GLOBAL EXPLORATION ROADMAP

SUPPLEMENT AUGUST 2020

LUNAR SURFACE EXPLORATION SCENARIO UPDATE

INTERNATIONAL SPACE EXPLORATION COORDINATION GROUP
ISECG

ABOUT THIS SUPPLEMENT

The Global Exploration Roadmap (GER) is a non-binding product of the International Space Exploration Coordination Group (ISECG). The GER presents a shared international vision for human and robotic space exploration and is based on the coordinated programmes, initiatives and goals of the ISECG agencies. This coordinated vision from the ISECG agencies around the world recognises that the difficult and long-term challenges of spaceflight are best achieved through cooperative ventures.

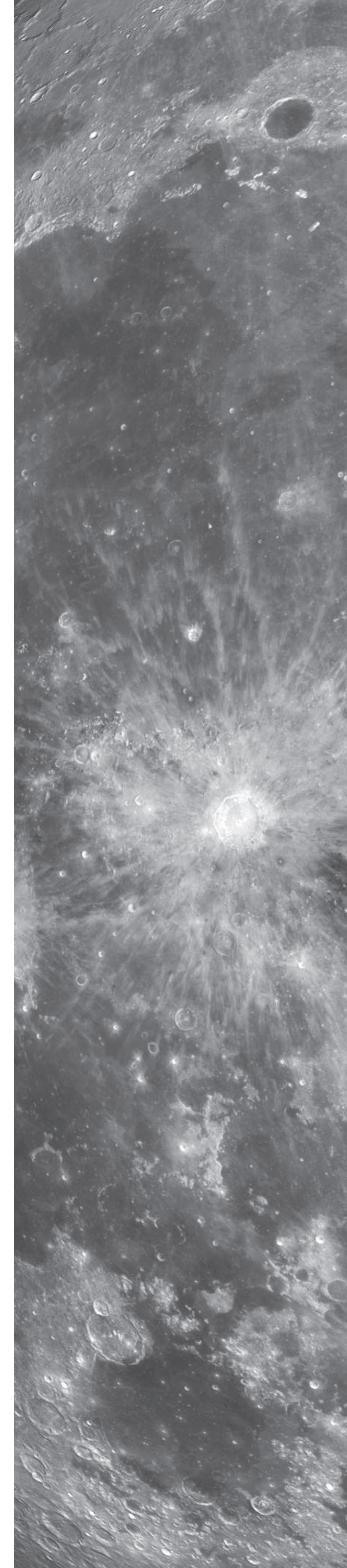
The GER reflects an exploration strategy that begins with the International Space Station (ISS) and extends to the Moon, asteroids, Mars and other destinations. This strategy builds on a shared set of exploration goals and objectives and reflects missions that will provide substantial benefits to the citizens of Earth.

Since the release of the GER in January 2018, many ISECG space agencies* have set new national priorities and intensified and accelerated lunar exploration plans. These ambitious exploration plans, coupled with new agency participants in the ISECG, created the opportunity to produce a Supplement to the 2018 GER that extends and refines the ISECG Lunar Surface Exploration Scenario. This scenario update supplements the 2018 GER by introducing the newly joined ISECG organisations (cf. Chapter 1) and updating agency lunar exploration plans (cf. Chapter 2). This GER Supplement also includes a newly formulated set of common objectives for a sustainable lunar surface exploration campaign (cf. Chapter 3) and the updated Lunar Surface Exploration Scenario (cf. Chapter 4) describes the architecture elements and the exploration campaign that progressively meet these lunar surface exploration objectives and serve as preparation for missions to Mars and for further activities on the Moon.

This GER Supplement will be used to support coordination efforts among space agencies by providing context for establishing solid partnerships and executing successful missions. Partnerships of all types—amongst government agencies, academia, public-private entities and within the private sector—provide the best ideas and solutions from around the globe. Space exploration is an inherently global endeavour.

In February 2020, the upgraded version of the mobile robot assistant CIMON-2—developed in Germany—successfully premiered with ESA-Astronaut Luca Parmitano on the ISS. Image Credit: ESA/DLR/NASA

"Space agencies" refers to government organisations responsible for space activities.



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EXECUTIVE SUMMARY

The 2018 Global Exploration Roadmap (GER) captures a shared vision from space agencies* participating in the International Space Exploration Coordination Group (ISECG) for international collaboration based upon a common set of exploration goals, objectives and identified benefits to humanity. Since then, many space agencies have renewed their focus on the Moon, both for its scientific opportunities and to demonstrate capabilities that will also prepare for human missions to Mars and for further activities on the Moon. This renewed focus has led ISECG agencies to update the Lunar Surface Exploration Scenario and capture the latest developments in lunar exploration planning from around the globe in this GER Supplement. The ISECG membership has also expanded with the addition of nine new organisations since the last GER release. This growth reflects the increasingly important role of spaceflight endeavours in providing economic and societal benefits to people on Earth while leveraging international cooperation to achieve scientific and exploration goals. In parallel, commercial space activities are achieving new capabilities for spaceflight leading to economic conditions suitable for business sustainability that have opened the spaceflight frontier to new entrants and new government strategies for science and human exploration of the solar system.

This GER Supplement describes the latest mission scenario and architecture for human and robotic lunar surface missions and preparatory activities for Mars. This Supplement integrates renewed and emerging national plans and commercial capabilities among ISECG participating countries. Leveraging the ISECG goals and sustainability principles (from the 2018 GER), a set of 12 lunar exploration objectives was formulated with rational and performance measure targets defined and then incorporated into one scenario with three phases:

- Phase 1: Boots on the Moon
- Phase 2: Expanding and Building
- Phase 3: Sustained Lunar Opportunities

ISECG SUSTAINABILITY PRINCIPLES

- ***Affordability*** Innovative approaches to enable more with available budgets.
- ***Partnerships*** Provide early and sustained opportunities for diverse partners.
- ***Human-robotic Partnerships*** Maximise synergies between human and robotic missions.
- ***Exploration Benefit*** Meet exploration objectives and generate public benefits.
- ***Capability Evolution and Interoperability*** The stepwise evolution of capabilities with standard interfaces.
- ***Robustness*** Provide resilience to technical and programmatic challenges.

"Space agencies" refers to government organisations responsible for space activities.

Additionally, this Supplement captures the increasing interest and associated mission planning in lunar in-situ resource utilisation (ISRU), communication systems, lunar transportation, surface power and dust mitigation technologies. These capabilities, combined with new commercial payload delivery services, will also benefit science and academic communities by providing more frequent and lower-cost missions to the Moon and, ultimately, Mars.

Evolved lunar surface exploration and ultilisation scenarios reflect plans for a near-term series of robotic missions followed by humans returning to the Moon in this decade. Rather than looking at individual missions, the scenario depicts a stepwise development of an increasingly capable lunar transportation system to the lunar surface, traversing systems on the lunar surface, and infrastructure supporting them that will enable cooperative science and human exploration efforts leading toward a sustained presence on the lunar poles and incorporating lunar surface activities as analogues in preparation for human missions to Mars. These efforts emphasise landed downmass to eventually support four crewmembers per mission and mobility systems that dramatically enhance science return and exploration distances around a lunar pole base camp.

Sustained exploration and presence on the lunar surface are not the only goals for future exploration; rather they are part of a collection of incremental advancements, each adding to our combined knowledge of the Moon and preparing for continued exploration across the solar system, starting with Mars. These activities are also a driver for innovation and economic growth. Advancements in technologies touching every aspect of everyday life—health and medicine, public safety, consumer goods, industrial productivity, transportation and many others are a direct result of space exploration. In the last several years, job creation and economic growth have been accelerated by private investments in the space sector.

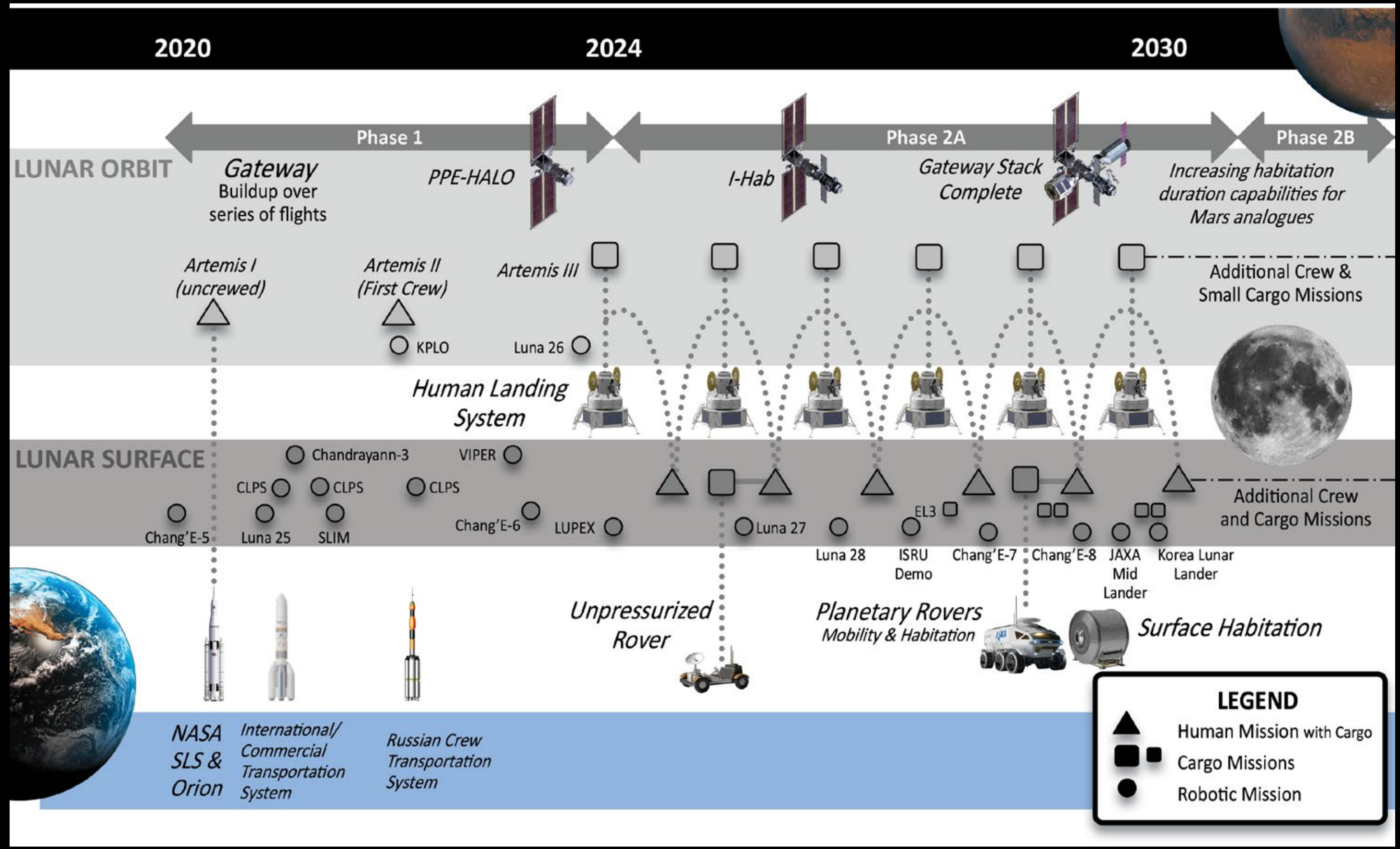
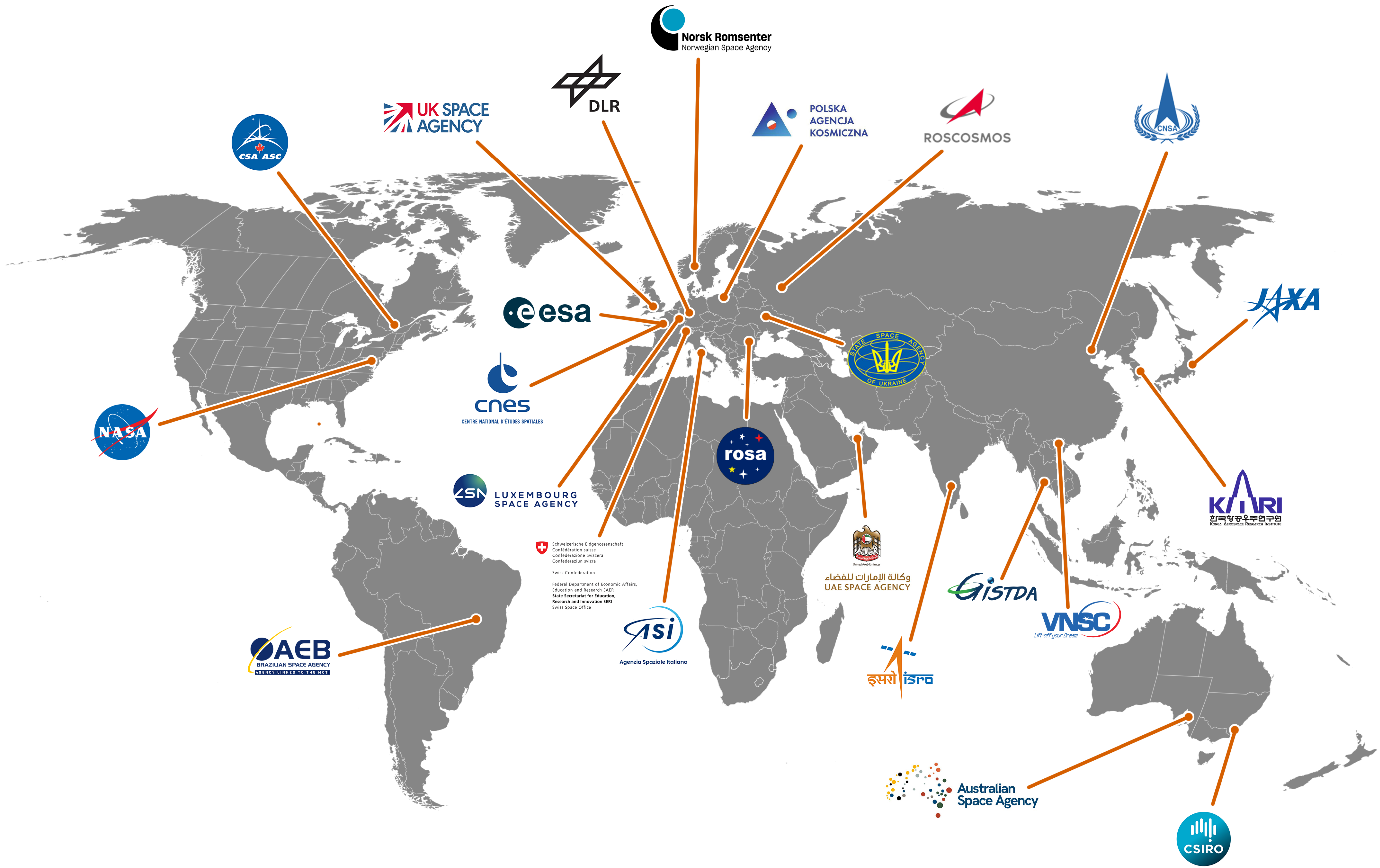


Figure 1. Updated ISECG Lunar Surface Exploration Scenario.

