



Europe's Space Exploration Programme Following Space19+

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Director of Human and Robotic Exploration

ESSC Meeting
15 May 2020

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European Space Agency

Space19

The Space19 logo is a 3D cube with a white face in the center containing a blue circle with a white plus sign. The other faces of the cube are colored: top (grey), left (teal), right (blue), bottom-left (red), and bottom-right (yellow).

→inspiration, competitiveness and responsibility

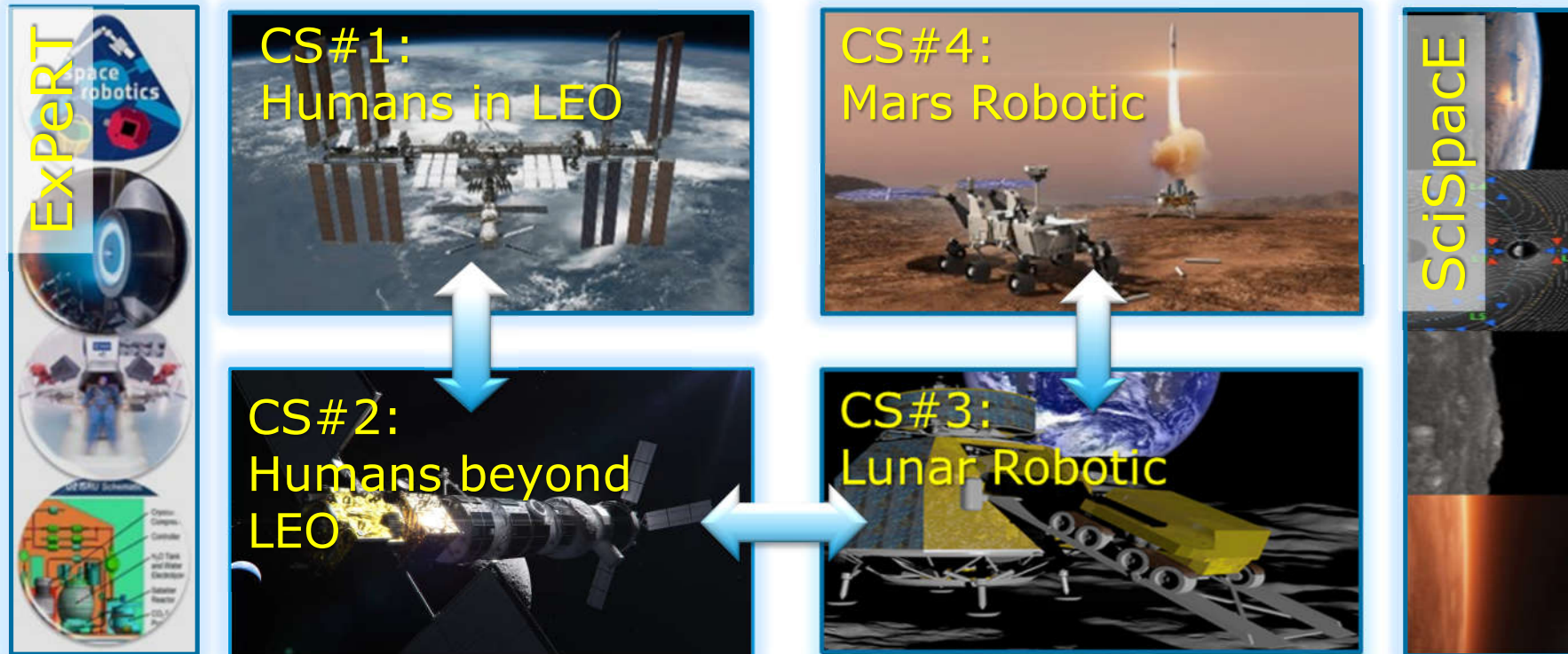
In summary: ESA is ready for the 2020's



E3P following Space19+

1 Programme = 4 Cornerstone campaigns + 2 transversal activities

→ 2000M€ investment compared with 1500M€ following 2016 Ministerial





CS#1: Humans in LEO
Research in Low Earth Orbit benefiting Earth

CS#1: Humans in LEO
Research in Low Earth Orbit benefiting Earth

Space19+ actions

- ✓ ISS Exploitation including barter costs
- ✓ Missions for existing astronaut corps
- ✓ New astronaut selection for post-2024 assignment
- ✓ Modernisation of European operations → 'Columbus 2030'
- ✓ Stimulation of commercial research → 'Business in Space Growth Network'

Progress already in 2020



- CoKa - EDRS terminal launched
- Bartolomeo installed

→ Successful *Beyond* mission

→ New SciSpacE research approved

→ HRE Science Data Centre opened 11 February

Sounding rockets

Parabolic flight

Ground Based Facilities

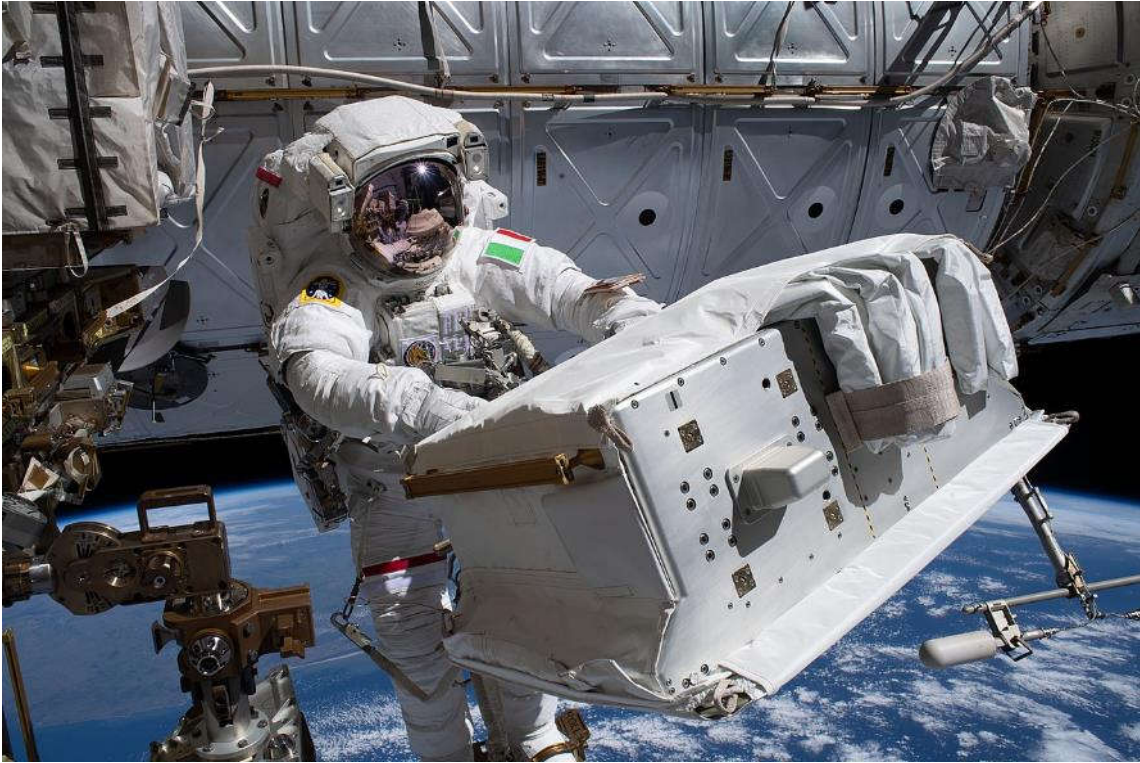
International Space Station



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Beyond: AMS EVAs



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'Beyond' – Mission Accomplished



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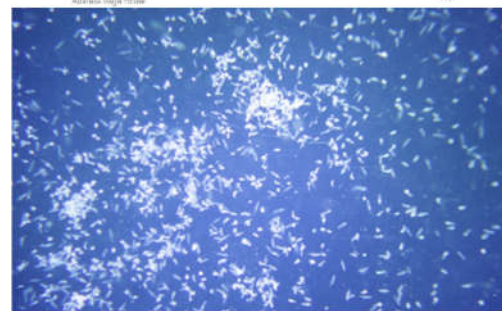
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International Space Station research (1)



“Rotifer-B1” experiment: spaceflight effects on gene expression

- Launch to ISS with SpX-19 on 5th of December 2019
- Return from ISS with SpX-19 on 7th of January 2020



