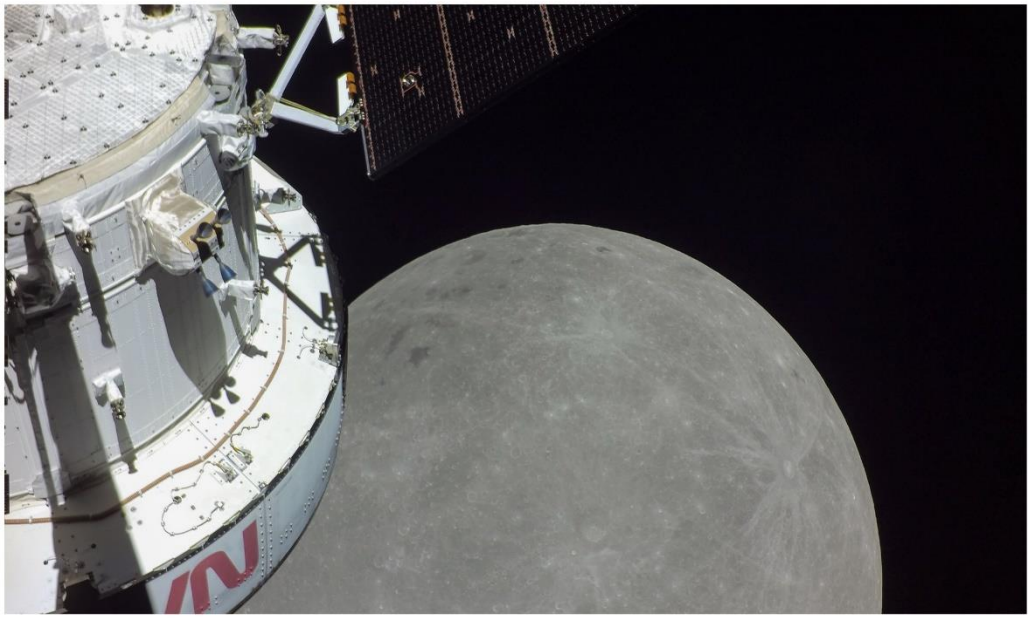
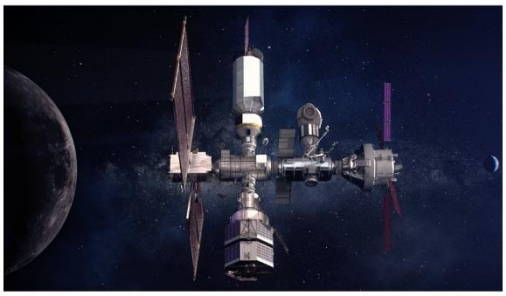
NASA
Office of Inspector General

NASA's Partnerships with International Space Agencies for the Artemis Campaign





January 17, 2023

IG-23-004

Office of Inspector General

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RESULTS IN BRIEF

NASA's Partnerships with International Space Agencies for the Artemis Campaign

January 17, 2023 IG-23-004 (A-22-04-00-SOD)

WHY WE PERFORMED THIS AUDIT

NASA's Artemis campaign is working toward landing humans on the Moon in 2025 with the ultimate goal of crewed missions to Mars in the 2030s. Additional objectives include biannual robotic and scientific missions to the lunar surface, establishment of an orbiting lunar outpost known as Gateway, and development of a base camp with lunar rovers on the Moon. Achieving these ambitious objectives is both technically challenging and enormously expensive, with NASA's financial contributions to Artemis projected to cost $93 billion between fiscal years 2012 and 2025. Consequently, NASA officials have stated that partnerships with international space agencies are critical to achieving a robust and sustainable presence on the Moon as a precursor to a human mission to Mars. At the same time the Artemis Accords—signed by 23 countries over the last 2 years—illustrate wide international interest in space exploration as they seek to establish principles for cooperation among civil space agencies and governance on the use of outer space to increase the safety of operations, reduce uncertainty, and promote its sustainable and beneficial use for peaceful purposes.

Key early Artemis commitments from the Canadian Space Agency, European Space Agency (ESA), and Japan Aerospace Exploration Agency (JAXA) include the provision of a Gateway habitat, communications satellites, spacecraft service modules, external robotics, astronauts, and lunar rovers. ESA has explored establishing a permanent Moon base, while JAXA is examining upgrades to its logistics vehicle used to deliver supplies to the International Space Station (ISS). While NASA is leaning into its deep experience over the past 30 years working with a variety of international partners on the ISS by establishing long-term Artemis commitments from many of these same partners, international cooperation for Artemis may be hindered by fluctuating political guidance, uncertain budgets, and restrictive policies concerning the control of mission-related information both in the United States and abroad.

In this audit we evaluated (1) NASA's plans to coordinate and integrate international partner contributions with its Artemis efforts, (2) impediments NASA faces when partnering with international space agencies, and (3) the cost implications of working with partner space agencies. To complete this work, we interviewed NASA and U.S. Departments of State and Defense officials, conducted site visits at ESA and JAXA locations in the Netherlands and Japan, and surveyed seven international space agencies. We reviewed relevant Artemis and Moon to Mars documents; international partner agreements; agreement processing metrics; export control laws; and NASA budget, contract, and cost data. We also engaged The Aerospace Corporation to analyze the cost, schedule, and complexity of domestic and international uncrewed, robotic, and human space flight projects.

WHAT WE FOUND

Interest in the Artemis campaign is high across the international space community, as evidenced by NASA's 54 Artemis-related international instruments and the 23 signatories to the Artemis Accords. However, the Agency lacks an overarching strategy to coordinate Artemis contributions from international space agencies and entities. Except for the Gateway Program, the Artemis campaign does not have comprehensive forums—boards, panels, and working groups—for its international partners to routinely discuss topics such as flight and mission planning, safety, and research integration. In contrast, the ISS Program–seen as a model of long-term international space cooperation–employs these forums as well as on-site representation from partner agencies. While the architecture or blueprint for the first three Artemis missions is well established, NASA lacks an overall architecture beyond Artemis IV for lunar exploration of the

Moon that includes estimated costs to be borne and responsibilities assumed by its international partners. In May 2022, NASA took steps to develop such an architecture that would inform a "blueprint for sustained human presence throughout the solar system," but it is too early to tell if these efforts will clarify the potential funding, roles, and responsibilities required of international partners for participation in the Artemis campaign. Additionally, current Artemis agreements are pursued bilaterally with interested parties without an overall cooperative framework that addresses the legal structure, program development, or partner roles and responsibilities.

U.S. export control regulations of defense articles and commercial items—governed by rules known as the International Traffic in Arms Regulations (ITAR) and Export Administration Regulations (EAR)—are designed to protect U.S. national interests and intellectual property. However, they can be overly complex and restrictive, and their implementation in international agreements, policies, and how space flight systems are classified routinely limit NASA's international collaborations on Artemis. For example, international agreements do not allow the use of partner astronauts and sharing of information with them during the periods prior to and after conclusion of a mission. In addition, unlike the ISS, the Artemis campaign lacks a unique EAR classification of specific space flight items or consistent jurisdiction and classification of Artemis elements, such as the Orion spacecraft, that would simplify the timely exchange of space flight items and technical information with international partners.

With costs for the Artemis campaign likely to reach hundreds of billions of dollars over the next two decades, NASA is trying to make its Moon to Mars plans more sustainable by sharing costs with its international partners. Partners are helping to defray costs by providing a capability—such as space flight hardware and related operations, robotics, or enhanced lunar communication—with a value for the capability determined at the outset of the agreement rather than allocating a specific percentage of costs to each partner or creating an ongoing obligation to include partner astronauts on future missions. Finally, our analysis showed that uncrewed and robotic space flight projects in which NASA works with international partners have, on average, experienced less cost growth despite higher levels of complexity. One possible reason is the use by NASA's international partners of trade studies and firm-fixed-price contracts to aid in controlling project costs. Given its deep space ambitions and current budget profile, NASA will be unable to achieve its long-term Artemis objectives without effectively incorporating international partner cost management strategies.

WHAT WE RECOMMENDED

To increase the effectiveness and affordability of Artemis integration efforts with international partners, we recommended NASA senior leadership (1) establish a coordination strategy with NASA's international partners that includes recurring forums specifically for Artemis Accords signatories interested in participating in the Artemis campaign; (2) establish NASA-led Artemis campaign boards and working groups for partners with agreed-upon commitments and provide opportunities for liaison representation from international partner agencies; (3) issue a detailed strategy and architecture for missions beyond Artemis IV that considers potential international partner roles and responsibilities; (4) perform a detailed gap analysis and cost estimate for Artemis missions beyond Artemis IV that will help inform a cost-sharing strategy with international partners; (5) establish a full-time export control team dedicated to Artemis programs in support of space flight developments; (6) review export control requirements and consider additional roles for partner astronauts to increase their utilization in NASA space flight operations; (7) establish a full-time export control team dedicated to the Artemis programs in support of space flight operations; (8) coordinate with other federal agencies to develop a unique EAR classification for the Gateway program; (9) execute Artemis agreements with key international space agency partners to ensure partner roles and responsibilities are clearly understood and allow for efficient and timely partnerships in support of Artemis; and (10) develop an automated routing method for processing international agreements within NASA to increase timeliness.

We provided a draft of this report to NASA management who concurred with 9 of our 10 recommendations and described planned actions to address them. We consider the proposed actions responsive and will close them upon completion and verification. However, the Agency non-concurred with Recommendation 4 and it will remain unresolved pending further discussions with NASA.

For more information on the NASA Office of Inspector General and to view this and other reports visit https://oig.nasa.gov/.

TABLE OF CONTENTS

Acronyms

ASA	Australian Space Agency
ASI	Agenzia Spaziale Italiana (Italian Space Agency)
CLPS	Commercial Lunar Payload Services
CSA	Canadian Space Agency
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center)
DSN	Deep Space Network
EAR	Export Administration Regulation
ESA	European Space Agency
ESM	European Service Module
ESPRIT	European System Providing Refueling Infrastructure and Telecommunication
GERS	Gateway External Robotics System
HALO	Habitation and Logistics Outpost
HLS	Human Landing System
ICPS	Interim Cryogenic Propulsion Stage
IGA	Intergovernmental Agreement
I-Hab	International Habitation Module
INTA	National Institute of Aerospace Technology
ISA	Israel Space Agency
ISECG	International Space Exploration Coordination Group
ISS	International Space Station
ITAR	International Traffic in Arms Regulation
JAXA	Japan Aerospace Exploration Agency
MBRSC	Mohammed Bin Rashid Space Centre
MOU	Memorandum of Understanding
OIG	Office of Inspector General
OIIR	Office of International and Interagency Relations
PPE	Power and Propulsion Element
SLS	Space Launch System
UAE	United Arab Emirates
UAESA	United Arab Emirates Space Agency

INTRODUCTION

International coordination in space flight has been a fundamental component of the successes that NASA has achieved throughout its history, and collaboration with international entities is key to the Agency's Artemis campaign. The Artemis campaign is working toward landing humans on the Moon by the end of 2025 with the eventual goal of crewed missions to Mars in the 2030s. The Agency's plans are based on significant participation and partnerships with international space agencies and entities who have made or are negotiating long-term commitments to the Artemis effort.

NASA's multi-decade Artemis plans are extremely ambitious, with the Agency taking an important early step as it launched the first test of the combined rocket and capsule on an uncrewed mission to the Moon's orbit in November 2022. Looking forward, besides landing astronauts on the Moon's South Pole, Artemis objectives include biannual robotic and scientific missions to the lunar surface, establishment of an orbiting lunar outpost named Gateway, and development of ground infrastructure on the Moon. Key early commitments from the Canadian Space Agency (CSA), European Space Agency (ESA), and Japan Aerospace Exploration Agency (JAXA) include provision of a Gateway habitat, communications satellites, spacecraft service modules, external robotics, astronauts, and lunar rovers. ESA has also explored the concept of establishing a permanent Moon base, while JAXA is examining ways to upgrade its logistics vehicle currently used to deliver supplies to the International Space Station (ISS or Station).

Orion Spacecraft Stacked on Top of the SLS Rocket for the Artemis I Mission

Source: NASA.

With NASA's contributions to Artemis projected to cost $93 billion between fiscal years 2012 and 2025, NASA officials have repeatedly stated that international partnerships are key to achieving a sustainable and robust presence on the Moon while preparing to conduct a human mission to Mars. NASA is already tapping into its experience working with a wide variety of international partners on the ISS by gaining long-term commitments from many of these same partners for a venture that could span decades. However, international cooperation for Artemis may be hindered by political guidance, budgets, and policies concerning the control of information, both in the United States and abroad.

Our overall audit objective was to examine NASA's efforts to partner with other space agencies for the Artemis missions. Specifically, we evaluated (1) NASA's plans to coordinate and integrate international partner contributions with its Artemis efforts, (2) impediments NASA faces when partnering with

international space agencies, and (3) the cost implications of working with partner space agencies. See Appendix A for details of the audit's scope and methodology.

Background

While NASA did not label its return-to-the-Moon efforts "Artemis" until 2019, the Administration provided guidance to the Agency in 2017 with publication of Space Policy Directive-1 which stated that "the United States will lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars and other destinations."[1] The directive specifically required commercial and international partnerships to achieve a sustained Moon-Mars effort. NASA's plans also recognize the importance of mission sustainability when international partners are involved. The 2020 Artemis Plan—which identified the key science, technology, and human missions, as well as commercial missions needed to achieve the Agency's lunar goals—also highlighted the importance of international partnerships.[2] Although initial lunar planning dates back 5 years, some Artemis efforts began under previous programs and already included international participation. For example, work on the Orion Multi-Purpose Crew Vehicle (Orion) spacecraft that will transport astronauts to the Moon first started in 2006 under the Constellation Program.[3] As a way to pay for its share of ISS common system operations costs, in 2012 ESA agreed to build the service module for the Orion and currently has six European Service Modules (ESM) on contract with the manufacturer (Airbus Defence and Space).[4]

The Artemis Accords

The Artemis Accords (Accords) establish principles for cooperation among civil space agencies and governance on the use of outer space, including the Moon, Mars, comets, and asteroids, to increase the safety of operations, reduce uncertainty, and promote its sustainable and beneficial use for peaceful purposes.[5] The United States and Australia, Canada, Italy, Japan, Luxembourg, United Arab Emirates, and the United Kingdom first signed the Accords on October 13, 2020. Since then, 15 other countries have signed (in the following order): Ukraine, Republic of Korea, New Zealand, Brazil, Poland, Mexico, Israel, Romania, Bahrain, Singapore, Colombia, France, Saudi Arabia, Nigeria, and Rwanda. As of December 2022, 23 countries have signed the Accords. Table 1 describes the agreed-upon principles in the Accords.

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[1] White House Space Policy Directive-1, *Reinvigorating America's Human Space Exploration Program* (December 11, 2017).

[2] NASA, *Artemis Plan: NASA's Lunar Exploration Program Overview* (September 2020).

[3] The Constellation Program was established during the George W. Bush Administration in 2006 and canceled under the Obama Administration in 2010. Constellation was similar to Artemis in that it sought to return humans to the Moon, explore the solar system, and promote international and commercial participation in space exploration.

[4] Common system operations costs are common costs for operating the U.S. Orbital Segment of the Station—to include cargo and crew transportation—that the United States, Canada, Japan, and ESA share in agreed-upon percentages.

[5] The Artemis Accords affirm the importance of compliance with the January 27, 1967, *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies* ("Outer Space Treaty"). The Accords expand on the Outer Space Treaty with a focus on the exploration of the Moon by civil space agencies. However, while the Outer Space Treaty says "States shall be responsible for national space activities whether carried out by governmental or non-governmental entities," under the Accords, the commitment to openly share scientific data is not intended to apply to private sector operations unless such operations are being conducted on behalf of a signatory to the Accords.

Table 1: Artemis Accords Principles

Principle Title	Description
Peaceful Purposes	Conduct activities for peaceful purposes and in accordance with relevant international law.
Transparency	Disseminate information regarding national space policies and space exploration plans in accordance with respective national rules.
Interoperability	Develop interoperable and common exploration infrastructure and standards to enhance space-based exploration, scientific discovery, and commercial utilization.
Emergency Assistance	Render necessary assistance to personnel in outer space who are in distress.
Registration of Space Objects	Register any relevant space object per the Registration Convention.
Release of Scientific Data	Openly share scientific data.
Preserving Outer Space Heritage	Preserve spacecraft, artifacts, landing sites, and other evidence of activity on celestial bodies.
Space Resources	Utilize space resources in a manner that complies with the Outer Space Treaty and in support of safe and sustainable space activities.
Deconfliction of Space Activities	Notify partner nations of operations and coordinate to respect safety zones to prevent harmful interference.
Orbital Debris	Plan for the mitigation of orbital debris, including the safe, timely, and efficient passivation and disposal of spacecraft at the end of their missions.

Source: NASA Office of Inspector General (OIG) summary of Artemis Accords document dated October 13, 2020.

While complementary in nature, signatories to the Accords are not committed to participating in NASA's Artemis campaign. To participate in the Agency's exploration of the Moon, countries and space agencies must enter into separate agreements with NASA that define their level of participation and contributions.

International Participation in Artemis Missions

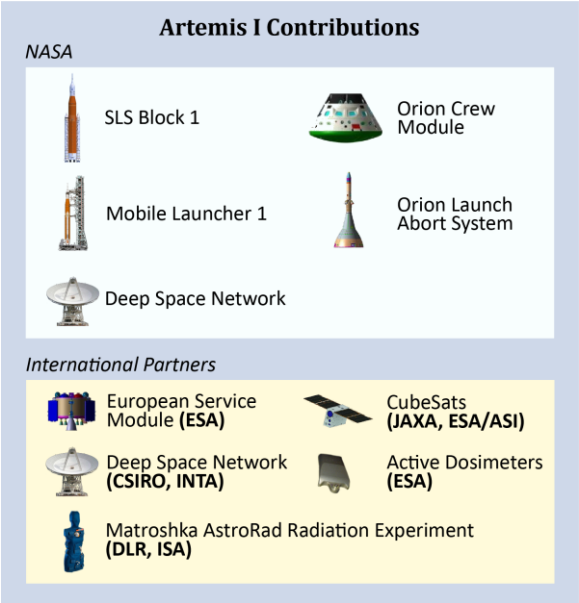
Artemis I

The inaugural flight of the Artemis missions, known as Artemis I, served as an uncrewed test flight for the first version of NASA's Space Launch System (SLS) rocket (known as Block I), the Orion crew capsule, and associated ground systems—such as the Mobile Launcher 1—necessary for launch.[6] While NASA developed nearly all of the major components required for the Artemis I launch, one significant exception is the Orion's ESM, which was provided by ESA.[7] Launched from Launch Complex 39B at Kennedy Space Center on November 16, 2022, the Artemis I mission lasted 25.5 days, circled the Moon, and returned to Earth.

[6] NASA will have two mobile launchers—Mobile Launcher 1, which is already developed, and Mobile Launcher 2, which is currently in development—at Kennedy Space Center that will serve as the ground structure to assemble, process, transport to the pad, and launch various iterations of the integrated SLS/Orion system.

[7] The service module provides most of the propulsion, power, and cooling systems for the Orion crew module.

In addition to testing the SLS and Orion, Artemis I deployed 10 small satellites at various points along the journey to lunar orbit. Known as CubeSats, these shoebox-sized satellites gathered lunar and space data and were developed by NASA, universities, and research centers, as well as international space agencies. JAXA provided two CubeSats to test radiation imaging of the Earth and carry a very small lunar lander, and the Italian Space Agency (Agenzia Spaziale Italiana—ASI) contributed, via a process supported by ESA, one CubeSat to provide imagery and other optical communication capabilities. All Artemis I CubeSats were selected based on their ability to address NASA's Strategic Knowledge Gaps related to exploration of the Moon and Mars.[8] Artemis I also included a set of ESA active dosimeters flying inside Orion along with two identical manikins developed by the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt—DLR) and Israel Space Agency (ISA) to study radiation exposure throughout the mission.[9]



Finally, the Artemis I mission tested NASA's Deep Space Network (DSN) communications capabilities.[10] Though the DSN is funded by NASA and managed by the Jet Propulsion Laboratory, the Agency has separate agreements with Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Spain's National Institute of Aerospace Technology (INTA) to operate antennas in those countries and ensure constant communications availability. The DSN also handled communications for the Artemis I CubeSats.

Commercial Lunar Payload Services

With its first delivery scheduled in 2023 after the Artemis I mission, NASA's Commercial Lunar Payload Services (CLPS) initiative plays an important role in the overall Artemis campaign by delivering NASA, commercial, and international payloads to the Moon. As part of the Lunar Discovery and Exploration Program in the Science Mission Directorate, CLPS awards cover end-to-end delivery services, including integration, launch and landing, and mission operations.[11]

Contractors are encouraged to fly payloads in addition to those for NASA, including from commercial and international partners. For example, one of the first CLPS missions is expected to be Peregrine

[8] Strategic Knowledge Gaps represent gaps in knowledge or information required to reduce risk, increase effectiveness, and improve the design of robotic and human space exploration missions. NASA uses Strategic Knowledge Gaps to help inform research and investment strategies and prioritize technology development for human and robotic exploration.

[9] An active dosimeter provides real-time, chronological radiation exposure monitoring and detection. The Matroshka AstroRad Radiation Experiment is a collaboration between DLR, ISA, Lockheed Martin Corporation, and NASA that uses two female manikin torsos, one wearing a radiation protection vest developed by Israeli company StemRad, to investigate and compare radiation exposure.

[10] The DSN—comprised of giant radio antennas that command, track, and monitor interplanetary spacecraft missions—will handle all communications for Artemis missions once the Orion capsule leaves low Earth orbit, including trajectory corrections and orbital insertion near the Moon. The DSN has antennas located in three main facilities: one near Barstow, California; a second near Madrid, Spain; and a third near Canberra, Australia.

[11] Rather than NASA controlling or overseeing the contractor's designs, systems, processes, or infrastructure, the Agency purchases a service from the company using a firm-fixed-price contract.

Mission 1 from Astrobotic Technology, Inc., which will carry several NASA payloads as well as deliver a lunar rover developed by a British lunar robotics company and payloads provided by four other countries. In fact, three of the first seven CLPS missions have international payloads (see Table 2).

Table 2: Initial CLPS Missions with International Payloads (as of September 2022)

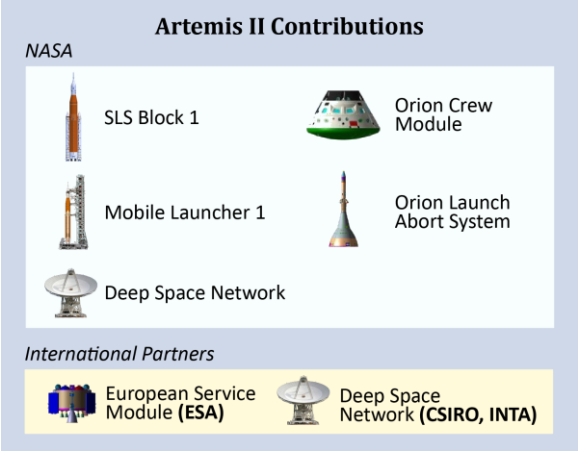
Mission	Contractor	Contract Award	Launch Date	International Payload Description[a]
Peregrine Mission 1	Astrobotic Technology, Inc.	$79.5M	2023	• Small autonomous robots (Mexico) • Personal mementos (Germany) • Rover (United Kingdom) • Commemorative plaque (Hungary) and capsule (Japan) • Radiation detector (Germany)
Blue Ghost Mission 1	Firefly Aerospace, Inc.	$93.3M	2024	• Lunar navigation system experiment (Italy)
Intuitive Machines Mission 3	Intuitive Machines, LLC	$77.5M	2024	• Laser retroreflector (ESA) • Lunar space environment monitor (Republic of Korea)

Source: NASA OIG representation of NASA CLPS information.

[a] The international payloads for Peregrine Mission 1 are all customers for Astrobotic Technology, Inc. while the international payloads on Blue Ghost Mission 1 and Intuitive Machines Mission 3 are partnerships with NASA.