ISECG AGENCIES WORLD MAP



CHAPTER ONE

GROWING GLOBAL MOMENTUM

The steadily increasing number of ISECG agencies underscores the growing global interest and momentum for going forward to the Moon and Mars. Since the 2018 GER release, the number of ISECG agencies has increased from 15 to 24. Below is a summary of the of the new organisations along with the date they joined:

BRAZILIAN SPACE AGENCY (AUG 2020)

The Brazilian Space Agency (Agência Espacial Brasileira—AEB), a government agency established in February 1994 with the purpose of promoting the development of space activities of national interest, is responsible for the formulation, coordination, and implementation of the National Policy for the Development of Space Activities. AEB seeks to ensure that the downstream market for space-based products and services meets the needs of Brazilian society. Additionally, AEB´s efforts are targeted at consolidating the Brazilian space industry, increasing its competitiveness and capacity for innovation. The Agency views space cooperation as a critical tool to leverage resources and reduce risks, favoring the joint development of technological and industrial projects that generate valuable outcomes to both Brazil and its international partners.

Advances in space science and the use of space applications in everyday life inspire positive developments in the formulation of improved public policies and in the design of business-oriented space diplomacy that delivers sustained prosperity to all. As the key body of the Brazilian space ecosystem, AEB understands that becoming a full ISECG member will grant the agency the opportunity to learn from top performers, build on a widespread culture of collaboration and innovation and take a more active part in the international space agenda. Further information about AEB can be found at **https://www.aeb.gov.br**.

AUSTRALIAN SPACE AGENCY (FEB 2019)

On 1 July 2018, the Australian Government established the Australian Space Agency (ASA) with the intent of transforming and growing a globally respected space industry. Australia's long history of supporting space exploration dates back to the 1960's, with the efforts of the existing ISECG member Commonwealth Scientific and Industrial Research Organisation (CSIRO), and is now increasing its ability to participate in global efforts for the peaceful use of space. Australia has strong capabilities in robotics and remote operations, artificial intelligence, space domain awareness, advanced communications, health, and remote medicine. Australia is increasing its capacity and facilities in areas including:

- Mission and robotics command and control centres
- Ground station networks
- Space manufacturing and space data analytics
- Introducing industry programmes to collaborate internationally and support global plans to reach the Moon and continue on to Mars

ASA looks forward to sharing ideas and contributing to the international efforts to solve the challenges related to achieving ISECG goals. For more information about the Australian Civil Space Strategy, visit **https://www.industry.gov.au/strategies-for-the-future/australian-space-agency**.

GEO-INFORMATICS AND SPACE TECHNOLOGY DEVELOPMENT AGENCY (APR 2020)

The Geo-Informatics and Space Technology Development Agency was founded in 2000. GISTDA's primary objective has been the development of geo-informatics and space technology and these core functions are divided into two segments: ground and space. Since its inception nearly 20 years ago, GISTDA has focused on developing Earth observation satellite technology and applications and building the professional capacity of Thailand and Southeast Asia by investing in human capital and training. Another critical element of GISTDA's mission is building and leveraging its domestic space industry.

Recently, Thailand has broadened its focus to include space exploration. Under the umbrella of Earth Space System, they announced the Ministry of Higher Education, Science, Research and Innovation initiative, which aims to increase space exploration research and development within Thailand. GISTDA is Thailand's main space agency and has officially launched its Space Exploration Program which has the following focus areas:

- Scientific research in low-Earth orbit, the Moon and beyond
- Increasing space technology capacities of exploration, scientific payload and instrument, robotic rover, spaceflight and spaceport
- Building awareness in the space exploration sector
- Supports Thailand to New Space Economy

GISTDA joined ISECG to help Thailand become a contributing member of the global space exploration community and to assist in expanding the global space economy. For more information about GISTDA, visit **https://www.gistda.or.th**.

LUXEMBOURG SPACE AGENCY (SEP 2019)

The Luxembourg Space Agency was founded in 2018. LSA's primary focus is to develop the space sector in Luxembourg by creating new and supporting existing companies, developing human resources, facilitating access to funding and supporting academic research. The agency executes the National Space Economic Development Strategy, manages national space research and development programmes and leads the *SpaceResources.lu* initiative. LSA also represents Luxembourg within the European Space Agency (ESA), which the country has been a member of since 2005, and participates in space-related programmes of the European Union (EU) and the United Nations (UN).

The Luxembourg Space Agency is excited to partner with ISECG and is dedicated to aiding efforts to advance global coordination in space exploration. In the coming years, the exploration and utilisation of space resources are set to generate attractive opportunities. LSA is committed to supporting and nurturing the growing commercial space industry and contributing to the peaceful exploration and sustainable utilisation of resources from celestial bodies, including the Moon and near-Earth objects such as asteroids. For more information about LSA, visit **https://www.space-agency.lu**.

NORWEGIAN SPACE AGENCY (JAN 2020)

The Norwegian Space Agency is a government agency under the Ministry of Trade, Industry and Fisheries. The Agency was established in 1987, when Norway became a member of ESA. NOSA is responsible for organizing Norwegian space activities, particularly with respect to ESA and the EU, and for coordinating national space activities. Space activities have a large strategic value for Norway, with its vast ocean areas and as one of the world's northernmost areas.

Norwegians have always been pioneers when it comes to exploring the unknown and have a long tradition for operating in harsh and remote environments. With increased international focus on space exploration comes new challenges, leading to increased scientific and technological knowledge. NOSA sees this as a great opportunity for innovation that could be useful both in space and on Earth, widening the scope for Norwegian activities.

NOSA views their membership in ISECG as an opportunity to expand their perspective and work with international entities towards mutual goals for exploration. For more information about NOSA, visit **https://www.romsenter.no/**.

POLISH SPACE AGENCY (NOV 2018)

The Polish Space Agency (POLSA) was founded in 2014 and joined the ISECG in 2018. POLSA is deeply committed to the ISECG's principles and primary objective of shared cooperative international space exploration. Poland has a rich history of space discovery and exploration that has benefitted humankind for centuries. POLSA's priorities include:

- National space sector enhancement
- Robotic, sensor and lander mission
- Advancing the use of space technology for everyday life
- Space professional development

For more information about POLSA, visit **https://polsa.gov.pl/**.

ROMANIAN SPACE AGENCY (MAR 2019)

Created in 1995, the Romanian Space Agency (ROSA) was born out of the Romanian Commission for Space Activities (CRAS), which was established in 1968. ROSA is a self-funded public institution and is coordinated by the Ministry of Education and Research—National Authority for Scientific Research and Innovation. ROSA acts as the financing agency for the national research programmes on Space, Aeronautics and Security; chairs the inter-agency Security Research working group; serves as the national coordinator for the Space Situational Awareness (SSA) Programme; and is the Competent Authority for the Galileo Public Regulated Service (PRS). ROSA is also the Romania representative in all international space organisations and coordinates all of the nation's space-related activities. Joining the ISECG provides ROSA a new framework and broader opportunities for cooperating and collaborating with space agencies worldwide. For more information about ROSA, visit **http://www2.rosa.ro/index.php/en/**.

SWISS SPACE OFFICE (MAR 2019)

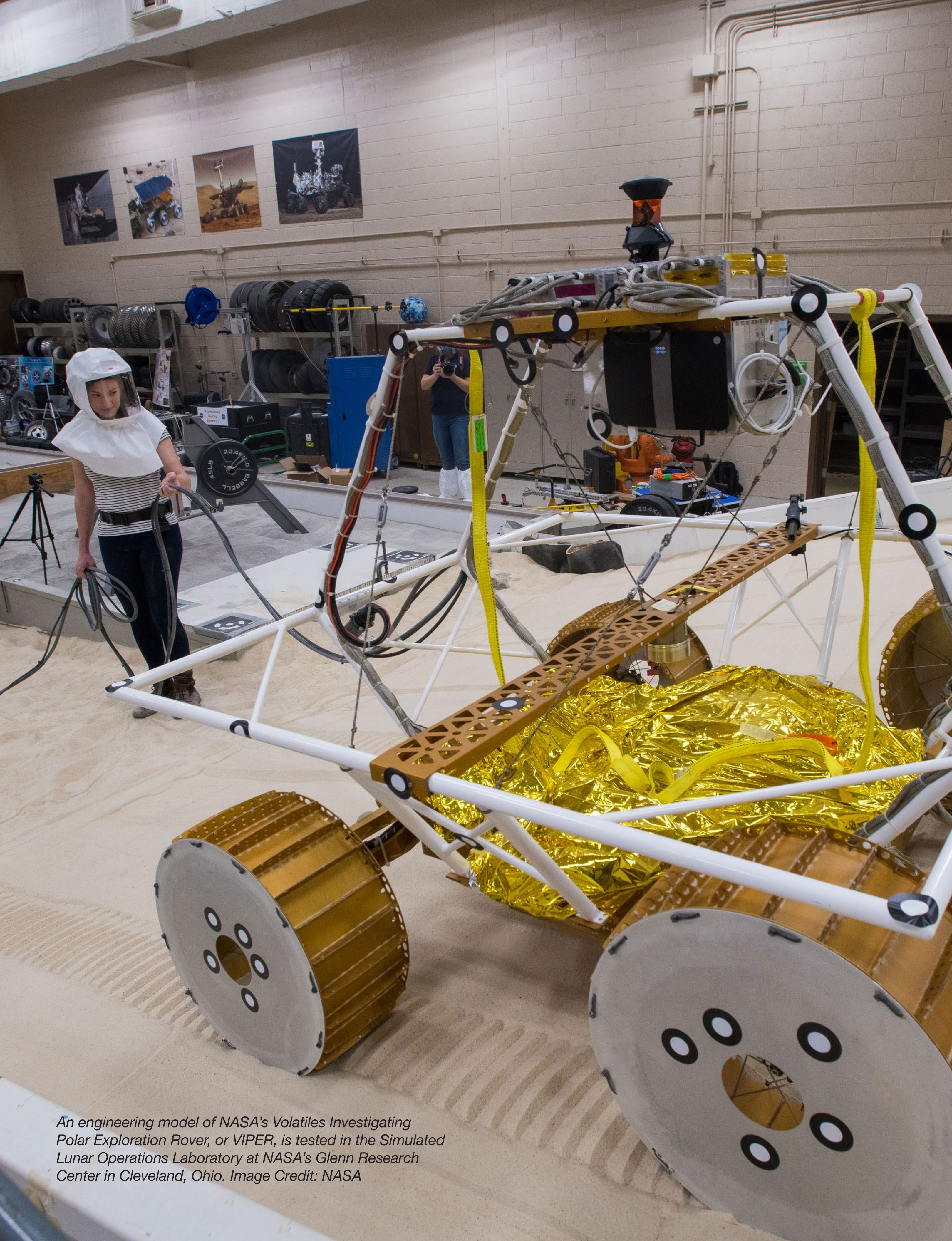
The Swiss Space Office is an integral part of the State Secretariat for Education, Research and Innovation (SERI) in the Federal Department of Economic Affairs, Education and Research (EAER). Its main responsibility is to prepare and implement the Swiss Space Policy, primarily through participation in ESA programmes.

The main focus of SSO in exploration is science, the development of space technologies and international collaboration. The development and utilisation of space infrastructures to the benefit of society are a key element of the Swiss Space Policy. Space exploration enables continuous improvement in understanding humanity's place in the universe. These endeavours simultaneously deliver tangible results in science and technology, which are directly applicable on Earth. For more information about SSO, visit **https://www.sbfi.admin.ch/sbfi/en/home/research-and-innovation/space.html**.

