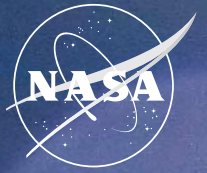


National Aeronautics and
Space Administration



GIANT LEAPS START HERE

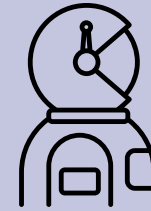
2022 ANNUAL REPORT

NASA's Johnson Space Center

VANESSA WYCHE
DIRECTOR
JOHNSON SPACE CENTER

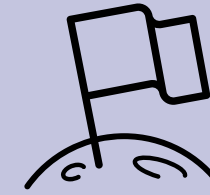


There are five additional aspirations that set the tone for Johnson's future and will enable the team to break the bonds of gravity, set foot on our lunar neighbor once more and build a foundation that will see another 20 years of constant human presence in space. These transformative approaches guide the center 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.



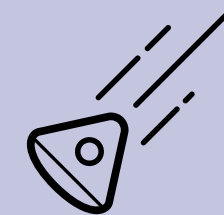
**EXPLORE NEW
DESTINATIONS
NOW**

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.

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.

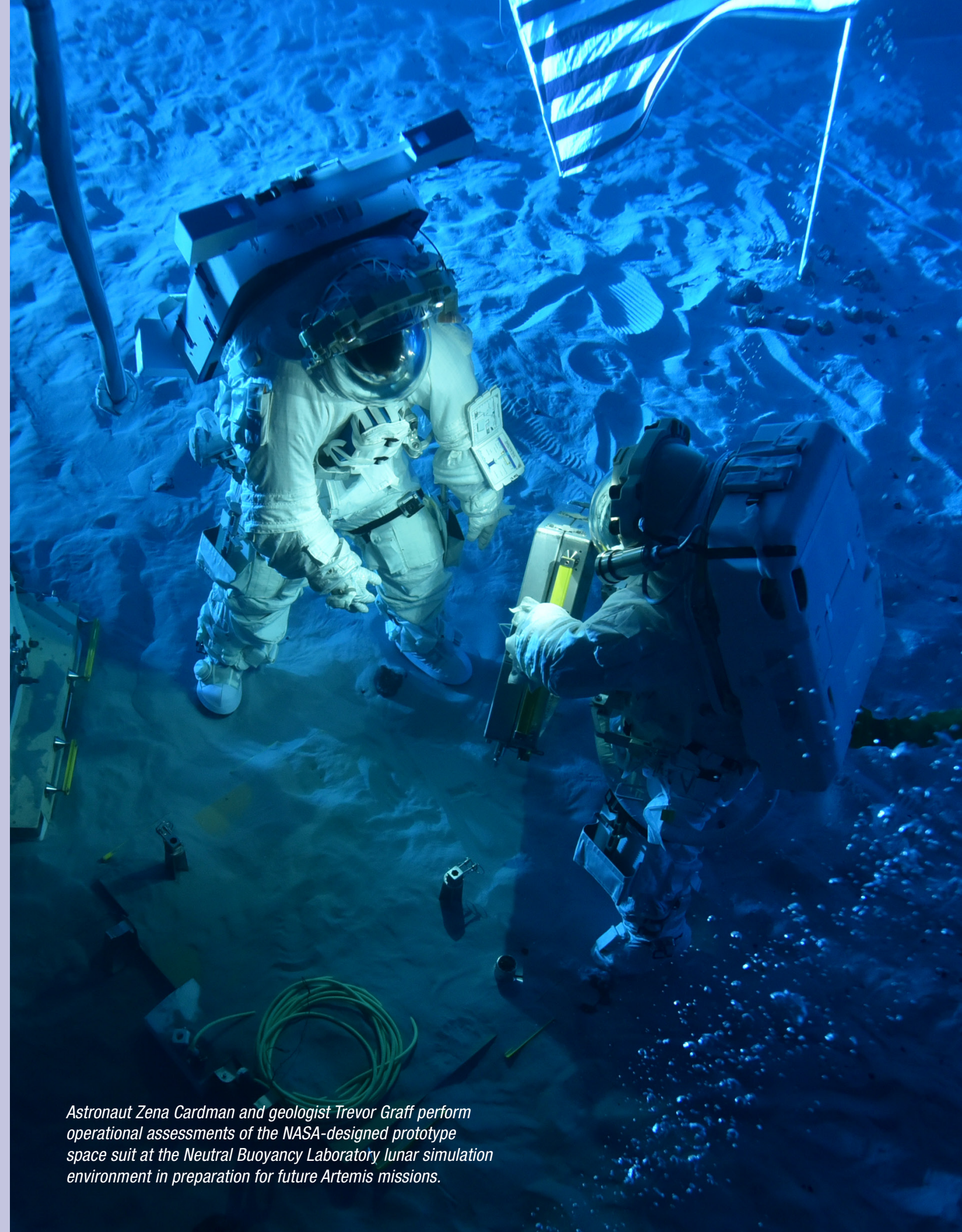
NASA'S Johnson Space Center is the hub of human spaceflight and the iconic setting to some of humankind's greatest achievements. As the home of the nation's astronaut corps, Mission Control Center, International Space Station, Orion, and Gateway programs, Johnson plays a critical role in leading human 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 program. We completed a major milestone toward our goal of landing the first woman and the first person of color on the lunar surface with the launch of Artemis I, an integrated, uncrewed flight test of our Orion spacecraft and Space Launch System rocket. The first launch of astronauts aboard Orion is expected on the Artemis II mission. This will be the next milestone in 2024 paving the way for the first launch of astronauts to the surface of the Moon.

The year 2023 will also see great progress with Gateway, a space station orbiting the Moon that will provide vital support for a sustainable, long-term human return to the lunar surface, as well as a staging point for deep space exploration. Additionally, two companies are expected to deliver payloads to the Moon as part of our Commercial Lunar Payload Services initiative, which enables commercial vendors to quickly land science and technology payloads on the lunar surface.

Johnson is the home of NASA's new Extravehicular Activity and Human Surface Mobility Program (EHP) that is working with industry to develop the next generation of spacesuits and lunar rovers. The new spacesuits are being developed in cooperation with industry partners Axiom Space and Collins Aerospace, and will allow testing of the new designs on the space station and the lunar surface. Under this commercial partnership, the participating companies would be free to rent the vehicles to other companies when not in use by NASA. EHP will manage development of both suits and rovers from the program office located here at Johnson. The new Lunar Terrain Vehicle Services contract will allow moonwalkers to explore the challenging environment of the lunar South Pole. Under this commercial partnership, the participating companies would be free to rent the vehicles to other companies when not in use by NASA. EHP will manage development of both suits and rovers from the program office located here at Johnson.

Also at Johnson, NASA's Health and Human Performance program will begin simulating long-duration missions to Mars in a new habitat built specially to support one-year missions by test subjects here on Earth. Crews of non-astronaut test subjects will live and work in a new 3D-printed Crew Health and Performance Analog (CHAPEA) habitat, simulating the challenges of future human missions on the surface of Mars. These longer simulations will build on a series of Human Exploration Research Analog (HERA) 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 will see a variety of crew and vehicle traffic in the coming months. We plan to celebrate the splashdown of NASA's SpaceX Crew-5 mission, the launch and return of NASA's SpaceX Crew-6, and the launch and return of NASA's Boeing Crew Flight Test mission of Starliner, the first flight of astronauts aboard NASA's second provider of commercially built and owned spacecraft launching from American soil. We also anticipate the launch of NASA's SpaceX Crew-7. In 2024, NASA expects to launch its eighth regular crew rotation mission to the space station on a U.S. crewed launch vehicle. Both SpaceX and Northrop Grumman are set to launch additional supplies and equipment to the space station over the next two years, and a third commercial cargo carrier, Sierra Nevada, will begin its station resupply missions. Following the first private space mission to the space station in 2022, NASA is working with Axiom Space to continue private missions to the station under a formal agreement that is helping NASA nurture a robust commercial low-Earth orbit economy. In Houston, the newest class of astronaut candidates will graduate in 2023 after completing two years of rigorous training, becoming eligible for exciting missions to the space station and potentially the Moon. 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 eventually 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 to greater heights and remote corners of the solar system. I invite you to join us on our missions as we inspire a new generation of explorers to reach greater heights. You are invited to explore NASA Johnson's efforts in 2022 in the pages that follow.



Astronaut Zena Cardman and geologist Trevor Graff perform operational assessments of the NASA-designed prototype space suit at the Neutral Buoyancy Laboratory lunar simulation environment in preparation for future Artemis missions.

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 Texas universities, private companies, and nonprofits, and we are constantly seeking new paths for 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 (MSC) in 1961, on a 1,000-acre site donated by Rice University. MSC 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

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's mission expands in coming decades to accommodate missions to more distant destinations, Texas will continue to provide a perfect home base for training, planning, and command. NASA Johnson is leading the way by providing astronaut training, Mission Control Center operations, the International Space Station program, Human Research, and Commercial Crew leadership, and the center is a primary contributor to the agency's Artemis program with Orion, Gateway, and Exploration Architecture, Integration and Science.

