

2024 ANNUAL REPORT

NASA's Johnson Space Center

National Aeronautics and
Space Administration



GIANT LEAPS START HERE



VANESSA WYCHE
DIRECTOR
JOHNSON SPACE CENTER



We **DARE** to expand frontiers
We **UNITE** with our partners to complete bold missions
We **EXPLORE** space for the benefit of humanity

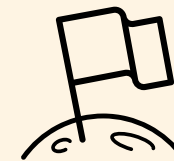
Dare | Unite | Explore is a call to action to leverage lessons learned and apply them to even more daring destinations in the solar system. It's not just a vision, but a strategy to keep Johnson centered and engaged as the hub of human space exploration. As commercial and international space travel partnerships continue to evolve, this strategy is designed to remove barriers to effective business practices while leveraging the human spaceflight legacy of the Apollo generation for the benefit of the Artemis Generation.

There are five additional aspirations that set the tone for Johnson's future and will enable the team to break the bonds of gravity, set foot on our lunar neighbor once more, and build a foundation that will see another 20 years of constant human presence in space. These transformative approaches guide Johnson as it serves the United States as the home of human space exploration. They will become even more critical as NASA maps a path forward that includes even more daring destinations. These principles, when supported by the heart and soul of our united Johnson team, will give a new generation something to remember — and dream about.



**REVOLUTIONIZE
THE HUMAN
EXPERIENCE
IN SPACE**

SOLVES CHALLENGES
TO ADVANCE HUMAN
PRODUCTIVITY
IN SPACE.



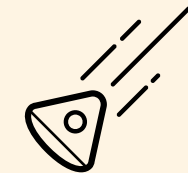
**EXPLORE NEW
DESTINATIONS
NOW**

SENDS HUMANS INTO
THE SOLAR SYSTEM
FASTER AND FARTHER.



**CREATE
GAME
CHANGERS**

PROVIDES CRITICAL
EXPERIENCE
AND CHAMPIONS
INNOVATION.



**PROPEL
THE SPACE
ECONOMY**

EXPANDS THE SPACE
ECONOMY LOCALLY
AND NATIONALLY.



**LEAD
GLOBALLY**

UNLEASHES
THE POWER OF
INTERNATIONAL
HUMAN EXPLORATION.

Front Door of NASA's Johnson Space Center and White Sands Test Facility

Johnson's Front Door website (www.nasa.gov/johnson/frontdoor) showcases multiple avenues for you to collaborate with our programs and experts. Whether you represent industry, government, academia, or the general public, you can explore the opportunities, capabilities, technology and data available to you. Collaboration opportunities exist in multiple areas including robotics, software, energy production and storage, in-situ resource utilization, mission planning and execution, human subsystems, and more. Johnson offers an extensive catalogue of capabilities and services that can be made available to partners through a range of NASA programs and agreements.



Front Door of NASA's
Johnson Space Center

NASA's Johnson Space Center is the hub of human spaceflight and the iconic setting for some of humankind's greatest achievements. Home to America's astronaut corps and the Mission Control Center, more human spaceflight programs are led from Johnson today than ever in history: the International Space Station, Orion, Gateway, Commercial Low Earth Orbit, Extravehicular Activity and Human Surface Mobility, and Exploration Operations. NASA Johnson also shares leadership of the Commercial Crew Program with the deputy program management office located here. We play a critical role in leading human space exploration and enhancing technological and scientific knowledge. With our next giant leap, we will pave the way beyond low Earth orbit to the Moon through our Artemis campaign.

Since our last report in 2022, we completed major milestones toward our goal of landing astronauts on the lunar surface through the Artemis campaign, including the announcement of the four astronauts who will venture around the Moon on the Artemis II mission. That crew is targeted to launch aboard the Orion spacecraft in 2026. Future Artemis crew members may be assigned from NASA's newest class of astronauts, who we welcomed in March 2024 during a graduation ceremony in Houston. After their successful completion of two years of rigorous training, those astronauts are eligible for exciting missions to the International Space Station and potentially the Moon.

Throughout 2024, we also saw great progress with Gateway, a space station that will orbit the moon and provide vital support for a sustainable, long-term human return to the lunar surface, as well as a staging point for deep-space exploration. The Gateway space station's Habitation and Logistics Outpost (HALO), one of four modules where astronauts will live, conduct science, and prepare for lunar surface missions, is one step closer to launch following welding completion. In addition, Intuitive Machines successfully delivered six NASA payloads to the South Pole region of the Moon as part of our Commercial Lunar Payload Services (CLPS) initiative, which enables commercial vendors to deliver NASA science and technology payloads to the lunar surface. The Intuitive Machines-1 mission marked the first U.S. landing on the Moon in over 50 years.

Johnson is the home of NASA's Extravehicular Activity and Human Surface Mobility Program that is working with industry partners to develop the next generation of spacesuits and lunar rovers. The new spacesuits are being developed in cooperation with industry partner Axiom Space and will allow testing of the new designs on the space station and the lunar surface. Three other industry partners—Intuitive Machines, Lunar Outpost, and Venturi Astrolab—were awarded contracts to develop the lunar terrain vehicles that Artemis astronauts will use to travel around lunar landing sites, supporting scientific discovery and long-term human exploration on the Moon. NASA intends to begin using the lunar terrain vehicles for crewed operations during Artemis V.

Also at Johnson, NASA's Human Health and Performance Program saw the first of three simulated long-duration missions to Mars in a new habitat crafted specifically to support one-year missions by test subjects here on Earth. Crews of non-astronaut volunteers lived and worked in the 3D-printed Crew Health and Performance Analog (CHAPEA) habitat, simulating the challenges of future human missions on the surface of Mars, including "marswalks," robotic operations, habitat maintenance, exercise, and crop growth. These longer simulations will build on a series of Human Exploration Research Analog missions that have been expanding our understanding of how the challenges of deep-space exploration can be met through shorter, ever-expanding campaigns in a smaller habitat.

Working with our commercial partners, the International Space Station saw a variety of crew and vehicle traffic. We celebrated the splashdown of NASA's SpaceX Crew-7 mission, the launch and return of NASA's SpaceX Crew-8, the launch of NASA's SpaceX Crew-9, and the launch and landing of the Starliner spacecraft during NASA's Boeing Crew Flight Test mission. The mission marked the first flight of astronauts aboard the Boeing-built-and-owned spacecraft. In 2025, the station will celebrate its 25th year of continuous human presence in space for the benefit of humanity. NASA also expects to launch its 10th and 11th regular crew rotation missions to the space station on a U.S. crewed launch vehicle. Both SpaceX and Northrop Grumman launched additional supplies and equipment to the space station, and a third commercial cargo carrier, Sierra Nevada, will begin its station resupply missions in 2025. NASA is working with Axiom Space to continue private missions to the station under a formal agreement that is helping NASA open access to space, following the successful launch and splashdown of Axiom Mission 3 in early 2024.

Our workforce is laser-focused on the next giant leap forward to our lunar neighbor, to build outposts in uncharted territory while revolutionizing the strategies and technologies that will open up the universe. Today, we are yielding phenomenal achievements on the space station by testing technologies that will help us travel farther into space. Tomorrow, we will leap higher to the remote edge of the solar system.



NASA astronaut and Expedition 72 Flight Engineer Don Pettit sets up one of his "Science of Opportunity" experiments aboard the International Space Station. For this specific experiment, Pettit grew thin wafers of water ice using the orbiting lab's freezer, and photographed them in front of a white, blank computer screen and polarizing filter to display the colorful fragments of ice crystals. Credit: NASA

Johnson Economic Impact

NASA's Johnson Space Center is working toward a bright future and improving life on Earth today with new technology, research, and science. Located on over 1,700 acres in Houston, our roots are strengthened through partnerships with universities, private companies, and nonprofits, and we are constantly seeking new paths for state and local collaboration. NASA is setting its sights on deep space exploration, and Texas will play a critical role in that mission.

History of Johnson

NASA established its Manned Spacecraft Center in 1961, on a 1,000-acre site donated by Rice University. The center later was renamed to honor former president Lyndon B. Johnson, an early champion of NASA's Texas operations. Houston provided NASA with the economic, logistical, and intellectual support needed for human spaceflight. Today, NASA employs about 10,000 public and private workers in Texas, contributing to local and state economies, as well as university and commercial research.



Texas Economic Snapshot

NASA Johnson continues to serve as the leader and originator of human spaceflight, continuously drawing the aerospace industry to the Greater Houston region and Texas every year. As the center continues to evolve in the coming decades to accommodate missions to more distant destinations, Texas will continue to provide a perfect home base for training, planning, and flight command. NASA Johnson is leading the way by providing astronaut training, Mission Control operations, leadership for the International Space Station, human research, and commercial crew programs. Additionally, the center is a primary contributor to the agency's Artemis campaign hosting the Orion and Gateway Programs, and the Exploration Architecture, Integration, and Science Directorate.

Total Johnson Budget	Total Johnson Expenditures in Texas	Johnson - White Sands Test Facility Budget
\$5.43B	\$2.75B	\$87M

Johnson Space Center Total Budget by Program

International Space Station Program	\$1.05B
Orion Program	\$1.23B
Human Research Program	\$122M
Commercial Crew Program	\$54M
Gateway Program	\$417M
Commercial Cargo Program	\$862M
Exploration Operations Program	\$7M
Extravehicular Activity and Human Surface Mobility Program	\$364M
Commercial Low Earth Orbit Development Program	\$174M
Astromaterials Research and Exploration Science	\$62M
Business Development and Technology Integration Office	\$33M

Select NASA Expenditures in Texas

Small Businesses	\$473.2M	Veteran-Owned Businesses	\$21M
		Non-Profit and University Awards	\$37.7M

Our People - NASA's Johnson Space Center Workforce

Total Johnson Workforce

# Federal Employees	3,407
# Contractors	9,134
Total # JSC Workforce	12,541

Total Johnson Workforce in Texas

# Federal Employees	2,999
# Contractors	7,289
Total # in Texas	10,288

White Sands Test Facility Workforce

# Federal Employees	48
# Contractors	415
Total # WSTF Workforce	463

Workforce Representation

Engineer or Scientist	75%	Hold at Least a Bachelor's Degree	96%
Perform Science, Technical or Aerospace Work	77%	Hold a Graduate Degree	45%
Hold Science, Engineering or Technical Degrees	80%		

STEM Education Leadership in Texas

NASA Johnson's Office of STEM Engagement strives to immerse students in NASA's work, enhance science, technology, engineering, and math literacy, and inspire the next generation to explore. We create unique opportunities and authentic learning experiences by leveraging NASA's people, content, and facilities. Students and educators in the state of Texas are strong beneficiaries of these engagement opportunities and they are helping to build the state's future STEM workforce. Since 1999, NASA has collaborated with the state of Texas to engage more than 14,400 students in the Texas High School Aerospace Scholars program. In fiscal year 2024, more than 2,000 students and educators from the state of Texas participated in the program and other NASA STEM engagement opportunities, including internships, student challenges, research opportunities, educator professional development, and other STEM engagement offerings.

Texas Students in NASA College and K12 Engagements	1,704
Texas Students in NASA STEM Challenges	310
Texas Students with NASA Internships	153
Texas Students Attending Minority Serving Institutions Engaged with NASA STEM	881
Texas Students in High School Aerospace Scholars in Fiscal Year 2024	802
Texas Students in High School Aerospace Scholars Since 1999	14,400
Texas High Schools/Homeschools Represented in High School Aerospace Scholars	303
Texas Cities Represented in Texas High School Aerospace Scholars	161
Texas Educators in NASA-Led Professional Development	124
Texas Participants in NASA Research Opportunities	49
Number of Federal Legislative Districts in Texas Represented in STEM Engagements	38
Number of Two Year Institutions in Texas Represented in STEM Engagements	30
Number of Four Year Institutions in Texas Represented in STEM Engagements	120

NASA's Johnson Space Center at a Glance

NASA's Lyndon B. Johnson Space Center is known as the agency's human spaceflight center. It is home to not only the NASA astronaut corps, but also the key center for several major NASA programs and organizations. From our current operations aboard the International Space Station to our operations under the Artemis campaign, Johnson's 12,541 contractors and civil servants are involved in the day-to-day execution of the agency's missions, research, and future programs. Here are some of the center's key roles.

