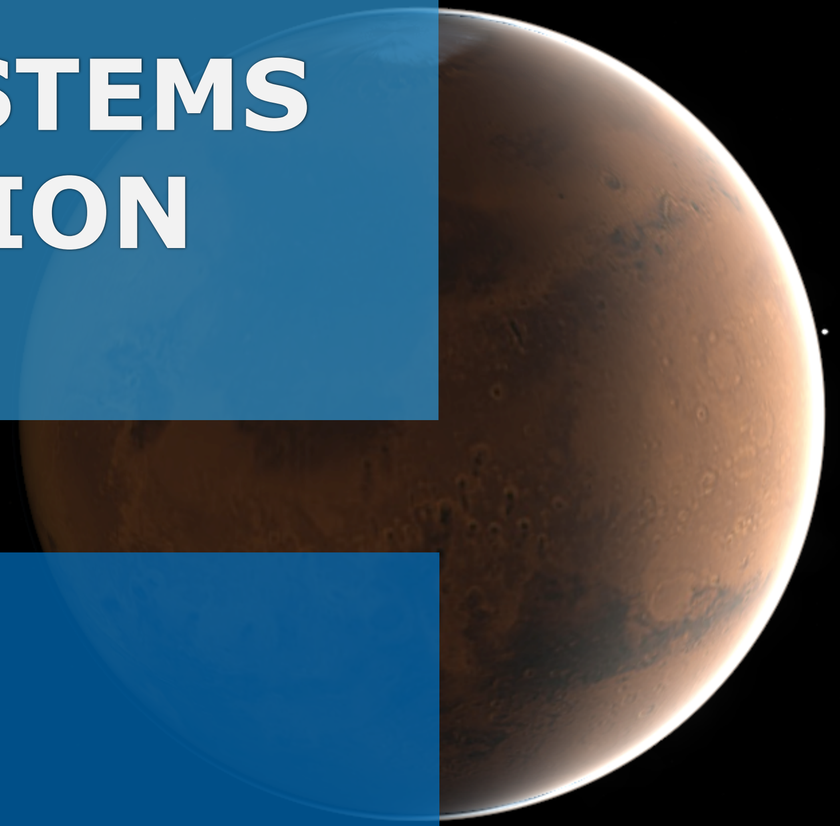
AVIONICS SYSTEMS for EXPLORATION MISSIONS



Guillermo Ortega (ESA)

10th ADCSS Avionics Workshop

AVIONICS SYSTEMS for EXPLORATION MISSIONS session objectives

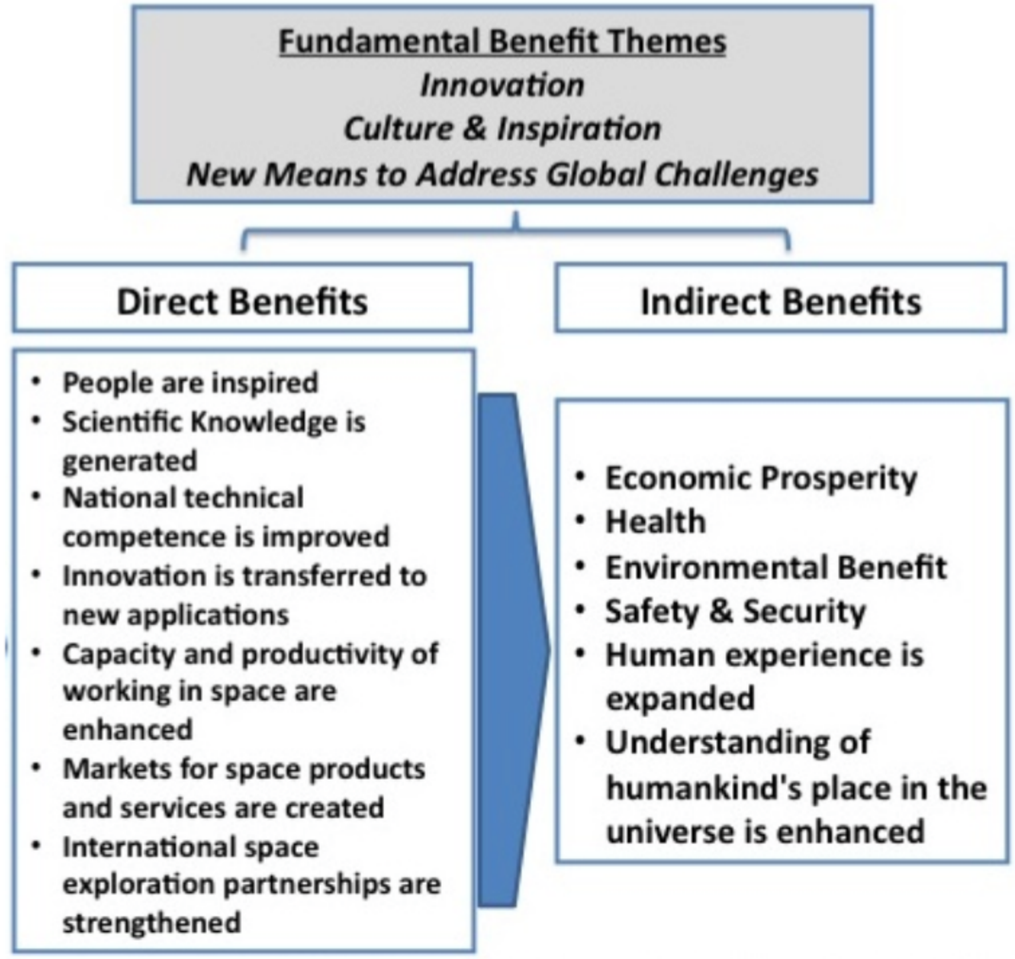
- To review the challenges and achievements from past successful exploration activities (missions, mission studies, research and development work, hardware developments, etc.) in the three areas of GNC, data handling and on-board software.
- To share the lessons learnt during the development, implementation and operational use of exploration missions and technologies in the area of avionics.
- To discuss the current avionics needs and requirements raised by the upcoming exploration missions and technology to interplanetary and small body destinations, and discuss shared priorities and possible roadmaps for future endeavours.
- To highlight problems and solutions in the areas of autonomy and FDIR of avionics systems for exploration missions

