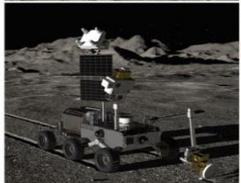
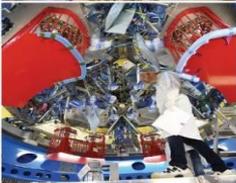


***E3P Period 2
Presentation to Belgian Actors
30 September 2019***

Frank De Winne





High level goals - Human and Robotic exploration



- Lead Europe's human journey into the Solar System using a partnership with robotic missions as precursors and scouts
- Initiate history-making projects that will determine Europe's role in global space exploration for the next decade and beyond

High level outcomes consistent with ESA's agreed exploration strategy

- New knowledge; economically valuable innovation; inspiration of the next generation; and expanded international cooperation

Europe can only afford one space exploration programme !

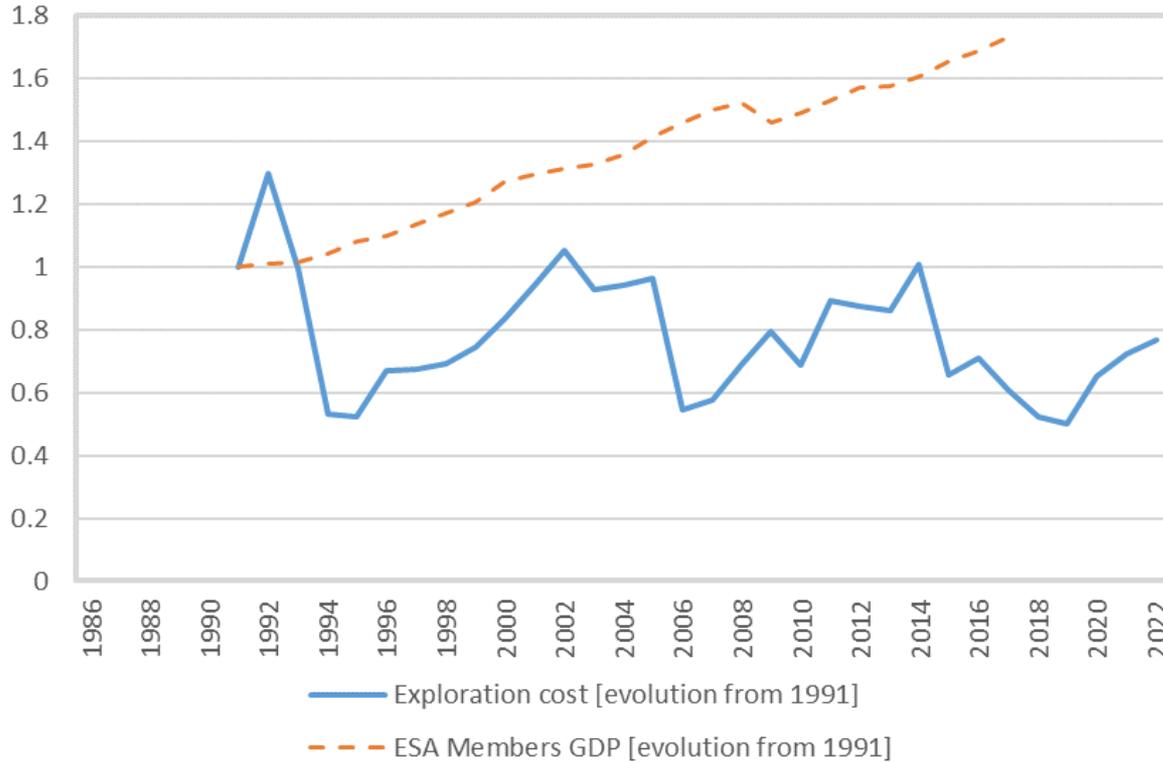


An ambitious programme

E3P2 will enable the:

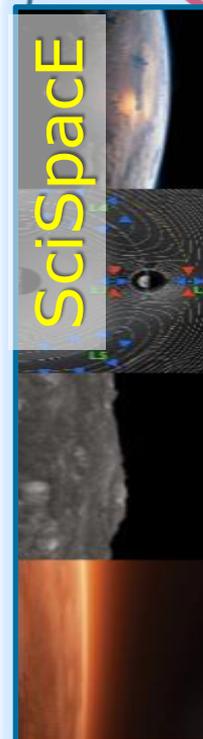
- First European to travel beyond LEO
 - and potentially the first European on the Moon
- First use of a European commercial transportation service to the Moon
- First test of the feasibility of using space resources on the Moon
- First round-trip to Mars, to return samples to be analysed in European laboratories for decades to come

ESA Exploration Programme Cost versus GDP (2019 e.c.)