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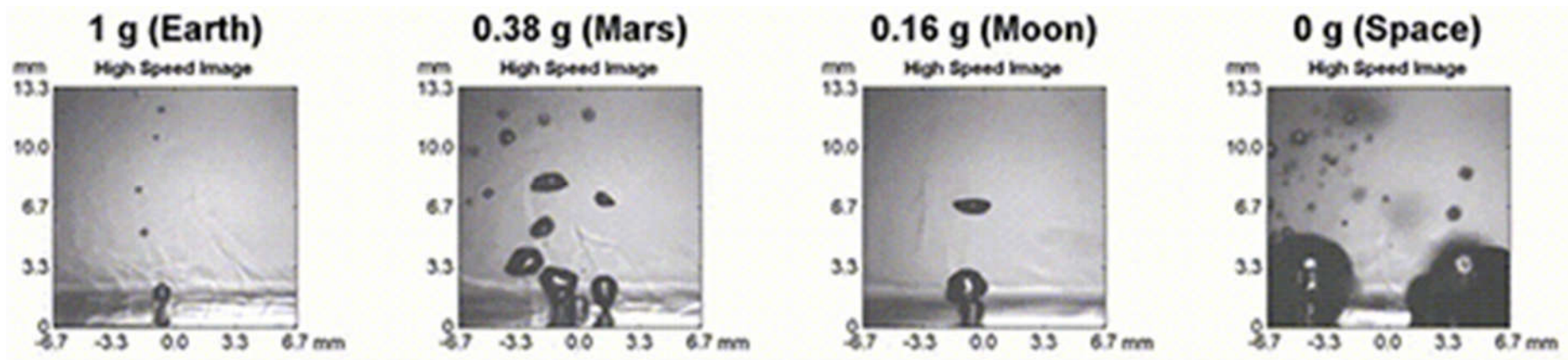
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International Space Station research (2)



“Multiscale Boiling” experiment: boiling processes in microgravity

- Nominal runs until March 2020
- Additional run from Q4/2020 until Q1/2021 under discussion

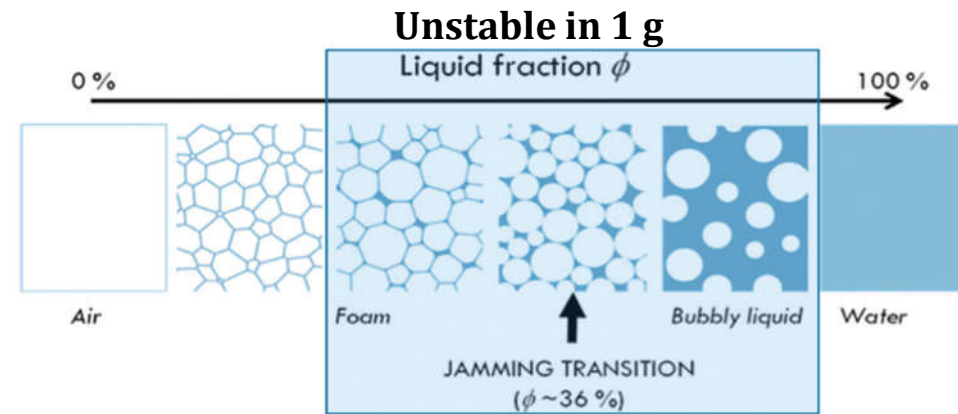
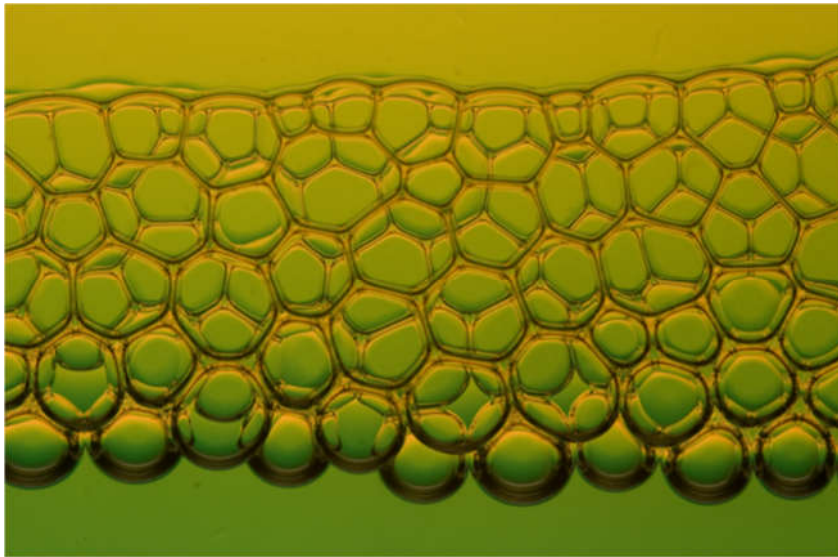


International Space Station research (3)



“Foam-C” experiment: structural rearrangement and evolution of bubble size

- Launch to ISS with SpX-19 on 5th of December 2019
- Implementation planned Q2 2020

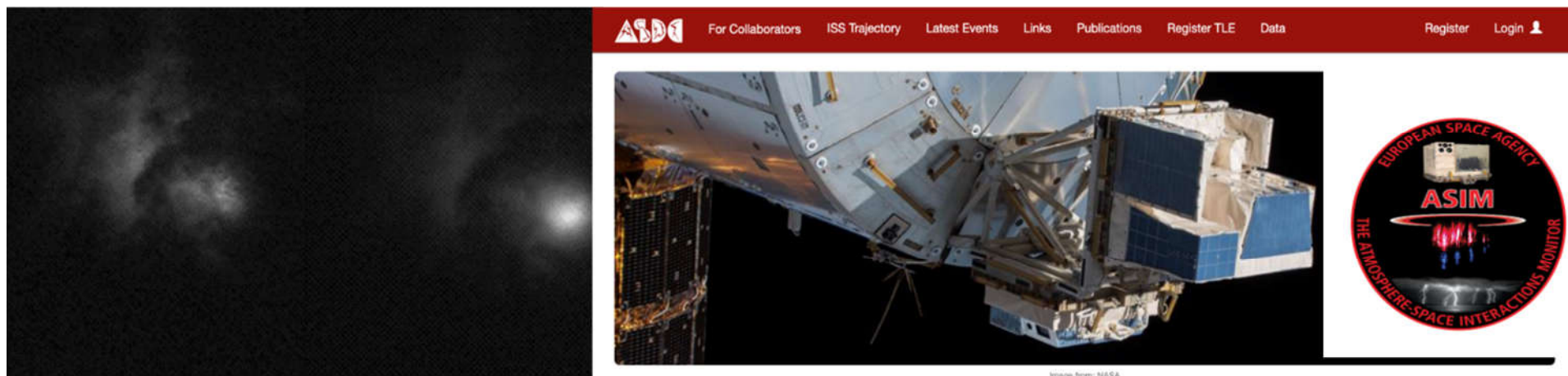


International Space Station research (4)

Atmosphere Space Interaction Monitor (ASIM)



- Data available via ASIM Science Data Center since November 2019
- Two main instruments studying Transient Gamma-ray Flashes and Transient Luminous Events
- Implementation continuing until at least September 2021



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Image from: NASA

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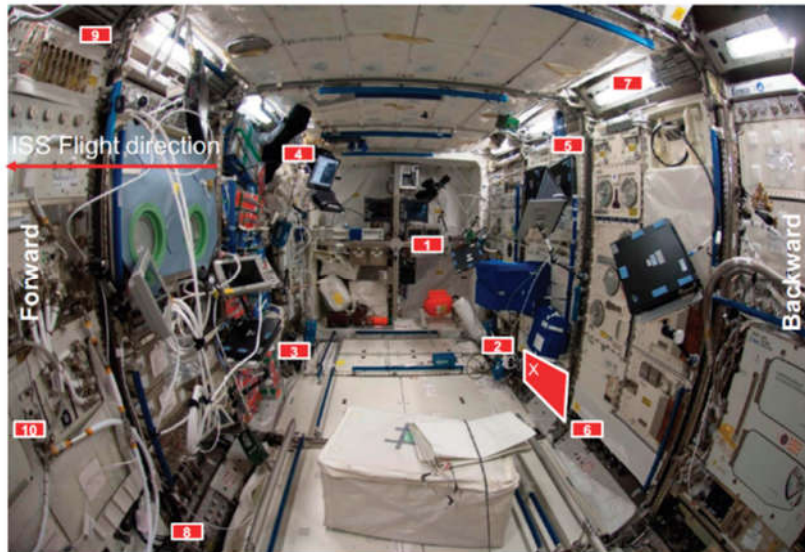


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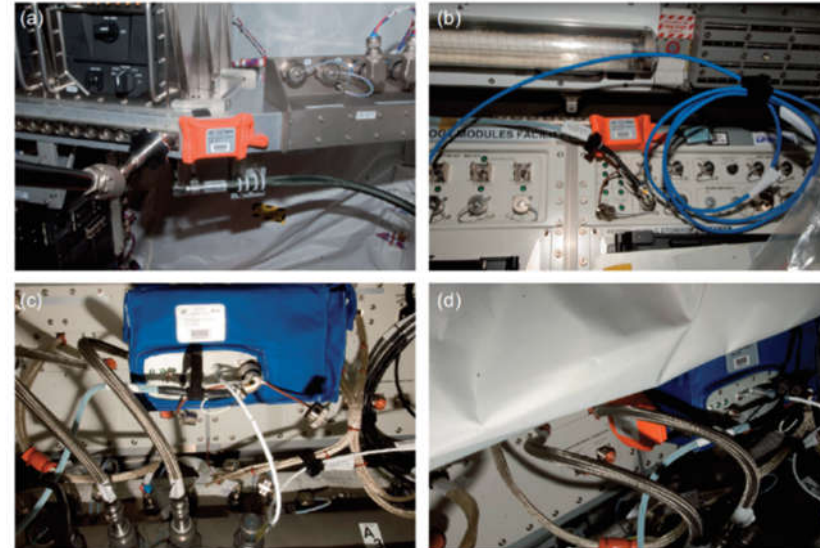
International Space Station research (5)



- Upload of DOSIS-3D PDPs with SpX-20 marks the start of the first joint ESA/CMSA experiment implementation!