DLR, CNES, and ESA convenors

- Prof. Dr. Johann Bals
  - Deutsches Zentrum für Luft und Raumfahrt (DLR)
  - Institut für Systemdynamik und Regelungstechnik
- Dr. Michele Delpech
  - Centre National d'Etudes Spatiales (CNES)
  - GNC and Avionics Lead and Expert
- Dr. Guillermo Ortega
  - European Space Agency
  - Head of the GNC Section

The need for a Broad Agreement: Benefits Stemming from Space Exploration

- Space exploration satisfies the human need for knowledge
- Space exploration drives efficiently the development of science and technology with spin-offs
- Space exploration stimulates the creation of both tangible and intangible benefits for humanity
- Space exploration provides new opportunities for business development
- Space exploration has become a **global challenge**: cannot afford race or competition and need partnership



https://www.globalspaceexploration.org/c/document_library/get_file?uuid=0c15349f-e2b8-4bd0-bcd9-0b0acbf3efc3&groupId=10812

Space Exploration Development Areas

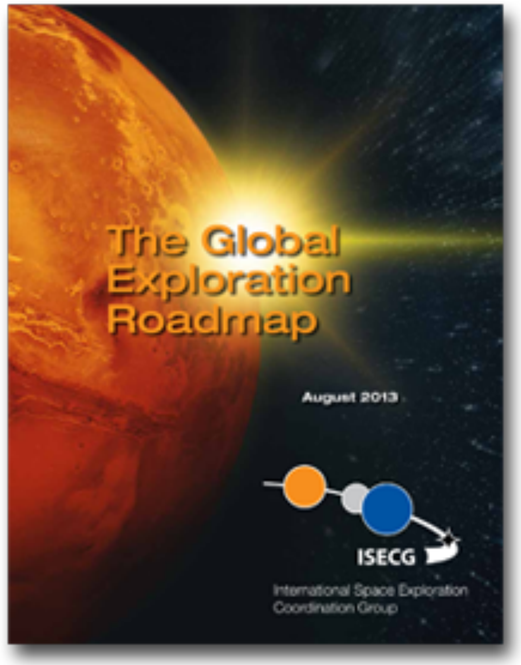
	Knowledge	Innovation	Business development
Discovery	Search for life	Public engagement	Need to know what is out there
Technology	New materials, new propulsion,	Robotics, computing	Spin-offs
Planetary defence	Neutralisation of planetary threats	High speed targets interception	Situation awareness
Medicine	Understanding diseases	New treatments	Patient markets
Tourism	Need of change	New experiences of trips, stay in space	Arranged trips
Mining	Composition of asteroids	Drilling, packing, storing	Extraction of metals

ISECG: International Space Exploration Coordination Group

http://www.globalspaceexploration.org/members

- Established in 2007, it was born in response to "The Global Exploration Strategy (GES): The Framework for Coordination," developed by fourteen space agencies
- It is a voluntary, non-binding international coordination mechanism through which individual agencies may exchange information regarding interests, objectives, and plans in space exploration with the goal of strengthening both individual exploration programs as well as the collective effort
- This GES Framework Document articulated a shared vision of coordinated human and robotic space exploration focused on Solar System destinations
- The following space agencies are ISECG members (in alphabetical order): **ASI** (Italy), **CNES** (France), **CNSA** (China), **CSA** (Canada), **CSIRO** (Australia), **DLR** (Germany), **ESA** (European Space Agency), **ISRO** (India), **JAXA** (Japan), **KARI** (Republic of Korea), **NASA** (United States of America), **NSAU** (Ukraine), **Roscosmos** (Russia), **UKSA** (United Kingdom)