Total JSC Budget	Total JSC Expenditures in Texas	Johnson - White Sands Test Facility Budget
\$5.65B	\$2.69B	\$78M

Johnson Space Center Total Budget by Program

International Space Station Program	\$1.05B
Orion Program	\$1.34B
Human Research Program	\$117M
Commercial Crew Program	\$56.3M
Gateway Program	\$449M
Commercial Cargo Program	\$1.13B
Exploration Operations Program	\$5M
Commercial Low-Earth Orbit Development Program	\$113M
Astromaterials Research and Exploration Science	\$59M
Business Development and Technology Integration Office	\$104.5M

Select NASA Expenditures in Texas

Small Businesses	\$442M	Veteran-Owned Businesses	\$34M
Self-Certified Small Disadvantaged Businesses	\$64M	Non-Profit and University Awards	\$67M
Woman-Owned Businesses	\$105M	Minority-Owned Businesses	\$58M

Our People - NASA's Johnson Space Center Workforce

Total Johnson Workforce

# Federal Employees	2,946
# Contractors	8,843
Total # JSC Workforce	11,789

Total Johnson Workforce in Texas

# Federal Employees	2,896
# Contractors	7,214
Total # in Texas	10,110

White Sands Test Facility Workforce

# Federal Employees	50
# Contractors	350
Total # WSTF Workforce	400

Workforce Representation

Engineer or Scientist	75%	Are Minorities	32%
Perform Science, Technical or Aerospace Work	76%	Are Female	36%
Hold Science, Engineering or Technical Degrees	80%		
Hold at Least a Bachelor's Degree	96%		
Hold a Graduate Degree	45%		

FY22 Education Leadership in Texas

Individual High Schools/Homeschools in Texas	852
Individual High Schools/Homeschools Represented in Texas Aerospace Scholars	334
Texas Cities Represented in Texas Aerospace Scholars	219
Texas Students that Have Participated in Texas Aerospace Scholars Since 1999	15K
Texas Community Colleges Represented in Texas Aerospace Scholars	15
Texas Minority Serving Institution Colleges and Universities in MUREP Initiatives	17

Johnson's Office of STEM Engagement leverages NASA's unique capabilities to advance STEM education, and human space exploration. Students in Texas have a unique opportunity to participate in Texas Aerospace Scholars – encouraging students to explore unlimited career possibilities in science, technology, engineering and mathematics (STEM) with human space exploration as its central theme.

NASA's Minority University Research and Education (MUREP) Project engages under-represented populations through a wide variety of initiatives. Multiyear grants are awarded to assist minority serving institutions' faculty and students conducting research of pertinent missions.

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 not only home to the NASA astronaut corps, but is also the key center for several major NASA programs and organizations. The Johnson community is made up of nearly 11,800 contractors and civil servants who are involved in the day-to-day execution of NASA's missions, research and future programs. Here are some of NASA Johnson's key roles.

International Space Station Program Management Office

Johnson is home to the management and integration of operations associated with the world's most complex multi-national space laboratory. The International Space Station is entering its third and most productive decade as a groundbreaking scientific platform in microgravity. The third decade is one of results, building on our successful global partnership to verify exploration and human research technologies to support deep space exploration, continue to return medical and environmental benefits to humanity, and lay the groundwork for a commercial future in low-Earth orbit.

Commercial Crew Program

In collaboration with Kennedy Space Center and the American aerospace industry, the center 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

A new office was established in 2020 as NASA opened the International Space Station for commercial business, unleashing U.S. industry on the path to a commercial economy in low-Earth orbit. NASA is partnering with industry to achieve this commercial economy. The first private astronaut mission enabled by these partnerships is already in the history books, with many more to follow.

Artemis

The Orion and Gateway Program Offices are housed at Johnson. Along with supporting the Human Landing System Program, the center will lead the way to develop these critical components to the agency's next lunar program.

Orion Program

The Orion spacecraft is the safest, most capable vehicle for deep space travel, and will take astronauts farther in space 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 in orbit around the Moon as a vital component of NASA's Artemis missions. Gateway will host capabilities for sustained exploration and research in deep space, including docking ports for a variety of visiting spacecraft, space for crew to live, work, and prepare for lunar surface missions, and on-board science investigations. Gateway is a critical platform for developing technology and capabilities to support future Mars exploration.

Extravehicular Activity and Human Surface Mobility Program

The overarching goal of the Extravehicular Activity (EVA) and Human Surface Mobility (HSM) Program is to provide safe, reliable, and effective spacewalk and HSM capability that allows astronauts to maximize their exploration potential, while also surviving outside in the harsh Lunar and Martian environments away from the confines of a base camp or spacecraft.

Human Research Program

NASA's Human Research Program conducts research and develops countermeasures for the five 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, and NASA aims to understand and manage those risks through research in ground-based analogs, the International Space Station, and lunar mission studies.

Human Health and Performance Directorate

The Human Health and Performance Directorate (HH&P) is the primary organization focused on enhancing crew health and performance and mitigating the risks associated with human spaceflight. With three offices, three divisions and over 900 employees, all HH&P 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 at NASA's Johnson Space Center touches every program and part of sending humans to space. The people who serve this program work to train astronauts in a variety of facilities on land in spacecraft mockups, underwater in NASA's enormous Neutral Buoyancy Laboratory, and in the air in T-38 jet aircraft. They also plan human missions to space and then direct and implement them from NASA's iconic Mission Control Center.

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

The NASA-unique flight control teams of experienced engineers, medical officers and technicians who 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 are housed at the center in Houston.

Astronaut Selection and Training

An experienced NASA team screens and selects each diverse class of U.S. astronauts to lead our NASA missions and explore our universe. The majority of training for all space explorers from the U.S., 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 Johnson Space Center and is responsible for providing engineering design, development, and test support for crew equipment, numerous flight experiments, and all space flight programs assigned to Johnson, including the space station and advanced spacecraft.

Business Development and Technology Integration Office

Johnson Space Center 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. NASA Johnson's Office of Business Development and Technology Integration 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 predicting risk to spacecraft.

Mars Sample Receiving Project Office

Johnson will house the new Mars Sample Receiving Project office, responsible for receiving and curating the first samples returned from the Red Planet. The project office will recover, contain, transfer, assess safety, curate, and coordinate scientific investigation of the samples collected by NASA's Mars 2020 Perseverance rover, which are expected to arrive on Earth in 2033.

Office of Safety and Mission Assurance

The Safety and Mission Assurance Directorate (SMA) provides system safety, reliability, and risk analysis for the human spaceflight programs. The directorate works with Program Offices to reduce risk by providing technical assessments, analytical services and guidance on SMA requirements throughout the program and project lifecycle.

White Sands Test Facility

The White Sands Test Facility (WSTF) is a remote, self-contained, hazardous testing facility managed by Johnson Space Center, and located near Las Cruces, New Mexico. WSTF supports space exploration operations and research like no other NASA organization, as it has unique and comprehensive testing and analysis capabilities used by NASA, other government agencies, and commercial industry.

Business Development and Technology Integration Office

NICK SKYTLAND

JSC CHIEF TECHNOLOGIST
AND DIRECTOR
BUSINESS DEVELOPMENT
AND TECHNOLOGY
INTEGRATION OFFICE



Johnson Space Center 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. NASA Johnson's Office of Business Development and Technology Integration 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. It is also an incubator for innovative approaches, technology development and technology transfer, providing a front door into NASA's Johnson Space Center for both traditional and new space partners and customers. In these unprecedented times of exploration, the office helps the center, the agency and our partners go further toward the future of human spaceflight.

Partnership Pursuits

Partners with industry and academia using public and private partnerships to create products and services that meet NASA and industry needs, leveraging Technology Programs, Technology Transfer and Space Act Agreements to develop trusted relationships and drive new initiatives.

Strategy and Opportunity Formulation

Helps Johnson go further by turning opportunities into partnerships, actions, and sustainable collaborations, formulating effective partnership agreements and developing strategic capabilities and initiatives.

Technology Transfer

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

Technology Integration

Leads execution of Johnson's technology initiatives and strategy to accelerate the sustainable long-term human exploration and utilization of space, and supports the innovator community with hands-on development opportunities, best practices and use of common resources.

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 solve hard problems.

2022 Accomplishments

- Formed the Business Development & Technology Development Office in July 2022.
- Led the execution of the Johnson technology portfolio and technology solicitations (78 Johnson technology projects totaling just over \$65 million in terms of direct dollars and Full Time Equivalent received by Johnson projects).

- Held 75 exploratory conversations, managed more than 85 relationships and formulated 184 agreements with an average completion time of 84 days.
- Provided critical Government Task Agreement support for Human Launch Systems, Exploration Extravehicular Activity Services, Lunar Terrain Vehicles, and Gateway.
- Executed 81 NASA crowdsourced projects worth \$2.8 million, with an estimated cost savings of \$4.9 million (and 45 other federal agency projects worth \$11.6 million, with savings of \$11.3 million.)
- Completed the NASA Open Innovation Services Contract 2 On-Ramp activity that added 13 new vendors (for a total of 32 crowd vendors/communities, with total membership of over 200 million people), and raised the contract cap value from \$25 million to \$175 million to accommodate forecasted increased utilization.
- Engaged in impactful Small Business Innovation Research (SBIR)/Small Business Technology Transfer outreach to historically underserved communities, including several Alaska universities, the Hispanic Association of Colleges and Universities, and the first SBIR Phase II awarded to a Tribal College and University.



International Space Station Program

The International Space Station has been home to humans in space for more than 20 years. The station is our nation's catalyst for growing an economy in space and is NASA's springboard to the Moon and Mars. It's the largest and most productive laboratory ever to orbit the Earth. The dawn of a new era in space is here as SpaceX's Crew Dragon is now routinely delivering crews to the space station and will soon be joined by Boeing's Starliner.

