**MEMORANDUM**

**TO: Republican MEMBERS OF THE SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION**

**FROM: REPUBLICAN COMMITTEE STAFF**

**DATE: JULY 9, 2019**

**RE: AVIATION & SPACE SUBCOMMITTEE HEARING: “NASA EXPLORATION PLANS: WHERE WE’VE BEEN AND WHERE WE’RE GOING”**

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On Tuesday, July 9th, 2019, at 2:30 p.m. in room XX of the XX Senate Office Building, the Subcommittee on Aviation and Space will hold a hearing entitled, “NASA Exploration Plans: Where We’ve Been and Where We’re Going.” The purpose of this hearing is to honor the upcoming 50th anniversary of the National Aeronautics and Space Administration’s (NASA) Apollo 11 mission and the United States landing the first man on the moon. Senator Cruz will preside. The following witnesses will testify:

Potential Witness Panel 1

* Jim Lovell / Michael Collins or other Apollo astronaut
* “Hidden Figures” Human Computer
* Gene Kranz- Former NASA Flight Director at JSC. Best known for serving as the flight director during Apollo 11 and is credited for helping save the lives of the crew of Apollo 13.
* Homer Hickam- Former NASA Engineer. Homer’s 1998 memoir *Rocket Boys*, was the basis for the 1999 film *October Sky*. Homer serves on Vice President Pence’s National Space Council Users’ Advisory Group.

Potential Witness Panel 2

* Mary Lynne Dittmar, President of the Coalition for Deep Space Exploration
* Boeing or SpaceX Commercial Crew Representative
* Gen. Lester Lyles (USAF, Ret.), Chair, Exploration and Discovery Subcommittee, National Space Council Users’ Advisory Group
* TBD, United Launch Alliance

**LIKELY TOPICS OF DISCUSSION**

* The events and policies leading to the United States landing the first man on the moon.
* The history of the National Aeronautics and Space Administration’s (NASA) human spaceflight program.
* Lessons learned from the Apollo missions and how they relate to today’s space exploration initiatives.

**BACKGROUND**
On September 12, 1962, at the height of the U.S. Cold War with the Soviet Union (U.S.S.R.), President John F. Kennedy challenged the American people to land men on the moon by the end of that decade.[[1]](#footnote-2) At the time, NASA was still a fledgling agency, having only been instituted in 1958 as the federal agency with the primary responsibility for the development of civilian aerospace research.[[2]](#footnote-3) The difficulty of successful spaceflight was seen by both the U.S. and the U.S.S.R. as being representative of technological dominance and ideological superiority, and having a presence in space quickly became a matter of national security.

The Soviet Union had an early lead in the space race, having launched Sputnik I, the first artificial satellite, in 1957, with Sputnik II launching a dog named Laika into orbit the next month and Sputnik III following less than a year later.[[3]](#footnote-4) In April 1962, the Soviet cosmonaut Yuri Gagarin became the first man to enter Earth’s orbit aboard the single-pilot spacecraft Vostok I.[[4]](#footnote-5) The U.S. was not far behind, with NASA’s Project Mercury and the Gemini Program resulting in continuously increasing spaceflight capabilities. The space race culminated on July 20, 1969, when U.S. astronaut Neil Armstrong became the first man on the moon as part of the Apollo 11 mission.[[5]](#footnote-6)

President Kennedy’s challenge was fulfilled with the Apollo 11 mission, but it required years of sustained focus on increasing spaceflight capabilities and consistent support from Congress, multiple presidential administrations, and the public for NASA to accomplish the task. NASA’s human spaceflight program continued to evolve as technological capabilities advanced, with the Space Shuttle Program and the International Space Station marking distinct and innovative eras in space exploration. July 20, 2019, marks the 50th anniversary of the first human moon landing, and the lessons learned through the Apollo Program continue to inform NASA’s efforts to return to the moon and eventually land humans on Mars.

**KEY SPACEFLIGHT PROGRAMS**

*Project Mercury*Project Mercury, initiated in 1958, was the United States’ first program intended to send a man to space. The mission had three specific objectives: to orbit a manned spacecraft around Earth; to investigate man’s ability to function in space; and to recover both man and spacecraft safely.[[6]](#footnote-7) The Mercury spacecraft, a small, single astronaut capsule, was designed specifically for the mission. NASA conducted multiple test flights that were either unmanned or had primates aboard prior to the first manned missions.[[7]](#footnote-8) The first flights of both the Redstone and Atlas rockets failed, but the lessons learned from those attempts and the success of all three launches with primates onboard, including one in which a primate named Enos orbited the Earth twice, gave NASA the confidence to proceed with manned flights.

From 1961 to 1963, astronauts made a total of six spaceflights during Project Mercury, with two being suborbital flights launched on Redstone rockets and the other four reaching orbit and circling Earth after being launched on Atlas rockets.[[8]](#footnote-9) A total of seven astronauts were selected for Project Mercury, though astronaut Deke Slayton was prevented from flying due to a health issue. The first Mercury flight, which took place less than a month after Yuri Gagarin’s flight, made Alan Shepard the first American in space; he would later walk on the moon as commander of the Apollo 14 mission. John Glenn became the first American to orbit Earth during the third Mercury flight.