International Space Station Program Office

After more than a quarter of a century of operation, the International Space Station continues to make extraordinary contributions to science, research, and ultimately life on Earth. It is an exciting time in low Earth orbit where the space station continues to thrive as a busy laboratory maintaining an incredibly high research and operational tempo—and it is not slowing down anytime soon. The orbiting laboratory continues to be fully utilized and is pressing full steam ahead for continual maximization of this world-class global asset. NASA Johnson is home to the management and integration of operations for this multi-national laboratory.

Commercial Crew Program

In collaboration with Kennedy Space Center and the American aerospace industry, NASA Johnson is helping develop and operate a new generation of spacecraft and launch systems capable of carrying crews and cargo to low Earth orbit and the space station.

Commercial Low Earth Orbit Development Program

Through NASA's Johnson-based Commercial Low Earth Orbit Development Program, the agency is partnering with private industry to enable NASA's vision of a self-sustaining, commercially enabled low Earth orbit economy, within which NASA is one of many customers.

Exploration Operations Office

Through the Artemis campaign, NASA will send astronauts to explore the Moon for scientific discovery, economic benefits, and to build the foundation for the first crewed missions to Mars—for the benefit of all. The Exploration Operations Office is responsible for the Moon-to-Mars architecture processes and products necessary to optimize the full capabilities of vehicles and systems across the agency's Artemis campaign. Exploration Operations ensures that Artemis mission requirements are fully defined, coordinated, and integrated for use by the operations teams to conduct successful missions.

Orion Program

The Orion spacecraft is the safest, most capable crewed vehicle for deep space travel, and will take astronauts farther than a spacecraft built for humans has gone before. Built by NASA and lead contractor Lockheed Martin, Orion will carry up to four astronauts. It is the only spacecraft capable of sustaining crew for up to 21 days in deep space and withstanding high-speed re-entry from the vicinity of the Moon.

Gateway Program

The Gateway Program is an international collaboration to establish humanity's first space station around the Moon as a central component of NASA's Artemis campaign. Gateway will host capabilities for sustained exploration and research in deep space, including docking ports for a variety of visiting spacecraft, space for astronauts to live, work, and prepare for lunar surface missions, and onboard science investigations. Gateway is an important platform for developing technology and capabilities to support future Mars exploration.

Extravehicular Activity and Human Surface Mobility Program

The Extravehicular Activity and Human Surface Mobility Program serves as NASA's program to develop next-generation spacesuits, human-rated rovers, and tools along with all required spacewalking support systems that will enable astronauts to survive and work outside the confines of a spacecraft in order to explore on and around the Moon.

Human Research Program

NASA's Human Research Program pursues cutting-edge methods that support safe, productive human space travel. The program studies how spaceflight affects human bodies and behaviors through science conducted on Earth and in space. Such research drives NASA's mission to keep astronauts healthy on future journeys to the Moon, Mars, and beyond.

Human Health and Performance Directorate

The Human Health and Performance Directorate is the primary organization responsible for crew health and performance and mitigating the risks associated with human spaceflight. With three offices, three divisions, and over 1,000 employees, all functions are ultimately aimed at achieving the mission while optimizing human health and performance throughout all phases of spaceflight.

Flight Operations Directorate

The Flight Operations Directorate touches every aspect of sending humans to space on NASA missions. This skilled workforce trains astronauts in facilities on the ground in spacecraft mockups, underwater in NASA's Neutral Buoyancy Laboratory, and in the air in T-38 jet aircraft. The directorate also plans human spaceflight missions and executes them from Houston's Mission Control Center.

Mission Control Center for the Space Station, Commercial Crew, and Orion

The NASA flight control teams of experienced engineers, medical officers, scientists, and technicians are housed at the center in Houston. They work with international counterparts and commercial space companies to develop mission plans and keep a constant watch on flight crew activities, monitoring space systems and crew health and safety.

Astronaut Selection and Training

An experienced NASA team screens and selects each class of U.S. astronauts to lead our NASA missions and explore our universe. The majority of training for all space explorers from the United States, international partner countries, and even private industry takes place at the center's state-of-the-art facilities, including the Space Vehicle Mockup Facility, Neutral Buoyancy Laboratory, and virtual reality simulators.

Engineering Directorate

NASA Johnson's Engineering Directorate is the premiere organization for the design and development of human spacecraft and human systems integration. It is one of the largest organizations at the center and is responsible for providing engineering design, development, and test support for crew equipment, numerous flight experiments, and all spaceflight programs assigned to NASA Johnson, including the space station and advanced spacecraft.

Business Development and Technology Integration Office

NASA Johnson continues to partner with industry and academia on the development of broadly applicable technologies to advance the future of human spaceflight and expand the space economy locally and nationally. The Business Development and Technology Integration Office serves as the front door into the center for traditional and new space partners. The office is focused on capturing and developing new capabilities for human exploration and is responsible for forming innovation discovery, early-stage technology integration, technology transfer and licensing, and new partnerships.

Exploration Architecture, Integration and Science Directorate

The Exploration Architecture, Integration, and Science Directorate supports NASA's human and science exploration programs with expertise in exploration architecture, mission planning, systems engineering, planetary and space science, and program integration and assessments.

Astromaterials Research and Exploration Science

Johnson curates the world's largest collection of astromaterials, including materials from the Moon, Mars, Sun, asteroids, comets, and other stars. Scientists research planetary and space environments to investigate the origin and evolution of our solar system. The team is also the global leader and expert on orbital debris and assessing risk to spacecraft. Also based at Johnson, the Mars Sample Receiving Project Office is responsible for receiving and curating the first samples returned from the Red Planet. The project office recovers, contains, transfers, assesses safety, curates, and coordinates scientific investigation of the samples collected by NASA's Mars 2020 Perseverance rover, which are expected to arrive on Earth in 2033.

Safety and Mission Assurance Directorate

The Safety and Mission Assurance Directorate provides system safety, reliability, and risk analysis for the majority of human spaceflight programs. The directorate works with program offices to reduce risk by providing technical assessments, analytical services, and guidance on safety and mission assurance requirements throughout the program and project lifecycle. The organization also works to identify, characterize, mitigate, and communicate risks by implementing an assurance model that is efficient, effective, and provides value to its customers.

White Sands Test Facility

The White Sands Test Facility is a remote, self-contained, hazardous testing facility managed by Johnson Space Center, and located near Las Cruces, New Mexico. White Sands' mission is to provide the expertise and infrastructure to test and evaluate spacecraft materials, components, and propulsion systems to enable the safe exploration and use of space. These unique capabilities are used by NASA, other government agencies, and commercial industry.

Mission Support

NASA Johnson is home to seven mission support organizations that enable mission success through their work in security and facilities maintenance, communications, information technology, procurement, legal support, equal opportunity, and finance. These teams are integral to NASA Johnson's successful operations so it can continue its mission of safe human space exploration.

Aerospace in Texas

Johnson has over 400 industry partners and over 100 contractor agreements with companies whose offices are spread across Texas and the nation. The center creates a true STEM pipeline from middle school through college with its Texas High School Aerospace Scholars program and university partnerships, equipping the future of aerospace and building the foundation for human missions to the Moon and Mars through NASA's Artemis campaign.

The following map showcases a small portion of Johnson's industry, aerospace, and university partners that have offices in the state of Texas. The complete list of NASA's current Space Act Agreements and Johnson's current contractors is available online at www.nasa.gov/partnerships and www.nasa.gov/johnson/jsc-contractors. For more information about aerospace in Texas, visit <https://go.nasa.gov/texasinspace>. Information about Johnson's university partnerships can be found at www.nasa.gov/johnson/university-collaboration.



*These industry partners also have contract agreements with Johnson

Exploration Park

Johnson leads human spaceflight through its many Texas-based industry, university, and contract partnerships, while also supporting the development of commercial space through Exploration Park, a 240-acre parcel of land on the center's southwest corner. Exploration Park fosters a collaborative development environment that increases commercial access and enhances the United States' commercial competitiveness in the space and aerospace industries.



Exploration Park. Credit: American Center for Manufacturing and Innovation Properties

Exploration Park provides additional opportunities for NASA to work with partners in order to share information about building commercial space stations in low Earth orbit, and designing lunar-capable commercial spacesuits and lunar landers. These services will be widely available to customers in government, industry, and academia, accelerating human access to space. NASA approved two Exploration Park facilities in 2024, the first with Texas A&M University and the second with the American Center for Manufacturing and Innovation. The campus will incorporate an applied research facility and plans to partner with multiple stakeholders across academia, state and local government, and regional economic development organizations. The research facility will include simulated lunar and Mars landscapes through Texas A&M University's Space Institute. Texas A&M held a ceremonial groundbreaking for their Space Institute in November 2024 and construction began in January 2025.



Texas A&M University's Space Institute. Credit: Texas A&M University

To learn more about Exploration Park, visit www.nasa.gov/centers-and-facilities/johnson/exploration-park/.

Aerial photo of Johnson Space Center showing the land reserved for Exploration Park facilities (highlighted). Credit: NASA



Business Development and Technology Integration Office

NICK SKYTLAND

JSC CHIEF
TECHNOLOGIST
AND DIRECTOR



NASA Johnson continues to partner with industry and academia to advance the future of human spaceflight and to propel the space economy. The Business Development and Technology Integration Office serves as the front door for the center, engaging both traditional and new space partners. The office is focused on capturing and developing new capabilities for human exploration and is responsible for partnerships, early-stage technology development, technology transfer and licensing, and open innovation. In these unprecedented times of exploration, the office propels the center, the agency, and its partners to go farther toward the future of human spaceflight.

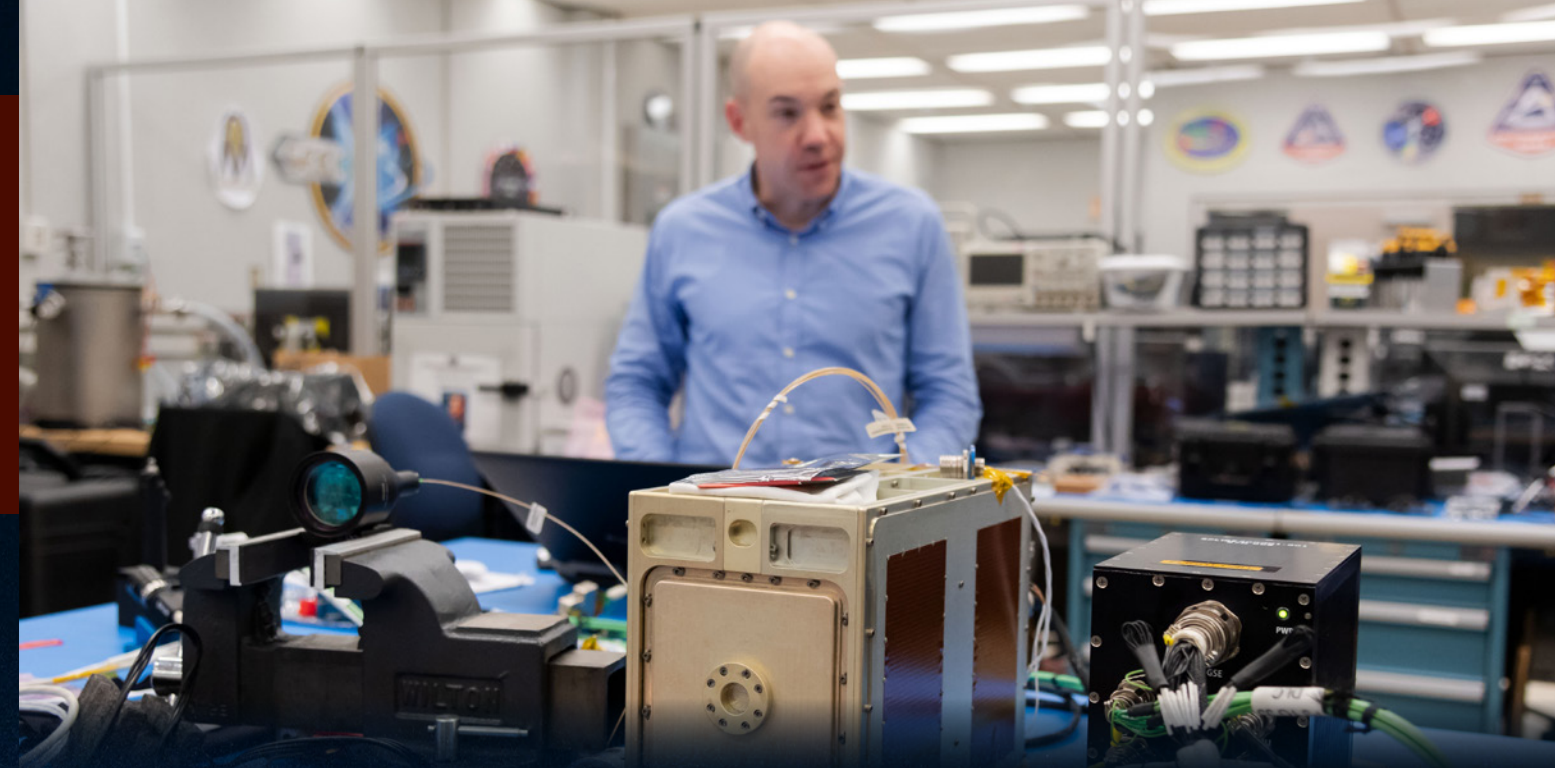
NASA's Carbothermal Reduction Demonstration (CaRD) project successfully extracts oxygen from lunar soil simulant for the first time in a vacuum environment. This paves the way for Artemis to one day extract and utilize in situ resources in a lunar environment. CaRD is a Johnson-led Space Technology Mission Directorate (STMD) project within the Business Development and Technology Integration Offices technology integration portfolio. Credit: NASA

