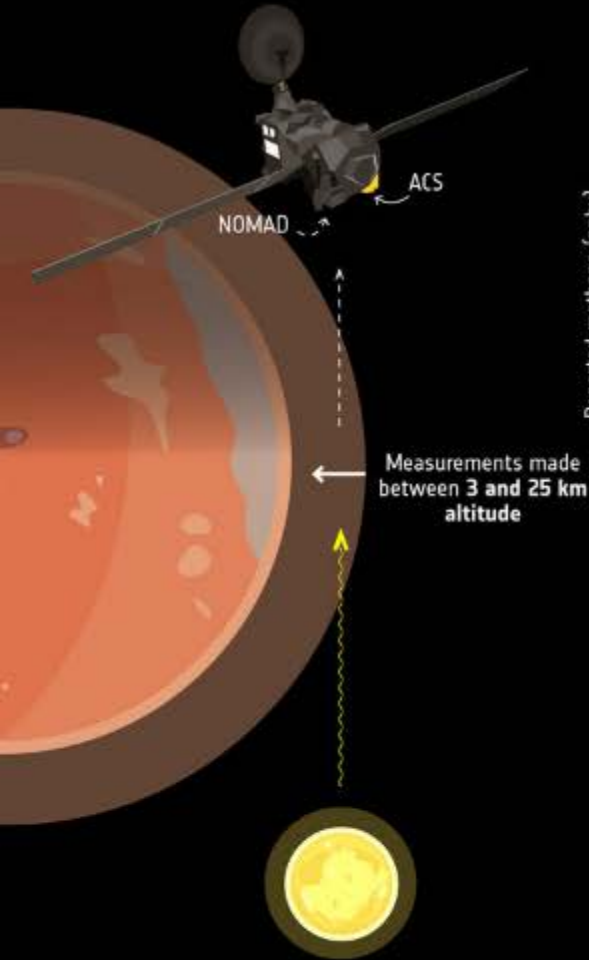
North polar dunes on Mars on 25 May 2019 / ESA, Roscosmos, CaSSIS, CC BY-SA 3.0 IGO



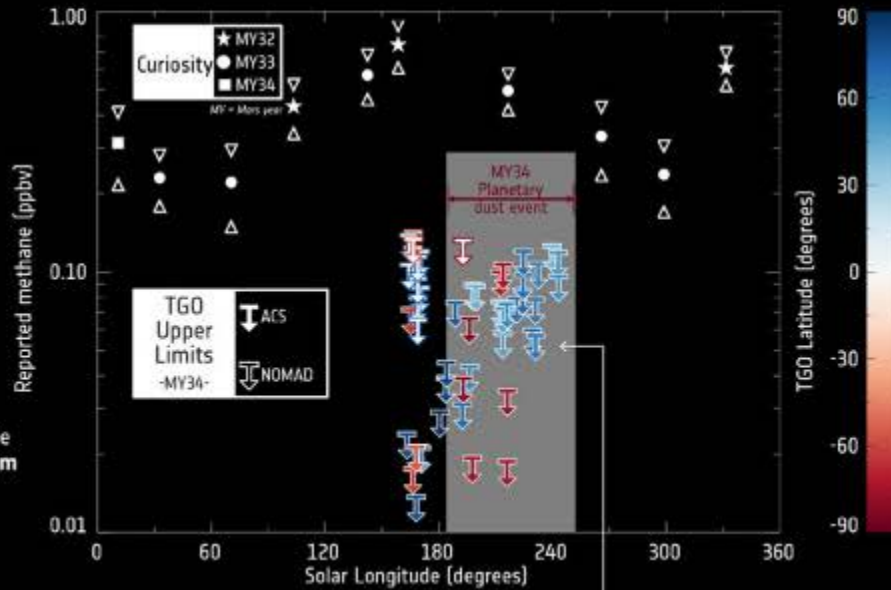
Bright & dark streaks in Locras Vallis on Mars, 20 June 2019 / ESA, Roscosmos, CaSSIS, CC BY-SA 3.0 IGO

# → FIRST RESULTS FROM THE EXOMARS TRACE GAS ORBITER

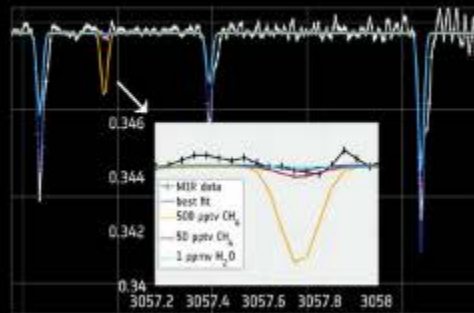
TGO's first detailed global analysis of the martian atmosphere finds an upper limit of methane 10–100 times lower than all previous reported detections.