The success of Project Mercury provided the foundation for NASA’s human spaceflight program moving forward. Beyond learning how to safely launch humans into orbit, NASA also studied how humans could live, and how their spacecraft would operate, in space.
 *Gemini Program*Following the completion of Project Mercury, NASA conducted the Gemini program, in which pairs of astronauts were launched to orbit for the first time.[[9]](#footnote-10) In addition to having capacity for an additional astronaut, the Gemini capsule had additional movement and operational capabilities in space, including the ability to change its orbit. The Gemini capsule was launched on a reconfigured missile, the Titan II rocket.

Project Gemini consisted of 12 missions, flown in 1965 and 1966, with two uncrewed missions preceding the first manned flight on Gemini 3. Multiple milestones were reached during the project, including the first U.S. spacewalk (Gemini 4); missions that lasted a week in orbit (Gemini 5) and later two weeks (Gemini 7); missions wherein one spacecraft met each other in orbit (Gemini 6A and 7, and 8) and even connected, using one vehicle’s engine to move both vehicles (Gemini 10); and the highest flight NASA had conducted (Gemini 11). Each of those milestones were integral to successfully landing U.S. astronauts on the moon, whether it was studying the effects of spending multiple days in space on the human body, testing spacesuits and learning how astronauts could operate outside of a spacecraft, or connecting multiple spacecraft together on-orbit.

*Apollo Program*The Apollo Program marked the first and last time that humans walked on the lunar surface. The Program spanned 11 missions from 1968 until 1972; of those, four were uncrewed missions designed to test the equipment necessary for a lunar landing.[[10]](#footnote-11) The Program was designed to establish U.S. preeminence in space, establish the technology necessary to meet other national interests in space and enable human capability to work in the lunar environment, and to carry out a program of scientific exploration of the moon. The flight mode chosen to reach the moon was a lunar orbit rendezvous, using Saturn IB boosters for the Earth orbit flights and the Saturn V rocket for the lunar flights. The Apollo spacecraft itself was made up of three parts: the command module (CM), the crew’s quarters and flight control section; the service module (SM) for the propulsion and spacecraft support systems; and the lunar module (LM), the vehicle that provided transportation to and from the lunar surface and supported the crew’s activities there.

While the Apollo Program as a whole was a resounding success, it began with a tragedy. On January 27, 1967, during a preflight test for Apollo 1, a fire ignited in the command module and quickly spread through the cabin, which had an atmosphere consisting entirely of oxygen.[[11]](#footnote-12) Astronauts Virgil Grissom, Edward White, and Roger Chaffee lost their lives in the fire. The Apollo Program was delayed as NASA officials investigated the accident and reconfigured the command modules. The next crewed mission would be Apollo 7 on October 11, 1968, which successfully tested the revised command and service module (CSM), demonstrated live television broadcasting capabilities in space, and completed a rendezvous demonstration with the upper stage of a Saturn V rocket.[[12]](#footnote-13)

The Apollo 8 mission, which launched on December 21, 1968, was the first crewed mission to orbit the moon; the iconic “Earthrise” photograph was also captured on this mission.[[13]](#footnote-14) The mission demonstrated translunar injection; CSM navigation, communications and midcourse corrections; consumable assessment; and passive thermal control.[[14]](#footnote-15) The mission successfully completed all of its objectives, allowing NASA to refine its systems and procedures for future lunar missions. These systems and procedures would be further tested on the Apollo 9 mission, launched on March 3, 1969, the primary objective of which was an Earth-orbital engineering test of the first crewed LM.[[15]](#footnote-16) The LM was tested as a self-sufficient vehicle capable of performing active rendezvous, docking, and abort maneuvers, and the crew demonstrated the procedures necessary to transfer from the docked CSM to the LM. The Apollo 10 mission launched from Cape Kennedy on May 18, 1969, and encompassed all aspects of a crewed lunar mission except for the actual landing. It was the first flight of a complete Apollo spacecraft to operate around the moon, and the LM descended to approximately nine miles off of the lunar surface before ascending to the rendezvous point and docking with the CSM. All mission objectives were achieved, with the launch trajectory being so satisfactory that only one of the four planned midcourse corrections was needed.[[16]](#footnote-17)

On July 16, 1969, the Apollo 11 mission launched from Cape Kennedy with Commander Neil Armstrong, Command Module Pilot Michael Collins, and Lunar Module Pilot Edwin “Buzz” Aldrin onboard. The primary mission objective was to complete the national goal set by President Kennedy of performing a crewed lunar landing and returning to Earth. Secondary objectives included the deployment of a television camera to transmit signals back to Earth, deployment of several scientific instruments, and collection of lunar rock samples.[[17]](#footnote-18) The crew landed on the moon’s Sea of Tranquility on July 20, 1969. Apollo 11 Mission Commander Neil Armstrong, the first human on the moon, famously declared as he set foot on the lunar surface, “That’s one small step for a man, one giant leap for mankind.” An estimated 650 million people watched the televised event. Aldrin stepped onto the lunar surface 20 minutes after Armstrong, and spent one hour and 33 minutes on the surface; Armstrong was on the surface for a total of about two and a half hours. In addition to the television camera, the pair left on the lunar surface a U.S. flag, commemorative medallions bearing the names of the three astronauts who lost their lives in the Apollo 1 accident (as well as two cosmonauts who had also died in accidents), and miniature silicon disk containing goodwill messages from 73 countries and the names of congressional and NASA leaders. The crew began ascent procedures after 21 hours and 36 minutes on the moon’s surface, and returned safely to Earth on July 24, 1969.