The Global Exploration Roadmap



http://www.nasa.gov/sites/default/files/files/GER-2013_Small.pdf

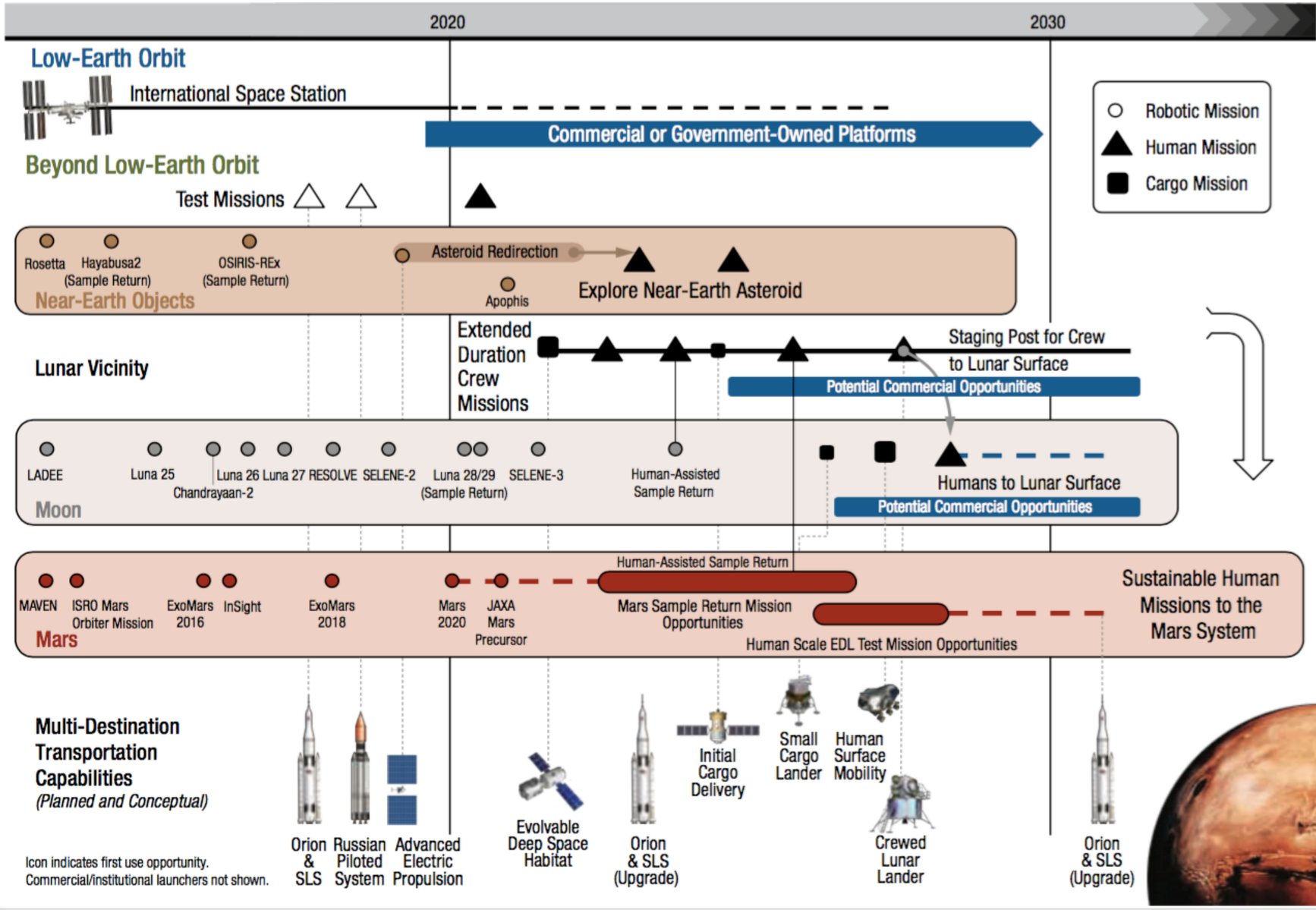
- The GES roadmap is being developed by space agencies participating in the International Space Exploration Coordination Group (ISECG)
- The roadmap builds on the vision for coordinated human and robotic exploration of our solar system that was established in May 2007 and updated in 2011 and in August 2013
- It reflects a coordinated international effort to prepare for collaborative space exploration missions beginning with the International Space Station (ISS) and continuing to the Moon, near-Earth asteroids, and Mars