Positions of the PDPs within ISS Columbus Laboratory



DOSIS 3D hardware in Columbus: (a) PDP at star cone position; (b) PDP at the upper part of EPM facility; (c) DOSIS-MAIN-BOX beneath EPM Module; (d) Triple PDP mounted on left side of DOSIS-MAIN-BOX



Commercial ISS Services offer new research opportunities



ICE Cubes

"Our Expertise for Your Experiment"

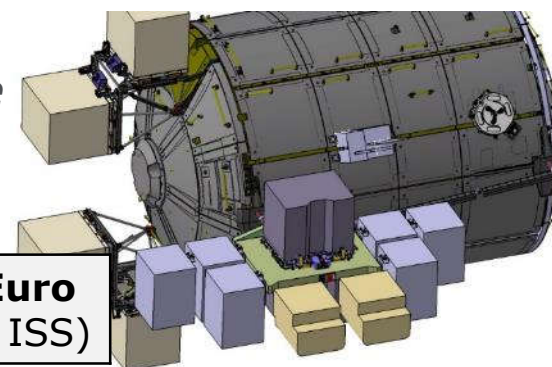


www.icecubesservice.com

50,000 Euro (1U,
4 months on ISS)

Bartolomeo

"Your All-in-One Space Mission Service"



from 326,000 Euro
(3-8U, 1 year on ISS)

airbus.com/space/space-infrastructures/Bartolomeo.html



Bioreactor Express



Science & tech experiments exploiting the KUBIK incubation facility

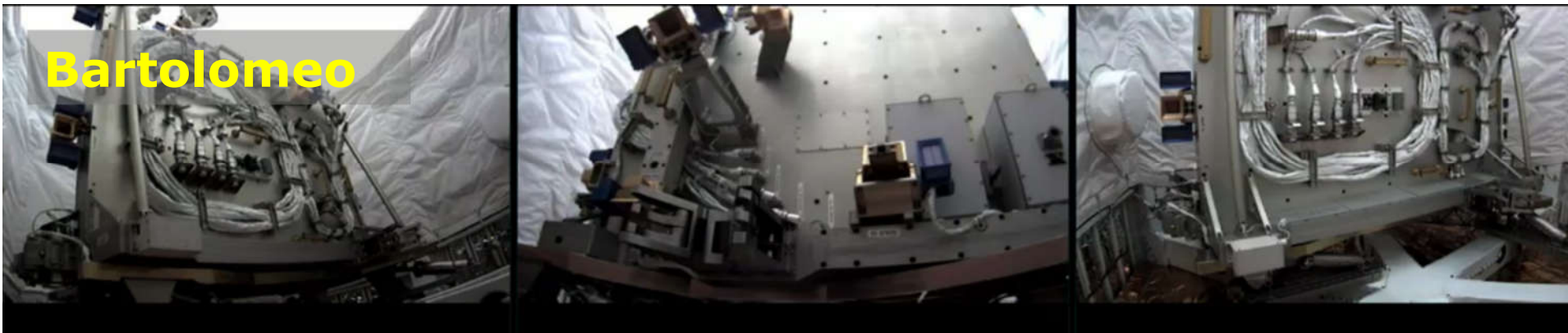
www.bioreactorexpress.com



from 160,000 Euro
(8 ECs, 14 days on ISS)



Bartolomeo



Installed by robotic arm on the forward-facing side of Columbus 2 April



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OUTLOOK 2020



- Definition of 20 ISS Human Research proposals
- Definition of 15 proposals for future EML utilization
- Solicitation for experiments making use of live-cell imaging (AO-2020-FLUMIAS)
- Solicitation for material science samples making use of external exposure facility (AO-2020-SESAME)

5 November 2020: 20 years of ISS operations



ESA RESEARCH ON CONCORDIA STATION

- WO2019: completed with 4 ESA-selected experiments
- WO2020: on-going with 4 ESA-selected experiments
- WO2021: preparations have started



ESA PARTICIPATION IN SIRIUS ISOLATION PROGRAMME

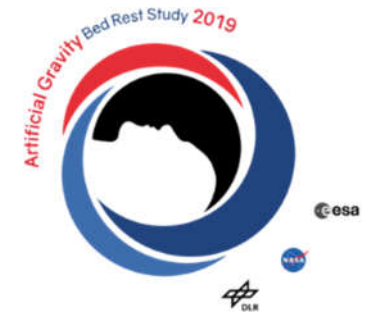
- Integration of ESA-selected experiments into overall science programme to start
- Start of first isolation study: November 2020



ESA BEDREST AND DRY IMMERSION STUDY PROGRAMME



- Joint ESA/NASA 60d bedrest study “AGBRESA” (Artificial Gravity BedRest Study with ESA) completed



OUTLOOK 2020 :

- Definition of upcoming bedrest and dry-immersion studies has started
- AO-2020-Bedrest: solicitation of experiments during next 2 bedrest studies
- AO-2020-DryImmersion: solicitation of proposals supporting validation of the dry-immersion model

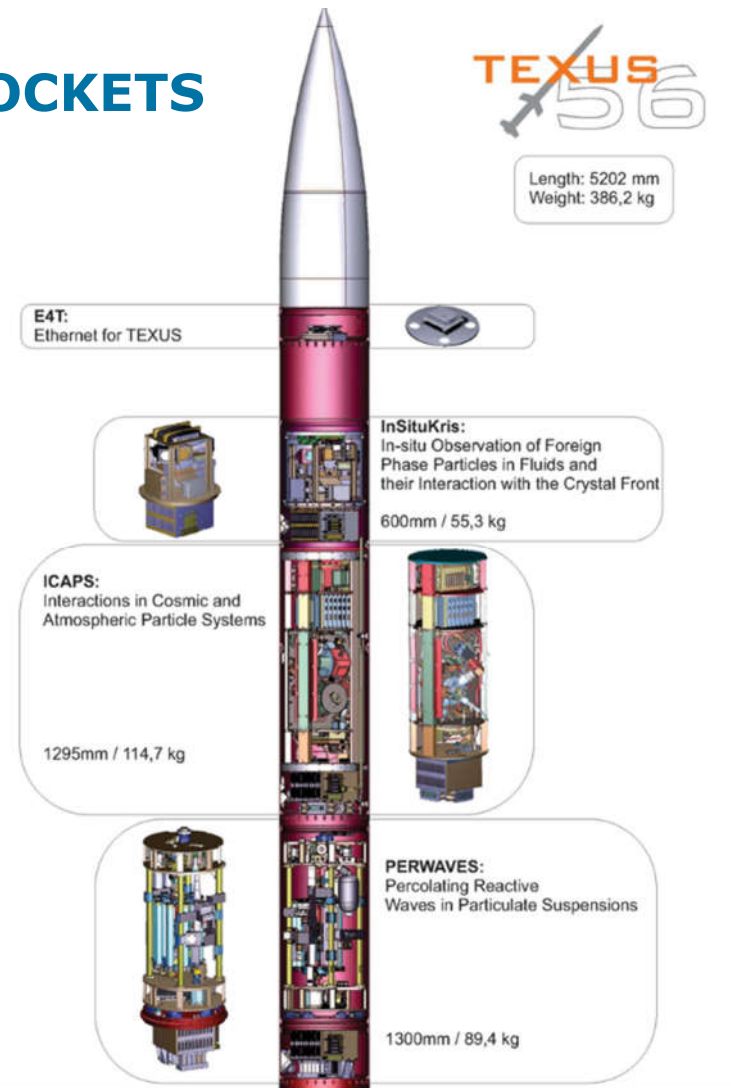


ESA RESEARCH USING SOUNDING ROCKETS

- TEXUS-56 (2019): ESA payloads ICAPS and Perwaves

OUTLOOK 2020+ :