Space Laboratory

The station is the largest and most-visited spacecraft in the history of spaceflight. It has enabled nearly 3,000 investigations conducted by more than 4,000 researchers from more than 100 countries. It's important to note that the amount of research on board has and will continue to increase as commercial spacecraft carry additional crew to the station. The array of different disciplines represented on the station range from biology and biotechnology to Earth and space science,

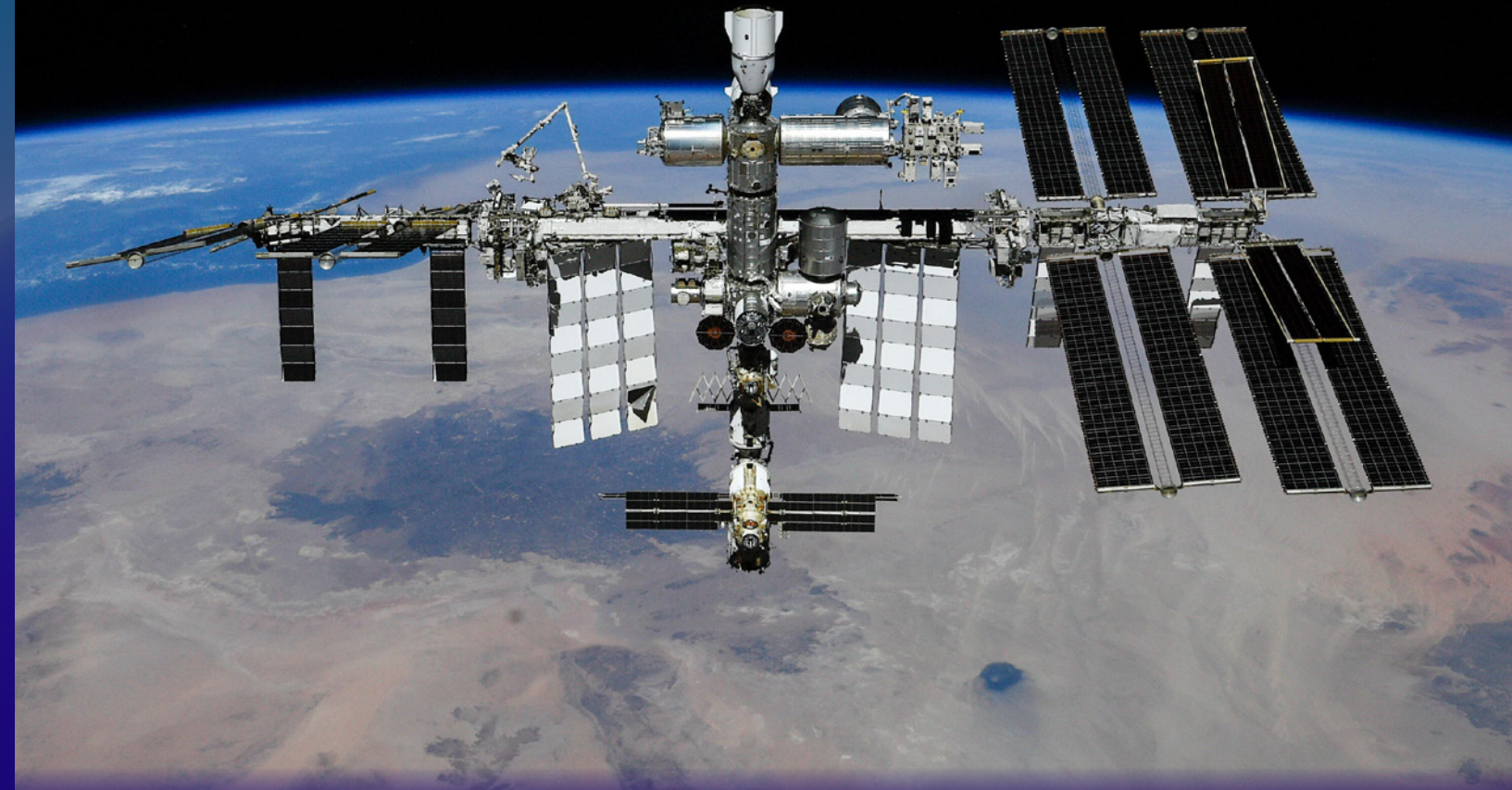
JOEL MONTALBANO
PROGRAM MANAGER
INTERNATIONAL SPACE
STATION PROGRAM



educational activities, human research, physical science, and technology.

Deep Space Exploration

NASA continues to prepare for an expanded presence on the Moon and Mars, and is leveraging the capabilities of the station to make this vision a reality. New technologies and materials run through a gauntlet of trials and tests designed to push them to their limits. Because of the incredible research conducted on this unique platform, our 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. They have designed a space suit that can act as its own mobile life-support system, and much more.

Commercial Space Market

A new market in low-Earth orbit is taking shape, and the station is the destination for this new commercial space race. Companies use the station to carry out new work in research and technology development. New contracts to deliver human and other cargo continue to lay foundations of a future working in space.

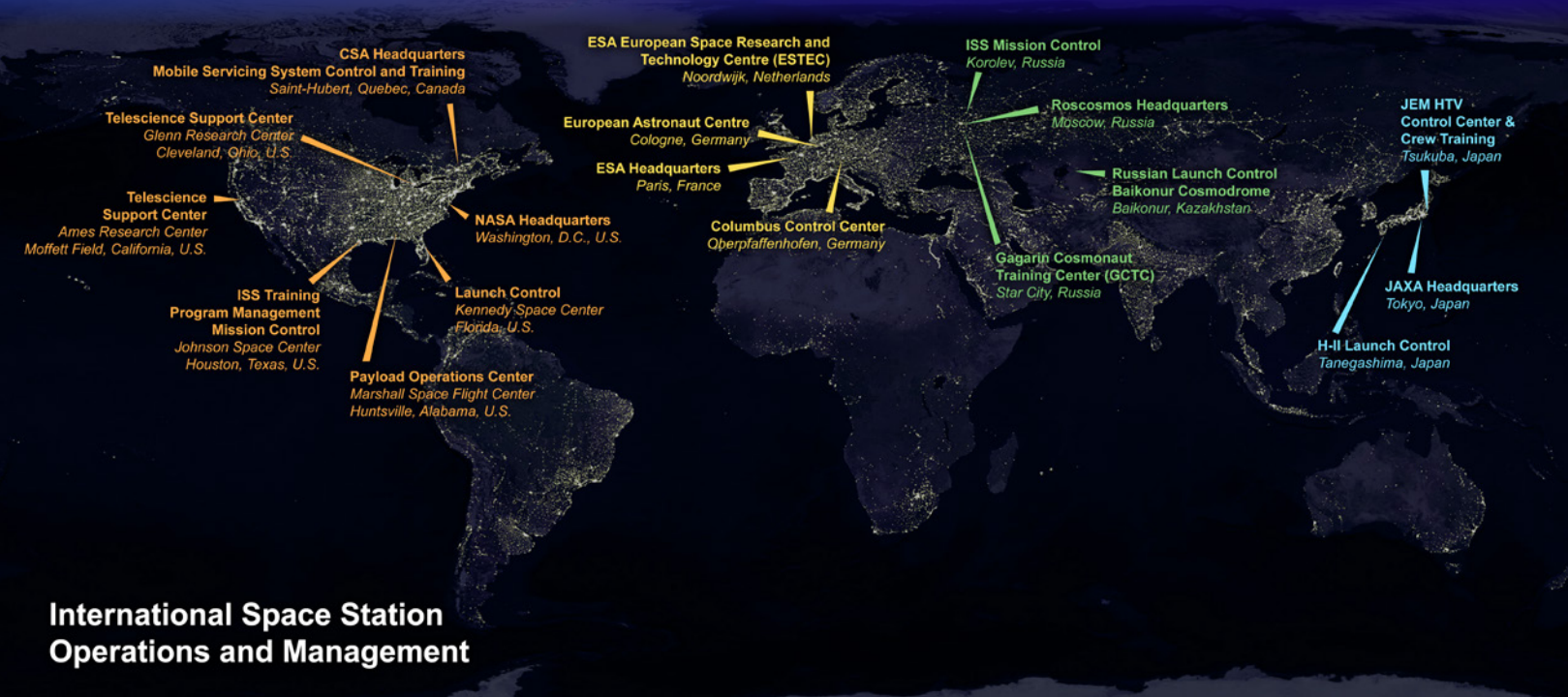
Global Partnership

The space station wasn't built by one nation, and it takes a diverse team to keep the vehicle supplied and in working order. The future of spaceflight is made more sustainable

by this model for global partnership. The shared benefit of this U.S.- led international effort advances shared goals and rewards in space exploration.

Benefits for Humanity

The national lab offers a unique environment to perform research that allows the development not just of pharmaceuticals, but also better product development across a wide range of industries that may not have otherwise realized the benefits of using the space station for research. This research could have profound impacts for life on Earth, while driving the growth of a robust commercial marketplace in space.



Commercial Crew Program

NASA's Commercial Crew Program began launching crews from United States soil in 2020, and is now ensuring a steady supply of astronauts is onboard the space station conducting 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. The station is critical for NASA's continued research into understanding and overcoming the challenges of long-duration spaceflight necessary for human journeys into deep space, including Mars. The Commercial Crew Program represents a revolutionary approach to government and commercial collaborations for the advancement of space exploration.

STEVEN STICH

PROGRAM MANAGER
COMMERCIAL CREW
PROGRAM



Goal

NASA, SpaceX, and Boeing – with the help of contractors throughout America – are achieving historic progress. Men and women at locations across the country have dedicated countless hours to the Commercial Crew Program to achieve a common goal: maintain our nation's ability to launch humans to the International Space Station from U.S. 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 our pursuits in space. Transporting pressurized scientific research and cargo and increasing the station crew enables twice the amount of scientific 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 efforts on building spacecraft and rockets for deep space exploration.

