Artemis: An Overview of NASA's Activities to Return Humans to the Moon

Steve Creech
NASA Headquarters
300 E St. SW
Washington, DC 20546
steve.creech@nasa.gov

John Guidi
NASA Headquarters
300 E St. SW
Washington, DC 20546
john.guidi@nasa.gov

Darcy Elburn
NASA Headquarters
300 E St. SW
Washington, DC 20546
darcy.e.elburn@nasa.gov

***Abstract*—NASA is well underway in its plans to return humans to the Moon and build long-term infrastructure both in orbit and on the surface. Following the Artemis I and Artemis II flight tests, NASA will begin crewed landings and regular missions to the Moon. Artemis will return value to the American public and the global community, enable groundbreaking scientific discovery, and prepare NASA and its partners for exploration of the solar system. Work on the initial Human Landing System (HLS), procurement activities for future HLS, and work on the initial modules of the lunar-orbiting Gateway are underway. International partnerships are playing a critical role in the planning, development, and execution of these missions. As of December 2021, three international partners have entered agreements to contribute to the Gateway and 14 nations have signed the Artemis accords. A new spacesuit acquisition strategy will stimulate economic growth and meet the growing needs of NASA and emerging customers. Requirements development is underway for an unpressurized lunar surface rover and plans for a pressurized rover, foundation surface habitat, and the Artemis Base Camp are in work. This paper will provide an update on the HLS demonstration missions and the procurement status for HLS services; a comprehensive look at the Gateway's components and related statuses; a summary of planned surface systems; and an outline of the strategies NASA will use to successfully implement these plans, preparing for humanity's next giant leap: Mars.**

TABLE OF CONTENTS

1. INTRODUCTION.....1
2. WHY THE MOON? 1
3. STRATEGY.....1
4. HUMAN LANDING SYSTEM 3
5. THE GATEWAY 4
6. SPACEWALK SYSTEMS.....5
7. LONG-TERM SURFACE OPERATIONS 5
8. ENABLING MARS 5
9. CONCLUSION 6
REFERENCES 6
BIOGRAPHY 5

1. INTRODUCTION

NASA's rich history of human spaceflight has laid the foundation for today's vision: to maintain U.S. leadership in space and establish a lasting presence on and around the Moon. Through Artemis, NASA will land the first woman and the first person of color on the lunar surface. These historic accomplishments will signal the start of a new era in human exploration, and the build-up towards a regular cadence of lunar missions.

Space Policy Directive-1, issued in December 2017, instructs NASA to, "Lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities. Beginning with missions beyond low-Earth orbit, 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]

Establishing a long-term human presence on and around the Moon and conducting the first human mission to the surface of Mars will be among the most challenging technical enterprises in human history.

NASA's human spaceflight activities embrace an expansive portfolio, but it's been almost 50 years since we last sent astronauts to deep space. The Moon is the natural location to revive human activities in deep space and develop the infrastructure in orbit and on the surface to support repeatable missions that grow in duration and complexity. Building on more than two decades of operations aboard the International Space Station (ISS) in low-Earth orbit (LEO) and leveraging the agency's wealth of experience with groundbreaking exploration, now is the time to ensure strategic U.S. global leadership in space, build back better through innovation, strengthen global alliances, and develop technologies to solve challenges here on Earth.

Along the way, NASA will inspire and cultivate a diverse Science, Technology, Engineering, and Math (STEM) workforce. The Artemis generation will enable continued work in the lunar environment, solve Earth's most critical problems, and reach new destinations in our solar system, starting with these missions. [2]

2. WHY THE MOON?

The Moon is a treasure trove of science, and we have barely begun to discover what it can tell us. The knowledge we

acquire through a sustained human and robotic presence on the surface and in orbit will help us better understand the universe and our home planet.

By studying the geology of the Moon, Artemis astronauts will gather new data key to understanding planetary processes, the impact history of our Earth-Moon system, and the history of our Sun.[3] Lunar samples returned during the Apollo Program dramatically changed our view of the solar system, and scientists continue to unlock new secrets from those samples today.