Artemis II

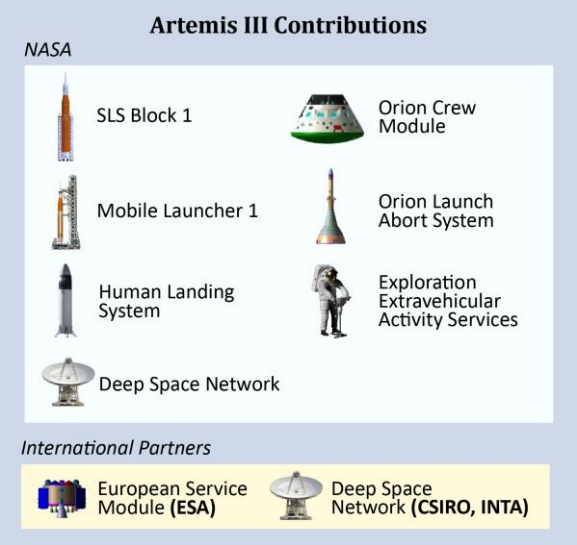
Artemis II, the second lunar test flight, will be the first crewed flight to the Moon since the Apollo Program. Prior to the journey to the Moon and lunar flyby, several capabilities critical for future crewed Artemis missions will be tested. First, the expended SLS upper stage known as the Interim Cryogenic Propulsion Stage (ICPS) will be used as a target for a demonstration of the Orion capsule's handling and provide operational experience for future undocking operations.[12] Next, the crew will evaluate Orion's onboard life support, exercise, and habitation equipment. Finally, NASA's DSN will be assessed to ensure communications capabilities. Once validation of the Orion life support systems is completed, the Orion's ESM will then initiate a trans-lunar injection maneuver and put the four crew members—one of whom will be a Canadian astronaut per an agreement with Canada—on a path towards the Moon.



[12] The ICPS is a single-engine liquid hydrogen/liquid oxygen-based system that provides in-space propulsion after the solid rocket boosters and core stage are jettisoned. During Artemis I, the ICPS gave Orion the push needed to fly beyond the Moon before the spacecraft returned to Earth.

Artemis III

The Artemis III mission will last approximately 30 days and culminate in the landing of two astronauts on the Moon.[13] Following a launch on the SLS rocket, the Orion's ESM and capsule will transport the Artemis crew to lunar orbit. There the Orion capsule will dock with the pre-positioned Human Landing System (HLS) Starship, which two of the crew members will use to travel to the lunar surface. While on the surface for up to a week, the astronauts will leave the HLS to conduct lunar excursions. Upon completion, the HLS will launch from the Moon and return the astronauts to the Orion capsule in lunar orbit before Orion heads back to Earth and lands in the Pacific Ocean.



Artemis IV and Future Missions

While NASA is supplying most space flight elements for Artemis I, II, and III, the missions following the initial Moon landing will incorporate additional partner contributions, including the Gateway, resupply operations, and activities on the lunar surface. At this point in time, the primary international partners for post-Artemis III missions are ESA, JAXA, and CSA.

In late 2024, Artemis IV-related activities will begin with the co-manifested launch of the Gateway's initial elements—the Power and Propulsion Element (PPE) and Habitation and Logistics Outpost (HALO), which will be provided by Maxar Technologies and Northrop Grumman, respectively—and fly on a Space Exploration Technologies Corp. (SpaceX) Falcon Heavy rocket.[14] While HALO is a U.S. component of the Gateway, JAXA will provide its batteries and ESA will provide the HALO Lunar Communication System which is the first element of the European System Providing Refueling Infrastructure and Telecommunication (ESPRIT). During the approximately 12 months it will take for the PPE and HALO to travel to the Gateway's lunar orbit, NASA will finish building the SLS Block 1B—the second version of the SLS rocket—and Mobile Launcher 2 ground system.[15] By 2027 the Agency expects to launch its Artemis IV mission, during which a crewed Orion capsule and the International Habitation Module (I-Hab)—additional living quarters for Gateway crew provided by ESA and JAXA—will launch on the SLS Block 1B rocket to lunar orbit. Once the crew arrives in lunar orbit with the Gateway, they will use the Orion spacecraft to dock the I-Hab to the Gateway, thereby incorporating it into the larger Gateway station. Afterwards, the crew will conduct a lunar landing on an HLS and return to Earth in Orion.

Artemis V's mission in 2028 will include deliveries of additional international contributions to the Gateway (see Figure 1). CSA will provide the Gateway External Robotics System (GERS) with the Canadarm3 delivered to the Gateway via a Deep Space Logistics Specialized Delivery Mission on the

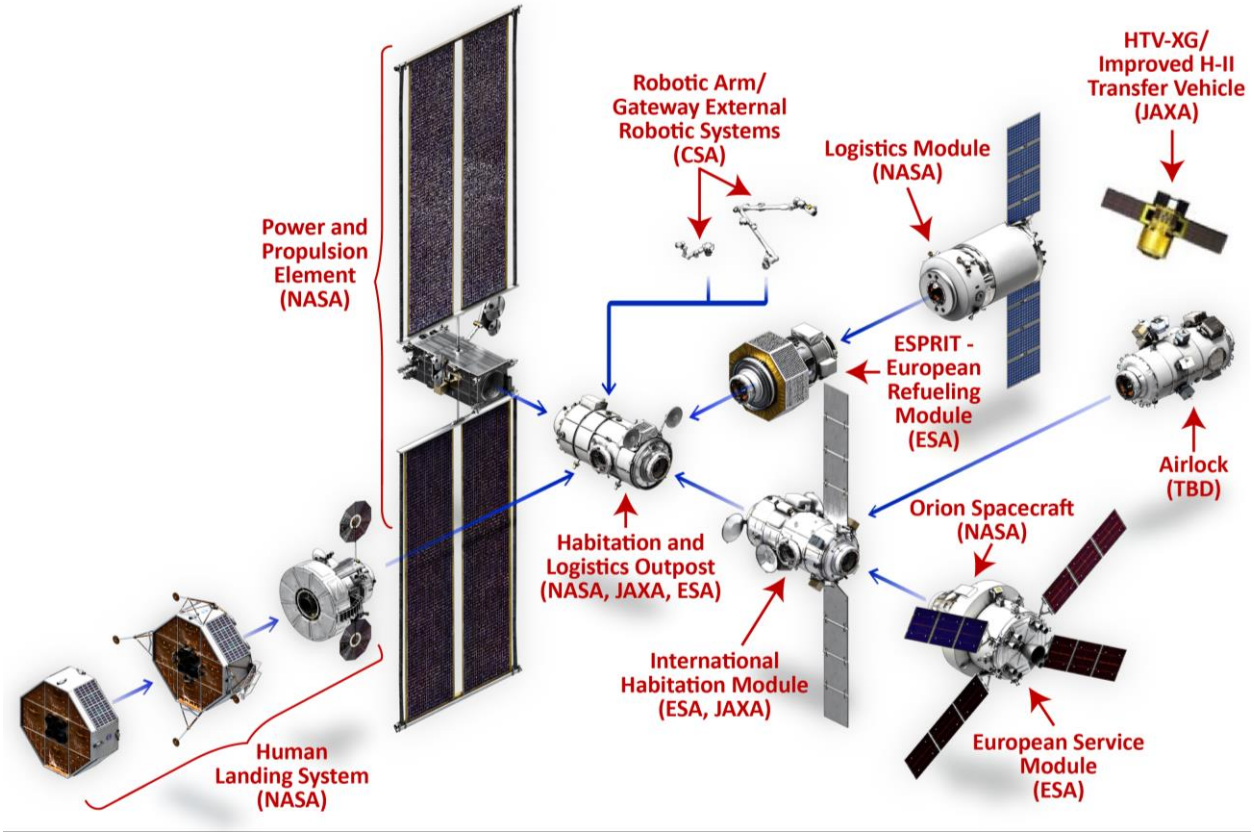
[13] Currently, NASA is committed to landing the first woman and first person of color on the Moon during its Artemis missions.

[14] The PPE will power and propel the spacecraft in orbit while HALO will provide a docking location for the Orion capsule and living and working spaces for crew members staying less than 30 days. Several additional payloads will be launched with the PPE/HALO, two of which will be contributed by international partners: ESA will provide the European Radiation Sensors Array, while JAXA will provide the Internal Dosimeter Array.

[15] After the PPE and HALO are integrated on the ground and launched together, the co-manifested vehicle must rely on Solar Electric Propulsion to arrive at its lunar orbit, a relatively slow method of transportation compared to chemical propulsion.

Gateway Logistics Services contract.[16] GERS will enable ground controllers and the Gateway crew to capture incoming vehicles, conduct science, and perform maintenance on the station. The second element of ESPRIT—the European Refueling Module—also provided by ESA, will supply additional habitable space, cargo storage, refueling capabilities, and windows similar to the European-built Cupola on the ISS.[17] Once the crew completes the integration of GERS and ESPRIT's European Refueling Module with Gateway, they will board an HLS and explore the lunar surface with a pre-positioned Lunar Terrain Vehicle—an unpressurized rover that astronauts can drive on the Moon's surface—provided by NASA.

Figure 1: Planned Gateway Elements by Space Agency (as of November 2022)



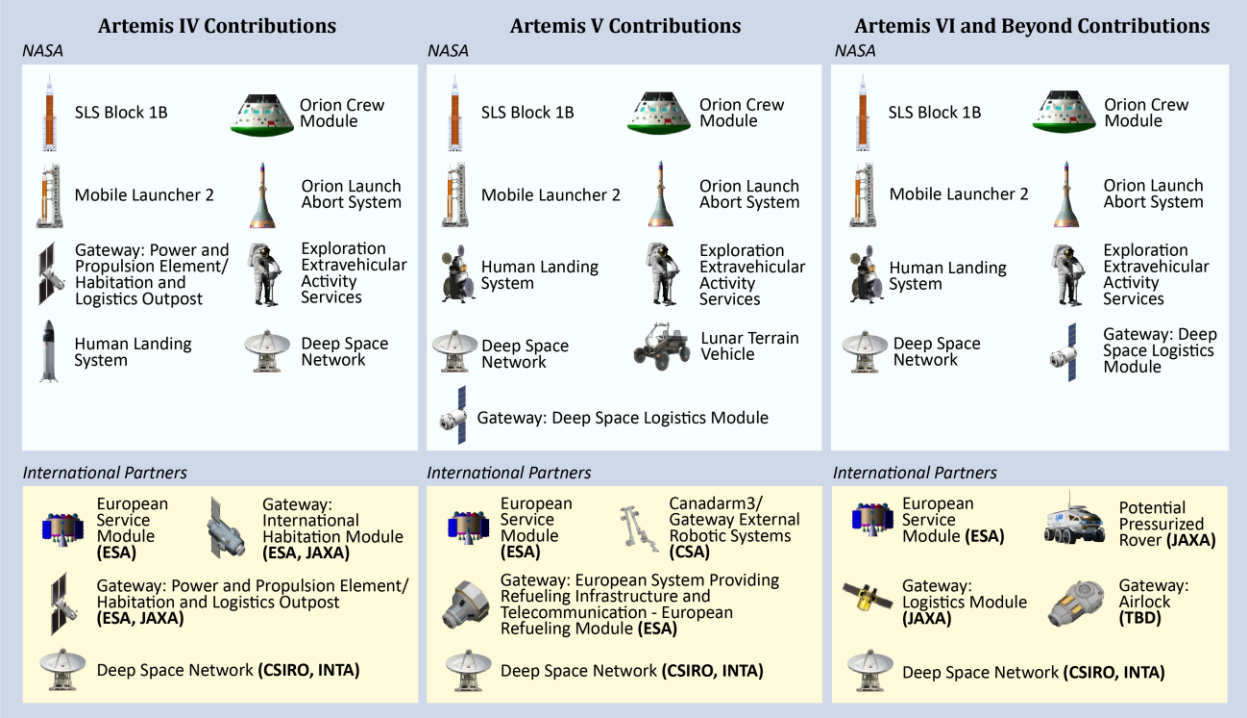
Source: NASA OIG presentation of Agency information.

The Gateway Program is currently in discussions with an international partner to provide a crew and science airlock, which NASA hopes to have ready for delivery on an SLS Block 1B rocket during Artemis VI in 2029. For logistics deliveries, Gateway will continue to use the Deep Space Logistics office for ongoing resupply services. Gateway will augment logistics needs using a new vehicle expected to be provided by JAXA, as the agency is currently developing an improved version of its HTV-X cargo resupply vehicle—

[16] The Deep Space Logistics office at Kennedy Space Center is responsible for procuring services for transporting cargo, equipment, and consumables to enable exploration of the Moon and Mars. The Gateway Logistics Services contract selects U.S. commercial providers to deliver cargo, experiments, and other supplies to the Gateway in lunar orbit.

[17] Contracted by ESA and built under the guidance of Italy, the Cupola is a small module designed for the observation of operations outside the ISS such as robotic activities, the approach of vehicles, and spacewalks. Its six side windows and a direct nadir viewing window provide views of Earth and celestial objects. See the "Italian Space Agency" section in Appendix B for a photo.

HTV-XG—which can be used for Gateway logistics resupply. With regard to the lunar surface, JAXA is working with Japanese automobile partners to develop a pressurized lunar rover, which the agency hopes to be available by the end of this decade. See Appendix B for further information on NASA's international partnerships for the Artemis missions.



To help coordinate these efforts, NASA is creating an architecture or "blueprint" to determine where all Artemis mission contributions, including those from international partners, fit into the Agency's overall Moon to Mars plans. These plans include not just the Artemis campaign but also cargo and crewed missions to Mars. To assist its planning efforts, NASA identified 50 objectives for its Moon to Mars plans and met with current and potential partners in July 2022 during the Farnborough International Airshow in England to receive feedback on those objectives. This feedback helped inform NASA's announcement in September 2022 of the revised 63 objectives that were decided upon.

Policy and Process for International Agreements

The National Aeronautics and Space Act of 1958 identified the need for and encouraged cooperation with the international space community.[18] This guiding principle continues to be a relevant part of current national space policy and the Artemis campaign.[19] International agreements are the legal instrument designed to promote appropriate cost and risk-sharing

> As stated in the 2020 National Space Policy, "the United States will lead and strengthen enduring international partnerships to preserve and sustain future activity and so that all nations and all people can benefit from space and improve our way of living on Earth and in space."

[18] NASA's legal authority to sign international space cooperation agreements and engage in international cooperation is derived from the National Aeronautics and Space Act of 1958, 51 U.S.C. § 10101, et seq., including 51 U.S.C. §§ 20102(d)(7), 20113(e), and 20115.

[19] The White House, *National Space Policy of the United States of America* (December 9, 2020).

among international partners, and augment U.S. capabilities by leveraging existing and planned space capabilities of allies and partners.

Under current Agency guidelines, the Office of the Administrator and Office of International and Interagency Relations (OIIR) are the only NASA organizations permitted to conclude legally binding international agreements.[20] NASA's international agreements are typically coordinated with foreign government agencies but may involve a foreign non-governmental entity wherein each partner funds its respective contributions and all cooperation must be consistent with U.S. foreign policy objectives.[21] Partnerships on NASA projects are required to have scientific and technical merit, exhibit specific benefits to the Agency, and support mission directorate objectives.[22]

Colombia Becomes the 19th Country to Sign the Artemis Accords

Colombian Vice President and Foreign Minister Marta Lucía Ramírez signs the Artemis Accords as NASA Deputy Administrator Pam Melroy looks on at NASA Headquarters on May 10, 2022.

Source: NASA.

Before agreement negotiations begin, OIIR receives an agreement request from NASA program and project offices, visiting researchers, government officials, or international partners. OIIR staff will assemble the draft agreement in the relevant format using standard text based on various factors including NASA's previous relationship with the international partner, the time horizon of the project, the nature of the cooperation, and after consultation with the Office of the General Counsel, appropriate NASA mission directorate, and international partner. OIIR then routes the agreement through NASA Headquarters for concurrence and, if appropriate, submits it to the U.S. Department of State's Bureau of Oceans and International Environmental and Scientific Affairs, for the State Department Office of the Legal Advisor to determine if the Case-Zablocki Act is applicable, requiring State Department approval.[23] The State Department uses five criteria to determine whether an international agreement is governed by the Act: (1) identity and intention of the parties, (2) significance of the arrangement, (3) specificity of the parties' responsibilities, (4) necessity for multiple parties, and (5) the format of the agreement.[24] If the Case-Zablocki Act applies, the Circular 175 (C-175) process is a required step prior to the negotiation of the agreement.

The C-175 process was designed to ensure that international agreements are carried out within constitutional and other legal limits with appropriate involvement by the State Department. For initial review, the State Department receives the draft agreement from NASA, along with any supporting documents, to review and modify. The agreement package then circulates for interagency clearance.

[20] In limited cases, OIIR may "delegate" agreements for development or signature outside of OIIR. However, OIIR is still responsible for entering completed agreements into the System for International and Interagency External Relations Agreements database, which is the official electronic repository for the Agency's international agreements.

[21] International agreements are nonreimbursable or reimbursable agreements when an agreement partner is a foreign entity.

[22] Partner contributions are not required to be equivalent to NASA's contribution.

[23] The Case-Zablocki Act of 1972 (1 U.S.C. § 112b) requires federal agencies to obtain approval from the State Department's Office of Space and Advanced Technology for international agreements that are legally binding under international law and involve significant obligations for the United States.

[24] 22 C.F.R. § 181.2 (2006).

Once clearance is received, the State Department submits the package to the Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs authorization and subsequently notifies OIIR when the C-175 authority has been granted.

After authorization has been received, NASA will negotiate the agreement with the partner to include any additional details and changes raised during each country's review process. Changes from negotiations are subject to a second State Department review known as the final review. At NASA, OIIR coordinates the Agency's compliance with the review process.[25] Agreements may be signed once negotiations between NASA and the partner have concluded and the State Department has finalized its approval. Once signed, the agreement is archived in NASA's System for International and Interagency External Relations Agreements database and a copy is sent to the State Department.

NASA's international agreements may be governed by either U.S. or international law, depending on the partner, nature of cooperation, and other factors.[26] Regardless of the governing law, NASA's responsibilities under any agreement are subject to relevant U.S. laws.

International Instruments for Artemis Missions

International cooperation with foreign partners can take many forms and therefore OIIR determines the type of agreement (instrument) to use based on NASA's relationship with the partner and the nature of cooperation. Table 3 provides a description of the common types of instruments that NASA is utilizing for Artemis.

[25] In some cases, added steps such as language conformance and diplomatic note exchanges accompany the negotiation process.

[26] Per the Space Act Agreements Guide, if an agreement is under U.S. law, it must include the U.S. Federal Law Clause. These agreements may go to the State Department for review. Agreements under international law will go to the State Department for subsequent review and the C-175 process (if applicable). If there is no clause, the agreement is presumed to fall under international law.

Table 3: Common International Instruments Used for Artemis Missions

Format	Description
Space Act Agreement	A broad term for any agreement conducted under the National Aeronautics and Space Act of 1958 to establish a set of legally enforceable commitments between NASA and a partner requiring the obligation of NASA resources. The following agreements are considered Space Act Agreements with the exception of a Statement of Intent.
Intergovernmental Agreement	An agreement between two or more governments for cooperative planning, resource sharing, joint operations, and more.
Memorandum of Understanding	A type of agreement that provides a framework for cooperation under a broad set of guidelines that describe roles and responsibilities between two parties.
Umbrella/Framework Agreement	A government-to-government or agency-to-agency top-level legal construct that establishes the broad basis for cooperation.
Implementing Arrangement	Generally utilized under a Framework Agreement, but also at times under an Intergovernmental Agreement and Memorandum of Understanding, established to implement specific cooperation to include concrete guidelines, provisions, and scope between participating entities.
Letter Agreement	An agreement typically utilized early in a project's formulation or for simple data exchange cooperation.
Statement of Intent	Non-binding instrument used to scope broad, top-level cooperative ideas that will later be included in a legally binding instrument.

Source: NASA OIG summary of Artemis instrument types.

To gain an initial political commitment while a formal agreement is being coordinated and negotiated, the Agency may decide to utilize non-legally binding instruments. Examples of these instruments include Statements of Intent, Letters of Intent, Terms of Reference, NASA "Protocols," or Technical Understandings. These instruments can be advantageous for parties to document proposed responsibilities, advocate for a future project, or represent proposed responsibilities that will be included in a subsequent legally binding instrument. NASA has signed 19 non-legally binding instruments for the Artemis campaign with ASI, ESA, and JAXA, as well as the Brazilian Space Agency; Centre National D'Études Spatiales; the Government of Italy; Japan's Ministry of Education, Culture, Sports, Science and Technology; Luxembourg Space Agency; Polish Space Agency; and the UK Space Agency.[27] These statements include topics such as the intent for lunar cooperation, surface utilization, and exploration.

As of October 2022, NASA had 54 Artemis-related instruments (binding and non-binding) with 22 international entities, representing 15 countries and ESA. Agreements with ESA and JAXA account for 23 of the 54 agreements (43 percent) while the remaining 31 agreements (57 percent) involve international entities and partners from Australia, Brazil, Canada, France, Germany, India, Israel, Italy, Luxembourg, Poland, Republic of Korea, Switzerland, United Arab Emirates, and the United Kingdom. Agreements include ESM contributions, Gateway cooperation under the ISS Intergovernmental Agreement (IGA), launch and post-launch activities on Artemis I, and lunar study agreements.

[27] The number of non-legally binding instruments is based on information as of October 2022.

Table 4: Artemis Instruments with International Partners by Type (as of October 2022)

Corresponding International Partner	MOU	Letter Agreement	Statement of Intent	Implementing Arrangement	Other Instruments	In Negotiation
Australia/ASA					1	
Brazil/AEB			1			
Canada/CSA	1			1		
Europe/ESA	5	2	7	2		
France/CNES			1	1		1
Germany/DLR				1		
India/ISRO				1	1	
Israel/ISA				1		1
Italy/ASI		1	2	2	2	
Japan/JAXA/MEXT	1	4	5		1	
Luxembourg/LSA			1			
Poland/POLSA			1			
Republic of Korea/ KARI and KASI				1		1
Switzerland/ University of Bern		1				
United Arab Emirates/UAESA/MBRSC				1		
United Kingdom/ UKSA	1		1			

Source: NASA OIG presentation of OIIR information.

Note: Memorandum of Understanding (MOU), Australian Space Agency (ASA), Brazilian Space Agency (AEB), Centre National D'Études Spatiales (CNES), Indian Space Research Organisation (ISRO), Ministry of Education, Culture, Sports, Science and Technology (MEXT), Luxembourg Space Agency (LSA), Polish Space Agency (POLSA), Korea Aerospace Research Institute (KARI), Korea Astronomy and Space Science Institute (KASI), United Arab Emirates Space Agency (UAESA), Mohammed Bin Rashid Space Centre (MBRSC), and UK Space Agency (UKSA).

Export Control Considerations

Artemis is a multinational effort which already includes partners from 15 countries and ESA. Given the size and complexity of the endeavor, communication is key to the success of these collaborations, especially in the exchange of project information and technology between partners. That said, NASA has an important responsibility to safeguard the sensitive and often proprietary technologies that are crucial for NASA missions and U.S. national security. Therefore, any exchange of project information and technology between international partners must comply with U.S. export control regulations.[28] Export controls are restrictions applied by the U.S. government to the transfer of certain information or goods, such as software, technical data, and technology, to foreign entities. NASA's Export Control Program works with Artemis-related programs to ensure the appropriate authorizations are in place for exchanging information or equipment. NASA and its contractors are required to obtain licenses prior to exporting certain items and information to international partners. NASA missions and projects may require separate licenses for multiple pieces of equipment or technical information, a process that can take up to 4 months for each license.

U.S. export controls are principally governed by two sets of regulations: International Traffic in Arms Regulations (ITAR) and Export Administration Regulations (EAR). ITAR is administered by the State Department and controls the export of "defense articles," which include space launch vehicles, certain types of spacecraft, and other defense-related services and information that are placed on the U.S. Munitions List.

Administered by the U.S. Department of Commerce, the EAR controls the export of "dual-use" items that have both military and commercial application. Similar to the ITAR, EAR has its own list of regulated exports known as the Commerce Control List. Five factors govern restrictions under the EAR: (1) classification of the item on the Commerce Control List, (2) country of ultimate destination, (3) ultimate end user, (4) ultimate end use, and (5) type of transaction, including methods of contracting and financing. Figure 2 provides a summary of these two export control regulations.

[28] An export is the transfer of anything to a foreign person or destination by any means, anywhere, anytime. An export can involve a commodity, software, technical data, technology, and defense service. NASA's Export Control Operations Manual provides standard processes to implement the Agency's Export Control Program across all Centers. NASA's Export Control Program seeks to ensure that all NASA exports are conducted in accordance with U.S. export control laws and regulations.

Figure 2: Summary of Export Control Laws, Regulations, and Policies (as of September 2022)

The goal of export control laws and regulations is to protect U.S. national security and policy interests. Both the International Traffic in Arms Regulations (ITAR) and Export Administration Regulations (EAR) include criminal and civil penalties for export control violations that can result in monetary penalties, imprisonment, or both.