The Apollo Program included six more missions, with five more lunar landings. The Apollo 13 mission, which was intended to also land on the lunar surface, was forced to circle the moon without landing and return to Earth following an explosion onboard the spacecraft. During the Apollo 14 mission, America’s first astronaut, Alan Shepard, set a new distance record by walking more than 9,000 feet across the lunar surface. Apollo 15 was the first of the three Apollo “J” missions that featured increased capabilities for longer stays, and was the first mission to include a lunar rover. While Apollo 16 experienced issues that resulted in the flight being a day shorter than intended, astronauts still completed three moonwalks, collecting 209 pounds of samples and travelling over 16 miles in a lunar rover. The final Apollo mission, Apollo 17, included the first scientist-astronaut to land on the moon, Lunar Module Pilot Harrison Schmitt. It was the most extensive lunar exploration of the program, including three moonwalks that each lasted over seven hours over the three day stay and a sample return of 243 pounds of material. By the end of the Apollo Program, a total of 12 U.S. astronauts walked on the moon. *The Space Shuttle Program and International Space Station*In the 50 years following the Apollo Program, NASA’s human spaceflight program focused more on sustainable activities in low-Earth orbit (LEO) than on human lunar exploration. From 1981 to 2011, NASA flew 135 missions on a fleet of five space shuttles – Columbia, Challenger, Discovery, Atlantis, and Endeavour. The space shuttle was the first reusable spacecraft and pushed the boundaries of engineering and science, completing missions that repeatedly carried people to orbit, launched, recovered, and repaired satellites, conducted scientific research, and launched and constructed the International Space Station (ISS).

The largest structure in space, the ISS has allowed humans to have a continuous presence in LEO since the first crew arrived on November 2, 2000. While the Apollo Program was launched due to a sense of international competition during the Cold War era, the ISS functions due to extraordinary international cooperation, particularly between the U.S. and Russia. Aboard the ISS, international crews of up to six astronauts perform cutting-edge science in laboratory modules provided by the U.S., Russia, Japan, and Europe. Since the completion of the Space Shuttle Program, the U.S. has relied on Russian Soyuz rockets to transport crew to the ISS; by the end of the 2019 calendar year, U.S. astronauts will be transported to the ISS onboard U.S. rockets launched from U.S. soil for the first time as part of the Commercial Crew program.[[18]](#footnote-19)

*Project Artemis*
Speaking before the National Space Council on March 26, 2019, Vice President Mike Pence directed NASA to have U.S. astronauts, including the first woman to land on the lunar surface, land on the moon’s south pole by 2024.[[19]](#footnote-20) The directive was named the Artemis Program, after the twin sister of the Greek god Apollo. Rather than one-off lunar missions like the ones performed during the Apollo Program, NASA intends for the Artemis Program to develop the capabilities for a sustained human presence on the moon by 2028. By developing an exploration outpost and in situ resource utilization, NASA intends for the moon to eventually enable human missions to Mars.

The Artemis Program will utilize NASA’s heavy lift exploration rocket, the Space Launch System (SLS), which consists of a core stage, upper stage, and the payload, which will hold either cargo or the Orion crew vehicle. The first flight of SLS, Artemis-1 (formerly EM-1), will fly the Orion crew vehicle using the Interim Cryogenic Propulsion System (ICPS) upper stage manufactured by United Launch Alliance.  It is a modified version of ULA’s Delta IV upper stage currently used for national security and science payload launches.  For later missions, NASA plans to develop a more powerful upper stage known as the Exploration Upper Stage (EUS). EUS will have nearly twice the power of the ICPS and will be able to launch heavier payloads to the moon and Mars.

A key component of the Artemis Program will be the development of the lunar Gateway, a command and service module that is capable of being positioned in a variety of lunar orbits.[[20]](#footnote-21) The Gateway would allow astronauts to access the entire lunar surface and would support the development of a reusable human lander system for sustainable lunar exploration, scientific research, in situ resource utilization, and other activities as capabilities evolve and advance.