- Preparations for implementation of CHYPI-Flower
- Preparations for 2 Sounding Rocket missions



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ESA'S GROUND-BASED RADIATION RESEARCH PROGRAMME



- Completion of selection of experiments submitted to AO-2019-IBER

OUTLOOK 2020+ :

- Completion of implementation of experiments stemming from AO-2017-IBER
- Preparation of implementation of experiments stemming from AO-2019-IBER
- Joint ESA/FAIR Radiation Summer School

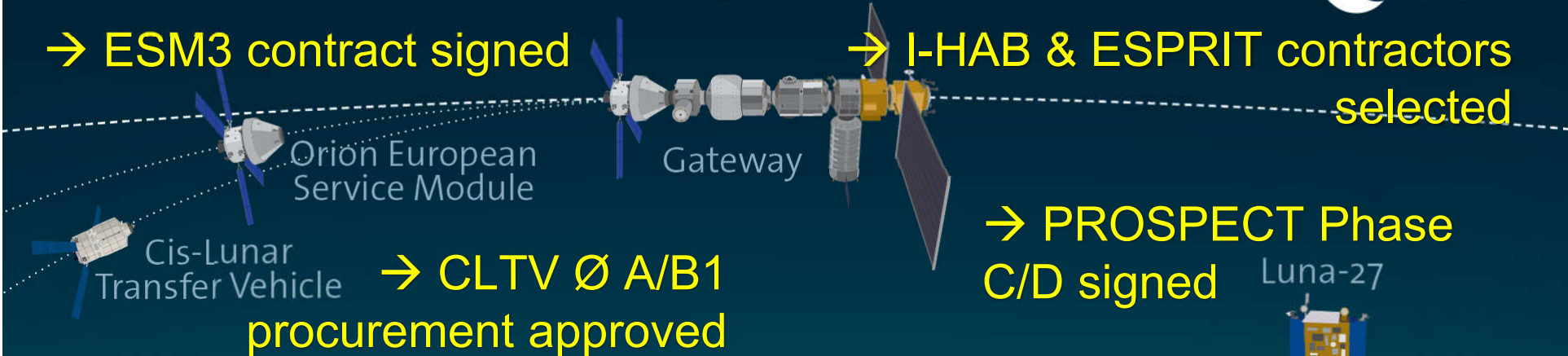


Forward to the Moon – Progress in 2020



→ ESM3 contract signed

→ I-HAB & ESPRIT contractors selected



→ CLTV Ø A/B1 procurement approved

→ PROSPECT Phase C/D signed

→ EL3 Ø A/B1 procurement approved

European Large Logistic Lander

Good progress of Gateway MoU negotiations

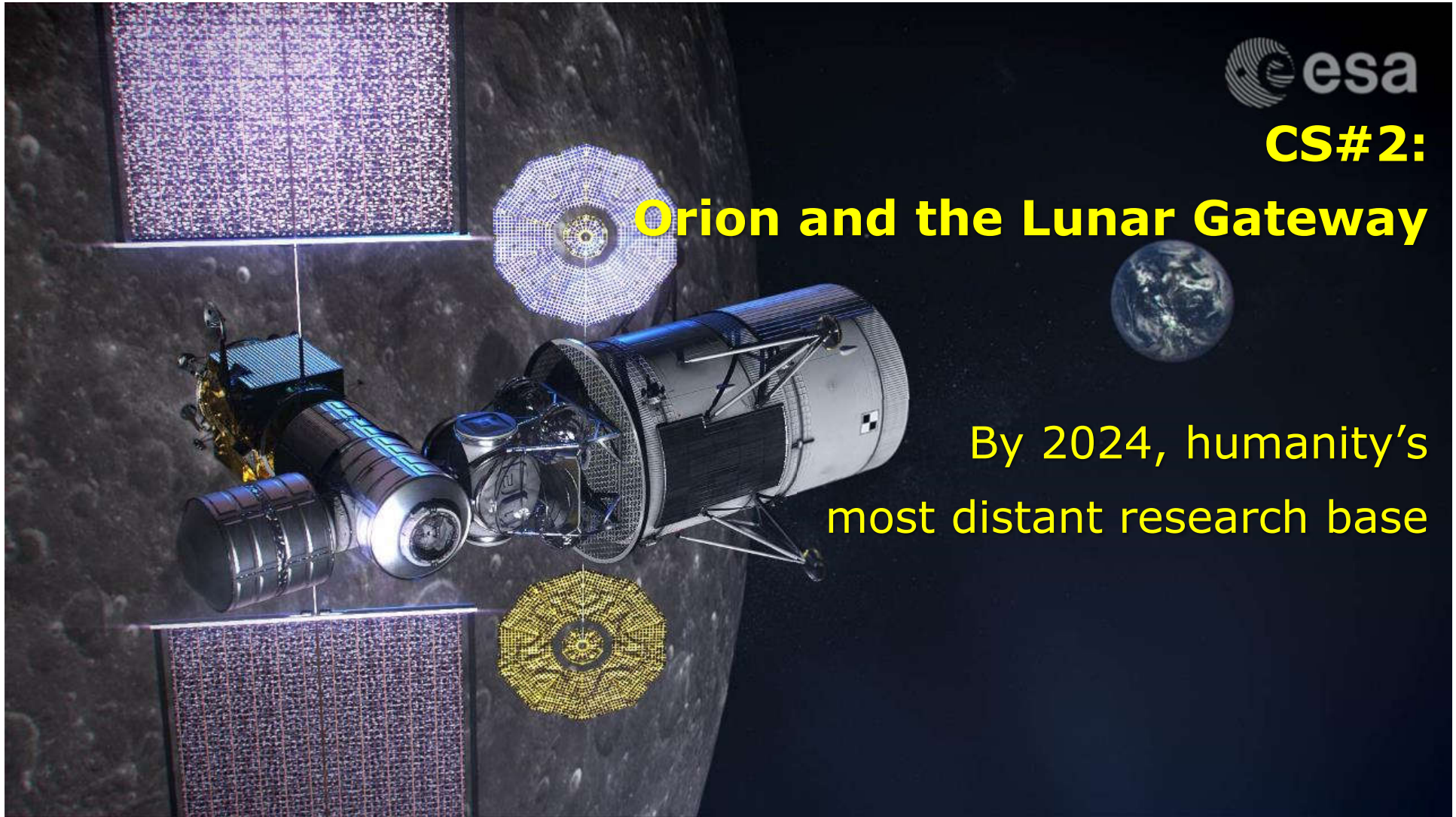




CS#2:

Orion and the Lunar Gateway

**By 2024, humanity's
most distant research base**



Artemis Lunar Programme Updates (1/2)



- NASA's Plan for Sustained Lunar Exploration and Development released on 2 April
 - Moon surface activities and preparation for human trip to Mars
- In addition to "Boots on the Moon(2024)", importance of Gateway in NASA's sustained lunar exploration re-emphasised
- NASA Power and propulsion element (PPE) and habitation and logistics outpost (HALO) will be launched together in late 2023
- 1st Gateway Logistics Service (GLS) contract awarded by NASA to SpaceX

ARTEMIS



Artemis Lunar Programme Updates (2/2)



International selection of first 2 scientific payloads for Gateway:

- Radiation package to be provided by ESA
- Space weather package to be provided by NASA

OUTLOOK 2020:

- Solicitation for exobiology samples making use of external exposure facility
- Solicitation for analysis of radiation monitoring data