VIETNAM NATIONAL SPACE CENTER (JAN 2020)

Established in 2011, the Vietnam National Space Center is governed by the Vietnam Academy of Science and Technology (VAST), which administers and advances research and development and technology applications. VAST is working with VNSC to increase Vietnam's space science and technology capabilities with additional investments in national training and infrastructure. The VNSC is proud to be one of ISECG's newest agencies and is poised to cooperate, partner and contribute as needed in order to serve the common peaceful purpose of the ISECG.

VNSC's primary focus is to facilitate international cooperation and the agency has become an active member of several international organisations including the International Astronautical Federation (2012), Committee on Earth Observations (2013) and Group on Earth Observations (2014). VNSC also oversees the management and implementation of the Vietnam Space Center Project—one of Vietnam's largest science and technology investments. For more information about VNSC, visit **https://vnsc.org.vn/en/**.



An engineering model of NASA's Volatiles Investigating Polar Exploration Rover, or VIPER, is tested in the Simulated Lunar Operations Laboratory at NASA's Glenn Research Center in Cleveland, Ohio. Image Credit: NASA

CHAPTER TWO

MAJOR UPDATES IN LUNAR EXPLORATION PLANS

Since 2018, ISECG agencies have made significant updates to explorations plans, with a special emphasis on lunar missions and polar volatiles. Most agencies have become increasingly interested and committed to exploring the Moon's polar regions and in implementing long-term sustainable exploration missions based on international cooperation and commercial participation. These exploration plans include strategies that follow the established spaceflight practice where robotic missions come first and are primarily driven by scientific and technology demonstration objectives. Then more complex and capable robotics systems will be developed and become extensions of human lunar explorers. As these human and robotic capabilities merge, they are incorporated into the overarching mission strategies, which will significantly enhance exploration capabilities.

CREWED LUNAR EXPLORATION AND SUPPORTING MISSIONS

The United States has announced a new lunar exploration programme—Artemis—that soon will enable human missions to the Moon and in a manner that is sustainable long-term and tests the systems and operations necessary to prepare for future human Mars missions. The National Aeronautics and Space Administration's (NASA's) Artemis missions will enable human missions to the lunar surface beginning in 2024 and target sustainable lunar exploration by 2028. The first Artemis mission will launch in 2021 (uncrewed full system test), followed by Artemis II in 2023 (crewed mission in cislunar space) and will culminate with Artemis III in 2024 with a crewed mission to the lunar surface.

Following Artemis III, crewed missions with two crewmembers will fly to the lunar surface annually and then increase to four crewmember missions in 2028. The European Space Agency (ESA) has provided the European Service Module (ESM) for the Orion spacecraft, which has been integrated with the Orion capsule for the Artemis I mission. ESM2 is under development and procurements for ESM3 through ESM6 were approved in 2019 by the European ministers to support this sequence of Artemis missions. ESA is also studying options for providing science and logistic capabilities with an implementation decision planned for 2022. The study includes plans for a cislunar transfer vehicle (CLTV) or a European Large Logistics Lander (EL3) with a capability to deliver large (1.5-2 tonnes) in-situ science and technology payloads or cargo for human lunar surface activities.

Since the GER's release in 2018, the concept of the cislunar Gateway has matured to include a high-solar electric power and propulsion element (PPE) and a pressurised Habitation and Logistics Outpost (HALO) that will be integrated for launch in 2023.

NASA also recently awarded the first Gateway Logistics Services (GLS) contract to SpaceX to deliver cargo, experiments and other supplies to the outpost. Echoing the success of the Commercial Resupply Services programme, GLS will leverage commercial partners to deliver logistics to the Gateway, supporting lunar operations while building experience and technologies that can support the first human mission to Mars.

In early 2019, Canada announced its plan to develop and contribute an advanced, next-generation, artificial intelligence-enabled robotic system for Gateway. The smart robotic system will perform critical operations and support the deployment of science and technology experiments at Gateway.

In June 2020, Japan renewed the Basic Plan on Space Policy, which states that Japan will support the Artemis programme by contributing to the Gateway through habitation technologies and logistic capability, and aim to contribute to human lunar surface missions by transportation vehicles on the lunar surface, so that Japanese astronauts can actively participate in the Artemis mission. A Japan Aerospace Exploration Agency (JAXA) crew mobility capability could also provide an opportunity to leverage lunar surface activities to simulate and refine plans for the first human Mars surface mission.

Following decisions taken at the ESA Council meeting at ministerial level end of 2019 (Space19+), in addition to contributing to Gateway transportation with ESMs, ESA will:

1. Supplement the Gateway's PPE/HALO communication system with an enhanced communication string before 2024.
2. Contribute the International Habitation Module (I-HAB), which will increase habitation capability and the number of docking ports in 2025.
3. Develop a refuelling system and viewing capability (ESPRIT) to contribute to the sustainability of the Gateway.
4. Provide external radiation sensors to the PPE.

The Gateway will provide a next-generation deep space platform from which to conduct science investigations outside the protection of the Earth's Van Allen radiation belts. The international science community has identified heliophysics, radiation, and space weather as high-priority investigations to conduct on the Gateway. The Gateway is a vital part of the international community's deep space exploration plans, along with NASA's Space Launch System (SLS) rocket, Orion spacecraft, and the human landing system that will carry astronauts to the surface of the Moon in preparation for sending humans on a historic first journey to Mars.

The State Space Agency of Ukraine (SSAU) recently announced a new addition to its Ukrainian Space Programme for 2021-2025, which includes opportunities for contributing to the Artemis missions as well as the European Moon Village Association initiative. SSAU is working on three major lunar activities:

1. Creating a power plant for the lunar base—once established—that will be powered by solar energy. The technology for the power plant is based on innovative electrolysis technology and can be used to produce rocket fuel within the lunar base environment.
2. Developing a 6U CubeSat that will be in a selenocentric orbit and provide images of the Moon from several vantage points allowing terrain imaging and measuring spectral changes on the lunar surface.
3. Manufacturing a solar-thermoelectric generator designed to produce renewable energy. The generator would retain its functionality absent solar radiation by absorbing heat from the lunar surface.

ROBOTIC LUNAR EXPLORATION MISSIONS

Many individual robotic missions aim to understand the science and exploration value of the lunar poles. This portfolio of missions form a de-facto international Polar Exploration Campaign beginning with regional surveys (i.e., ground truth for ice, resources and local chemistry at diverse locations), followed by site exploration and preparation of locations identified as high priority. This campaign will ultimately support international sustained lunar surface activity. Robotic lunar missions that have either flown or have been formally approved for further study and/or funded by space agencies through 2030 (since publication of the 2018 GER) are outlined in Table 2 of this Supplement. The growing list of institutional missions (complemented by private-sector initiatives that are not shown in Table 2) underscores that there remains continued scientific interest and highlights both the scale of this cooperative effort globally and the human-robotic partnership required for sustainable lunar surface exploration.

China National Space Administration (CNSA)
On 3 January 2019, the Chang'e-4 mission achieved the first ever soft landing on the far side of the Moon and the Yutu-2 rover was deployed. CNSA is also implementing phase three of the Chinese Lunar Exploration Programme, which will entail collecting samples from the near side of the Moon, returning them to Earth—all to be accomplished by Chang'e-5 in 2020. Chang'e-6 is the backup mission to Chang'e-5, and its implementation is dependent on the status of the Chang'e-5 mission. Along with the implementation of all three phases of the Chinese Lunar Exploration Programme, CNSA plans to initiate both the Chang'e-7 and Change'e-8 missions from 2023 to 2030. The objective of these missions is to establish a prototype of the International Lunar Research Station (ILRS) at the lunar South Pole and construct and operate a platform supporting large-scale scientific exploration, demonstrate technologies and develop and utilise lunar resources.

Canadian Space Agency (CSA)
The CSA has the on-going Lunar Exploration Accelerator Program (LEAP), which supports lunar technology development, in-space demonstration and science missions. LEAP, in conjunction with international partners, plans to send payloads to the lunar surface by 2024. These payloads may include mobility and other science or technology demonstrations.

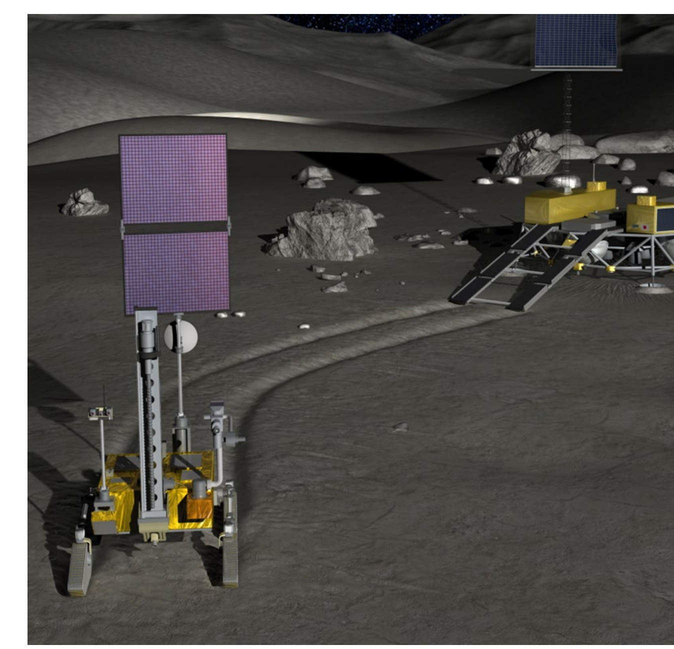
European Space Agency (ESA)
ESA is developing payloads—which build on prior investments—on partner-led missions including contributing to Roscosmos' missions Luna 25 and Luna 27 and the NASA Commercial Lunar Payload Services (CLPS) programme.

ESA has partnered with industry and is working on defining a high-data-rate lunar communication commercial service starting with the Lunar Pathfinder mission. Lunar Pathfinder is a relay satellite scheduled to be in lunar orbit by 2023. It should be followed by the development of a more capable high-performance lunar communication and navigation services (LCNS) constellation that will support sustained robotic and human exploration and is expected to be operational by late 2025.

ESA also recently approved system studies to demonstrate the technical and programmatic feasibility of a Cislunar Transfer Vehicle (CLTV) or a European Large Logistic Lander (EL3). The EL3 is a key capability designed to deliver scientific or logistic payloads to any location on the lunar surface. Its missions can include cargo delivery, sample return or scientific and/or technology demonstrations (e.g., extraction of oxygen from lunar regolith). The implementation planning decision will be concluded in late 2022 and launch is tentatively scheduled for 2027/2028.

Indian Space Research Organisation (ISRO)
ISRO launched Chandrayaan-2 on 22 July 2019 with the goal of demonstrating an end-to-end lunar mission capability, including insertion of an orbiter in lunar orbit, and soft landing and roving on the lunar surface. The mission was originally designed to last one year. The orbiter, which was equipped with eight advanced payload instruments, was successfully inserted into a 100 km orbit. The orbiter experiments are performing very well and are expected to contribute much to lunar science at the end of the now-extended mission of nearly 7 years. However, the mission was unable to soft land the lander and rover. The Indian government approved a follow-on mission, Chandrayaan-3, which is expected to launch in 2021, and has a lander and rover carrying the same set of payloads as Chandrayaan-2. ISRO is also working with JAXA to conduct a feasibility study for a joint lunar exploration mission.

Japan Aerospace Exploration Agency (JAXA)
JAXA continues to focus on developing lunar surface capabilities using the Smart Lander for Investigating Moon (SLIM) mission. SLIM will demonstrate pinpoint landing technology and is planned for launch in 2021/2022. JAXA, in cooperation with ISRO, is also planning a Lunar Polar Exploration (LUPEX) mission slated for launch in the 2023/2024 timeframe. The aim of this mission is to obtain knowledge of lunar water resources and to explore the suitability of the lunar polar region for the establishment of a lunar base. JAXA is working towards sending small missions to lunar orbit in the early 2020s in order to increase industry's capability and maintain the science community's interests. JAXA is also working to develop a medium-sized lander by the late 2020s that is capable of providing logistics support for human lunar surface missions and/or conducting science missions.

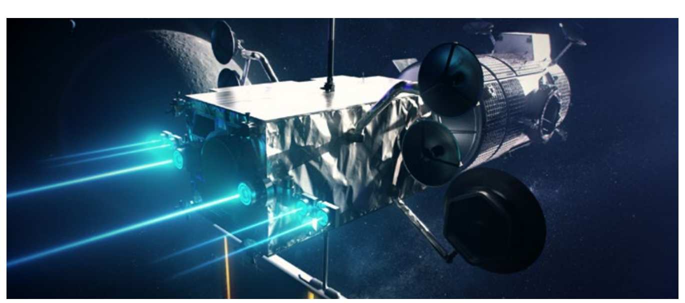


Lunar Polar Exploration (LUPEX). Image Credit: JAXA

Korea Aerospace Research Institute (KARI)
KARI has plans to launch the Korea Pathfinder Lunar Orbiter (KPLO) in 2022. The main objectives of the KPLO mission are 1) developing the critical technologies for lunar exploration; 2) performing scientific investigations on the lunar environment including topographic map for future lunar landing mission; and 3) realising and validating new space technology. The second lunar mission is a robotic lunar lander planned for launch by 2030.