On May 23, NASA announced the selection of Maxar Technologies to develop and demonstrate power, propulsion, and communications capabilities for Gateway, including the solar electric power and propulsion element (PPE) that will make up the first module of the Gateway.[[21]](#footnote-22) The firm-fixed price contract has a maximum total value of $375 million, and the PPE is expected to launch on a commercial rocket in late 2022. NASA has also selected three commercial moon landing service providers (Astrobotic, Intuitive Machines, and Orbit Beyond) that will deliver science and technology payloads under the Artemis’ Program Commercial Lunar Payload Services (CLPS) contract.[[22]](#footnote-23) Each company will provide end-to-end commercial payload delivery services to NASA, including payload integration and operations, launch from Earth, and landing on the lunar surface. On June 14, NASA issued a draft solicitation for U.S. companies to deliver logistics services to the Gateway, including cargo, science, and supply payloads, with the maximum contract award for all Gateway services over 15 years valued at $7 billion.[[23]](#footnote-24)
 **LEGISLATIVE INITIATIVES***Space Frontier Act*The *Space Frontier Act of 2019*, S. 919, which was introduced by Senators Cruz, Sinema, Wicker, and Markey on March 27, 2019, and favorably reported by the Commerce Committee on April 3, would also authorize advancements in NAS integration. Among other provisions, the Space Frontier Act would streamline launch and reentry regulations at the DOT by requiring the DOT to issue a final rule creating technology-neutral performance requirements that apply to both expendable and reusable launch and reentry vehicles.

*Commercial Space provisions included in FY19 NDAA*The *John S. McCain* *National Defense Authorization Act for Fiscal Year 2019* (P.L. 115-232) contained a provision that prohibits the imposition by the Secretary of Defense of commercial space launch requirements duplicative of those imposed by the Secretary of Transportation under chapter 509 of title 10, United States Code. The provision allows the Secretary of Defense to waive this prohibition, upon notification of the Secretary of Transportation, if he determines that imposing a requirement is necessary to avoid negative consequences for the national security space program.

*NASA Enhanced Use Leasing Extension Authorization Act*The *NASA Enhanced Use Leasing Extension Authorization Act of 2018* (P.L. 115-403), introduced in the 115th Congress by Senator Roger Wicker, extended through 2019 the authority for NASA to lease its non-excess real property and related personal property.

*NASA Transition Authorization Act of 2017*The *NASA Transition Authorization Act of 2017* (P.L. 115-10), which was signed into law by President Trump on March 21, 2017, calls for NASA to prioritize the technologies and capabilities best suited to equip the U.S. for a human mission to Mars and beyond. The language also highlights long-term goals for NASA, as determined by Congress, including expanding human presence beyond LEO, demonstrating progress toward achieving an expanded human presence, and enabling both human habitation on another celestial body and a thriving space economy. That law also declares that advancing space science and maintaining robust science and exploration programs in an effort to enable greater understanding of the solar system and the origin of the Earth are the intent of Congress.

**RECENT EXECUTIVE BRANCH ACTIVITY**

*Space Policy Directive-1*

In December 2017, President Trump signed Space Policy Directive-1 (SPD-1), which directs NASA to lead an innovative and sustainable program of exploration to enable human expansion across the solar system. SPD-1 also instructs NASA to lead the return of humans to the Moon, for long-term exploration and utilization, followed by human missions to Mars and other destinations.[[24]](#footnote-25)

*Space Policy Directive-2*

In response to industry concerns about the complexity of the overall U.S. regulatory framework, the Administration has made several reform proposals, including Space Policy Directive-2, *Streamlining Regulations on Commercial Use of Space* (SPD-2, issued in May 2018).[[25]](#footnote-26) In SPD-2, President Trump directed the DOT to review the regulations that govern licensing of commercial launch and reentry. The FAA published a notice of proposed rulemaking on April 15, 2019, to streamline and increase flexibility in the FAA’s commercial space launch and reentry regulations, and remove obsolete requirements.[[26]](#footnote-27)

*Space Policy Directive-3*

On June 18, 2018, President Trump signed Space Policy Directive-3 (SPD-3), *National Space Traffic Management Policy*.[[27]](#footnote-28) This new directive shifts responsibility for providing SSA data to satellite operators from the DoD to the DOC. SSA data is used to inform satellite operators if there is a potential for a collision with another passing satellite or piece of debris. This allows operators the opportunity to maneuver their satellite (if it is maneuverable) out of harm’s way. The Air Force currently provides SSA services and issues collision warnings to satellite operators around the world. Under this directive, these responsibilities would be transferred to DOC.

This directive also instructs DOC to create an open-source data repository of publicly releasable SSA data and to develop stronger relationships with private organizations to more easily share SSA data. However, DoD will continue to maintain the full authoritative catalogue of space objects. DOC is also instructed to develop standards and best practices for pre-launch risk and on-orbit collision assessments.

NASA is also given new responsibilities under SPD-3 to lead efforts in updating the U.S. Orbital Debris Mitigation Standard Practices and establish new guidelines for both satellite design and operation. Along the same vein, DOT will work with the DOC, and FCC, to incorporate the updated debris mitigation standards into their respective licensing processes.

*Space Policy Directive-4*

On February 19, 2019, President Trump signed SPD-4 directing the Secretary of Defense to submit a legislative proposal to Congress that would authorize the establishment of the Space Force as the sixth branch of the armed forces.[[28]](#footnote-29) As a military service under the Department of the Air Force, SPD-4 envisions the Space Force assuming all civilian and military personnel conducting or directly supporting space operations from the rest of the DoD.[[29]](#footnote-30) Discussions of this proposal are ongoing in the House and Senate Armed Services Committees as those committees work on the 2020 NDAA.