GER objectives

- **Develop Exploration Technologies and Capabilities**: Develop the knowledge, capabilities, and infrastructure
- **Engage the Public in Exploration**: Provide opportunities for the public to engage interactively in space exploration
- **Enhance Earth Safety**: planetary defense and orbital debris management mechanisms
- **Extend Human Presence**: continually increasing the number of individuals beyond Earth orbit
- **Perform Science to Enable Human Exploration**: characterizing the effect of the space environment on human health and exploration systems
- **Perform Space, Earth, and Applied Science**: Engage in science investigations of, and from, solar system destinations and conduct applied research
- **Search for Life**: Determine if life is or was present outside of Earth and understand the environments that support or supported it
- **Stimulate Economic Expansion**: Support or encourage provision of technology, systems, hardware, and services from commercial entities and create new markets based

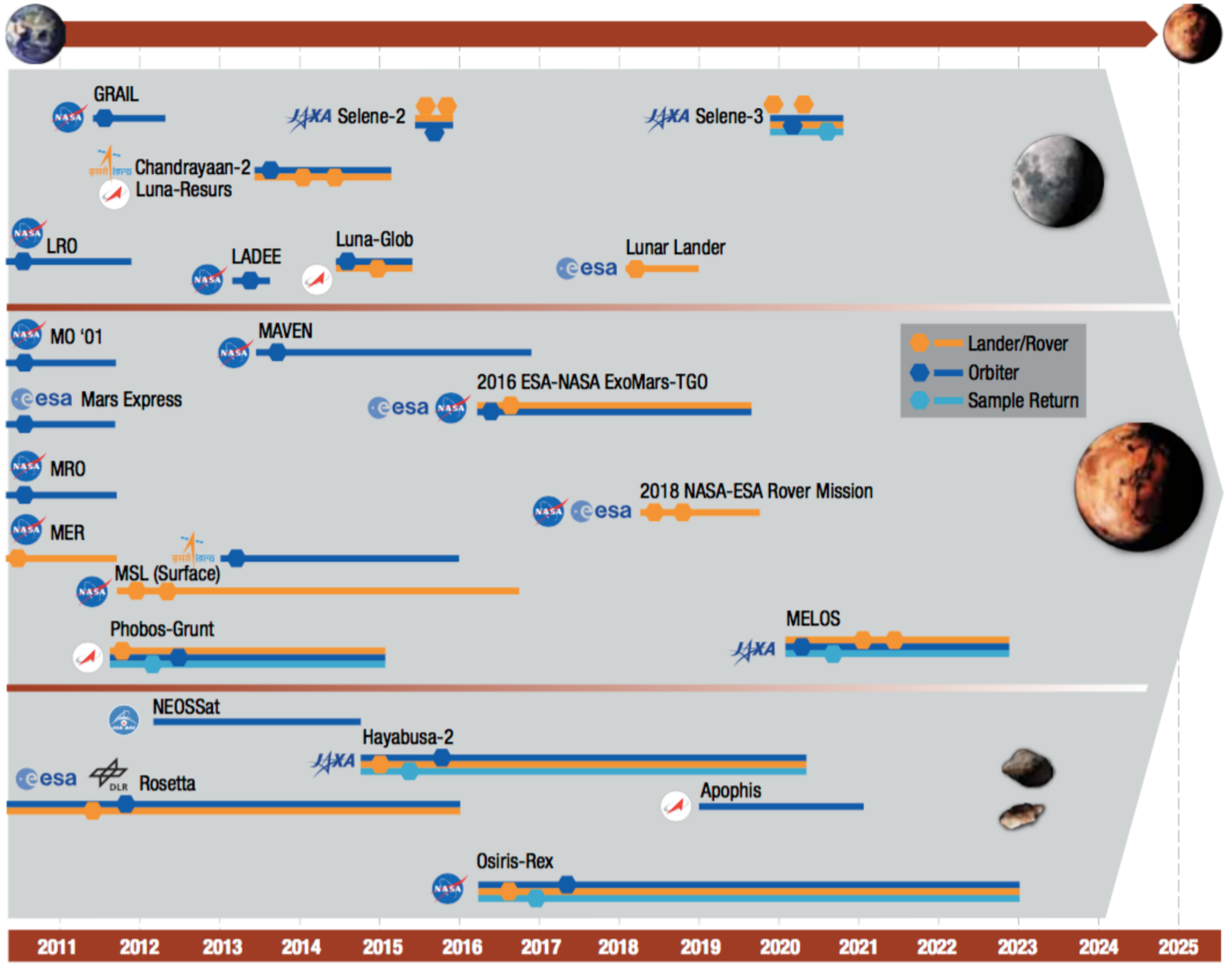
GER top level view

- Till 2020, there are missions to the Moon
- From 2020 till 2030 there are missions to Mars
- Combinations of robotics, cargo, and human missions
- All ISECG partners participate: "Exploring Together"
- Focus on "Delivering value to the public" paradigm