More challenging landing sites will offer even more scientifically rich conditions. Artemis missions will target the lunar South Pole, home to more extreme environments than humans have ever visited before. The region is massively cratered, with areas that are bathed in sunlight and shrouded in darkness. The craters are brutally cold but elevated areas can grow extremely hot. These factors increase risk but offer greater scientific rewards.

Experiments on Artemis missions will collect new information on the character and origin of polar volatiles.[3] The South Pole is known to contain deposits of water ice that may be used by future explorers for drinking, cooling, producing oxygen, and making rocket fuel. Robotic Artemis missions like Volatiles Investigating Polar Exploration Rover (VIPER) will tell us more about the source and concentration of water ice and inform resource maps that will shape future exploration plans.[3]

Development of technologies like in-situ resource utilization (ISRU), fed by Artemis missions, will enable longer duration human missions to destinations farther from Earth.

Humanity has always been fascinated by the Moon. As with Apollo, the Artemis missions will capture the imaginations of people around the globe. The international team bringing these missions to life, and crews selected from the most diverse astronaut corps in history, will allow the next generation to see themselves in Artemis. Coordinated outreach efforts across NASA will connect students with opportunities to participate in the missions, and to pursue careers in STEM and other fields. The agency has also undertaken internal efforts to support early career employees. NASA is committed to establishing the lunar economy and creating lasting opportunities on Earth.

3. STRATEGY

These missions require the rigor, experience, and history that NASA is known for and an infusion of innovation from a wide range of partners both familiar and new.

Throughout this century, NASA has focused on increasing private-sector involvement in space, laying a foundation for long-term exploration where government agencies are one of several customers in a vibrant space economy. Working with commercial partners enables NASA to focus its attention forward, while industry teams zero in on iterating, streamlining, and manufacturing at a faster pace. NASA's priority is safely meeting exploration goals through efficient and effective work. Clearly defined roles and responsibilities, along with constant collaboration and communication, are critical. The agency will maintain oversight of commercial work on NASA hardware and systems to ensure they meet requirements and high standards for safety.

Increasing the use of services-based contract models, like those used by Commercial Crew Program, across the human spaceflight portfolio is freeing up resources within NASA to look further into the future and to focus on facilitating smooth integration between entities. Artemis programs have the benefit of knowledge sharing and are learning from and building on the lessons of other NASA teams who have worked on these types of contracts. Human landing systems and exploration extravehicular activity (xEVA) systems acquisitions will both use service-based contracts to facilitate Artemis missions.

NASA's Commercial Lunar Payload Services (CLPS) initiative allows rapid acquisition of lunar delivery services from American companies for payloads that advance capabilities for science, exploration, or commercial development of the Moon. To date, 14 vendors are eligible for CLPS missions, and the first deliveries are scheduled for 2022.[4]

Our nation is not alone in making plans to explore the Moon. Countries of all sizes are enthusiastic about our plans, and our international partners have expressed great interest in collaboration. NASA is also contributing to other nations' science missions and pursuing opportunities for emerging space nations to participate.

For example, data collected by ShadowCam, a NASA instrument on the Korean Aerospace Research Institute's Korea Pathfinder Lunar Orbiter (KPLO) mission, will tell us more about shadowed regions and possible future landing sites. Nine NASA scientists have joined the KPLO team, showing support for growing space economies and workforces around the world.[5]

The Canadian Space Agency (CSA), the European Space Agency (ESA), and the government of Japan have entered agreements to contribute to the Gateway and 14 nations have signed the Artemis accords so far, committing to safe and peaceful operations and cooperation in the lunar environment.

NASA's investments in the growing space economy, the global space community, and the next-generation STEM workforce are building a strong and sustainable foundation for generations of exploration to come. Along with strategic development of advanced exploration systems, these tactics will enable NASA to meet the substantial challenges and achieve the ambitious goals of Artemis.

4. HUMAN LANDING SYSTEM (HLS)

To put the first woman and first person of color on the Moon, NASA needs capable, safe, and efficient human landing systems to take astronauts from lunar orbit to the surface and back again.