### Comparing TGO and Curiosity data

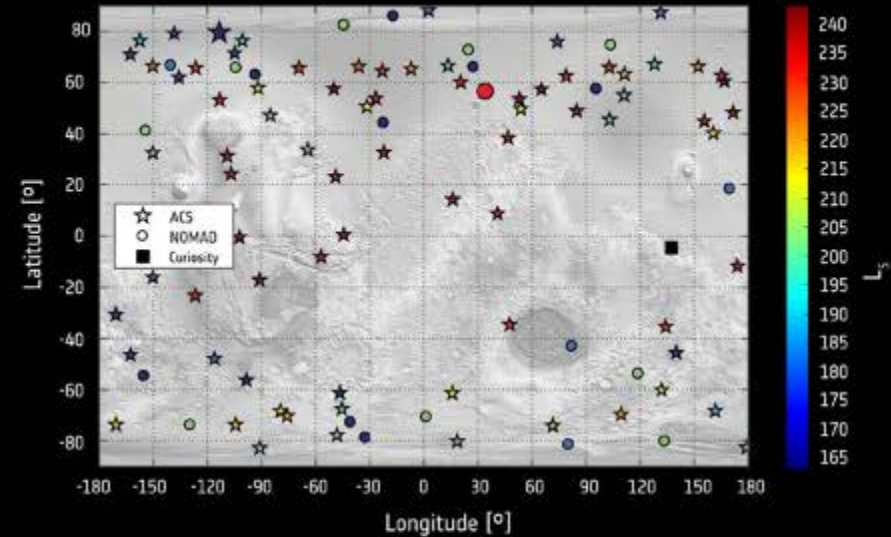


Upper limit ten times lower than previous reported detections



Measured data plotted against synthetic spectra show accurate measurement