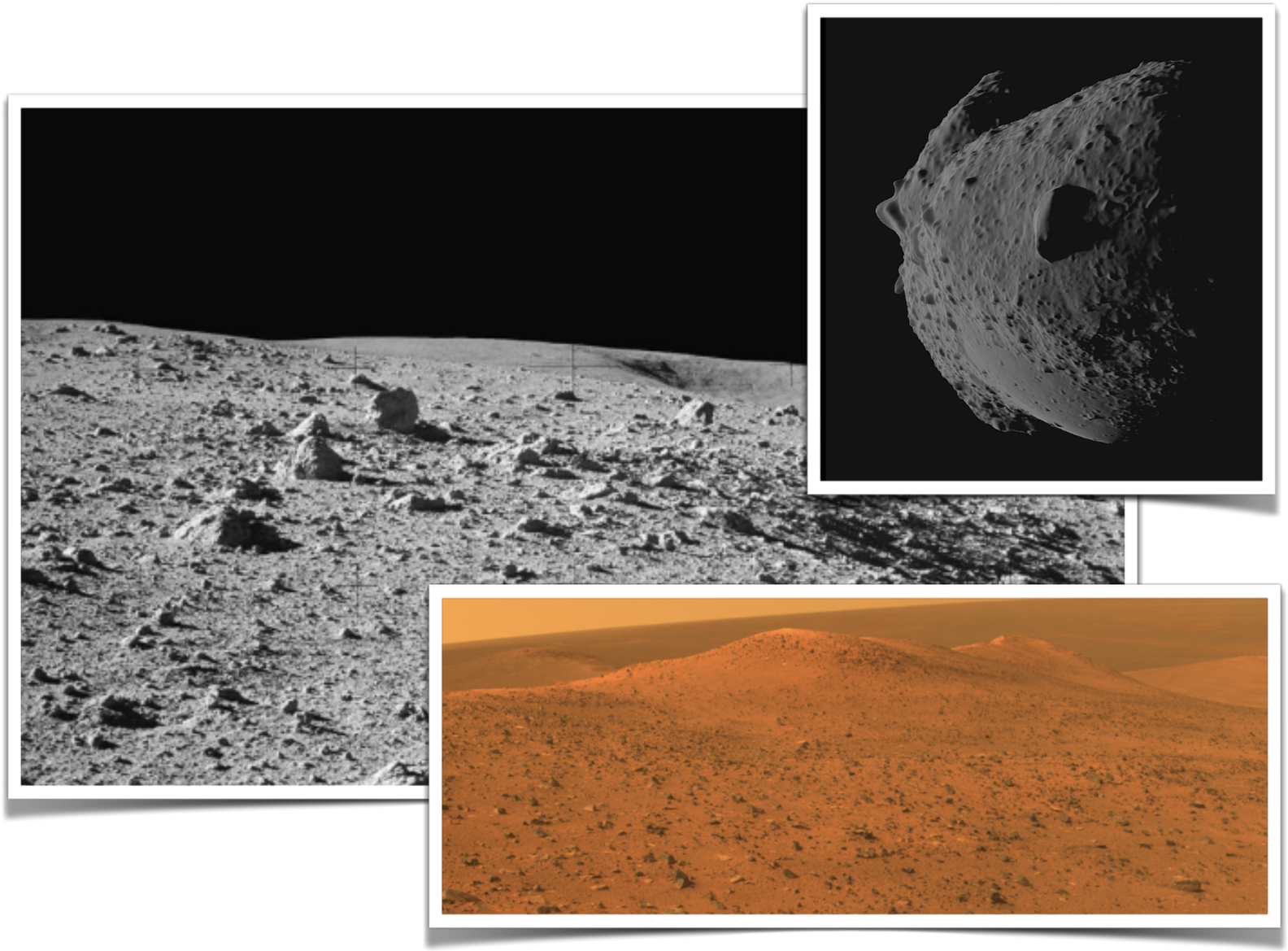
International Robotic Missions for Exploration