Partnership Pursuits

Builds strategic partnerships with industry and academia to advance both NASA's mission and commercial interests through new business capture, technology sharing, and joint initiatives.

Strategy and Opportunity Formulation

Transforms promising opportunities into actionable collaborations to enable groundbreaking insights, creation of strategic capabilities, development of new technology, and growth of the space economy.



NASA's Safe and Precise Landing – Integrated Capabilities Evolution (SPLICE) Project Manager checks out the system at NASA Johnson. The SPLICE project is developing and exercising a suite of sensors, computer technologies, and algorithms to enable accurate precision landing and hazard avoidance for the Moon, Mars, and other planetary surfaces. SPLICE is a Johnson-led Space Technology Mission Directorate project within the Business Development and Technology Integration Office's technology integration portfolio. Credit: NASA

Technology Transfer

Promotes and facilitates the transfer of useful technologies to the government and commercial sectors, to enable the public to directly benefit from the ingenuity and creativity of our outstanding researchers.

Technology Integration

Manages the early-stage technology portfolio to accelerate the sustainable long-term human exploration and utilization of space and supports the innovator community by providing hands-on development opportunities, best practices, and forums for collaboration.

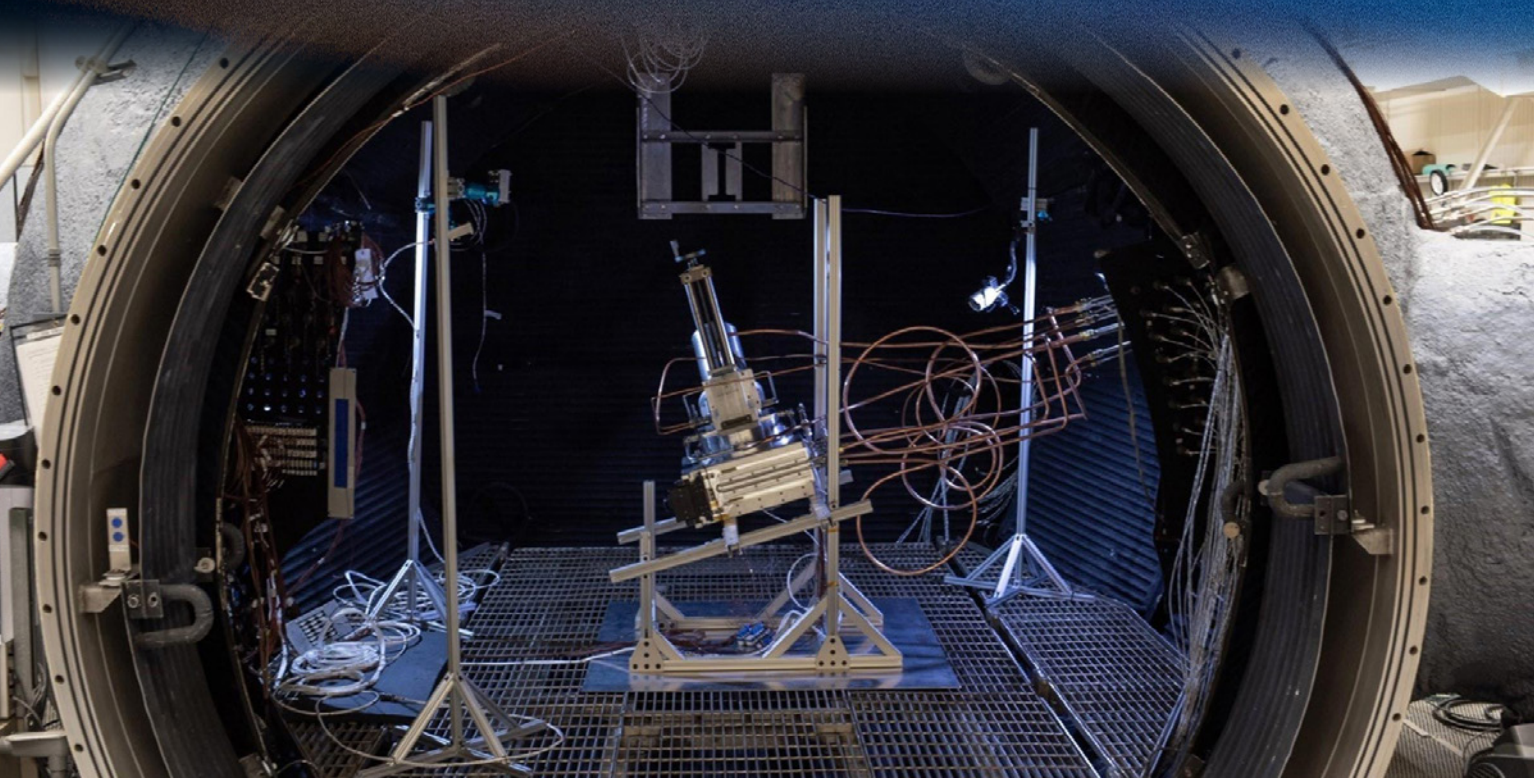
Center of Excellence for Collaborative Innovation

Works across NASA and other federal agencies to educate and facilitate the use of open innovation (crowdsourcing) to help programs and projects tackle high-stakes challenges.

2024 Accomplishments

- Launched a new front door website featuring 399 NASA Johnson and White Sands capabilities across 54 core domains and six business lines. In its first year, the website averaged 4,738 total views and 2,720 unique visitors per month, making up one-fourth of all web traffic to NASA Johnson.

- Established Exploration Park and selected two key partners, Texas A&M University and American Center for Manufacturing and Innovation.
- Led the execution of the NASA Johnson innovation and technology portfolio, including 50 projects representing \$130 million of total investment.
- Executed 178 agreements on behalf of NASA Johnson, reducing the average completion time by 65 days.
- Facilitated 23 innovation and strategy sessions for 14 organizations.
- Reported 232 total New Technology Reports, leading the agency (minus NASA's Jet Propulsion Laboratory) in the total number of filings.
- Negotiated and executed 41 new license agreements for patented NASA Johnson technology, the highest in center history and the second highest in the agency this year.
- Launched the NASA Open Innovation Academy which provides a half-time rotation for 5-10 participants per year to learn about open innovation and ultimately become an in-situ ambassador/resource for their home organization.



International Space Station Program

After more than a quarter of a century of operation, the International Space Station continues to make extraordinary contributions to science, research, and ultimately life on Earth. It is an exciting time in low Earth orbit where the space station continues to thrive as a busy laboratory maintaining an incredibly high research and operations tempo—and it is not slowing down anytime soon. The orbiting laboratory continues to be fully utilized and is pressing full steam ahead for continual maximization of this world-class global asset.

Enabling Benefits to Humanity

Nov. 2, 2025, marks the 25th anniversary that humans have lived and worked continuously in microgravity for the benefit of humanity, conducting cutting edge science and research every step of the way. Since its inception, the orbiting laboratory has hosted more than 4,000 research

The International Space Station's cupola, also known as "the window to the world," has seven windows for observing the Earth, as well as spacewalks, and spacecraft arrivals and departures. Credit: NASA

DANA WEIGEL
PROGRAM MANAGER



investigations representing more than 5,000 researchers from more than 100 countries.

The International Space Station carries an impressive array of research facilities supporting hundreds of experiments at any given time across every major science discipline. The disciplines on the station range from biology and biotechnology to Earth and space science, educational activity, human research, physical science, and technology.

Technologies and missions developed for human spaceflight have thousands of applications on Earth, boosting the



Expedition 68 Flight Engineer Koichi Wakata of JAXA (Japan Aerospace Exploration Agency) completes a task in his spacesuit during his second spacewalk. Credit: NASA

economy, creating new career paths, and advancing everyday technologies all around us.

Fostering International Collaboration

One of the International Space Station Program's greatest accomplishments is as much a human achievement as it is a technological one—how best to plan, coordinate, and monitor the varied activities of the program's many organizations. The space station is one of the most complex international collaborations ever attempted by multiple nations. Contributors from across the partnership function interdependently, enhancing its capability and benefits to far exceed what any individual nation or organization could provide on its own.

This model has created a blueprint for other programs, like the Artemis Accords, and provides a foundation for future global partnerships in spaceflight. The global benefit of this U.S.-led international effort advances shared goals and rewards in space exploration.