Proposed programme is result of 2 year dialogue

6 Activities; 4 Cornerstone campaigns; 1 Programme



Cornerstone 1

Humans in Low Earth Orbit

Cornerstone 2

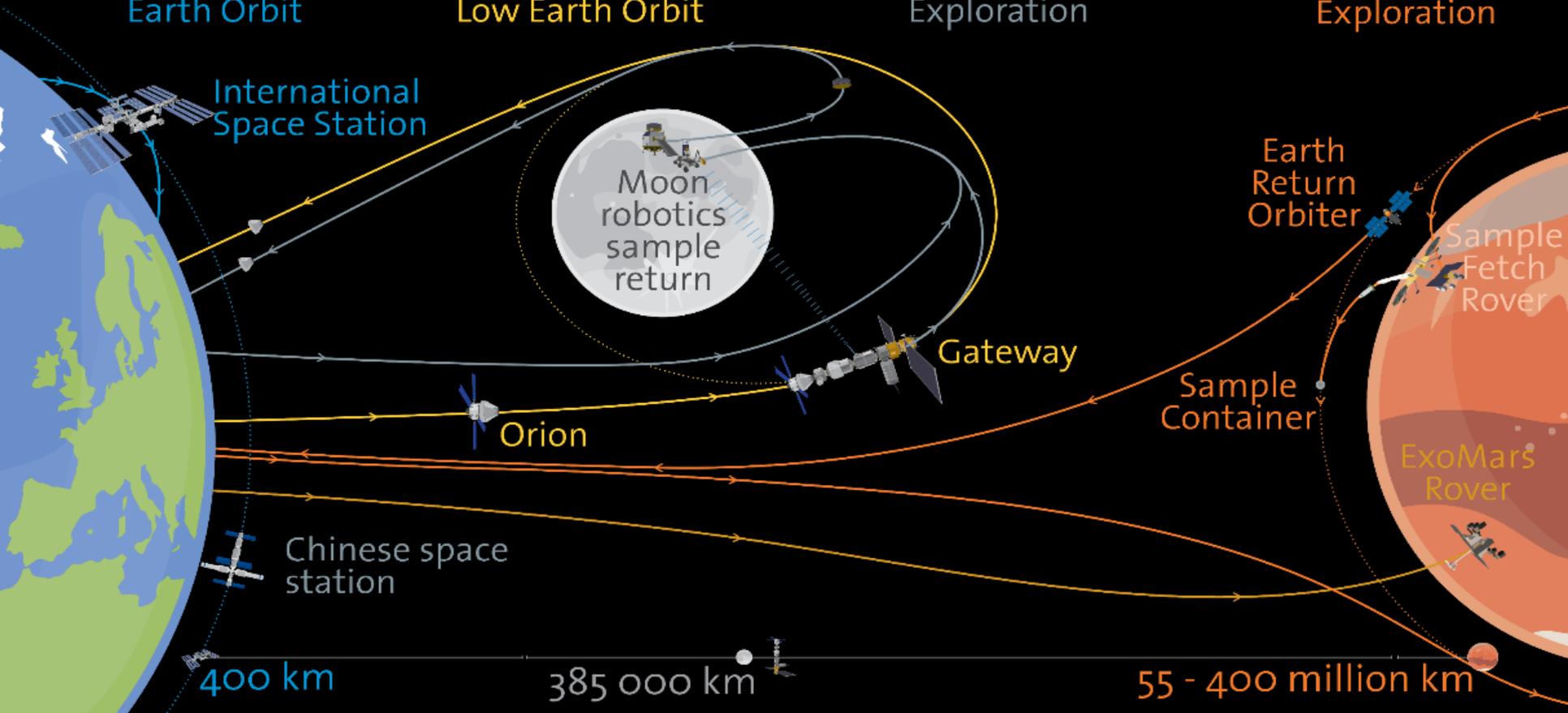
Humans beyond Low Earth Orbit

Cornerstone 3

Robotic Lunar Exploration

Cornerstone 4

Robotic Mars Exploration



→ HUMAN AND ROBOTIC EXPLORATION ECONOMIC IMPACT



E3P Period 2 projected 2020–2025

Cornerstone 1 Budget invested in industry: 790
Humans in Low Earth Orbit GDP impact: 2460
Total tax revenue for ESA countries: 640

Cornerstone 2 Budget invested in industry: 350
Humans Beyond Low Earth Orbit GDP impact: 1100
Total tax revenue for ESA countries: 280

Cornerstone 3 Budget invested in industry: 150
Lunar robotic GDP impact: 450
Total tax revenue for ESA countries: 120

Cornerstone 4 Budget invested in industry: 440
Mars robotic GDP impact: 1370
Total tax revenue for ESA countries: 350

Source: Open University

Figures in M€

Each €1 ESA invests in industry creates €0.8 in tax revenue for ESA countries



Each €1 ESA invests in industry creates €3 in immediate economic impact



Employment figures

→ HUMAN AND ROBOTIC EXPLORATION EMPLOYMENT



E3P Period 2 projected 2020–2025

Employment figures in person years



Each job sustained by ESA contracts to industry creates two additional jobs in the space and broader economy



#Space19plus



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

Space19+ actions

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

Columbus 2030

Enable



LEO Commercialization



Increased ISS Utilization



Modernize



Ground Infrastructure



Business Processes



On-Orbit Infrastructure

ISS benefits for Europe

→ INTERNATIONAL SPACE STATION BENEFITS FOR EUROPE



<h3>BETTER TOGETHER</h3> <p>1998: ESA meets International Space Station</p> <p>strong partnership and international cooperation</p> <ul style="list-style-type: none"> 15 international partners 230 individuals from 18 countries visited the ISS 	<h3>PROFITABLE SPACE</h3> <p>each euro spent on the Space Station produces €1.8 added value to European economies</p> <p>1€ = 1.8€</p> <p>€7B government revenues from ESA spending</p> <p>90% spent in ESA participating countries</p> <p>every 100 jobs in the space sector linked to the Space Station creates 90 additional jobs</p>	<h3>INSPIRATION</h3> <p>43K teachers trained per year</p> <p>educational kits for schools</p> <p>university lectures</p> <p>student nano-satellites and hands-on projects</p>
<h3>KNOWLEDGE FOR SOCIETY</h3> <p>1850+ european researchers</p> <p>800+ experiments</p> <p>Source: PricewaterhouseCoopers, ESA</p>	<h3>COMPETITIVE INDUSTRY</h3> <p>the partnership established Europe as a reliable international partner</p>	<p>4M friends Facebook</p> <p>6M followers Twitter</p> <p>85M views YouTube</p>

European Space Agency

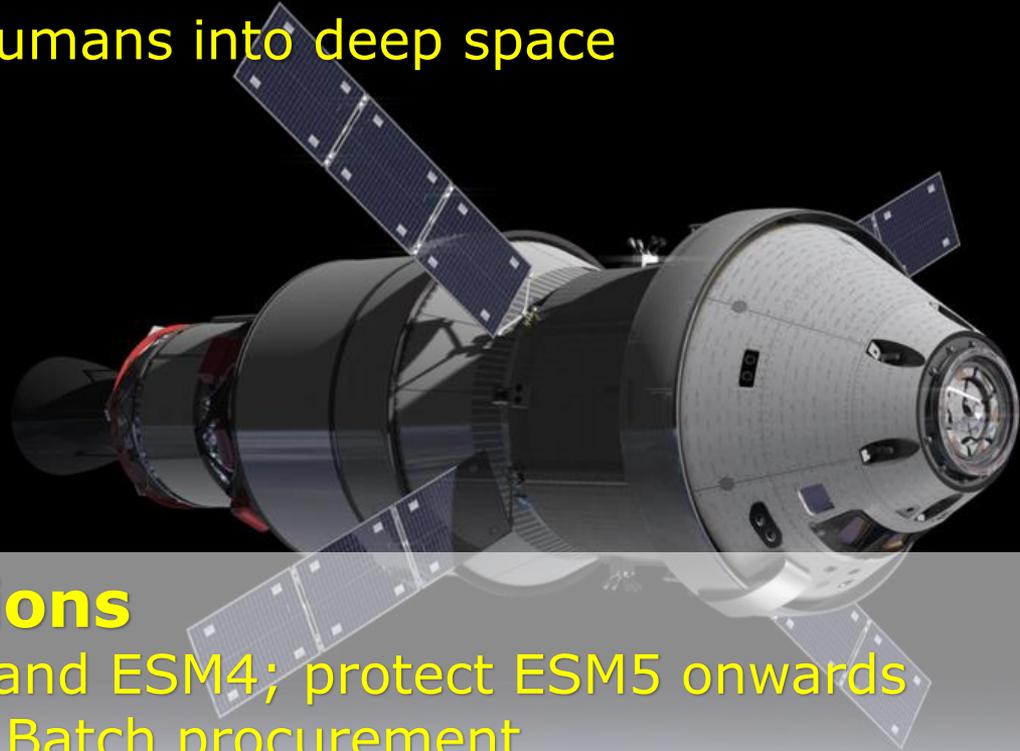
ESA UNCLASSIFIED

D. Parker | 23/09/2019 | Slide 12



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

CS #2 : The Lunar Gateway



By 2025, humanity's most remote research base



Power Propulsion Element (NASA)