of water, while methane is constrained to below a few tens of pptv (parts per trillion by volume)

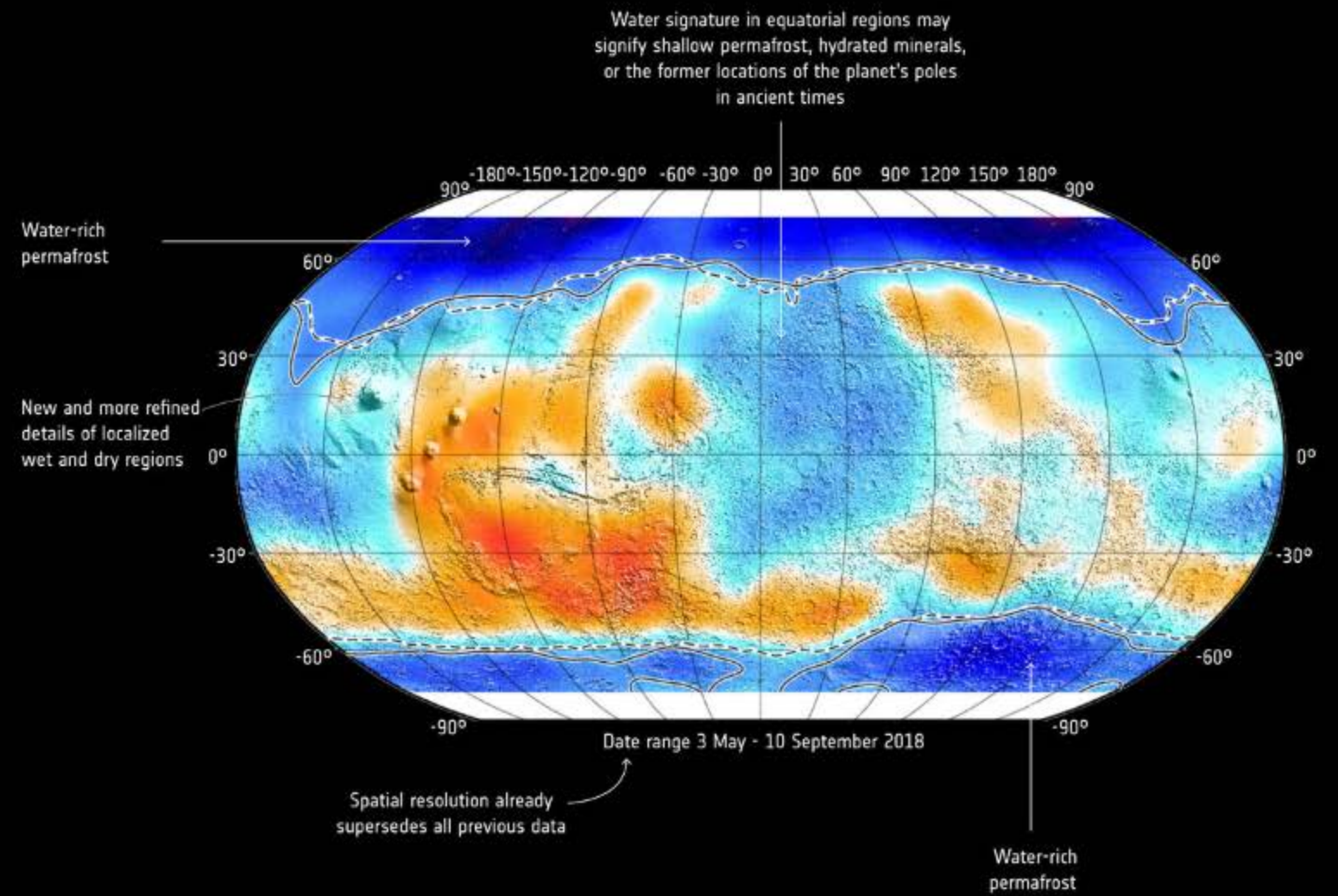
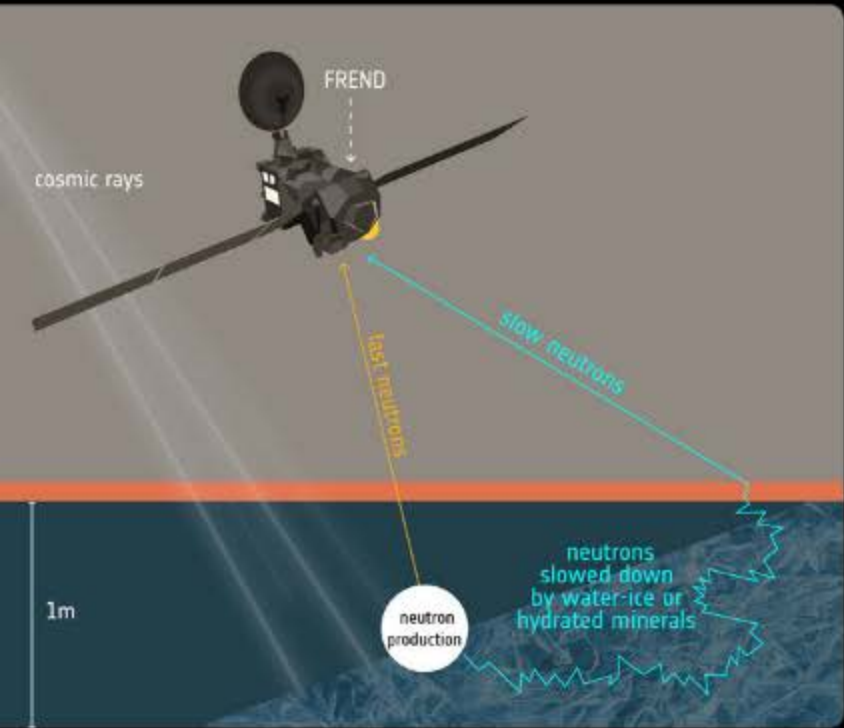
### Map of methane detection attempts