Safety

Crew safety remains NASA's primary responsibility and priority for all human spaceflight programs. Since the beginning of NASA's Commercial Crew Program, safety has been built into the agency's requirements as a direct result of NASA's extensive experience in human spaceflight systems development and operations. 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. Both companies have been put through a rigorous certification program that includes an uncrewed test flight to the space station to demonstrate their ability to safely fly before astronauts climb onboard. These commercial systems are required to meet NASA's safety and performance requirements to be certified to transport NASA and international partner astronauts to the space station.



Commercial Crew's Approach

NASA identified a need for a crew transportation system and a broad set of requirements 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 return safely to Earth. Interested companies are free to design in a way they think is best and are encouraged to apply their most efficient and effective manufacturing and business operating techniques. The companies own and operate their hardware and infrastructure. NASA's engineers and aerospace specialists work closely with the commercial companies, allowing for substantial insight into the development process and offering expertise and available resources. The Commercial Crew Program is the first time this model has been implemented for human-rated spacecraft, enabling NASA to

acquire transportation services on firm fixed-price contracts, 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.

Commercial Crew Astronauts

More than a dozen astronauts from six countries have traveled to the space station onboard a SpaceX Crew Dragon since its first crewed launch in 2020. Two astronauts are training for the 2023 crewed test flight of Boeing's Starliner CST-100, with more already assigned to the long-duration missions that will follow once the spacecraft is fully certified.

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
COMMERCIAL
LOW-EARTH ORBIT
DEVELOPMENT
PROGRAM

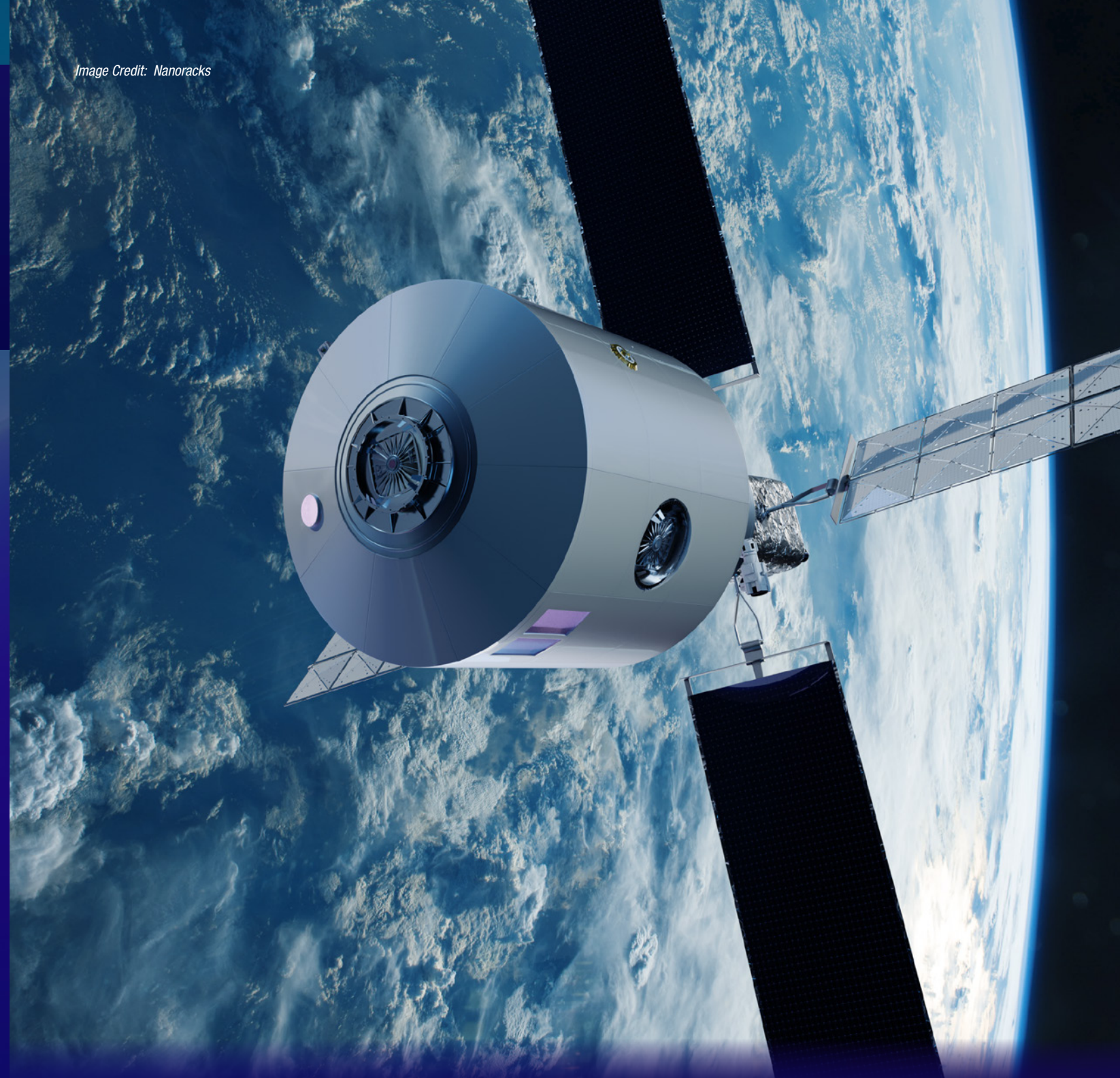


A robust and competitive low-Earth orbit economy is vital to continued progress in space. The United States is committed to encouraging and facilitating the growth of the U.S. commercial space sector that supports U.S. needs, is globally competitive, and advances U.S. leadership in the next generation of new markets and innovation-driven entrepreneurship. NASA has developed a long-term vision to achieve this goal and, one day, NASA will become one of many customers in low-Earth orbit. This plan builds on, uses the capabilities of, and applies the lessons learned from over a decade of work and experience with commercial companies. The Commercial Low-Earth Orbit Development Program Office at Johnson was established in 2020 to

enable NASA's vision of a self-sustaining market in low-Earth orbit. The Program Office's main goal is to support the development of commercially owned and operated low-Earth orbit destinations from which NASA, along with other customers, can purchase services and stimulate the growth of commercial activities in low-Earth orbit to sustain these future commercial destinations. As part of this plan, the Commercial Low-Earth Orbit Development Program, jointly with the International Space Station Program, is enabling industry to expand commercial enterprise in low-Earth orbit by capitalizing on the capabilities of the space station, including purchase of space station resources for commercial purposes; providing an early destination for private astronaut missions; and stimulating demand in manufacturing and production for future commercial low-Earth orbit destinations. Transition of low-Earth orbit operations to the private sector will yield efficiencies in the long term, enabling NASA to shift resources toward deep space exploration.

NASA has made rapid progress in these efforts to build a low-Earth orbit economy. The agency has opened the International Space Station for commercial business, and has offered opportunities for industry to conduct commercial activities aboard. In support of these activities, NASA developed a pricing policy for dedicated commercial and marketing activities aboard the orbiting laboratory. The agency selected Axiom Space to design and develop one or more commercial modules to attach to the station. NASA also selected Blue Origin, Nanoracks, and Northrop Grumman, with their associated commercial partners, to develop designs of space stations and other commercial destinations in low-Earth orbit. NASA and Axiom Space successfully completed the first private astronaut mission to the International Space Station in 2022. Axiom Space was selected for the second private astronaut mission, and the third and fourth missions are expected to be announced by

Image Credit: Nanoracks



the agency in early 2023. NASA also announced awards for in-space manufacturing initiatives, as well as collaboration opportunities between the agency and industry partners.

The extension of International Space Station operations to 2030 will continue to return benefits to the United States and humanity as a whole, while preparing for a successful transition of capabilities to commercially owned and operated low-Earth orbit destinations. NASA has contracted

for one or more commercial modules to be attached to a space station docking port. The agency also awarded Space Act Agreements for design of three free-flying commercial space stations. U.S. industry is developing these commercial destinations to begin operations in the late 2020s for both government and private-sector customers, concurrent with space station operations, to ensure these new capabilities can meet the needs of the U.S. and its partners.



Orion Program

Orion is the safest, most capable 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. This year, NASA set records with Artemis I – the first of several increasingly complex missions to build a sustainable presence on the surface of the Moon and in lunar orbit. Orion successfully flew around the Moon in a distant retrograde orbit to test the systems of the spacecraft, including the European Service Module, in the extreme environment of deep space before flying astronauts on Artemis II. This achievement will demonstrate NASA's commitment and capability to extend human presence to the Moon and eventually to Mars. Early in 2023, Orion's heat shield performance – one of the main objectives of Artemis I – will be assessed after inspection at Kennedy Space Center, where Orion will remain for further evaluation and offloading of several reusable elements. Eventually it will be shipped to the Glenn Research Center's Armstrong Test Facility in Ohio,

HOWARD HU
PROGRAM MANAGER
ORION PROGRAM



for abort-level acoustic vibration and other environmental testing. With a successful Artemis I mission complete, NASA and its lead contractor Lockheed Martin continue to process the Orion spacecraft for Artemis II and build Orion for Artemis III – the mission that will land astronauts on the Moon. Moving from design and development, NASA procured Orion spacecraft for Artemis III through V in 2019, and recently ordered production of spacecraft for Artemis VI through Artemis VIII. By ordering Orion production in groups of three spacecraft, NASA is capitalizing on efficiencies available in the supply chain to improve production, lower costs, and allow for reusability. Orion is a multinational project involving all 50 states of the U.S., plus Washington, D.C.



and Puerto Rico, and 10 European countries. It drives innovation and advanced manufacturing techniques, boosting American manufacturing competitiveness. NASA has provided more than 1,000 data products to commercial partners to help enable the agency's collaborative approach to exploring deep space and low-Earth orbit. We currently have more than 3,500 employees working on Orion across the country. Since the program's inception, more than 2,900 subcontractor and supplier companies nationwide have contributed to Orion. Texas is home to more than 250 of those small and large businesses. NASA's Space Launch System rocket and Orion spacecraft, along with the commercial human landing system and the Gateway in orbit around the Moon, are NASA's backbone for deep space exploration.