Advancing Deep Space Exploration

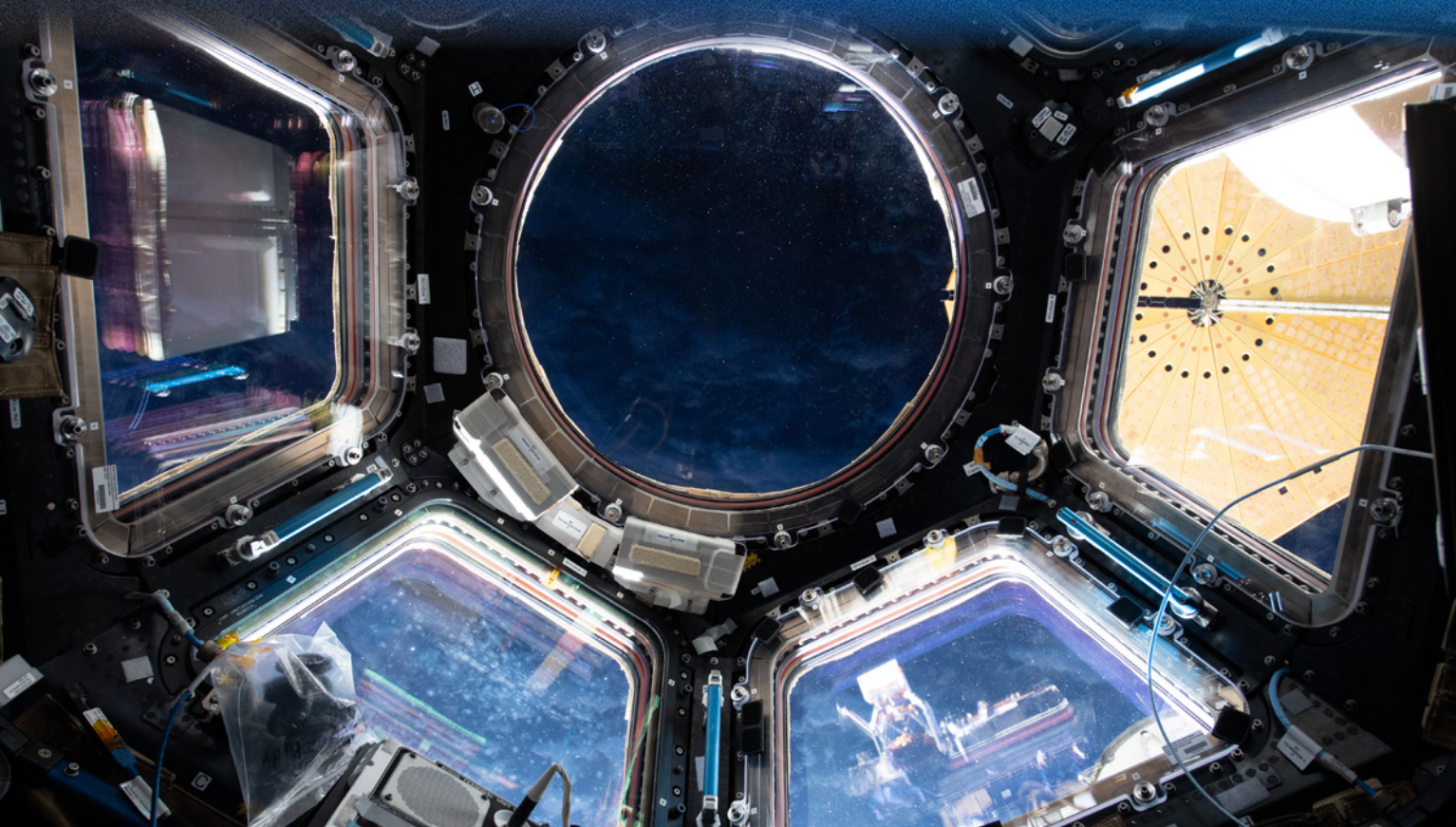
NASA continues to prepare for an expanded presence on the Moon and Mars and is leveraging the capabilities of the space station to make this vision a reality. Advanced technologies, including critical life support and crew exercise systems, as well as new materials, run through a gauntlet of trials and tests designed to push them to their limits as we push our exploration farther into the cosmos.

Because of the incredible research conducted on this unique platform, scientists and engineers have been able to learn more about creating extraterrestrial habitats for our explorers, and how 3D printing can potentially be used to create spare parts, tools, and materials on demand during journeys to the Moon and Mars.

Developing a Low Earth Orbit Economy

NASA and the International Space Station have helped lead a renaissance in human spaceflight as we envisioned with the launch of the Commercial Resupply Services contract and the Commercial Crew Program—each over 10 years ago. Today, commercial companies are providing services to private astronauts in low Earth orbit, more people are flying to space, and American industry is identifying its own motivations for activity in low Earth orbit as an important part of a growing economy in space.

What we have learned and built over time with more than a quarter century of space station operations has been critical to support our science and research priorities and a new market in low Earth orbit. NASA's Low Earth Orbit Microgravity Strategy builds on the agency's extensive human spaceflight experience to advance future scientific and exploration goals. By leveraging commercial and international partnerships, NASA aims to maintain its leadership in microgravity research and ensure continued benefits for humanity both on and off the Earth.



Commercial Crew Program

NASA's Commercial Crew Program began launching crews from the United States in 2020 and now ensures there is a steady supply of astronauts aboard the space station to conduct science for the benefit of humanity. Commercial transportation to and from the space station provides the capability for additional research and discovery on the orbiting laboratory, along with critical redundancy in spacecraft and systems both from the United States and international partners. NASA's Commercial Crew Program has opened access to low Earth orbit to more people than ever before, as private companies now fly their own missions with roots in what was developed with NASA.

The Commercial Crew Program represents a revolutionary approach to government and commercial collaborations for the advancement of space exploration.

Goal

NASA, SpaceX, and Boeing—with the help of contractors throughout America—are achieving historic progress. Team members at locations across the country have

The Starliner spacecraft on NASA's Boeing Crew Flight Test mission docks to the Harmony module's forward port as the International Space Station orbited 262 miles above Egypt's Mediterranean coast. Credit: NASA

STEVEN STICH
PROGRAM MANAGER



dedicated countless hours to the Commercial Crew Program to achieve a common goal: maintain our nation's ability to safely launch humans to the International Space Station from American soil. Facilitating the development of U.S. commercial crew space transportation systems to provide safe, reliable, cost-effective access to and from the station and low Earth orbit ensures our nation can maximize the return on its pursuits in space. Transporting pressurized and time-sensitive scientific research and cargo and increasing the station crew has enabled twice the amount of research to be conducted.

By encouraging private companies to provide human transportation services to and from low Earth orbit, NASA has been able to focus more of its own resources on building spacecraft and rockets for deep space exploration.

Safety

Since the beginning of NASA's Commercial Crew Program, safety has been built into the agency's requirements, design and construction standards, and approach to redundancy as a direct result of NASA's extensive experience in human spaceflight systems development and operation.

NASA and its commercial crew partners, Boeing and SpaceX, have developed systems that prioritize crew safety and survival, including launch pad emergency escape and egress systems and in-flight abort capabilities. Both companies underwent a rigorous certification program that included an uncrewed test flight to the space station to demonstrate their ability to safely fly before launching astronauts. These commercial systems are required to meet NASA's safety and performance requirements to be certified to transport NASA and international partner crew members to the space station.

Commercial Crew's Approach

Due to the retirement of the space shuttle, NASA needed a crew transportation system and a broad set of requirements



NASA, Roscosmos, and SpaceX support personnel watch as the SpaceX Dragon Endeavour spacecraft is moved aboard the SpaceX recovery ship MEGAN shortly after it landed with NASA astronauts Matthew Dominick, Michael Barratt, and Jeanette Epps, and Roscosmos cosmonaut Alexander Grebenkin. Credit: NASA

that would be necessary to ensure crew safety. In the case of commercial crew, the need centered around a safe, reliable, and cost-effective means of getting humans to low Earth orbit, including the International Space Station, and returning them safely to Earth.

NASA's engineers and aerospace specialists work closely with Boeing and SpaceX, allowing for substantial insight into development and operational processes by offering expertise and resources. The Commercial Crew Program was the first time this model was implemented for human-rated spacecraft, enabling NASA to acquire transportation services on firm fixed-price contracts and ensuring safe, reliable, and cost-effective access to space. NASA also is spurring economic growth through this program as potential new space markets are created while providing a model for other agency organizations to collaborate with private industry.

Commercial Crew Astronauts

More than 36 astronauts from eight countries have traveled to the space station aboard a SpaceX Dragon as part of NASA's Commercial Crew Program since 2020, with a regular cadence of one launch approximately every six months. NASA astronauts Butch Wilmore and Suni Williams launched on the Starliner spacecraft for NASA's Boeing Crew Flight Test in 2024. Starliner returned to Earth without crew, allowing teams to gather necessary data to evaluate future plans. Having two providers allows Wilmore and Williams to return on a Dragon spacecraft in early 2025.

American Ingenuity

Returning these launches to American soil has significant economic benefits, with suppliers working in states across the country on commercial crew spacecraft systems.



Commercial Low Earth Orbit Development Program

ANGELA HART
PROGRAM MANAGER



NASA's Commercial Low Earth Orbit Development Program is using a two-phase strategy to support the development of commercial destinations in low Earth orbit and enable the agency to purchase services as one of many customers. This strategy for low Earth orbit builds on the successful legacy of agency commercial cargo and crew programs that are now delivering important research, supplies, and astronauts to the International Space Station.

During Phase 1, which extends through 2025, the agency is supporting multiple commercial companies through both funded and unfunded agreements for the early design and development of commercial low Earth orbit destinations. The first funded effort is a commercial destination at the International Space Station, awarded to Axiom Space in 2020. The second funded effort is for commercial,

free-flying destinations that go directly to orbit. Under the second effort, NASA is supporting Blue Origin and Starlab Space through funded Space Act Agreements awarded in 2021. In addition, NASA is partnering with seven U.S. companies to meet future commercial and government needs through the Collaborations for Commercial Space Capabilities-2 initiative. The companies selected for unfunded Space Act Agreements in 2023 were Blue Origin, Northrop Grumman, Sierra Space, SpaceX, Special Aerospace Services, ThinkOrbital, and Vast Space.

Sierra Space's LIFE (Large Integrated Flexible Environment) habitat following a full-scale ultimate burst pressure test at NASA's Marshall Space Flight Center in Huntsville, Alabama. Credit: Sierra Space



Inside the quiet room of the Acoustics Lab, Zach Jones of NASA's Human Health and Performance Directorate speaks with Northrop Grumman's Grant Cooper and Jay Boucher and Leah Honey and Cooper Burluson of NASA's Commercial Low Earth Orbit Development Program during a Human Systems Integration Technical Interchange Meeting. Credit: NASA

NASA has made rapid progress through these Phase 1 efforts, with the agency and partners completing various levels of design reviews and closing out a multitude of milestones associated with the funded and unfunded agreements. The Commercial Low Earth Orbit Development Program also has hosted a series of technical interchange meetings with commercial partners on a variety of topics to share best practices and lessons learned from decades of human spaceflight experience as industry continues to develop commercial destinations.

The agency has also opened the International Space Station for business and has offered opportunities for commercial activities aboard the orbiting laboratory. In support of these

activities, NASA and Axiom Space successfully completed the second and third private astronaut missions to the space station in 2023 and 2024. Axiom Space was selected for the fourth private astronaut mission, targeting a launch to the station no earlier than Spring 2025.

Phase 2 will focus on the certification of destinations and the purchase of services. NASA will issue requests for proposals issued in late 2025, with Phase 2 service contract award(s) expected in the 2026 timeframe. Phase 2 solicitations will be free and open competitions, accessible to any U.S. company to propose. Any company meeting the request requirements may submit a proposal, even if it did not have a Phase 1 contract or agreement with the agency.

Orion Program

Orion is the safest, most capable crewed vehicle for deep space travel. It will take astronauts farther in space than any spacecraft built for humans has gone before. Built by NASA and lead contractor Lockheed Martin, Orion will carry up to four astronauts. It is the only spacecraft capable of sustaining crew for up to 21 days in deep space and withstanding high-speed re-entry from the vicinity of the Moon.