**PREVIOUS COMMITTEE ACTIVITY**

On March 13, 2019, the Senate Commerce Committee held a hearing entitled, “The New Space Race: Ensuring U.S. Global Leadership in the Final Frontier.” That hearing examined the changing state of play in space exploration and competition, including the National Aeronautics and Space Administration’s (NASA) strategy for maintaining U.S. leadership in space, ensuring U.S. space industry competitiveness, and addressing challenges to U.S. spacefaring preeminence, principally from the People’s Republic of China.

On May 14, 2019, the Senate Commerce Committee Subcommittee on Aviation and Space held a hearing entitled, “The Emerging Space Environment: Operational, Technical, and Policy Challenges.” That hearing examined U.S. civil-military coordination, cooperation, and related issues within the space domain.

On May 8, 2019, the Senate Commerce Committee held a full committee hearing entitled, “New Entrants in the National Airspace: Policy, Technology, and Security Issues for Congress.” That hearing examined the current state of our National Airspace System (NAS), the status of integration efforts by the Federal Aviation Administration for new entrants (including commercial space launch and reentry providers) into the NAS, and the policy, technology, and security challenges that remain.

**WITNESS BIOGRAPHIES**

*Panel 1*

*James Arthur Lovell Jr.* Mr. Lovell is a former NASA astronaut, Naval Aviator, mechanical engineer, and retired Navy captain. Lovell is known for being the commander of the ill-fated Apollo 13 mission, which suffered a critical failure in route to the Moon but was brought back safely to Earth through the efforts of the crew and mission control. In addition to being part of the Apollo 13 crew, Lovell was the command module pilot of Apollo 8, the first Apollo mission to enter lunar orbit. He is one of only 24 people to have flown to the Moon and the first of only three people to fly to the Moon twice as well as the only one to have flown there twice without making a landing. Lovell was the first person to fly in space four times. He is a recipient of the Congressional Space Medal of Honor and the Presidential Medal of Freedom (in 1970, one of 17 recipients in the group Space Exploration).

*Michael Collins*. Mr. Collins is a former U.S. astronaut who was the command module pilot of Apollo 11, the first manned lunar landing mission. A graduate of the U.S. Military Academy at West Point, New York, Collins transferred to the air force, becoming a test pilot at Edwards Air Force Base in California. He joined the space program in 1963. Gemini 10, manned by Collins and command pilot John W. Young, was launched on July 18, 1966. After a rendezvous with an Agena target vehicle, the two men used the Agena’s engines to propel them to a record altitude of 764 km (475 miles), where Collins left the spacecraft to remove equipment needed for a micrometeorite experiment from the aft end of the Gemini and attempted unsuccessfully to attach similar equipment to the Agena. He succeeded in retrieving an instrument from the Agena, but his activity was cut short because the Gemini craft was low on fuel. Gemini 10 returned to Earth on July 21. On July 16, 1969, Collins was launched to the Moon in the Apollo 11 mission with commander Neil A. Armstrong and lunar module pilot Edwin E. Aldrin, Jr. Armstrong and Aldrin landed on the Moon in the lunar module Eagle on July 20 while Collins remained in the command module Columbia, circling the Moon at an altitude of 97–121 km (60–75 miles). On July 21 Armstrong and Aldrin rejoined him, and the following day the astronauts left lunar orbit. They splashed down in the Pacific Ocean on July 24. The three astronauts spent 18 days in quarantine to guard against possible contamination by lunar microbes. During the days that followed and during a tour of 21 nations, they were hailed for their part in the opening of a new era in humankind’s exploration of the universe. Apollo 11 was his last space mission; later in 1969 Collins was appointed assistant secretary of state for public affairs. In 1971 he became the first director of the National Air and Space Museum in Washington, D.C., and in 1978 he became undersecretary of the Smithsonian Institution. From 1980 to 1985 he was vice president for field operations for Vought Corporation, an American aerospace firm. He wrote four books, including an account of the Apollo 11 mission, Carrying the Fire (1974), and a history of the American space program, Liftoff (1988).

*Edwin “Buzz” Eugene Aldrin*. Mr. Aldrin is an American engineer and a former astronaut and fighter pilot. As the Apollo Lunar Module pilot on the Apollo 11 mission, he and mission commander Neil Armstrong were the first two humans to land on the Moon.