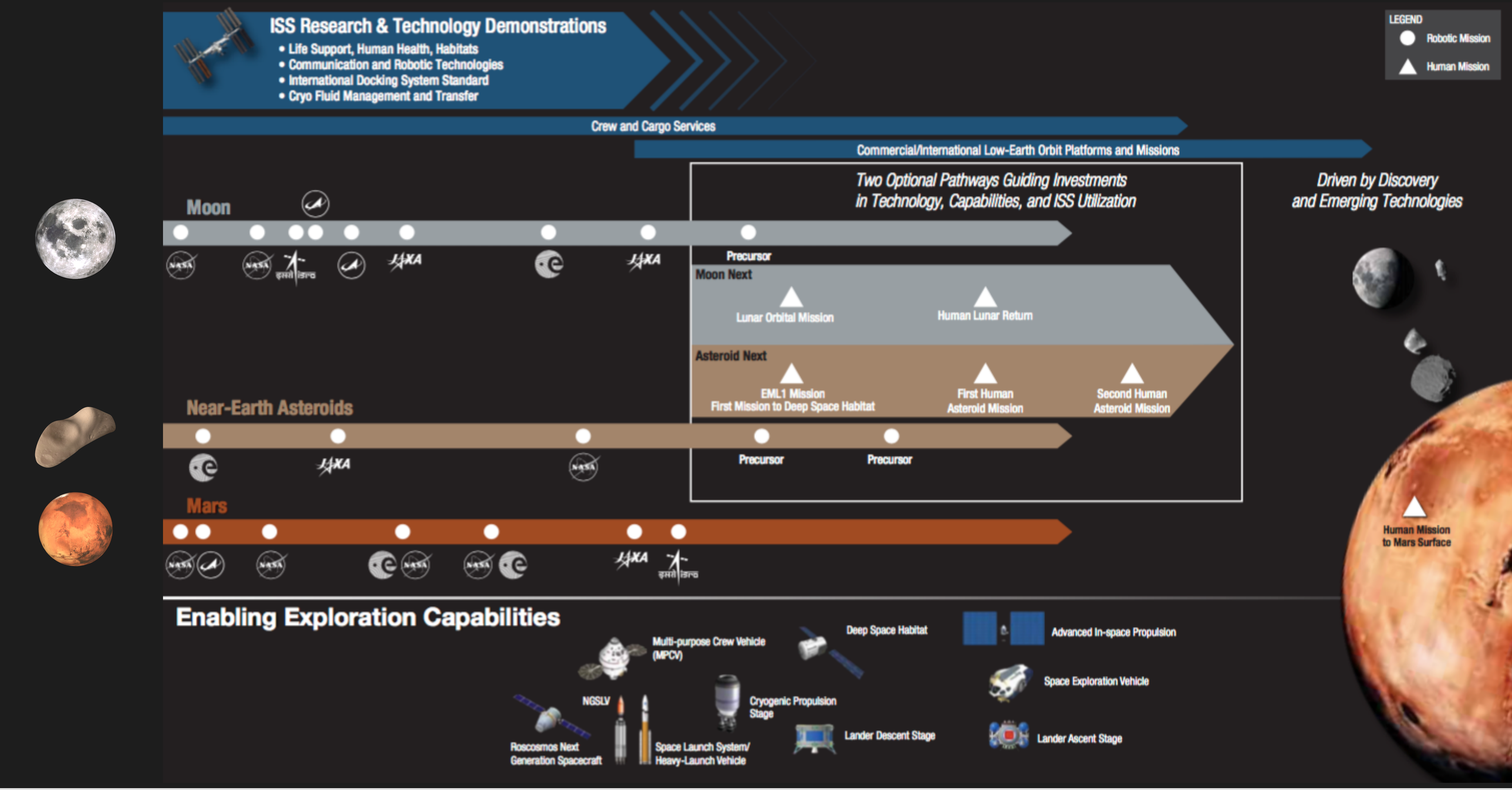
- Robotic missions have served as the precursors to human exploration missions
- They define the boundary conditions and environments necessary to prepare future human exploration of the planets and moons
- These robotics missions identify potential hazards and characterise areas of the planetary surface for subsequent human exploration and scientific investigation