U.S. Department of State ITAR 22 CFR §120-130	U.S. Department of Commerce EAR 15 CFR §730-774
ITAR controls the export of goods and technical data that are principally used in military or intelligence applications, including critical defense articles, services, and technologies. These items are identified on the U.S. Munitions List and include certain items listed in the Missile Technology Control Regime Annex.	EAR controls goods and technologies that have multiple uses - civil, commercial, and some military - and intelligence applications. These items are identified on the Commerce Control List and include certain items found in the Missile Technology Control Regime Annex.

If an item is listed on the USML or CCL, an export authorization determination is required such as a license, exemption, exception, or no license.

U.S. Munitions List (USML)	Commerce Control List (CCL)
- Military satellites - Military ground equipment - Launch vehicles - Guided and ballistic missiles - Rockets, torpedoes, bombs, mines - Parts critical for military functions - Services of USML and CCL satellites - GPS receivers	- Satellites and ground equipment not on the USML - Radiation hardened integrated circuits - Specified electronics - Specified optical sensors - Parts not on the USML and other CCL - New satellite-related items or technology - Specified radar instruments

Source: NASA OIG presentation of ITAR and EAR laws, regulations, and policies.

In 2009 President Obama announced the Export Control Reform initiative, a comprehensive review of the U.S. export control process, in an effort to reform the system by increasing protections for more sensitive national security items while reducing unnecessary barriers to exporting less-sensitive items.[29] As a result, items such as specific electronic and radar instruments that were once considered ITAR were moved from its U.S. Munitions List to EAR's less restrictive Commerce Control List. In addition, the NASA Authorization Act of 2010 called for export control policies "that protect the national security of the United States while also enabling the United States and its aerospace industry to undertake cooperative programs in science and human space flight in an effective and efficient manner and to compete effectively in the global marketplace."[30]

Despite these reforms, in a 2016 report we found that NASA continued to face significant challenges with U.S. export control regulations when dealing with international partnerships.[31] We reported that U.S. export control regulations hindered dialogue between NASA and its partners, causing frustration

[29] These initiatives were later codified under the Export Controls Act of 2018 (Pub. L. No. 115-232, Subtitle B, Part I), which became law on August 13, 2018.

[30] National Aeronautics and Space Administration Authorization Act of 2010, Pub. L. No. 111-267 (2010).

[31] NASA Office of Inspector General (OIG), *NASA's International Partnerships: Capabilities, Benefits, and Challenges* (IG-16-020, May 5, 2016).

with project planning and implementation and reducing the competitiveness of the U.S space industry. We also noted that several NASA initiatives—the published NASA Export Control Operations Manual, preparing Technology Transfer Control Plans for each program and project, and identifying technical experts to help with export control—could reduce export control burdens.[32]

Impact of Political and Budgetary Processes on NASA Space Exploration Priorities

NASA's space exploration plans often change course with new presidential administrations and even annually as NASA's budget is determined by Congress. While the executive branch sets the vision, the legislative branch codifies the requirements and allocates the funding. Without the support of both branches of government, NASA is limited on what it can accomplish.

In the past 15 years, the Agency's space flight priorities have shifted with almost every presidential administration. In 2004, President George W. Bush announced his "Vision for Space Exploration" that was codified by the NASA Authorization Act of 2005.[33] The Vision for Space Exploration directed NASA to develop a sustained human presence on the Moon, including a robust precursor program for Mars exploration and to promote exploration, science, commerce, and U.S. preeminence in space. As a result, NASA established the Constellation Program in 2006 to achieve its human exploration goals beyond low Earth orbit.

However, in 2009 the Obama Administration sanctioned a review of U.S. human space flight plans which determined that Constellation in its then-current configuration would not succeed. In response, President Obama requested in 2010 that Congress cancel the Program in favor of having private companies develop space flight systems that would take NASA astronauts to low Earth orbit. With resources freed up, NASA engineers would instead focus on developing technology to explore deep space (initially near-Earth asteroids), the moons of Mars, and Mars itself.

When President Trump took office in 2017, he issued Space Policy Directive-1, which once again pivoted the nation's priorities for human space exploration. No longer would NASA's near-term mission be the retrieval of asteroid material, but instead a lunar landing by 2028.[34] In 2019, this goal was accelerated when the Administration committed to sending humans back to the Moon by 2024 in a program eventually renamed Artemis. In 2020, the White House released the National Space Policy, which strongly supported leveraging international cooperation to achieve Artemis goals.

The Biden Administration in 2021 elected to maintain the Artemis campaign—the first major deep space human exploration effort to survive a change in presidents since Apollo—which recently received a fiscal year 2023 appropriation of almost $7.5 billion for its Deep Space Exploration Systems, the funding

[32] Published in 2015, the NASA Export Control Operations Manual provides background information on export control regulations and relevant policies and outlines the general process for identifying controlled information and obtaining licenses. The Technology Transfer Control Plan is created at the beginning of a project to guide the project team in the exchange of information with foreign partners.

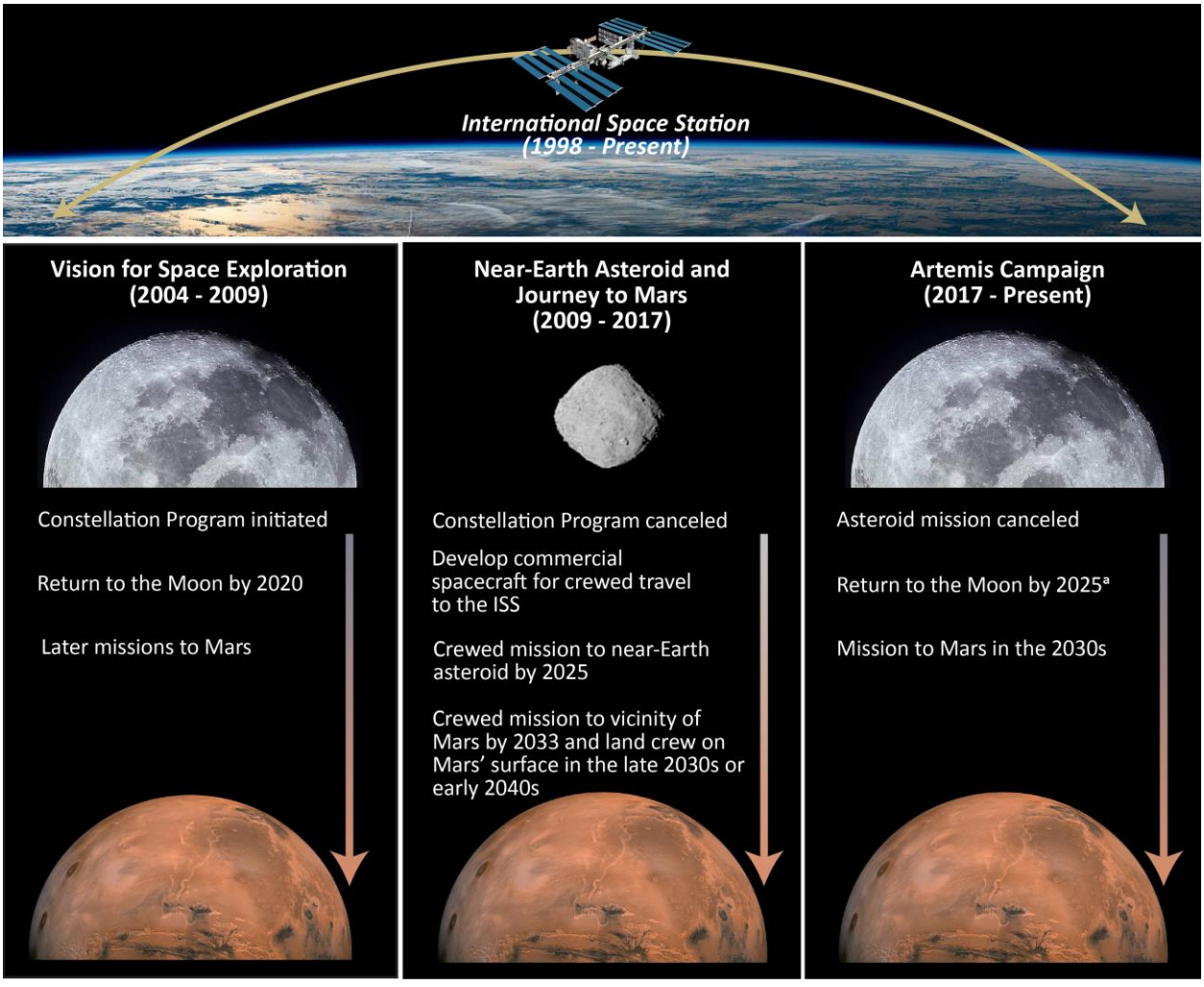
[33] National Aeronautics and Space Administration Authorization Act of 2005, Pub. L. No. 109-155 (2005).

[34] The Asteroid Redirect Mission was intended to develop a robotic spacecraft to visit a large near-Earth asteroid and collect a multi-ton boulder from its surface. It would then redirect the boulder into orbit around the Moon, where astronauts would explore it and return samples to Earth. Space Policy Directive-1 ended this mission.

category under which most Artemis systems fall.[35] Further, the Memorandums of Understanding (MOU) signed in late 2020 between NASA and CSA, ESA, and JAXA for the Gateway signaled the U.S. government's commitment to Artemis and signified to the partners that they could expect a measure of stability at least over the next few years. See Figure 3 for changes in space exploration goals and strategies since 2004.

In contrast to the changes to NASA's deep space human exploration goals across multiple presidential administrations, the ISS Program has operated as an island of stability over the past two decades. To that end, early participation and long-standing commitments by international partners have contributed to the Station's continuous operations with U.S. and partner astronauts in orbit since 2000.

Figure 3: Changes in NASA's Exploration Goal or Strategy (2004 to 2022)



Source: NASA OIG presentation of Agency information.

[a] Originally scheduled for 2028, the return to the Moon date was accelerated to 2024 and has since slipped to at least 2025.

[35] The vast majority of the 2023 Deep Space Exploration Systems appropriations (98 percent) includes Common Exploration Systems Development (Orion, SLS, and Exploration Ground Systems) and Artemis Campaign Development (Gateway, HLS, Advanced Cislunar and Surface Capabilities, Exploration Extravehicular Activity and Human Surface Mobility).

Each respective nation must navigate its government's political and budgetary processes to secure funding for its space endeavors before entering into an international collaboration. For the United States, Congress is ultimately responsible for appropriating NASA's funding.[36] The budgetary process operates on an annual basis and is often significantly delayed as Congress negotiates the final details. In recent history, this has led to months of continuing resolutions—in which programs are temporarily funded at the same level as the previous fiscal year—before the final budget for the year is released, making it difficult for program managers to plan their activities.

CSA and JAXA also prepare annual budgets, whereas ESA operates on a 3-year budget cycle. The ESA Ministerial Council meets on average every 3 years to realign the agency's strategy, during which any major projects are endorsed with funding committed through the next Ministerial meeting.[37] The most recent ESA Ministerial Council meeting was held in November 2022 in Paris, France. ESA officials told us there are pros and cons to allocating funds in this manner. What it offers in stability, it loses in flexibility as it is more difficult to change direction or obtain additional funding mid-cycle.

[36] During the Apollo era, NASA received 4 percent of the federal budget, whereas today that figure is less than half a percent.

[37] The Council is ESA's governing body and provides the policy guidelines within which ESA develops the European space program. Each member state is represented on the Council and has one vote.

INTERNATIONAL INTEREST FOR THE ARTEMIS CAMPAIGN REMAINS HIGH WHILE NASA'S LONGER RANGE PLANS FOR ITS PARTNERS ARE STILL EVOLVING

While interest in NASA's Artemis campaign remains high across the international space community, the Agency lacks an organized plan to coordinate with interested partners and assess the viability of their potential contributions. Although the architecture for the first three missions is well established, NASA does not yet have an overall architecture for exploration of the Moon beyond Artemis IV that includes estimated costs that could be borne by its partners. Several international partners cited this as an issue, and its absence may limit NASA's ability to meet its Artemis objectives if the initial architecture document scheduled to be released in 2023 does not address partner concerns. Additionally, partners are experiencing confusion and a lack of integration into their roles in Artemis given that all current Artemis agreements are pursued bilaterally without an overall cooperative framework that addresses the legal structure, program development, or partner roles and responsibilities.

International Interest in Artemis Is High

Given the scientific and exploration potential that the Moon and Mars hold, NASA's Artemis campaign has drawn significant interest from space agencies around the world. This sentiment was echoed in responses to questionnaires we sent to seven partner space agencies, as well as in many of our interviews with officials from NASA and two of those agencies.[38] The high level of interest is also exemplified by NASA's 54 Artemis-related international instruments and the 23 signatories to the Artemis Accords.

In addition to contributions ESA and JAXA have already committed to providing the Artemis missions—such as service and habitat modules, CubeSats, and a transfer vehicle—both agencies are exploring development of launch capabilities with their Ariane 6 and H3 rockets, respectively, that could provide cargo to the Gateway or lunar surface, potentially saving NASA hundreds of millions of dollars in launch costs. ESA and JAXA officials we met with noted that their agencies are eager to contribute to Artemis in the hopes that their astronauts, many of whom have space flight experience on the ISS, will be included in crewed missions to the Moon. NASA has also implemented agreements with several other space agencies—including those from India for its Chandrayaan-3 lunar lander, Israel for its Beresheet-1 lunar mission, and the United Arab Emirates for its robotic mission to Mars—to contribute in varying degrees

[38] We sent questionnaires to seven space agencies and received replies from each: ASI, CSA, ESA, ISA, JAXA, the Australian Space Agency, and United Arab Emirates Space Agency. We also conducted in-person interviews with officials from ESA and JAXA during site visits to their agency locations in the Netherlands and Japan.

to NASA's Moon to Mars plans.[39] The United Arab Emirates government, whose space agency was formed only 8 years ago, also has an agreement under which Emirati astronauts train alongside NASA astronauts at Johnson Space Center (Johnson) to prepare for future space missions.

NASA's international partners have a wide range of capabilities the Agency can use for future exploration of the Moon and Mars. While many of the confirmed contributions and potential capabilities are complementary, overlap between capabilities will require close coordination by NASA and the partner space agencies. Table 5 shows the confirmed and potential contributions to Artemis missions from NASA and seven international space agencies.

Table 5: Confirmed and Potential Artemis Contributions of NASA and Selected Space Agencies (as of November 2022)

Major Elements for Sustainable Lunar Exploration	ASA	ASI	CSA	ESA	ISA	JAXA	NASA	UAESA
Robotic Exploration	●		●	●	●	●	●	○
Launch Services to Lunar Orbit				○		○	●	
Astronauts			●	●		○	●	○
Crew Transportation				●			●	
Cargo Transportation				○		●	●	
Gateway			●	●		●	●	○
Surface Transportation						○	●	
Surface Habitation		○					○	
Lunar Communications	○	○	○	●		○	●	
Lunar Power Systems			○				○	

Source: NASA OIG representation of partner agency information gained via questionnaires, interviews, and open-source information.

Note: Confirmed contributions (●) and potential contributions (○). In consultation with OIIR, we selected these seven international space agencies because they are either significant contributors to Artemis or notable emerging space agencies. Summaries of these space agencies can be found in Appendix B. Australian Space Agency (ASA) and United Arab Emirates Space Agency (UAESA).

While entirely separate from the Artemis campaign, the Artemis Accords have drawn significant international interest, with 23 countries signed onto the Accords and more in negotiations.[40] Going forward, these countries reflect potentially untapped partner contributions for future Artemis missions. However, with such a high level of interest, NASA faces challenges in managing partner expectations, determining the appropriate level of participation in Artemis, and integrating Artemis contributions

[39] See Appendix C, *NASA International Instruments for Artemis Missions*, for a complete listing of Artemis-related instruments that NASA has signed with its international partners. Chandrayaan-3 is an Indian Space Research Organisation mission that aims to put a lunar lander and rover near the lunar South Pole in 2023. Beresheet-1 was Israel's first lunar mission and the first attempt by a private company to land on the Moon. The mission achieved lunar orbit but was lost during an April 2019 landing attempt. The Emirates Mars Mission, or "Hope Probe" (Al-Amal), launched in July 2020 with an orbiter to study the Martian atmosphere.

[40] NASA officials told us that countries view signing the Accords as an entry point to participation in NASA's lunar missions. Though signing the Accords is not a prerequisite for substantial contributions to—or guarantee of cooperation in—Artemis missions, it is nevertheless noteworthy that a significant number of space agencies have agreed to a common set of principles for peaceful space exploration and development.

from these countries into the Artemis campaign regardless of scope. Given the partners' overlapping capabilities and overriding interest in having astronauts from their countries involved in lunar missions, NASA runs the risk of duplicative efforts, disorganized synchronization of all space flight systems, and potentially disappointing its partners as each vies to get its astronauts to the Moon.

Artemis Missions Need Better Coordination and Integration of International Partner Participation

NASA would benefit from an overarching strategy to coordinate the Artemis contributions of international space agencies or entities. The lack of a coordinated approach makes it difficult for NASA to manage expectations regarding an international partner's potential contribution and creates confusion about what they should contribute. This theme became apparent in responses to our questionnaires and in our on-site meetings with ESA and JAXA officials. In contrast, the ISS Program complies with NASA's program management requirements and has established program boards, panels, and working groups that include its international partners.[41] These forums provide routine opportunities for the ISS Program and its partners to discuss topics such as flight and mission planning, safety, and research integration. The ISS Program also has on-site representatives from their partner agencies—as well as NASA representatives who serve as liaison to ESA and JAXA—to help overcome communication and cultural differences, which Program officials described to us as extremely useful. While the Gateway Program has program boards and panels, the Artemis campaign as a whole does not currently have this level of comprehensive forums for its international partners.

Instead, communication among Artemis participants typically occurs on an ad hoc basis during international space conferences (e.g., the International Astronautical Congress and Space Foundation's Space Symposium), in addition to bilateral interactions between NASA and interested partners.[42] In lieu of routine meetings coordinated by NASA, organizations like the International Space Exploration Coordination Group (ISECG)—a voluntary forum of international space agencies, of which NASA and several other Artemis partners are members—serve as de facto coordination groups for spacefaring nations. In fact, 15 of the 23 Artemis Accords signatories are also members of the ISECG.

Though not a binding document, the 2020 Global Exploration Roadmap Supplement from the ISECG specifies lunar surface exploration objectives and notional elements needed to meet those objectives.[43] Given the overlap between ISECG members and Artemis participants, documents such as the Supplement can serve as valuable starting points for a shared common vision for lunar exploration and settlement. However, these high-level documents lack the details necessary for coordination of highly complex lunar missions and programs such as Artemis.

[41] NASA Procedural Requirements 7120.5F, *NASA Space Flight Program and Project Management Requirements* (August 3, 2021) requires identifying boards and panels and describing any use of special boards and committees in the project plan.

[42] The International Astronautical Congress is an annual event that covers all space sectors and topics with more than 6,000 participants including space agency officials, industry representatives, and scientists. The Space Foundation's Space Symposium brings together space leaders from around the world to discuss and plan for the future of space exploration.

[43] An update to the 2020 Global Exploration Roadmap Supplement was released in October 2022. While the objectives remain the same, the 2022 update includes a chapter discussing the scientific priorities enabled by lunar surface exploration.

Partner Costs, Contributions, Roles, and Responsibilities Are Unclear After Artemis IV

Beyond Artemis IV, NASA lacks an overall architecture (blueprint) for exploration of the Moon that includes estimated costs borne and responsibilities assumed by its international partners. As a result, NASA and its partners are not clear on what type of lunar surface infrastructure they can afford, and partners are unsure of their specific roles and responsibilities. For the first four Artemis missions, NASA established five international partnerships and has generally coordinated the contributions provided by the partners. While there have been numerous discussions in forums such as the ISECG about Moon exploration options, there has been no formal examination of the costs associated with exploration of the lunar surface, nor a formal assignment of partner roles and responsibilities. Although Artemis IV is not scheduled to launch until 2027, given the long lead times associated with developing space flight systems and the lunar infrastructure, commitments by NASA and its partners to develop specific capabilities and systems need to be made sooner rather than later.

During previous space exploration campaigns, NASA developed a detailed system architecture. For example, the Agency's 2009 *Human Exploration of Mars: Design Reference Architecture* included specific details on objectives, launch vehicles, and surface systems. In contrast, neither NASA's Plan for Sustained Lunar Exploration and Development nor the Artemis Plan, both published in 2020, are as robust or include any details as specific as the 2009 document.[44] Additionally, the 2009 document outlined key challenges that NASA faces in pursuit of human exploration of Mars, many of which provided collaboration opportunities with international partners depending on the partners' areas of expertise. In recognition of the importance of a clearly defined architecture, the 2022 NASA Authorization Act notes that successful Artemis missions need "a well-developed and executable timeline, budget, and mission architecture" and "clearly defined roles for NASA, international partners, and nongovernmental partners."[45]

Without a clearly defined Artemis architecture that includes realistic cost estimates, it has been difficult for NASA to fully assess and capitalize on international partner resources and capabilities. This increases the funding risk for NASA's partners—without a clear sense of NASA's needs and the associated requirements, partners do not have sufficient information to work with their governments to identify potential contributions to the effort. Representatives from several international partners that we interviewed expressed frustration about the lack of a detailed lunar surface architecture from NASA, noting that it is difficult for them to develop their own budgets and determine what they can ultimately contribute to Artemis. While budgets for NASA's programs fluctuate year to year, several international partners try to identify their potential contributions years in advance and often require detailed trade studies that examine cost, schedule, performance, and system requirements. Additionally, funding is often more difficult to obtain without binding agreements detailing the specific contribution arrangements.

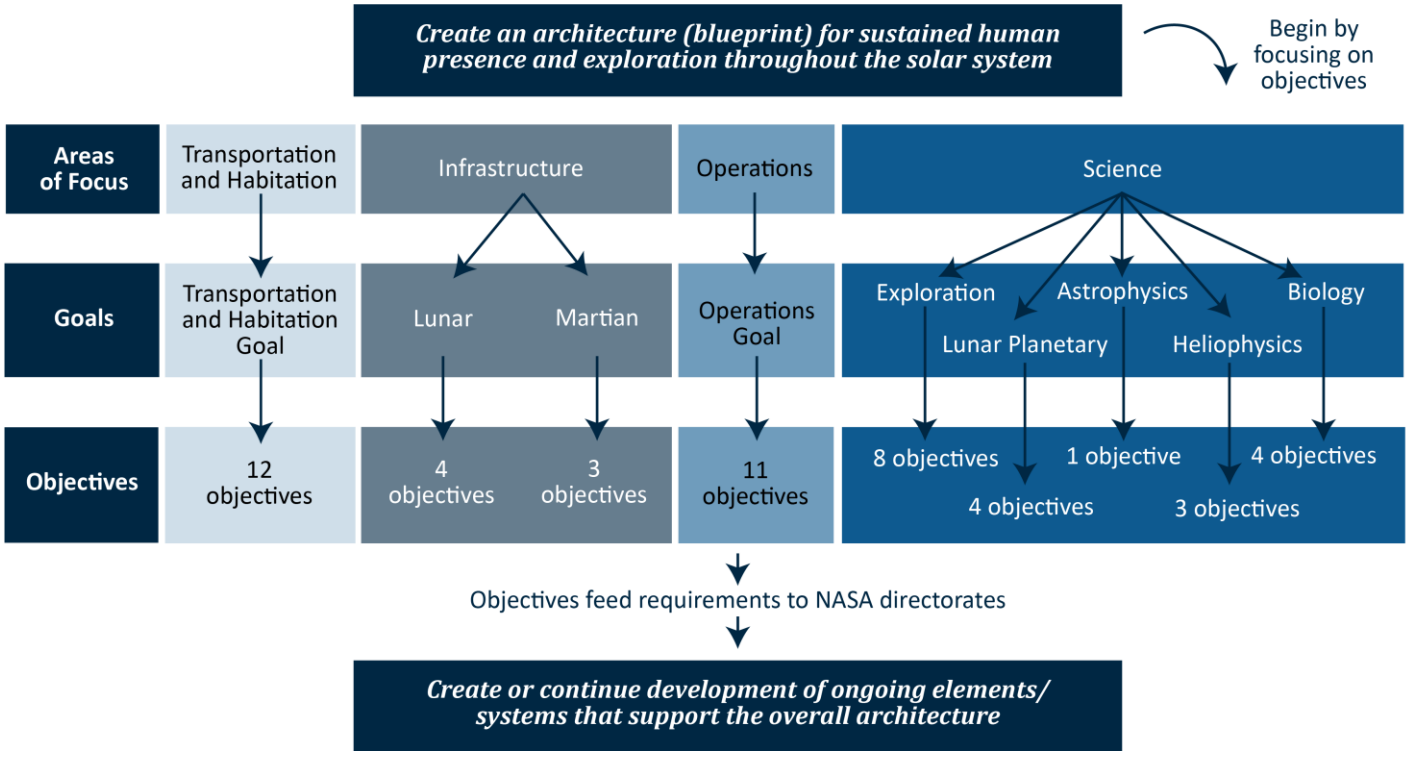
In May 2022, NASA leadership took initial steps to develop such an architecture, seeking feedback on various Moon and Mars exploration objectives that would inform a "blueprint for sustained human presence throughout the solar system" (see Figure 4). The 50 objectives were divided into four areas of

[44] *NASA's Plan for Sustained Lunar Exploration and Development* (April 2020) was released in response to a National Space Council request for a plan for sustained lunar presence. The document briefly describes high-level exploration goals, early Artemis missions, and the elements needed to establish an Artemis Base Camp on the Moon.

