Status and Outlook for European Exploration Envelope Programme

David Parker and HRE Team

ESSC, 23 November 2017

AGENDA

1. **Introduction**
   - Exploration goals and discussions
2. **E3P Current Programme – Status update**
   - Progress since CM 16
3. **E3P Future Programme - Element Status**
   - Overall Programme Structure
   - Candidate Cornerstone Missions
   - Candidate Exploration Technology Demonstrators
   - Candidate Missions of Opportunity
4. **E3P Future Programme - Affordability**

Exploration is Strategy-Driven

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

Global Exploration Strategy Framework Document, 2007

Scientific Programme

'bottom-up'

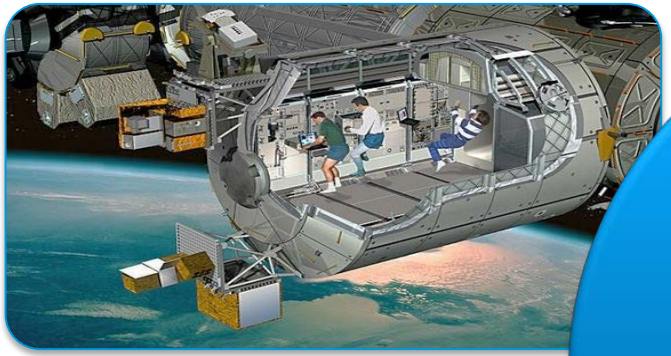
➢Enabled by **competitive selection** among proposals from the science community in astrophysics, solar physics, planetary science etc.

Exploration

'top-down'

➢Enabled by step-wise increase of complexity to achieve the **long-term goal** of extending human reach to Mars surface

Why Explore ?

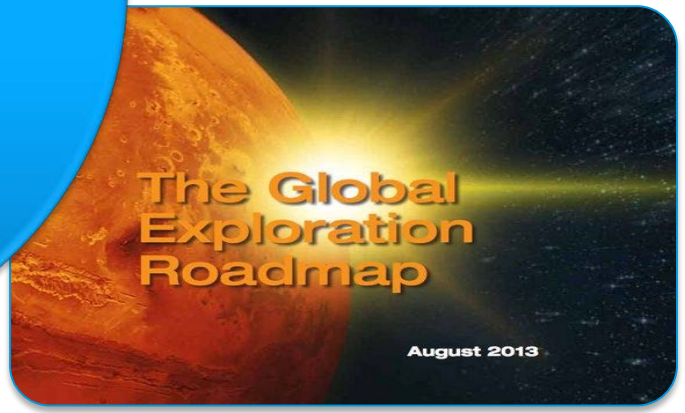


New knowledge

Challenge driven innovation

Inspiration

Global partners



Current International Planning

Using the International Space Station

Missions: 6-12 months

Return: Hours

~400 km/250 miles

Operating in the Lunar Vicinity

Missions: 1-12 months

Return: Days

~380,000 km/240,000 miles

Leaving the Earth-Moon System

Missions: 2-3 years

Return: Months

~220 million km/140 million miles

Advancing technologies, discovery and creating economic opportunities

Reaching the Mars Surface

One year stay

Limited return opportunities

Autonomy required

Utilize local resources

Mobility for Science

A step-wise journey from the safety of Earth's orbit, to the vicinity of the Moon and then into the Solar System

ESA Exploration Envelope Programme (E3P)

Programme approved at ESA's 2016 Council meeting at ministerial level

- **Delivering the 2014 European Exploration Strategy**
- **Aligned with resolution "Space 4.0 for a United Space in Europe"**
- **Open-ended programme, integrating existing and new ESA exploration activities**
- **Humans and robots**
- **LEO, Moon, and Mars**
- **Internationally coordinated (Global Exploration Roadmap)**

2. E3P PERIOD 1 STATUS

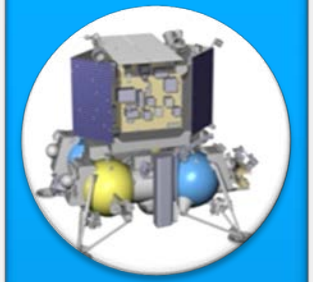
E3P First Period (2017-2019)

Europe aboard the ISS

World-class science in space

Propulsion & power for first 2 Orion missions

First Mars life-search rover



Taking Europe to lunar surface

Tomorrow's missions and tech

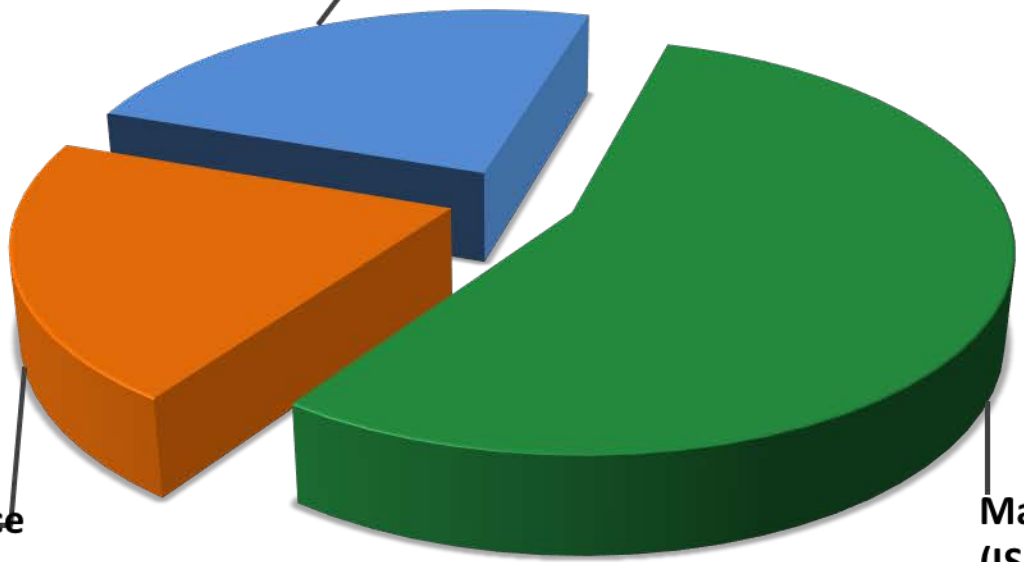
Increased synergy between robotic and human exploration