National Aeronautics and Space Administration (NASA)
The Commercial Lunar Payload Services (CLPS) project was developed by NASA to procure delivery of payloads to the lunar surface from commercial providers. There are currently 14 companies on the CLPS contract, all of whom can compete when NASA releases a request for a lunar surface delivery. Early commercial delivery manifests will conduct science experiments, test technologies, and demonstrate capabilities to help NASA explore the Moon and prepare for crewed missions. Typically, these CLPS deliveries have additional payloads from entities other than NASA, e.g., universities, companies, other US government agencies, and/or international space agencies.

NASA has currently awarded contracts for four surface deliveries to both polar and non-polar lunar locations beginning in 2021 (see Table 1). The expected cadence for deliveries is approximately one every six months. NASA is utilising the CLPS capability for one of these deliveries to land the Volatiles Investigating Polar Exploration Rover (VIPER) on the South Pole to investigate the location and concentration of water ice in the region and takes samples to inform future science and human missions to the South Pole. VIPER is scheduled to land in the South Pole region of the Moon in late 2023.



The Gateway. Image Credit: NASA

TABLE 1

NASA's currently awarded contracts for surface deliveries to both polar and non-polar lunar locations beginning in 2021

YEAR	CLPS PROVIDER	MANIFEST	LOCATION
2021	Astrobotic	Science/ Technology	Lacus Mortis
2021	Intuitive Machines	Science/ Technology	Oceanus Procellarum
2022	Masten	Science/ Technology	Polar Region
2023	Astrobotic	VIPER rover	Polar Region

Roscosmos
Roscosmos adjusted the timeline of its Luna series of missions to explore the lunar poles. These updates are as follows:

- Luna-25 Lander Mission (Luna-Glob-Lander) scheduled for launch in 2021.
- Luna-26 Orbital Mission (Luna-Resurs-Orbiter) scheduled for launch in 2024. This mission will study the lunar surface from low polar orbit (approximately 50–100 km).
- Luna-27 Landing Mission (or Luna-Resurs-Lander) scheduled for launch in 2025. These missions are being developed in conjunction with ESA. ESA will provide communications, precision landing, hazard avoidance, drilling, sampling, sample analysis and ground support to these missions.
- Luna 28 (Luna Resource 2 or Luna-Grunt Rover) scheduled for launch in 2027. This is a cryogenic polar volatiles sample return mission and is a follow-up mission for Luna 27 (also proposed by Roscosmos).

Russian manufacturers and research institutes are conducting R&D activities on advanced methods and system design to provide navigation and communication services for lunar exploration users.

TABLE 2

Robotic lunar missions performed since the 2018 GER and planned by ISECG agencies

MISSION	AGENCY/LAUNCH DATE	DESCRIPTION/OBJECTIVES
Queqiao	CNSA 2018	Communication relay satellite.
Chang'e-4	CNSA 2018	Far side scientific lander and rover.
Chandrayaan-2	ISRO 2019	Polar scientific orbiter, lander, and rover.
Chang'e-5	CNSA 2020	Near side sample return.
Luna 25	Roscosmos 2021	Lunar volatile prospecting. Soft landing technology demonstration.
Chandrayaan-3	ISRO 2021	Lunar polar lander and rover.
Artemis I	NASA/ESA 2021	Uncrewed Orion/ESM flight with science and technology payloads. Deployment of cubesats in lunar orbit.
SLIM	JAXA 2021/22	Pinpoint landing technology demonstration.
KPLO	KARI 2022	Polar scientific and technology demonstration orbiter.
Chang'e-6	CNSA 2022-2024	Polar volatiles sample return.
VIPER	NASA 2023	Lunar polar rover. Polar science and volatiles.
LUPEX	JAXA/ISRO 2023/24	Polar lander and rover. Polar science and understanding the distribution and characterization of volatiles.
Luna 26	Roscosmos 2024	Polar scientific orbiter. Polar volatiles mapping.
Luna 27	Roscosmos with ESA 2025	Polar science, volatile prospecting and acquisition. Drill technology demonstration.
EL3 (TBC)	ESA 2027/2028	Science and/or logistic capabilities.
Luna 28	Roscosmos 2027	Cryogenic polar volatiles sample return.
ISRU demo	ESA 2027	In-situ end-to-end extraction of oxygen from lunar regolith.
Chang'e-7	2023-2030	Prototype of International Lunar Research Station (ILRS).
Chang'e-8	2023-2030	Prototype of International Lunar Research Station (ILRS).
Mid Lander	JAXA Late 2020's	Transport logistics and/or science.
Korea lunar lander	KARI 2030	Technology demonstration.

CHAPTER THREE

LUNAR SURFACE EXPLORATION OBJECTIVES

Based on the ISECG Goals and Objectives and Sustainability Principles, published in the 2018 GER, a set of dedicated Lunar Surface Exploration Scenario Objectives was developed (see Table 3). This set of objectives is based on the principle that human lunar surface exploration should focus on preparation for human Mars missions and for sustainable activities on the Moon leveraging ISRU.

The Lunar Surface Exploration Scenario Objectives in Table 3 are the drivers for the updated ISECG Lunar Exploration Scenario. For each lunar surface objective, there is a rationale that maps to one or more higher-level ISECG goals and corresponding performance measure targets. These performance targets can be achieved in a single mission or over a series of missions. These targets provide a guidepost for long-term goals but are flexible and will evolve over time to support agency priorities. The objectives in Table 3 are prioritised according to how they are executed in the ISECG scenario. The final five objectives will be executed throughout the scenario.

Several of the objectives necessitate a fixed location to support completion, such as long-duration habitation and ISRU, whereas other objectives require diverse locations on the Moon and long-range mobility. These competing objectives led ISECG members to adopt an approach where initial capabilities are continually leveraged while additional capabilities are added.

Concept design of a pressurised rover. Image Credit: Toyota

ESA astronaut Matthias Maurer and spacewalk instructor Hervé Stevenin collecting rock samples using new tool prototypes and documenting them with the Electronic Field Book during the PANGAEA-X test campaign in Lanzarote, Spain. Image Credit: ESA–A. Romeo.

TABLE 3

Lunar Surface Exploration Scenario Objectives

Expand Human Presence into the Solar System	Understand Our Place in the Universe	Engage the Public	Stimulate Economic Prosperity	Foster International Cooperation

OBJECTIVE	RATIONALE	ISECG GOAL	PERFORMANCE MEASURE TARGET*
Demonstrate human landing/ascent capability to and from the lunar surface.	To mitigate the risk for future human Mars exploration and for future government activities and commercial markets on the lunar surface. Number of crew should be as many as possible considering the nature of international programme, but within the realistic constraints of crew transportation capability planned by governments and envisioned commercial missions.		4 crew
Demonstrate a range of cargo delivery capabilities on the lunar surface for large surface elements and logistics.	To mitigate the risk for future human Mars exploration and for future government activities and commercial markets on lunar surface. As much cargo capability as possible is desired. Cargo capacity performance measure range is driven by: 1) Mass of crew consumables necessary for sortie mission will be around 1-2 tons; and 2) current human ascent module is estimated to be 9 tons.		>9 t for large surface elements, >1 t for logistics, x cubic meters of cargo delivered.
Demonstrate Extra Vehicular Activity (EVA) capabilities on the lunar surface.	To mitigate the risk for future human Mars missions and sustainable lunar exploration and for commercial activities on the lunar surface.		Reusable EVA systems with reasonably minimal maintenance including onsite dust management/mitigation and science sampling/curation techniques.
Demonstrate human long-range traversing capability on the lunar surface.	To mitigate the risk for future human Mars exploration and for future government activities and commercial markets on the lunar surface. Mobility capability design life of 10,000 km is the total round-trip distance to explore and traverse the five crew sites indicated in the 2018 GER.		10,000 km (cumulative)
Demonstrate reliability of human long-duration habitation capability and operational procedures on the lunar surface.	To mitigate the risk for future human Mars exploration and for future government activities and commercial markets on the lunar surface. Systems need to be capable of environmental extremes (e.g., temperature, radiation, pressure). Demonstration of human long-duration habitation and reliability can be achieved over a series of crewed and uncrewed missions, yielding the confidence for long-duration missions on the Moon and Mars. Astronaut operations need to be implemented and checked in different operative scenarios.		500 days (cumulative)
Demonstrate crew health and performance sustainability to live and work on the lunar surface for a sufficient duration to validate Mars surface missions.	To understand the human health effects of low gravity and deep space environment for long-duration missions on the Moon and notional Mars crewed surface mission. A number of medium-duration missions are expected to address the ability to understand how crew health and performance are affected by long duration exposure in the deep space environment.		TBD days (continuative) Comprehensive evaluation needed to determine the minimum duration and number of missions.
Demonstrate in-situ resource production and utilisation capability sufficient for crew transportation between lunar surface and Gateway and lunar surface utilisation needs.	To expedite sustainability for future human Moon and Mars exploration and to identify future commercial markets on the lunar surface.		Produce 50 tons of propellant per year.
Conduct effective global human/robotic cooperative science exploration to perform groundbreaking science.	To accomplish lunar objectives specified in the ISECG Science White Paper, "Scientific Opportunities Enabled By Human Exploration Beyond Low-Earth Orbit" as well as lunar objectives identified by ISECG agencies.		Comprehensive evaluation needed to determine value of science.
Develop infrastructure (e.g., power and communication systems) necessary to achieve the objectives for sustained exploration.	To demonstrate and establish infrastructure capabilities including a certain level of power and communication systems for achieving objectives such as long-duration habitation, ISRU, diverse science and public engagement. Commercial activities rely on infrastructure to stimulate economic growth.		300 kW of power generation and 1 Gbps for data rates, availability of TBD systems.
Engage the public in general and the youth in particular with human/robotic lunar surface exploration by bringing the action to large audiences, making full use of the state-of-the-art technology and through new ways of communication.	To inspire new generations, increase awareness of the relevance of space, and recognise the importance of different perspectives and domains of knowledge present in different scientific endeavours. Also, public participation is necessary in the long run to ensure sustainability of such plans (civic engagement/empowerment). If space exploration is a topic of interest to the public, the public has increased its potential to participate in policy making or at least influence it. Show the relevance of STEM and inspire young people to follow in those footsteps.		On national level as feasible, measuring positive public attitude towards lunar surface exploration (e.g., > 30% agreement) through surveys, website hits, social media impact, etc.
Implement new commercial arrangements that stimulate economic prosperity and foster commercial opportunities.	To achieve commercially led sustainable (i.e., market-driven economy with diminishing reliance on governments) economic activities on the Moon, new commercial arrangements are essential.		Increasing number of commercial partners or stakeholders providing critical lunar services year after year.
Provide a large number of collaboration opportunities for international partners to contribute to the lunar surface scenario.	To encourage global participation in the lunar surface scenario, inclusive of a range of contributions from science to hardware.		More than 100 nations' participation to lunar surface scenario.

Performance measure targets reflect long-term objectives and can be achieved in a single mission or over a series of missions across several decades.

CHAPTER FOUR

UPDATED LUNAR SURFACE EXPLORATION SCENARIO

The Lunar Surface Exploration Scenario integrates recent key updates to the GER's lunar exploration plans with the lunar surface exploration objectives. The mission scenario is divided into three phases (Boots on the Moon, Expanding and Building and Sustained Lunar Opportunities) to more clearly describe and focus the activities that achieve both lunar objectives for Mars and further lunar activities.

The update includes lunar orbit and lunar surface activities and reflects more detail on the buildup of Gateway in lunar orbit along with Artemis missions and the timing of upcoming robotic missions. On an annual basis, planned utilisation for the human lunar lander is primarily crewed missions along with options to pre-emplace infrastructure such as rovers and habitation elements.