The Apollo Program set out to prove NASA could land humans on the Moon and return them safely to Earth. With Artemis, we will return to the Moon long-term, which requires greatly expanded capability and a strategy that allows for more frequent missions. To achieve this, NASA seeks to foster the development of commercial expertise and technologies.

In late 2019, NASA asked American industry for proposals to design and develop a human lander for the first Artemis human mission to the surface (including the execution of one uncrewed flight test) under the Next Space Technologies for Exploration Partnerships (NextSTEP-2) Broad Agency Announcement Appendix H, referred to as Option A. Initial base period contracts were awarded to Blue Origin Federation, Dynetics, and SpaceX to advance their designs. Following a short-term contract extension to complete its evaluation, selection, and contract award process, NASA publicly announced in April 2021 that the agency selected SpaceX to move forward with its human landing system and land the first two American astronauts on the lunar surface under Artemis.[6]

After the Government Accountability Office upheld NASA's procurement process and decision, NASA awarded the Option A contract to SpaceX in July 2021. After and the Court of Federal Claims upheld NASA's procurement process and decision in November 2021, work resumed.

Since November 2021, the NASA and SpaceX teams have reinitiated regular update meetings, completed several contract milestone payment reviews, and held program management and technical review site visits at SpaceX facilities in both Boca Chica, TX, and Hawthorne, CA. In addition, several collaboration tasks and Government Task Agreements (GTAs) have been initiated and approved for particular areas of focus where SpaceX has requested the use of NASA expertise or facilities.

Looking forward, NASA is accelerating procurement opportunities for future crewed Artemis missions that will build a routine cadence of human transportation services to and from the lunar surface.

In July 2021, NASA released a solicitation seeking new commercial-led work to mature HLS designs and study risk reduction solutions under the NextSTEP-2 Broad Agency Announcement Appendix N. In September 2021, NASA selected five U.S. companies to participate: Blue Origin Federation of Kent, Washington; Dynetics (a Leidos company) of Huntsville; Lockheed Martin of Littleton; Northrop Grumman of Dulles; and SpaceX of Hawthorne.[7]

NASA's HLS technical teams are fully engaged with the Appendix N providers and have established working groups that are divided by area of study. These groups are conducting weekly meetings to answer questions and provide clarification on the HLS sustaining mission requirements and NASA-directed trade studies.

NASA's Lunar Exploration Transportation Services (LETS) solicitation will secure transportation for future routine crewed surface missions. LETS will build on the risk reduction activities completed under Appendix N as well as on previous public-private HLS work.

The agency initiated collaboration with industry in the agency's first formal step towards procuring regular crewed transportation to the lunar surface by releasing a request for information (RFI) in July 2021.[8] This RFI asked U.S. companies for feedback to inform the agency's plan for purchasing HLS services to ferry astronauts from the Gateway in lunar orbit to the surface of the Moon and back. This work will help to polish requirements for LETS.

NASA's goals are to enable the safest and most affordable long-term approach to accessing the lunar surface and to eventually be one of many customers purchasing lunar transportation services in a thriving lunar economy.

5. THE GATEWAY

When we go to the Moon with Artemis, we are going to stay, and an orbiting outpost is critical to long-term access. The Gateway will serve as a staging point for astronauts on their way to the lunar surface and as an outpost for unprecedented deep space science and technology investigations, advancing capabilities for human exploration beyond cislunar space.

NASA has focused development of the Gateway on the initial critical elements required to support early Gateway missions: the Power and Propulsion Element (PPE), the Habitation and Logistics Outpost (HALO), and logistics capabilities.

The PPE is the initial building block of the Gateway, providing the thrust to transfer itself and the HALO module from an initial earth orbit to lunar orbit and to maintain that orbit around the Moon. It will also generate power for the other modules, and provide communications between Gateway and Earth, including Moon-to-Earth communications relay in concert with a European provided lunar communications system. In May 2019, NASA awarded a contract to Maxar Technologies to develop the PPE.[9]

In December 2021, the PPE team completed the Gateway Power and Propulsion Element (PPE) Maxar Preliminary Design Review (PDR). This put the team on track to complete Critical Design Review (CDR) in late spring 2022. Two thrusters are being tested concurrently at NASA's Glenn Research Center in support of PPE: Busek's 6-kW string and Aerojet Rocketdyne's 12-kW Advanced Electric Propulsion System.

