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## Front Cover:

The 2022 Strategic Plan cover images reflect the breadth and depth of NASA's efforts in aeronautics and space research, exploration, and discovery. NASA will continue to lead the world in space, in collaboration with the Nation's robust commercial space industry, academic institutions, and international partners. NASA will remain the preeminent authority in space and aeronautics through groundbreaking science and research, returning Americans to the Moon, preparing for Mars, enabling faster, greener aviation, and engaging the public.

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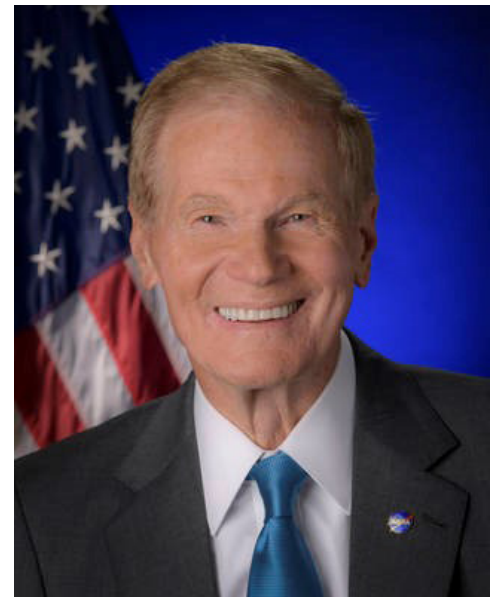
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# Letter from the Administrator

March 28, 2022

It is my pleasure to share NASA's 2022 *Strategic Plan*. This plan underscores the priorities of the Biden-Harris Administration throughout our Agency's activities: strengthening the United States' (U.S.) global leadership in space and aeronautics; tackling the climate crisis; building a sustainable human presence at the Moon and continuing human exploration on towards Mars; spurring innovation that builds back better and creates jobs; leading an alliance of international partners to enhance cooperation in space and stimulate commercial activities in low Earth orbit; and advancing diversity, equity, inclusion and accessibility in a way that inspires present and future generations. NASA's Strategic Plan aligns our priorities and activities around four themes: Discover, Explore, Innovate, and Advance. The Strategic Goals and Objectives that comprise these four themes are designed to work hand in hand with NASA's Vision and Mission.



NASA will build on our leadership in human spaceflight with Artemis, a sustainable exploration program that will land the first woman and person of color on the Moon, develop an outpost in cislunar space, and build the science and technological capabilities needed for missions to Mars—and beyond. Through collaboration with international partners and U.S. industry, NASA will also continue to advance cutting-edge science and technology on the International Space Station (ISS), expanding commercial opportunities and enabling continuation of groundbreaking research conducted in this orbiting laboratory through the rest of this decade until the development of commercial space stations that can support this important work.

NASA will continue to deepen our understanding of Earth, the solar system, and the cosmos through our science missions. We will also move forward with our next-generation Earth System Observatory. The Agency continues to urgently prioritize our understanding of the effects of climate change and conduct critical research to address its effects at home and abroad. We will do this by providing science data that is transparent, inclusive, accessible, and reproducible using open data portals—empowering and connecting the global scientific community through NASA's work in Earth observation and research. This key information will also guide efforts related to disaster mitigation, fighting forest fires, and improving agricultural processes. Further, NASA's work in advanced vehicle technologies, efficient airline operations and sustainable aviation fuels will lead the nation to a sustainable, net-zero carbon emissions aviation future. This Agency will continue to be a world leader in understanding, analyzing, and addressing climate change.

As we push the frontiers of space and aeronautics in close collaboration with the private sector, we will spur new capabilities. For example, faster, safer space transportation; greater access to surface destinations; and new capabilities in space utilities and resource utilization will enable NASA's future space missions, while also fostering growth and job creation in domestic industries. Aeronautics capabilities such as low-impact supersonic flight, as well as safer, cleaner, and faster aviation technologies will revolutionize commercial air transportation by reducing emissions from the aviation sector, improving efficiency and effectiveness for the traveling public, and ensuring that the U.S. remains the global leader in aerospace for decades to come.

As the world's premier Agency in space exploration and research, NASA will prioritize cooperation with the international community, industry, and academia. The continued growth of the Artemis Accords enables us to strengthen our ties with spacefaring allies; establish a set of shared principles for a safe, sustainable future in space; and improve our Nation's standing in the world. NASA will continue to advance

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the goal of space sustainability, encouraging norms of behavior and supporting broad adoption of debris mitigation guidelines, to ensure our current activities in space do not limit the opportunities, resources and activities for future generations operating in space. We will also build on the success of the Commercial Orbital Transportation System, Commercial Cargo, and Commercial Crew programs, catalyzing additional commercial activity in space to expand opportunities in low Earth orbit for both established players and small businesses.

NASA contributes to our Nation's economic competitiveness, fueling growth in American industry and supporting quality, high-paying jobs across the country. The economy of every U.S. state benefits from NASA activities. We work with small businesses, industry, academia, and other government agencies to address our research and engineering challenges, and to transfer out our technologies, capabilities, and data for public benefit.