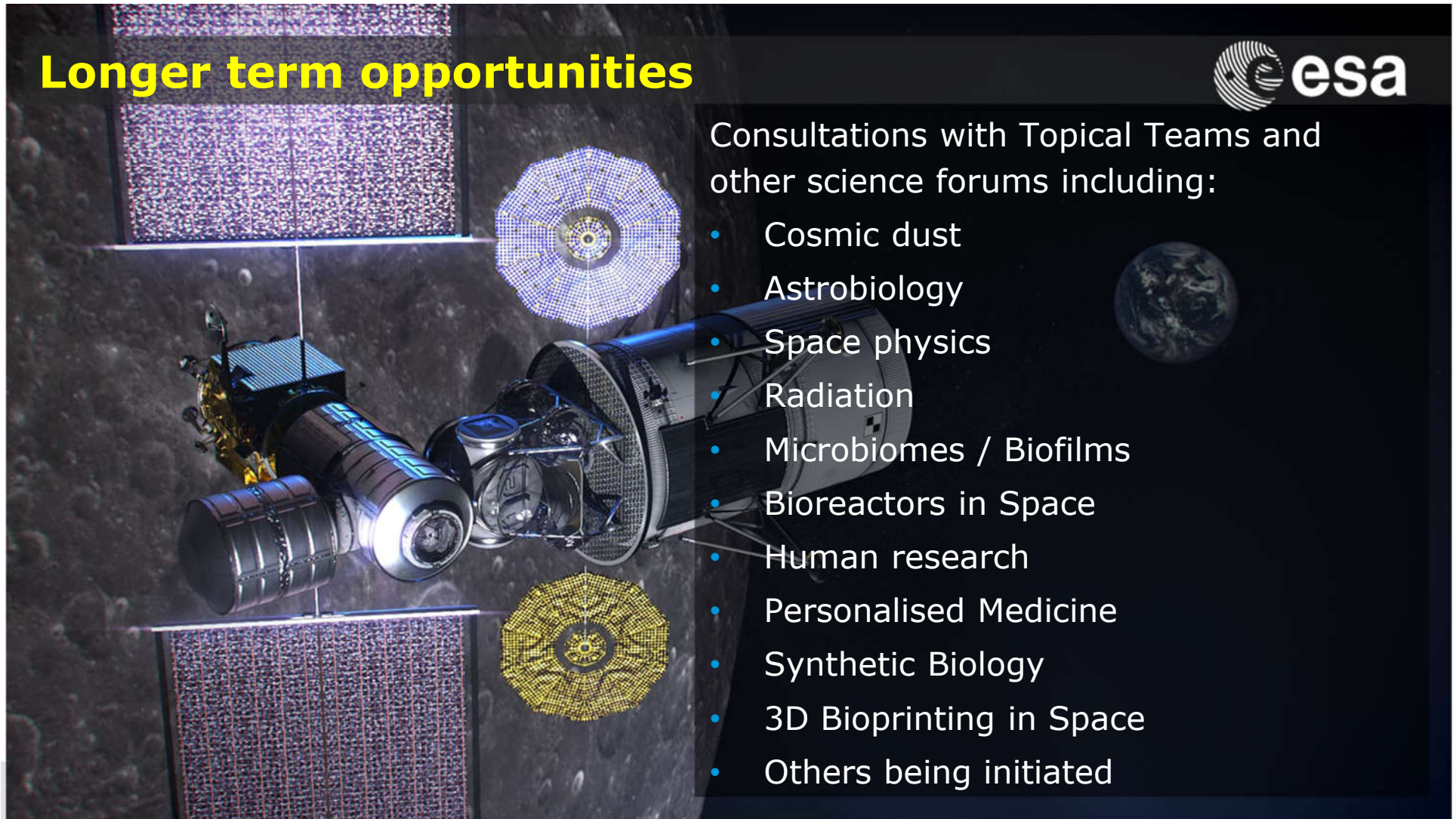


Longer term opportunities



Consultations with Topical Teams and other science forums including:

- Cosmic dust
- Astrobiology
- Space physics
- Radiation
- Microbiomes / Biofilms
- Bioreactors in Space
- Human research
- Personalised Medicine
- Synthetic Biology
- 3D Bioprinting in Space
- Others being initiated

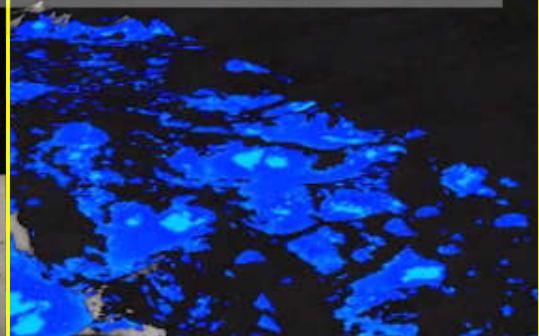


CS#3: Lunar Robotic exploration



Missions of Opportunity

PROSPECT Searching for water at the Moon's polar regions



Contract Signature:
30 January 2020 at Leonardo, Milan



ROSCOSMOS



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***Future Strategic opportunity
now starting definition***



European Large Logistic Lander (EL3)

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Gateway + robotic missions
= sustainable human exploration



3 novel examples where ESA is preparing for this future ...



NASA Apollo Next Generation Sample Analysis Program (ANGSA)



Opening and analyses of an Apollo 17 core sample that has remained sealed since its collection in 1972

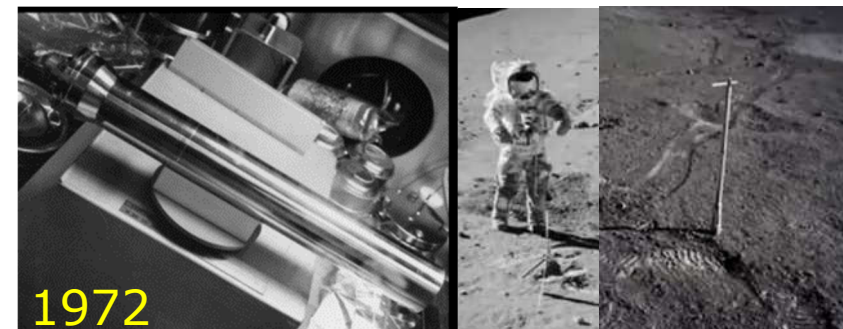
European participants: **ESA**, Manchester University and Open University

ESA's role:

- Assist with preliminary sample characterisation and protocols
- Support design and build of gas extraction device
- Consolidate lessons learned for future missions
- Derive engineering and mission requirements for:
 - New sample containment concepts
 - Future mission and curation design synergies for Mars Sample Return



Upper core segment 73002 at the Apollo sample curation facility.



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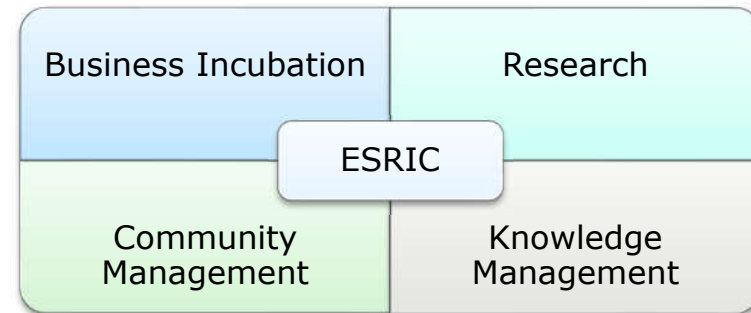
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European Space Resources Innovation Centre



ESRIC Objectives:

- Advance ESA and Luxembourg Space Resources Strategy
- Become a hub and excellence for Space Resources research
- Support business development in Space Resources
- Engage and broaden the community



Credit: B. Lomax

ESRIC Establishment Progress:

- Implementation plan presented at PB-HME
- Negotiations ongoing to establish equipment hosting agreement
- Procurement of initial equipment and utilisation project approved

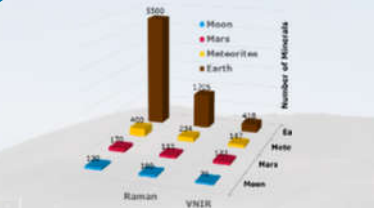


PANGAEA Planetary Surface Operations Tool Suite

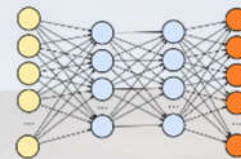
Situational Awareness & Science Decision Support



Handheld Spectrometers
Mineral identification



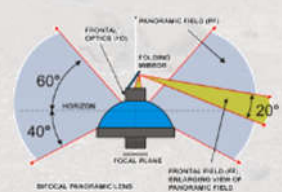
Planetary Minerals Libraries
Knowledge retrieval



Machine Learning
Autonomous classification



Field Ops
(Crew & Rovers)



External imaging devices
Situational Awareness & Context



- Geolocated **Data collection**
- **Data Harmonization**
- **UI for Science Ops**
- Disruption Tolerant **Information Exchange**