Human Lander System (NASA)

Robot arm (CSA)

ESPRIT Refueller

Logistics Vehicle (NASA)

Crew Airlock (Russia, TBC)

US Hab (TBC, NASA)

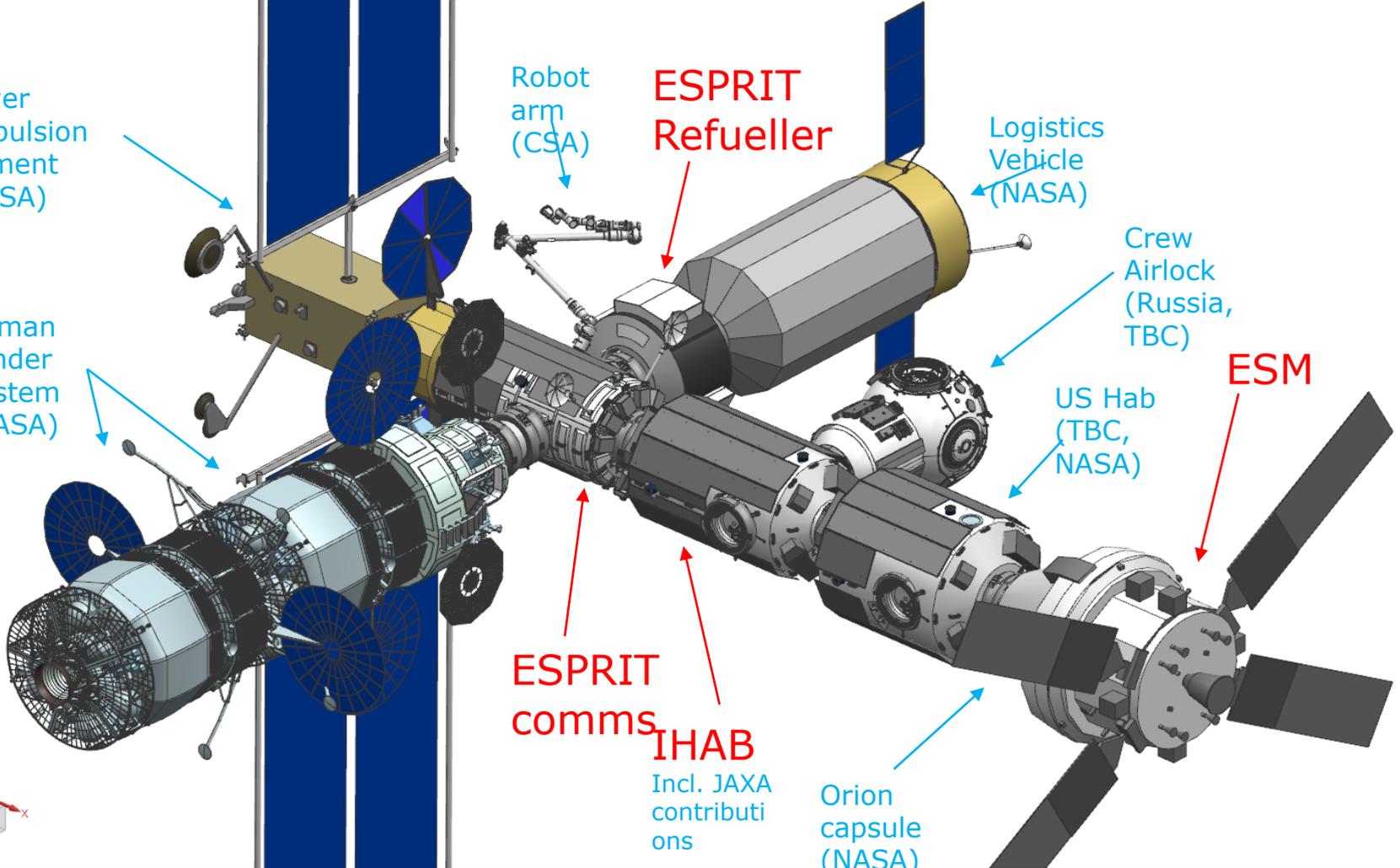
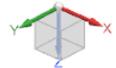
ESM