#Exomars

# → FIRST RESULTS FROM THE EXOMARS TRACE GAS ORBITER

## First map of subsurface water distribution



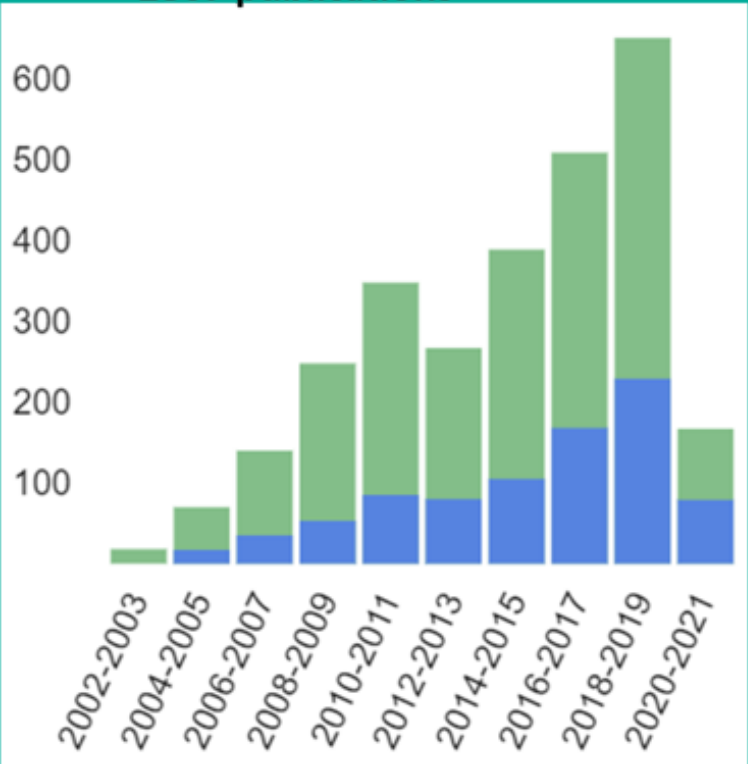
#Exomars



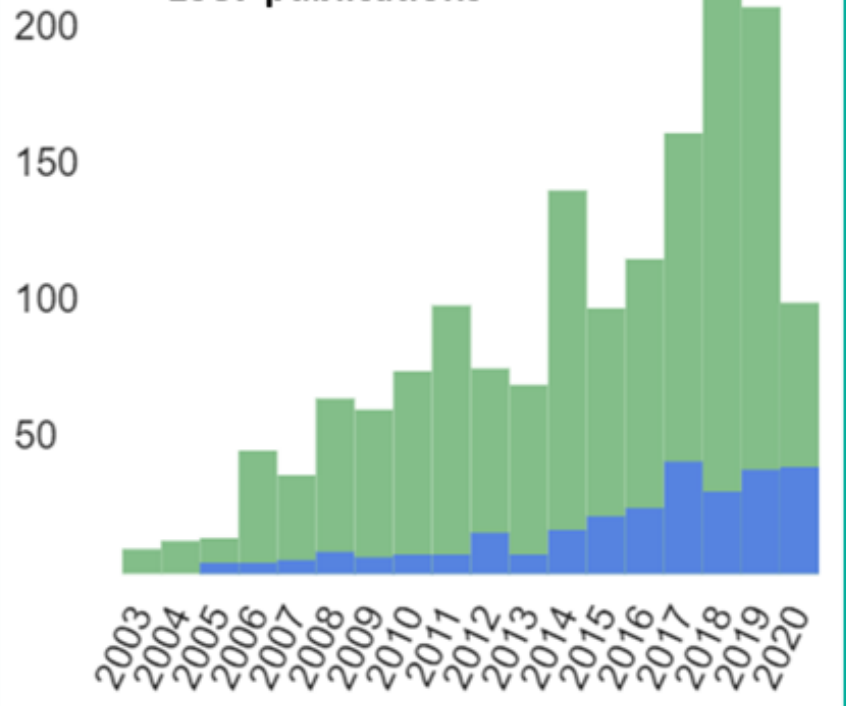
# Publications referring to ExoMars



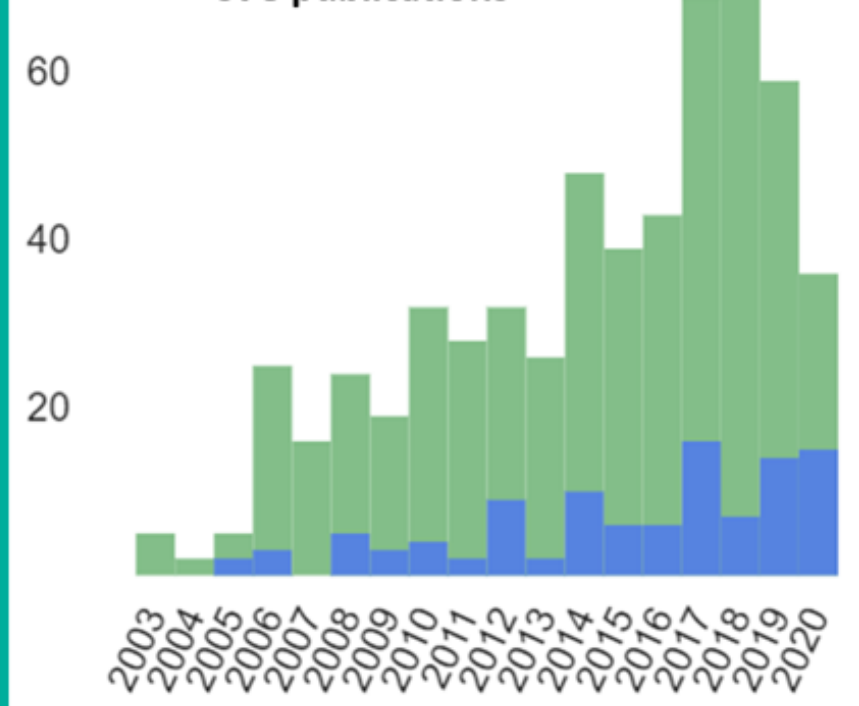
**Full text "ExoMars"**  
2807 publications