Since CM16, we have …

- ✓ Agreed a baseline funding allocation between E3P programme activities following CM16
- ✓ Confirmed continuation of ExoMars
- ✓ Approved two Commercial Partnership projects (ICE Cubes and Bartolomeo) and first exploration product PPP (IBDM)
- ✓ Announced a reduction in the ESA internal costs → increase of science and technology work
- ✓ Agreed a plan to modernise ISS operations to help maximise benefits out to 2024, and started a task force to accelerate experiment delivery

→ If the modernisation plan for ISS operations is secured, cost savings will be further re-invested in SciSpacE and ExPeRT

E3P Period 1 – Industrial Procurements



E3P Period 1 Total Industrial Procurements: 1197.7 M€

Commercial partnerships

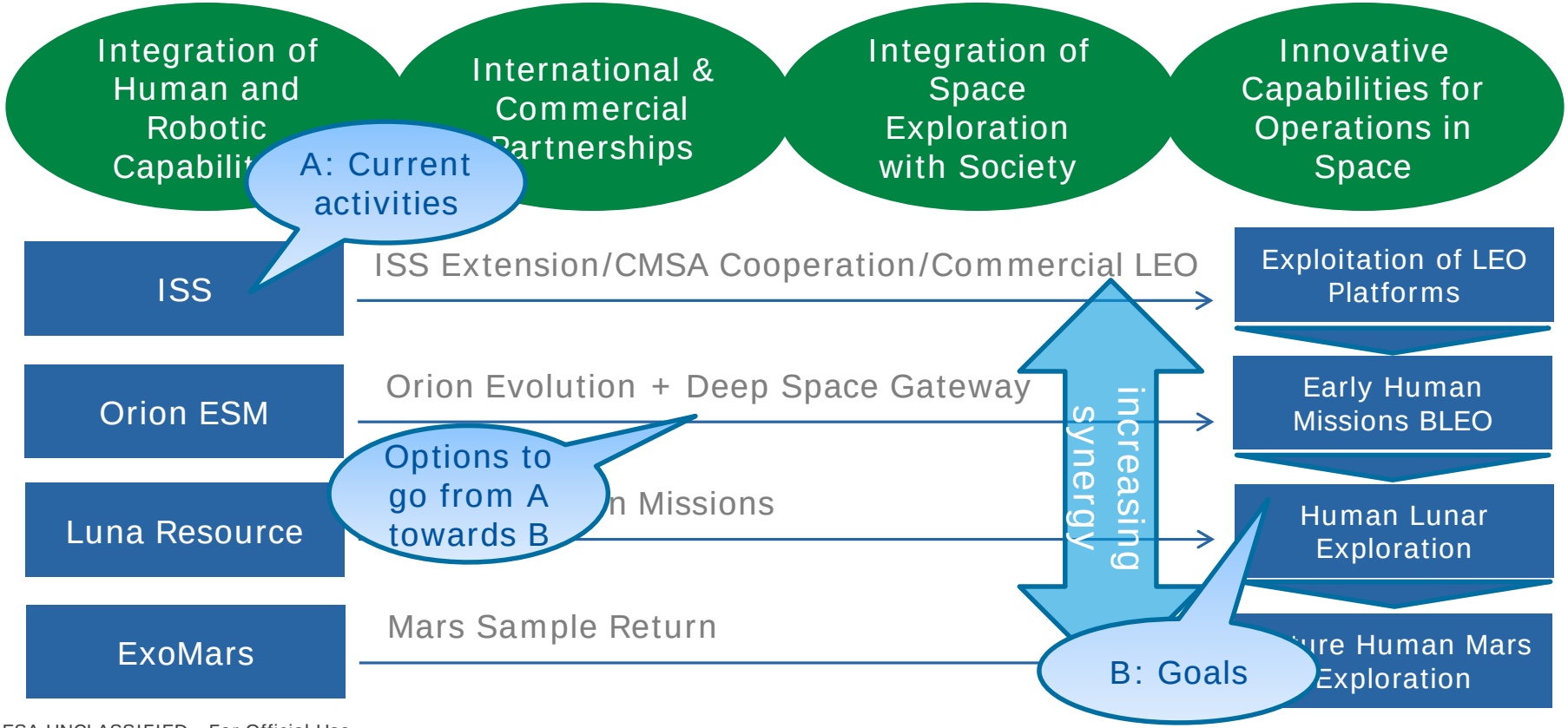
In spirit of Space 4.0, ESA is stimulating business partnerships in exploration:

- Small, quick payloads aboard ISS – ICECubes (SAS)
- PPP for exploration product – International Berthing and Docking Module (QinetiQ)
- External payload platform for ISS – Bartolomeo (Airbus)
- Transport to lunar orbit & telecoms relay (SSTL/Goonhilly)
- Transport to lunar surface (PTScientists)
- DreamChaser for Europe (OHB consortium)
- AO for Post-ISS LEO ideas
- Study of lunar ISRU technology demonstrator

3.
E3P FUTURE PROGRAMME - OVERVIEW

Roadmap Towards ISEF, Council 18 and CM19

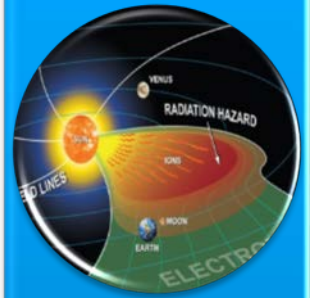
E3P Future Mission Roadmap (simplified version)



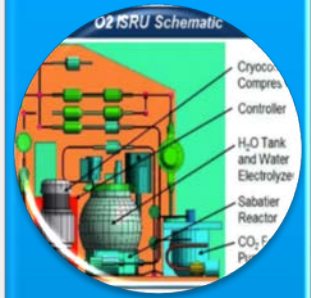
Technologies for Space Exploration

GNC, energy and robotics, AI in challenging applications

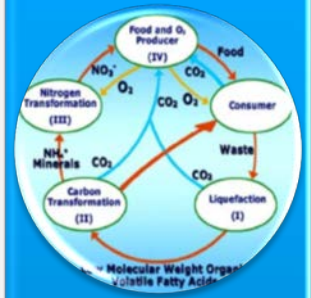
High power electric propulsion for flexibility & efficiency



Radiation protection far outside the Van Allen belts



In-situ resource utilisation to 'live off the land'



Closed-cycle life support to minimise logistics for distant missions

Radical ideas: e.g. artificial gravity and human stasis

technical challenges for exploration

Candidate E3P Elements up to 2030

CORNERSTONES

1. LEO **exploitation >2024** (ISS and transitioning to post-ISS commercial partnerships)
2. Early Human mission beyond LEO (**ESM + DSG**)
3. Sample return (Moon, Phobos, **Mars**)
4. Human lunar surface exploration, initiated with **robotic precursor mission**