ESPRIT comms

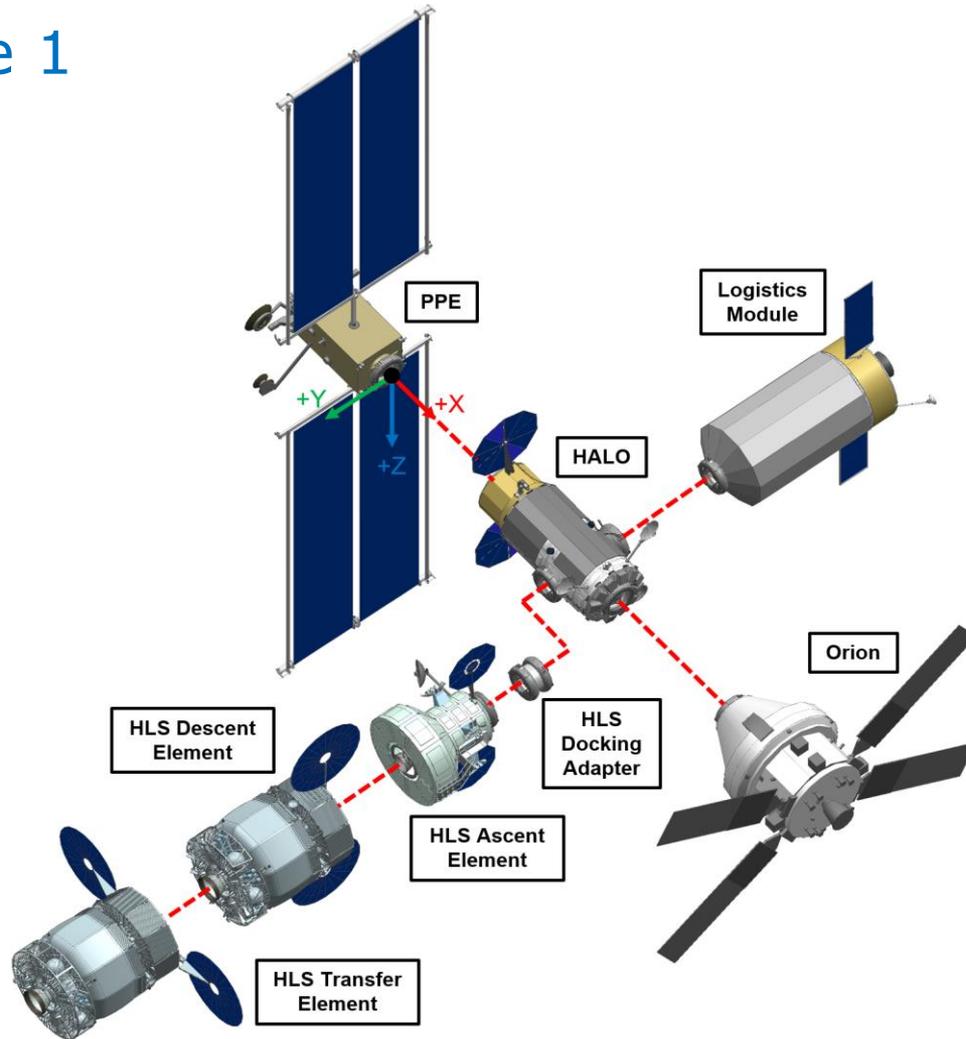
IHAB

Incl. JAXA contributions

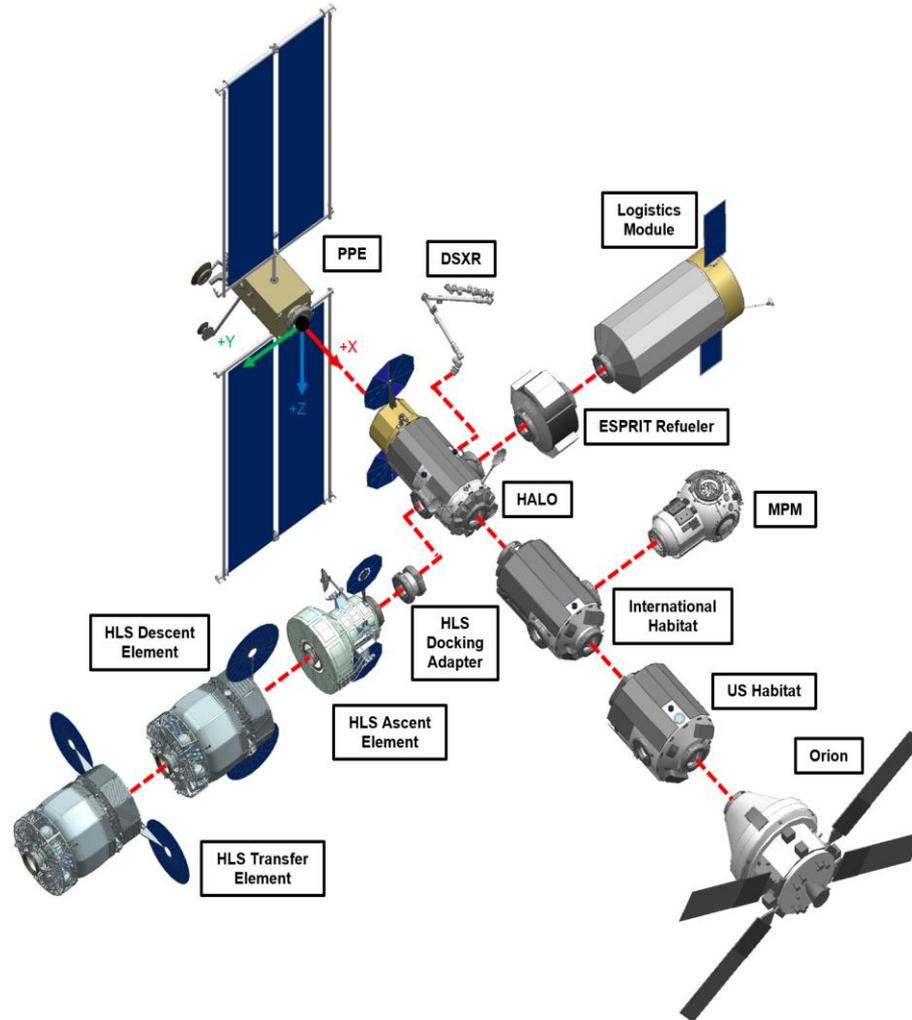
Orion capsule (NASA)



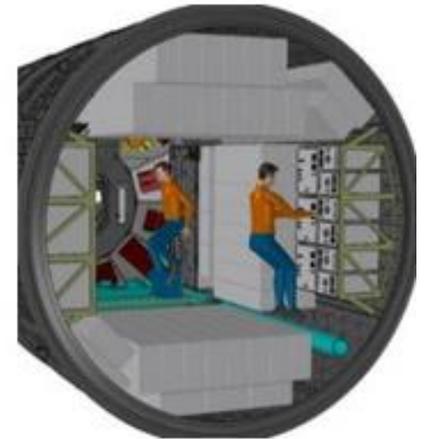
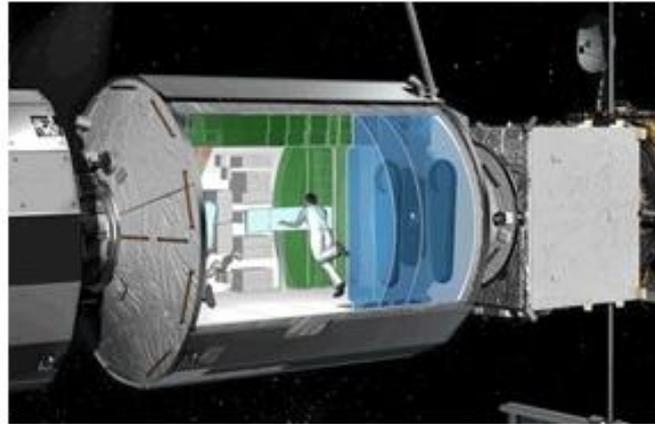
Gateway Phase 1