The HALO will be the Gateway's hub, providing three docking ports for aggregation of other Gateway elements and visiting vehicles. Its primary purpose is to provide crew accommodations and workspace for the visiting astronauts when they arrive in Orion and as they prepare for departure to the lunar surface. This module provides the backbone for command, control, and power distribution across the lunar outpost, and hosts other core functions including science investigations via internal and external payload accommodations, and communications with lunar surface expeditions.

In May 2020, NASA awarded Northrop Grumman Space a contract to design the Gateway's HALO module, leveraging the company's experience building its Cygnus spacecrafts, which are currently used to deliver cargo to the International Space Station.[10] The initial contract award funded HALO's design and development through completion of its PDR, allowing the HALO design to mature significantly, before completion of the system PDR closeout in May 2021.[11] This maturation enabled NASA to definitize the final contract phase for the HALO module's development, delivery, and integration with PPE in July 2021.[12]

Northrop Grumman Space's contract also funds the initial design and analysis necessary to integrate HALO with PPE in preparation for a co-manifested launch. Integration design work between HALO and PPE is well underway in preparation for the independent modules to be mated at the launch site and launched together on a SpaceX Falcon Heavy.

Additionally, in February 2021, NASA selected SpaceX as the first U.S. commercial provider under the Gateway Logistics Services contract to deliver cargo, experiments, and other supplies to Gateway.[12]

Building on more than 20 years of partnership on the International Space Station, critical elements of the Gateway will be provided by NASA's international partners. The Canadian Space Agency (CSA), the European Space Agency (ESA), and the government of Japan have entered agreements committing to building the Gateway with NASA.[13]

These partnerships are critical to the Gateway from the beginning. HALO will feature robotic interfaces provided by CSA and batteries provided by JAXA. ESA will contribute the HALO Lunar Communication System (HLCS) which will provide the Gateway with data, voice, and video communications and connect with ESA's European System Providing Refueling, Infrastructure and Telecommunications (ESPRIT) Refueling Module (ERM).

International partners are also involved in the utilization of the Gateway for science. Two early payloads from ESA have been selected to measure radiation in Gateway's unique orbit. JAXA will provide instruments for one of these payloads. Both payloads will be launched with PPE and HALO.

As NASA and its partners continue to expand the Gateway with additional modules and capabilities, CSA's planned contributions include the outpost's external robotics system (Candadarm3), robotic interfaces, and end-to-end robotic operations. ESA will provision the International Habitat (I-HAB) and refueling modules, along with enhanced lunar communications and two European Service Modules for the Orion spacecraft. The Japan Aerospace Exploration Agency's (JAXA) planned contributions include the I-HAB's environmental control and life support systems, batteries, thermal control, and imagery components, all of which will be integrated into the module by the ESA prior to launch. These capabilities are critical for sustained Gateway operations during both crewed and uncrewed time periods.

NASA now has every major piece of the initial Gateway configuration on contract, is working with major international partners, and has established initial plans for science utilization of the orbiting lab. The co-manifested launch of PPE and HALO is planned for no earlier than 2024 and NASA expects to have this initial configuration in its Near Rectilinear Halo Orbit (NRHO) and ready for use by astronauts during the Artemis IV mission.

6. SPACEWALK SYSTEMS

The next era of human space exploration requires revolutionary spacewalk systems to protect astronauts from harsh environments and enable improved capability for performing critical mission tasks. Advanced exploration spacesuits are the core of spacewalk systems, but extravehicular activities (xEVAs) also require a complete suite of hardware to conduct spacewalks, custom tools for suited sample collection, and the associated vehicle interfaces for servicing, recharge, and consumables exchange.

To procure spacesuits that will allow astronauts to walk, jump, kneel, spelunk, and climb with new degrees of freedom, NASA is embracing commercial partnerships to optimize spacesuit technology and inspire innovation. These new capabilities will allow expanded exploration range and improved sample collection, while this new procurement strategy will bolster the growing xEVA systems industry.