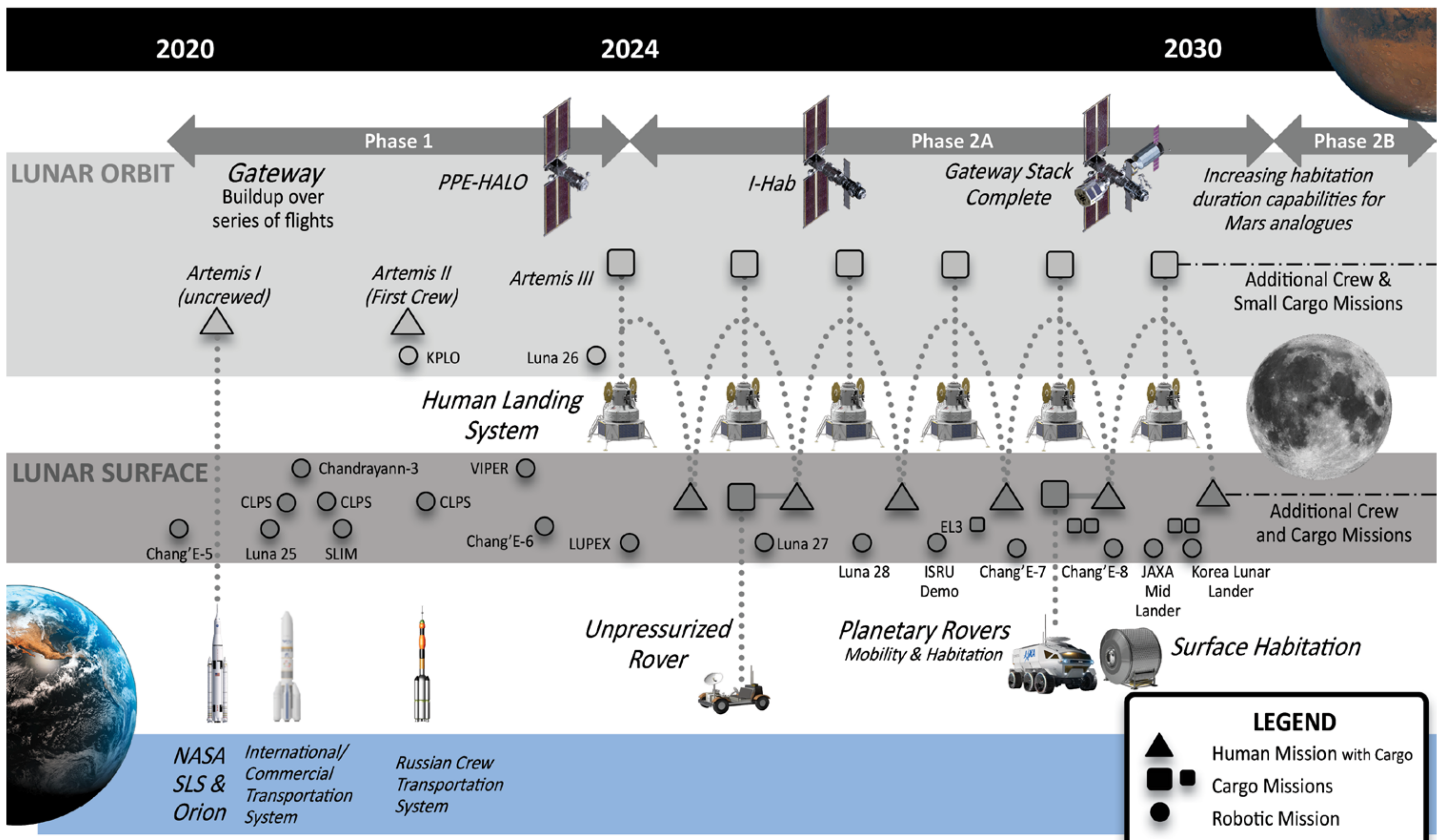
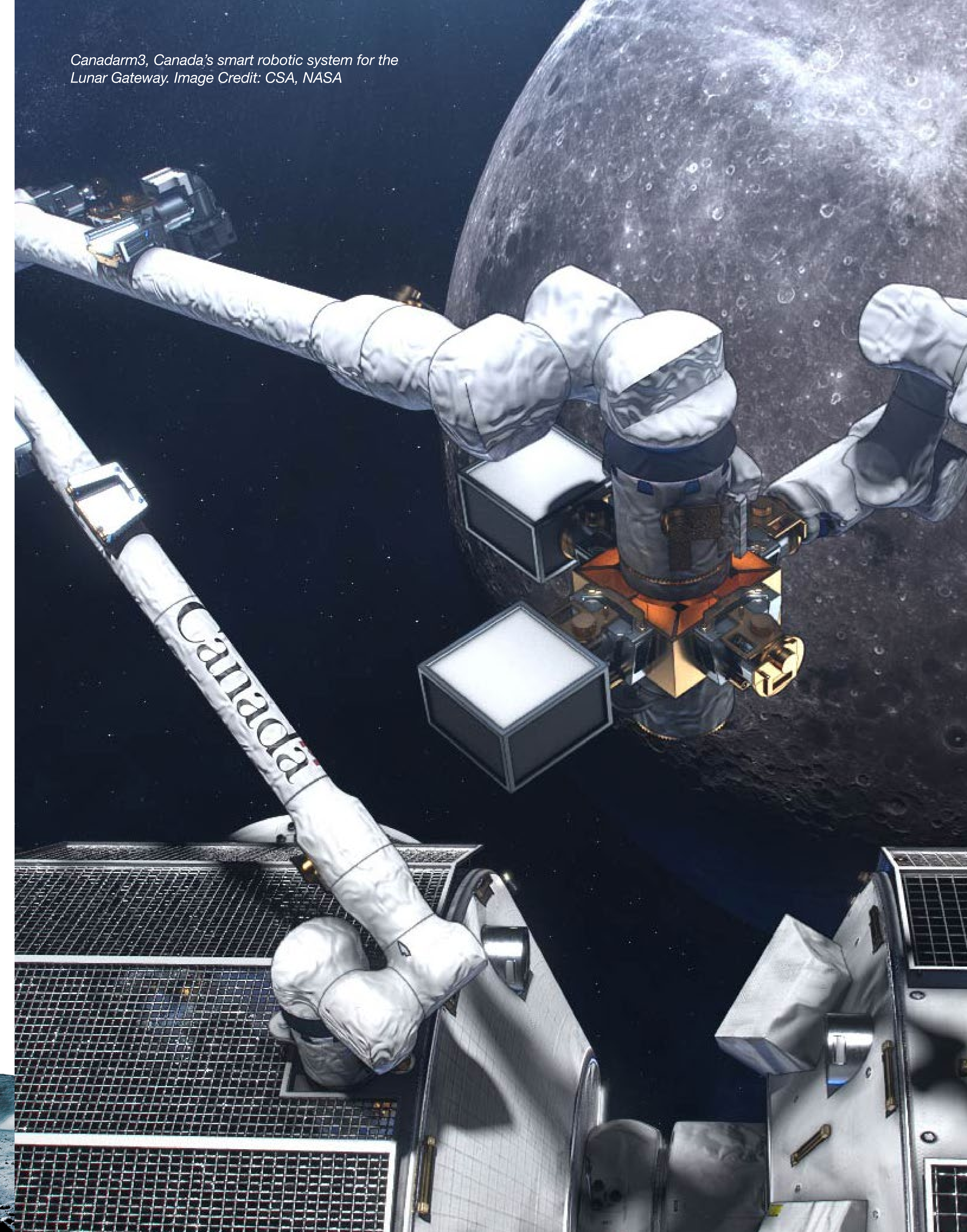


Figure 1. Updated ISECG Lunar Surface Exploration Scenario.



Canadarm3, Canada's smart robotic system for the Lunar Gateway. Image Credit: CSA, NASA

NOTIONAL ELEMENT CONCEPTS

Table 4 shows several key notional elements needed to support the lunar surface scenario. These elements are sequenced from initial or early capabilities to later capabilities and support the phased approach.

TABLE 4

Key Elements of Lunar Surface Exploration Scenario

PHASE	ELEMENT	FUNCTION
1	Crew Vehicle	Vehicle provides transportation for a crew of four between Earth and the lunar vicinity, including sustainment of the crew during space travel and providing safe reentry from deep space. As an example, NASA's Orion spacecraft has a four-crew, 21-day capability.
	Unpressurised Rover	Provides transportation on the lunar surface for two extra-vehicular activity (EVA)-suited crew with payload. The range of the unpressurised rover is targeted to be greater than 2 km for each excursion. The rover may be used during uncrewed periods through tele-operations.
	Human Lander	Initial capability will provide transportation for two crew between the lunar vicinity and the lunar surface, with an evolutionary goal of four crew, for up to an 8-day mission.
	EVA Suits	Dedicated suit system for use in deep space in microgravity locations or on the lunar surface to allow crewmembers to perform extra-vehicular activities (EVA) for up to 8 hours. EVA suits are planned to be used through a conventional airlock system and evolve to support suitport capability.
	Small Landers / Robotic Precursors	Delivery of cargo to the lunar surface. Target range of cargo is 10s-100s of kg. Robotic precursors for science, utilisation and potential pathfinder for technology demonstrations.
2A	Small Pressurised Rover	Provides mobility of up to 600 km per mission and habitation for two crew on the lunar surface for up to 42 days. Assumed reuse over multiple crew missions and ability to locate to new landing sites between crew missions.
	Logistics Capability	Delivery of logistics and cargo to the lunar vicinity. Depending on launch vehicle, a range of cargo between ~2000 to 3400 kg can be accommodated to Gateway.
	Medium-Class Cargo Landers	Delivery of cargo to the lunar surface. Target range of cargo is ~1000-2000 kg. Cargo can include science payloads, logistics and equipment.
	Communications Relay	Uplink and downlink of data between lunar surface and Gateway or Earth. Communication bands under consideration include S-band, X-band, Ka-band and optical comm. Gateway elements can fill this need.
	Power	Provides supplemental power generation and storage to localized assets (such as ISRU demonstrations, rover recharge, habitat) on the lunar surface. Target of ~17 kW to support Phase 2A operations.
	Utility Rovers	Provides mobility options to support science and ISRU. Payload accommodations of 25-250 kg. Capable of traveling up to 2000 km.
	ISRU Pilot Plant	Subscale version of the Phase 3 operational plant that demonstrates ~1/100 of the oxygen needed from the Phase 3 operational plant. Will prove safety of operations and reliability needed for the operational plant.
2B	Long-Duration Habitation	Lunar surface habitation to support four crew for up to 60 days. Assumes provisions are delivered separately or with the crew and sufficient volume is available, which may be provided by several pressurised surface elements.
	Reusable Human Lander	Provides crew transportation between lunar vicinity and the lunar surface. Reusable ascent element for a crew of four for a multiple stage lunar lander. Propellant for ascent element can be supplied on orbit or on the surface.
	Nuclear Power	Modular power system sized to provide ~10 kW for the lunar day or night. Multiple units can provide power to meet infrastructure demands.
	ISRU Plant	Operational ISRU plant capable of producing ~50 tonnes of propellant per year. Electrolysis is used to create hydrogen and oxygen for propellant for a reusable lander. Excavation, collection and storage would be part of the plant system.
3	Crewed Hopper	Provides unpressurised two-way crew transportation within a 1000 km range of the landing site for a crew of four EVA-suited astronauts. Hopper is assumed to be refueled on the lunar surface between uses.

CAMPAIGN APPROACH

The updated Lunar Surface Exploration Scenario implements a phased approach and follows the sustainability principles established in the 2018 GER. It begins with human lunar return, then transitions to expanding and building up capabilities on the lunar surface and enabling sustained lunar opportunities. These phases build upon each other and will eventually lead to achieving Mars mission capability. Throughout the scenario, there is an emphasis on the advancement of knowledge and sustainable expansion of utilisation and commercial opportunities.

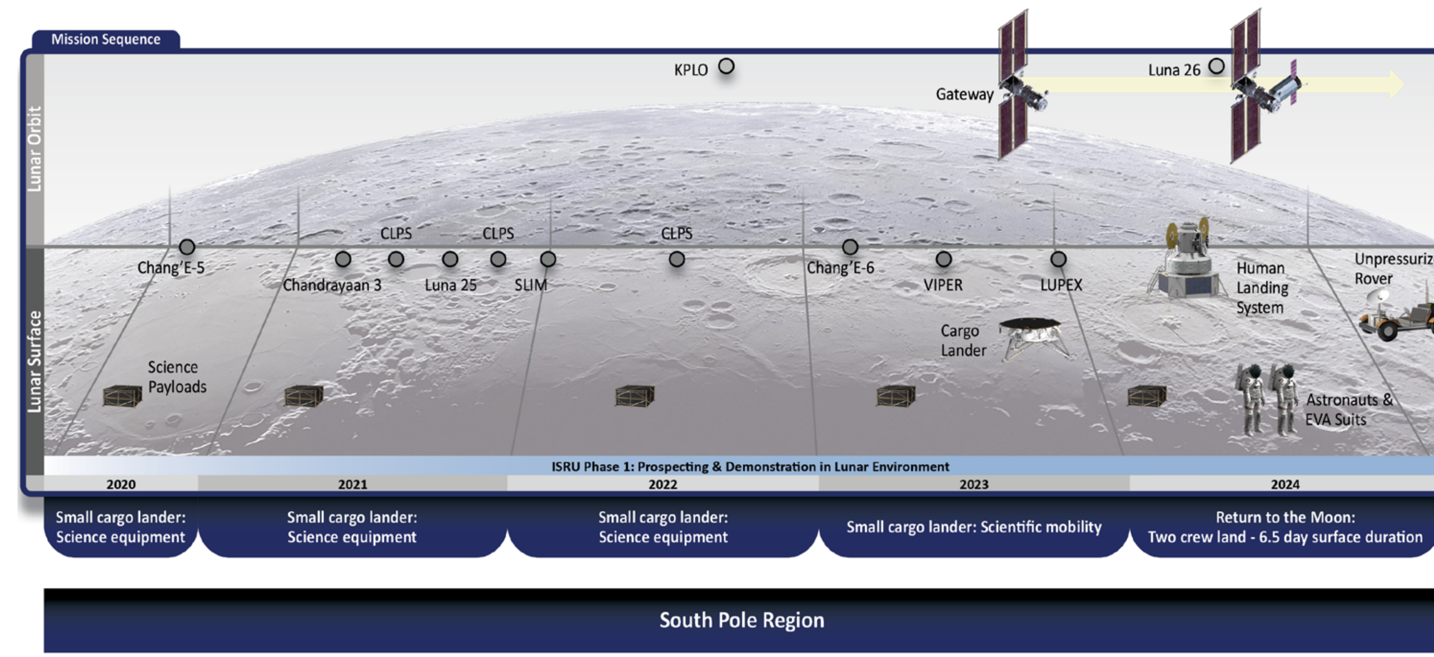


Figure 2. Phase 1: Boots on the Moon—South Pole.