**Abstract "ExoMars"**  
1587 publications



**Abstract "ExoMars+rover"**  
578 publications

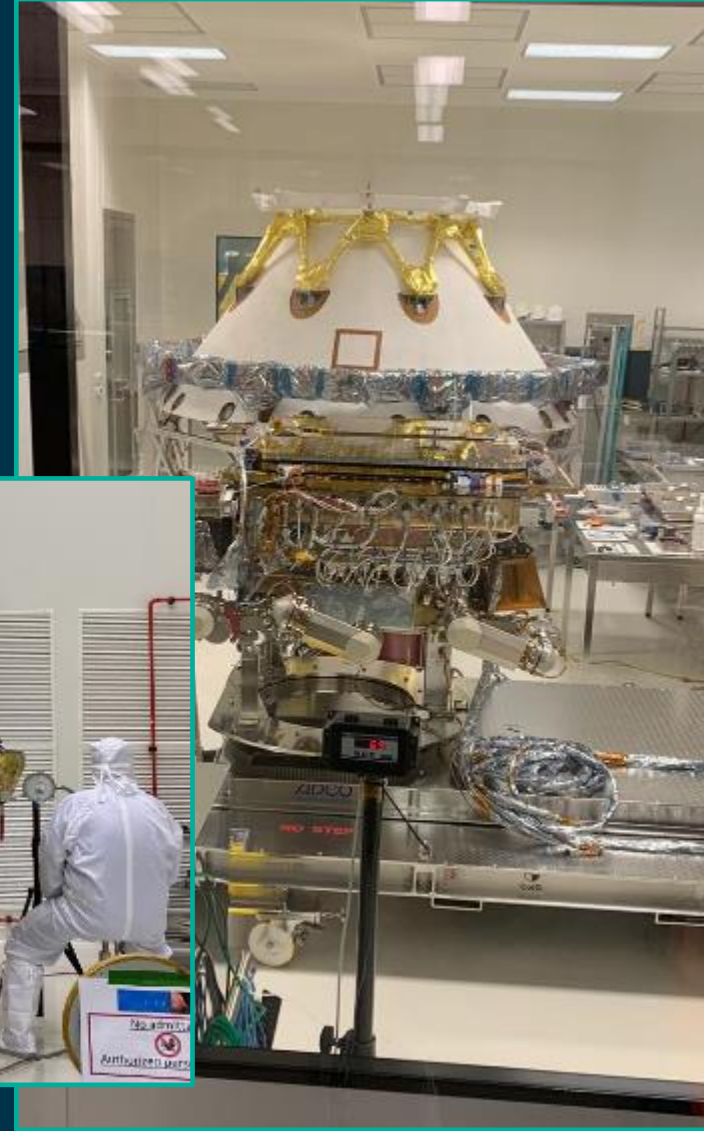


22 October 2020

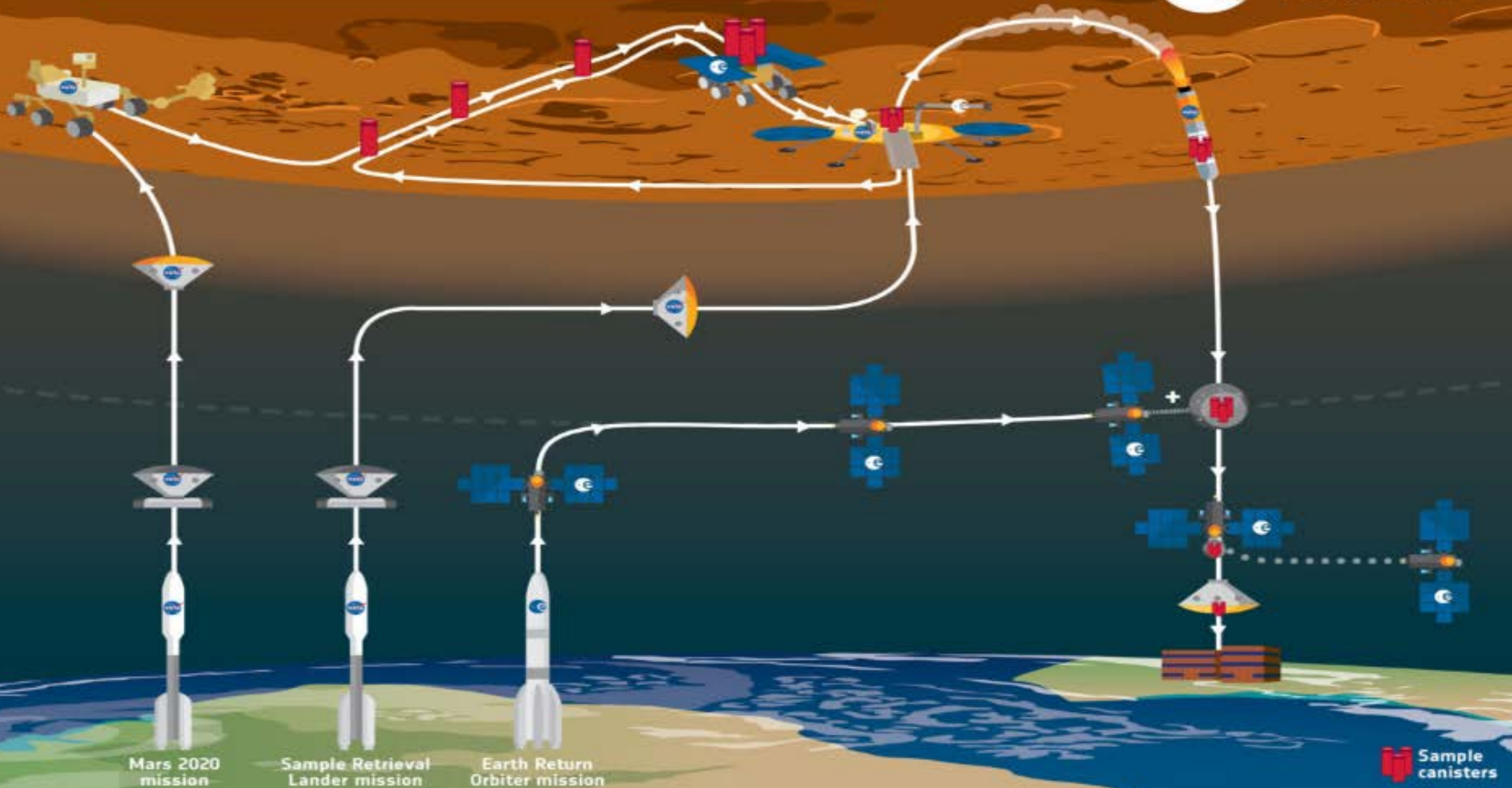
■ refereed ■ non refereed



# Rover and Descent Module in Torino



# → MARS SAMPLE RETURN





### Sustainable Agriculture

#### Groen Agro Control - The Netherlands

Growing and fertilising vegetables, development of a smart service helping horticulturalists to fertilise plants and maximise their growth.