Born in Glen Ridge, New Jersey, Aldrin graduated third in his United States Military Academy at West Point class in 1951, with a degree in mechanical engineering. He was commissioned into the United States Air Force, and served as a jet fighter pilot during the Korean War. He flew 66 combat missions and shot down two MiG-15 aircraft. After earning a Sc.D. degree in astronautics from the Massachusetts Institute of Technology, Aldrin was selected as a member of NASA's Astronaut Group 3, making him the first astronaut with a doctoral degree. His doctoral thesis was Line-of-Sight Guidance Techniques for Manned Orbital Rendezvous, earning him the nickname "Dr. Rendezvous" from fellow astronauts. His first space flight was in 1966 on Gemini 12 during which he spent over five hours on extravehicular activity. Three years later, Aldrin set foot on the Moon at 03:15:16 on July 21, 1969 (UTC), nineteen minutes after Armstrong first touched the surface, while Command Module Pilot Michael Collins remained in lunar orbit. A Presbyterian elder, Aldrin became the first person to hold a religious ceremony on the Moon when he privately took communion. Upon leaving NASA in 1971, he became Commandant of the U.S. Air Force Test Pilot School. He retired from the Air Force in 1972, after 21 years of service. His autobiographies Return to Earth, (1973) and Magnificent Desolation (2009), recount his struggles with clinical depression and alcoholism in the years after leaving NASA. He continued to advocate for space exploration, particularly a human mission to Mars, and developed the Aldrin cycler, a special spacecraft trajectory that makes travel to Mars possible using less time and propellant. He has been accorded numerous honors, including the Presidential Medal of Freedom in 1969, and is listed in several Halls of Fame.

*Mary Winston Jackson*. Mary Winston Jackson was born in Virginia in 1921 and excelled academically in a time of racial segregation. Her math and science skills earned her a position as a "human computer" for NACA, and she later became NASA's first black female engineer. Along with serving a vital role in the development of the space program, she helped other women and minorities advance their careers. Jackson died in February 2005 at the age of 83. The story of her groundbreaking contributions to NASA was later dramatized in the 2016 film Hidden Figures.

*Eugene Francis "Gene" Kranz*. Mr. Kranz is an American aerospace engineer, a retired fighter pilot, and a retired NASA Flight Director and manager. Kranz served as NASA's second Chief Flight Director, directing missions of the Gemini and Apollo programs, including the first lunar landing mission, Apollo 11. He is best known for directing the successful efforts by the Mission Control team to save the crew of Apollo 13, and was later portrayed in the major motion picture of the same name by actor Ed Harris. He is also noted for his close-cut flattop hairstyle and the dapper "mission" vests (waistcoats) of different styles and materials made by his wife, Marta Kranz, for his Flight Director missions. A personal friend of the American astronauts of his time, Kranz remains a prominent and colorful figure in the history of U.S. manned space exploration, the embodiment of "NASA tough-and-competent" of the Kranz Dictum. Kranz has been the subject of movies, documentary films, and books and periodical articles. Kranz is a recipient of a Presidential Medal of Freedom. In a 2010 Space Foundation survey, Kranz was ranked as the #2 most popular space hero.

*Homer Hadley Hickam Jr.*  Mr. Hickman is an American author, Vietnam veteran, and a former NASA engineer who trained the first Japanese astronauts. His 1998 memoir Rocket Boys (also published as October Sky) was a New York Times Best Seller and was the basis for the 1999 film October Sky. Hickam's body of written work also includes several additional best-selling memoirs and novels, including the "Josh Thurlow" historical fiction novels and his 2015 best-selling Carrying Albert Home: The Somewhat True Story of a Man, his Wife, and her Alligator. His books have been translated into many languages.

*Panel 2*

*Dr. Mary Lynne Dittmar*. Dr. Mary Lynne Dittmar is a 25-year veteran of the space industry specializing in strategy, public engagement and space policy, Mary Lynne assumed leadership of the Coalition in October of 2015. Under her leadership the Coalition has grown from 5 companies to more than 70 over the past three years and is a recognized source for information, education and outreach in support of NASA’s programs, space commerce, the aerospace industry, and American leadership in space. Before starting her own consulting firm in 2004, Dr. Dittmar coordinated R&D and later managed Flight Operations for The Boeing Company on the International Space Station Program. Later, she acted as a special advisor to the NASA Astronaut Office before her appointment as Boeing Chief Scientist for Commercial Utilization of the ISS. More recently she was Senior Policy Advisor to the Center for the Advancement of Science in Space (CASIS), which manages the International Space Station National Laboratory. She has also served as a senior advisor to NASA, the DoD, and the FAA. Mary Lynne is a Fellow of the National Research Society and an Associate Fellow of the American Institute for Astronautics and Aeronautics. From 2012-2014 she served as a member of the National Research Council Committee on Human Spaceflight, and is in her second term as a member of the Executive Committee of the Space Studies Board of the National Academies of Sciences, Engineering and Medicine. In June of 2018 she was appointed by the NASA Administrator to the Users’ Advisory Group of the National Space Council, and in October of that year was appointed by the Secretary of the Department of Transportation to the Commercial Space Transportation Advisory Committee for the FAA. Dr. Dittmar resides in Washington, D.C.