[45] National Aeronautics and Space Administration Authorization Act of 2022, Pub. L. No. 117-167 (2022).

focus—Transportation and Habitation, Infrastructure, Operations, and Science—and were developed to outline the overarching goals that drive NASA's architecture, plans, and efforts toward the overall goal. These objectives were refined in part by a gap analysis performed by the Agency (a comparison of current/planned efforts to goals to determine shortfalls), as well as separate workshops during the summer of 2022 for U.S. industry and international partners. After receiving over 5,000 comments on the initial objectives list from these workshops and other feedback processes, NASA updated it to include 13 additional objectives in September 2022. The list now includes a set of "Recurring Tenets"—overarching themes that were common across all objectives—the first of which cites the importance of international collaboration to achieve common goals.

Figure 4: NASA 2022 Blueprint for Sustained Human Space Exploration (as of August 2022)



Source: NASA OIG presentation of Agency information.

NASA's initial lunar surface architecture, in addition to several white papers explaining the Agency's Moon to Mars objectives and architecture development processes, was planned to be completed by late 2022; however, Agency officials told us that early 2023 is more likely and that it will be updated on an annual basis. In January 2023, NASA will hold the first annual Architecture Concept Review during which key Agency stakeholders will assess the initial architecture, as well as discuss draft schedules, cost estimates, and an overall strategy for working with international partners.

This baseline architecture can then be used for planning and budgeting purposes and as a shared vision to ensure alignment across programs, mission directorates, and partner space agencies. NASA would also be able to use the architecture as an evaluation tool to determine how, or if, suggested partner contributions fit within their overall lunar surface framework. While the Agency's actions are encouraging, it is too early to tell if these efforts will adequately clarify the potential funding, roles, and

responsibilities required of international partners for participation in the Artemis missions. NASA's plan to host additional workshops in the future may help coordinate these efforts.

NASA Lacks an Overarching Intergovernmental Agreement for Artemis with Its International Partners

Although increased international cooperation is a key principle of the Artemis Plan, a high-level framework that addresses the legal structure for planned cooperation and contributions on the surface of the Moon has yet to be developed. Currently, all Artemis contributions are pursued through bilateral agreements in which NASA and an interested partner negotiate with each other. NASA's piecemeal approach to executing its bilateral agreements with Artemis partners results in a lack of integration and coordination challenges among partners. Although the Artemis Accords function as a diplomatic instrument to centralize guiding principles, they are not intended to define program development, roles, and responsibilities.

In the absence of an overarching Artemis-related agreement, NASA has used its existing agreement created for international partner contributions on the ISS and applied that framework to development of the Gateway which has similar partners and functions. However, NASA and two key partners acknowledged during our interviews that given the difference in missions, the IGA cannot be used for Artemis activities beyond the Gateway. Moreover, as the ISS IGA was established with four partner countries or entities—CSA, ESA, JAXA, and Roscosmos (Russia's space agency)—and signed by 15 countries, adding additional countries would be extremely time consuming.

The ISS Program utilizes a three-tiered agreement structure which, according to space agency officials we interviewed, facilitates effective communication among NASA and its partners. First, the ISS IGA exists as a foundational agreement that details long-term cooperative legal frameworks. Second, four MOUs between NASA and the cooperating space agencies cover specific provisions, as well as articulate roles and responsibilities, a management structure, and other bases for cooperation. Third, several Implementing Arrangements between ISS partners further detail particular aspects of the MOUs. As shown in the following case study, the ISS represents a successful, large-scale human space flight mission with a detailed legal and operational framework outlining specific international partner contributions and expectations. The challenge for NASA is instituting an Artemis agreement structure that could have more partners than the ISS, includes multiple unique missions to the lunar surface, and holds the partnerships together for decades to come.

International Space Station—
A Case Study in International Collaboration

The ISS has maintained a continuous human presence since 2000 and is supported by five space agencies: NASA, Roscosmos, ESA, JAXA, and CSA. Through a shared vision, a detailed legal framework, and continuing political and budgetary support, the ISS remains the premier example of how international collaboration can result in decades of successful space operations. The first launch and assembly of ISS components occurred in 1998 and subsequent launches of American, Russian, European, Canadian, and Japanese elements helped transform the Station into the world's preeminent orbital platform for research and development. Onboard the ISS, multinational crews conduct unique microgravity experiments in physics, microbiology, human health, and Earth science that advance scientific understanding of our planet, develop advanced technologies, and inspire the leaders of tomorrow. Over the past two decades, 258 individuals from 20 countries have visited the Station while thousands of researchers based on the ground, representing more than 100 countries, have had nearly 3,000 microgravity experiments conducted on the ISS.

ESA Astronaut Works to Complete the Installation of a Solar Array on the ISS

Source: NASA.

The ISS IGA, first signed in 1998, anchors the ISS's three-tiered legal framework for international cooperation. Article 1 of the IGA establishes a long-term international framework on the basis of a genuine partnership for the utilization of a permanently inhabited civil space station for peaceful purposes. The four MOUs below the IGA outline the distribution of roles and responsibilities for operating the Station jointly. The ISS partners used a suite of approaches to cover their portion of the costs related to shared responsibilities based on their contribution to the ISS as a whole. These costs are commensurate with the percentage of the ISS's research resources each of these partners have a right to use. Cost sharing was key to the Station's affordability, given that by 2022 NASA alone has invested approximately $118 billion in the development and operation of the ISS.[46] In addition to the MOUs, a variety of bilateral Implementing Arrangements distribute concrete guidance and tasks among the partners.

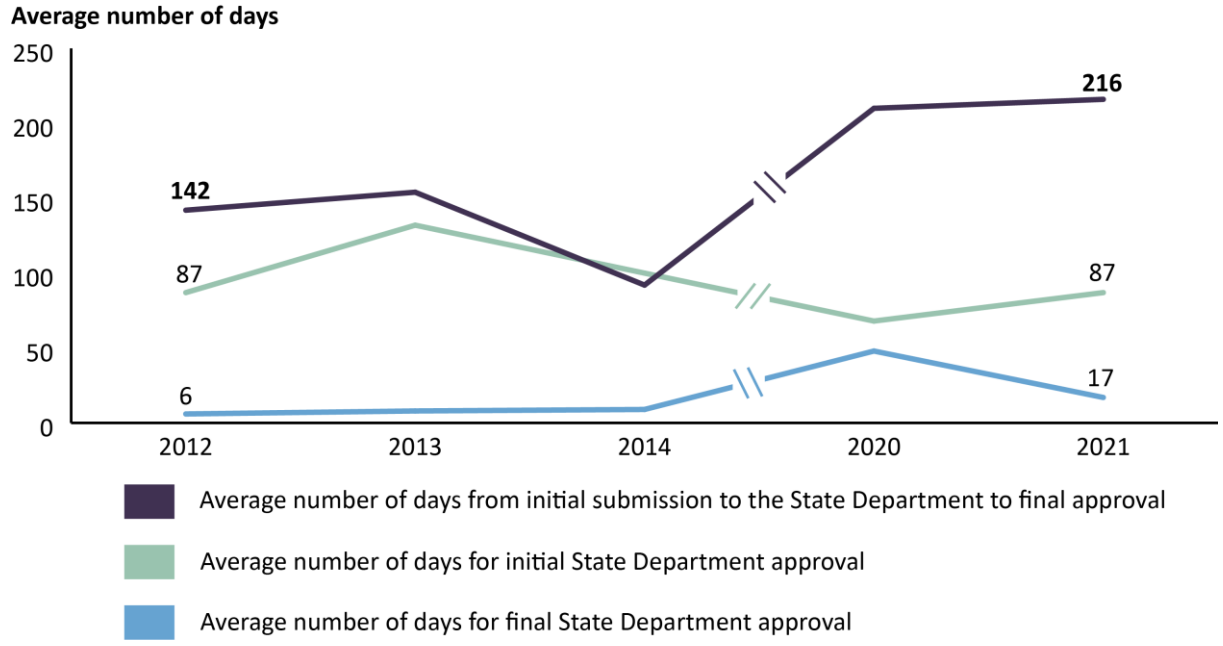
When asked in 2016 about the ISS's legacy, the NASA official who led the negotiations on the IGA stated, "I think that part of the legacy is the fact that it established a framework for all these countries to work together successfully for the long term. What I hope it will have as a legacy for the future is that it's a stepping stone in research, in human spaceflight, in evolution to the next step." In sum, the detailed legal framework that spelled out the responsibilities and commitments of the international partners has been key to 25 years of successful ISS operations 200 miles above Earth.

[46] This figure includes approximately $11 billion for the Space Station Freedom (which although never completed evolved into the ISS); $74 billion for Station development, operations, research, and associated Space Shuttle flights from fiscal years 1994 through 2013; and approximately $33 billion spent from fiscal years 2014 through 2022 to include Commercial Crew Program and development costs. These were actual costs not adjusted for inflation.

Agreement Processing Times Remain Long

Despite initiatives by NASA's OIIR and International Law Practice Group, along with efforts to address observations we made in a 2016 report, the timeline for agreement processing remains lengthy. On average, since 2012, the overall processing time once an agreement is initially submitted to the State Department to when NASA receives final approval for signature has increased a total of 74 days—from 142 days in 2012 to approximately 216 days in 2021. We found that the greatest increase of time is during the negotiation stage with NASA international partners and also during the State Department's final review, which saw an increase from an average of 6 days in 2012 to 17 days in 2021. In our assessment, the increase can be attributed to two factors—errors in processing the agreements and that the State Department has only one primary legal officer and one legal Treaty Affairs officer to review NASA agreements—both of which contribute to lengthy processing.[47] Final approval of an agreement is also subject to approval of a signed memorandum at the Assistant Secretary level or Bureau of Oceans and International Environmental and Scientific Affairs Director level, which can lead to delays if that official is on travel or otherwise busy with higher priority items. State Department officials acknowledged these issues and were trying to improve the process. Figure 5 details the State Department's average number of days to approve agreements, including in total (from initial submission to final approval), as well as initial and final agreement processing review times.

Figure 5: Average Number of Days for the State Department to Approve Agreements (2012 to 2021)



Source: NASA OIG presentation of OIIR information.

Note: Average number of days rounded for initial submission to final approval in 2021 (purple line), for initial approval in 2020 and 2021 (light green line), and for final approval in 2020 and 2021 (light blue line). Data in the graphic is based upon an examination of complete information available for 11 of the 17 agreements in 2020, and 7 of 13 agreements in 2021.

[47] State Department legal staff also have additional backup attorneys who routinely review NASA agreements.

While we attribute the lengthy agreement processing primarily to the State Department's limited staffing and processing errors, OIIR's procedures could be more fully automated to improve processing time. At NASA, OIIR internally routes agreements through email, leaving a margin for error and potential loss of processing time. OIIR moved from an internal paper-based review process for agreement packages to an email-based one in 2020. While this shift was a step in the right direction towards more efficient agreement processing, OIIR staff still do not have access to an agreement at any given point in the process. OIIR does, however, conduct weekly meetings with the State Department to aid in agreement prioritization and to maintain rapport.

In our 2016 report, we suggested OIIR establish more framework agreements with international partners to reduce approval time for Implementing Arrangements and proposed OIIR establish an electronic tracking system for agreements. Other suggestions in the report advised that to speed up the C-175 process, NASA should prioritize the 2-week processing period under a blanket approval for standardized Implementing Arrangements under existing frameworks that was approved in 2014.[48] Since our 2016 report, NASA has completed framework agreements with Brazil (new agreement to replace the old version), the United Arab Emirates, Republic of Korea, ESA (limited to Earth science activities), and New Zealand. OIIR is in the process of executing comprehensive frameworks with Japan, Spain, Luxembourg, Australia, and a new one with Ukraine to replace the old version. Because these framework agreements take considerable amounts of time to complete, NASA is unable to take advantage of the agreed upon 2-week processing period for these Implementing Arrangements. However, even for existing Implementing Arrangements that could fall under the 2-week period, the State Department is not adhering to the limits and the overall processing time has increased. We also suggested NASA discuss the determination of agreement significance with the State Department to potentially reduce the number of agreements that must go through the C-175 process. Due to the high level of investment and legal requirements related to the Artemis campaign, many corresponding agreements are categorized as significant, meaning they are subject to the elaborate but necessary C-175 process.

Regardless of NASA's continued efforts to improve processing times on its end, limited State Department legal staff assigned to review NASA agreements and those of other federal agencies hinder the timeliness of the agreement process. Furthermore, the complexity and magnitude of some Artemis-related agreements that require extensive State Department review increases the risk of potential confusion and longer negotiation processes between NASA and its international partners.

[48] NASA sought and received in June 2014 a modified approval process for new Implementing Arrangements or extensions to existing Implementing Arrangements with each of the countries and agencies with whom NASA has established frameworks in place, with the exception of Canada and Russia. Although this process still requires NASA to submit an Implementing Arrangement to the State Department for approval, it sets a 2-week timeframe for the action officer to obtain all necessary clearances and approvals and to issue guidance to OIIR that allows negotiations with the partner to proceed.

OVERLY COMPLEX AND RESTRICTIVE EXPORT CONTROL RULES HINDER NASA FROM FULLY UTILIZING ITS INTERNATIONAL PARTNERSHIPS

U.S. export control regulations are designed to protect U.S. national interests and intellectual property, but their implementation in international agreements, policies, and how space flight systems are classified routinely limit NASA's Artemis collaborations with international partners and inhibit future collaborations. For example, international agreements do not allow the use of partner astronauts and sharing of export controlled information with them during the periods prior to being assigned a mission and after the conclusion of a mission. In addition, unlike the ISS, the Artemis campaign lacks a unique EAR classification of specific space flight items or consistent jurisdiction and classification of Artemis elements that would simplify the timely exchange of space flight items and technical information with foreign partners. However, other complex programs with international involvement like the James Webb Space Telescope can provide valuable lessons with respect to dealing with and streamlining export control issues that can be applied to NASA's Artemis efforts.

Export Control Authorizations Restrict the Use of International Astronauts and Exchange of Information

In an astronaut's multi-decade career, typically only 30 days to 6 months are served in space. For NASA astronauts, their remaining time is spent on the ground in roles involving training, developing new spacecraft, communicating with other astronauts in space during missions, and serving in various management roles. Our January 2022 audit report examining the Agency's astronaut corps found that an overall corps of 44 was the lowest in 20 years and that NASA may not have a sufficient number of qualified astronauts to serve in these important roles.[49] A number of these important ground-based duties could be fulfilled by international astronauts located at NASA facilities. Moreover, going forward NASA will be integrating significant partner space flight systems into its Artemis campaign that require additional astronaut assistance in operations, development, and training. However, these opportunities are currently not fully realized due to a lack of policy to incorporate foreign astronauts in these roles and by the international agreements signed by NASA and its partners that limit their assignments. Under current conditions, partner astronauts can only receive export controlled information once they are assigned to a specific exploration mission, such as a Commercial Crew launch, Russian Soyuz launch, or Artemis flight. Approval to export is limited to the scope of the international agreement and the availability of an export authorization, leaving NASA unable to utilize the astronaut's expertise for ground-based tasks.[50]

[49] NASA OIG, *NASA's Management of Its Astronaut Corps* (IG-22-007, January 11, 2022).

[50] For Artemis II, NASA plans to begin mission-specific training for astronauts 12 months prior to flight.

Multiple factors related to the export control regime complicate the use of partner astronauts and sharing of information with them. First, a related "requirement" must exist to receive an export control authorization, such as a license, in order to utilize the astronauts. While NASA's international agreements with its partners provide the requirement, existing Gateway agreements currently only provide justification for access to facilities and sharing of information once a foreign astronaut is assigned to a specific mission. In addition, according to NASA officials, even after foreign astronauts are selected to work with NASA by their home agency on a specific program or mission and have a requirement via an agreement, it takes an inordinate amount of coordination and up to 8 months to complete the onboarding and export control processes, given the multiple entities involved in supporting the authorization, particularly if an export license was required. Contractors also present challenges due to their desire to protect their trade secrets and proprietary information. In our judgment, NASA and its contractors need to find the correct balance between protecting information and allowing acceptable access. If these current restrictions and the clearance procedures are left unchanged, it will negatively impact operations of the numerous Artemis space flight systems as partner astronauts increase in number and gain more responsibilities.

Because NASA has not decided whether to increase foreign astronauts' technical roles in its programs, the Agency is missing out on opportunities for international partner astronauts to participate in and contribute more fully to NASA missions. This is a long-standing issue that has frustrated NASA's Astronaut Office for many years. For example, a Canadian astronaut who reported to duty at Johnson in August 2009 and initially worked on the ISS Program—and potentially could be serving on Artemis II—was restricted from participating in Artemis-related activities, including monitoring preparations involving SLS technical data for the Artemis I mission at Kennedy Space Center. Likewise, international partner astronauts are limited in the work they can perform at Johnson's Mission Control Center given the large amounts of proprietary data from commercial contractor activities because contractors will not allow them access to that information. At this point in time, JAXA has opted not to send an astronaut to Johnson to prepare for the Gateway missions since they are not allowed access to NASA's space flight systems despite the fact that Gateway was established as a multinational program.

Export control restrictions also complicate NASA's communication with international partners, impede the use of the partners' knowledge and experience, and present possible barriers to expanding such partnerships. For example, according to NASA officials, foreign partners have been asked to leave meetings related to Artemis, the James Webb Space Telescope, and the launch of The Boeing Company's Commercial Crew Starliner spacecraft to the ISS because export authorizations were not in place and the partners were not "cleared."[51] Looking forward, partner agencies have told us delays in the export control process could present issues during emergency situations in space flight operations when access and information would need to be immediately shared.

NASA Lacks a Unique EAR Classification for Artemis Elements

Export regulations generally restrict the sharing of specified missile technology and space flight technology with international entities. As a result of these restrictions, for example, NASA sometimes limits the technical data it shares with its Gateway partners even though other space agencies are

[51] An authorization is required for anything NASA and its contractors provide to foreign partners. If the authorizations are not in place, foreign partners are not allowed to attend meetings where critical issues are being discussed or will be asked to leave when these issues arise.

providing key subsystems—i.e., ESA and JAXA who are providing service, communication, and habitation modules that will be docked or integrated with the Gateway. Failure to adhere to ITAR restrictions has serious implications for both the Agency and the individual that fails to comply.[52] To streamline the process of reviewing exports to determine jurisdiction and classification and obtaining the necessary export authorizations, NASA has requested a unique EAR classification for certain Artemis-related elements and technology from the State and Commerce Departments—similar to the regulation update implemented for the ISS that released it from the ITAR to EAR. This would ensure a consistent jurisdiction and classification under the EAR for these items.

During the 2009 Export Control Reform initiative, regulations were revised to move certain ISS technical data from under the ITAR to EAR and create a unique EAR classification for the Station's hardware and data. This simplified the process for NASA to exchange hardware and data with international partners, and ensured timely development of the space flight system and continued operations of the Station. Unlike the ISS, NASA lacks a unique EAR classification separating the specific items from ITAR regulations for key Artemis elements such as the Orion and Gateway. Further complicating matters, some Orion components now fall under ITAR while others are restricted under EAR. The Orion Program requested a Commodity Jurisdiction in 2007 that was not granted at the time due to both its placement on the U.S. Munitions List and the view that the components were more sensitive than those used for the ISS.[53] As a result, the Program has had to expend an additional effort to navigate between the separate ITAR and EAR regulations, resulting in additional work by the export control support team.

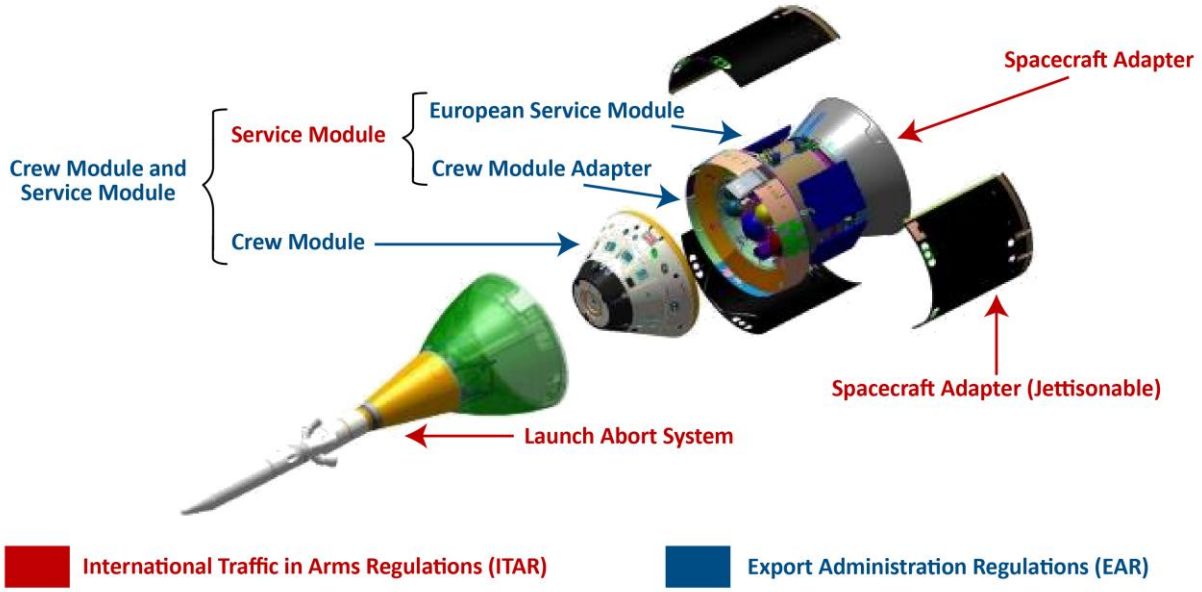
Although the intent of the Export Control Reforms was to simplify the process, according to several export control representatives we spoke to it had the opposite effect.[54] Prior to the initiative, all items within a spacecraft were classified as either ITAR or EAR. However, a spacecraft can now include items that fall under a combination of ITAR and EAR regulations, which has made the process more complicated. Figure 6 illustrates the confusion when Orion spacecraft components individually fall under the ITAR or EAR classifications, but when components are combined to form another system they may be governed by the other regulation. For example, the ESM and Crew Module Adapter are both separately classified as EAR, but when combined together to form the Service Module the system is classified as ITAR. According to NASA officials, this results in an inordinate amount of time spent by export control representatives determining which regulation applies and under what circumstances, and whether the applicable authorization process should be routed to the State Department or Department of Commerce.

[52] ITAR and EAR both contain potential criminal and civil penalties. A failure to comply with ITAR can result in criminal penalties of up to $1 million or 20 years of imprisonment for each violation, and civil penalties of up to $500,000 and debarment from future exports. EAR violations can result in up to $1 million or up to 20 years imprisonment in addition to civil penalties. There can also be administrative action taken with significant consequences. For example, the NASA OIG has investigated multiple cases involving suspected improper release of export controlled information. In one case, the NASA employee elected to retire in lieu of disciplinary action, while in another, that person's employment was terminated, they were denied U.S. citizenship, and sent back to their home country.

[53] A Commodity Jurisdiction request is made to the State Department to determine whether a particular good or service is a product that is covered under the U.S. Munitions List and therefore subject to ITAR restrictions.

[54] These initiatives were later codified under Pub. L. No. 115-232 (2018), which provides detailed legislative authority for the President to implement export control provisions. As a result, items such as specific electronic and radar instruments that were once considered ITAR were moved from its U.S. Munitions List to the EAR's Commerce Control List.

Figure 6: Orion Spacecraft Export Classifications (as of October 2022)



Source: NASA OIG presentation of Agency information.