Orion Spacecraft Artemis II Progress

At NASA's Kennedy Space Center, engineers are outfitting the Orion crew module and its European Service Module for the Artemis II mission that will carry astronauts around the Moon. Both elements were powered on for the first

time, and technicians have been performing electrical and mechanical work to support a series of functional tests to ensure the spacecraft systems are routing power and operating as designed. All three of Orion's launch abort motors for the Artemis II test flight also are at Kennedy and ready for integration and stacking.

Orion Spacecraft Artemis III Progress

NASA's Super Guppy aircraft flew the heat shield for Artemis III — the mission that will see astronauts landing on the Moon — from Lockheed Martin's facility in Colorado, to Kennedy. In the coming months, technicians will attach blocks of ablative material to the heat shield and install them on the bottom of Orion's crew module. The Artemis III crew module is also undergoing assembly of interior and exterior secondary structures at Kennedy, while the Airbus team is working on the Artemis III European Service Module in Bremen, Germany.

Gateway Program

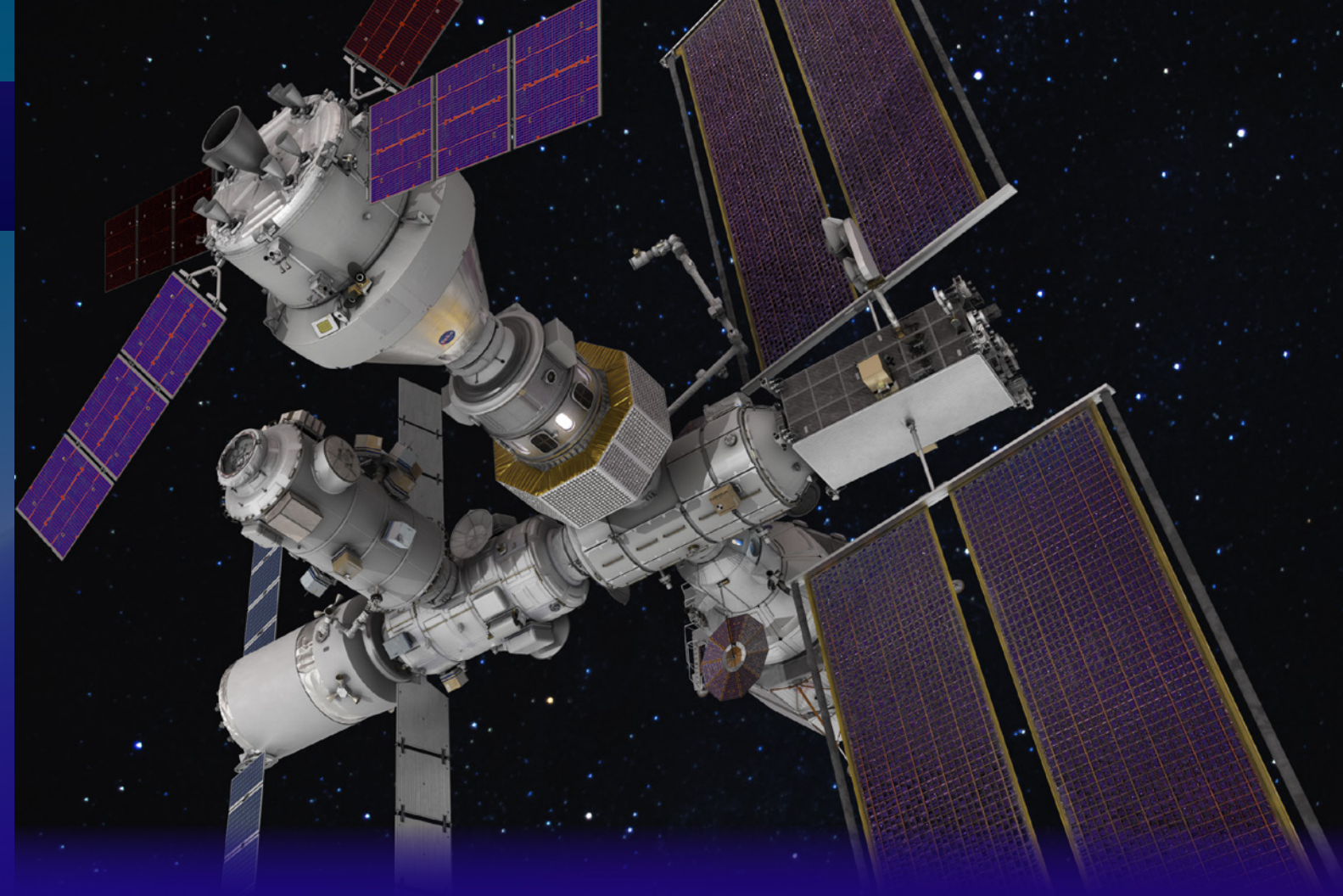
The Gateway Program is the centerpiece of the architecture for a sustained presence at the Moon, with a mission statement of: "Creating the cislunar springboard for cooperative and sustainable human deep space exploration." Gateway will be a human-tended space station in orbit around the Moon and a critical part of the Artemis missions. Gateway symbolizes the expansion of NASA's partnerships into deep space, with international partner contributions, U.S. elements managed at multiple NASA centers, and commercial partners. From the Johnson Space Center, the Gateway Program provides global leadership for our partners. The Program is developing integrated software development and autonomy, labs to support development and flight verification testing, integrated performance analyses and integrated safety, and flight operations from Houston for Gateway's minimum 15-year design life.

Gateway is an incrementally built and deployed spacecraft, which will provide unprecedented access to the Moon and enable sustainable lunar exploration, science, and technology development. Gateway will be instrumental in exploration of the Moon and Mars by providing the first permanent infrastructure at the Moon, which will serve as a staging point for lunar surface activities and build knowledge for deep space exploration to places like Mars. Continuous

DAN HARTMAN
PROGRAM MANAGER
GATEWAY PROGRAM



deep space science and technology investigations onboard will help provide insight into the environments in cislunar space. Gateway's NASA-led components will be provided by commercial partners, enhancing the emerging lunar economy. Maxar Technologies in Westminster, Colorado, is providing Gateway's Power and Propulsion Element (PPE), providing power, maneuvering, attitude control, and communications for Gateway. Northrop Grumman Space of Dulles, Virginia is building the Habitation and Logistics Outpost (HALO), the initial habitation element for crew. NASA has 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. SpaceX will also launch the integrated PPE and HALO to Gateway's unique orbit around the Moon.