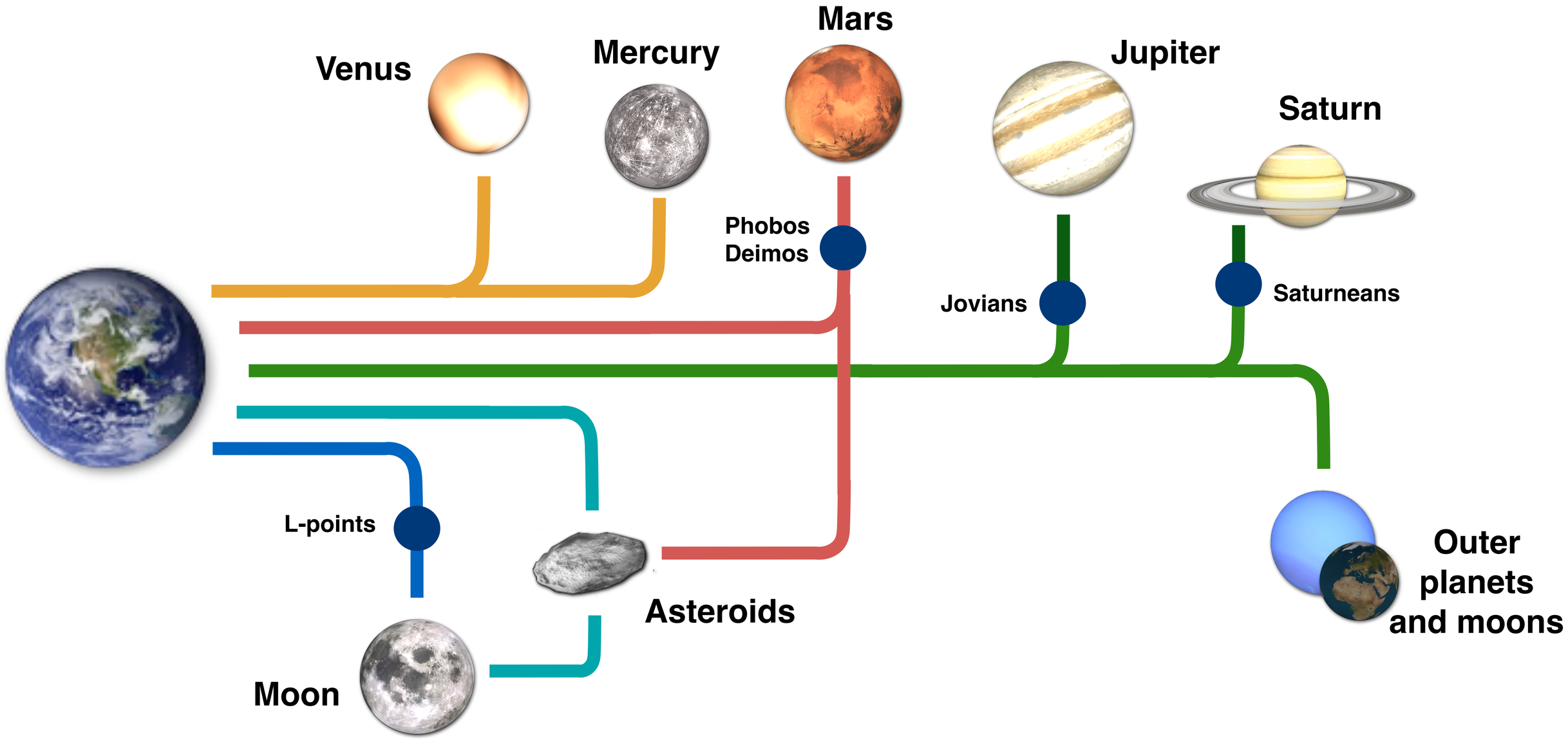
3 Main Destinations Jointly

- **Moon**:
  - Deep Space Habitat or Crew Transport Habitat (CTH)
  - In situ research in un-explored regions and Moon bases
  - Human lunar surface missions
- **Asteroids**:
  - Exploration of a Near-Earth Asteroid for Planetary Defence and Mining
- **Mars:**
  - Human presence
- …and **ISS** as the first stepping stone




ISS Research & Technology Demonstrations
• Life Support, Human Health, Habitats
• Communication and Robotic Technologies
• International Docking System Standard
• Cryo Fluid Management and Transfer
LEGEND
Robotic Mission
Human Mission
Crew and Cargo Services
Commercial/International Low-Earth Orbit Platforms and Missions
Two Optional Pathways Guiding Investments in Technology, Capabilities, and ISS Utilization
Driven by Discovery and Emerging Technologies
Moon
Precursor
Moon Next
Lunar Orbital Mission
Human Lunar Return
Asteroid Next
EML1 Mission
First Mission to Deep Space Habitat
First Human Asteroid Mission
Second Human Asteroid Mission
Near-Earth Asteroids
Precursor
Precursor
Mars
Human Mission to Mars Surface
Enabling Exploration Capabilities
Multi-purpose Crew Vehicle (MPCV)
Deep Space Habitat
Advanced In-space Propulsion
Space Exploration Vehicle
NGSLV
Cryogenic Propulsion Stage
Roscosmos Next Generation Spacecraft
Space Launch System/ Heavy-Launch Vehicle
Lander Descent Stage
Lander Ascent Stage