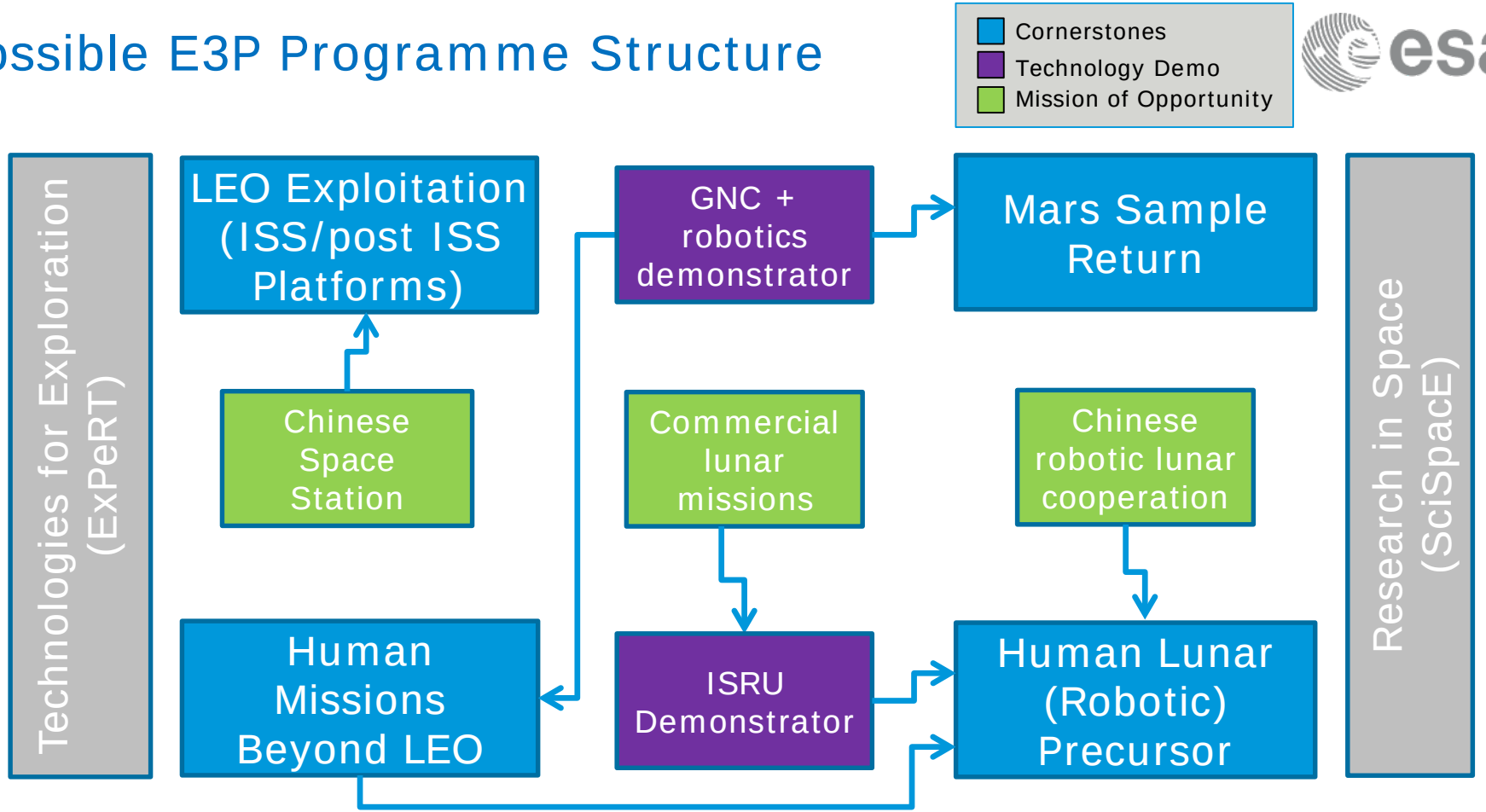
TECHNOLOGY DEMONSTRATORS

1. GNC/rendezvous/robotics demonstrator
2. ISRU demonstrator

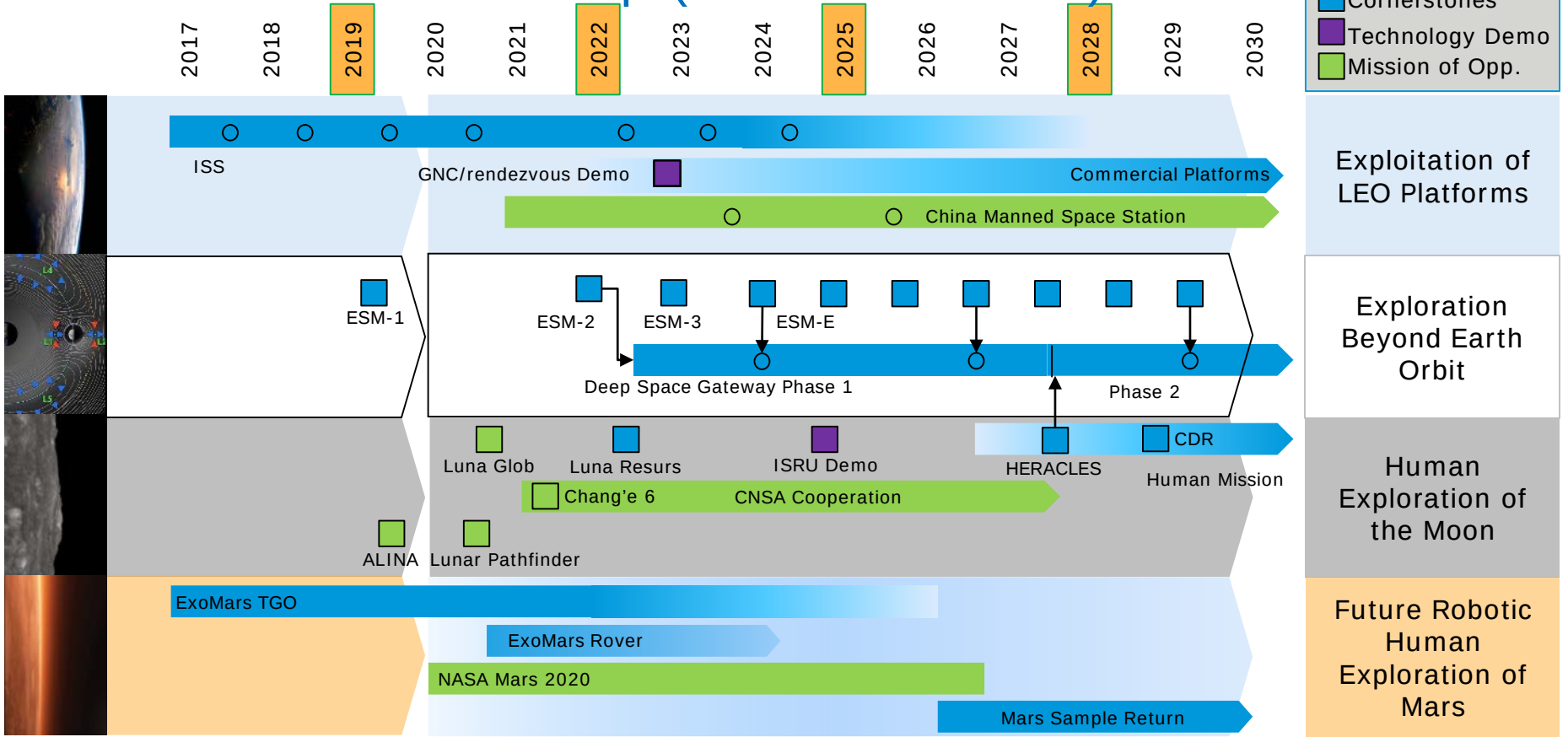
MISSIONS OF OPPORTUNITY

1. Cooperation with CMSA on Chinese Space Station (**CSS**)
2. Commercialised lunar missions (communication, logistic services)
3. Cooperation with CNSA on robotic lunar exploration

Possible E3P Programme Structure



Possible Mission Roadmap (detailed version)



Future Elements

3.1 CANDIDATE CORNERSTONES

ISS Beyond 2024 ?

Policy decision on future of LEO required at CM19

- ✓ No new ESA infrastructure for ISS foreseen
- ✓ US defining criteria for ISS retirement e.g. *status of BLEO exploration and maturity of transition to commercialised LEO*
- ✓ Further commercialise ESA ISS operations and utilisation ?
- ✓ Market stimulation activities ?