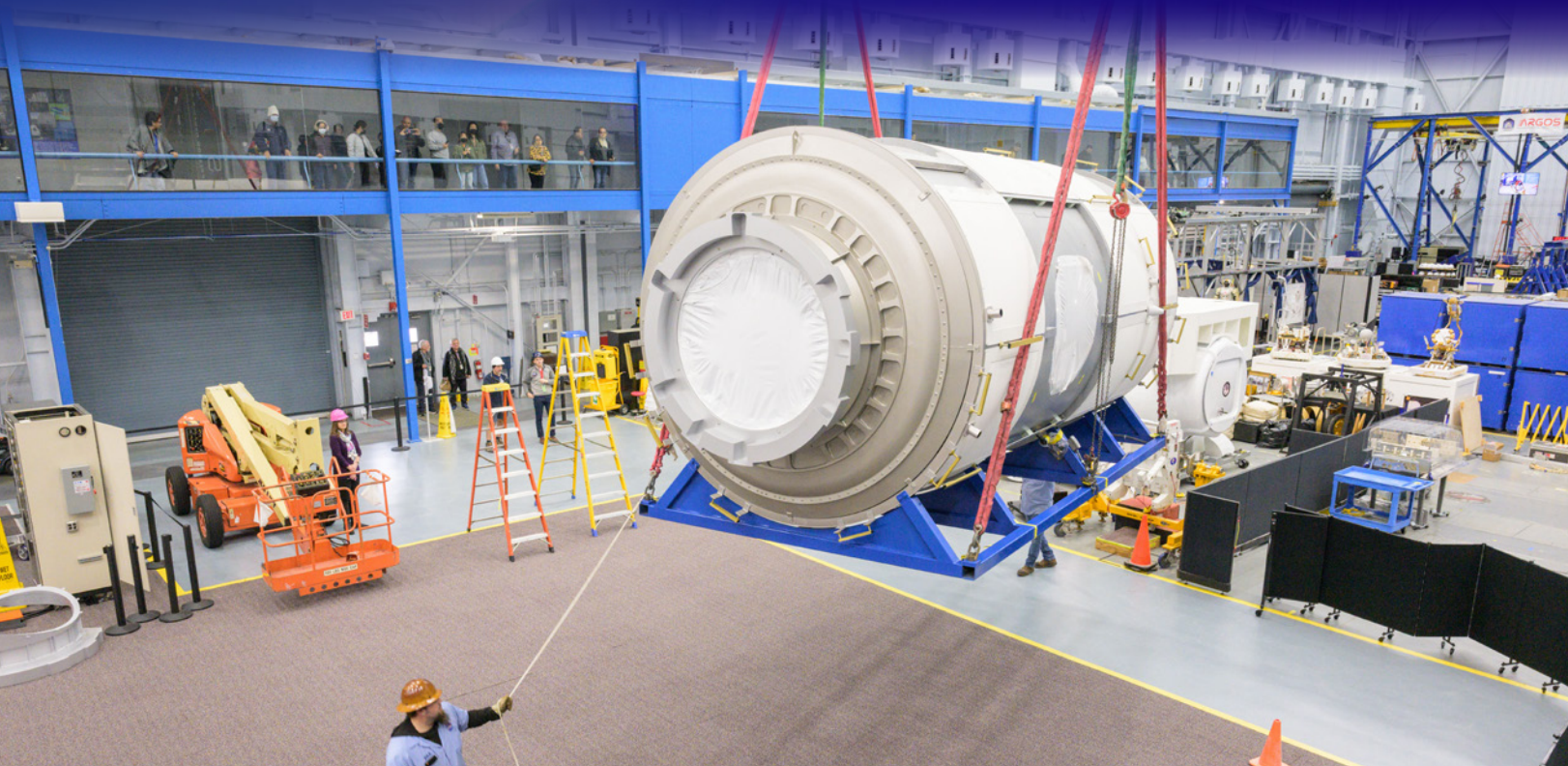


International Partners

The Canadian Space Agency (CSA) will contribute external robotics systems (including a robotic arm), robotic interfaces, and end-to-end robotic operations. ESA (European Space Agency) is providing the International Habitation (I-HAB) module, with contributions from the Japanese Aerospace Exploration Agency (JAXA), I-HAB will provide the heart of Gateway's life-support systems, and additional space for crew to live and work. JAXA will provide I-HAB's environmental control and life-support system, batteries, thermal control, and imagery components. ESA will also provide the European System Providing Refueling, Infrastructure and Telecommunications, or ESPRIT Refueling Module (ERM). ERM will provide refueling, storage, windows, and enhanced lunar communications. These agreements strengthen the broad effort by the U.S. to engage international partners in sustainable lunar exploration as part of the Artemis program, and demonstrate the technologies needed for human missions to Mars. As Gateway's capabilities grow with additional modules, mission durations will increase, creating opportunities for longer stays on and around the Moon.

Milestones

- All major U.S. elements for the integrated Gateway spacecraft are under contract, with flight and ground hardware in development.
- In 2020, the U.S. Government finalized Gateway international agreements with Canada, Europe, and Japan.
- NASA has selected three radiation science payloads as the first scientific investigations to fly aboard the Gateway. The science payloads 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.
- In FY2023, the Gateway Program will proceed to its Key Decision Point I that will mark the Program's transition from formulation to implementation. At the project level, multiple preliminary and critical design reviews will help mature the integrated spacecraft's design and initiate hardware integration and testing.



Extravehicular Activity and Human Surface Mobility Program

LARA KEARNEY
PROGRAM MANAGER
EXTRAVEHICULAR
ACTIVITY AND
HUMAN SURFACE
MOBILITY PROGRAM



The Extravehicular Activity (EVA) and Human Surface Mobility (HSM) Program (EHP) provides safe, reliable, and effective spacewalk and HSM capabilities that allow astronauts to survive and work outside the confines of a base spacecraft. The program is developing the future today by continuing spacewalk advancement on the International Space Station and preparing for the next giant leap by providing crew exploration capability on the Moon and other planets, which involves not only space suits, but also vehicles that will allow astronauts to explore further afield than just their landing sites.

The needs of future missions are becoming clearer as we learn from the Artemis I mission and prepare for future missions. Teams are already working to develop the

infrastructure and industry partnerships needed for the success of exploration in low-Earth orbit, on the Moon, and beyond. EHP will play critical roles in landing the first woman and the first person of color on the surface of the Moon.

Extravehicular Activity (EVA) Support

The International Space Station has been a monumental feat of science and engineering that has been home to humans in space for more than 20 years. The continued expansion of the station is made possible through spacewalks and related service activities. As NASA and

its international partners extend the life of the station until 2030, the necessary upgrades and improvements made through spacewalks will enable the legacy of scientific exploration to continue. As humans explore farther into space than ever before – and on the lunar surface during the Artemis missions, and eventually on Mars – spacewalk capability will enable humans to continue to set foot deeper into the cosmos.

Spacesuits

These individual spacecrafts that humans wear to explore space are vital to our exploration goals. In 2022, NASA embarked on the new Exploration Extravehicular Activity Services (xEVAS) contract, which leverages the innovation of industry to provide the best value to the taxpayer and nurture a healthy commercial space economy. Under xEVAS, industry vendors will develop new spacesuits for use in low-Earth orbit, as well as on the surface of the Moon. These new spacesuits will be provided as a service to NASA and available for other private or commercial entities to utilize.

Lunar Terrain Vehicle

When humans return to the lunar surface during Artemis V, they will be able to venture farther and conduct

more science than ever before with a new Lunar Terrain Vehicle. This unpressurized rover will bring the latest technologies to the forefront for astronaut mobility and remotely commanded vehicles as NASA partners with industry to provide the vehicle for the missions. The Lunar Terrain Vehicle Services contract will spur a new age of commercial interest in the space industry, and leverage industry innovations to benefit NASA's Artemis program.

Pressurized Rover

To establish a long-term presence on the lunar surface, astronauts will use a pressurized rover to extend their exploration and science missions. They will complete spacewalks farther away from base camp and extend their time on the lunar surface. Astronauts will be able to live, sleep, and conduct science freely inside the cabin of the rover, as well as perform spacewalks with the flexibility for missions to last for extended periods of time. NASA is looking at both commercial and international collaboration for development of the pressurized rover, currently targeting a 2030 delivery date for Artemis IIV.



Human Research Program

NASA's Human Research Program, or HRP, conducts research and develops countermeasures for the five 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, and NASA aims to understand and manage those risks through research in ground-based analogs, the International Space Station, and lunar mission studies. HRP pursues methods and technologies to support safe, productive human travel. Through science conducted in these environments, the team scrutinizes how spaceflight affects human bodies and behaviors. Such research drives NASA's quest to innovate ways to keep astronauts healthy and mission-ready as space travel expands to the Moon, Mars, and beyond.

DAVID BAUMANN
DIRECTOR
HUMAN RESEARCH
PROGRAM



Analog

Analog environments are on Earth that mimic spaceflight conditions. HRP uses several ground-based analogs, including :envihab in Germany, Antarctic stations, Nazemnyy Eksperimental'nyy Kompleks (NEK) in Russia, and the NASA Space Radiation Laboratory in Brookhaven, New York.



The Human Exploration Research Analog, or HERA, is housed at Johnson Space Center, and supports roughly four 45-day missions per year. HERA's next campaign will start in late 2023 and include studies from the European Space Agency, and participants from the Mohammed bin Rashid Space Centre in the United Arab Emirates. Ground-based analogs provide a unique way to study the effects of space exploration on humans without leaving Earth. In particular, these missions offer access to a large pool of volunteer participants, along with state-of-the-art equipment that doesn't need to be launched into space.

Partnerships

To protect astronauts as NASA ventures farther into space, HRP works closely with innovative minds all over the country. These experts come from a variety of universities, commercial partners, and other government organizations, along with NASA's international partners. One of those valuable partnerships is the Translational Research Institute for Space Health, or TRISH, a cooperative agreement with a consortium led by Houston-based Baylor College of Medicine. Other members of this consortium include the California Institute of Technology in Pasadena and the Massachusetts Institute of Technology in Cambridge.

Milestones

Scientists from the Space Radiation Element within HRP, which focuses on predicting and managing radiation risks

associated with human spaceflight, joined the White House's Cancer Moonshot initiative this year. These NASA scientists are working with doctors and researchers across the federal government to help cut the nation's cancer death rate by at least 50% over the next 25 years. HRP has contributed to cancer studies over the years, from exploring shielding strategies to protect against space radiation exposure to identifying biomarkers that could serve as early indicators of the disease.

NASA approved the HRP-proposed inflight payload activities planned for inclusion in the Artemis II Mission Definition Baseline. This paves the way for HRP to begin integration work with representatives from Orion and the Exploration Ground Systems programs, to capture potentially groundbreaking data on human responses to spaceflight when crews fly on Artemis II.

A multinational analog crew that included two U.S. members completed an eight-month SIRIUS-21 Mission in July 2022. Data from this spaceflight simulation study will help scientists examine how long-term isolation and confinement affects crew interactions, health, and physiology. The data will also help scientists develop methods and technologies to mitigate and counteract risks associated with isolation and confinement on future extended missions into space.

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 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 U.S. soil. Johnson Engineering continues to enable the Artemis program 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 Lander Systems program. In 2022, Engineering also executed a myriad of essential Government Furnished Equipment projects in support of human spaceflight programs.

These projects include continued spacesuit development through the xEMU project; launch entry suit and crew survival hardware for Orion; critical capabilities in crew systems such as waste management, tools, air monitoring,

JULIE KRAMER-WHITE

DIRECTOR
ENGINEERING
DIRECTORATE



portable fire extinguisher and other emergency systems; unique scientific instruments for measuring reentry environments on Orion; as well as key technology development targeted to reduce risk on future exploration capabilities and systems. Engineering also has partnered with multiple Commercial Lunar Payload Services providers to provide engineering consultation and collaboration, payload development and test support that amplifies their capability. Johnson Engineering is providing expertise to the Lunar Terrain Vehicle project through procurement development and evaluation support, technical insight and oversight roles, and development of a ground test unit. Johnson Engineering supports our programs through collaboration with other NASA centers, many contractors and universities around the country. Bringing these diverse



perspectives and experienced teams together allows us to solve exceptionally difficult problems in innovative ways.