#### Water Purification Using Nanotechnology and Proteins

#### Aquaporin Space Alliance ApS - Denmark

Bio-mimetic membranes are nature's own water filter and facilitate rapid, highly selective water transport. Enable the substitution of the existing multi-filtration beds.

#### Paper-based Analytical Device for Water Quality

#### bioMérieux - France

Based on a dry microbiology technology, the palm sized device is capable of detecting and counting bacterial microflora in just one millilitre of water.

#### Drinking Water Filtration Treatment

#### University of Kenitra - Morocco

Facility powered by renewable energy sources filters nitrates out of groundwater and provides fresh water to students and local community.

#### Circular Sanitation Units

#### Semilla Sanitation - The Netherlands

Drinking water units, sanitary facilities, and mobile waste water treatment systems: sustainable, self-sufficient, implemented on location, no waste.

#### Compact Biological Aerated Filters

#### Veolia Water Technologies - United Kingdom

BioStyr™ eliminates all pollution, both organic, nitrogenous, and particulate compounds. Combines biological treatment, clarification, and filtration into one cost-effective system.

#### Artificial Intelligence for Improved Security

#### Space Applications Services - Belgium

Advanced software solutions to enable cost-effective intelligence gathering, semi-automated scanning and analysis in eras of security concerns across Europe.

#### LNG Boil-Off Gas Reliquefaction Units

#### Air Liquide - The Netherlands

LNG bunker vessels equipped with novel reliquefaction solution to reduce the evaporation losses in the LNG supply chain.

#### Innovative High-Performance Textiles

#### Schoeller Textil AG - Switzerland

New fabrics to improve heat transfer, sweat management and physical comfort with excellent antibacterial properties. Garments have ultra-short drying times and are perfect for high-performance occupations incl. athletes, fire fighters, mine workers and the armed forces.

#### Circular Beer Production

#### De Koningshoeven Brewery - The Netherlands

Responsible and environment-minded production process minimising the water waste. Received the Dutch Water Innovation Price of 2018.



### Resilient and Sustainable Urban Development

#### XTU Architects - France

Complex of three green eco-conscious buildings, new generation façade build with microalgae, environment-conscious design and architecture.

#### Water Recycling System at French Open 2020

#### FGWRS - France

Firmus Grey Water Recycling System implemented to reduce energy and water waste in the Roland Garros Stadium and training grounds.



### Remote Ultrasound Systems

#### AdEchoTech - France

Melody device enables remote diagnosis, used by rural hospitals, care homes and prisons across Europe and in Canada to investigate cardiac, abdominal, pelvic and urinary tract conditions.

#### Hospital Treatment Devices for Chronic Wounds

#### Terraplasma - Germany

Medical mobile treatment of acute and chronic wounds, cold atmospheric plasma to inactivate bacteria (multi-drug resistant organisms and viruses)

#### Smart Indoor Air Quality Solution

#### Airgloss - Italy

Cost-effective units detecting and measuring a wide range of indoor contaminants, improving indoor environmental quality and well-being.

#### Communication System Through the Eyes

#### Eye Speak - Portugal

Novel stand-alone glasses as means of communication designed to allow people with extreme communication and mobility limitations to speak.

#### Tempus-Pro Telemedicine Devices

#### Aid Medical Emergency Teams - Spain

Two ESA-supplied all-in-one monitor with telemedicine capabilities for emergency response healthcare professionals, enable remote assessment, reduce potential exposure to COVID-19.

#### High-Resolution Scanners for Bone Research

#### Scanco Medical - Switzerland

High-resolution peripheral quantitative CT as a new dimension in the imaging of bone and joints by providing 3D images in vivo, only exposing the patient to very low levels of radiation.





# MELiSSA Activities in ExPeRT (1/2)

## Micro-Ecological Life-Support System Alternative

**Scientific Studies POMP 2 (Pool of MELiSSA PhDs),**  
MELiSSA Foundation

Q3-2020: full budget committed, 5 PhDs

**MELiSSA System Studies, Univ. Clermont Auvergne**  
(FR)

Activity expected to complete by March 2021

**Compartment 1 characterization and Volatile Fat**  
**Acids conversion, University of Ghent (BE) & sub-co**

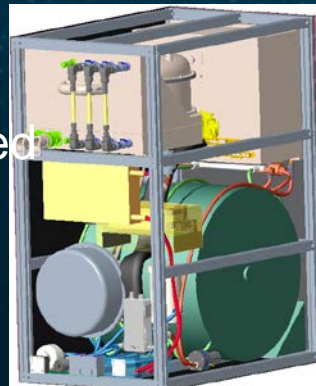
Q3 2020: Long-term tests finalized, transition to  
maintenance mode for biological processes, analysis  
of samples collected during test period initiated.