ISS is benchmark for assessing alternatives

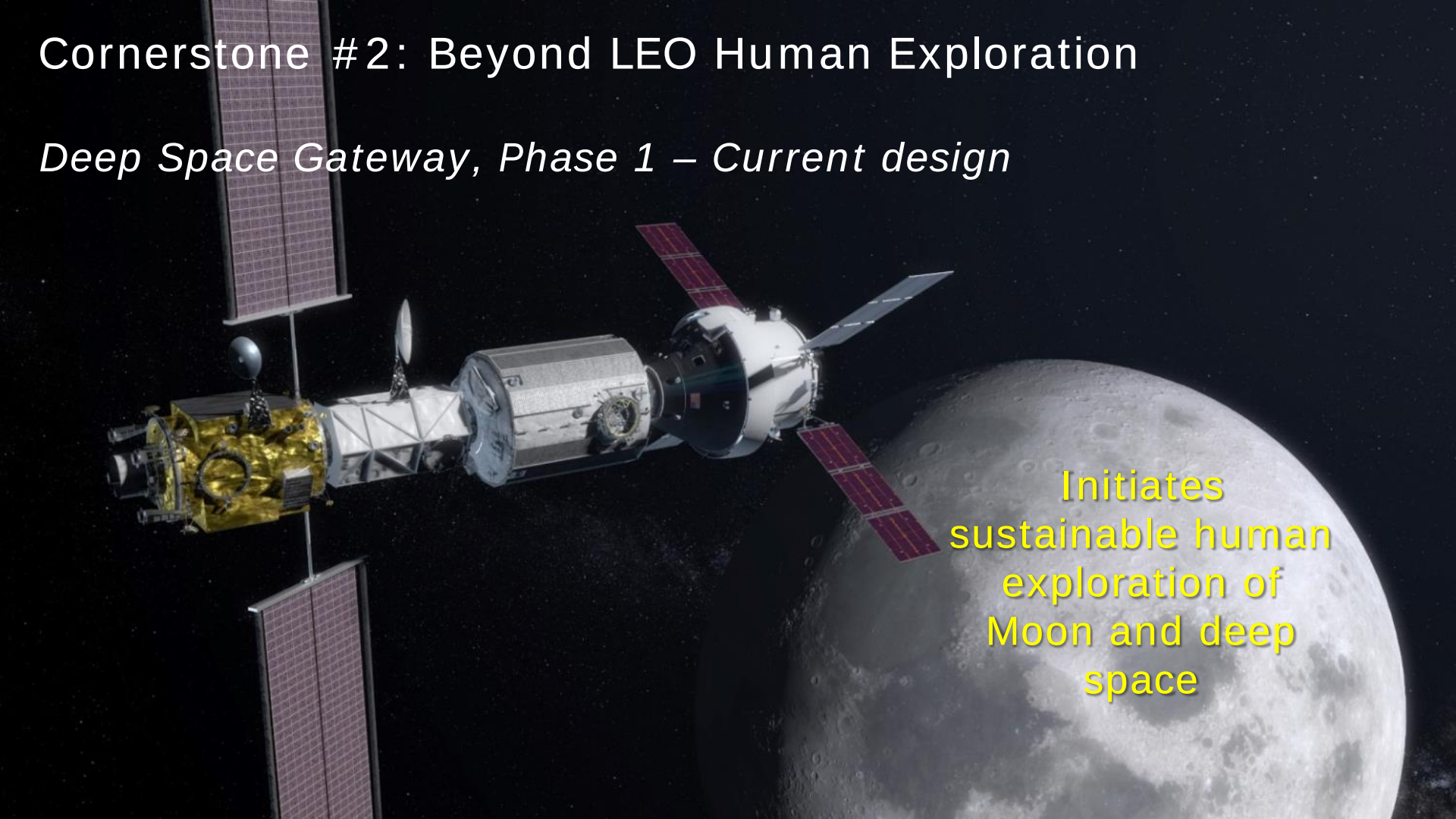
ISS benefits today

1. ~ 1 Astronaut mission per year
2. 300 hours of crew time per year for science
3. Regular access to a laboratory & resources for research community
4. 500-600 kg/year of up/down load for science/technology

ESA E3P Permanently Open Announcement of Opportunity for co-funded studies of post-ISS platforms

Cornerstone #2: Beyond LEO Human Exploration

Deep Space Gateway, Phase 1 – Current design



Initiates sustainable human exploration of Moon and deep space

Human Mission BLEO

Goal: Establish ESA as key partner of NASA in human transportation and operations beyond LEO

Implementation

- With ISS partners (NASA, JAXA, CSA, Roscosmos)
- Future phases may be open to new Partners
- Balance CSOC 2020-2024 barter plus investments
- Decision on roles at Council June 2018, financial commitments at CM19