NASA published a request for proposal (RFP) in September 2021, inviting companies to compete for the agency's future purchase of xEVA Services (xEVAS) for use on the International Space Station, during Artemis lunar surface missions, and as needed on Gateway in lunar orbit.[14] The final RFP was significantly informed by industry comments received in response to a request for information (RFI) and draft RFP that were released earlier in 2021. NASA is targeting award in April 2022.

This approach will support and encourage emerging U.S. companies to provide EVA services to a range of customers (including space tourism companies and purveyors of permanent, commercial space stations) without NASA as an intermediary. Collaboration will leverage NASA's skills, expertise, and capabilities, and incentivize collaboration with

government by making government facilities and infrastructure available for use by service provider(s).

Building on more than 55 years of lessons learned during spacewalks, teams at Johnson Space Center (JSC) will continue technical risk reduction efforts for next generation spacesuits by completing the design verification testing of NASA's in-house exploration spacesuit, known as the Exploration Extravehicular Mobility Unit (xEMU). NASA will make data from its design and development work available for use by industry. NASA will further reduce risk by upgrading unique EVA test facilities, including human rated vacuum chambers and reduced gravity test systems, and making them available for xEVAS provider(s) after contract award.

The JSC workforce remains critical to the success of future spacesuit programs and will provide insight and oversight and participate in collaboration teams with selected service provider(s) via Government Task Agreements. The JSC team will continue to lead EVA mission planning and crew training to support Artemis and space station missions. This adjustment in strategy will allow the JSC engineering development team to transition EVA risk reduction focus to address the future challenges of building lunar surface infrastructure and sending humans to Mars, as the new service provider(s) come on board.

By uniting with commercial industry partners for work on this critical capability, NASA will energize the space economy, revolutionizing the human experience in space.

7. Long Term Surface Operations

To effectively explore more of the lunar surface, future Artemis crews will need transportation for themselves, their tools, and samples they collect. The lunar terrain vehicle (LTV) is an unenclosed rover that two astronauts will drive while wearing their EVA spacesuits. Unlike the Apollo lunar roving vehicle, the LTV will not only be a means of crew transportation, but an autonomous system, able to continue scientific exploration when the crew is not present. This will greatly expand reach and scientific capacity on the Moon.

Requirements development for LTV is underway, including "survive the night," studies to evaluate multiple operational approaches to enable the vehicle to withstand multi-day durations in the dark and cold environment of the lunar night. An RFI to inform these studies was released in September 2021.[15]

As frequent surface missions continue, infrastructure will be built up in orbit and at the South Pole, through a combination of CLPS, NASA, and partner missions. Additional modules will be added to Gateway to expand habitation, science, and logistics capacity. On the surface, NASA will establish Artemis Base Camp. A pressurized rover will enable two crew to explore a greater area of the south pole region, living and working inside the vehicle without suits for approximately two weeks. The addition of a foundation surface habitat, and supporting logistics capabilities, will enable four crew longer-duration surface missions and exponentially increase the amount of data astronauts can collect.[16]

Enhancing capabilities such as power stations, surface communication and navigation aids, and technology demonstrations will be instrumental in growing the capability of the Artemis Base Camp. As mission lengths and capabilities grow, opportunities for international partnership, commercial innovation, and human research will expand. Data these crews collect will impact biological science and medicine on Earth and inform plans for missions farther into deep space.

8. Enabling Mars

Exploration architectures being developed for the 2030s focus on establishing a sustained presence in cislunar space and on the surface and on assessing and advancing human exploration systems required for missions beyond the Earth-Moon system, including to Mars. Prototype systems for Mars exploration will be tested first on and around the Moon to reduce future mission risk. Prototype systems will include advanced technologies needed for long duration human spaceflight such as closed-loop life support systems. These missions will continue cross-discipline science activities combined with lunar surface prospecting and resource utilization activities.

With the infrastructure and foundations developed in earlier Artemis missions, additional opportunities will be open for international and commercial partners to utilize proven cislunar and surface systems. Diverse robotic precursor missions will refine current science knowledge and improve understanding of the detailed location and concentration of lunar volatiles. This work will enable robust lunar ISRU development and provide a proving ground for surface and transit infrastructure critical for exploration of Mars and beyond.