*Christopher Ferguson*. Christopher Ferguson is the Boeing Test Pilot Astronaut & CST-100 Starliner Director of Crew and Mission Systems Boeing's Commercial Crew Program. As Boeing's first commercial test pilot astronaut, Christopher J. Ferguson will be among the first to fly to space aboard the CST-100 Starliner – a system that is on a course to open up space to more people than ever before. Ferguson is uniquely qualified to pilot the Starliner on its maiden flight to the International Space Station, having led the development of the spacecraft's mission systems and crew interfaces. Since the beginning of Boeing's Commercial Crew Program in 2011, Ferguson has worked with NASA’s Human Exploration and Operations Directorate; Johnson Space Center’s Engineering, Flight Crew and Mission Operations organizations; and NASA's Commercial Crew Program at Kennedy Space Center to ensure Boeing’s design supports NASA’s human rating requirements. He also played a key leadership role in the development and testing of system concepts and key technologies for the spacecraft's launch and ground systems. A retired U.S. Navy captain and former NASA astronaut, Ferguson piloted STS-115 (Atlantis) and commanded STS-126 (Endeavour) and the final shuttle mission, STS-135 (Atlantis). He has logged more than 40 days in space and 5,700 hours in high-performance aircraft. He also served as deputy chief of the NASA Astronaut Office and was spacecraft communicator (CAPCOM) for the STS-118, STS-120, STS-128 and STS-129 missions. His experience in crew communications, both on orbit and in the CAPCOM role, is a strong asset to Boeing and the Starliner team. Ferguson holds a Bachelor of Science degree in mechanical engineering from Drexel University and a Master of Science degree in aeronautical engineering from the Naval Postgraduate School. He has been recognized with numerous service awards, including the Legion of Merit, Distinguished Flying Cross, Defense Meritorious Service Medal, Navy Strike/Flight Air Medal, NASA Spaceflight Medal (three), Navy Commendation Medal (three) and the Navy Achievement Medal.

*Michael S. Hopkins*. Mr. Hopkins was selected by NASA as an astronaut in 2009. The Missouri native is currently training for Crew-1, the first post-certification mission of SpaceX’s Crew Dragon spacecraft – the second crewed flight for that vehicle – and his second long duration mission aboard the International Space Station. Hopkins and his crewmates are working closely with SpaceX to develop their new spacecraft systems, which will provide roundtrip crew transportation services to the International Space Station and, along with Boeing’s Starliner, return the ability to launch humans into space from United States soil. Previously, Hopkins was member of the Expedition 37/38 crew and has logged 166 days in space. He launched from the Baikonur Cosmodrome in Kazakhstan to the International Space Station in September 2013. During his stay aboard the station, he conducted two spacewalks totaling 12 hours and 58 minutes to change out a degraded pump module. He holds a Bachelor of Science in Aerospace Engineering from the University of Illinois and a Master of Science in Aerospace Engineering from Stanford University. Hopkins currently supports International Space Station Operations at the Johnson Space Center.

*Victor J. Glover, Jr.* Mr. Glover was selected as an astronaut in 2013 while serving as a Legislative Fellow in the United States Senate. He is currently training for Crew-1, the first post-certification mission of SpaceX’s Crew Dragon spacecraft – the second crewed flight for that vehicle – and a long duration mission aboard the International Space Station. Glover and his crewmates are working closely with SpaceX to develop their new spacecraft systems, which will provide roundtrip crew transportation services to the International Space Station and, along with Boeing’s Starliner, return the ability to launch humans into space from United States soil. The California native holds a Bachelor of Science in General Engineering, a Master of Science in Flight Test Engineering, a Master of Science in Systems Engineering and a Master of Military Operational Art and Science. Glover is a Naval Aviator and was a test pilot in the F/A‐18 Hornet, Super Hornet and EA‐18G Growler. He and his family have been stationed in many locations in the United States and Japan and he has deployed in combat and peacetime.

*General Lester Lyles (USAF, Ret.).* General Lester L. Lyles (born April 20, 1946) is a former United States Air Force general, Vice Chief of Staff of the United States Air Force, and Commander, Air Force Materiel Command, Wright-Patterson Air Force Base, Ohio. After retirement from the Air Force in 2003, he became a company director for General Dynamics, DPL Inc., KBR Incorporated, Precision Castparts Corp., MTC Technologies, Battelle Memorial Institute and USAA. Lyles is also a Trustee of Analytic Services and a Managing Partner of Four Seasons Ventures, LLC.