Phase 1: Boots on the Moon

The updated mission scenario focuses on human missions to the surface of the Moon. NASA has announced bold plans to send humans to the Moon beginning in 2024, and other agencies, such as Roscosmos, CSA, and JAXA, are considering plans to enable human exploration of the Moon with several prospecting missions to support the 2024 goal. ESA is providing the ESM element of Orion and is planning lunar surface exploration activities after 2024. The ESA-DLR LUNA analogue facility provides a realistic environment for technology testing, procedures development, crew and ground personnel training, and end-to-end integrated simulations of EVA and robotic surface operations. Given the time frame for sending humans to the Moon, it is unlikely that there will be large infrastructure on the Moon to support initial missions. It is anticipated that initial capabilities will include small (cargo) landers—to support science and resource characterisation— as well as Gateway, a human lander, EVA hardware and an unpressurised rover.

Phase 2: Lunar Exploration—Expanding and Building

Following the initial human missions to the Moon, the updated mission scenario moves toward a sustained lunar presence that includes a focus on mobility, exploration and science, with demonstration of pressurised rover capabilities and resource utilisation. To support these missions, periodic cargo transportation will be needed. After mobility and exploration activities have been fully demonstrated, a shift to surface sustainability and Mars-focused demonstrations will occur, including enhanced pressurised rovers, longer-duration habitation, power systems and ISRU. The progression of capability then moves from local to regional exploration using at least one pressurised rover and is performed early on at the South Pole. The areas of exploration will be limited to locations that receive no more than eight consecutive days of continuous darkness. With the delivery of the first pressurised rover, Mars surface mission analogues become possible, while a second pressurised rover will greatly increase science and human exploration capabilities within a lunar region.

After the first several crewed missions, additional capabilities will be delivered to the lunar surface (i.e., upgrades to the pressurised rovers or new pressurised rovers enabling survival through a full lunar night of 14 days). This will allow crewmembers (and tele-operated science roving missions) to visit new sites outside of the South Pole region and explore the various sites outlined in the 2018 GER—with the rovers traversing to the new sites between crewed missions.

After completing several missions of expanding exploration capability and building infrastructure (Phase 2A), the focus will return to the South Pole for longer-duration habitation and ISRU.

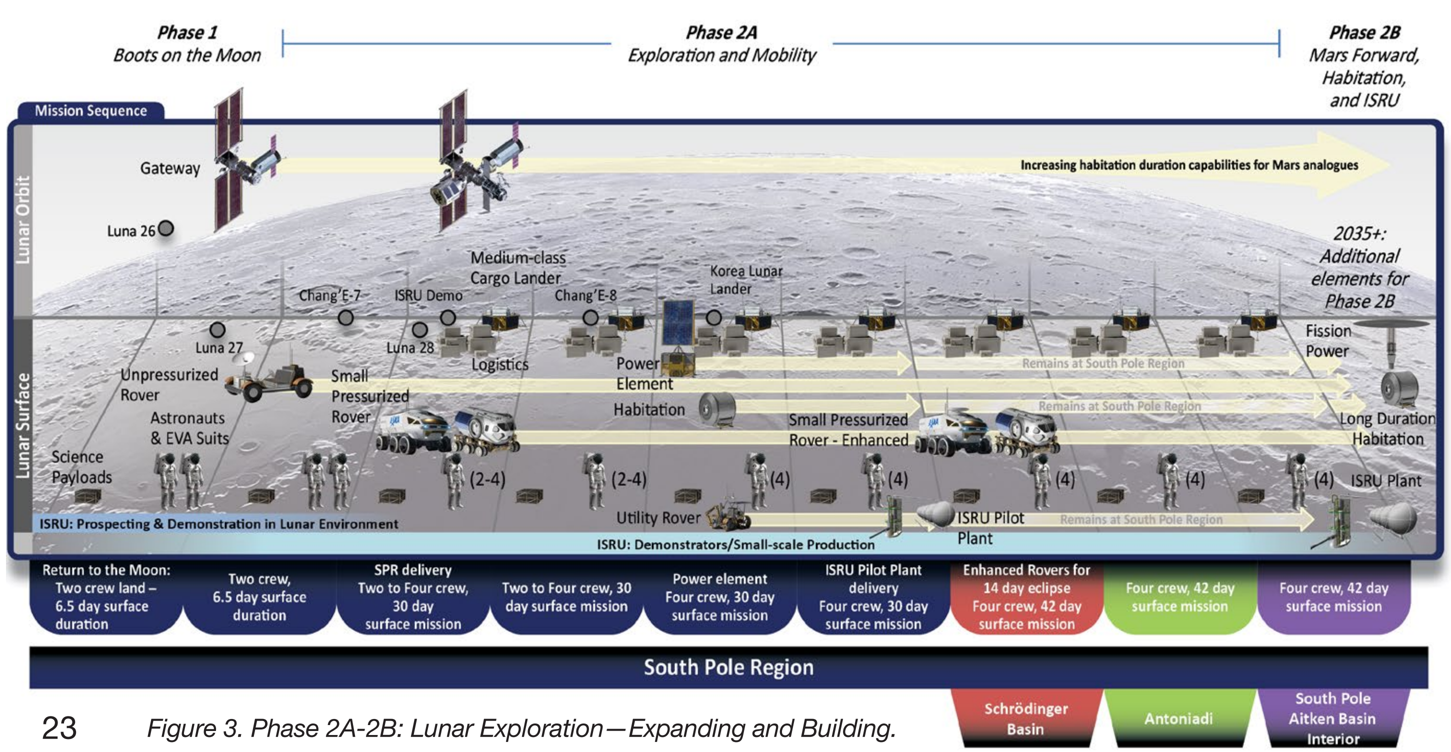


Figure 3. Phase 2A-2B: Lunar Exploration—Expanding and Building.

Additional habitation capabilities will be required to meet longer durations on the surface (e.g., closed-loop life support, crew health and performance, in-situ food/plant production, etc.). ISRU pilot and demonstration plants, and power to support the infrastructure and ISRU will also be needed. Figure 4. shows a potential end state for Phase 2B, focusing on the objectives related to longer durations on the lunar surface. Another key aspect for architecture capabilities includes looking at dissimilar redundancies for several of the key elements. These experiences and enhanced capabilities will prepare agencies for the first human mission to Mars.

Phase 3: Sustained Lunar Opportunities

The updated mission scenario envisages laying the foundation for a sustained and vibrant lunar presence in the coming decades. This sustainable vision includes stimulating opportunity through technology testing, investing in infrastructure and creating opportunities accessible through partnerships with international governments, academia and industry. The potential capabilities that aid a sustainable lunar surface economy may include long-duration habitation operations, associated commercial developments, mobility systems (providing global access), and ISRU production and operation. These would be built upon the basic infrastructure (power, communications, etc.) provided during the first two phases, which will occur within the next two decades.

As access to and from the lunar surface becomes more commonplace and affordable, the viability of lunar economies will improve over time and open Earth's nearest celestial body for ongoing human discovery and development. Governments would shift their investment focus to support exploring other frontiers, including Mars exploration missions. While the more detailed assessment of sustained lunar opportunities is not within the scope of this Supplement, ISECG agencies envision a future lunar surface with robust economic activity that lay the foundation for exploration across the solar system with robotic and human missions.

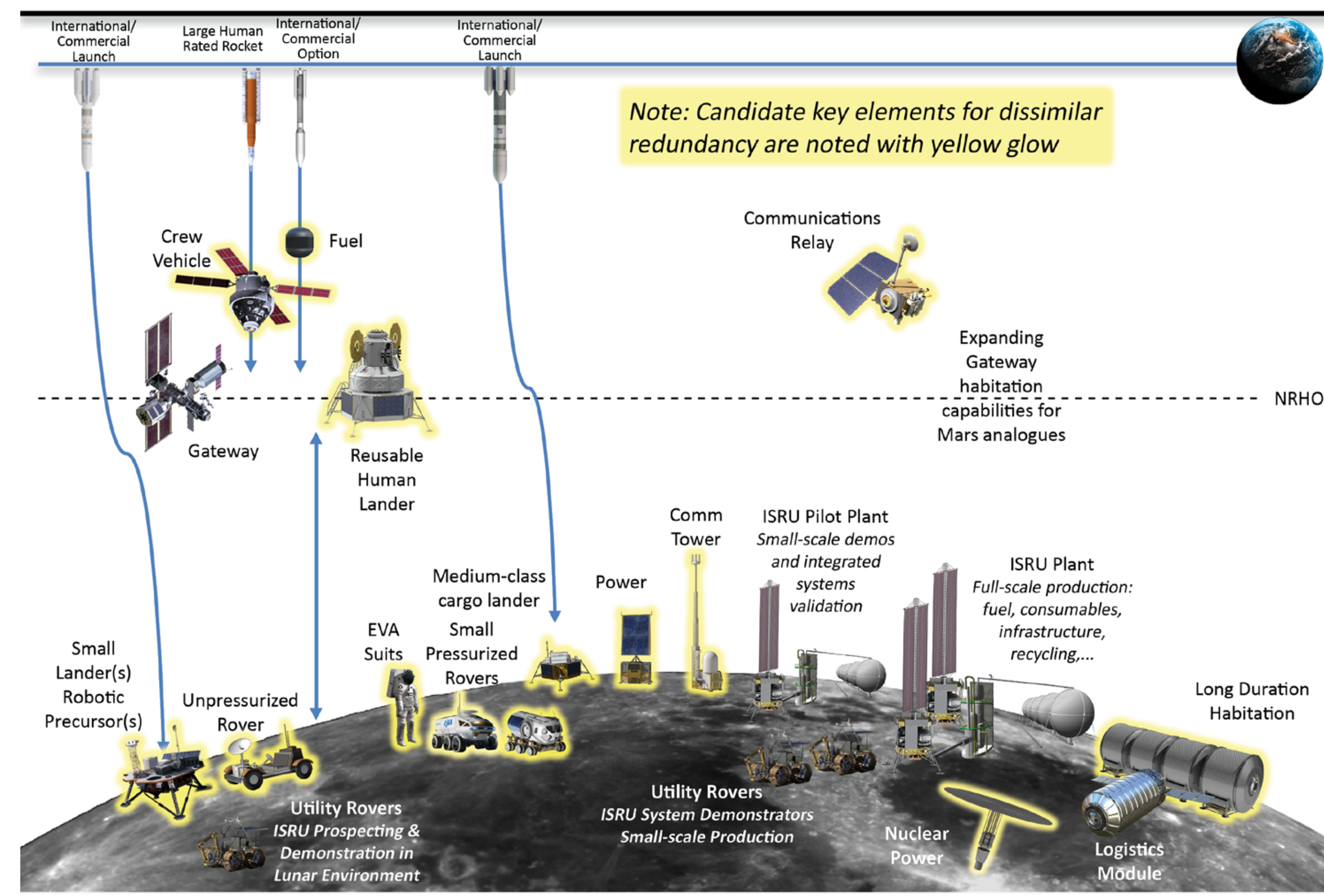
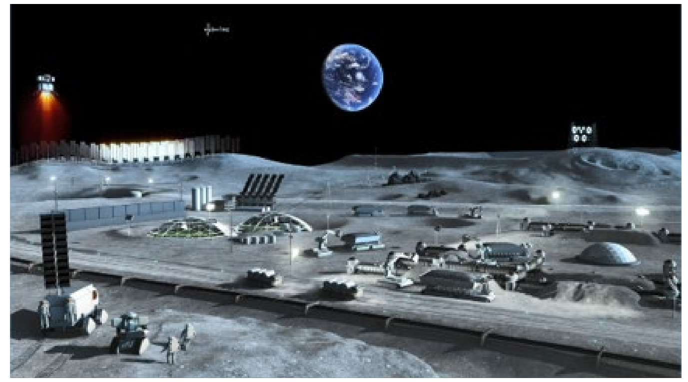