During this time, lunar surface stays may potentially increase to a duration analogous to Mars surface expeditions, allowing NASA to verify procedures and mission operations for future Mars missions. These scientific and exploration architectures also include the first opportunities to demonstrate human Mars exploration elements.

The first step in NASA's human Mars campaign will likely be developing and adding Mars-forward systems and analog activities into lunar operations. A key goal of Artemis is to gain operational experience on systems similar to those required for crewed Mars exploration. By getting time on systems in the cislunar region, relatively close to Earth, we will gain the confidence needed to make the next giant leap to Mars.

9. CONCLUSION

With Artemis I and II flight tests steadily approaching, NASA teams are hard at work preparing to put the first woman and first person of color on the Moon. The Initial HLS is under contract and planning for sustaining HLS services procurement is underway. All initial Gateway capability elements are under contract and proceeding to system-level PDR and module-level CDRs. Exploration suit procurement is underway with NASA targeting award in April 2022. LTV formulation activities are underway and pressurized rover pre-formulation efforts are continuing. The Artemis era has truly begun.

NASA's progress on and around the Moon over the next decade will ensure the United States can send the first humans to Mars in the 2030s.

Artemis represents an integrated approach to deep space exploration using the best of NASA's cross-disciplinary capabilities and commercial and international partnership opportunities. The capabilities and technology developed and demonstrated throughout Artemis will establish the foundation for sustainable exploration to Mars and other deep-space destinations with the highest possible standards of safety and the highest level risk mitigation that can be achieved.

By reflecting our world and representing more of Earth, Artemis will inspire and drive the next generation of STEM professionals. A growing lunar economy will expand the opportunities NASA continues to create in low-Earth orbit and on the ground.

These missions represent the best path to achieve the objectives set out in SPD-1 and return humans to the Moon. Artemis will lay the groundwork for a sustainable, permanent lunar presence with crewed and uncrewed systems through this decade and beyond.

REFERENCES

[1] Reinvigorating America's Human Space Exploration Program, Space Policy Directive-1, Dec. 11, 2017

[2] M. Smith et al., "The Artemis Program: An Overview of NASA's Activities to Return Humans to the Moon," 2020 IEEE Aerospace Conference, 2020, pp. 1-10, doi: 10.1109/AERO47225.2020.9172323.

[3] Artemis III Science Definition Team Report, Dec. 7, 2020

[4] Commercial Lunar Payload Services Overview, Jun. 24, 2021, https://www.nasa.gov/content/commercial-lunar-payload-services-overview

[5] NASA Selects Nine Scientists to Join Korea Pathfinder Lunar Orbiter Mission, Mar. 30, 2021, https://www.nasa.gov/feature/nasa-selects-nine-scientists-to-join-korea-pathfinder-lunar-orbiter-mission

[6] NASA. (2021). Source Selection Statement, Appendix H: Human Landing System, Option A Next Space Technologies for Exploration Partnerships-2 (NextSTEP-2)

[7] Artemis NASA Selects Five U.S. Companies to Mature Artemis Lander Concepts, Sept. 14, 2021, https://www.nasa.gov/press-release/nasa-selects-five-us-companies-to-mature-artemis-lander-concepts

[8] NASA Seeks Industry Feedback for Artemis Moon Landing Services, Jul. 21, 2021, https://www.nasa.gov/human-landing-systems/nasa-seeks-industry-feedback-for-artemis-moon-landing-services.html

[9] NASA Awards Artemis Contract for Lunar Gateway Power, Propulsion, May 23, 2019, https://www.nasa.gov/press-release/nasa-awards-artemis-contract-for-lunar-gateway-power-propulsion

[10] NASA Awards Northrop Grumman Artemis Contract for Gateway Crew Cabin, Jun. 5, 2020, https://www.nasa.gov/press-release/nasa-awards-northrop-grumman-artemis-contract-for-gateway-crew-cabin