Activity finalization planned for Q4 2020

**BIORAT 1, RUAG (CH) & subcos, Bioreactor air**  
regeneration demo based on photo-synthesis

Q3 2020:

- Solid-Loop Test  
Readiness Review  
successfully completed
- Change Request to  
address outcome of  
Phase B1 – more  
engineering needed



**Follow-on activities approved June & Sep. IPC:**

- MELiSSA Plant Characterisation Unit
- MELiSSA Pilot Plant
- MELiSSA Precursor of Food Production Unit
- MELiSSA BIORAT 1 - Air regeneration bioreactor  
demo (fiche will be updated at the Feb 2021 IPC)
- MELiSSA BIORAT 2 - Urine nitrification bioreactor
- MELiSSA System Studies and PhDs research

# MELiSSA Activities in ExPeRT (2/2)

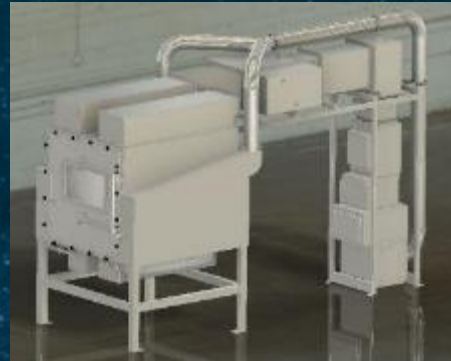
## Micro-Ecological Life-Support System Alternative

### Plant Characterization Unit for closed-loop Life Support System, Enginsoft (IT) & sub-cos.

Q3-2020:

Life test to be performed during the whole month of November.

Closure of activity planned in December 2020



### MELiSSA Pilot Plant, UAB (ES) & subcontractors

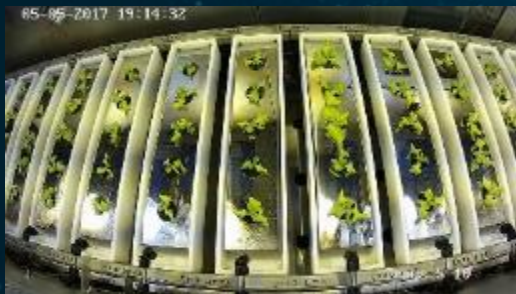


Q3-2020:

- Lab work resumed almost back to nominal situation (Covid-19 interruption); processes running in continuous mode, integration tests performed.
- Refurbishment of the Higher Plants Compartment planned in Q4-2020

### Precursor of Food Production Unit (Nutrient Module & Microbial Contamination Control Module), TAS (IT) & sub-cos.

Q3 2020: Root Module life tests completed; Nutrient Module critical technologies breadboard tests finalized; activity completion planned in November 2020



→ 7 days



→ 7 days



# green ISS research helps green building in Paris

<http://youbenefit.spaceflight.esa.int>



Credit: XTU Architects and SymBIO<sup>2</sup>



# Exploration beyond Space19+

## *Towards a mature programme*

E3P is a child that will become an adult:

- born in 2016
- growing and learning in 2019
- maturing in 2022

## OUR PLAN

- ❑ Engage delegations → successful September workshop
- ❑ Strengthen links with other directorates; classical and non-space industry

## Options analysis to define next steps of strategy implementation

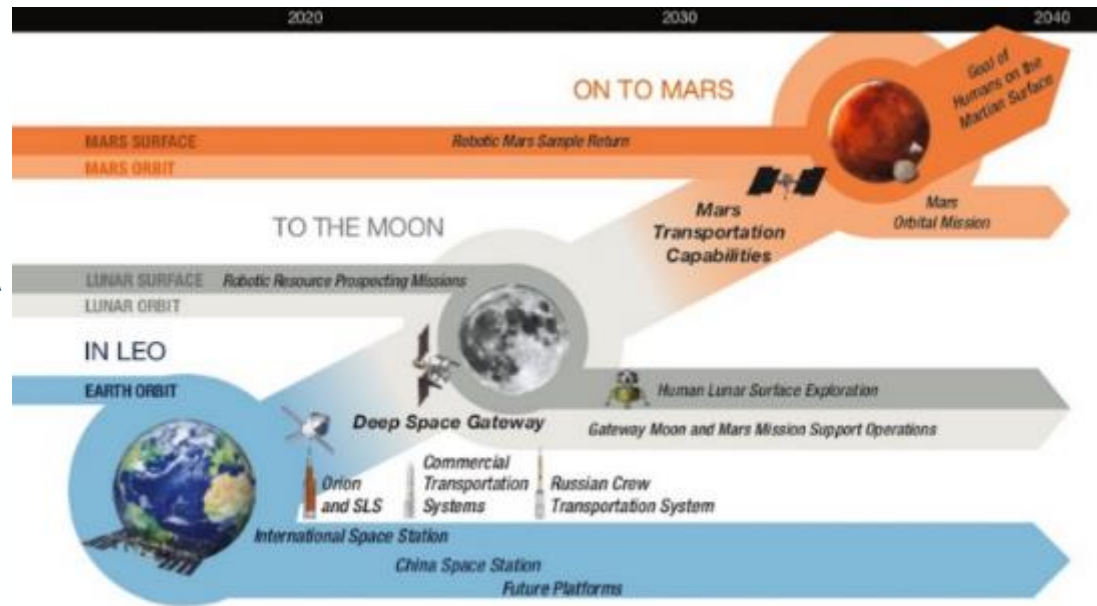
- ❑ **Future of LEO:** *ISS remaining lifetime, post-ISS and commercial activities ?*
- ❑ **European boots on the Moon by 2030:** *why, how, what, when ?*
- ❑ **Post-2030 Mars robotic and human preparation:** *Europe's roles ?*