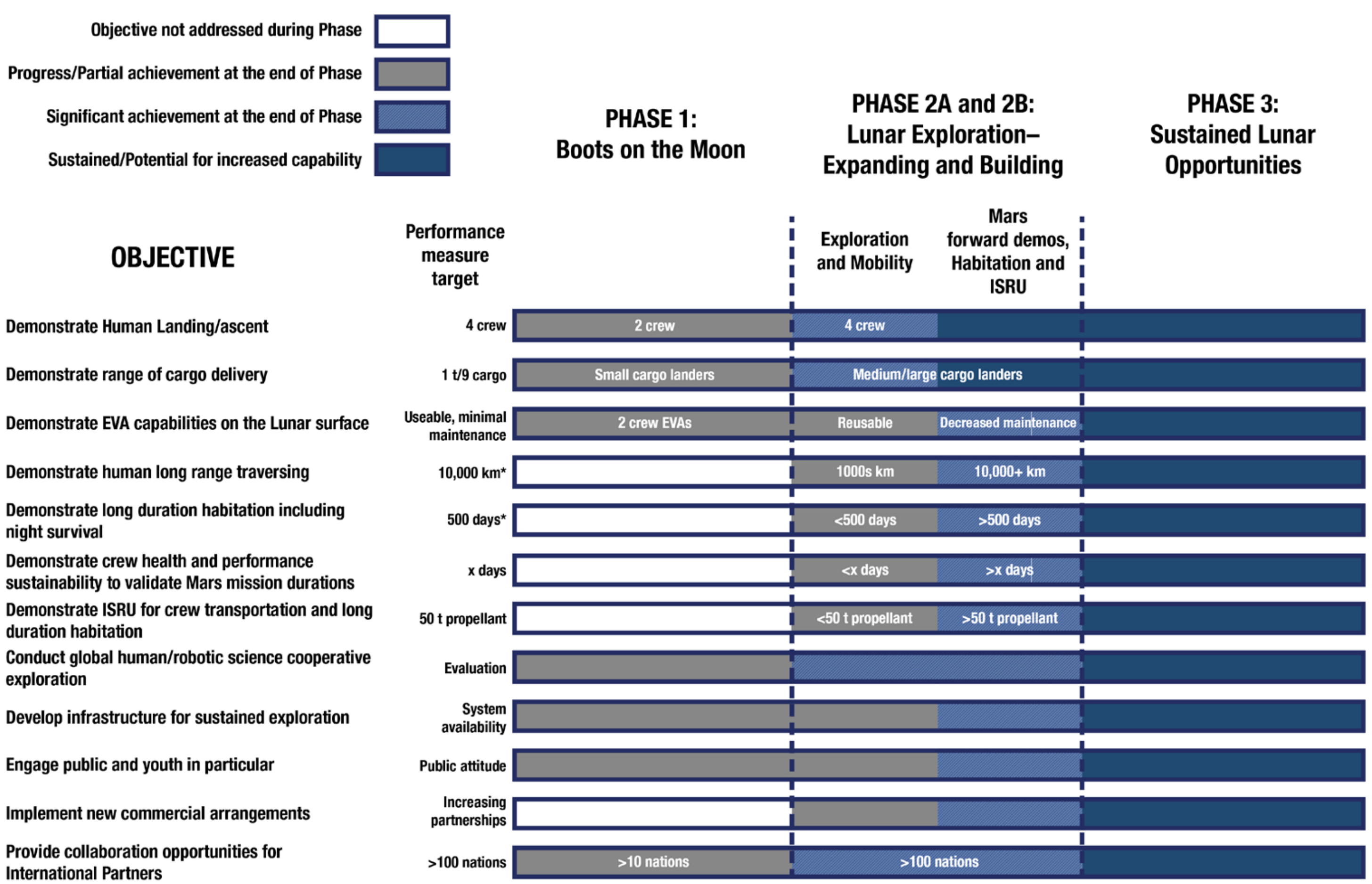
Figure 4. Expanding and Building—Longer Duration and Increased Utilisation (Phase 2B End State).

PROGRESSION ON OBJECTIVES

Given the implementation of the updated Lunar Surface Exploration Scenario, Figure 5 shows the progression of achieving the lunar surface exploration objectives over time. Objectives such as science, engaging the public, collaborative partnerships, preparing for Mars and enabling commercial endeavours are front and centre throughout the entire Lunar Surface Exploration Scenario. Other segments of the scenario, such as Phase 1: Boots on the Moon, focus on demonstrating specific objectives. In this case, the first phase is to demonstrate landing and ascent and delivery of cargo to the lunar surface.



A Future Vision of a Fully Developed Lunar Economy.
Image Credit: JAXA



Note: Assumes reuse of capabilities into following phases
**** Cumulative over one to several missions***

Figure 5. Objectives Progression across Phases.

CHAPTER FIVE

INCREASING INDUSTRY CAPABILITIES

Over the past decade, ambitions and capabilities to explore space and transport humans, robots and cargo to low-Earth orbit and beyond have increased significantly. In the past, these capabilities were only achievable through the resources and support of governments. Now missions are rapidly transitioning from being the exclusive purview of large agency development programmes to include more non-government actors using a services-based model or having entire missions executed by private companies around the world. While governments will continue to invest in key space technologies, projects and missions to explore LEO and beyond, ISECG agencies expect to leverage emerging capabilities for use in planning future spaceflight science and exploration activities. Leveraging these new capabilities will lower overall costs and benefit their countries by providing them access to new economies and technologies.

Some space agencies have responded to these increasingly successful private-sector capabilities with novel spaceflight acquisition approaches that both achieve the agency goals and provide private companies with opportunities to reduce risk while refining their economic operations systems and broadening their customer range. ISECG agencies welcome and support these new partnerships for both the benefits provided to the domestic economies as well as their contributions to achieving international space exploration goals.

CSA's Juno rover operating at night and simulating soil sampling in lunar permanently shadowed regions.
Image Credit: CSA

APPENDIX

LIST OF ACRONYMS

AEB	Brazilian Space Agency
ASA	Australian Space Agency
ASI	Italian Space Agency
CLPS	Commercial Lunar Payload Services
CLTV	Cislunar Transfer Vehicle
CNES	National Centre for Space Studies
CNSA	China National Space Administration
CRAS	Commission for Space Activities
CSA	Canadian Space Agency
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DLR	German Aerospace Center
EAER	Federal Department of Economic Affairs, Education and Research
EL3	European Large Logistics Lander
ESA	European Space Agency
ESM	European Service Module
EU	European Union
EVA	Extra-Vehicular Activity
GER	Global Exploration Roadmap
GISTDA	Geo-Informatics and Space Technology Development Agency
GNSS	Global Navigation Satellite System
HALO	Habitation and Logistics Outpost
HTV-X	Next-Generation H-2 Transfer Vehicle
I-HAB	International Habitation Module
ILRS	International Lunar Research Station
ISRO	Indian Space Research Organisation
ISRU	In-Situ Resource Utilisation
ISECG	International Space Exploration Coordination Group
JAXA	Japan Aerospace Exploration Agency

KARI	Korea Aerospace Research Institute
KPLO	Korea Pathfinder Lunar Orbiter
LCNS	Lunar Communication and Navigation Services
LEAP	Lunar Exploration Accelerator Program
LEO	Low-Earth Orbit
LSA	Luxembourg Space Agency
LUPEX	Lunar Polar Exploration
NASA	National Aeronautics and Space Administration
NOSA	Norwegian Space Agency
NRHO	Near Rectilinear Halo Orbit
POLSA	Polish Space Agency
PPE	Power and Propulsion Element
PRS	Public Regulated Service
ROSA	Romanian Space Agency
Roscosmos	Roscosmos State Corporation for Space Activities
SERI	State Secretariat for Education, Research and Innovation
SLS	Space Launch System
SSA	Space Situational Awareness
SSAU	State Space Agency of Ukraine
SSO	Swiss Space Office
UAESA	United Arab Emirates Space Agency
UK Space Agency	United Kingdom Space Agency
VAST	Vietnam Academy of Science and Technology
VIPER	Volatiles Investigating Polar Exploration Rover
VNSC	Vietnam National Space Center

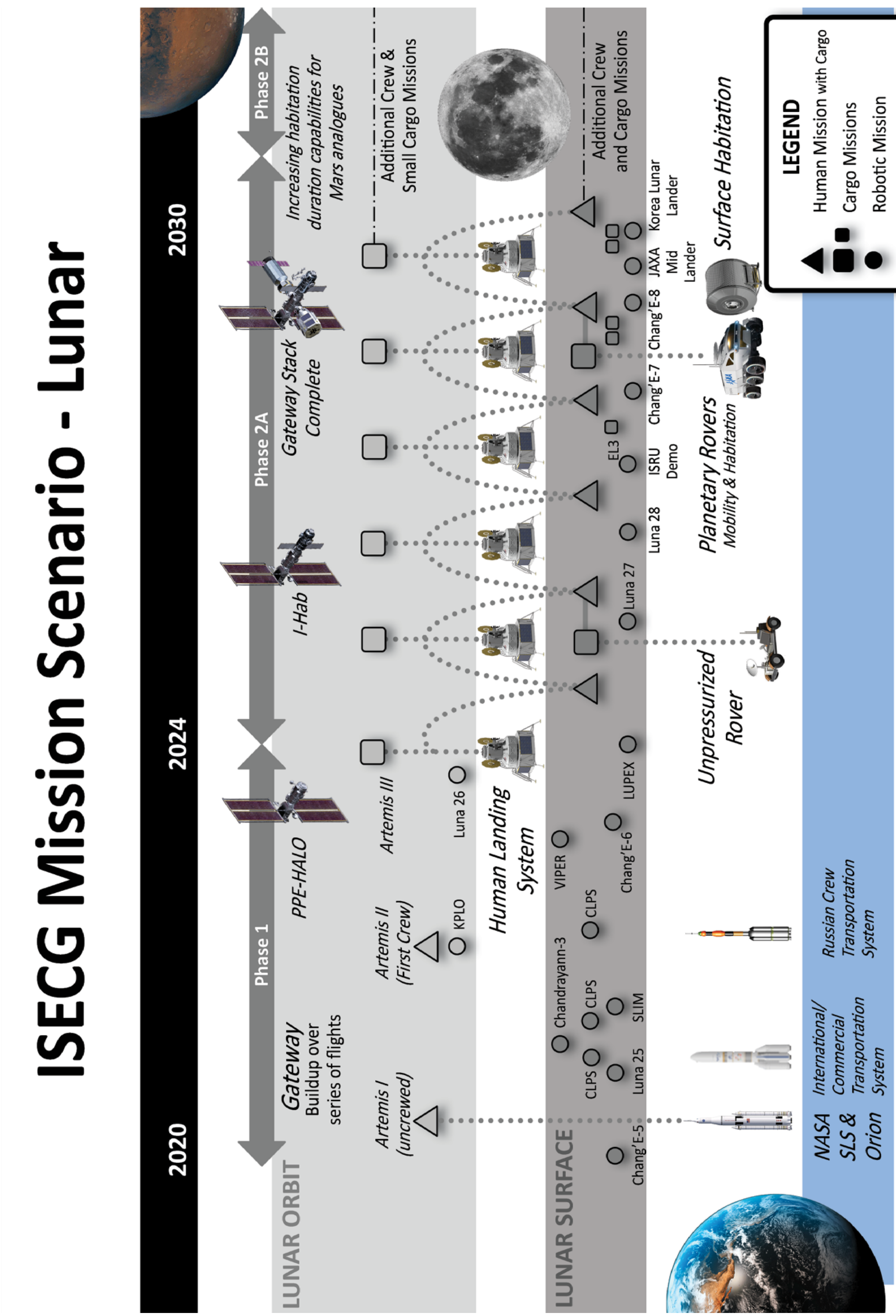


Figure 1. Updated ISECG Lunar Surface Exploration Scenario.

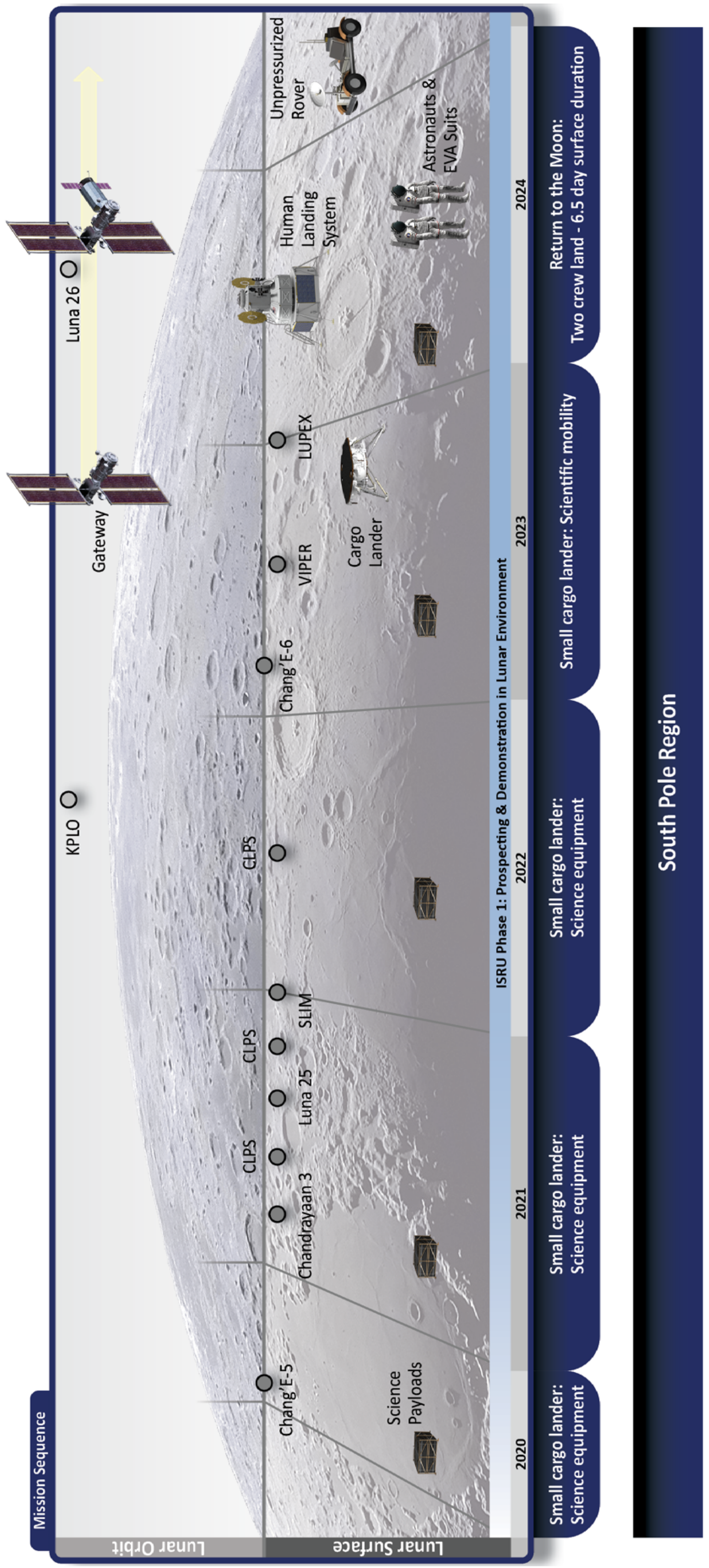


Figure 2. Phase 1: Boots on the Moon—South Pole.