Science & Mission Support





Cornerstone 4
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

Ambitious decade of robotic Mars exploration

Trace Gas Orbiter

→ TGO science and data relay continuing

→ ERO contractor selected

Earth Return Orbiter

ExoMars Rover

→ Rosalind Franklin environmental tests completed

→ SFR advanced
Ø B2 approved

MSR priority confirmed in NASA 2021 Budget

Sample Fetch Rover

Sample Transfer Arm

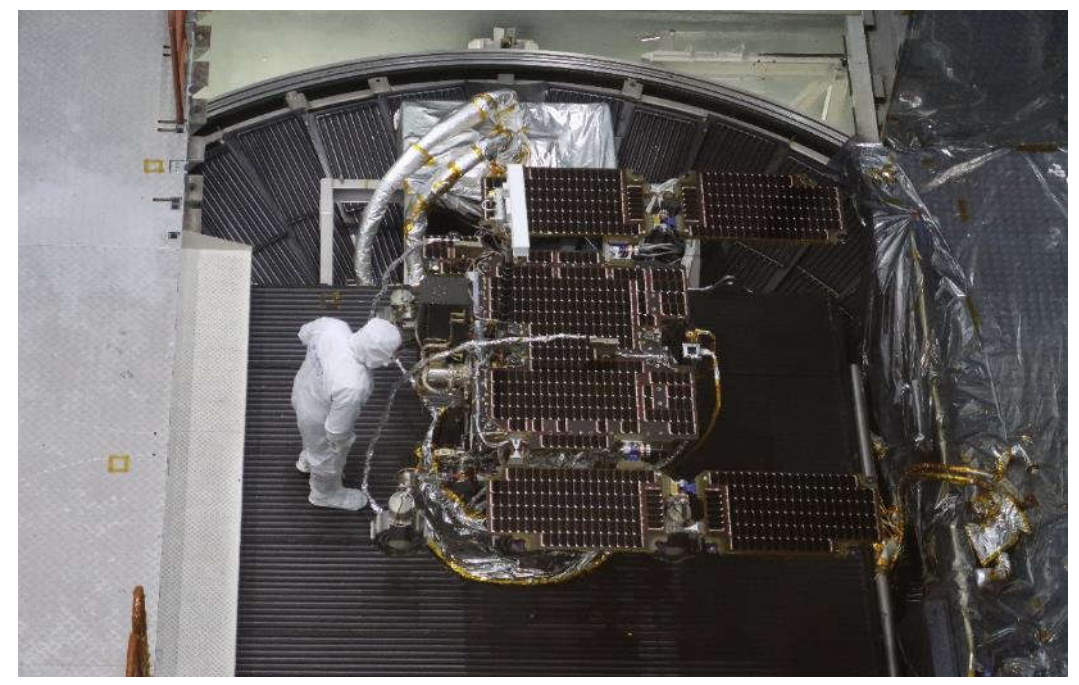
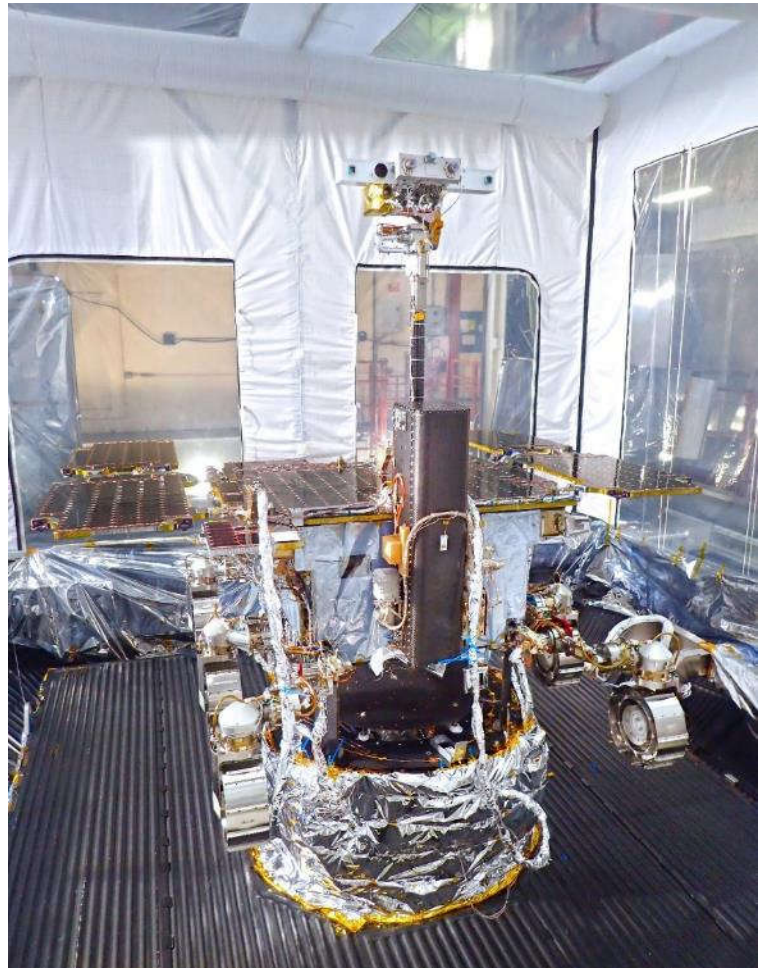
ExoMars has made positive progress ...



- All ExoMars Rover Surface Platform hardware was delivered and integrated to execute Cruise, EDL and Landing Operations tests under environmental conditions in TASinF Cannes
- The Spacecraft TB-TV and Acoustic Tests were conducted successfully
- After thorough validation at Airbus F Toulouse, the Rosalind Franklin Rover was delivered 10 February to TASinF for system level electrical/EMC system compatibility tests
- The Parachute system design was updated and six dynamic extraction ground tests successfully completed at JPL with both parachutes → two new High Altitude Drop Tests remain for later in 2020
- The Russian lander propulsion system underwent qualification testing



Rover Module



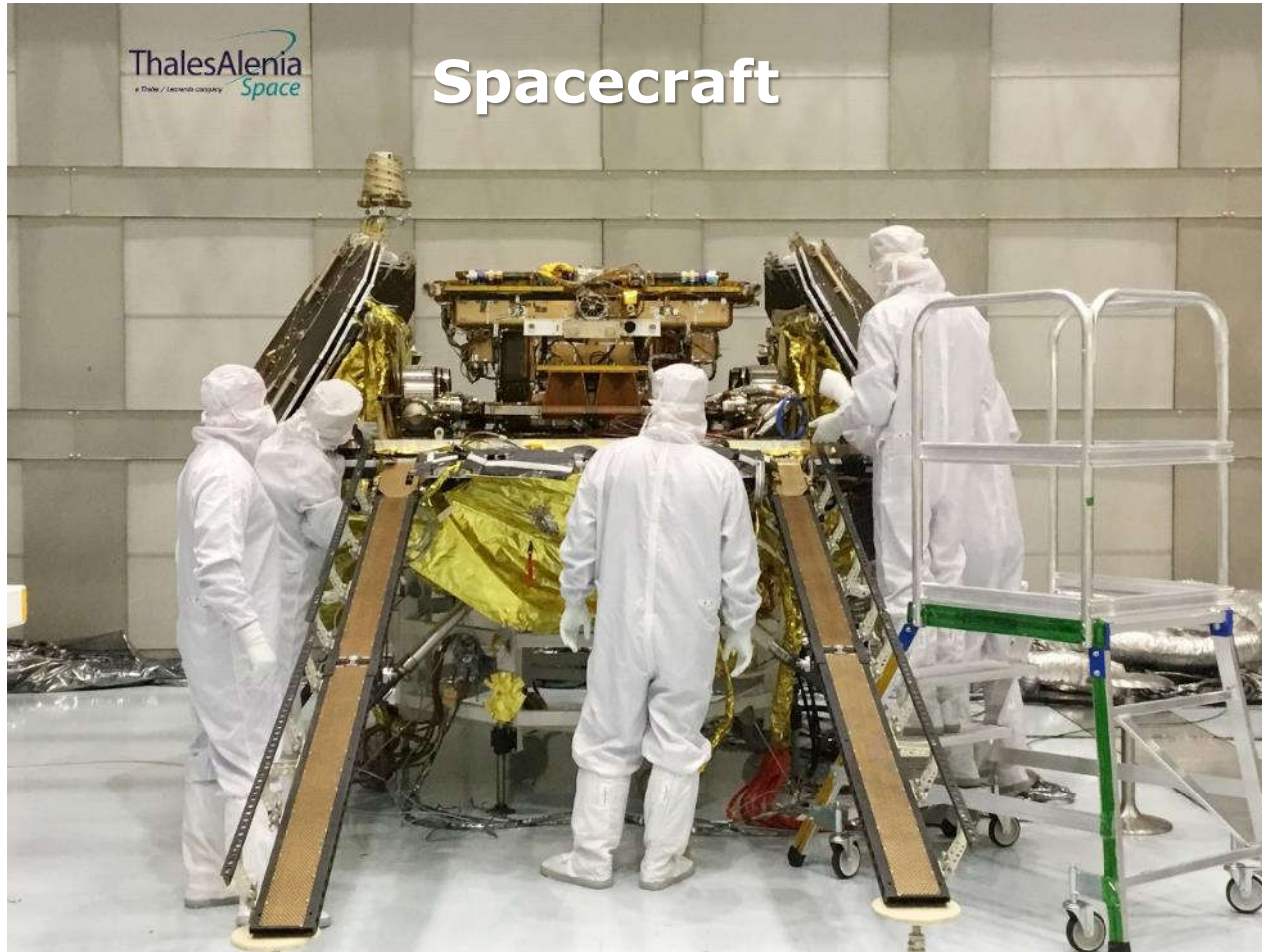
Rosalind Franklin after Thermal vacuum testing at ADS-F Toulouse