## PLUS

- ❑ Even stronger narrative why exploration matters to Europe

# Outlook for 2022 (3/3):

## Even stronger Europe in a Global context

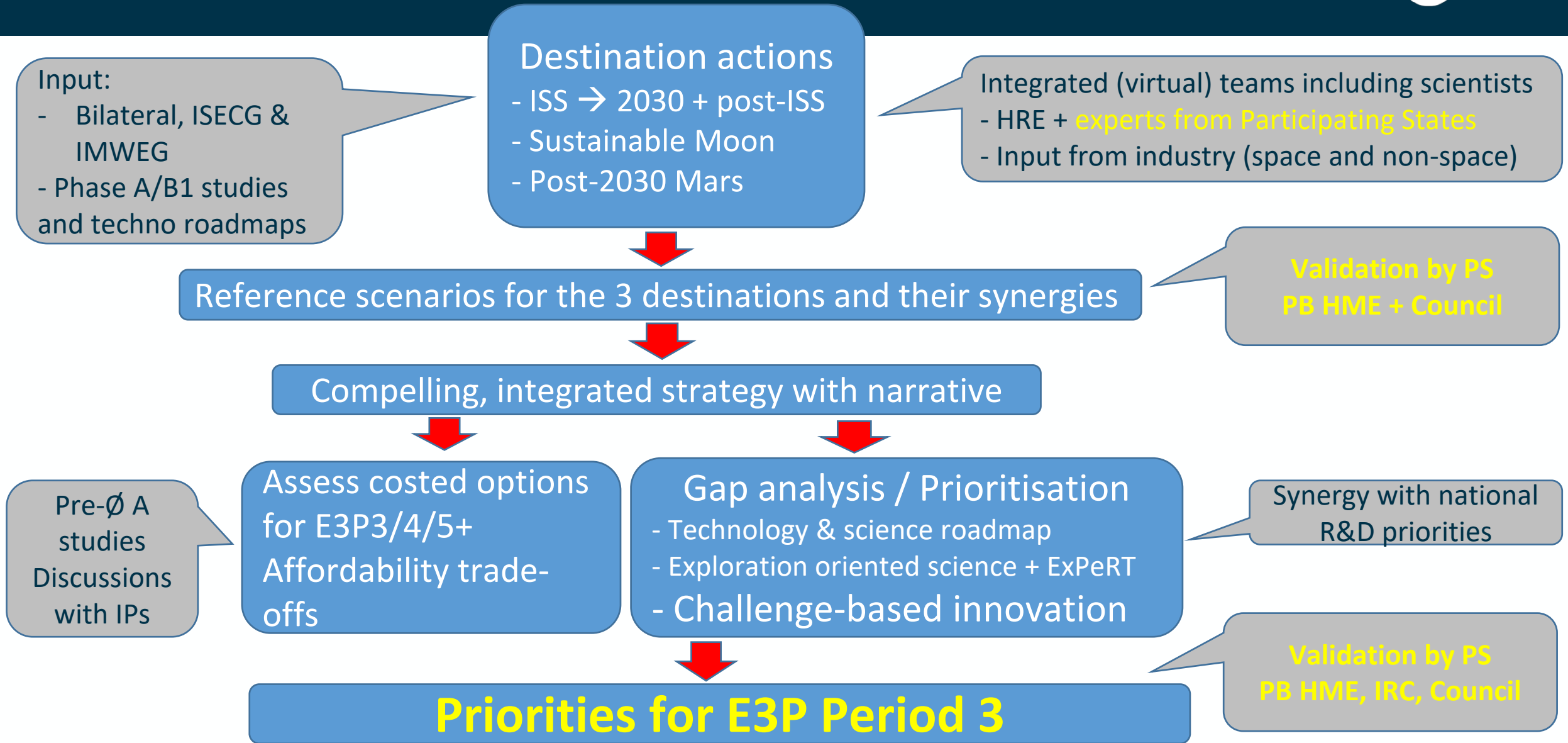


Continued Implementation of Projects, Science, & Operations agreed at Space19+

Begin Implementation of new Projects, Science, Operations

Study new Projects & Technologies for E3P4/5/+

# Plan – now until 2022







Low  
Earth  
Orbit

Moon

Mars

**THANK YOU**

**<http://youbenefit.spaceflight.esa.int>**

**we explore. you benefit.**

Human Spaceflight and Robotic Exploration