Partnerships

The Engineering Directorate continues to actively pursue external partnerships to augment and support almost all aspects of design, development, test and evaluation (DDT&E) of spacecraft systems, and technology development. Existing partnerships include those with aerospace companies, non-aerospace industries, other government agencies, and academia. Partnerships of note in 2022 include support to Human Lander Systems for advancing key areas of system design and mission design; leveraging spacesuit design expertise and testing capabilities to advance the DDT&E of a new EVA System for both zero gravity and lunar surface use; supporting Commercial Lunar Payload System providers in their efforts to return the U.S. to the surface of the Moon; leveraging advanced avionics development investments into the Gateway Program for the use of Time-Triggered Gigabit Ethernet (TTGbE) systems, which will be the backbone of its command and control network; and university and industry collaborations on materials and techniques for additive manufacturing of heatshields. We are also working with the Houston Innovation Community to expand the Houston

Aerospace Community by enabling small businesses and start-ups through the identification of technology development opportunities. Johnson Engineering continues looking toward the future, and is actively exploring partnerships in lunar mobility, communication and power systems. Johnson Engineering renewed an International Space Act Agreement to continue developing robotic manipulation technologies for not-normally-crewed facilities or spacecraft.

VIPER

Volatiles Investigating Polar Exploration Rover (VIPER) is the first resource-mapping mission on another celestial body. The mission is tasked with prospecting for lunar resources in permanently shadowed areas in the lunar south pole region of the Moon. VIPER will give us surface-level detail of where water is and how much is available for use on the lunar surface. With this close-up view, we can begin to develop water resource maps of the Moon that tell us the best spots to harvest water. The rover hardware is being designed, tested, and integrated with its instruments by the center. Commercial Lunar Payload Services, also managed at Johnson, will oversee VIPER's delivery to the lunar surface through a chosen commercial provider. VIPER has a planned launch date of November 2024.

Exploration Architecture, Integration and Science Directorate

BURT LAWS
DIRECTOR (ACTING)
EXPLORATION
ARCHITECTURE,
INTEGRATION AND
SCIENCE DIRECTORATE



The Exploration Architecture, Integration and Science Directorate (EAIS) 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 us get there. This is the agency'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.

EAIS continues to support Artemis missions through integration across NASA programs and enterprises that are venturing to the Moon and beyond. This includes Gateway,



Orion, the Space Launch System, Commercial Lunar Payload Services, Human Landing System, Extravehicular Activity and Human Surface Mobility, and lunar surface and mission planning, among other initiatives. EAIS 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. EAIS seeks answers to fundamental questions about the origins and dynamics of our solar system, the availability of resources, and opportunities for human habitation beyond Earth.

Astromaterials Research and Exploration Science

The Astromaterials Research and Exploration Science (ARES) Division of EAIS 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. ARES is a key participant in NASA's Artemis program, providing expertise in sample collection and curation, imagery, lunar science research, and lunar surface science mission planning. ARES is also home of the new

Mars Sample Receiving Project office. The team is also the global leader and expert on orbital debris and predicting risk to spacecraft.

Mars Sample Receiving Project Office

Johnson will house the new Mars Sample Receiving Project office, responsible for receiving and curating the first samples returned from the Red Planet. The project office will recover, contain, transfer, assess safety, curate, and coordinate scientific investigation of the samples collected by NASA's Mars 2020 Perseverance rover, which are expected to arrive on Earth in 2033.

Commercial Lunar Payload Services

NASA's Commercial Lunar Payload Services (CLPS) initiative allows rapid acquisition of lunar delivery services from American companies for payloads that advance capabilities for science, exploration or commercial development of the Moon. Through CLPS, NASA is attempting to catalyze a market for lunar delivery services and leverage the entrepreneurial and innovative commercial space industry.



Flight Operations Directorate

The Flight Operations Directorate (FOD) at NASA's Johnson Space Center touches every program and part of sending humans to space. The people who serve this program work to train astronauts in a variety of facilities on land in spacecraft mockups, underwater in NASA's enormous Neutral Buoyancy Laboratory (NBL), and in the air in T-38 jet aircraft.

The mission of the Space Vehicle Mockup Facility (SVMF) is to provide world-class training for spaceflight crews and their support personnel, and high-fidelity hardware for real-time mission support. A major task of the SVMF is to support Engineering and Mission Operations evaluations for the International Space Station, Orion, Gateway and other

NORMAN KNIGHT
DIRECTOR
FLIGHT OPERATIONS
DIRECTORATE



Artemis exploration programs. All mockups and part-task trainers are available to support troubleshooting on the ground any time problems develop on orbit in real time.

The mission of the NBL is to prepare for space missions involving spacewalks. NASA team members use the NBL to develop flight procedures, verify hardware compatibility, train astronauts, and refine spacewalk procedures during flight as necessary to ensure mission success. In addition



to training space station crews for spacewalks to maintain and upgrade the orbital facility, astronauts use the NBL to test prototype spacewalk tools and techniques for future use on the space station, and for exploration missions to the Moon and beyond.

Ellington Field is the heart of Johnson Space Center's flying operations. NASA's primary function at Ellington is training astronauts for spaceflight. The field is also a base for administrative, cargo transport and high-altitude aircraft, with many types of NASA aircraft at the hangers.

FOD also plans human missions to space and then directs and implements them from NASA's iconic Mission Control Center, where teams of flight controllers watch over the International Space Station and its inhabitants around the clock. The center has served as the nerve center for American human spaceflight since June 1965. The concepts of mission control developed in the early years of the space program are still in use today, even as human missions have grown more complex and now include international and commercial partners. Starting with missions lasting only

a few hours or a few days, monitoring of the International Space Station is an ongoing, round-the-clock activity.

This year, Mission Control saw four new flight directors take the helm as the 2021 class graduated and earned their callsigns. Now over 100 people have held the role since NASA's inception, and the number is quickly growing. FOD welcomed seven new flight directors-in-training in 2022. The White Flight Control Room became a pillar in history this year, as flight controllers shared historic moments of the Artemis I mission. They worked hard to learn everything they could about the Orion spacecraft as it reached its record-breaking distance from the Earth for a human-rated spacecraft and returned home once again.

Whether it's involved in a space station mission, or a mission to the Moon, this team holds itself to the highest standard. Vigilance, competence, and teamwork are just a few words used every day within the Flight Operations Directorate as the team carries out its duties in the pursuit of exploration in human spaceflight.

Human Health and Performance Directorate

The Human Health and Performance Directorate (HH&P) is the primary organization focused on enhancing crew health and performance while mitigating the risks associated with human space exploration. With three offices, three divisions, and more than 900 employees, all HH&P functions target optimizing astronaut health and performance throughout all phases of human space exploration.

Partnerships

HH&P engages in partnerships in many capacities through academia, industry, government, and international partners.

- Microbiologists have shared their techniques for handheld DNA sequencing with the Centers for Disease Control (CDC) in a joint approach to microbial monitoring to reduce antimicrobial resistance. Johnson benefits by obtaining CDC expertise toward method design, optimization and insight regarding how antimicrobial resistance evolves in spaceflight. Long-term, Johnson will transfer microbial isolates to the CDC to perform resistance testing on the organisms.

JOHN T. SIMS

DIRECTOR
HUMAN HEALTH
AND PERFORMANCE
DIRECTORATE



- Flight surgeons and scientists teamed with AEXA Aerospace to complete a holo-portation with a physician “visit” aboard the space station. This demonstration showcased how the innovation reconstructed and transmitted a physician in real-time, in a high-quality, 3D model. Results from this technology demonstration may expand Artemis telemedical capabilities.
- Interagency agreements with the U.S. Navy, Army, and Air Force offer mechanisms to augment HH&P capabilities through temporary personnel placements and fellowships, as well as technical exchanges. Military flight surgeons and aerospace physiologists work at Johnson alongside NASA physicians and scientists to gain experience in space life sciences, while sharing their best practices. Similarly, partnerships



with U.S. Army Combat Capabilities Development Command and the U.S. Army Research Institute of Environmental Medicine team with NASA physiologists and biomechanists. They engage in solving common problems regarding soldier and astronaut performance for improving suit design, fit, and metabolic models.

- HH&P collaborated with colleagues at Glenn Research Center on a project involving the Glenn airplane engine aero-acoustic fan technology. This focused on designing highly efficient and quiet fans for spaceflight vehicles, and infusing this technology into NASA’s Exploration Program. A metal spacecraft cabin ventilation fan prototype, suitable for ground testing, was designed, built, and tested at Johnson and Glenn in 2021 and 2022. In response to interest from other aerospace companies, the project released a NASA Technical Report of the fan geometry, computer-aided drawings, and flowlines for infusion into NASA Exploration vehicles.

Milestones

- A team of physicians, flight surgeons, and other medical personnel within HH&P led COVID-19 countermeasures to prevent impacts to astronaut health, training, and mission objectives. This enabled the continuation of human spaceflight throughout the pandemic. These COVID-19 countermeasures continue to evolve, and are being adopted in a post-COVID world to ensure the furtherance of agency goals while protecting NASA personnel.