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Spacecraft



Flight Landing
Module at TASinF
Cannes showing the
Rover STM and the
deployment ramps

...But gradual schedule erosion occurred

- Slow **Russian avionics** debugging at TASinI in May-Oct. 2019 delayed the **central software** and so the spacecraft functional and operations validation tests
- Avionics **malfunctions/failures** encountered on four Russian equipment: at least one must return to Russia for troubleshooting
- **Limited visibility** on Russian-led qualification and acceptance tests (i.e. for the Descent Module separation and propulsion systems)
- Despite 3 shifts 7/7 work since May 2019, DM/SCC **AIT activities were slower** than expected due to delayed hardware with limited AIT specifications and design documentation from Lavochkin
- **Negative schedule contingency** with respect to the launch window opening (26 July 2020)

→ **Covid-19 strongly impacting Russian/European work**

Main Recommendation of Inspectors General + Project Joint Report to DGs

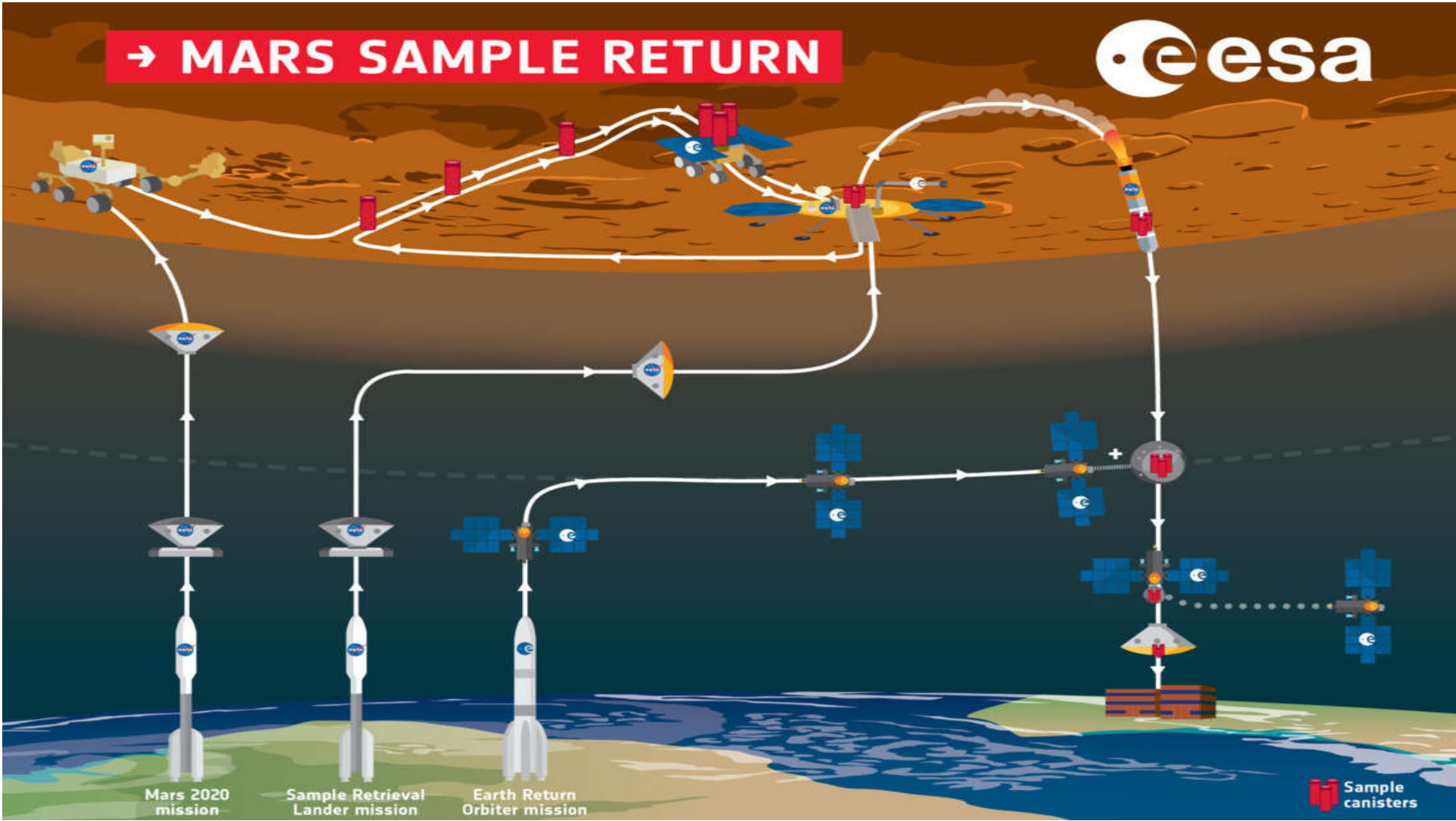


*In view of the current ExoMars-2020 delays, the main risks/mitigations presented above, and considering the lack of schedule contingencies, maintaining the ExoMars RSP launch between the 26 July and the 11 August 2020 has become incompatible with the successful delivery of the Rover and Landing Platform on Mars. **It is therefore recommended to adjourn the ExoMars launch to September/October 2022***

- **Replanning for 2022 launch underway**
- **Financial contingency included in Space19+ proposal**



→ MARS SAMPLE RETURN



Mars 2020 mission

Sample Retrieval Lander mission

Earth Return Orbiter mission

Sample canisters

→ MARS SAMPLE RETURN



Science preparation actions include:

- Sample Analogue Curation Facility at ECSAT operational and supporting research
- ESA recruiting dedicated planetary sample scientist
- Open selection of European scientists to be part of Mars 2020 campaign regarding sample selection
 - → ESA AO for up to 5 *Returned Sample Scientists* issued at end of March 2020
- Setting up of new MSR Science Planning Group (MSPG) to support executive of NASA and ESA

Mars 2020
mission

Sample Retrieval
Lander mission

Earth Return
Orbiter mission

Sample
canisters

MSR Science Planning Group (MSPG)



- ESA and NASA preparing a joint MSR campaign
- One of the key elements of the partnership is to establish the Science Management Plan (SMP) to give all partners a fair opportunity to participate in the scientific discovery process
- MSPG was put in place in 2019 and delivered a framework and findings for Mars sample science management in Nov. 2019

FINDING #11: Two functional groups are needed as quickly as possible following approval to proceed with the MSR Campaign: the MRSH Council and the MSR Science Planning Group 2



MSR Science Planning Group Phase 2: Tasks



→ Provide inputs to a MSR Science Management Plan (SMP)

→ Technical issues related to the science of MSR

- Sample sterilization, including consideration of the effects of sterilization on the science as well as implications for the SRF
- Use of penetrative imaging on the sample tubes before they are opened
- As needed, propose quantitative sample quality-related requirements for the transport/handling of the samples during the MSR flight campaign

→ Develop approaches and a working list of high-level requirements for the SRF that can be used in cost estimation and budgeting

→ A list of key decision points related to the Mars returned samples with inputs from science, curation, and planetary protection, and represent them on a master timeline