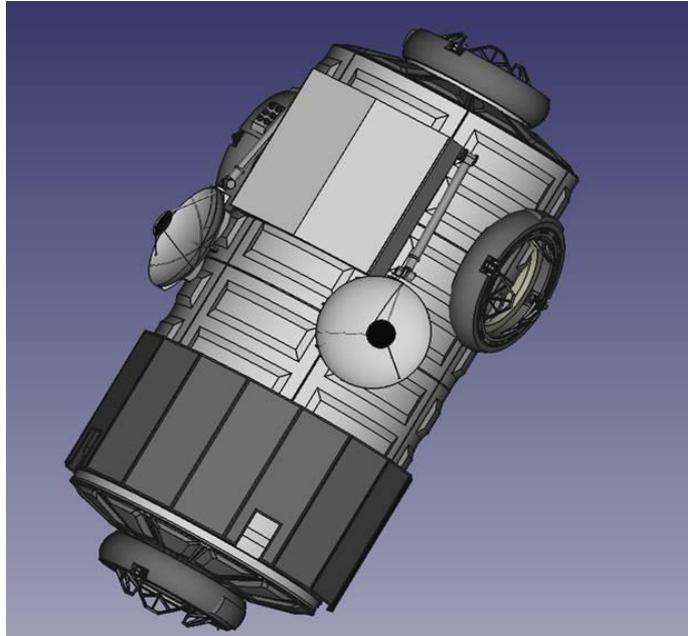
Gateway Phase 2



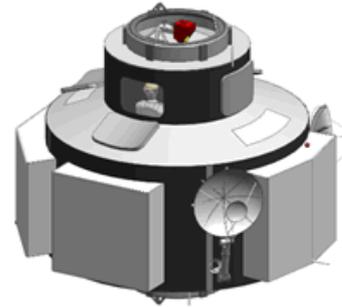
International Habitat concept (I-HAB)



European System Providing Refuelling, Infrastructure and Telecommunication (ESPRIT)



TAS-F/OHB



ADS-F





Forward to the Moon



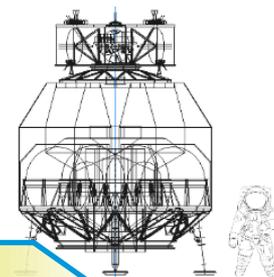
CS #3 - Four Theme Robotic Lunar Campaign



CLPS Lander



Lunar Resource Lander



Opportunity science & technology missions

Mission Phase A/B1/B2

European Large Logistics Lander

Lunar Pathfinder comsat



Commercial Lunar products and services

Payload Phase B1/B2

Space Resources Campaign

Period 2 (2020-22)

Period 3 (2023-25)

Period 4 (2026-28)



Main activities in CS#3 (1/2)

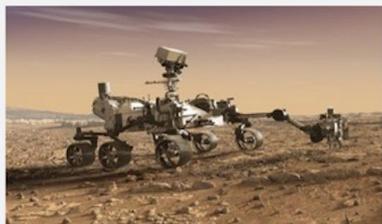


Activity	Sub-activity
PILOT/ PROSPECT	Completion & operation of PILOT and PROSPECT for Lunar-27
Lunar Science & technology missions of opportunity	Build, fly, operate payloads selected in 2019, and for Chang'e 6; Build future payloads for Period 3 implementation
	International Lunar Science and Research Team; Support to ground-based sample analysis
	International Lunar Research Station Study (CNSA)
	Small lunar science mission Phase A/B1 x 2 (geophysics)
Commercial Lunar Products and Services	Implementation of Lunar Pathfinder Mission Service
	Lunar Communication and Navigation Service Phase B
	Maturation of critical payload technologies up to TRL 5

Main activities in CS#3 (2/2)

Activity	Sub-activity
European Large Logistic Lander	Phase A generic lunar cargo vehicle (2 parallel studies)
	Phase B1 definition (2 parallel studies)
	Critical technologies up to TRL 5 (GNC + propulsion)
	Phase B2 schedule protection
Space Resources (ISRU)	European Innovation Centre for Space Resources
	Study of ISRU applications to future missions
	Phase B1 of ISRU demonstration payload(s)
	Phase B2 of ISRU payload ; technology de-risking

CS#4 – Notional MRS elements



**Sample Caching Rover
- NASA
(Mars 2020)**

- *Sample acquisition and caching*



Sample Retrieval Lander - NASA

- *Sample Fetch Rover*
- *Mars Ascent Vehicle*
- *Sample Transfer Arm*
- *Orbiting Sample container (OS)*