Like it did with Orion, NASA requested a unique EAR classification for the Gateway in 2021 that is still pending implementation. Without a classification change for the elements, the Program must conduct a time-intensive review and determine the jurisdiction and classification of each export and obtain the necessary licenses from the State or Commerce Departments (or both) when necessary. NASA's International Law Practice Group, which advises the Agency on issues of international concern including export control, supports a change for Gateway that would move classification for the system under the EAR's Commerce Control List, making it substantially easier to exchange information with international partners working on Gateway. However, the rulemaking process of evaluating the technologies that are part of the Gateway's Power and Propulsion Element (PPE) for potential removal from the U.S. Munitions List has not been completed.[55]

NASA initially intended for the PPE to be reviewed through the State Department's Commodity Jurisdiction process in 2019; however, adjudication of that request was delayed by interagency disagreement and withdrawn after 2 years due in part to changes in the underlying configuration of the spacecraft. In 2020, NASA announced that it planned to co-manifest and launch the PPE with another Gateway element, the Habitation and Logistics Outpost (HALO). The combination of the two systems created a new spacecraft that, in turn, changed the relevant facts for the the appropriate jurisdiction and classification analysis.[56] In July 2021, NASA and the related contractors—Maxar Technologies (PPE) and Northrop Grumman (HALO)—completed independent analyses and assessed that the combined PPE

[55] Rulemaking is the process federal agencies use for putting laws into action, usually through regulations.

[56] In February 2020, NASA announced plans to integrate the elements on the ground at Kennedy Space Center and launch the PPE and HALO systems together in November 2023 in a co-manifested payload using a commercial launch service provider—later announced as SpaceX. NASA made this decision in order to reduce risk by avoiding a first-time on-orbit integration of the two elements and to save the cost of a second launch vehicle and service module, a strategy that also gained more time for PPE development.

and HALO system could be submitted for classification under the EAR rather than ITAR. With the system under EAR jurisdiction, the information would be subject to the control of the Department of Commerce, which would simplify the classification of exports and approval of authorizations. While NASA's Export Control Program agreed in principle on a Gateway reclassification with interagency participants approximately a year ago, the process stalled because of a combination of factors that have delayed ITAR regulatory reforms. However, conversations have continued and NASA export control officials said a reclassification could be granted within the next year.[57]

Development of the James Webb Space Telescope provides an illustrative case study in how NASA successfully navigated the complexities of the government export control process.

James Webb Space Telescope Project— A Case Study in Navigating Export Control Complexities

James Webb Space Telescope project officials recognized early in its development that the export control process was going to be complex and could result in delays involving cooperation with their international partners. To address this concern, they established an export control team who became experts in the technologies exchanged with CSA and ESA, and helped facilitate the processing of authorizations to the State or Commerce Departments. Additionally, the project had annual face-to-face discussions with ESA and its Ariane Program—responsible for launching the telescope on an Ariane 5 rocket from Europe's Spaceport located in French Guiana—to discuss all export control issues, review lessons learned from previously addressed issues, and conduct a survey of upcoming issues that might need to be addressed. According to project officials, the meetings proved to be extremely useful in developing guidance that helped gain quicker authorizations from the State or Commerce Departments for the sharing of information.

James Webb Space Telescope Folded Before It Is Encased in the Fairing of an Ariane 5 Rocket for Launch

Source: ESA.

[57] U.S. Munitions List Category XV—which governs spacecraft—is currently under interagency review following a request for public feedback and, according to the Fall 2022 Unified Agenda, the State Department seeks to propose amendments to the category.

INTERNATIONAL PARTNERSHIPS CAN PROVIDE SIGNIFICANT COST BENEFITS TO NASA

With the potential for the Artemis campaign to cost hundreds of billions of dollars over the next two decades, NASA is trying to make its Moon to Mars plans a more sustainable venture by sharing costs with its international partners. While ISS cost sharing provides a successful model for funding a collaborative space flight project, NASA has taken a different, capabilities-based approach for Artemis—and specifically the Gateway—that does not allocate a specific percentage of costs to each partner or create an obligation for NASA to launch international partner astronauts on future missions. In addition, NASA benefits from working with international partners on space flight development in part due to both lower average cost growth on projects and their partners' historical success at controlling project costs. Given its current budget profile, NASA will be unable to achieve its long-term Artemis objectives without effectively incorporating international partner cost management strategies.

Cost-Sharing Strategies with Partners Are Still Evolving for Artemis Missions

NASA has decades of experience assigning costs to partners to help make a program more economically viable and is seeking to do so for the Artemis campaign. For the ISS Program, NASA relies on international partners to contribute almost 25 percent of the costs to run the U.S. segment of the Station.[58] Under the ISS model, rather than making a monetary payment, an international space agency either performs common system operations or provides contributions to offset the obligation—such as the ESM. The percentage of costs contributed is equal to each partner's utilization of Station resources. For example, ESA's contributions alone have totaled almost $7.8 billion over the life of the ISS Program.[59] This model of cost sharing defrays overall costs to NASA and helps ensure the continuity of the program since NASA can rely on that level of funding from its partners year after year.[60] In contrast, under a capabilities model a partner provides a capability such as space flight hardware and related operations and systems engineering, with its value determined at the outset of the agreement. This model more closely resembles a traditional science mission where a partner provides a specific instrument. Using this form of agreement for the Gateway reduces accounting, reduces unbounded obligations on both NASA and the international partners, and enables partners to provide contributions in the future to grow the partnership.

[58] The ISS is divided into two segments—the U.S. Orbital Segment and Russian Orbital Segment. The U.S. Orbital Segment is composed of hardware from JAXA, ESA, CSA, and NASA. While these four agencies share the segment's common system operations costs, Russia alone is responsible for the costs of operating the Russian Orbital Segment. For the U.S. Orbital Segment, JAXA contributes 12.8 percent, ESA 8.3 percent, and CSA 2.3 percent of the shared costs. The remaining 76.6 percent is borne by NASA.

[59] U.S. dollar values based on the euro exchange rate as of October 1, 2022.

[60] The first ISS component was launched in 1998, and the ISS has been continuously occupied since 2000.

In contrast to the ISS, for the first three Artemis missions we estimate that less than 6 percent of the human space flight mission costs will be borne by international partners.[61] Moreover, NASA has specifically elected to move away from the ISS model of cost sharing and instead is using a capabilities approach to the Gateway and other missions. That said, NASA stands to realize significant cost sharing under the capabilities model—potentially tens of billions of dollars—with its partners for the Gateway and future Moon explorations. Partner capabilities include potential launch vehicles, robotics, resupply ships, rovers, and surface habitation (see Table 5). In particular, since launch vehicles are a major cost of space exploration, partners providing these capabilities would likely significantly defray NASA's costs. Clearly, greater cost sharing between NASA and its international partners would better help ensure long-term stability for the Agency's Moon to Mars plans. To further illustrate, the following case study highlights an effective collaboration between NASA and ESA.

[61] For this purpose, mission costs are NASA's production and operations costs of the systems required for the mission, with the exception of the HLS which also includes development costs. Mission costs exclude low cost science payloads, CubeSats, and mission support such as the DSN.

European Service Module—A Case Study in International Collaboration

The ESM is one of ESA's most significant contributions to the Artemis campaign and marks the first time an international partner had a system on a NASA human space flight program's critical path, meaning any slippage would increase the program's duration. The Orion Service Module—which includes the ESM and NASA Crew Module Adapter—is the powerhouse of Orion and is integrated with the Crew Module to form the Orion spacecraft. A NASA official described the collaboration as "cutting an integrated spacecraft in half" with two separate space agencies each responsible for half—presenting a systems engineering and integration challenge.

The ESM was derived from ESA's Automated Transfer Vehicle, which had previously delivered cargo to the ISS but was decommissioned in 2015 after five successful flights. In anticipation of its retirement, in 2012 ESA agreed to provide the ESM for Orion as an offset to their ISS common system operations costs and to compensate NASA for transportation costs to the Station and other supporting services. At that point, Orion's prime contractor Lockheed Martin Corporation was 2 years into their own service module design. When ESA took over, Lockheed Martin was hesitant to share existing designs that they considered proprietary information, forcing ESA to essentially begin with a "clean sheet" design.

The European Service Module Moved to the Lift Station Inside the Assembly Bay at Kennedy Space Center on April 29, 2022

Source: NASA.

In addition to the late start, the number of requirements NASA levied on ESA grew as the project developed and mission parameters changed or were updated, and differing engineering standards had to be negotiated and ultimately agreed upon. ESA also faced intense schedule pressure to meet NASA's ambitious 2016 delivery for a launch that, as of the 2012 agreement, had been scheduled for December 2017. Although ESA did not deliver the first ESM until 2018, its development was not responsible for the delayed launch of Artemis I. Moreover, ESA's spending on the first ESM—650 million euros (nearly $637 million) for ESM development and production costs to fly on Artemis I, and 2.1 billion euros (nearly $2.1 billon) on the ESM program overall—represents the most significant partner monetary expenditure to date for the Artemis campaign.[62]

Despite its challenges, the collaboration is considered a success by both ESA and NASA. Both agencies credit routine communication among NASA, ESA, and prime contractors Lockheed Martin and Airbus Defence and Space at all program levels as a key factor in that success. To date, NASA and ESA have negotiated for the provision of five ESMs for future Artemis missions, with two provided through the Gateway MOU as part of ESA's Gateway partnership contribution and the remaining three as offsets to ISS obligations and services.

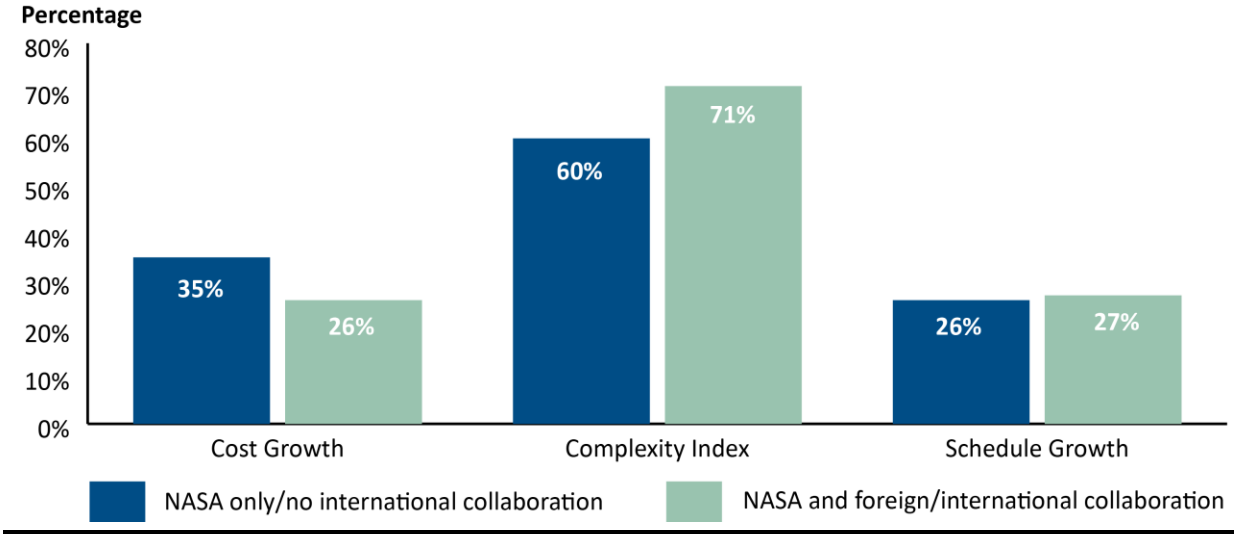
[62] U.S. dollar values as of October 1, 2022.

NASA Space Flight Projects Experienced Less Cost Growth on Average When Working with International Partners

Although limited project management data is available on human space flight projects involving international partners, detailed historical data for uncrewed and robotic projects may be indicative of cost and schedule growth for Artemis programs in the future. At our request as part of this audit, The Aerospace Corporation (Aerospace) in August 2022 updated the study performed during our previous analysis of international partnerships in 2016 and again found the average cost growth for uncrewed and robotic projects with international collaboration is lower in comparison to NASA-only projects, despite being larger in size and scope, more complex, and more expensive overall. Further, schedule slippage on international projects was held within 1 percent of NASA-only projects despite higher levels of technical complexity.

Aerospace concluded that NASA's uncrewed and robotic missions with international collaboration experienced an average of 26 percent cost growth during the development phase compared to 35 percent for NASA projects without such collaboration. The average developmental cost for projects with international partners was $810 million, while missions involving only NASA averaged $440 million. The lower cost growth is noteworthy as projects with international collaboration—such as OSIRIS-Rex and Mars 2020—are, on average, more expensive to develop and more complex.[63] When Aerospace rated the projects' technical complexity, they found international missions were, on average, more complex (71 percent) than those without such collaboration (60 percent). The difference in average schedule slippage was negligible—27 percent for international missions compared to 26 percent for projects run solely by NASA. Figure 7 compares the average cost growth, complexity, and schedule growth of NASA projects with and without international collaboration.

Figure 7: Average Cost Growth, Complexity, and Schedule Growth During Development for Uncrewed and Robotic Missions from 1989 to 2021

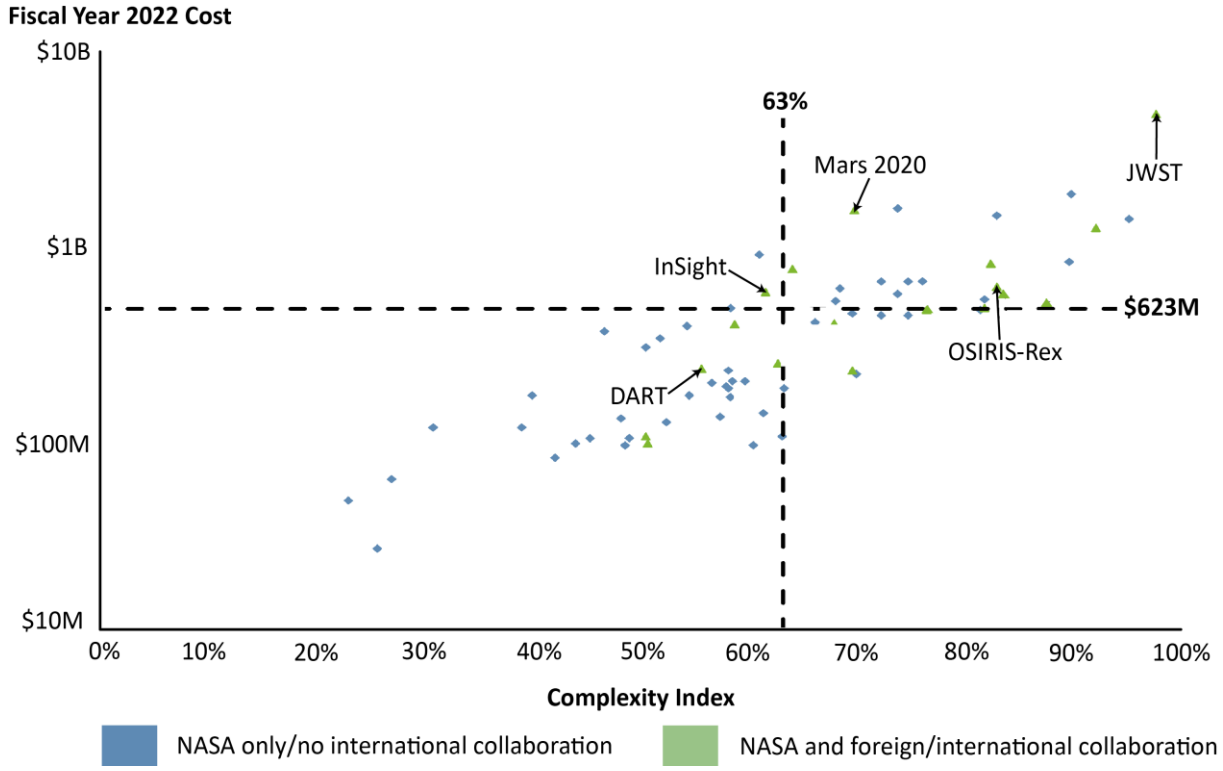


Source: NASA OIG presentation of Aerospace data.

[63] OSIRIS-Rex launched in 2016 to travel to the near-Earth asteroid Bennu and will return a small sample back to Earth in 2023. Mars 2020 launched in 2020 and landed in 2021 on Mars to search for signs of microbial life.

While the complexity of NASA's uncrewed and robotic projects with international partners tends to be greater, so does the overall cost of the missions. Figure 8 shows that missions with international collaboration trend towards being both more complex and more expensive.[64]

Figure 8: Cost and Complexity Relationship for NASA-Only Projects Compared to Projects with International Collaboration



Source: NASA OIG presentation of Aerospace Corporation data.

As part of their study, Aerospace offered several possible reasons for the lower cost growth in NASA projects with international collaboration. They found that international partners may provide improved cost estimates at the outset of a project that help inform budgeting; additional clarity on requirement identification, deconfliction, and coordination; and additional focus on preventing possible cost overruns. Likewise, ESA officials told us that detailed trade studies and thorough cost estimates are how they gain an understanding of costs and technical requirements prior to embarking on a project. Because trade studies can aid in firming up requirements early in the project's life cycle, ESA is often able to use firm-fixed-price contracts—in which the contractor agrees to deliver a product or service at an agreed-upon and firm set price—which result in less cost growth.[65]

[64] We selected five partnered missions to highlight in this graph (1) OSIRIS-Rex; (2) InSight—the Interior Exploration using Seismic Investigations, Geodesy and Heat Transport—launched and landed in 2018 on Mars to study the planet's crust, mantle, and core; (3) Mars 2020; (4) DART—Double Asteroid Redirection Test—launched in 2021 and in 2022 successfully tested the technology needed to defend Earth from asteroids or comet hazards; and (5) JWST—James Webb Space Telescope. We selected these five projects due to their high level of international participation and the general public's awareness of the projects.

[65] Fixed-price contracts provide a set price which does not change even if the contractor's costs increase during the performance period. However, this does not hold true if the government issues requirement changes to the contractor.

While we did not independently verify the extent to which these factors have an impact on the costs of ESA projects, NASA has had prior success with managing cost growth and holding contractors accountable on fixed-price contracts, namely with its Commercial Crew Program. SpaceX's contract has experienced only a 5 percent cost growth during development. Moreover, The Boeing Company has absorbed nearly $1 billion in losses due to its unsuccessful performance to date with the Starliner, losses NASA would have otherwise been responsible for had the contract been cost-reimbursement. In comparison, the Artemis Exploration Systems Development programs' major contracts are cost-reimbursement—in which the Agency agrees to pay all allowable costs the contractor incurs in delivering the service or product—and have experienced a 41 percent cost growth in development since 2014.[66]

[66] Exploration Systems Development Division consists of three major programs: Orion, SLS, and Exploration Ground Systems.

CONCLUSION

NASA's international partners are committed to the Artemis missions and bring multiple capabilities to this multi-decade endeavor, including spacecraft, astronauts, communication systems, launch vehicles, and ground capabilities on the Moon's surface. However, NASA's approach to engaging these interested partners would benefit from a cohesive strategy and forum to coordinate its efforts. Futhermore, the Agency lacks both an overall architecture for human exploration of the Moon beyond Artemis IV that includes cost and an overall cooperative framework that addresses legal structures, program development, and partner roles and responsibilities. While the Agency is in the process of developing a lunar surface architecture, the lack of an overall blueprint creates an integration vacuum and confusion among partners, jeopardizing international partners' long-term participation in NASA's Moon to Mars plans.

In our 2016 report on NASA's international partnerships, we highlighted the negative impact that U.S. export control regulations have on international collaboration. In this audit, we noted additional specific impediments: the inability to use foreign astronaut resources prior to and after mission activities and the time-intensive nature of export control that would allow for the effective exchange of information with foreign partners. These issues can be attributed in part to the restrictive wording in international agreements and the lack of EAR classification for specific Artemis space flight items. To help process export control authorizations, we found that other complex programs with international involvement, like the James Webb Space Telescope, were able to minimize negative effects with a dedicated export control team.

Finally, NASA has significant incentives to work with international partners on Artemis, such as sharing costs to help make the Agency's exploration goals achievable and sustainable. NASA benefits from working with international partners on space flight development projects in part due to lower average cost growth compared to NASA-only projects without such collaboration. With NASA's current budget profile projecting $93 billion in Artemis costs between fiscal years 2012 and 2025, more effective international partner participation and cost management strategies would better position NASA to achieve its long-term Artemis objectives.

RECOMMENDATIONS, MANAGEMENT'S RESPONSE, AND OUR EVALUATION

To increase the effectiveness and affordability of Artemis integration efforts with international partners, we recommended the Associate Administrator for Exploration Systems Development Mission Directorate and the Director of Space Architectures, in conjunction with the Associate Administrator for International and Interagency Relations:

1. Establish a coordination strategy with NASA's international partners that includes recurring forums specifically for Artemis Accords signatories that are (or are interested in) participating in the Artemis campaign.
2. Establish NASA-led Artemis campaign boards and working groups for partners with agreed-upon commitments with NASA, and provide opportunities for liaison representation from international partner agencies.
3. Issue a detailed strategy and mission architecture for beyond Artemis IV that considers potential international partner roles and responsibilities.
4. Perform a detailed gap analysis and cost estimate for Artemis missions beyond Artemis IV that will help inform a cost-sharing strategy with international partners.
5. Establish a full-time export control team dedicated to the various Artemis programs in support of space flight developments.

In addition, we recommended the Associate Administrator for Space Operations Mission Directorate:

6. Review export control requirements and consider additional roles for partner astronauts to increase their utilization in NASA space flight operations, to include amending existing agreements if necessary.
7. Establish a full-time export control team dedicated to the Artemis programs in support of space flight operations.

We also recommended the Associate Administrator for International and Interagency Relations:

8. Coordinate with other federal agencies to gain a unique EAR classification for the Gateway as appropriate.
9. In conjunction with NASA's Mission Directorates and the State Department, execute appropriate Artemis agreements with key international space agency partners to ensure partner roles and responsibilities are clearly understood and allow for efficient and timely partnerships in support of Artemis.
10. Develop an automated routing method for the processing of international agreements within NASA.

We provided a draft of this report to NASA management who concurred with 9 of the 10 recommendations in the report. We consider management's comments responsive to

Recommendations 1, 2, 3, 5, 6, 7, 8, 9, and 10 and therefore these recommendations are resolved and will be closed upon completion and verification of the proposed corrective actions. The Agency non-concurred with Recommendation 4 and we find its proposed actions unresponsive. Consequently, this recommendation will remain unresolved pending further discussions with the Agency.

NASA non-concurred with Recommendation 4, which addresses the need to perform a detailed gap analysis and cost estimate for Artemis missions beyond Artemis IV that will help inform a cost-sharing strategy with international partners. NASA's official response to this recommendation follows a pattern of non-concurrences with previous Office of Inspector General recommendations that identified the need to determine the overall cost of the Artemis campaign and each individual Artemis mission. For this report, the Agency stated in its response that the Artemis campaign is not bounded in such a way as to accommodate conducting a cost estimate, but that NASA's processes to consider partnerships include determining resource availability. While "resources" encompasses many of the other factors NASA considers in its existing processes—such as workforce, industrial base capability, supply chain, and timing—it is only through a comprehensive cost estimate that NASA can appropriately incorporate the effects of funding availability into its analysis. NASA's continued refusal to estimate the cost of the Artemis campaign hinders the Agency's processes of considering international partnerships, reduces insight and transparency into the affordability of Artemis and, in turn, makes it more difficult to determine international partners contributions needed to make the campaign successful.

Management's comments are reproduced in Appendix D. Technical comments provided by management and revisions to address them have been incorporated as appropriate.

Major contributors to this report include Ridge Bowman, Human Exploration Audits Director; Kevin Fagedes, Assistant Director; Gina Bartholomew; Kelsey Dalton; Anna David; Tyler Martin; Daniel Mills; Tyler Mitchell; Lauren Suls; and Shani Dennis.

If you have questions about this report or wish to comment on the quality or usefulness of this report, contact Laurence Hawkins, Audit Operations and Quality Assurance Director, at 202 358 1543 or laurence.b.hawkins@nasa.gov.

PAUL MARTIN

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Date: 2023.01.12 12:27:37 -05'00'

Paul K. Martin
Inspector General

APPENDIX A: SCOPE AND METHODOLOGY

We performed this audit from January 2022 through December 2022 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

In this audit, we examined NASA's efforts to partner with international space agencies in support of the Artemis missions. Specifically, we evaluated NASA's plans to coordinate and integrate international partner contributions to its Artemis efforts, what impediments NASA faces when partnering with international space agencies, and the cost implications of working with partner space agencies.

Our review was conducted at Johnson Space Center, Marshall Space Flight Center, ESA, and JAXA. In addition, we conducted interviews with NASA senior officials and staff from OIIR; the Office of Technology, Policy, and Strategy; the Office of the Chief Financial Officer; the Exploration Systems Development and Science Mission Directorates; the Advanced Exploration Systems Division (now Artemis Campaign Development Division); and the Gateway, ISS, James Webb Space Telescope, and Orion Program Offices. We also interviewed legal counsel from the International Law Practice Group, NASA astronauts from the Astronaut Office, and officials from the State and Defense Departments. The audit team led two group sensing sessions—with export control representatives and OIIR personnel—to identify issues from small groups of subject matter experts in a non-attributional setting.