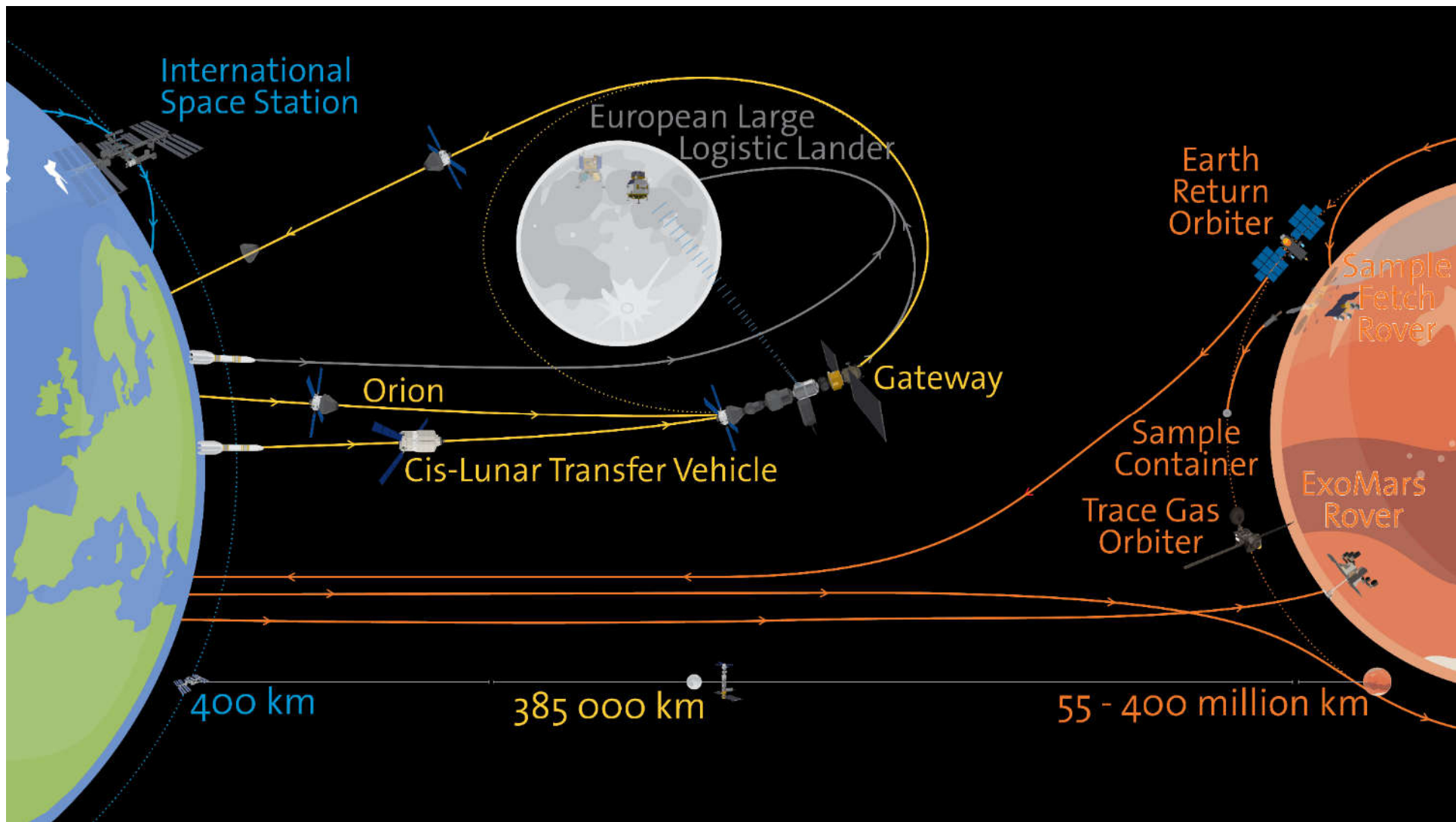


MSR Science Planning Group Phase 2



- Joint Terms of Reference (ToR) signed 4 April 2020
- AO issued on 6 April 2020 by ESA and NASA in parallel
- Expected start is 31 May 2020
- Expected end date is 30 April 2021
- Up to 25 team members will be selected based on experience in the organization and management of large-scale national and international collaborative scientific activities, involvement in one or more sample return planning and/or flight activities, and experience with sample-related scientific issues associated with sample containment and analyses

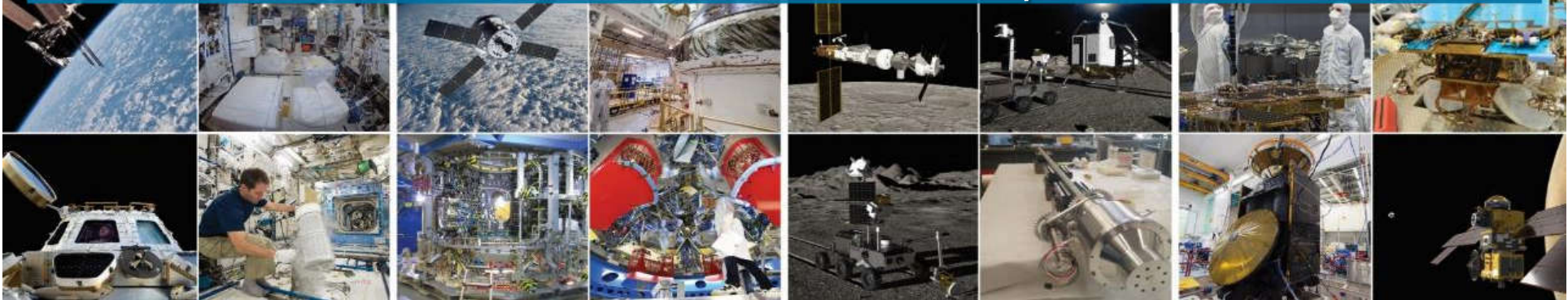






Space19+ has determined the next decade and beyond

- *Europe using the ISS for world-class research and developing an economy in Low Earth Orbit*
- *Joining our international partners by sending the first European explorers to the Moon*
- *Europe as a global leader in robotics, artificial intelligence and commercial services for lunar and Mars exploration*



ADDITIONAL SLIDES ON FSL



EDR2 Status and Utilisation Plans



EDR2 is installed in HTV-9 and ready for launch at the end of May 2020

- To be installed in COL1D4 during HTV-9 mission and used for stowage temporarily
- Transfer from D4 to O1 is pending FSL activities and readiness of EDR2 Class 2 payloads
- Class 2 Payload hardware readiness:
 - Metal 3D Printer NET Q2/Q3 2021
 - Live Cell Imaging (aka Flumias) NET Nov 2022
 - VIP-GRAN-ISS NET end-2022 (ops readiness)
 - HTH-2 NET Q2 2023 (ops readiness)
 - HTH-1 still in negotiation phase (ops readiness as of ~Q1 2026)

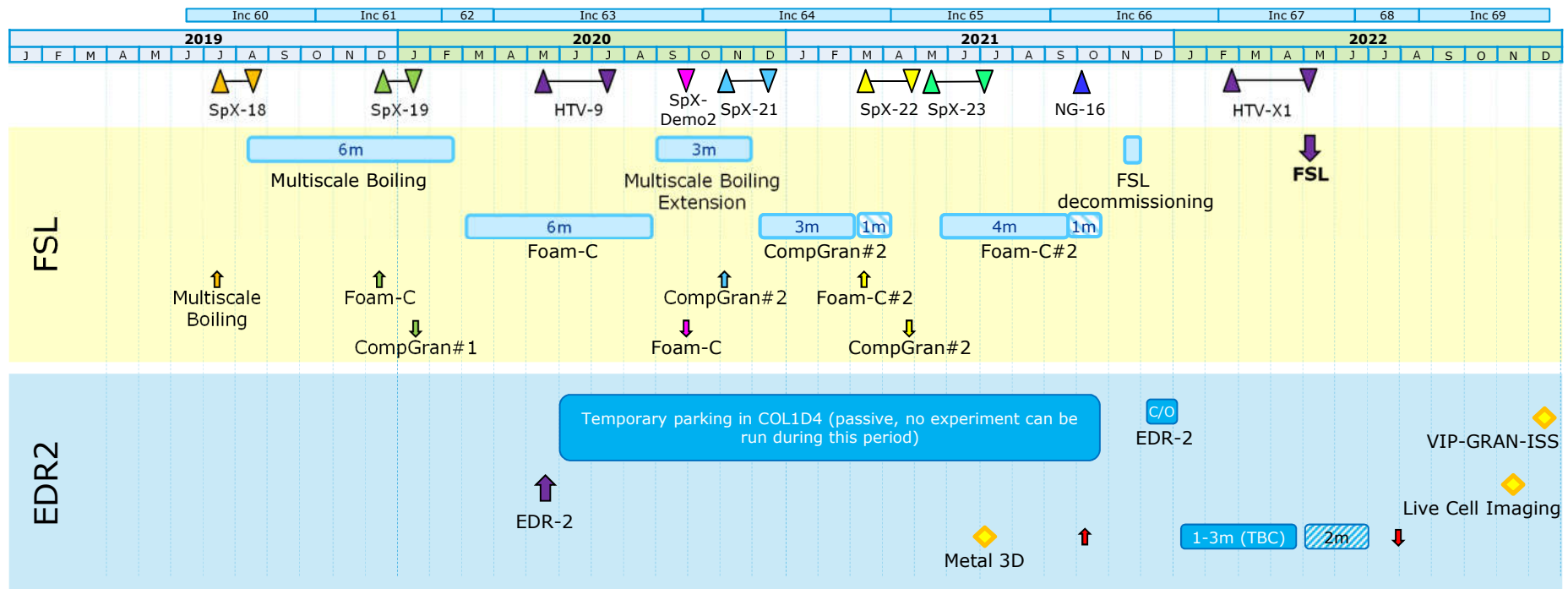


FSL and EDR2 Utilisation Plan



- EDR2 uploaded on HTV-9 and temporarily parked in COL1D4
- ETC disposed with HTV-9
- FSL disposed with HTV-X1

- ◆ Expected readiness
- ↑ Upload
- ↓ Return/Trash



EDR2 Utilisation

- Flights arbitrarily assigned, Flight Plan will change
- Schedule subject to change based on HW and Ops readiness



- M3DP: Metal 3D Printer
- Live Cell Imaging
- VIP-GRAN-ISS
- HTH-2: Heat Transfer Host 2