1. President John F. Kennedy, Moon Speech at Rice University, September 12, 1962. Available at: <https://er.jsc.nasa.gov/seh/ricetalk.htm> [↑](#footnote-ref-2)
2. National Aeronautics and Space Administration (NASA), “National Aeronautics and Space Act of 1958 (Unamended),” Signed by the President on July 29, 1958. Available at: <https://www.hq.nasa.gov/office/pao/History/spaceact.html> [↑](#footnote-ref-3)
3. NASA, “Sputnik and the Dawn of the Space Age,” October 10, 2007. Available at: <https://history.nasa.gov/sputnik/> [↑](#footnote-ref-4)
4. NASA, “Yuri Gagarin: First Man in Space,” April 13, 2011. Available at: <https://www.nasa.gov/mission_pages/shuttle/sts1/gagarin_anniversary.html> [↑](#footnote-ref-5)
5. NASA, “Apollo 11 Overview,” May 15, 2019. Available at: <https://www.nasa.gov/mission_pages/apollo/missions/apollo11.html> [↑](#footnote-ref-6)
6. NASA, “About Project Mercury,” August 3, 2017. Available at: <https://www.nasa.gov/mission_pages/mercury/missions/program-toc.html> [↑](#footnote-ref-7)
7. NASA, “Project Mercury Uncrewed Missions,” April 2, 2004. Available at: <https://www.nasa.gov/mission_pages/mercury/missions/unmanned-flights.html> [↑](#footnote-ref-8)
8. NASA, “Mercury Crewed Flights Summary,” November 30, 2006. Available at: <https://www.nasa.gov/mission_pages/mercury/missions/manned_flights.html> [↑](#footnote-ref-9)
9. NASA, “Gemini: Bridge to the Moon.” Available at: <https://www.nasa.gov/specials/gemini_gallery/> [↑](#footnote-ref-10)
10. NASA, “the Apollo Missions,” February 1, 2019. Available at: <https://www.nasa.gov/mission_pages/apollo/missions/index.html> [↑](#footnote-ref-11)
11. NASA, “Apollo 1,” August 7, 2017. Available at: <https://www.nasa.gov/mission_pages/apollo/missions/apollo1.html> [↑](#footnote-ref-12)
12. NASA, “About Apollo 7, the First Crewed Apollo Space Mission,” October 12, 2018. Available at: <https://www.nasa.gov/mission_pages/apollo/missions/apollo7.html> [↑](#footnote-ref-13)
13. NASA, “This Week in NASA History: Apollo 8 Captures ‘Earthrise’ ­– Dec. 24, 1968,” December 21, 2018. Available at: <https://www.nasa.gov/centers/marshall/history/this-week-in-nasa-history-apollo-8-captures-earthrise-dec-24-1968.html> [↑](#footnote-ref-14)
14. NASA, “Apollo 8,” January 9, 2018. Available at: <https://www.nasa.gov/mission_pages/apollo/missions/apollo8.html> [↑](#footnote-ref-15)
15. NASA, “Apollo 9,” February 17, 2019. Available at: <https://www.nasa.gov/mission_pages/apollo/missions/apollo9.html> [↑](#footnote-ref-16)
16. NASA, “Apollo 10,” January 11, 2019. Available at: <https://www.nasa.gov/mission_pages/apollo/missions/apollo10.html> [↑](#footnote-ref-17)
17. NASA, “Apollo 11 Mission Overview,” July 24, 1969. Available at: <https://www.nasa.gov/mission_pages/apollo/missions/apollo11.html> [↑](#footnote-ref-18)
18. NASA, “NASA’s Commercial Crew Program: Boeing Test Flight Dates and SpaceX Demo-2 Update,” April 3, 2019. Available at: <https://blogs.nasa.gov/commercialcrew/2019/04/03/nasas-commercial-crew-program-boeing-test-flight-dates-and-spacex-demo-2-update/> [↑](#footnote-ref-19)
19. Jeff Foust, *Space News*, “Pence calls for human return to the moon by 2024,” March 26, 2019. Available at: <https://spacenews.com/pence-calls-for-human-return-to-the-moon-by-2024/> [↑](#footnote-ref-20)
20. NASA, “Sending Astronauts to Moon in 2024: NASA Accepts Challenge,” April 9, 2019. Available at: <https://www.nasa.gov/feature/sending-american-astronauts-to-moon-in-2024-nasa-accepts-challenge> [↑](#footnote-ref-21)
21. NASA, “NASA Awards Artemis Contract for Lunar Gateway Power, Propulsion,” May 23, 2019. Available at: <https://www.nasa.gov/press-release/nasa-awards-artemis-contract-for-lunar-gateway-power-propulsion> [↑](#footnote-ref-22)
22. NASA, “NASA Selects First Commercial Moon Landing Services for Artemis Program,” May 31, 2019. Available at: <https://www.nasa.gov/press-release/nasa-selects-first-commercial-moon-landing-services-for-artemis-program> [↑](#footnote-ref-23)
23. NASA, “NASA to Partner with American Industry to Supply Artemis Moon Missions,” June 14, 2019. Available at: <https://www.nasa.gov/feature/nasa-to-partner-with-american-industry-to-supply-artemis-moon-missions> [↑](#footnote-ref-24)
24. Space Policy Directive-1, Dec. 11, 2017. Available at: <https://www.whitehouse.gov/presidential-actions/presidential-memorandum-reinvigorating-americas-human-space-exploration-program/>. [↑](#footnote-ref-25)
25. Available at: <https://www.whitehouse.gov/presidential-actions/space-policy-directive-2-streamlining-regulations-commercial-use-space/>. [↑](#footnote-ref-26)
26. <https://www.govinfo.gov/content/pkg/FR-2019-04-15/pdf/2019-05972.pdf>. [↑](#footnote-ref-27)
27. Available at: <https://www.whitehouse.gov/presidential-actions/space-policy-directive-3-national-space-traffic-management-policy/>. [↑](#footnote-ref-28)
28. <https://www.whitehouse.gov/presidential-actions/text-space-policy-directive-4-establishment-united-states-space-force/>. [↑](#footnote-ref-29)
29. <https://spacepolicyonline.com/news/text-of-space-policy-directive-4-spd-4-establishing-a-u-s-space-force/> [↑](#footnote-ref-30)