We sent detailed questionnaires to survey seven international space agencies and all agencies provided responses through written correspondence. Two provided information through onsite interviews. The results of these surveys are incorporated in the report and in Appendix B. In June and July 2022, we visited ESA and JAXA, during which time we conducted interviews with agency officials and observed agency operations. For ESA, we also conducted interviews with one of their commercial contractors and observed their operations.

We performed document reviews of federal, NASA, and other criteria; partner international agreements; agreement processing metrics; the Global Exploration Roadmap Supplement; NASA's Plan for Sustained Lunar Exploration and Development; the Artemis Plan; NASA organizational charts; the Artemis mission manifest; export control laws, regulations, and tracking sheets; NASA budgetary documents; relevant contract information and cost data; prior NASA Office of Inspector General and Government Accountability Office audit reports; and the Government Auditing Standards Yellow Book.

The Aerospace Corporation

We engaged Aerospace to perform a data analysis on the cost, schedule, and complexity implications of uncrewed and robotic space flight projects involving only NASA, projects where NASA collaborated with other U.S. agencies, and projects where NASA engaged in international collaboration. Aerospace maintains a significant data set for the examination of relationships between uncrewed and robotic space system costs and schedules and the implications of various collaboration approaches. For this analysis, Aerospace assembled cost and schedule data for more than 100 missions launched over the

past 30 years (1989 to 2021) using an Aerospace-developed database of mission technical specifications, costs, development time, and cost and schedule growth during development.

To understand how technical complexity relates to budget and schedule, a complexity index model was derived based on performance, mass, power, and technology choices to arrive at a broad representation of the system for the purposes of comparison. Aerospace uses a complexity index—a matrix of 30 to 40 technical factors to place, in rank order, the complexity of a particular spacecraft relative to all the other spacecraft in the data set. Complexity is tied to demonstrable objective technical parameters (e.g., number of instruments, mass, power, performance, subsystem characteristics, pointing accuracy, downlink data rate, technology choices). These descriptive parameters are normalized based on the applicable range as designated by the programs in the database, that is, they are given as percentile values for the data set. The total flight system development cost (payload instruments and spacecraft bus, excluding launch and operations) is the independent variable against which the complexity is compared.

We also engaged Aerospace to conduct a new study focusing on NASA human space flight programs and projects to begin developing an analysis on the cost, schedule, and complexity. Aerospace did not have this data readily available, so this was considered a new data collection effort. Aerospace included 19 human space flight missions in the model. The cost and schedule data available was limited, and there was not a large enough sample to draw statistical conclusions. The complexity-based risk assessment model developed for human space flight missions uses the same methodology as that of the uncrewed and robotic missions. Complexity parameters include mass, power, mission duration, destination, crew size, habitable volume, and system type.

Assessment of Data Reliability

We relied upon limited computer-generated data as part of performing this audit. We assessed the reliability of the data generated by NASA's System for International and Interagency External Relations Agreements database for international agreements by reviewing existing information about the data and system that produced them, as well as interviewing Agency officials knowledgeable about the data. We also assessed the reliability of data generated by NASA's Concur travel database by (1) verifying the data with NASA Office of Inspector General's Office of Data Analytics, (2) reviewing existing information about the data and system that produced them, and (3) performing tests for obvious errors in accuracy and completeness. We determined that the data was sufficiently reliable for the purposes of this report.

Review of Internal Controls

We assessed internal controls and compliance with laws and regulations necessary to satisfy audit objectives. However, because our review was limited to these internal control components and underlying principles, it may not have disclosed all internal control deficiencies that may have existed at the time of this audit.

Prior Coverage

The NASA Office of Inspector General and Government Accountability Office have issued 21 reports of significant relevance to the subject of this report. Unrestricted reports can be accessed at https://oig.nasa.gov/audits/auditReports.html and https://www.gao.gov, respectively.

NASA Office of Inspector General

NASA's Management of the Mobile Launcher 2 Contract (IG-22-012, June 9, 2022)

NASA's Volatiles Investigating Polar Exploration Rover (VIPER) Mission (IG-22-010, April 6, 2022)

NASA's Management of Its Astronaut Corps (IG-22-007, January 11, 2022)

NASA's Management of the International Space Station and Efforts to Commercialize Low Earth Orbit (IG-22-005, November 30, 2021)

NASA's Management of the Artemis Missions (IG-22-003, November 15, 2021)

Artemis Status Update (IG-21-018, April 19, 2021)

NASA's Management of the Gateway Program for Artemis Missions (IG-21-004, November 10, 2021)

NASA's Management of the Orion Multi-Purpose Crew Vehicle Program (IG-20-018, July 16, 2020)

Audit of NASA's Development of Its Mobile Launchers (IG-20-013, March 17, 2020)

NASA's Management of Space Launch System Program Costs and Contracts (IG-20-012, March 10, 2020)

NASA's Management of Crew Transportation to the International Space Station (IG-20-005, November 14, 2019)

NASA's Management of the Space Launch System Stages Contract (IG-19-001, October 10, 2018)

NASA's Management and Utilization of the International Space Station (IG-18-021, July 30, 2018)

NASA's Plans for Human Exploration Beyond Low Earth Orbit (IG-17-017, April 13, 2017)

NASA's International Partnerships: Capabilities, Benefits, and Challenges (IG-16-020, May 5, 2016)

Government Accountability Office

NASA Lunar Programs: Improved Mission Guidance Needed as Artemis Complexity Grows (GAO-22-105323, September 8, 2022)

NASA: Assessments of Major Projects (GAO-22-105212, June 23, 2022)

NASA Lunar Programs: Significant Work Remains, Underscoring Challenges to Achieving Moon Landing in 2024 (GAO-21-330, May 26, 2021)

NASA Human Space Exploration: Significant Investments in Future Capabilities Require Strengthened Management Oversight (GAO-21-105, December 15, 2020)

Export Controls: State and Commerce Should Improve Guidance and Outreach to Address University-Specific Compliance Issues (GAO-20-394, May 12, 2020)

NASA Lunar Programs: Opportunities Exist to Strengthen Analyses and Plans for Moon Landing (GAO-20-68, December 19, 2019)

APPENDIX B: INTERNATIONAL SPACE PARTNERSHIPS FOR ARTEMIS MISSIONS

We examined the overall capabilities of NASA's international partners for the Artemis missions. As part of our review, we visited ESA and JAXA as well as Thales Alenia Space in Italy and surveyed the seven international partners listed in Table 6 regarding their goals for lunar exploration, capabilities and skills, thoughts on the Artemis campaign, and barriers to international cooperation. The following summaries provide information about the governance, budget, key Artemis projects, capabilities, and opportunities for cooperation between NASA and its international partners.

Table 6: Select International Partners and Associated Space Agencies for the Artemis Missions

International Partner	Space Agency
Australia	Australian Space Agency (ASA)
Canada	Canadian Space Agency (CSA)
Europe/22 member states[a]	European Space Agency (ESA)
Israel	Israel Space Agency (ISA)
Italy	Agenzia Spaziale Italiana (Italian Space Agency/ASI)
Japan	Japan Aerospace Exploration Agency (JAXA)
United Arab Emirates	United Arab Emirates Space Agency (UAESA)

Source: NASA OIG.

[a] The 22 member states of ESA are Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, and the United Kingdom.

Australian Space Agency

Australia has a long history of working with NASA on space exploration and has been an integral contributor for every deep space mission the Agency has flown to date, including the Apollo 11 Moon landing. The Australian Space Agency (ASA) began operations in July 2018 with a mission to provide the Australian National Space Policy, coordinate government civil space matters, and support Australia's growing space industry. The delivery and implementation of Australian civil space programs is shared across several government agencies including the ASA, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Geoscience Australia, and the Bureau of Meteorology. Prior to 2018, CSIRO was the lead organization for coordinating space activities with NASA. As Australia's national science agency, CSIRO leads on a number of space science and research programs and continues to actively collaborate with NASA. On April 4, 2022, NASA signed a Joint Statement of Intent with the ASA to collaborate on Earth observation missions currently in development at both agencies. As of October 2022, NASA had 29 active agreements with Australian entities, including 2 with ASA and 2 with CSIRO. The Australian government has committed to tripling the size of its space sector and plans to create an additional 20,000 jobs by 2030 with a revenue goal of $7.8 billion (12 billion Australian dollars).[67]

Governance

ASA is headquartered in Adelaide, South Australia, under the Australian government's Department of Industry, Science and Resources and is accountable to the Minister for Industry and Science. ASA is structurally comprised of the Agency Head, Deputy Head, and the Office of the Space Regulator, with approximately 92 employees, in addition to its contractor employees. A non-statutory, independent, skills-based Advisory Board provides advice to the Head of the ASA, reviews and advises on the strategic direction and performance of the ASA, and supports the ASA to achieve its purpose. Three consultative groups—Australian Government Space Coordination Committee, Space Industry Leaders Forum, and the State and Territory Space Coordination Meeting—also keep the ASA informed on relevant space issues and ensure the agency is able to provide one voice for the civil space sector. As ASA expands and delivers on its exploration objectives, additional working groups have been created to manage the growing portfolio of responsibility. As a separate organization, CSIRO operates under direction from the Australian government which appoints a nine-member board and Chief Executive. CSIRO's Space and Astronomy headquarters is located at CSIRO's Marsfield site in Sydney. As of 2020, CSIRO employed 3,168 full-time research positions.

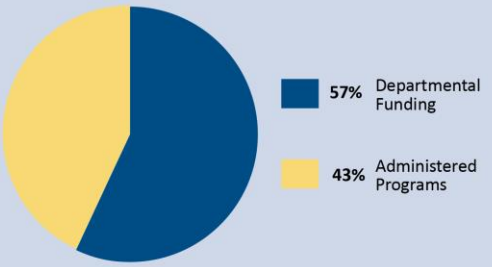
Budget

ASA's initial funding in 2018 provided approximately $26.5 million (41 million Australian dollars) over a 4-year period, and ASA's budget for fiscal year 2022 to 2023 allocates approximately $69.1 million (106.1 million Australian dollars), including a funding component of approximately $29.4 million (45.5 million Australian dollars) in Departmental Funding for staffing and operations and around $39.1 million (60.6 million Australian dollars) for programs including $15.4 million (23.8 million

[67] U.S. dollar values as of October 1, 2022.

Australian dollars) for ASA's Moon to Mars Initiative. ASA forecasts fiscal year 2023 to 2024 funding to increase significantly due to the maturation of existing programs and the announcement of new government funding including a new national space mission for Earth observation. Since 2018, the Australian government has invested more than $516.7 million (800 million Australian dollars) in civil space activities across a number of different government agencies.

Distribution of ASA's Fiscal Year 2022-2023 Budget Based on Work Type

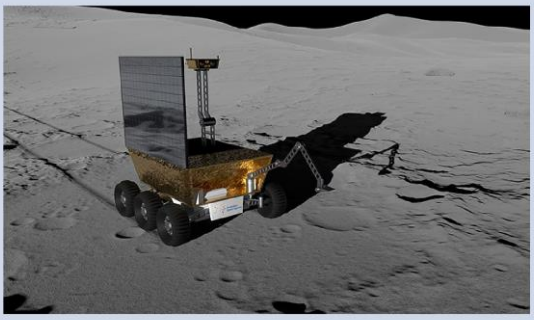


Source: NASA OIG analysis of space partner information.

Key Artemis Projects with NASA

Moon to Mars Initiative. Australia's Moon to Mars Initiative is a three-pronged plan with a forecasted $96.9 million (150 million Australian dollars) investment over a 5-year period that will invest in local business and technologies to support the Australian space industry as well as NASA's Artemis campaign for Moon and Mars missions. The first component, the Supply Chain Program, began in 2020 by offering grants and assistance for Australian projects that contribute to domestic and international supply chain services. The second component, the Demonstrator Program, also began in 2020 to support the development of Australian space projects such as propulsion technology, remote medicine applications, and satellite communications. The third component, the Trailblazer Program, began in 2021 and will allow Australian businesses and researchers to develop and build a lunar rover that will support the scientific investigation of the Moon. In September 2021, NASA and ASA signed an agreement to further support human and robotic lunar operations under the Artemis campaign. The agreement will allow an Australian-made 20-kilogram semi-autonomous rover to be launched and operated on the Moon as early as 2026. The rover will collect lunar soil and transfer it to NASA's in-situ resource utilization system on the lunar lander, a complementary capability for NASA and a key component to establishing a sustainable human presence on the Moon. The agreement is supported under the Trailblazer Program.

Rendering of Australian-Made Rover



Source: ASA.

Commercial Lunar Payload Services Initiative. In March 2021, CSIRO announced a 5-year agreement with U.S. aerospace company Intuitive Machines, LLC to support multiple lunar missions—the first flight will be under NASA's CLPS initiative. The Parkes radio telescope will be one part of Intuitive Machine's Lunar Telemetry and Tracking Network that utilizes telemetry, tracking, and command services. The Parkes radio telescope will help provide continuous communications with spacecraft and ground station support for Moon missions over the upcoming years.

CSIRO Communication Capabilities. The Canberra Deep Space Communication Complex, located at Tidbinbilla, Australia, houses CSIRO's radio telescopes that have supported space missions for over 60 years. The 64-meter CSIRO Parkes radio telescope, Murriyang, will be supporting the CLPS initiative as part of Intuitive Machines' Lunar Telemetry and Tracking Network. As the largest receiving ground station in the Network it will increase return data for the lunar exploration program. Additionally, CSIRO manages and operates one of NASA's three Deep Space Network (DSN) tracking stations. The Canberra tracking station has four antennas that provide continuous radio contact with DSNs around the world and enable constant observation of spacecraft on deep space missions.

CSIRO Parkes Radio Telescope

Source: CSIRO.

ASA Capabilities

ASA has reported their demonstrated and emerging capabilities in the following areas:

Demonstrated Capabilities

- Radio astronomy
- Developing advanced GPS applications
- Sensor technologies and robotics
- Satellite technology
- 3D simultaneous localization and mapping
- Advanced communication technologies
- Space tracking
- Space medicine and life sciences
- Earth observation including satellite calibration/validation, data analytics, modeling, and applications development

Emerging Capabilities

- Developing autonomous Moon rover
- Advanced robotics and automation
- Remote asset management
- Small satellite design
- Foundation services
- Instrumentation and component design
- Improved satellite communications and operation software
- Laser ranging and space debris tracking telescopes
- Launch services

Opportunities for Cooperation

Australia was one of the first eight countries to sign the Artemis Accords in 2020, signaling the country's interest in sharing joint principles that will guide space exploration into the future. Australia's continued partnership with NASA is also represented through ASA's $96.9 million (150 million Australian dollars) Moon to Mars Initiative that will support NASA's mission to return to the Moon. Australia's Moon to Mars funding will be spread out over the next 5 years by investing in local business and technologies that will support NASA's Artemis campaign, Gateway, and expeditions to Mars. Given Australia's demonstrated space capabilities related to Earth observation, space communications, and robotics, Australia will be a key counterpart to ensure international partnership goals are met as exploration to the Moon and Mars expands.

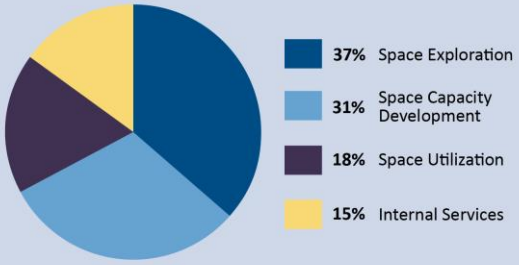
Canadian Space Agency

Established in 1989, the Canadian Space Agency's (CSA) objectives are to promote the peaceful use and development of space, advance the knowledge of space through science, and ensure that space science and technology provide social and economic benefits for Canadians. CSA focuses its activities and resources on three main areas: space exploration, space utilization, and space science and technology. In 2020, Canada signed the Artemis Accords. Additionally, working in collaboration with NASA and other ISS partners, Canada will contribute Canadarm3, an advanced robotic system that will be able to work autonomously on the Gateway. As of October 2022, NASA had 28 active agreements with Canada, 16 of which are with CSA.[68]

Governance

The CSA President serves as CSA's Chief Executive Officer and, under the direction of the Minister of Innovation, Science, and Economic Development, has control and supervision over the work, officers, and employees of the agency. CSA is headquartered in Saint-Hubert, Quebec, and has two other main locations in Gatineau, Quebec, and Ottawa, Ontario. The agency has approximately 709 employees, the majority of whom are employed at CSA's headquarters.

Distribution of CSA's Fiscal Year 2022-2023 Budget Based on Work Type



Source: NASA OIG analysis of space partner information.
Note: The sum does not add up to 100% due to rounding.

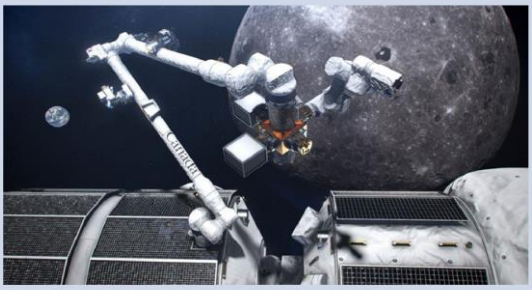
Budget

CSA's budget for fiscal year 2022 to 2023 is approximately $282.6 million (388.3 million Canadian dollars), which funds internal services, future Canadian space capacity development, space exploration, and space utilization.[69]

Key Artemis Projects with NASA

Canadarm3. A recognized leader in space robotics, Canada provided the Canadarm—a robotic arm used to transfer cargo and release satellites—on the Space Shuttle and Canadarm2 and the Special Purpose Dexterous Manipulator known as Dextre—a "handyman" robot that installs and replaces small equipment, replaces defective components, and tests new tools and robotic techniques—on the ISS. For

Rendering of Canadarm3 Mounted on the Outside of the Gateway



Source: CSA.

[68] The remaining 12 agreements are with Canadian universities, companies, and other government agencies.

[69] U.S. dollar values as of October 1, 2022.

Artemis, Canada will provide the Gateway's external robotics system, including the Canadarm3 next-generation robotic arm. The target date for delivering Canadarm3 to the Gateway is 2027. Canadarm3 will be designed to maintain, repair, and inspect the Gateway; relocate Gateway modules; help astronauts during spacewalks; and enable science both in lunar orbit and on the surface of the Moon.

CSA Astronaut Seats on Artemis Missions. For the CSA's Canadarm3 contribution, NASA will in kind provide two crew opportunities for Canadian astronauts on Artemis missions, one on Artemis II and the other on a Gateway mission. Canadian officials said they have not yet selected which of its four current astronauts will fly on the first mission, Artemis II.

CSA Astronaut Corps

CSA's active astronauts from left to right are Jeremy Hansen, Jennifer Sidey-Gibbons, Joshua Kutryk, and David Saint-Jacques.

Source: CSA.

CSA Capabilities

CSA has reported their demonstrated and emerging capabilities in the following areas:

Demonstrated Capabilities

- Astronaut training
- Space telescope (MOST)
- Science and technology for the Moon and Mars (LEAD)
- Space communications, including navigation, positioning, and timing services
- Radiation dosimetry (MOSFET and Matroshka-R)
- Science satellites, spacecraft, and instruments
- Space robotics (manipulators, on-orbit servicing systems, Canadarm, and Canadarm2)
- Vision, inspection, and rendezvous sensor systems (Dextre)
- James Webb Space Telescope (Fine Guidance Sensor, Near-Infrared Imager and Slitless Spectrograph)

Emerging Capabilities

- Space robotics (Canadarm3)
- Earth observation
- Space situational awareness and surveillance
- Satellite-based quantum key distribution
- Maintenance and refueling of satellites using robotic systems
- Smaller and more capable satellites
- Space telecommunications (ARTES)
- Advances in manufacturing and miniaturization across a range of markets and applications
- Mining of minerals or other resources from planets and asteroids

Opportunities for Cooperation

Canada supports the opportunities presented by emerging exploration, science, and commercial space activities. CSA is funding science and technology development in fields like artificial intelligence, robotics, and health through the CSA Lunar Exploration Accelerator Program.

European Space Agency

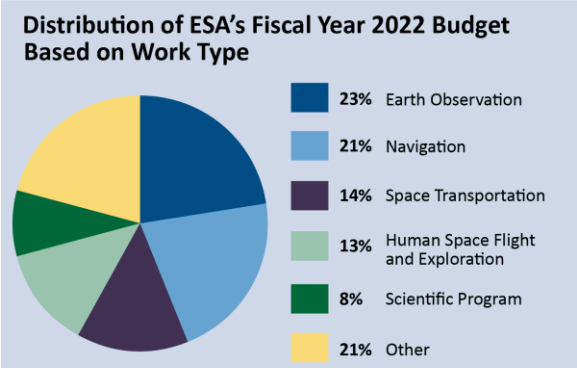
The European Space Agency's (ESA) mission is to shape the development of Europe's space capabilities and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world. Established in 1975, ESA integrated several existing national space programs to become Europe's interagency and intergovernmental space organization. The combined financial and intellectual resources of ESA's 22 member states enable the agency to pursue the broad scope of its space program, from studying Earth to the universe at large. In addition to the 22 member states, 5 other European countries have cooperation agreements with ESA, 3 European countries are associate members, and Canada takes part in some projects.[70] Cooperation between ESA and the United States is built around six programmatic pillars: space science, human space flight, satellite navigation, meteorology, Earth science, and space exploration. As of October 2022, ESA had 33 active cooperation agreements with NASA.

Governance

The ESA Council is the governing body of the agency and is comprised of one representative for each member state. The Director General is elected to the Council every 4 years and is responsible for the execution of the programs and ESA's general management. ESA employs approximately 2,200 people among its member states. While ESA headquarters is located in Paris, France, there are sites and offices across Europe with liaison offices around the world. ESA's principal research and development facility is the European Space Research and Technology Centre in Noordwijk, The Netherlands, where more than 2,000 specialists work and almost all ESA projects are managed except for launch systems. For its launch facilities, ESA shares "Europe's Spaceport"—the Guiana Space Centre in Kourou, French Guiana—with the French government. ESA funds two-thirds of the Spaceport's annual budget and has invested nearly $2 billion (2 billion euros) to date in developing and improving the ground facilities.[71]

Budget

ESA holds a Council meeting at the Ministerial level once every 3 years, on average, during which member states make decisions on programs to adopt or continue and their planned level of funding, allowing for a political continuity of mission. ESA's budget for fiscal year 2022 is approximately $7 billion (7.2 billion euros) and is funded by contributions of the member states. All members fund ESA's "mandatory" programs (approximately 16 percent of the annual budget). The remainder of the budget funds



Source: NASA OIG analysis of space partner information.

[70] The five European countries that have cooperation agreements with ESA are Bulgaria, Croatia, Cyprus, Malta, and Slovakia. The three associate member countries are Slovenia, Latvia, and Lithuania. Canada also sits on the ESA Council and takes part in some projects under a cooperation agreement.

[71] U.S. dollar values as of October 1, 2022.

"optional" programs, supported by interested member states who are free to choose their level of involvement. Approximately $170.5 million (174 million euros) of ESA's fiscal year 2022 budget was specifically allocated towards European contributions to the Gateway, ESM 4 and 5, and the European Large Logistics Lander. As these activities largely fall under the scope of "optional" programs, funding relies on the continued interest of member states.

Key Artemis Projects with NASA

European Service Module. Orion is the spacecraft NASA is developing to transport astronauts beyond low Earth orbit. ESA partnered with NASA to provide one of Orion's major components—the ESM—which is the powerhouse of the spacecraft as it provides in-space maneuvering capability, power, and other commodities necessary for life support, including consumables for the crew like water, oxygen, and nitrogen. Its radiators and heat exchangers keep the crew and equipment at a comfortable temperature, and the module's structure is the backbone of the entire vehicle.

European Service Module 2

Source: ESA.

International Habitation Module. The Gateway is a small space station that will enable sustainable exploration on and around the Moon while enabling research and demonstrating the technologies and processes necessary to conduct a future mission to Mars. ESA's contribution to this international endeavor includes building the second habitat for visiting astronauts, known as the International Habitation Module or "I-Hab" in collaboration with JAXA. I-Hab will dock between NASA's HALO module and the Orion capsule. I-Hab is targeted to launch on the Artemis IV mission in 2027.

Rendering of International Habitation Module

Source: Thales Alenia Space.

Rendering of ESPRIT

Source: ESA.