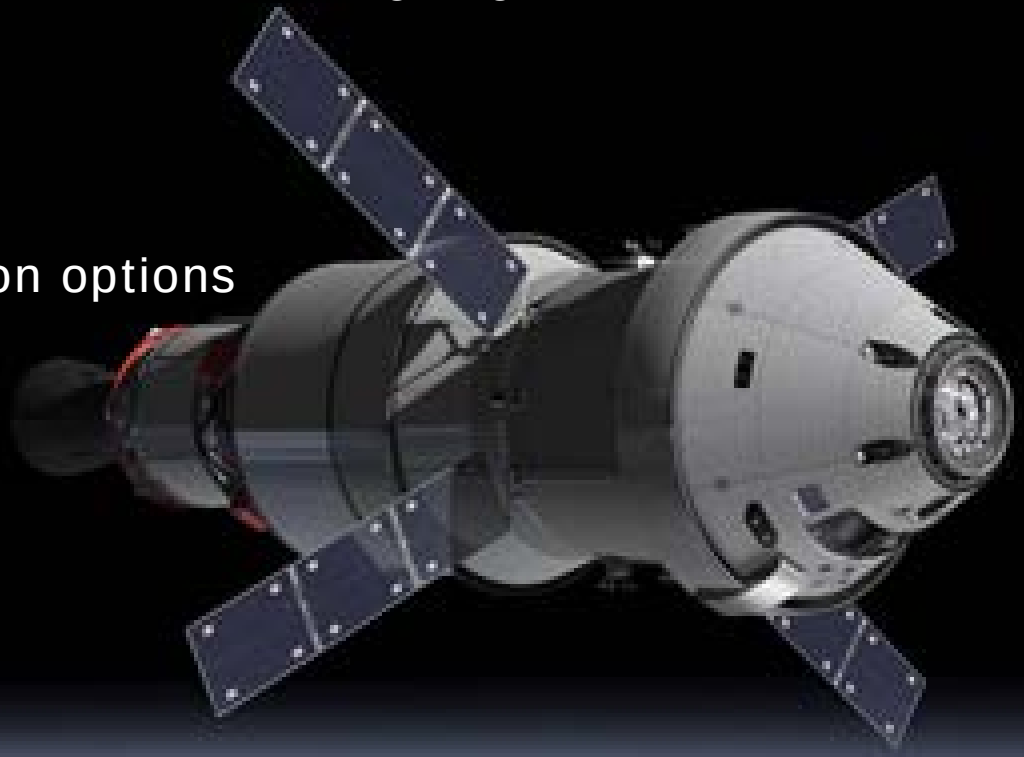
Outcomes

1. First European astronaut missions beyond LEO
2. Science and research in cis-lunar space
3. High power electric propulsion technology demonstration
4. Greater competence in human transportation & habitation technologies

European Service Module for Orion

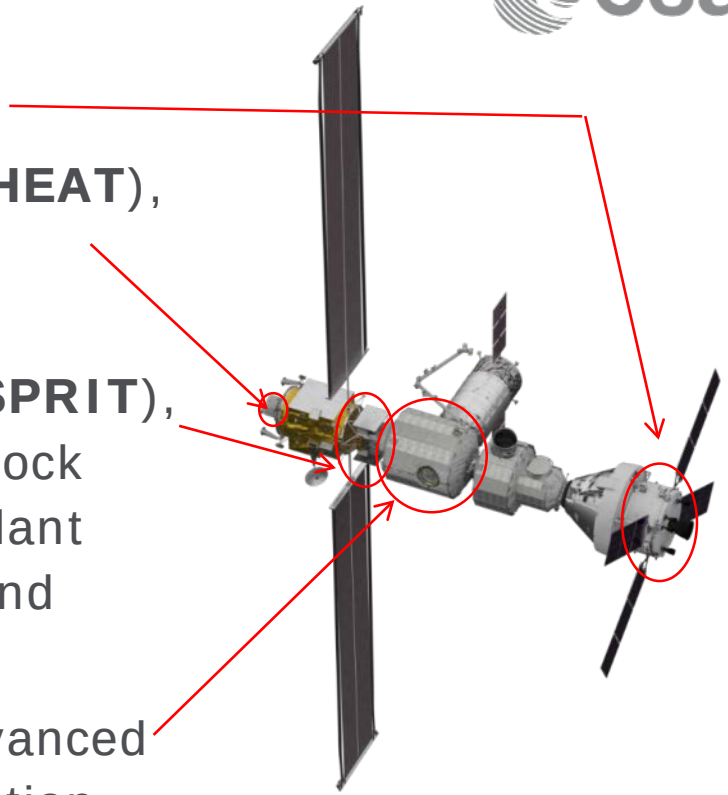
- Studies for upgrade of the ESM3 ongoing

- Various cost reduction options could be considered



Possible ESA contributions to DSG

- Orion **ESM Mk2**
- European Hall Effect Auxiliary Thruster (**E-HEAT**), a 20 kW Hall Effect thruster string
- European System Providing Refuelling, Infrastructure and Telecommunications (**ESPRIT**), with Avionics/Communication/Scientific Airlock Module, Docking system, tanks with propellant (Xe/Hydrazine) with refuelling capability; and external payload accommodation
- **Habitation Module** with CO_2 removal, advanced habitation architecture and radiation protection.

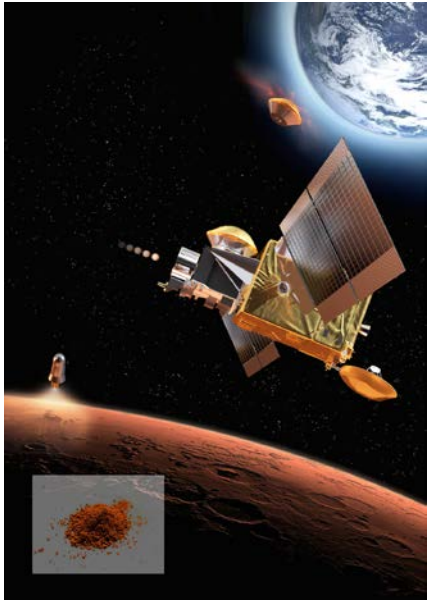


DSG - Joint HRE/SCI call for ideas closed 6 October

- 100 inputs from European science community
  - Astronomy – 12
  - Earth Sciences – 2
  - Life Sciences - 35
  - Physical Sciences – 11
  - Solar System Sciences - 25
  - Other – 15
- ESA's science advisory structure starting review
- **Workshop at ESA-ESTEC (5-6 December)**
- Integrate with NASA science definition in 2018