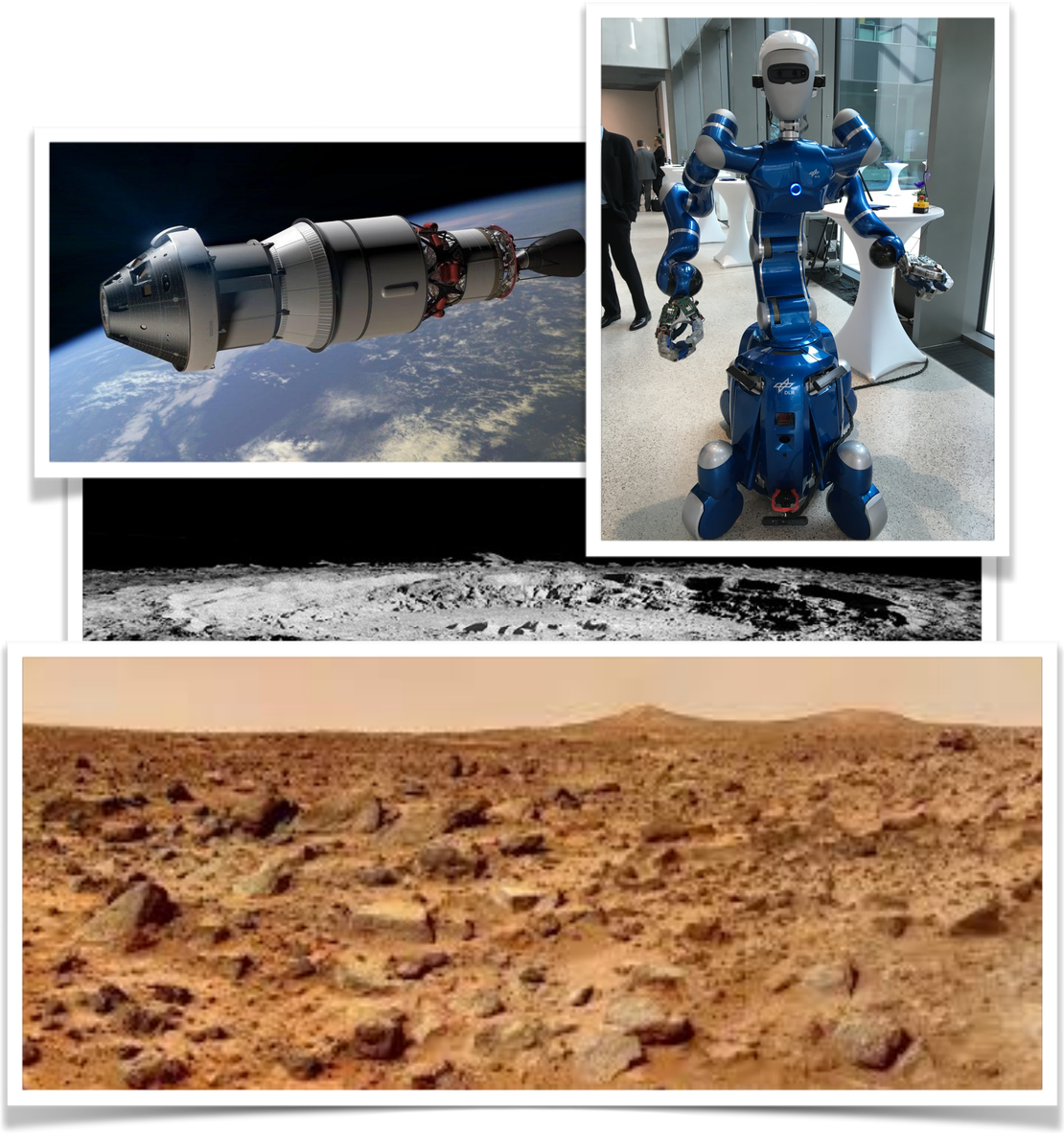
The Interplanetary Tube



Space Exploration Constraints

- **Affordability**: must be maintained over extended periods of time. Cost must be a consideration when formulating programmes and throughout programme execution. Innovations and integration of advanced technologies must be driven by the goal to reduce costs. Each agency's planned contributions must accommodate realistic expectations regarding cost and the future availability of funding
- **Partnerships**: broad international cooperation is not only critical for enabling increasingly complex exploration missions, but also an important contributor to achieving exploration value
- **Robustness**: flexibility to cope with unplanned changes or crisis situations, whether they are due to catastrophic events, changes in the partnership structure, adjustments in available funding or evolution of the exploration goals and objectives
- **Value**: commitment to goals and objectives and to deliver value to the public as well as to participating stakeholder communities, beginning early in the process and continuing throughout the journey

What about Avionics?



- Combinations of avionics systems for Spacecraft, Robots, Rovers, and Humans
  - spacecraft-robots
  - spacecraft-rovers
  - spacecraft-human
  - humans-robots
  - human-rovers
- Same avionics systems for different operating environments
  - Moon, Mars, asteroids, Earth
- …More information about avionics for exploration in the coming keynote speeches

Keynote speeches in this session

- **Avionics Systems for the Exploration of Asteroids and small moons**
  - Marco Mammarella (GMV)
- **Exploring the planets and avionics systems: challenges and opportunities**
  - Antonio Tramutola (Thales Alenia Space)
- **Avionics Systems Technology for New Exploration Scenarios**
  - ESA, DLR, CNES
- **Low cost avionics systems for fast track missions to the planets**
  - Tiago Hormigo (Spinworks)
- **Autonomy and FDIR of avionics systems for exploration**
  - Cristina Tato (SENER)