European System Providing Refueling Infrastructure and Telecommunication. ESA is also contributing two elements to the Gateway, together known as ESPRIT, which will supply enhanced communication, additional habitable space, cargo storage, refueling capability, and observation windows. The first element—the HALO Lunar Communication System—will launch as an integrated component of HALO in 2024 on a SpaceX Falcon Heavy rocket. The second element—the European Refueling Module—is targeted to launch on the Artemis V mission in 2028.

ESA Capabilities

ESA has reported their demonstrated and emerging capabilities in the following areas:

Demonstrated Capabilities

- Robotic satellite systems
- Systems integration
- Space communication and tracking
- Automated rendezvous and docking
- Astronaut crew and training
- Earth science and observation
- Navigation
- Pressurized modules
- Spaceport in French Guiana (launch site for Ariane, Vega, and Soyuz vehicles)
- Ariane 5, Vega, and Vega C launch vehicles
- Scientific instrumentation
- Thermal structure
- Propulsion technology (Smart-1)
- Space science
- Planetary exploration

Emerging Capabilities

- European Service Module
- I-Hab Module and ESPRIT
- Lunar communications
- Advanced rocket development (Ariane 6)
- Advanced lunar, planetary, and solar system exploration
- Advanced cyber security monitoring and management system

Opportunities for Cooperation

ESA's future goals center on propelling Europe's leadership and investment in the space sector while ensuring it is a sustainable endeavor. To achieve this, ESA plans to use Earth science and observations to pursue Europe's climate change goals as outlined in the Paris Agreement and European Green Deal. Further, ESA envisions expanding its constellation of satellites in low Earth orbit to provide connectivity and observation capabilities.

With respect to Artemis and future deep space exploration, many of ESA's goals intersect with NASA's strategic plan which positions both agencies to benefit from mutual cooperation. ESA's interests include providing lunar cargo transportation, communication and navigation services, and science and technology demonstrators; advancing its launcher sector with a focus on reusability; and using advanced robotics to remove orbital debris and provide in-orbit refueling and recycling. Additionally, ESA plans to train astronauts for lunar and deep space missions with an emphasis on landing the first European astronaut on the Moon by the end of the decade and in the long-term participating in a human mission to Mars. Due to the recent conflict in Ukraine and the resulting sanctions on Russia imposed by the European Union and individual ESA member states, the ExoMars mission, which was set to launch in September 2022, was halted. As ESA seeks to replace the Russian-built components, this may present opportunities for NASA and ESA to cooperate on this mission going forward considering the ongoing collaboration from both agencies on the Mars Sample Return mission.

Israel Space Agency

Israel is one of the smallest nations to house a space agency but has demonstrated its robust capabilities through satellite communications and remote sensing along with other technological developments. The Israel Space Agency (ISA) was established in 1983 and tasked with the responsibility to initiate, lead, and coordinate all civil space activities. ISA supports a diverse range of space research and development and aims to expand international cooperation in the field of space and cultivate future scientists and industry professionals through space education programs. The agency seeks to strengthen its existing capabilities in addition to pursuing investments in space exploration, space systems, and technology to further its position in the international space industry. As of October 2022, NASA had eight active agreements with Israeli entities, three of which are with ISA.

Governance

ISA is staffed with civil servants as well as external consultants and is a unit within the Ministry of Innovation, Science and Technology, headed by a Director and Chairman. Israel's 2022 Strategic Plan for Advancing the Israeli Civilian Space Industry set numerous objectives and targets for the upcoming decade, one of which aims to strengthen and develop the civilian space industry in Israel and quadruple the people employed in the space industry to 10,000. The strategic plan also addresses an increase in budget that will entail an investment of nearly $168 million (600 million Israeli new shekel) in the next 5 years.[72]

Budget

ISA's budget includes funding for projects with international partners, technology, science, research and development, logistics, education and public outreach, industry support, and investment in space infrastructure. Satellite and other research programs are often funded on a project-by-project basis.[73]

Key Artemis Projects with NASA

Matroshka AstroRad Radiation Experiment. A 2018 agreement between NASA, ISA, and the German Aerospace Center was signed for an experiment to test the AstroRad radiation protection vest on Artemis I. The investigation is called the Matroshka AstroRad Radiation Experiment and will fly two female manikin torsos—anatomical models of the human body manufactured to mimic bones, soft tissues, and organs of an adult female—to test the new vest while providing data on radiation levels during missions to

Matroshka AstroRad Radiation Experiment

Source: NASA.

[72] U.S. dollar values as of October 1, 2022.

[73] ISA requested that we not publish their budget numbers and breakdown.

the Moon. ISA provided the AstroRad vest for the first flight test of the SLS rocket and Orion spacecraft as part of the Artemis campaign. Data from the experiment will help NASA and its international partners assess and limit the effects of radiation exposure for deep space travel. In addition, the AstroRad vest was tested on the ISS by Israeli Eytan Stibbe as part of the first all-private Axiom Mission 1, which launched on April 8, 2022. Stibbe was the second Israeli to fly to space, the first being Colonel Ilan Ramon, who died with the entire crew onboard the Columbia Space Shuttle in 2003.

Colonel Ilan Ramon

Colonel Ilan Ramon was among seven astronauts who died when the Columbia Space Shuttle exploded upon its reentry to Earth in February 2003. Ramon was an experienced fighter pilot who served in the Israeli Air Force and was selected by NASA as a payload specialist. He serves as an important piece of Israel's history and remains an inspiration for the future of Israel in space.

Source: NASA.

Beresheet-1 and -2 Missions. SpaceIL, a non-profit organization in Israel, was established to promote science and education. In February 2019, SpaceIL launched the Beresheet-1 mission, a robotic lunar lander probe that was captured into lunar orbit but lost in April 2019 during its landing attempt. NASA contributed to this mission by installing a small laser retroreflector onto the lander to test its potential as a navigation tool. In 2020, SpaceIL announced it would pursue work on the Beresheet-2 mission.

Beresheet-2, Israel's second mission to the Moon, comprised of a lunar orbiter and two landers, is expected to be launched in 2026. The two landers are designed to split from the orbiter and land at separate locations on the Moon. Each lander is expected to include scientific payloads of about 3 to 5 kilograms in mass. The orbiter is expected to continue to orbit the Moon for over 2 years, facilitating live communication with research and education centers across the world. One of the Beresheet-2 landers is planned to land in the south polar region and carry a Linear Energy Transfer Spectrometer instrument. The spectrometer's scientific goal is to acquire knowledge of the lunar radiation environment and demonstrate the capabilities of a flight-proven radiation monitor on the lunar surface. These radiation measurements on the lunar surface are an important precursor to NASA's planned human exploration of the Moon through the Artemis campaign.

Rendering of Beresheet-2 Lunar Lander

Source: SpaceIL.

Israel Network for Lunar Science and Exploration. In 2010, NASA and ISA signed a joint declaration that recognized the Israel Network for Lunar Science and Exploration as part of an international effort to study lunar science and exploration. The declaration also made Israel a member of the NASA Center for Moon Research with the intention of promoting cooperation between the two agencies. The Israel Network's focused efforts are on laser communication, robotics, remote sensing, and other technologies for lunar missions.

ISA and Israel Space Industry Capabilities

ISA and Israel's space industry have reported their demonstrated and emerging capabilities in the following areas:

Demonstrated Capabilities

- Launch capabilities
- Unified ground stations
- Electric propulsion
- Lunar mission (landing)
- Earth observation satellites (inc. remote sensing via multispectral payload)
- Miniaturization and production of lighter satellites
- High-resolution imaging satellites
- Communications satellites

Emerging Capabilities

- Life science experiments
- Life support systems
- In-situ resource utilization
- In-space data processing
- Space radiation protection
- Remote sensing through hyper-spectral Earth observation satellites
- Micro-electric propulsion solutions for small satellite missions
- Industrial infrastructure for space systems
- Lunar lander, probes, and orbiter
- Gravity mapping and occultation measurements with ultrastable oscillators for deep-space missions

Opportunities for Cooperation

NASA and ISA have a long-standing symbiotic relationship in space exploration, scientific discovery, and research. Cooperation between the two agencies dates from the first Israeli astronaut being launched into space on a U.S. shuttle to present day, as Israel signed the Artemis Accords in 2022. This signature confirms Israel's commitment to the common set of principles for future space exploration and future shared goals on the lunar surface and beyond. Israel's participation in the space sector and continued partnership with NASA has the potential to expand into joint missions, workshops and meetings, personnel and scientific data exchanges, scientific instruments onboard aircraft and spacecraft, and other spacecraft and space research platforms.

Italian Space Agency

Founded in 1988, the Italian Space Agency—Agenzia Spaziale Italiana (ASI)—is responsible for coordinating and conducting Italian national space activities. The two major objectives of ASI's strategic vision are awareness of the space sector within Italian society and responsiveness to the goals and needs expressed by Italian citizens. In meeting these objectives, ASI hopes to strengthen cooperation with European and other world leaders in space. The agency's main activities include Earth observation, science and robotic exploration, and education and communication. Italy is a member of and major contributor to ESA, and the Italian industry has shown a particular expertise in building pressurized modules for both the ISS and Gateway. As of October 2022, NASA had 27 active agreements with Italy, 19 of which are with ASI.

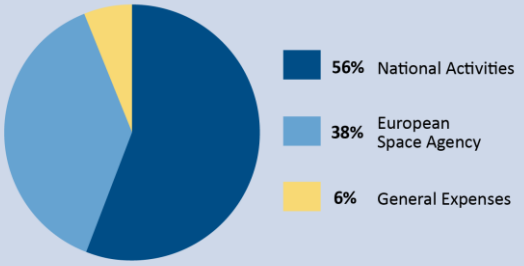
Governance

ASI is funded directly by the Italian government and reports to the Ministry for Education, University and Research. A president and board of directors manage ASI's activities. The agency is headquartered in Rome, Italy. In addition, ASI has the Center of Geodesy and Earth Observation in Matera, Italy, and a Space Center in Malindi, Kenya.

Budget

ASI's fiscal year 2022 budget of $1.8 billion (1.8 billion euros) funded agency contributions to ESA, general expenses, and national activities.[74] Contributions to ESA and the budget for national activities include these major activities: Earth observation (28 percent of budget); exploration and orbital infrastructures (17 percent); technologies and nanosatellites (15 percent); communication and navigation (8 percent); space transportation (8 percent); and other activities such as science research and education, ground infrastructures, and Artemis.

Distribution of ASI's Fiscal Year 2022 Budget Based on Work Type



Source: NASA OIG analysis of space partner information.

Cupola on the International Space Station

Source: NASA.

Key Artemis Projects with NASA

ASI has a close working relationship with NASA, taking part in building and servicing the ISS with Italian astronauts—five total have served onboard. Italy had a key role in manufacturing multiple modules and the Cupola for the Station, as well as contributing to building the Columbus European Laboratory. In

[74] U.S. dollar values as of October 1, 2022.

October 2020, Italy signed the Artemis Accords. A statement from the President of ASI said that subsequent implementation agreements would specify the details of Artemis cooperation and noted ASI's interest in providing crew habitats, lunar surface scientific investigations, and telecommunications services. In addition, ESA selected an Italian company—Thales Alenia Space—to be the prime contractor for the Gateway's I-Hab. In April 2021, ASI also contracted with Thales Alenia Space to do a feasibility study of design concepts for a multipurpose, flexible, and evolvable pressurized structure able to adapt to a wide range of applications to support a human presence on the Moon. One such concept is the Lunar Multi-Purpose Module.

Columbus European Laboratory

Source: ESA.

Lunar Multi-Purpose Module Concept

Source: ASI.

ASI Capabilities

ASI has reported their demonstrated and emerging capabilities in the following areas:

Demonstrated Capabilities

- Pressurized modules
- Space geodesy
- Satellite structures, components, and systems
- Global precipitation measurements
- Space communications
- Scientific instrumentation
- High energy astronomy

Emerging Capabilities

- In-situ analysis
- Lunar robotics
- Lunar communications
- Remote sensing
- Lunar based radioastronomy and Earth observation
- Liquid oxygen and methane engine development
- Descent and landing systems (reentry technologies)
- Lunar orbiters
- Inflatable structures
- Pressurized lunar logistics modules
- Surface mobility including microrover
- Advanded technology and exploration
- Ka-band deep space communications

Opportunities for Cooperation

ASI seeks to continue its ongoing cooperation with NASA and has identified areas of potential future cooperation on and around the Moon, including building and launching satellites into orbit. ASI and NASA also recognize Italy's industrial aerospace expertise and the potential it provides for U.S.–Italian industry-to-industry cooperation in support of Artemis, such as future habitats for the lunar surface, both permanent (shelter) and mobile (pressurized rover), as well as cargo for lunar logistics.

Japan Aerospace Exploration Agency

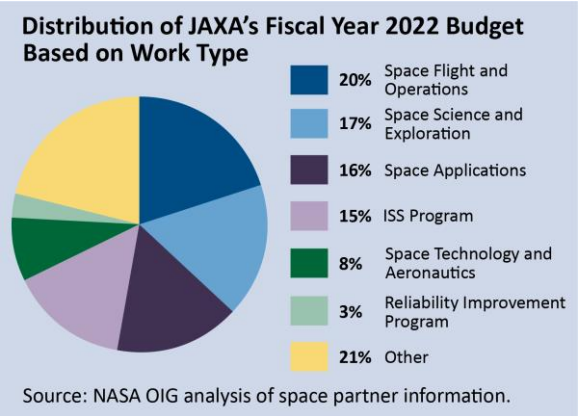
The Japan Aerospace Exploration Agency (JAXA) was created in 2003 through the merger of three institutions: Institute of Space and Astronautical Science, National Aerospace Laboratory of Japan, and National Space Development Agency of Japan. Designated as a core performance agency supporting the Japanese government's overall aerospace development and utilization, JAXA's purpose is to "Explore to Realize," reflecting its management philosophy of utilizing space and the sky to achieve a safe and affluent society. JAXA's main activities include human space flight, Earth and space science, space transportation, satellites, lunar and planetary exploration, and aeronautics. As of October 2022, NASA had 68 active agreements with Japanese entities, 36 of which are with JAXA.

Governance

JAXA is the core organization providing technical support for all Japanese government development and utilization of space projects. In April 2015, JAXA reorganized its structure to maximize its research and development efforts and changed from an independent administrative agency to a National Research and Development Agency. The Agency reports to the Ministry of Education, Culture, Sports, Science and Technology of the Government of Japan. Led by a president and several vice presidents, JAXA is headquartered in Tokyo, Japan, with an additional 24 facilities around the world and a staff of approximately 1,600.

Budget

In fiscal year 2022, Japan's space budget rose to $1.6 billion (223.8 billion yen), 4 percent over the previous fiscal year.[75] Approximately 17 percent ($278 million, 40.2 billion yen) of the space budget will fund space science and exploration programs, including activities related to the Artemis campaign, such as a commercial resupply vehicle, the Gateway, lunar landers, and rovers, among others.



Source: NASA OIG analysis of space partner information.

Key Artemis Projects with NASA

Artemis I CubeSats. JAXA jointly developed and built two CubeSats—small satellites about the size of a large shoebox that weigh no more than 30 pounds—with the University of Tokyo that were sent to space during NASA's Artemis I mission. After riding to space inside the Orion Stage Adapter, the CubeSats were deployed after Orion separated from the upper stage and was a safe distance away. One of the CubeSats—EQUULEUS (EQUilibriUm Lunar-Earth point 6U Spacecraft)—will fly to the Second

[75] U.S. dollar values as of October 1, 2022.

Lagrange Point and study the Earth's plasmasphere.[76] The other CubeSat—OMOTENASHI (Outstanding MOon exploration TEchnologies demonstrated by NAno Semi-Hard Impactor)—was intended to demonstrate the feasibility of a very small spacecraft exploring the lunar surface, as well as monitor radiation around the Moon, but during the Artemis I mission communication could not be established with the satellite.

Gateway. JAXA is a key international partner for the Gateway—a small outpost orbiting the Moon. The agency will provide batteries for the HALO, which is scheduled to launch in late 2024. JAXA will also provide habitation functions for the Gateway's I-Hab, scheduled to launch as part of Artemis IV in 2027. In addition, JAXA is investigating enhancements to its HTV-X cargo vehicle for Gateway logistics resupply missions. In exchange for JAXA's contributions to Gateway, NASA announced in November 2022 that, under the Gateway Implementing Arrangement, it will provide an opportunity for a JAXA astronaut to serve as a Gateway crew member on a future Artemis mission.

Pressurized Crew Rover. While NASA will lead the development of an unpressurized rover for the lunar surface, with the Lunar Terrain Vehicle slated to be operational for Artemis V in 2028, JAXA will develop a pressurized crew rover for later human missions to the Moon. Beginning in 2019, JAXA conducted joint research with the Toyota Motor Corporation to develop the lunar rover, with the agency now in the process of selecting an industry partner for the next stage of development. With an expected readiness date in the late 2020s, the rover will be able to support operations by two astronauts for up to 42 days.

Illustrations of the Improved H-II Transfer Vehicle (HTV-XG) Approaching the Gateway (left) and the Pressurized Crew Rover (right)

Source: JAXA.

Source: Toyota Motor Corporation.

[76] A Lagrange point is a position in space where different forces allow an object to stay still. Earth's plasmasphere is a region of dense, cold plasma that surrounds the Earth at about 90 kilometers (near 56 miles) above the Earth's surface.

JAXA Capabilities

JAXA has reported their demonstrated and emerging capabilities in the following areas:

Demonstrated Capabilities

- Robotics and manipulator systems
- High-definition optics
- Space logistics vehicle (HTV)
- Astronaut training
- Nanotech
- Pressurized space structures
- Human-rated space facilities (JEM)
- Launchers and associated launch sites (H-IIA and H-IIB)
- Space communications and tracking
- Satellite structures, components, and systems
- Exploration of Energization and Radiation in Geospace (ERG)
- Mercury exploration (BepiColombo)
- Cryogenic propulsion stage and related technologies
- Collecting and returning asteroid samples (Hayabusa and Hyabusa2)

Emerging Capabilities

- Long-term observation of Earth's environment (ALOS-4 and EarthCARE)
- Accurate landing of small probes on the lunar surface (SLIM)
- X-ray imaging and spectroscopy (XRISM)
- Exploration of in-situ resources at lunar poles
- Launch vehicle capable of reaching geostationary transfer orbit (H3)
- Broad lunar surface exploration with pressurized rover
- Exploration of Martian moons (MMX)

Opportunities for Cooperation

JAXA's interests include international collaborations with other space agencies, industry, and academia for sustainable human and robotic space exploration in and beyond low Earth orbit. While still an active participant in the ISS and continuing its efforts toward the expansion of low Earth orbit activities involving industry, JAXA's current focus is on exploration missions to the Moon and Mars, to include both robotic and eventually human missions. Towards that end, the Government of Japan announced a new goal to land a Japanese astronaut on the Moon in the late 2020s, the pursuit of which should create several opportunities for collaboration. Specific areas of interest are human mobility, including the crew rover, and the transportation necessary for lunar exploration, which would allow NASA to accelerate development and scientific research on the lunar surface.

United Arab Emirates Space Agency

Founded in 2014, the United Arab Emirates Space Agency (UAESA) aims to develop, foster, and regulate a sustainable space sector in the United Arab Emirates (UAE). The UAE space program has quickly established space power leadership in the Middle East region by investing in space science and technology, facilitating strategy and regulation, and contributing to international space projects with the global community. In 2020, the UAESA was among the first group of signatories to sign the Artemis Accords, confirming its commitment to valuing shared principles and advancing space exploration. As of October 2022, the UAE and NASA had 10 active agreements, 4 of which are with the UAESA.

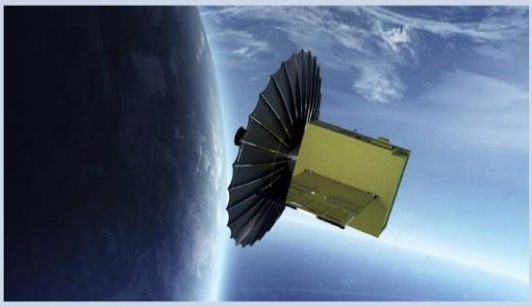
Governance

The UAESA functions as a federal government authority, which directs the UAE national space program, and is chaired by the UAE Minister of State for Public Education and Advanced Technology. A Board of Directors endorse space-related policies, strategies, and regulatory resolutions in alignment with the UAE's National Space Sector Strategy which aims to strengthen the UAE's role in space. The UAE's space sector is comprised of over 3,000 employees with more than 80 space companies, institutions, and facilities operating within the country. UAESA is headquartered in Abu Dhabi, UAE. The Mohammed Bin Rashid Space Centre (MBRSC) is located in Dubai, UAE, and is an integral entity for the UAE space program as it builds, operates, and analyzes Earth observation satellites.

Budget

The UAE's space program witnessed an increase of investment in the space sector with a record of approximately $2.5 billion (9 billion UAE dirham) in commercial spending over the past 4 years.[77] In 2022, the UAE government established the National Space Fund of $817 million (3 billion UAE dirham) to fund support for programs that support international and Emirati companies to cooperate in space sector engineering, sciences, and research applications. The Fund's first project to be launched to space will be a constellation of advanced remote sensing satellites using radar technologies to provide imaging capabilities.

Rendering of UAE National Space Fund's Radar Satellite Constellation



Source: UAESA.

[77] We were unable to determine an exact annual budget for UAESA. U.S. dollar values as of October 1, 2022.

Key Artemis Projects with NASA

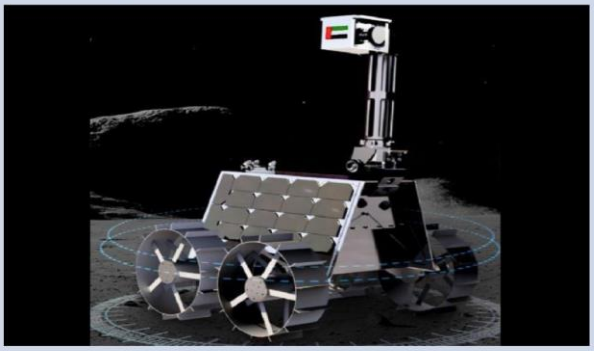
Hope Probe. Also referred to as the Hope Mars Mission or Emirates Mars Mission, the UAESA in collaboration with the MBRSC launched the unmanned "Hope Probe" in July 2020 from Japan with the intention to study Martian atmospheric conditions and climate. The spacecraft successfully entered Mars' orbit in February 2021. This flagship mission made the UAE the fifth country to send a probe to Mars. Hope was built by the MBRSC with assistance from various U.S. universities. The Hope Probe's mission is scheduled for a 2-year duration with the ability for further extension.

Emirates Lunar Mission. Announced in 2020, the Emirates Lunar Mission is the first Arab mission to explore the Moon. The mission includes Rashid, a compact rover that cleared all required tests and launched in December 2022. Rashid is equipped with two high-resolution cameras, a smaller microscopic camera, and a probe designed to study the Moon's surface. The rover is projected to land on the lunar surface in 3 to 4 months after its launch in a previously unexplored area to gather information in support of a future research station on the Moon and act as a stepping stone for future Mars exploration opportunities.

Hope Probe

Source: MBRSC.

Rendering of Emirates Lunar Mission Rover



Source: Dubai Media Office.

UAE Astronaut Program. The UAE Astronaut Program was established in 2017 and prepares the Emirati astronaut corps for scientific space exploration missions, supporting the UAE's vision of a prosperous future in space. In 2020, NASA signed a Reimbursable Space Act Agreement with the MBRSC to train UAE astronauts on ISS systems at Johnson Space Center. This agreement paves the way for closer relations between the United States and UAE and creates new opportunities for the UAE to become involved not just with the Station, but also Artemis and other NASA activities. UAE's four astronauts have begun their training alongside NASA astronauts. Hazzaa AlMansoori began in-house training at MBRSC, received additional training in Russia in 2018, and became the first Emirati in space when he embarked on an 8-day scientific mission to the ISS in 2019. This continued astronaut collaboration reflects the UAE's commitment to boosting its scientific and space capabilities and its long-standing bilateral cooperation with the United States. In July 2022, the UAE announced the first Arab astronaut to engage in a long-term space mission to the ISS. Astronaut Sultan AlNeyadi will spend 6 months aboard the Station during which he will conduct in-depth and advanced scientific experiments as part of the UAE's Astronaut Program.

UAE Astronaut Corps

Mohammad AlMulla (far left) and Nora AlMatrooshi (second from left) are the UAE's newest astronaut candidates. They join the UAE astronaut corps' two other members, Sultan AlNeyadi (second from right) and Hazzaa AlMansoori (far right).

Source: MBRSC.