[11] NASA, Northrop Grumman Finalize Moon Outpost Living Quarters Contract, Jul. 9, 2021, https://www.nasa.gov/press-release/nasa-northrop-grumman-finalize-moon-outpost-living-quarters-contract

[12] NASA Awards Contract to Launch Initial Elements for Lunar Outpost, Feb. 9, 2021, https://www.nasa.gov/press-release/nasa-awards-contract-to-launch-initial-elements-for-lunar-outpost

[13] NASA, Government of Japan Formalize Gateway Partnership for Artemis Program, Jan. 12, 2021, https://www.nasa.gov/press-release/nasa-government-of-japan-formalize-gateway-partnership-for-artemis-program

[14] NASA Seeks Spacesuit Services Proposals for Artemis, Space Station, Sept. 30, 2021, https://www.nasa.gov/feature/nasa-seeks-spacesuit-services-proposals-for-artemis-space-station

[15] NASA Prompts Companies for Artemis Lunar Terrain Vehicle Solutions, Aug. 31, 2021, https://www.nasa.gov/feature/nasa-prompts-companies-for-artemis-lunar-terrain-vehicle-solutions

[16] NASA Outlines Lunar Surface Sustainability Concept, Apr. 2, 2021, https://www.nasa.gov/feature/nasa-outlines-lunar-surface-sustainability-concept

BIOGRAPHY

Steve Creech *is the Assistant Associate Administrator (ADAA) for the Advanced Exploration Systems (AES) division within NASA's Exploration Systems Development Mission Directorate at NASA's Headquarters in Washington, DC.*

Creech previously served as the deputy manager and then manager for the Spacecraft/Payload Integration and Evolution Office within the Space Launch System (SLS) Program, overseeing development of spacecraft and payload interfaces for America's deep-space rocket for human and scientific exploration. Prior to that, he served as the Program's assistant manager for strategic development, leading business development, collaboration, and partnerships for future payload and capabilities.

He previously served as the Ares V integration manager and managed the Engineering Cost Group in the Office of Strategic Analysis and Communications at Marshall. He has served in a management role on several space flight programs throughout his career, including the Space Launch Initiative Program, the X-33, the X-34, and the Reusable Launch Vehicle Projects Office at Marshall.

Mr. Creech holds a bachelor's degree in Industrial Engineering from Mississippi State University. Honors include NASA's Medal for Exceptional Service and Distinguished Performance Award and the agency's prestigious Silver Snoopy, awarded by the Astronaut Office for professionalism, dedication, and outstanding support that greatly enhanced space flight safety and mission success.

John Guidi *is the Program Integration Manager of the Advanced Exploration Systems Division within NASA's Exploration Systems Development Mission Directorate.*

John joined NASA in 1987 at Kennedy Space Center with a bachelor's degree in Electrical Engineering from the University of Florida while later receiving a master's degree in Space Systems in 1992 (FIT) and masters in Engineering Management, 1994 (UCF). He served various positions within Shuttle Operations at KSC, including Shuttle Test Director, Launch Manager, and Shuttle Launch and Landing Division Chief. He moved to NASA headquarters/DC in 2005 as Operations Project Manager for the newly formulated Constellation Program and later as Ground & Mission Ops Program Executive. From February 2007 to February 2011, John served as Deputy Director, ESMD Strategic Analysis Division which provides integrated technical and management planning across ESMD and later joined HEOMD in 2011 as Deputy Director of the Advanced Exploration Systems Division, leading international partnerships, science integration and human spaceflight architecture strategic planning and analysis, later broadening in 2020 to include integration of Artemis mission systems development including the Human Landing System, Gateway, spacesuits, lunar rovers and surface habitats.

Darcy Elburn *is the lead strategic communicator for Advanced Exploration Systems (AES) at NASA Headquarters in Washington, DC. In this role Darcy integrates communications efforts relating to the AES portfolio across the agency and supports both the Artemis and Exploration Systems Development Mission Directorate (ESDMD) communications teams. Darcy previously served the agency by supporting the International Space Station Division at Headquarters as a strategic visual communicator. She holds a Bachelor of Arts in Philosophy from McDaniel College.*