Orion is one of NASA's foundational capabilities for deep space exploration. A key component of the Artemis campaign, Orion is a multinational project involving all 50 states and 10 European countries, driving innovation, advanced manufacturing techniques, and boosting manufacturing competitiveness. There are currently more than 3,500 employees working on Orion across the country, and since the program's inception, more than 2,900 subcontractors and

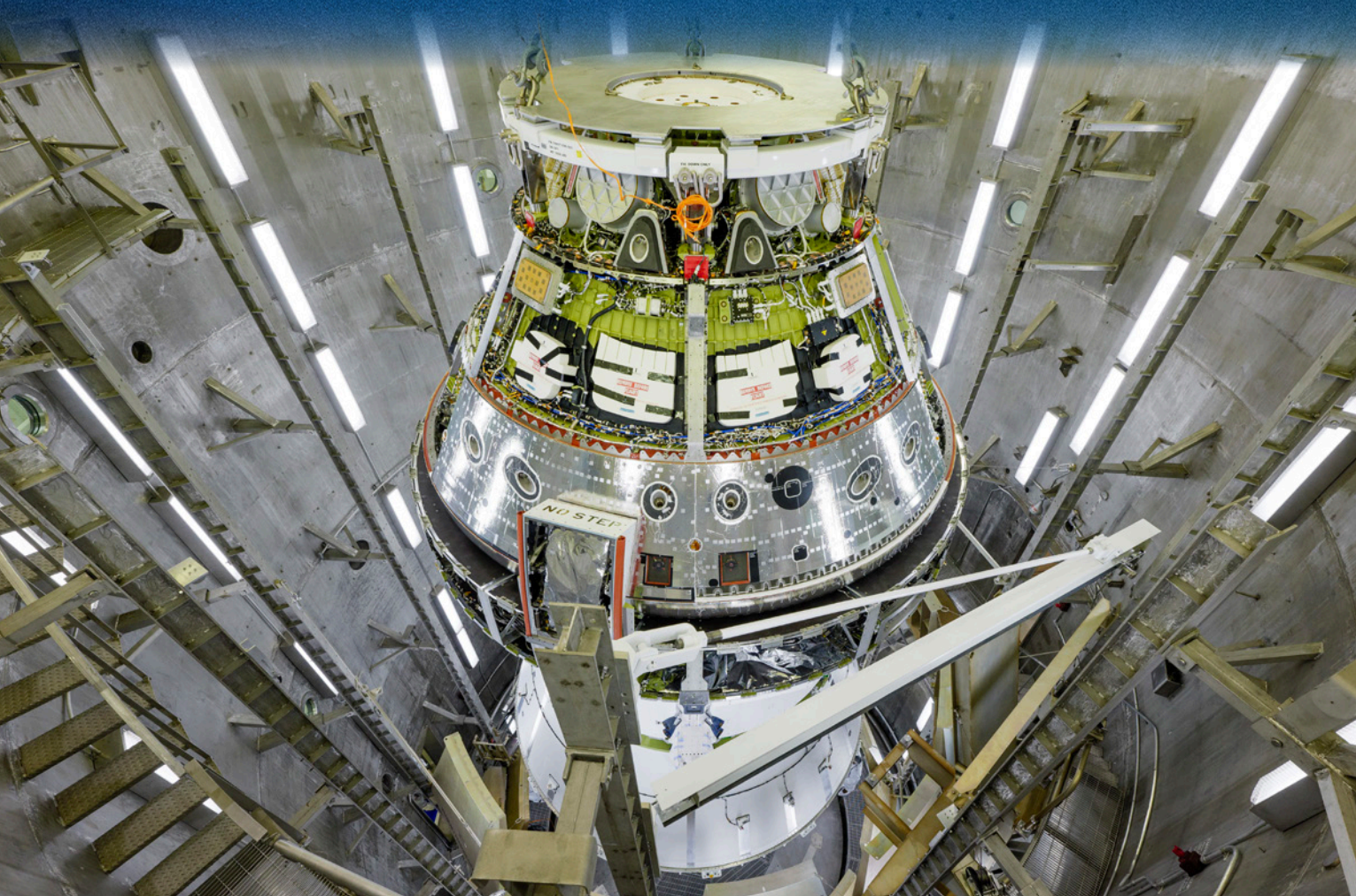
HOWARD HU
PROGRAM MANAGER



suppliers nationwide have contributed to Orion, with Texas home to more than 250 of those small and large businesses.

The Artemis I mission in 2022 was the first of several increasingly complex missions to build a sustainable lunar presence. Orion flew a record-setting 25.5-day mission around the Moon, traveled a total of 1.4 million miles,

Technicians use a 30-ton crane to lift NASA's Orion spacecraft on Friday, June 28, 2024, from the Final Assembly and System Testing (FAST) cell to the altitude chamber inside the Neil A. Armstrong Operations and Checkout building at NASA's Kennedy Space Center in Florida. The spacecraft, which will carry Orion's first crew around the Moon on Artemis II, underwent leak checks and end-to-end performance verification of the vehicle's subsystems. Credit: NASA



Orion's European Service Module 3 will provide propulsion, thermal control, and electrical power for NASA's Orion spacecraft set to carry four NASA astronauts to the lunar South Pole region of the Moon for the agency's Artemis campaign. Credit: NASA

and tested the systems of the spacecraft in the extreme environment of deep space before flying astronauts on Artemis II. Orion reached 268,563 miles from Earth, the farthest a spacecraft built for humans has ever gone.

After its successful mission around the Moon, the Artemis I crew module — now known as the Environmental Test Article — arrived at the Neil A. Armstrong Test Facility at NASA's Glenn Research Facility in Ohio in January 2024, where teams are performing abort-level acoustic vibration and other environmental testing to ensure Orion is ready for crew to fly on Artemis II. NASA and Lockheed Martin continue to process the Orion spacecraft for Artemis II, and build Orion for Artemis III, IV, and V missions:

Orion Spacecraft Artemis II Progress

At NASA's Kennedy Space Center, teams are working on the Artemis II spacecraft that will carry astronauts around the Moon. Teams joined Orion's crew and service module in October 2023 and powered on the integrated stack for the first time in November 2023. In 2024, at NASA Kennedy's Operations and Checkout Building, the spacecraft underwent two rounds of testing inside the altitude chamber, which simulates vacuum conditions of deep space. The team

checked out Orion for electromagnetic interference and electromagnetic compatibility in April, then conducted a series of qualification tests in July. In November, the Artemis II spacecraft returned to the altitude chamber for more testing.

Orion Spacecraft Artemis III Progress

The Artemis III crew module is at NASA Kennedy, undergoing installation of subsystems such as life support and propulsion. In September 2024, the Artemis III European Service Module arrived at NASA Kennedy from Airbus facilities in Bremen, Germany, and was joined with the crew module adapter.

Orion Spacecraft Artemis IV and V Progress

The Artemis IV crew module is also in work at NASA Kennedy, currently undergoing installation of secondary structures. The Artemis V crew module pressure vessel, the underlying structure of the spacecraft, is currently being welded together at NASA's Michoud Assembly Facility in New Orleans. The European Service Modules for Artemis IV and V are undergoing integration at Airbus facilities in Bremen before shipment to NASA Kennedy.

Gateway Program

The Gateway Program is a centerpiece of the architecture for long-duration human exploration of the Moon and Mars. Gateway symbolizes the expansion of NASA's partnerships from low Earth orbit to deep space, with international partner contributions, U.S. elements managed at multiple NASA centers, and commercial partners. As humanity's first lunar space station, Gateway is crucial for deep space exploration, enabling lunar surface missions, and serving as the testbed for Mars-forward capabilities. Global leadership of this expansive partnership is provided by the Gateway Program Office from NASA Johnson.

Gateway is an incrementally built and deployed spacecraft that will provide unprecedented access to the Moon, enabling science and technology development including advanced solar electric propulsion, roll-out solar arrays, refueling in deep space, and autonomous robotic technologies. Gateway's polar orbit is accessible by multiple launch vehicles, and reduces the relative propulsive cost for landers to access global surface sites.

Yasmin Ali, manager for the Gateway Program's Habitation and Logistics Outpost (HALO) Project Office, Christopher Johnson, deputy manager for the HALO Project Office, and astronaut Stan Love join Northrop Grumman HALO leaders and the Thales Alenia Space HALO workforce for a group photo beside HALO. In the background, rings of Gateway's other habitation module, Lunar I-Hab, are also visible. Credit: Thales Alenia Space

JON OLANSEN
PROGRAM MANAGER



The multi-purpose platform supports multiple Moon to Mars goals and objectives. Continuous deep space science and technology investigations aboard the space station will support the understanding of long-term effects of radiation on vehicle systems and the human body, microgravity studies of Mars-forward human health and performance, and testing of a future Mars-class transit habitat at Gateway prior to committing to Mars transit.

Gateway's NASA-led components are provided by commercial partners, enhancing the emerging lunar economy. Maxar Space Systems in Palo Alto, California,

is supplying Gateway's Power and Propulsion Element, providing power, maneuvering, attitude control, and communications for Gateway. Northrop Grumman Space of Dulles, Virginia, is building HALO (Habitation and Logistics Outpost), the initial habitation element for crew. The program is developing integrated software and autonomy, labs to support development and flight verification testing, integrated performance analyses and safety, and flight operations from Houston for Gateway's minimum 15-year design life. All of these elements will be integrated into a single initial configuration launched on a SpaceX Falcon Heavy for transit to Gateway's unique orbit around the Moon. NASA has also selected SpaceX of Hawthorne, California, as the first U.S. commercial provider under the Gateway Logistics Services contract to deliver cargo, experiments, and other supplies to Gateway.

International Partners

CSA (Canadian Space Agency) will contribute external robotics systems (including a robotic arm), robotic interfaces, and end-to-end robotic operations. ESA (European Space Agency) is providing the Lunar I-Hab module, with contributions from JAXA (Japanese Aerospace Exploration Agency). Lunar I-Hab will provide the heart of Gateway's life support systems, living quarters with additional space for crew, and expanded scientific opportunities. JAXA will provide environmental control and life support systems, batteries, thermal control, and imagery components. ESA will also provide the Lunar View module which will provide refueling capabilities, cargo storage, enhanced lunar communications, and windows to view deep space and the Moon. These agreements strengthen the broad NASA effort to engage international partners in sustainable lunar exploration as part of the Artemis campaign, and demonstrate the technologies needed for human missions to Mars.

The Mohammed Bin Rashid Space Centre (MRBSC) of the United Arab Emirates will provide Gateway's Crew and Science Airlock module for transfers of astronauts and hardware from the inside of Gateway to the vacuum of deep space. The partnership with MRBSC represents a major evolution of the United Arab Emirates' contributions to human space exploration.



The primary structure of the Gateway space station's HALO (Habitation and Logistics Outpost) module following welding completion at Thales Alenia Space in Turin, Italy. Credit: Thales Alenia Space

Milestones

- Gateway is in the full development phase for its first two elements—HALO and the Power and Propulsion Element—with an expected launch in 2027. Both pieces are proceeding through fabrication, assembly, testing, and installation of hardware. HALO will arrive in the U.S. for final outfitting in spring of 2025.
- The U.S. government finalized Gateway international agreements with Canada, Europe, and Japan in 2020, and the United Arab Emirates was announced as Gateway's airlock partner in 2024.
- NASA has selected three radiation science payloads as the first scientific investigations to fly aboard Gateway. These investigations will help scientists better understand unpredictable space weather from the Sun and galactic cosmic rays from deep space that astronauts and their equipment will encounter.
- ESA began initial fabrication of the Lunar I-Hab module that will be delivered to and integrated with Gateway on the Artemis IV mission in 2028.



Exploration Operations Office

HOLLY RIDINGS
DIRECTOR



NASA is establishing a long-term presence at the Moon for scientific exploration and discovery with our commercial and international partners, learning how to live and work far from home, and preparing for future human exploration of Mars. Through the Artemis campaign, NASA will send astronauts to the Moon using innovative technologies to explore more of the lunar surface than ever before, building the foundation for the first crewed missions to Mars.