Earth Return Orbiter - ESA

- *Capture and Containment System*
- *Earth Entry Vehicle*



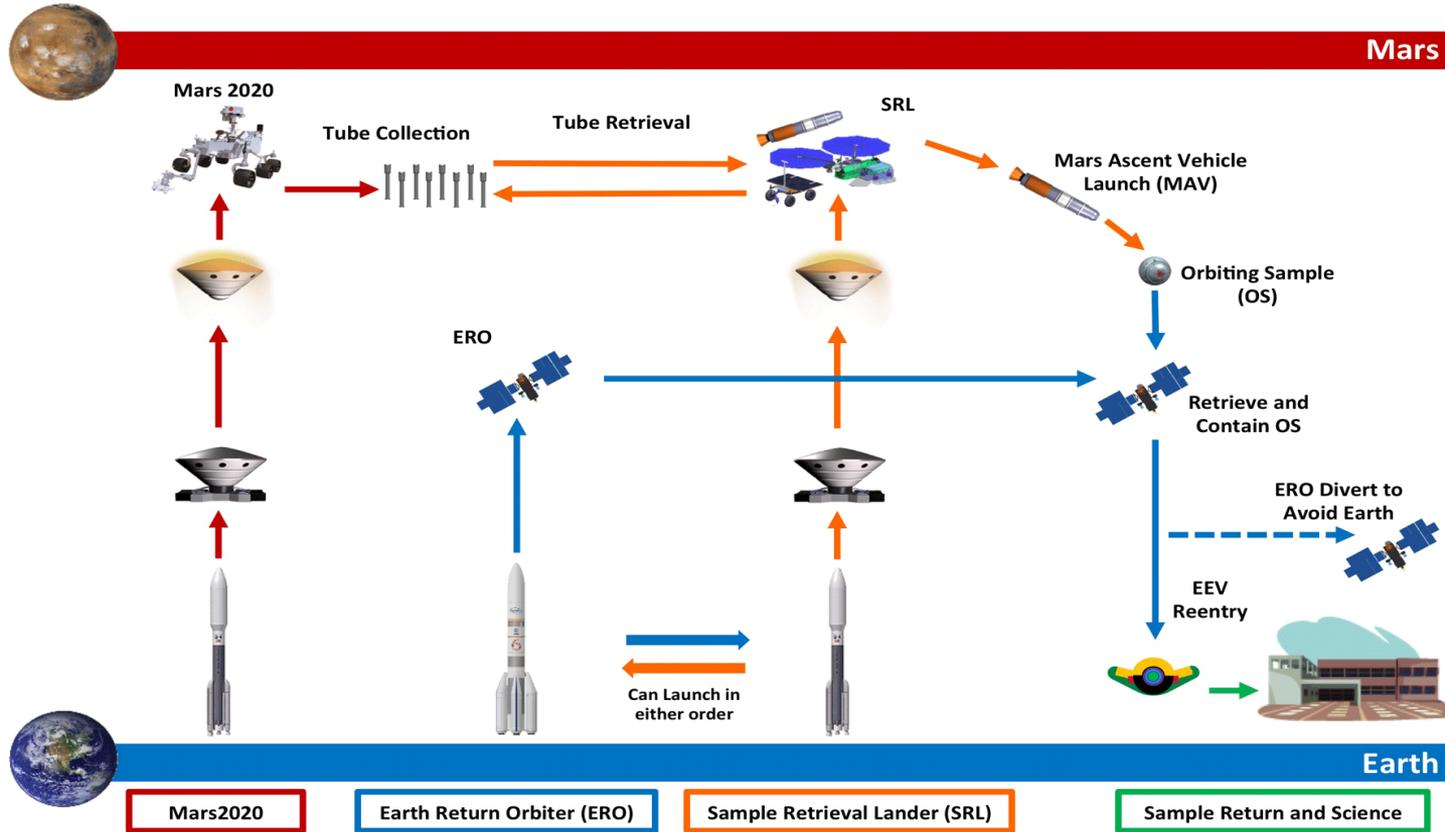
Mars Returned Sample Handling - International

- *Sample Receiving Facility*
- *Sample Curation Facility(ies)*
- *Sample science investigations*