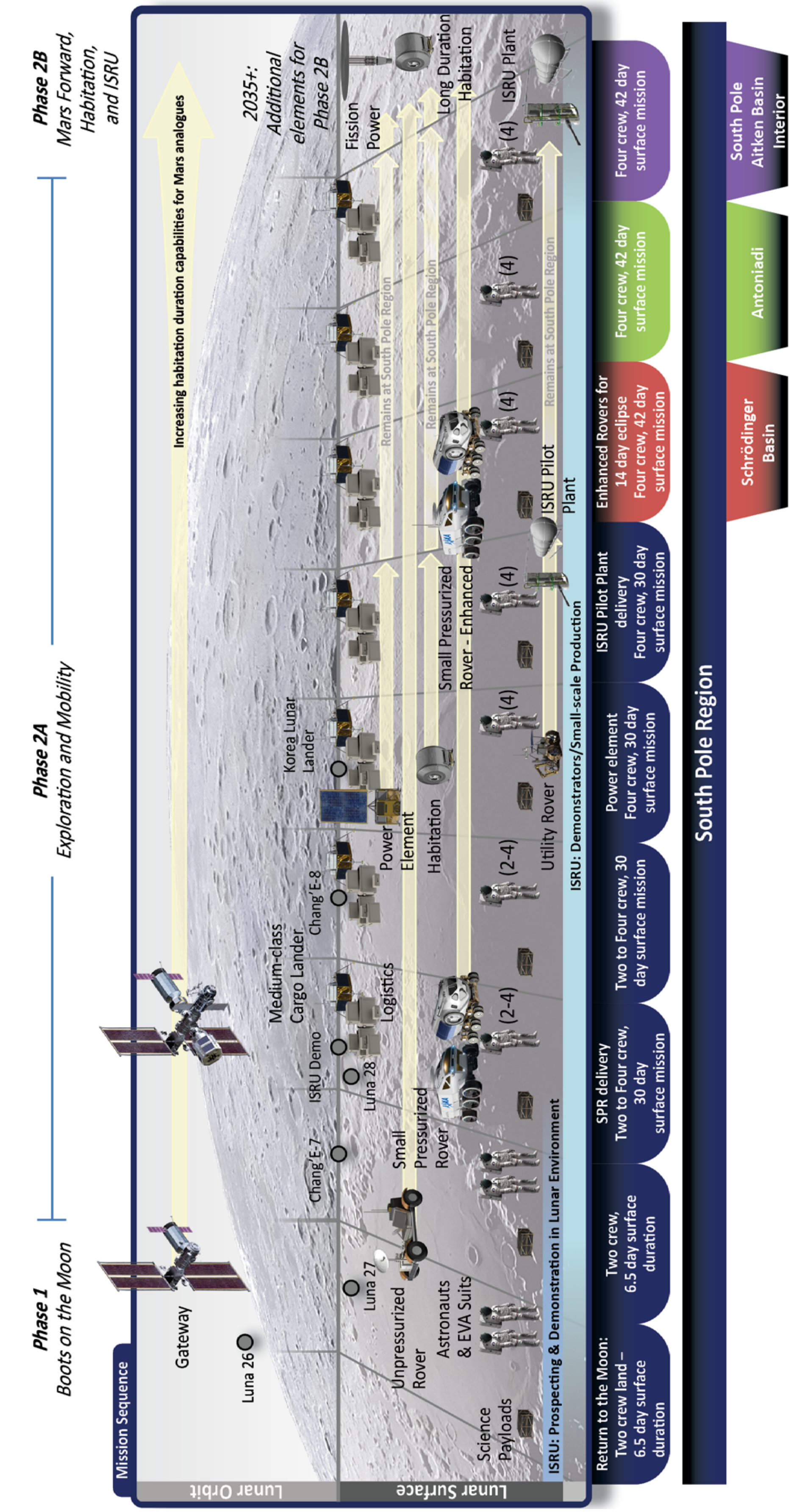


Figure 3. Phase 2A-2B: Lunar Exploration—Expanding and Building.

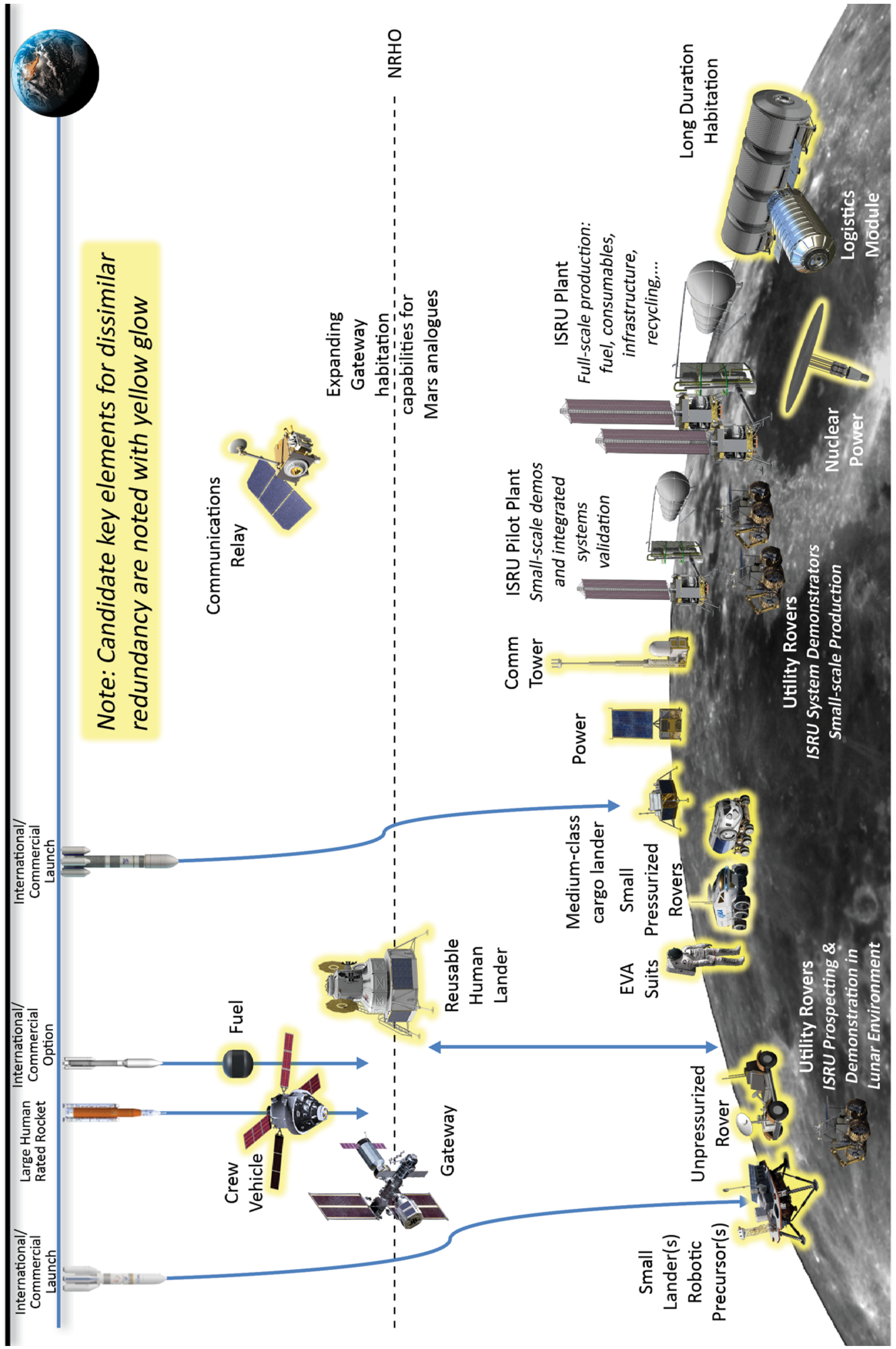


Figure 4. Expanding and Building—Longer Duration and Increased Utilisation (Phase 2B End State).

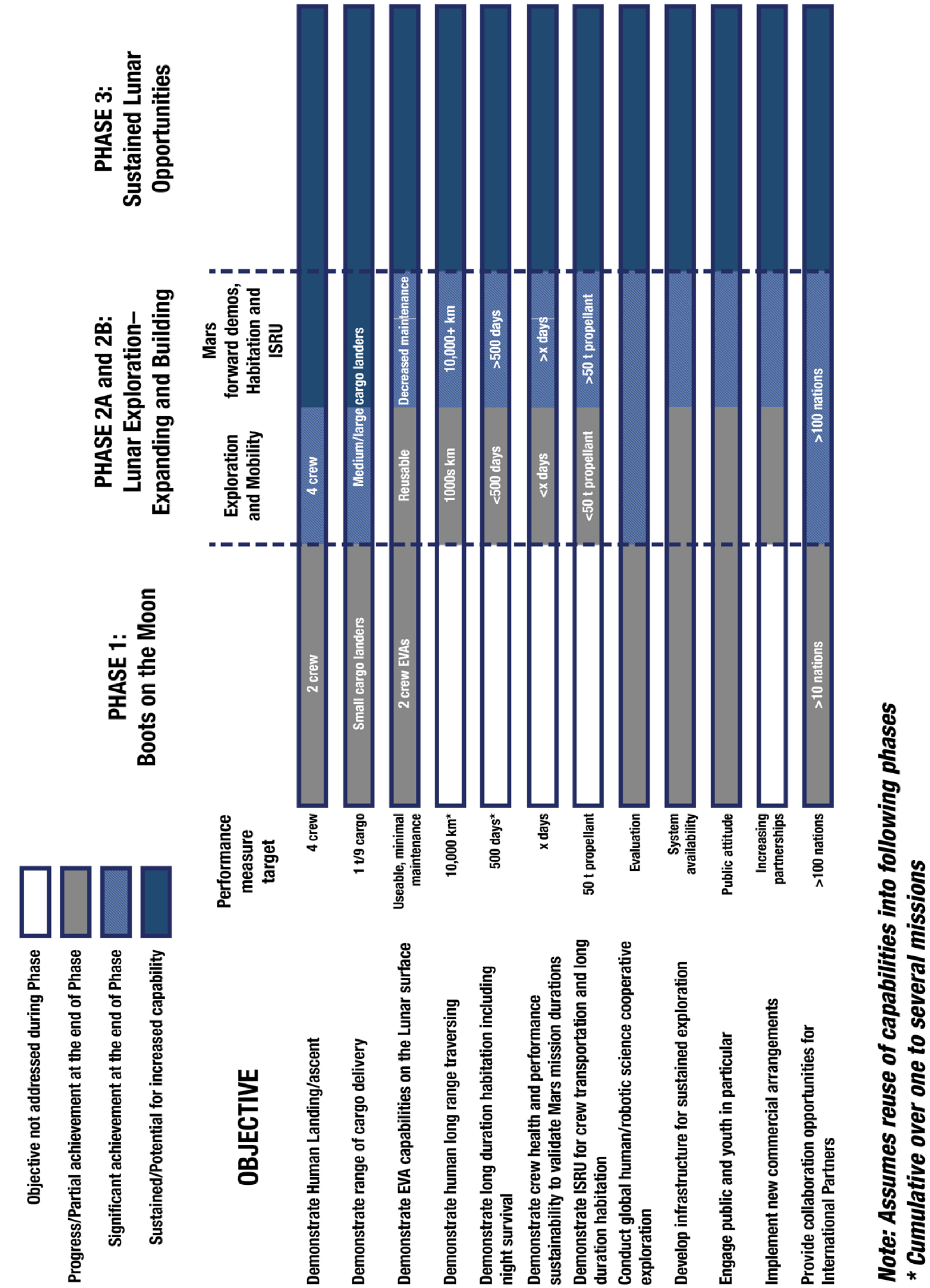


Figure 5. Objectives Progression across Phases.

ISECG is a voluntary, non-binding coordination forum of 24 space agencies. ISECG operates in accordance with the key principles set forth in the Global Exploration Strategy—which are open and inclusive, flexible and evolutionary—and is meant to foster mutually beneficial partnerships.

ISECG is committed to fostering the discussions in non-binding forums and to develop products that enable its members to take concrete steps towards establishing partnerships that reflect a globally coordinated exploration effort and enhance the benefits of space exploration for all.

For more information on ISECG activities and how to join, visit the ISECG public website,
https://www.globalspaceexploration.org

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