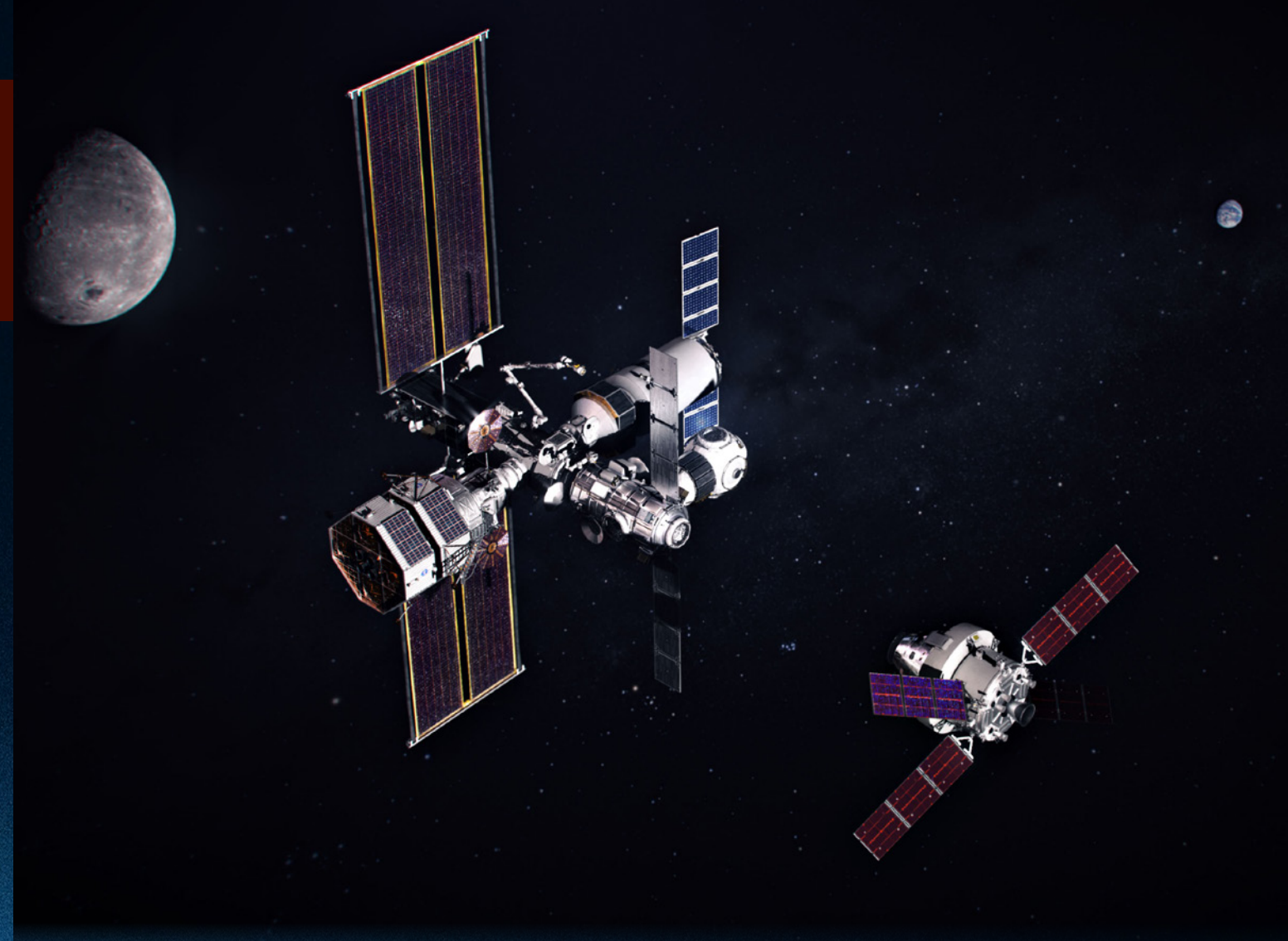
The Exploration Operations Office is responsible for the Moon-to-Mars architecture processes and products necessary to optimize the full capabilities of vehicles and systems across the agency's Artemis campaign. This means integrating the development of mission-level requirements,

objectives and priorities; payload and utilization capabilities, and logistics and resupply needs and dependencies across flight programs. The office is comprised of three teams:

Mission and Operations Integration

The Mission and Operations Integration team leads mission integration across the programs and organizations within the Artemis campaign on behalf of the Moon to

*Artist's rendition of the Exploration Extravehicular Mobility Unit, or xEMU, that will be worn on Artemis missions.
Credit: NASA*



Artist's rendition of Orion approaching the full Gateway configuration. Credit: NASA

Mars Program. Mission integration is executed in a collaborative manner with all Moon to Mars architecture elements, flight programs, and operations teams. This team also develops and maintains processes, procedures, and associated capabilities necessary to support the Artemis mission management team prior to and during mission execution.

Utilization Integration

The Utilization Integration team is responsible for Artemis activities related to the payload manifest, payload integration, and development and application of interoperability standards. The team serves as a customer-focused "front door" interface for the Science Mission

Directorate, Space Operations Mission Directorate, Space Technology Mission Directorate, among others, and is responsible for the development and execution of processes and products needed to fully integrate utilization activities, payload developers, and associated sponsors across the Artemis campaign.

Logistics Integration

The Logistics Integration team is responsible for development of integrated Artemis cargo allocations and resupply plans to facilitate development of feasible and effective launch, return, transfer, and disposal manifests and associated activities that are achievable within available vehicle and crew resources across all missions.

Extravehicular Activity and Human Surface Mobility Program

LARA KEARNEY
PROGRAM MANAGER



NASA's Extravehicular Activity and Human Surface Mobility Program is a cornerstone of the agency's Artemis campaign to return humans to the Moon and explore deep space. The program also plays a critical role supporting the International Space Station and the commercialization of low Earth orbit. It serves as the agency's program to develop next-generation spacesuits, human-rated rovers, and tools, along with all required spacewalking support systems that will enable astronauts to survive and work outside the confines of a spacecraft in order to explore on and around the Moon.

The program leverages NASA's expertise as well as commercial and international partnerships to provide spacewalking and surface mobility capabilities. Commercial partnerships enable NASA to benefit from industry innovations and efficiencies and allow the vendors to offer these services to the private sector, outside of NASA programs.

Extravehicular Activity Support

With the life of the International Space Station extended until 2030, NASA and its international partners must continue to regularly conduct spacewalks to expand new capabilities and maintain and upgrade critical systems and payloads. In 2024, the current Extravehicular Activity Space Operations contract was extended through September 2030, allowing the agency to maintain critical spacewalking capability on the space station. This entails sustaining engineering and processing of the legacy Extravehicular Mobility Unit spacesuit, tools and crew aids, hardware integration, mission planning, hardware development (as required), and real-time operations support for the space station through its end of life.

A concept image of JAXA's (Japan Aerospace Exploration Agency) pressurized rover on the surface of the Moon. Credit: Toyota



From left: Astrolab's FLEX, Intuitive Machines' Moon RACER, and Lunar Outpost's Eagle lunar terrain vehicle at NASA's Johnson Space Center. Credit: NASA

Next-Generation Spacesuits

The next generation of spacesuits is required for humans to live and work safely in low Earth orbit, deep space, and on the lunar surface. Under the Exploration Extravehicular Activity Services contract, Axiom Space has completed the preliminary design review of its lunar spacesuit, which astronauts will wear during NASA's Artemis III mission. Additionally, Axiom Space is working to prepare its lunar spacesuit for demonstration in a microgravity environment on the International Space Station to reduce risk for Artemis missions. These next-generation spacesuits will be provided as a service to NASA and will be available for other private or commercial entities to utilize.

Lunar Terrain Vehicle

As astronauts explore the South Pole region of the Moon during Artemis missions, they will be able to go farther and conduct more science than ever before thanks to a lunar terrain vehicle that will feature advanced technologies for power management, autonomous driving, and state-of-the-art communications and navigation systems. In 2024, NASA selected Intuitive Machines, Lunar Outpost, and Venturi Astrolab under NASA's Lunar Terrain Vehicle Services contract to advance capabilities for a lunar terrain vehicle. The three companies are currently in a one-year long feasibility study, with NASA planning to award a final demonstration task order in 2025 to one company to demonstrate its vehicle on the Moon.

Pressurized Rover

An enclosed and pressurized rover will enable astronauts to travel farther and conduct science in geographically diverse areas on the Moon by serving as a mobile habitat and laboratory for astronauts to live and work for extended

periods of time. In 2024, NASA and the Japan Aerospace Exploration Agency signed an implementing arrangement where Japan will design, develop, and operate a pressurized rover for crewed and uncrewed exploration on the Moon. NASA currently plans to use the pressurized rover on Artemis VII and subsequent missions over an approximate 10-year lifespan.

The flight design of Axiom Space's Axiom Extravehicular Mobility Unit (AxEMU) lunar spacesuit that NASA astronauts will wear during the Artemis III mission. Credit: Axiom Space



Human Research Program

NASA's Human Research Program (HRP) conducts research and develops strategies that counter five identified hazards of human spaceflight: radiation, isolation and confinement, distance from Earth, microgravity, and hostile/closed environments. These hazards pose risks to astronaut health and performance. NASA aims to understand and manage those risks through studies in ground-based analogs, the International Space Station, and commercial missions.

A New Research Suite

The most complex human life science experiment ever has begun on the space station—the Complement of Integrated Protocols for Human Exploration Research. Through this research suite, astronauts participate in an integrated set of 14 studies sponsored by NASA and international partner agencies.

The data will help scientists more deeply understand how the entire human body reacts to long durations in space. Astronauts flying on six-month and year-long missions can sign up to participate.

The four-person crew of the Polaris Dawn mission wear their SpaceX spacesuits ahead of their September 2024 launch. Credit: SpaceX



DAVID BAUMANN
DIRECTOR



Ground-Based Analogs of Spaceflight

Analogs—environments on Earth that mimic spaceflight conditions—allow scientists to study the effects of space exploration on humans without leaving Earth. HRP uses several ground-based analogs to learn more about how spaceflight affects the human body.

One facility, called the Human Exploration Research Analog (HERA), is housed at Johnson. Since January 2023, HERA has supported four 45-day missions that simulate round-trip journeys to Mars and the isolation, confinement, and remote conditions that future deep space crews may experience.



The four crew members of the Human Exploration Research Analog's first mission in 2024 clasp hands above a hatch within their 650-square-foot habitat. Credit: NASA

Crew members participated in 15 to 18 human health and performance studies, including several led by international partners, that aim to assess team conduct, dynamics, and behavioral health, among other research questions.

Recent accomplishments include:

- A new research collaboration with the United Arab Emirates' Mohammed Bin Rashid Space Centre
- A mission that included one crew member from the United Arab Emirates
- A mission where each crew member hailed from a different cultural background outside the United States

Other analogs include:

- The National Science Foundation's Antarctic stations, to study how isolation and confinement affect immune systems and team dynamics
- The German Aerospace Center's :envihab bed rest facility, to study the eyes and brains of volunteers who induced the physiological effects of weightlessness by undergoing strict bed rest
- The U.S. Navy's Disorientation Research Device, better known as the Kraken, to study space motion sickness

- Parabolic flights run by ESA (European Space Agency) to study changes to sensorimotor and cardiovascular systems during weightlessness and partial gravity
- NASA's Space Radiation Laboratory at Brookhaven National Laboratory, to better characterize health risks from space radiation

A Commitment to Partnerships

HRP coordinated with partners including the Houston-based Translational Research Institute for Health (a NASA-funded consortium with various academic institutions) to fly science experiments on the fully commercial Polaris Dawn mission, which launched and returned in September 2024. This effort helped set a precedent for collecting data from non-governmental crews.

The HRP also worked with NASA's Office of Science and Technology Policy to support the federal Cancer Moonshot Initiative. Through HRP, NASA gave prioritized access for National Cancer Institute grant awardees to study heavy ion therapeutics.

Through the Complement of Integrated Protocols for Human Exploration Research, ground analogs, and fully commercial missions, the program works with partners around the world to innovate, leverage research funding, and accelerate risk mitigation.

Engineering Directorate

Johnson's Engineering Directorate specializes in the design, development, test, and evaluation of human spacecraft and human space exploration systems. The portfolio includes development and operational support for all U.S. human-rated spacecraft. That includes supporting missions as diverse as the continued operations and research capabilities of the International Space Station for over 20 years, and the Commercial Crew Program's historic development of commercial human-rated spacecraft to maintain flying astronauts to the station from American soil. Johnson Engineering continues to enable the Artemis campaign objectives to return humans to cislunar space, and on to Mars, through development and testing of the Orion vehicle and the Gateway deep space platform, as well as providing human systems expertise to Marshall Space Flight Center's Human Landing Systems program.

NASA's Volatiles Investigating Polar Exploration Rover sits inside Vacuum Chamber A as a part of a series of vehicle integration and environmental testing. Credit: NASA



**JULIE
KRAMER-WHITE**
DIRECTOR



Project Highlights

Engineering has made significant strides to reduce risk on future human spaceflight exploration capabilities and systems. Projects include testing the Orion spacecraft main engine, parachute release mechanism, and redesigning the Orion crew module battery; providing structural analysis of the space station's modules and assisting with robotic arm operations; conducting initial use and testing of the lunar terrain vehicle ground test unit; and supporting the Commercial Crew Program with the SpaceX Crew-8 port relocation and SpaceX Crew-9 launch. As part of NASA's Boeing Crew Flight Test, Johnson Engineering performed critical assessments and tests that enabled the return of the uncrewed Starliner spacecraft in September 2024. The directorate supports Johnson's programs through collaboration with other NASA centers, many contractors, and universities around the country. Bringing these unique perspectives and experienced teams together allows NASA to solve exceptionally difficult problems in innovative ways.