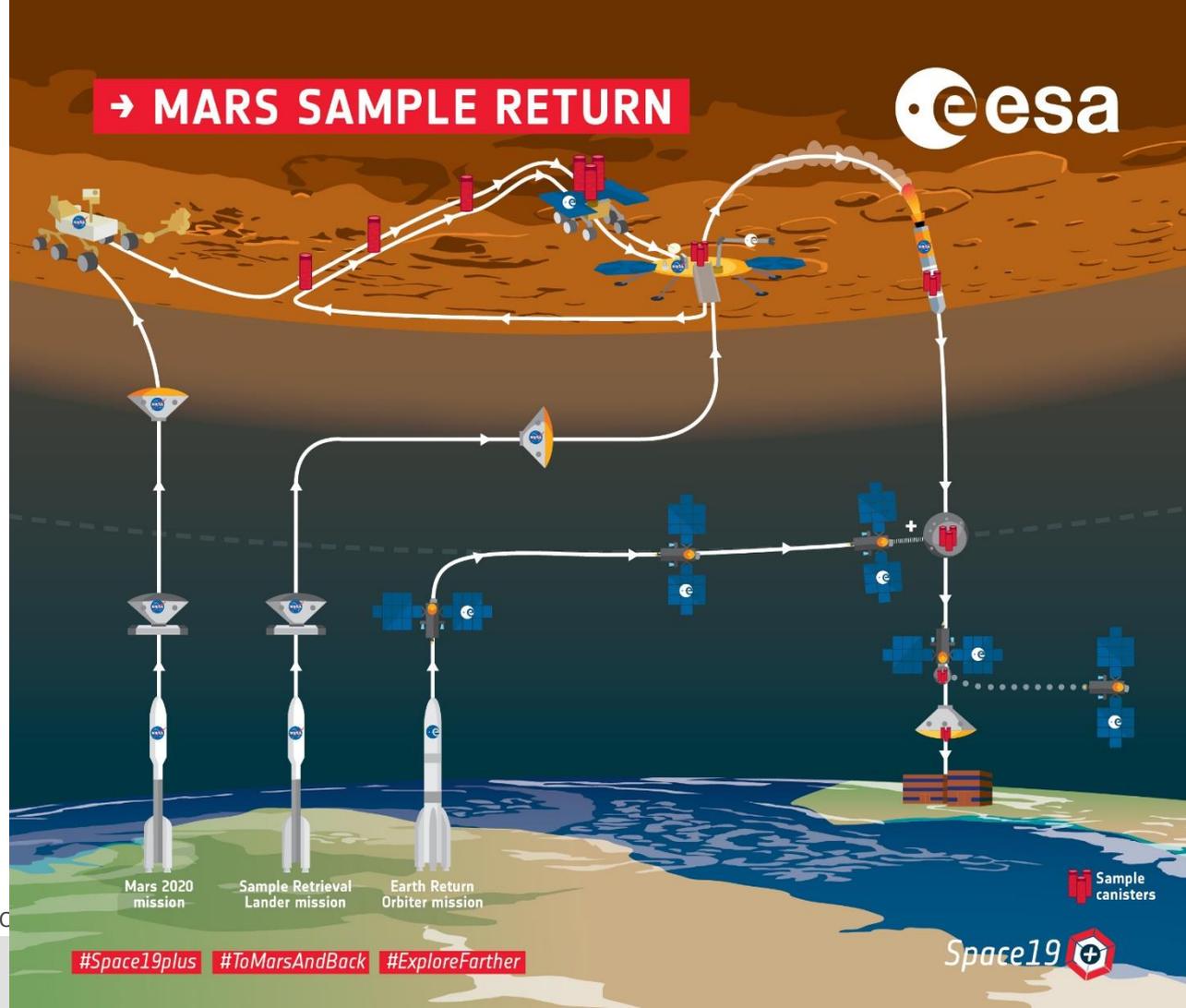
Flight Elements

Ground Element

MSR Reference campaign scenario



→ MARS SAMPLE RETURN



Mars 2020 mission

Sample Retrieval Lander mission

Earth Return Orbiter mission

Sample canisters

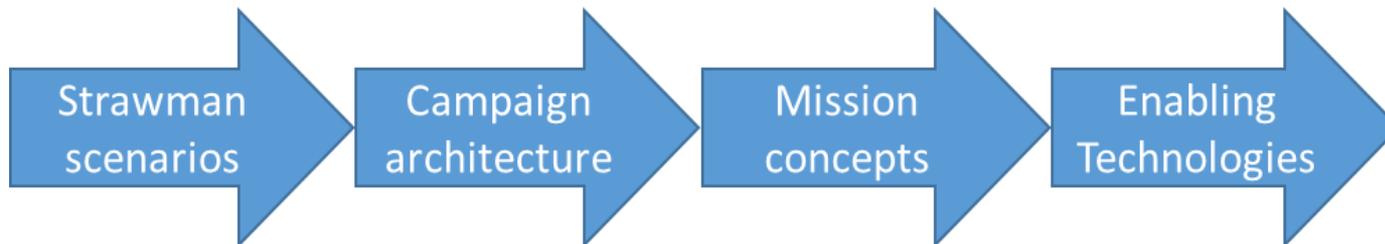
ESA UNCLASSIFIED - For C



#Space19plus #ToMarsAndBack #ExploreFarther



ExPeRT Studies logic



ExPeRT sub-elements	%	M€
Mission studies	25	20
Technologies	65	52
SpaceShips and int'l collaboration	10	8

ExPeRT - Indicative mission concept study phases



	Gateway	On the Moon	To Mars	On Mars	Previous/ planned
Deep space transportation	Phase A/B1	---	Phase 0	---	ATV, ESM
Logistics					
Lander/ Ascender	---	Phase A/B1	---	Phase 0	Schiaparelli Luna-27 EL3
Crewed	---	---	Phase 0	Phase 0	Columbus MPLM I-HAB
Surface activities					
Robotics	Phase A	Phase A/B1	---	Phase 0	ExoMars/MSR
Crewed	---	Phase A	---	Phase 0	Analogues



ExPeRT robotic exploration themes



Mission Title	Mission Concept	Mission Study	Priority (H/M/L)	Remarks
European Large Logistic Lander (EL3)		X (phase A/B1)	H	International collaboration
Lunar communication and Navigation		X (phase B1)	H	collaboration with D/NAV and D/TIA
ISRU demonstration payload(s)		X (phase B1)	H	Table 13 of ESA/PB-HME(2019)23
Moon Robotics	X	X tbc (Phase A)	H	DPTD
Mars Robotics	X		M	DPTD
Small Vehicles	X		M	DPTD



ExPeRT human exploration themes

Mission Title	Mission Concept	Mission Study	Priority (H/M/L)	Remarks
Cis-Lunar Transportation Vehicle (CLTV)	X (pre-Phase A)	X (phase A/B1)	H	Phase 0 started in 08/019
Deeper space Vehicles	X		M	DPTD
Surface Habitats	X		H	DPTD
Crew Mobility	X		M	DPTD



Technology

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

System Studies

- Main focus: robotic + human lunar

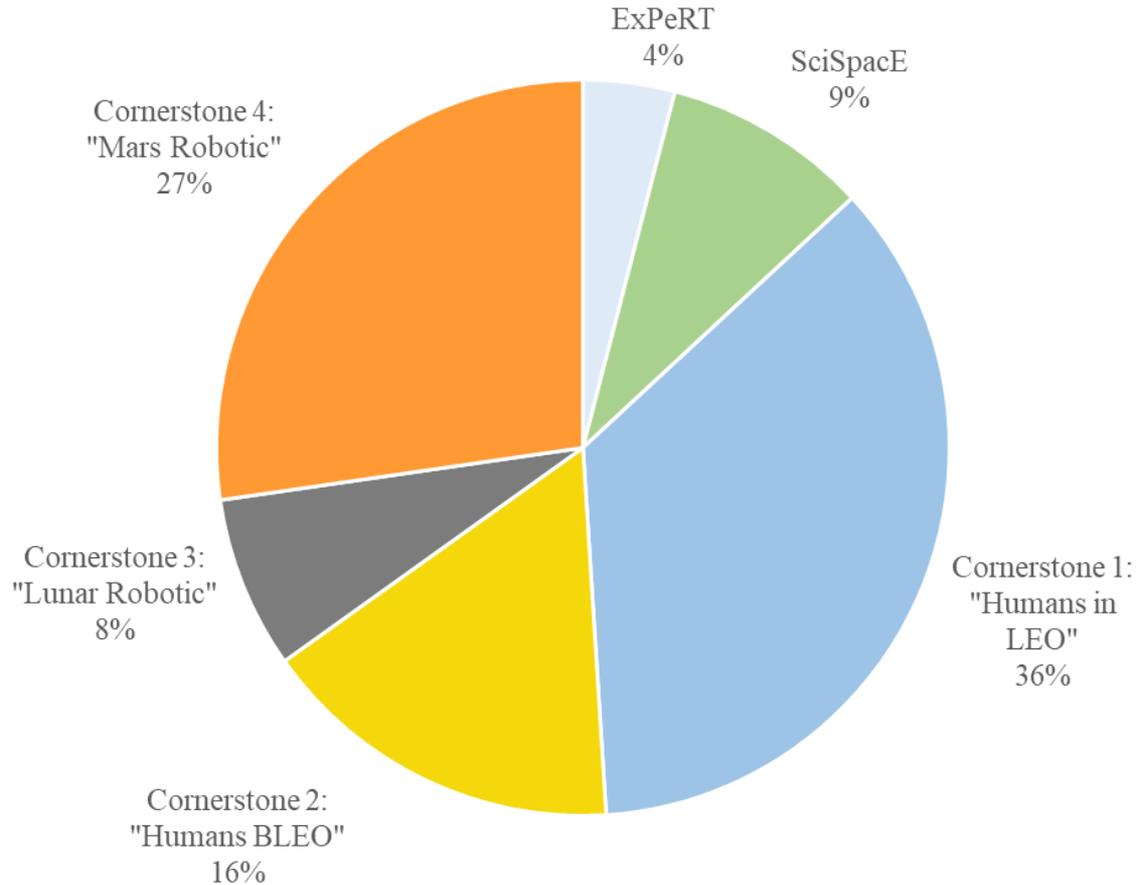
Proposed budget allocation: LTP Corridor +10%

Programme activities		Planned budget allocation (M€) 2019 e.c.
SciSpacE	9%	180
CS#1: "Humans in LEO"	36%	710
CS#2: "Humans beyond LEO"	16%	320
CS#3: "Moon Robotic exploration"	8%	150
CS#4: "Mars Robotic exploration"	27%	540
ExPeRT	4%	80
Grand TOTAL	100%	1980