Candidate Cornerstone #3: Mars Sample Return Mission

Goal: By 2030, return samples from Mars for study on Earth



Implementation

- Leverage Exomars heritage and 10 years of MREP preparation
- International partnership could be agreed by June 2018
- Decision on implementation phase (B2/C/D) at CM19, if 2026 launch confirmed

Outcome

1. Return of Mars samples cached by Mars 2020 rover for scientific investigations providing benefits over decades
2. Demonstration of autonomous Mars orbit rendezvous & capture, biosealing and Earth Return Capsule
3. Capabilities for future robotic sample return missions and human missions

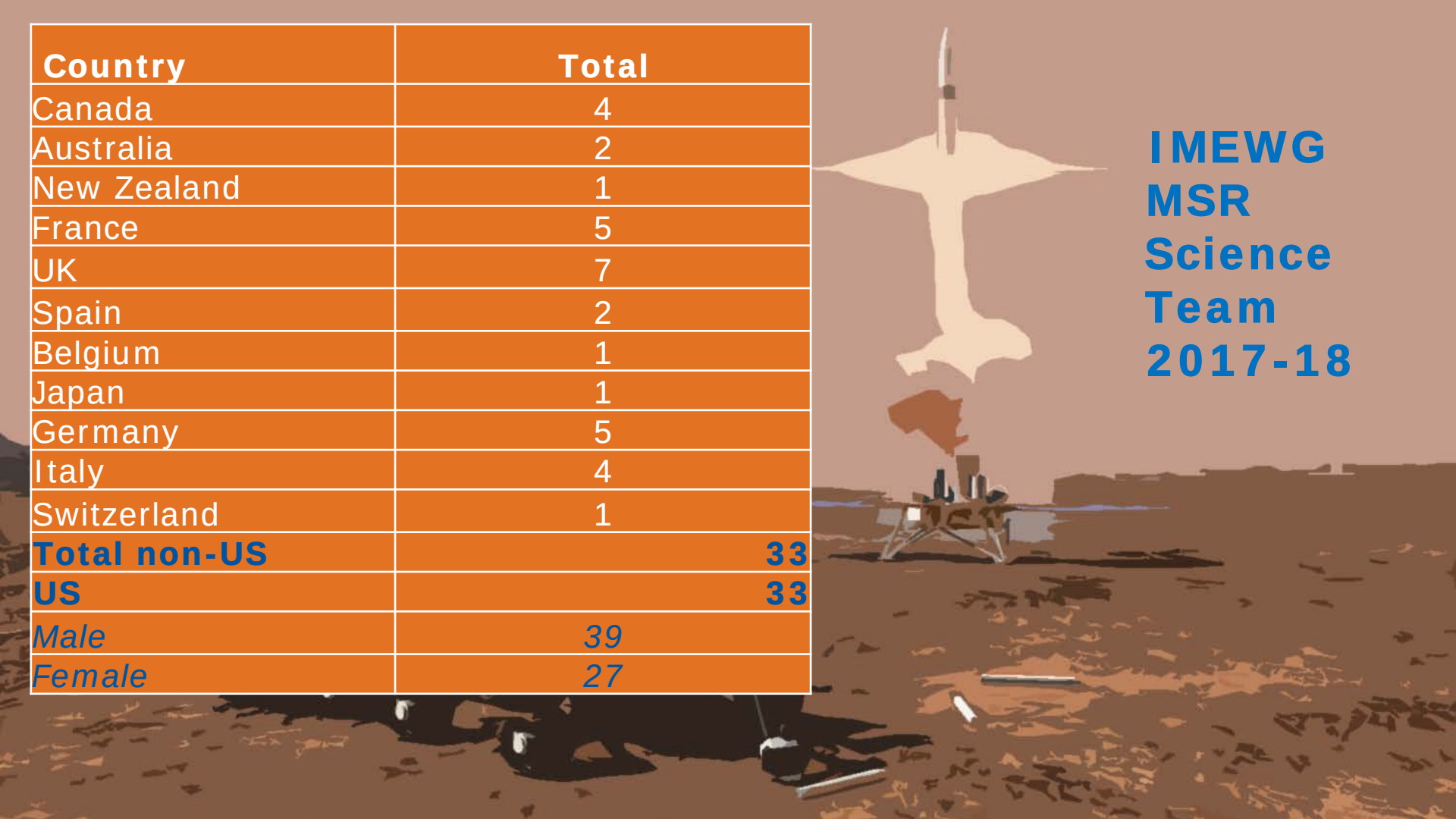
The First Round Trip to Mars ?

Mars Sample Return

MSR Science Definition

- MSR architecture now converging (NASA Mars2020 = caching mission)
- International science consultation mandated by IMEWG
  - ✓ What science is deliverable
  - ✓ science interests and dependencies
  - ✓ Workshop in early 2018
  - ✓ Reporting at Berlin MSR conference **24-27 April 2018**
  - ✓ Integrated into an international effort with NASA, others

Country	Total
Canada	4
Australia	2
New Zealand	1
France	5
UK	7
Spain	2
Belgium	1
Japan	1
Germany	5
Italy	4
Switzerland	1
Total non-US	**33**
US	**33**
Male	*39*
Female	*27*



IMEWG MSR Science Team 2017-18

Candidate Cornerstone #4: Precursor for Human Lunar Exploration

Goal: By 2030 demonstrate integrated human-robotic mission scenario in preparation of human lunar surface exploration