Technological Innovations

Engineering continues to contribute to the development of numerous technological advancements. In June 2024, NASA launched two CubeSat demonstrations on a commercial rocket, providing a low-cost model for frequent payload and experiment deliveries to low Earth orbit. The directorate also successfully completed vehicle integration and environmental testing for the agency's VIPER (Volatiles Investigating Polar Exploration Rover). Simulating the extreme environments of space, the unique Engineering-operated chamber facilities at NASA Johnson continue to support the testing and verification of spacecraft hardware and structures, including spacesuit acceptance testing for the Polaris Dawn mission and thermal vacuum testing of commercial solar power systems. As part of the Carbothermal Reduction Demonstration project, Johnson



On Aug. 2, 2024, NASA Johnson conducted a test where suited engineers demonstrated the capabilities of NASA's rover prototype, called the Ground Test Unit. Credit: NASA

Engineering teams successfully extracted oxygen from simulated lunar regolith, paving the way for astronauts to one day extract and use resources in a lunar environment.

Partnerships

Partnerships with aerospace companies, non-aerospace industries, government agencies, and academic organizations provide resources and expertise that enhance Engineering's capabilities. These collaborations create opportunities to advance all aspects of design, development, testing, and evaluation of spacecraft systems. Notably, the directorate has partnerships with all of the principal commercial vendors supporting the human landing system, lunar terrain vehicle, spacesuit development, and commercial destinations in low Earth orbit. These partnerships are critical for advancing key areas of system design and mission design, and for ensuring successful development and test of these human spaceflight systems. Johnson Engineering has also partnered with national laboratories, universities, and industry to advance state-of-the-art technology in hypersonic re-entry vehicles, with a particular emphasis on materials and techniques for additive

manufacturing of heatshields. The directorate also supports the agency's CLPS (Commercial Lunar Payload Services) initiative, which leverages the capabilities of American companies to deliver NASA science and technology to the lunar surface. Under CLPS, Engineering supported the development of several instruments onboard Intuitive Machines' IM-1 mission, which landed in the Moon's South Polar region in February 2024.

Future Outlook

Johnson Engineering continues to look toward the future and is actively pursuing new opportunities with external partners. The directorate has several Space Act Agreements with external organizations, ranging from an agreement with bp to expand the capabilities of visualization and simulation models to an agreement with Underwriters Laboratories to characterize and enhance the safety of lithium-ion battery cells. By fostering a collaborative environment, Johnson Engineering is accelerating the advancement of spacecraft design, efficiency, and sustainability, enabling a growing lunar economy and paving the way for exploration of the Moon, Mars, and beyond.

Exploration Architecture, Integration and Science Directorate

BURT LAWS
DIRECTOR



The Exploration Architecture, Integration, and Science Directorate supports NASA's human and science exploration programs with expertise in exploration architecture, mission planning, systems engineering, planetary and space science, and program integration and assessments.

Sending humans to Mars remains a long-term goal of NASA – and the Moon will help the agency get there. This is NASA's Moon to Mars exploration approach. Through Artemis, NASA will learn to live and work on another world in preparation for Mars. The architecture at the Moon will inform development of systems that will take humanity farther into space than ever before.

The Exploration Architecture, Integration, and Science Directorate continues to support the Artemis campaign through mission planning and integration across NASA programs and enterprises that are venturing to the Moon and beyond. The directorate weaves these exploration components together to deliver a cohesive and comprehensive strategy for mission planning and architecture, program integration, and science to extend human presence beyond low Earth orbit into cislunar space, to the Moon, and on to Mars. The organization seeks answers to fundamental questions about the origins and

Astromaterials processors use tools to collect asteroid particles from the base of the Origins, Spectral Interpretation, Resource Identification, and Security – Regolith Explorer (OSIRIS-REx) science canister. Credit: NASA



Intuitive Machines' Nova-C lunar lander, named Odysseus, lifted off on a SpaceX Falcon 9 rocket from NASA's Kennedy Space Center in Florida. Credit: Intuitive Machines

dynamics of the solar system, the availability of resources, and opportunities for human habitation beyond Earth.

Astromaterials Research and Exploration Science

The Astromaterials Research and Exploration Science Division is responsible for curating the world's largest collection of astromaterials, including samples from asteroids, comets, Mars, the Moon, the Sun, and dust from other stars. The ninth and most recent addition of asteroid Bennu samples from the OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, and Security – Regolith Explorer) mission is the ninth individual collection managed by the division. Expert curators inventoried and developed a catalog of the returned samples available for study by the global scientific community while scientists study the rocks and dust as part of the mission science team. The division is a key participant in NASA's Artemis campaign, providing expertise in sample collection and curation, geology training, imagery, lunar science research, and lunar surface science mission planning.

The Astromaterials Research and Exploration Science Division explores planetary worlds with scientists on

missions to Mars and Venus and manage the Mars Sample Receiving Project. It is the global leader and expert on orbital debris and predicting risk to spacecraft. Imagery experts plan the integrated imaging needs for human spaceflight missions, provide analysis of the condition and performance of spacecraft, support astronaut photography of Earth from the International Space Station, and coordinate space station remote sensing response to natural disasters and other dynamic events.

Commercial Lunar Payload Services

NASA's CLPS (Commercial Lunar Payload Services) initiative allows rapid acquisition of lunar delivery services from American companies for payloads that advance capabilities for science, exploration, or commercial development on the Moon. With lunar deliveries that have taken place and others that will follow, NASA will continue to support a growing lunar economy and leverage the entrepreneurial and innovative commercial space industry. Future deliveries are slated to include sophisticated science experiments and technology demonstrations as part of the agency's Artemis campaign.

Flight Operations Directorate

The Flight Operations Directorate is the world leader in human spaceflight operations, uniting NASA's partners, programs, and enterprise elements. It enables spaceflight success through the sharing of expertise and resources, and executes spaceflight missions that inspire the world.

This uniquely skilled workforce trains astronauts in a variety of facilities on the ground in spacecraft mockups, underwater in the Neutral Buoyancy Laboratory (NBL) at NASA's Sonny Carter Training Facility, and in the air in T-38 jets.

The Space Vehicle Mockup Facility provides hands-on training for spaceflight crews and their support personnel and high-fidelity hardware for real-time mission support. The mockup facility supports engineering and operational evaluations for the space station and Artemis campaigns. All mockups and trainers are available to troubleshoot on the ground anytime problems develop in space.

The NBL prepares crews and mission teams for spacewalks. NASA uses one of the world's largest indoor pools to develop flight procedures, verify hardware compatibility, train astronauts, and refine spacewalk procedures during

*Expedition 71 flight controllers on console during NASA's Boeing Crew Flight Test rendezvous and docking.
Credit: NASA*



NORMAN KNIGHT
DIRECTOR



flight as necessary to ensure mission success. Teams also use the NBL to test prototype spacewalk tools and techniques for future use on lunar missions.

At Ellington Field, the directorate operates a variety of aircraft in support of astronaut training, post-mission transport, airborne science campaigns, cargo transportation, and spaceflight support missions.

NASA's Christopher C. Kraft Jr. Mission Control Center is where flight controllers provide command and control to the International Space Station and monitor crew members' well-being around the clock. As NASA's hub of collaboration and computation, Mission Control links the ground to the crew and NASA with its partners during real-time operations and simulation training. Mission Control also supports space vehicle end-to-end testing for new vehicles flying to the space station and the Moon.



The newest astronaut class waves to a crowd during its graduation ceremony on March 5, 2024 at NASA's Johnson Space Center in Houston, following two years of astronaut training. Credit: NASA

Milestones

Flight Operations is proud to have supported another year of continuous scientific operations aboard the space station. In 2024, the directorate oversaw several crew rotations in support of Expeditions 70, 71, and 72. Mission Control also oversaw the execution of NASA's Boeing Crew Flight Test mission, sending the Starliner spacecraft to the station with crew for the first time. The Boeing and NASA teams gained extensive knowledge about the Starliner spacecraft's systems and operations to inform efforts toward future missions.

Flight Operations continues to contribute its decades of human spaceflight leadership and experience to vehicle and mission development efforts in low Earth orbit and NASA's lunar missions. This year, it provided operational expertise to commercial companies that have a Space Act Agreement with NASA via the agency's Commercial Low Earth Orbit Development Program. In addition, astronauts, flight directors, and operations experts met monthly with both human landing system providers, SpaceX and Blue Origin, to help inform their lander designs, and training and operations plans with end users in mind.

The Aircraft Operations group manages the WB-57 High Altitude Research Program supporting researchers in their

studies of the solar corona during the 2024 total solar eclipse. The aircraft's capabilities allowed for unprecedented analysis of the eclipse's totality. Eclipse studies had previously been limited to ground-based observations. By operating their instruments on the WB-57, researchers were able to avoid interference from Earth's atmosphere and ensure successful experiments regardless of weather. The directorate also provided SpaceX with real-time imagery collected from the WB-57 of three Starship launches.

Also in 2024, the organization celebrated the graduations of its newest recruits. Each member of NASA's newest group of flight directors completed their certifications, and, after two years of basic training, NASA proudly debuted its 23rd astronaut class. The astronauts earned their wings in a graduation ceremony in March and are now eligible for spaceflight.

Whether it's involved in executing a space station mission, completing test flights for a new vehicle, or planning a mission to the Moon, the Flight Operations team holds itself to the highest standards. Vigilance, competence, and teamwork are just a few words used every day within the directorate as the team carries out its duties in the pursuit of exploration in human spaceflight.

Human Health and Performance Directorate

MICHELLE FRIELING
DIRECTOR



The Human Health and Performance Directorate is the primary organization responsible for crew health and performance while mitigating the risks associated with human space exploration. More than 1,000 employees target optimizing astronaut health and performance throughout all phases of human space exploration.

Milestones

- The inaugural Crew Health and Performance Exploration Analog (CHAPEA) mission marked a significant milestone in NASA's effort to simulate long-duration, sustainable missions on the Moon and Mars. After completing a 378-day analog mission in a controlled, isolated environment with communication latency and resource restrictions, the crew's exit from the habitat represented a major achievement in the exploration of human health and performance for exploration class missions.
- The Carbon Dioxide Walk Back Study was designed to identify the highest carbon dioxide levels that allow crew members to perform a one-hour contingency walk back within acceptable cognitive and physical performance limits. Participants engaged in ground-based virtual

reality simulations of walking on the Moon, collectively covering 274 miles (440,000 meters). By evaluating the effects of different carbon dioxide levels on performance and symptom severity, the study's findings will contribute to the design and operational guidelines for the Exploration Extravehicular Mobility Unit spacesuit.

- A team of optometrists, scientists, and physicians associated with Human Health and Performance collaborated to publish a case report of a crew member with a significant case of Spaceflight Associated Neuro-ocular Syndrome (SANS), matching a documented genetic pattern of earlier studies. B vitamin supplements were flown to the International Space Station for the crew member to take while the station's carbon dioxide levels were decreased, resulting in a rapid reduction in swelling of the retina and the back of the eye. This case finding reinforced ongoing research studies.