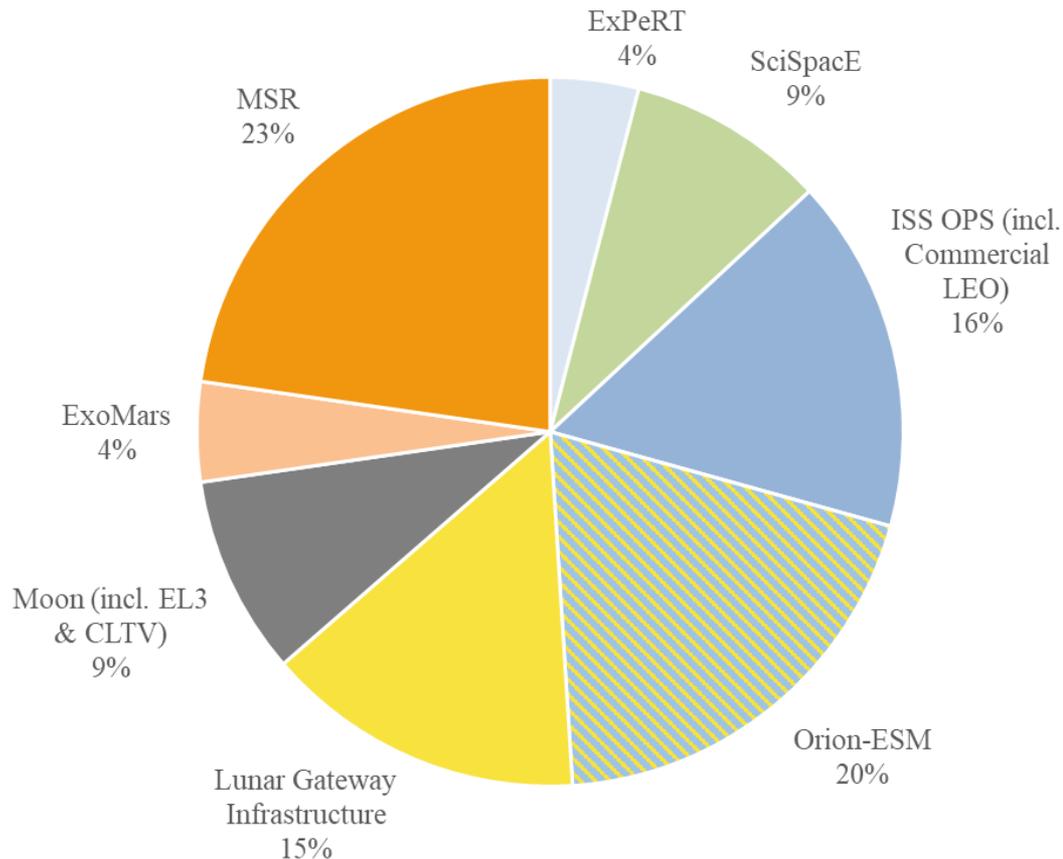
710 => 320 M€ ISS Ops + 390 M€ ESM Offsets

320 => 200 M€ I-HAB + 90 M€ ESPRIT + 30 M€ CLTV

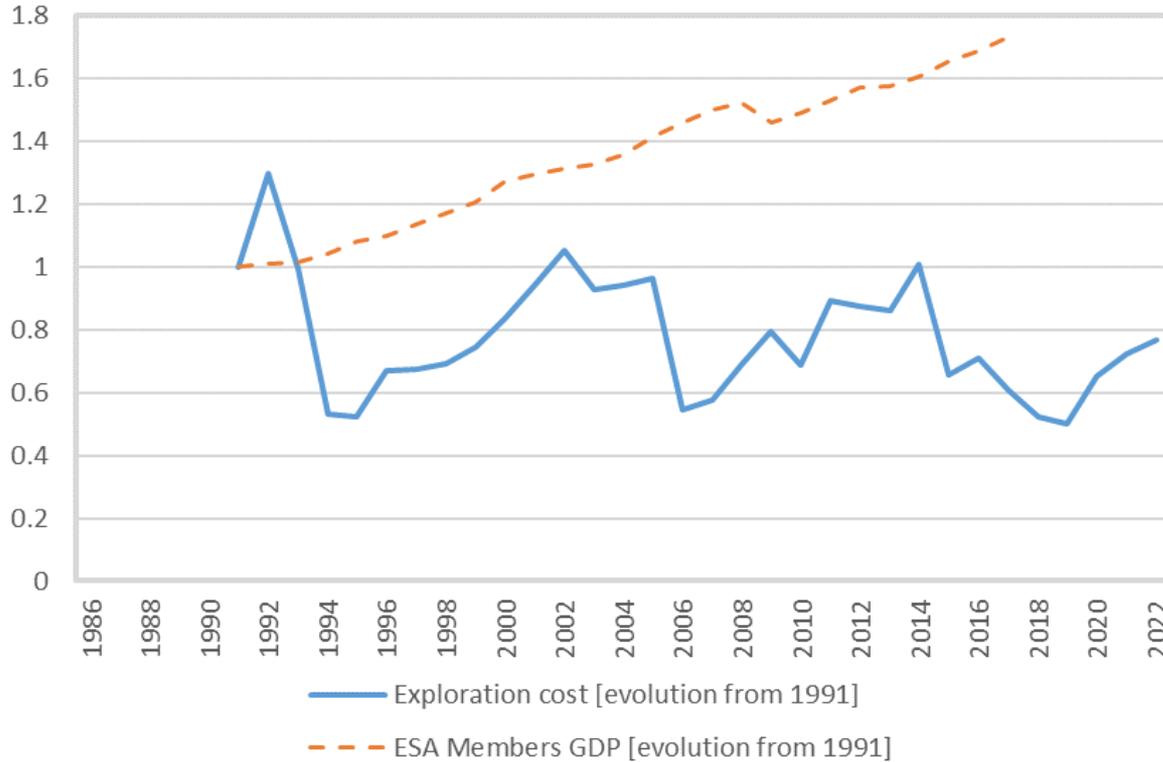
E3P2 commitment profile per product



E3P2 commitment profile per main activity



ESA Exploration Programme Cost versus GDP (2019 e.c.)



Belgium Business Case



- SciSpace : Science and Payload development
- CS1 : Continued to support to ISS Operations, Commercial activities, Modernisation
- CS2 : European Service Module, IBDM's, Communication, Avionics, Imagery
- CS3 : Imagery, Pilot, Prospect, Structures, Avionics, IBDM's
- CS4 : Power, Mechanisms, Imagery, Software
- Expert : Life Support, Radiation, Instrumentation

=> Total opportunities of 170 M€ in Period 2



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 



European Space Agency