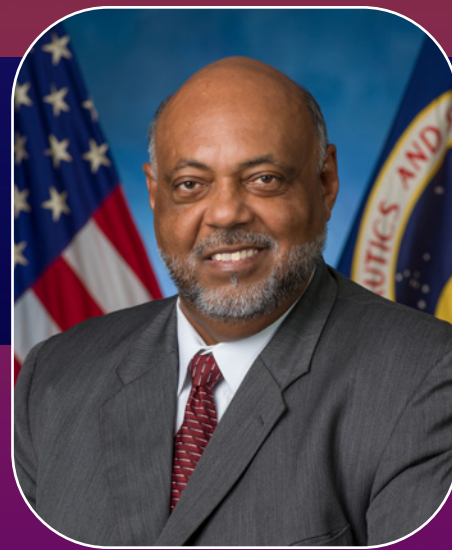
- The HH&P team of physiologists, bioengineers, and physicians worked closely with the Engineering Crew and Thermal Division to test and validate the Exploration Atmosphere Prebreathe Protocols for the Artemis missions to reduce decompression sickness (DCS) risk to acceptable levels. The Artemis Program calls for higher mobility demands on the lunar surface with lunar extravehicular activities, which may significantly increase the DCS risk as compared to microgravity spacewalks. This protocol was assessed in a three-day evaluation, followed by an 11-day test in a 20-foot hypobaric chamber, including six test subjects and two in-chamber doppler technicians. Future work includes an additional 11-day test planned for 2023 to further validate this Prebreathe Protocol.
- Construction of the Crew Health and Performance Exploration Analog (CHAPEA) habitat was completed at Johnson. The 1,700-square-foot, 3D-printed habitat will host four analog crew members for three subsequent, one-year Mars surface simulation missions beginning in summer 2023. The series of analogs will support research and test technologies to resolve potential problems on future human planetary missions. In December 2022, the CHAPEA team conducted a one-week, pre-mission test as a shakedown of the facility, procedures, simulated spacewalks, and operations. This test was critical to the success of the upcoming studies that enable the human exploration missions of tomorrow.



Office of Safety and Mission Assurance

The Safety and Mission Assurance Directorate (SMA) provides system safety, reliability, and risk analysis for the human spaceflight programs. The directorate works with program offices to reduce risk by providing technical assessments, analytical services and guidance on SMA requirements throughout the program and project lifecycle. It also ensures the safety and success of habitation systems by providing safety, reliability, and maintainability assurance in International Space Station mission operations and space station hardware and software sustaining engineering. SMA 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 Johnson and White Sands safety programs, while

WILLIE LYLES
DIRECTOR
OFFICE OF SAFETY AND
MISSION ASSURANCE



applying/developing engineering and system safety techniques to facilitate safe Johnson systems and operations. SMA also analyzes hazards to limit or eliminate consequences and investigates events to prevent recurrence. SMA's mission is also to identify, characterize, mitigate, and communicate risks by implementing an efficient and effective assurance model that is of value to its customers. SMA ensures safety and mission assurance is preeminent in multiple programs at



the center. The directorate is responsible for safety, reliability, and quality assurance processes and requirements. SMA is also responsible for Johnson's Knowledge Management and Quality Management Systems Office.

SMA provides regular reporting to Johnson Space Center organizations and personnel. The organization recently marked the 25th anniversary of the JSC Close Call system, which was established in 1995. Since its implementation, Johnson injury rates have decreased dramatically. Additionally, SMA tracked a dramatic decrease in injury and illness at Johnson in 2020 and 2021, while much of the workforce was teleworking and on-site employee presence was reduced due to the COVID-19 pandemic. SMA continues to ensure that the workforce is informed of safety measures as employees continue to transition back to more on-site work following the extended quarantine.



White Sands Test Facility

The White Sands Test Facility (WSTF) near Las Cruces, New Mexico, is a remote, self-contained, hazardous testing facility managed by Johnson Space Center. WSTF supports space exploration operations and research like no other NASA organization, as it has unique and comprehensive testing and analysis capabilities used by NASA, other government agencies, and commercial industry.

WSTF 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, composite overwrapped pressure vessels testing and analysis, and

JASON NOBLE
SITE MANAGER
WHITE SANDS
TEST FACILITY



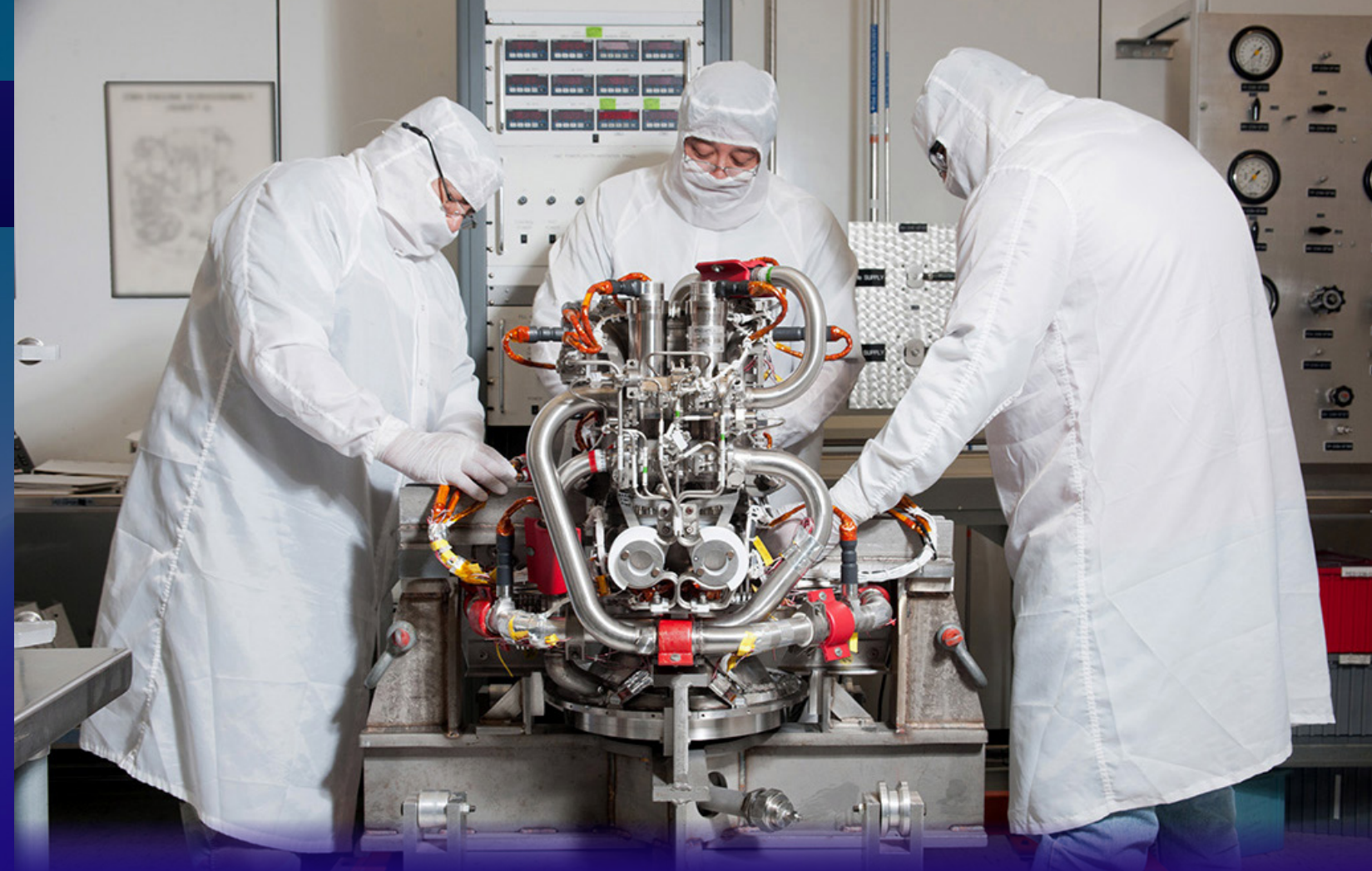
spaceflight component services. Much of the expert workforce that performs these testing activities lives in the Las Cruces area, with a small percentage commuting from Texas. The facility plays a key role conducting the agency's Flight Acceptance Standard Testing (FAST) and Hypervelocity Impact Testing (HVIT). With FAST, the WSTF team tests all materials that will launch on a human spacecraft to ensure they qualify with NASA's flammability and toxic off-gas standards. HVIT makes it possible to simulate micro-meteoroid orbital debris impacts, leading to safer designs and a greater understanding of the low-Earth orbit environment.

The team has leveraged this capability to design robust safety trainings for NASA, other government agencies and commercial providers. This enables others to safely work on research and testing, and unite with NASA to develop new capabilities for human spaceflight and benefits on Earth. WSTF 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 2022

Propulsion Testing

- Successfully hot-fire tested four heritage thrusters for the Boeing Space Technology Program 3, Department of Defense project
- Completed modal testing on the Boeing Service Module 2 for the NASA Commercial Crew Program
- Completed multiple hot-fire tests on TALOS (Thruster for the Advancement of Low-Temperature Operation in Space), including workhorse and development thrusters, and acceptance tested four additional thrusters slated to fly this spring



Materials and Components Laboratory Office

- Extravehicular Activity (EVA) 80 anomaly support
- Qualification and acceptance testing of commercial off-the-shelf valves for International Space Station air resupply
- NanoRack airlock trash bag testing for the International Space Station Program
- Brine processing assembly installation for space station water recycling system
- Polaris Dawn – HVIT for various spacesuit materials
- Ignition and burning risk testing for Dream Chaser isolation valve
- HVIT to support the Mars Sample Return capture, containment, and return system

Spaceflight Component Services

Orion service module main engine assembly support:

- Artemis IV – Completed refurbishment of a valve and pneumatic pack; initiated engine reassembly
- Artemis III – Developed procedure for installing emissivity tape onto engines
- Artemis I – Engine completed at WSTF (around 2016) and shipped to Kennedy Space Center performed exceptionally during Artemis I

International Space Station

- Initiated work to fabricate, qualify, and deliver a Contamination Detection Kit, which determines an approximate concentration of contaminant astronauts may potentially be exposed to during EVAs
- Completed annual acceptance testing of Respiratory Support Packs as a flight spare, in the event of immediate replacement needs during an on-orbit activity

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