The Crew Health and Performance Exploration Analog (CHAPEA) crew celebrates completion of the simulated Mars mission July 6, 2024, at NASA's Johnson Space Center in Houston. Credit: NASA



The exploration atmosphere breathable protocol test was completed in the 20-Foot Chamber at NASA's Johnson Space Center. Credit: NASA

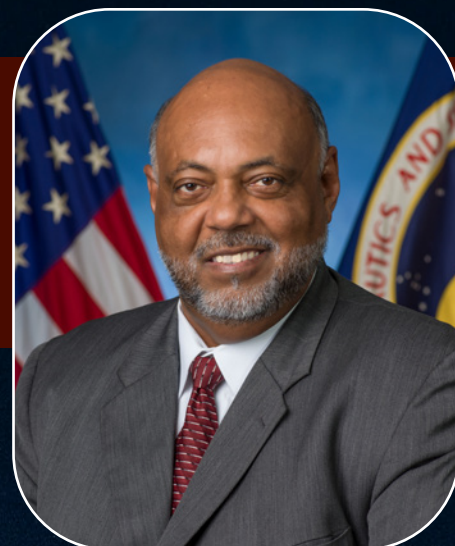
- The directorate's Space Radiation Analysis Group published detailed findings from the uncrewed Artemis I mission on space radiation hazards, validating the Orion spacecraft to protect crew from potentially hazardous radiation levels during future lunar missions. Radiation measurements taken inside Orion by 5,600 passive sensors and 34 active radiation detectors during its 25.5-day mission around the Moon and back provided important data on radiation exposure within Earth's Van Allen Belts.
- In support of Artemis missions, scientists and physicians are developing approaches that minimize time spent preparing the crew and their spacesuits to exit a lunar lander vehicle. A series of studies is evaluating alternative pre-breathe protocols to minimize the risk of astronaut decompression sickness.
- Flight surgeons and contingency specialists validated four high-fidelity incapacitated crewmember simulations from splashdown to a medical care facility as a training exercise in preparation for Artemis II. This test was executed in conjunction with the NASA Exploration Ground Systems and U.S. Navy medical teams during the Underway Recovery Test-11 off the coast of San Diego.
- The Immunology/Virology Laboratory successfully developed patented, novel flight hardware to image blood cells during spaceflight, allowing crew members to create and stain blood smears, which can then be examined using a mini microscope. The hardware, which could provide significant diagnostic capability during long duration spaceflight, was successfully demonstrated on the International Space Station earlier this year.
- Cardiovascular scientists initiated the Human Research Program funded Flight Thigh Cuff research study, which is the first inflight assessment of thigh cuffs as a possible countermeasure to SANS. The successful implementation of the Thigh Cuff study led to further interest by astronauts to use the cuffs early in their mission to relieve headward fluid shift and ocular symptoms associated with the adaptation to spaceflight. This countermeasure has been recently established for operational use aboard the station.
- Exercise scientists led the Earth-based assessment of the Orion flywheel system in preparation for its inaugural mission on Artemis II. This assessment included exercise hardware lifecycle requirements and multiple parallel objectives related to the system's functionality and acceptability. Early familiarization training was also completed by the Artemis II crew.

Safety and Mission Assurance Directorate

The Safety and Mission Assurance Directorate provides system safety, reliability, and risk analysis for the majority of human spaceflight programs. It also ensures the safety and success of habitation systems by providing safety, reliability, and maintainability assurance in International Space Station mission operations hardware and software sustaining engineering. The directorate administers the institutional safety program to assist management and employees in the prevention of injuries and mishaps, and to ensure excellence in hazardous operations. It does so by promoting and assessing NASA Johnson and White Sands

NASA astronaut Nichole Ayers and JAXA (Japan Aerospace Exploration Agency) astronaut Takuya Onishi attend an International Space Station spacewalk maintenance training session at NASA Johnson Space Center's Space Vehicle Mockup Facility. Credit: NASA

WILLIE LYLES
DIRECTOR



safety programs, while applying/developing engineering and system safety techniques to facilitate safe center systems and operations. The directorate also analyzes hazards to limit or eliminate consequences and investigates events to prevent recurrence. The directorate is responsible for



NASA astronaut and Expedition 71 Flight Engineer Jeanette Epps processes blood and saliva samples aboard the International Space Station's Harmony module. Credit: NASA

NASA astronaut Jonny Kim attends a spacewalk maintenance training at NASA Johnson's Sonny Carter Training Facility. Credit: NASA

safety, reliability, and quality assurance processes and requirements, as well as for NASA Johnson's Knowledge Management and Quality Management Systems Office.

Safety and Mission Assurance provides regular reporting to NASA Johnson organizations and personnel. The organization is preparing to celebrate the 30th anniversary of the Johnson Space Center Close Call system, which was established in 1995. Since its implementation, Johnson injury rates have decreased dramatically. Tracking this information has helped NASA Johnson and White Sands maintain the U.S. Department of Labor's Occupational Safety and Health Administration Voluntary Protection Program Star status - the highest level for exemplary worksites with successful safety and health management systems and low injury and illness rates.



White Sands Test Facility

The White Sands Test Facility is a remote, self-contained, hazardous testing facility managed by Johnson and located near Las Cruces, New Mexico. White Sands' mission is to provide the expertise and infrastructure to test and evaluate spacecraft materials, components, and propulsion systems to enable the safe exploration and use of space. These unique capabilities are used by NASA, other government agencies, and commercial industry.

White Sands has seven core capabilities: rocket propulsion systems testing; hypervelocity impact testing; propellants and aerospace fluids testing and analysis; oxygen systems testing and analysis; flight acceptance standard testing;

Two WSTF employees set up a large-scale flammability test in a testing chamber. Test results assist in the selection and certification of optimal materials for use in space. Credit: NASA



JASON NOBLE
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composite overwrapped pressure vessels testing and analysis; and spaceflight component services. Much of the expert workforce that performs these testing activities lives in the Las Cruces area, with a small percentage commuting from Texas.

The facility plays a key role in conducting the agency's Flight Acceptance Standard Testing and Hypervelocity Impact Testing. The White Sands team tests all materials that will launch on a human spacecraft to ensure they meet or exceed NASA's flammability and toxic off-gas standards. Hypervelocity testing makes it possible to simulate micrometeoroid orbital debris impacts, leading to safer spacecraft designs and a greater understanding of the low Earth orbit environment.

White Sands is playing a major role in returning astronauts to the Moon and continues to push the envelope in the development and innovation of spaceflight.

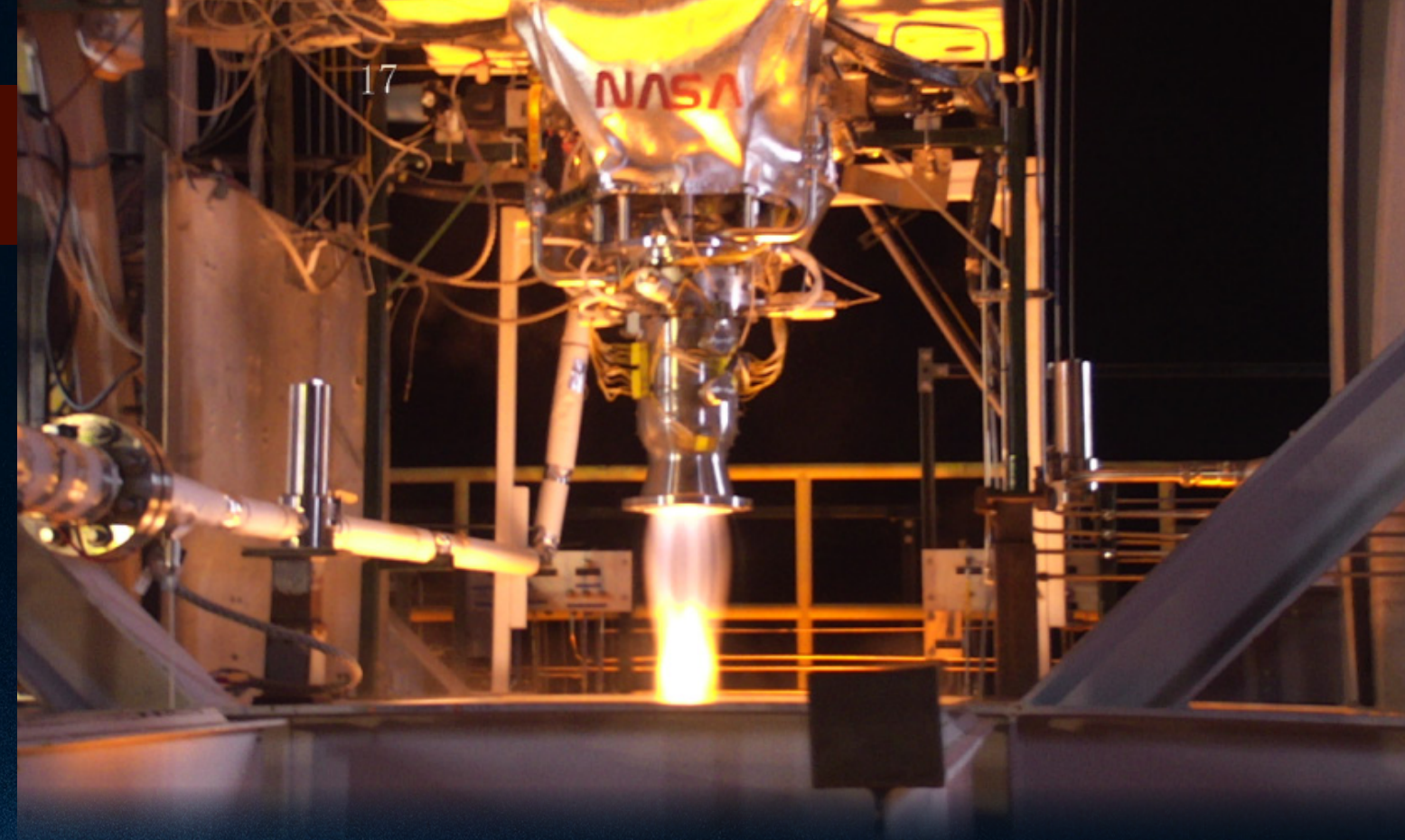
Highlights From 2024

Propulsion Testing

- Successfully hot-fired Reaction Control System thrusters in support of in-flight anomaly analysis for NASA's Boeing Crew Flight Test.
- Completed hot-fire testing for the Orion main engine injector built using additive manufacturing.
- Completed 133 test runs/sequences for the Stellar Nanosat Project.

Materials and Components Laboratory Office

- Collaborated with the NASA Engineering and Safety Center and the Massachusetts Institute of Technology to test SpaceX Commercial Crew Program flight components using various oxygen pressures and temperatures.



The Propulsion Test Office at NASA's White Sands Test Facility conducted a hot fire test of the new Orion Main Engine injector. Credit: NASA

- Performed flammability testing of specialized tape found on the Boeing Starliner and the International Space Station.
- Completed internal and external off-gas testing and analysis of the Orion Crew Survival System suit.
- Fifteen open-air Composite Overwrapped Pressure Vessel burst tests measured overpressure effects for the NASA Office of Safety and Mission Assurance; pressure test of an internal liner for Sierra Space.
- Completed propellant and oxidizer sensor sensitivity testing for the Boeing Commercial Crew Program.
- Conducted 593 hypervelocity impact tests for 24 projects, with customers including the Human Landing System Program, JAXA (Japan Aerospace Exploration Agency), James Webb Space Telescope, and the U.S. Navy.
- Performed hydrogen peroxide (92% pure) exposure tests —at 30-, 45-, 60-, 75-, and 110-day durations—for Sierra Space to determine effects of long-term exposure on materials and components.
- Completed ammonia exposure tests for Pacific Design to determine if degradation of material properties was present.
- Tested hydrazine-resistant rubber immersion for NuSpace to determine if degradation occurred.

- Performed multiple oxidizer and hydrazine sample analyses for Vandenberg Space Force Base to ensure samples were within specifications

Spaceflight Component Services

- Provided Orion service module main engine assembly support:
 - Artemis IV – Refurbishment work and shipment of engine to Johnson.
 - Artemis V – Continued refurbishment work on the Orion main engine, including series valve and pneumatic pack assembly and acceptance tests.
- Completed post hot-fire processing tasks of the Boeing Space Technology Program thrusters.
- Completed refurbishment and acceptance tests of the International Space Station Respiratory Support Pack and shipped the flight article to Johnson; conducted annual acceptance tests of the flight spare unit and repair of a training unit.

Provided component fabrication, processing, and acceptance tests for the International Space Station Contamination Detection Kit; conducted leak tests of the contamination sampler that was recently returned from the station.

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