Implementation

- Current study partnership of CSA + JAXA + ESA
- Leverage on Orion, DSG and commercial services
- Decision on definition phase (ExPeRT Phase A/B1) at CM19

Outcome

1. Return of lunar samples from multiple diverse locations
2. Demonstration of long range surface mobility and tele-ops
3. Risk reduction for human missions
4. Establishment of logistic cargo lander
5. Partnership and roles for human mission scenario

Future Elements

3.2 CANDIDATE TECHNOLOGY DEMONSTRATORS

Candidate #1: Lunar ISRU Demonstration Mission

Goal: Produce drinkable water/ breathable oxygen by 2025 with an ESA industrial procurement budget below 250 M€

Implementation

- Procured as commercial services (CM19 decision) for payload delivery & lunar communications
- ESA aim to leverage private-sector developed services (Lunar Pathfinder, PTS Alina mission, others)
- Engagement of new industrial sectors for ISRU payload development through partnerships

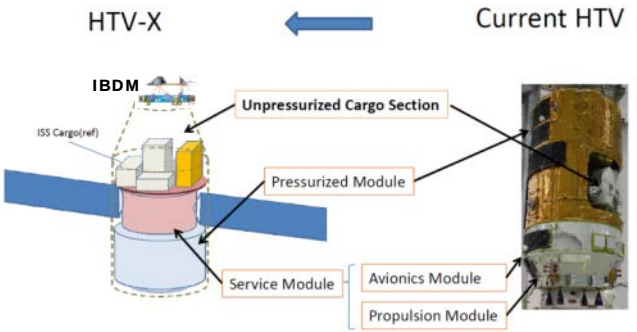
Mission Development

- ESA ITT for mission definition study in Sept 2017
- ESA ITT for terrestrial demonstrator study (demo plant breadboard & test campaign) in Jan 2018
- Mission concept review in mid 2018
- Mission feasibility & preparation phase from mid 2018

Candidate #2:GNC/Rendezvous/Robotics Demonstrator

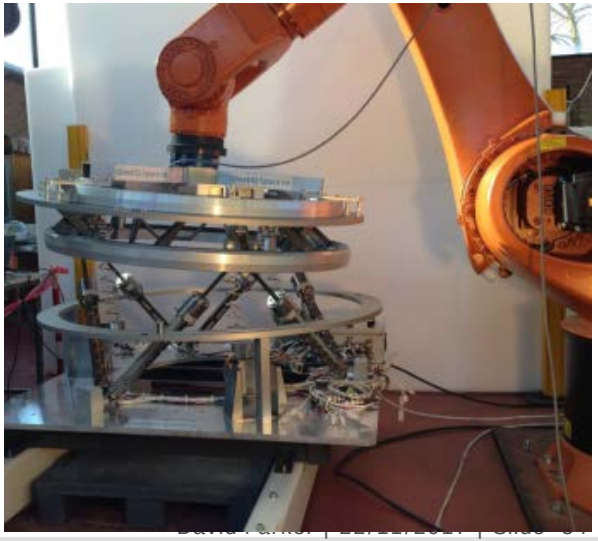
Goal: Demonstrate GNC/rendezvous/docking technologies for exploration, in-orbit assembly, servicing, debris removal etc.

Berthing demonstration for DSG



Implementation

- Leverage JAXA HTV-X demonstration mission to the ISS (with JAXA and CSA) or SpaceRider test flight
- First use of IBDM for docking and berthing
- Demonstrate advanced RDV sensors
- Build on ATV experience to prove capability for DSG, MSR etc.



Outcomes

1. Advancement of European skills in GNC, docking & sensors for both exploration and operational applications
2. Validation of new European exploration product (IBDM)
3. Risk reduction for commercial undertakings

Future Elements

3.3 CANDIDATE MISSIONS OF OPPORTUNITY

Candidate Opportunity #1: PPPs on Commercial Lunar Missions

Goal: Create first European BLEO exploration service businesses

Implementation

- ESA becomes a **user** of missions already under definition
- SSTL for transport to orbit and telecoms relay
- PT Scientists for surface transportation

Outcomes

1. A competitive European exploration services industry
2. Lunar Pathfinder orbiter implemented
3. Science/technology opportunities enabled using Alina
4. Services and capabilities support ESA technology missions such as ISRU demonstrator

Candidates #2 and #3: Cooperation with China (CMSA and CNSA)

Goal: Position ESA as a strategic partner of China and support integration of China in global exploration framework

Candidate #1: with CMSA on Chinese Manned Space Station

- Phased approach, phase 1 decision at CM19 with limited financial commitment

Candidate #2: with CNSA On Robotic Exploration

- Focused on science collaboration and exploitation of synergies with ESA missions

Outcome

- Additional opportunities for research in space and Astronaut missions
- Increased market for European human spaceflight products

Outcome

- Access to lunar samples
- Additional opportunities for European payloads to the Moon

Future Elements

4. AFFORDABILITY ASPECTS

Preliminary Conclusions

1. The 4 Cornerstone missions & **some** technology missions and missions of opportunity affordable with 600 M€/yr corridor:
2. A 650M€/yr corridor would be more robust
3. Near-term dialogue will focus on timely agreement on the overall plan & Cornerstones to be confirmed in 2018
4. The definition work on technology missions and missions of opportunity will determine feasibility & affordability by CM19


Low
Earth
Orbit
Moon
Mars
esa
Thank you
http://youbenefit.spaceflight.esa.int/
we explore. you benefit.
Human Spaceflight and Robotic Exploration