UAESA Capabilities

UAESA has reported their demonstrated and emerging capabilities in the following areas:

Demonstrated Capabilities

- Astronaut Program
- Earth observation satellites
- Robotic Mars probe
- Telecommunication and remote sensing satellite capabilities

Emerging Capabilities

- Operational lunar rover
- Space tourism
- Satellite technologies
- Airlock production
- Self-sustaining habitable Mars settlement
- Digital and Information Communication Technology solutions
- Launch services

Opportunities for Cooperation

With a long-term national strategic vision, developed space exploration capabilities, and continued international collaborations, the UAESA has the potential to generate new discoveries. Motivation and determination for continued discovery in space helps UAE develop capabilities in the field of space exploration and technologies. NASA and the UAESA have a strong bilateral relationship that has been demonstrated through numerous initiatives, projects, and agreements. The UAESA's collaborative efforts are showcased through its executed multiple projects with international partners and membership in the International Charter on Space and Major Disasters, Arab Union for Astronomy and Space Sciences, and Space Climate Observatory initiative. UAESA will be a key player for diversifying and strengthening the space economy by continuing its partnerships with the United States and other nations.

APPENDIX C: NASA INTERNATIONAL INSTRUMENTS FOR ARTEMIS MISSIONS

The table below summarizes the instruments NASA has with international partners for Artemis cooperation.

Table 7: Summary of NASA's International Instruments for Artemis Missions (as of October 2022)

Corresponding International Partner	Instrument Subject Matter	Activity	Mission Date	Format
Australia/ASA	In-situ Resource Utilisation (ISRU) rover	The rover will collect lunar rocks and dust and deposit it into a NASA ISRU experiment on the lander (that delivers the rover). The experiment will then attempt to extract oxygen from iron and silicon oxide compounds in the collected material.	TBD	Non-Reimbursable Space Act Agreement
Brazil/Brazilian Space Agency	Joint Statement for Cooperation in the Artemis Campaign	Expresses mutual desire to further develop cooperative lunar surface activities, with a specific focus on the Artemis campaign.	N/A	Statement of Intent
Canada/CSA	Gateway Cooperation	Gateway cooperation between NASA and CSA under the ISS IGA.	2024	Memorandum of Understanding
	Lunar Exploration Accelerator Program Lunar Rover Mission	The Lunar Rover Mission will advance eight key technologies for planetary rovers: mobility, communications, operations, thermal control for lunar night survival, power generation and storage, and semi-autonomous plus autonomous operations.	2026	Implementing Arrangement under Framework Agreement
Europe/ESA	Artemis Study	Details for NASA and ESA to study, discuss, and exchange necessary information regarding Artemis.	2022	Letter Agreement
	Dosimeters on Artemis I	ESA active dosimeters on Artemis I.	2022	Letter Agreement
	European Service Module	Details provision by ESA of ESM 1 through 3 to NASA.	2022	Implementing Arrangements under ISS IGA and ISS MOU
	Peregrine Ion Trap Mass Spectrometer	Will study the lunar water cycle.	2023	Memorandum of Understanding
	Gateway Cooperation	ESA and NASA Gateway cooperation under the ISS IGA.	2024	Memorandum of Understanding
	Retroflector	Will allow laser beams sent from Earth to be reflected back from the Moon to receivers on Earth.	2024	Memorandum of Understanding

Corresponding International Partner	Instrument Subject Matter	Activity	Mission Date	Format
Europe/ESA	Gateway ESM	Details provision by ESA of ESM 4 and 5 to NASA.	2026	Implementing Arrangement under ISS IGA and Gateway MOU
	Package for Resource Observation and In-Situ Prospecting for Exploration, Characterization, and Testing	A drill and sample analysis package that will be used to identify possible lunar resources (water, oxygen, etc.) that can be mined on the Moon.	2026	Memorandum of Understanding
	Lunar Pathfinder	A communications and data relay satellite that will provide communications services around the Moon.	TBD	Memorandum of Understanding
	Lunar Research and Exploration	Recognizes that NASA and ESA have a common interest in accessing the Moon for science, and in supporting and utilizing private sector capabilities and mission services on the lunar surface and vicinity.	N/A	Statement of Intent
	Joint Statement of Intent on Lunar Services	Recognizes future opportunities of interest regarding the Lunar Pathfinder mission, as well as future robotic missions and lunar surface activities.	N/A	Statement of Intent
	Joint Statement for Cooperation on the Surface of the Moon	Recognizes that NASA, with other international partners, intend to establish a sustainable human presence on the lunar surface that incorporates critical ESA contributions.	N/A	Statement of Intent
	Joint Statement Concerning Lunar Cooperation	NASA and ESA intend to advance shared goals in Artemis cooperation by documenting potential roles and responsibilities related to cargo transportation, communications and navigation, and Artemis utilization.	N/A	Statement of Intent
	Joint Statement Concerning Cooperation Opportunities for Lunar Surface Utilization for Science and Technology	Adds further detail to NASA's and ESA's expected Artemis cooperation in the areas of lunar surface utilization.	N/A	Statement of Intent
	Joint Statement Concerning Cooperation Opportunities for Lunar Surface Cargo Transportation	Adds further detail to concepts for NASA and ESA and Artemis cooperation in the area of lunar surface cargo transportation.	N/A	Statement of Intent

Corresponding International Partner	Instrument Subject Matter	Activity	Mission Date	Format
Europe/ESA	Joint Statement Concerning Cooperation Opportunities for Lunar Communication and Navigation Services	Adds further detail to NASA's and ESA's expected Artemis cooperation in the particular area of lunar communications and navigation.	N/A	Statement of Intent
France/Centre National D'Études Spatiales	Farside Seismic Suite	Pending completion of agreement, will return the agency's first seismic data from the far side of the Moon—a potential future destination for Artemis astronauts.	2025	Implementing Arrangement under Framework Agreement in negotiation
	Lunar Surface Electromagnetics Experiment	Will study the magnetic and electric fields on the Moon's surface and their interaction with fine dust particles.	2025	Implementing Arrangement under Framework Agreement
	Joint Statement on the Extension of the Framework Agreement and Future Cooperation	Recognizes a shared interest in studying potential opportunities for mutually beneficial cooperation in support of exploration missions beyond low Earth orbit.	N/A	Statement of Intent
Germany/DLR	Matroshka AstroRad Radiation Experiment (MARE)	Two phantoms (manikins) are being equipped with German Aerospace Center Institute of Aerospace Medicine-provided radiation sensors.	2022	Implementing Arrangement
India/Indian Space Research Organisation	Chandrayaan-3 LRA	NASA will provide a laser retroreflector array to the ISRO Chandrayaan-3 lunar lander mission.	2023	Implementing Arrangement under Framework Agreement
	Chandrayaan-2 and Chandrayaan-3	NASA will provide navigation and Deep Space Network support for Chandrayaan-2 and Chandrayaan-3.	2023	Reimbursable Agreement
Israel/ISA	Matroshka AstroRad Radiation Experiment (MARE)	Launch of the Matroshka AstroRad Radiation Experiment as a secondary payload on Artemis I.	2022	Implementing Arrangement under Framework Agreement
	Beresheet-2	Israel's second mission to land an Israeli spacecraft on the Moon. Cooperation has not yet been determined.	2025	In negotiation
Italy/ASI	ArgoMoon	Launch of ArgoMoon CubeSat as a secondary payload on Artemis I.	2022	Implementing Arrangement under Framework Agreement
	ArgoMoon CubeSat Dispenser	NASA to provide CubeSat dispenser and integration services on a reimbursable basis for ArgoMoon CubeSat.	2022	Reimbursable Space Act Agreement

Corresponding International Partner	Instrument Subject Matter	Activity	Mission Date	Format
Italy/ASI	Lunar GNSS Receiver Experiment	Will receive signals from both Global Position Systems and Galileo, the Global Navigation Satellite System (GNSS) operated by the European Union. The data gathered will be used to develop operational lunar GNSS for future missions to the Moon.	2023	Implementing Arrangement under Framework Agreement
	Artemis Study	Joint feasibility study regarding potential cooperation between NASA and ASI on Artemis.	2024	Letter Agreement
	Lunar Surface Multi-Purpose Habitation Modules Study	ASI to conduct preliminary design study of ASI-proposed Lunar Surface Multi-Purpose Habitation Modules.	TBD	Space Act Agreement
	Statement of Intent for Cooperation in the Artemis Campaign	Expresses mutual desire to further develop cooperative lunar exploration program, with a specific focus on returning humans to the surface of the Moon.	N/A	Statement of Intent
	Statement of Intent for Cooperation in Space Exploration	ASI's intention to expand bilateral cooperation in both science and human exploration with a focus on lunar cooperation.	N/A	Statement of Intent
Japan/JAXA/Ministry of Education, Culture, Sports, Science and Technology	Artemis I CubeSats Dispenser	NASA to provide CubeSat dispenser and integration services on a reimbursable basis for the CubeSats.	2022	Reimbursable Space Act Agreement
	Artemis I Deep Space Communication	Deep space communications and 3-way Doppler support for CubeSats on Artemis I.	2022	Letter Agreement
	Smart Lander for Investigating Moon	Landing technology demonstration for accurate lunar landing techniques. NASA will provide a laser retroreflector array and DSN support.	2023	Letter Agreement
	Gateway Cooperation	Gateway cooperation between NASA and Japan under the ISS IGA.	2024	Memorandum of Understanding
	Lunar Polar Exploration Mission	Joint rover and lander mission of the Indian and Japanese space agencies to explore the Moon's polar region. NASA is planning to provide a neutron spectrometer system for the rover.	2024/ 2025	Currently, the Letter Agreement is in negotiation; will be converted to Memorandum of Understanding (date TBD)
	Lunar Rovers and Mobility Systems Study	Continued collaboration for studying lunar surface mobility systems.	N/A	Letter Agreement

Corresponding International Partner	Instrument Subject Matter	Activity	Mission Date	Format
Japan/JAXA/Ministry of Education, Culture, Sports, Science and Technology	Joint Statement on Space Exploration	Recognizes previous space cooperation and affirms commitment to continuing operation in space exploration regarding the ISS, lunar vicinity, Mars, and deep space.	N/A	Statement of Intent
	Joint Statement on Collaborative Efforts for Lunar Exploration and Beyond	Recognizes shared vision for sustainable exploration in deep space, including returning humans to the Moon and eventual missions to Mars.	N/A	Statement of intent
	Joint Statement of Intent for Increased Cooperation in Civil Space Activities	Affirms committed partnership in all mission areas and confirms interest in continuing discussions on lunar exploration and other areas of collaboration.	N/A	Statement of Intent
	Joint Statement on Cooperation in Lunar Exploration	Realizes shared goals of advancing a sustainable human presence on the Moon and Mars.	N/A	Statement of Intent
	Joint Exploration Declaration of Intent for Lunar Cooperation	Declares intentions for cooperation on the ISS and Gateway, cooperation on lunar surface exploration, and future arrangements.	N/A	Statement of Intent
Luxembourg/ Luxembourg Space Agency	Joint Statement of Intent	Recognizes NASA's Artemis campaign and underlines potential for future collaborative initiatives such as space applications, space exploration, scientific data sharing, and education.	N/A	Statement of Intent
Poland/Polish Space Agency	Cooperation in the Field of Space Exploration	Recognizes establishment of a sustainable lunar presence with a view towards human exploration of Mars.	N/A	Statement of Intent
Republic of Korea/Korea Aerospace Research Institute	Korea Pathfinder Lunar Orbiter	First Republic of Korea lunar orbiter that will demonstrate a "space internet" and conduct scientific investigations of the lunar environment, topography, and resources, as well as identify potential landing sites for future missions. Includes NASA's ShadowCam instrument and communications support.	2022	Implementing Arrangement under Framework Agreement
Republic of Korea/Korea Astronomy and Space Science Institute	Lunar Space Environment Monitor	Will monitor variations in the near-surface space environment when the Moon is inside and outside of the Earth's magnetotail.[a]	2024	Implementing Arrangement under Framework Agreement in negotiation
Switzerland/ University of Bern	Laser-Ablation Time-of-Flight Mass Spectrometer	Designed for in-situ investigations of the chemical composition of planetary surfaces.	2026	Letter Agreement

Corresponding International Partner	Instrument Subject Matter	Activity	Mission Date	Format
United Arab Emirates/ UAESA/MBRSC	Human Spaceflight	Identify areas of interest within human space flight, including robotics and human space flight activities and utilization of the ISS and Gateway.	2016	Implementing Arrangement under Framework Agreement
United Kingdom/ UK Space Agency	Trailblazer	Trailblazer is a NASA-led mission for understanding the Moon's water cycle.	2023	Memorandum of Understanding
	Lunar Research and Exploration	Recognizes that the United States and United Kingdom have a common interest regarding lunar scientific research and exploration and access.	N/A	Statement of Intent

Source: NASA OIG analysis based on System for International and Interagency External Relations Agreements database information and OIIR presentation of Science Mission Directorate agreements.

[a] The Earth's magnetic tail is an extension of the same magnetic field experienced when using a compass. The Earth is enveloped in a bubble of magnetism, and in space, the solar wind presses against this bubble and stretches it, creating a long "magnetotail" in the downwind direction.

APPENDIX D: MANAGEMENT'S COMMENTS

National Aeronautics and Space Administration

Mary W. Jackson NASA Headquarters
Washington, DC 20546-0001

December 19, 2022

Reply to Attn of: Office of International and Interagency Relations

TO: Assistant Inspector General for Audits

FROM: Associate Administrator for International and Interagency Relations

SUBJECT: Agency Response to OIG Draft Report, "NASA's Partnerships with International Space Agencies for the Artemis Campaign" (A-22-04-00-SOD)

The National Aeronautics and Space Administration (NASA) appreciates the opportunity to review and comment on the Office of Inspector General (OIG) draft report entitled "NASA's Partnerships with International Space Agencies for the Artemis Campaign" (A-22-04-00-SOD) dated November 18, 2022.

In the draft report, the OIG makes ten recommendations addressed to the Associate Administrator for Exploration Systems Development, the Director of Space Architecture, the Associate Administrator for Space Operations, and the Associate Administrator for International and Interagency Relations.

Specifically, the OIG recommends the following:

Recommendation 1: Establish a coordination strategy with NASA's international partners that includes recurring forums specifically for Artemis Accords signatories that are (or are interested in) participating in the Artemis campaign.

Management's Response: NASA concurs. NASA invited space agencies from Artemis Accords signatories, and other space agencies who have expressed interest in Artemis, to an international Moon to Mars workshop this summer to have a meaningful dialogue regarding NASA's objectives. Exploration Systems Development Mission Directorate (ESDMD) and the Office of International and Interagency Relations (OIIR), with the Space Operations, Science, and Space Technology Mission Directorates, are developing a strategic approach for engaging international space agencies interested in contributing to the Artemis campaign, which includes Accords signatories. Additionally, NASA co-hosted a meeting of space agency heads of Artemis Accords signatories this past September which was very well attended. This will be the start of recurring dialogue with our international partners.

Estimated Completion Date: August 31, 2023.

Recommendation 2: Establish NASA-led Artemis campaign boards and working groups for partners with agreed-upon commitments with NASA and provide opportunities for liaison representation from international partner agencies.

Management's Response: NASA concurs. NASA is facilitating international partner participation in NASA-led Artemis campaign program boards and working groups, as well as liaison representatives from those international partners with whom NASA has established agreements, such as the Gateway and Orion programs. NASA anticipates establishing additional agreements for Artemis cooperation in the future and is committed to involving international partners in a manner appropriate to their roles and agreement responsibilities.

Estimated Completion Date: March 31, 2024.

Recommendation 3: Issue a detailed strategy and mission architecture for beyond Artemis IV that considers potential international partner roles and responsibilities.

Management's Response: NASA concurs. NASA is actively working on the detailed strategy and mission architecture for beyond Artemis IV in its Architecture Concept Reviews (ACR) that are being run by ESDMD's Architecture Development Office. These annual ACRs will set the architecture baseline for the Artemis Campaign and for the linkage between the Artemis Campaign and the Mars Campaign. Each ACR will also inform discussions with international space agencies regarding interest in potential contributions. Public rollout of the initial ACR is slated for Q1 2023. Potential international partner roles and responsibilities will be considered throughout the continuing ACR cycles.

Estimated Completion Date: March 31, 2023.

Recommendation 4: Perform a detailed gap analysis and cost estimate for Artemis missions beyond Artemis IV that will help inform a cost-sharing strategy with international partners.

Management's Response: NASA non-concurs. NASA has appropriately timed formal acquisition strategy meetings to evaluate requirements, perform analysis of alternatives to inform the acquisition strategy, support technical discussions with potential partners, and evaluate the concept in consultation with stakeholders as appropriate. Additionally, NASA has well-established processes to consider partnerships. These processes include developing acquisition strategies based on resource availability; impact on the Agency workforce; maintaining core capabilities; make-buy-partner decisions; supporting Center assignments; use of partnerships; and the availability of the industrial base capability and supply chain needed to design, develop, produce, and support the program or project, identifying risks associated with single-source or critical suppliers, and attendant mitigation plans. Moreover, the processes ensure proper timing of the decision for acquisition, alignment with national interest, and compliance with NASA's international partnership policies and processes. As part of the development and refinement of the architecture, NASA will

perform regular gap analyses which will also inform discussions of potential international partner contributions.

The processes described above are a rigorous approach. The Artemis Campaign is not bounded in such a way as to accommodate conducting a defensible cost estimate on a multi-decade campaign that includes technologies and acquisition strategies beyond our ability to reliably predict today.

Estimated Completion Date: N/A

Recommendation 5: Establish a full-time export control team dedicated to the various Artemis programs in support of space flight developments.

Management's Response: NASA concurs. NASA understands that the Artemis missions, which will return United States (U.S.) astronauts to the Moon, and include international partner astronauts on future missions, will require a standard and consistent approach to export control compliance. Careful enforcement of export control policies that consider the participation of international partners will be pivotal to secure successful international relationships in deep space while allowing appropriate technology transfer to assure mission success. To this end, NASA is establishing an export control team that will work closely with OIIR to oversee consistent compliance practices across Artemis missions. NASA has identified export control leads, to include relevant Center Export Administrators and empowered export control officials, whose activities will be integrated across programs, guided by a senior NASA official who will liaise with OIIR on burgeoning export control issues for future Artemis mission planning. This team will work throughout the upcoming year to grow this small but knowledgeable team and continue to make progress on establishing processes that are streamlined to Artemis mission goals and objectives.

Estimated Completion Date: December 31, 2023.

Recommendation 6: Review export control requirements and consider additional roles for partner astronauts to increase their utilization in NASA space flight operations, to include amending existing agreements if necessary.

Management's Response: NASA concurs. NASA plans on considering additional roles for international partner astronauts and commensurate export control requirements.

Estimated Completion Date: June 30, 2023.

Recommendation 7: Establish a full-time export control team dedicated to the Artemis programs in support of space flight operations.

Management's Response: NASA concurs. NASA understands that the Artemis missions, which will return U.S. astronauts to the Moon, and include international

partner astronauts on future missions, will require a standard and consistent approach to export control compliance. Careful enforcement of export control policies that take into account the participation of international partners will be pivotal to secure successful international relationships in deep space while allowing appropriate technology transfer to assure mission success. To this end, NASA is establishing an export control team that will work closely with OIIR to oversee consistent compliance practices across Artemis missions. NASA has identified export control leads, to include relevant Center Export Administrators and empowered export control officials, whose activities will be integrated across programs, guided by a senior NASA official who will liaise with OIIR on burgeoning export control issues for future Artemis mission planning. This team will work throughout the upcoming year to grow this small but knowledgeable team and continue to make progress on establishing processes that are streamlined to Artemis mission goals and objectives.

Estimated Completion Date: December 31, 2023.

Recommendation 8: Coordinate with other federal agencies to gain a unique EAR classification for the Gateway as appropriate.

Management's Response: NASA concurs. The Departments of State and Commerce hold the statutory authority to regulate exports of Gateway and Gateway elements. As such, implementation of a unique Export Administration Regulations (EAR) classification covering exports of Gateway and Gateway elements remains under the purview of the export control agencies. In March 2019, State and Commerce solicited public comment on streamlined export controls in civil space and several commenters expressed support for creating a unique EAR classification for Gateway and Gateway elements. Such a unique EAR classification already exists for the International Space Station and the James Webb Space Telescope, and analogous oversight of Gateway, where appropriate, would continue this streamlined framework.

Since then, NASA has engaged in ongoing interagency discussions with State and Commerce, as well as other interagency stakeholders, and will continue to do so regarding a unique EAR classification for Gateway and Gateway elements. NASA concurs that a unique EAR classification for Gateway and Gateway elements would clarify and streamline export control requirements across Artemis missions while furthering the national security and foreign policy objectives of U.S. export controls. NASA will continue to advocate such a regulatory change, which requires interagency agreement over the scope and text of the change, congressional notification under Section 38(f) of the Arms Export Control Act, and concurrent rulemaking by State and Commerce implementing this unique classification for Gateway and Gateway elements.

Estimated Completion Date: NASA anticipates completion of the interagency briefings by March 2023 and will continue engaging in interagency discussions until a unique classification for Gateway items, as appropriate, is implemented under the EAR.

Recommendation 9: In conjunction with NASA's Mission Directorates and the State Department, execute appropriate Artemis agreements with key international space agency partners to ensure partner roles and responsibilities are clearly understood and allow for efficient and timely partnerships in support of Artemis.

Management's Response: NASA concurs. NASA has several key international partnerships in place in support of Artemis and looks forward to growing that community in the near- and long-term. NASA plans to continue developing international agreements in 2023 to support the Artemis campaign missions and enable initial lunar surface hardware contributions from key international space agency partners. These agreements will address international partner roles and responsibilities in support of Artemis objectives. NASA will continue to coordinate with the State Department, other key U.S. Government partners, and international partner space agencies to enable efficient and timely conclusion of these agreements.

Estimated Completion Date: March 31, 2024.

Recommendation 10: Develop an automated routing method for the processing of international agreements within NASA.

Management's Response: NASA concurs. NASA concurs that electronic routing for the Agency would increase efficiency and effectiveness and has efforts underway to implement electronic routing. OIIR plans to leverage these Agency-wide efforts to implement an electronic routing system and, as soon as it is available, plans to utilize for international agreements. The Office of the Executive Secretariat is currently reviewing available systems for adoption within the Agency.

Estimated Completion Date: June 30, 2023.

We have reviewed the draft report for information that should not be publicly released and have not identified any information that should not be publicly released.

Thank you for the opportunity to review and comment on the subject draft report. If you have any questions or require additional information regarding this response, please contact Timothy Tawney at (202) 358-1867 or Katelyn Kuhl at (202) 358-3659.

Karen Feldstein

APPENDIX E: REPORT DISTRIBUTION

National Aeronautics and Space Administration

Administrator
Deputy Administrator
Associate Administrator
Chief of Staff
Associate Administrator for Technology, Policy, and Strategy
Associate Administrator for Exploration Systems Development Mission Directorate
Associate Administrator for Space Operations Mission Directorate
Associate Administrator for International and Interagency Relations
Associate Administrator for Science Mission Directorate
Director of Space Architectures

Non-NASA Organizations and Individuals

Office of Management and Budget
    Deputy Associate Director, Climate, Energy, Environment and Science Division

Government Accountability Office
    Director, Contracting and National Security Acquisitions

Agenzia Spaziale Italiana (Italian Space Agency/ASI)
    President of Agenzia Spaziale Italiana

Australian Space Agency (ASA)
    Head of Agency of ASA

Canadian Space Agency (CSA)
    President of CSA

European Space Agency (ESA)
    Director General of ESA

Israel Space Agency (ISA)
    Director General of ISA

Japan Aerospace Exploration Agency (JAXA)
    President of JAXA

United Arab Emirates Space Agency (UAESA)
    Minister of State for Advanced Technology and Chairwoman of the UAE Space Agency

Airbus Group, Inc.

Lockheed Martin Corporation

Maxar Technologies Holdings Inc.

Northrop Grumman Corporation

Space Exploration Technologies Corporation

Toyota Motor Corporation

Thales Alenia Space

The Aerospace Corporation

The Boeing Company

Congressional Committees and Subcommittees, Chairman and Ranking Member

Senate Committee on Appropriations
- Subcommittee on Commerce, Justice, Science, and Related Agencies

Senate Committee on Commerce, Science, and Transportation
- Subcommittee on Space and Science

Senate Committee on Homeland Security and Governmental Affairs

House Committee on Appropriations
- Subcommittee on Commerce, Justice, Science, and Related Agencies

House Committee on Oversight and Reform
- Subcommittee on Government Operations

House Committee on Science, Space, and Technology
- Subcommittee on Investigations and Oversight
- Subcommittee on Space and Aeronautics

(Assignment No. A-22-04-00-SOD)