NASA values our highly skilled, highly dedicated, and diverse workforce, and rely on and are inspired by their efforts toward achieving our Agency's Mission. Year after year, our employees have ranked NASA as the best place to work in the Federal Government among large agencies. NASA has held this ranking through the COVID-19 pandemic by building a culture that is resilient and flexible. We achieved new heights with our missions, such as the James Webb Space Telescope, while more than 80 percent of our workforce teleworked. As we look to the future and reflect on the challenges posed by the pandemic, NASA will take the best components of this experience in charting a new future for the Agency that embraces more flexibility and agility for employees to work without the geographic boundaries of past work models. NASA will be a hybrid work environment that gives our amazing employees the flexibility to provide their best contributions. This Agency continually reinforces a culture in which our employees feel they can be authentic, welcomed, respected, included, and engaged; receive fair, just, and impartial treatment; and can fully and independently access facilities, information, and communication technology, programs, and services. We have emphasized our dedication to these cultural norms by adding "inclusion" to our Core Values. NASA recognizes the need to better represent the diversity of the Nation. We strive to be a champion by surpassing current benchmarks for diversity, equity, inclusion, and accessibility for all, recognizing the continuously evolving demographics of this country. Our approach allows us to foster a culture where the differences and unique backgrounds of our leadership and workforce bolster our ability to develop innovative solutions, which ultimately allows us to better achieve our Mission. This document expands upon our strategy to address these challenges.

NASA inspires young explorers, scientists, and technologists — the Artemis generation — who will lead our Nation's skilled Science, Technology, Engineering, and Mathematics (STEM) workforce. We will grow and engage a dedicated and diverse workforce at all levels of the Agency, with a focus on equity and inclusion throughout our talent strategy. In turn, this will allow for broader perspectives and new innovative ideas, which NASA will utilize to deliver the best possible value across our missions and projects. As NASA has discovered from our hybrid work environment over these recent years, our future will continue to evolve to create more flexibility and agility in how we support the Mission, where we create breakthroughs, and how we use flexibility to increase who can support NASA's missions. We will also focus on increasing the diversity of the innovation community with which NASA engages. Accordingly, we will explore new approaches to broadening participation in NASA opportunities, including participation by underserved communities and individuals.

The *2022 Strategic Plan* reflects NASA's constancy of purpose, while emphasizing the need for transparency, public engagement, and cooperation with industry, academia, international, and other partners. This document advances the policy and priorities set forth by the Biden-Harris Administration, along with direction provided by legislation and appropriations. Following the course charted in the *NASA 2022 Strategic Plan*, we will meet the complex challenges of the future and continue to accomplish the unprecedented, inspiring the world in the process.



Bill Nelson

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# NASA Overview

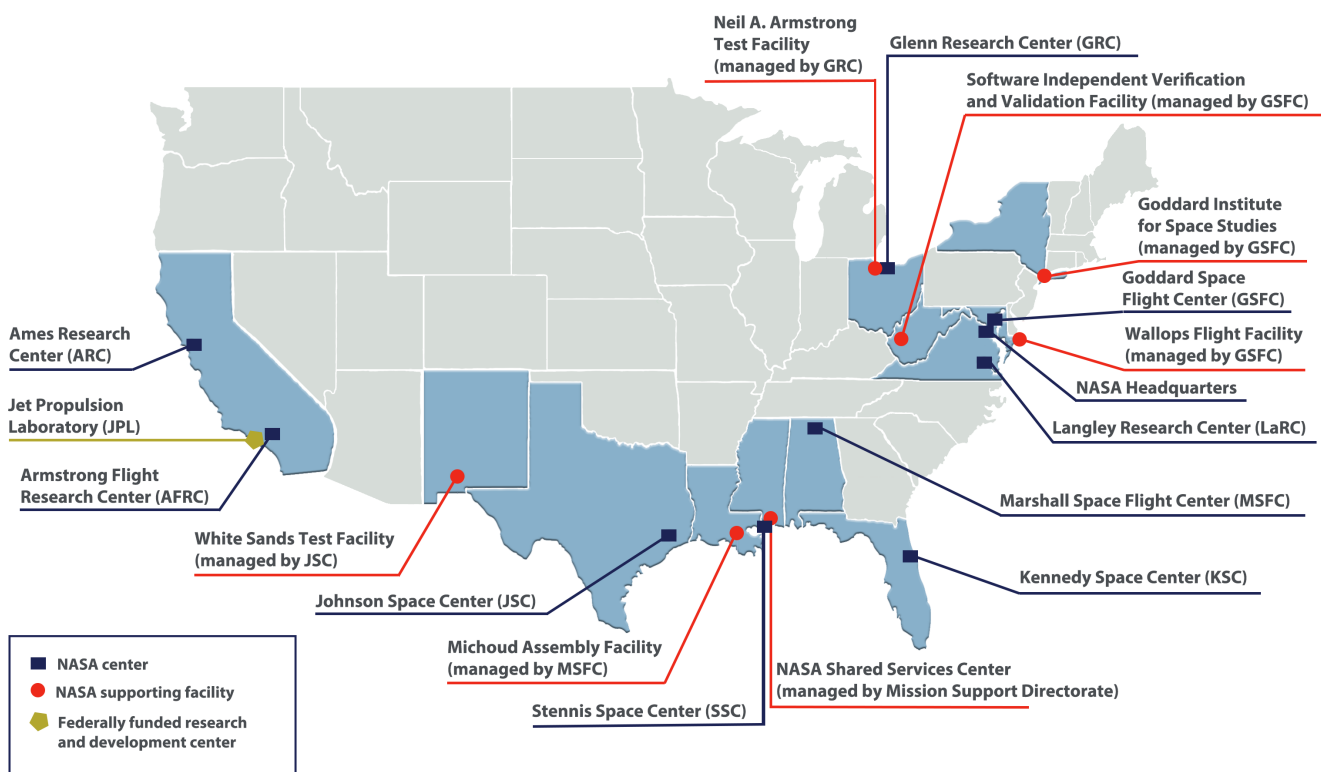
## Strategic Plan Information

NASA produces a strategic plan every four years — in accordance with the Government Performance and Results Act Modernization Act of 2010 (GPRAMA) — to outline our vision for the future and to provide a clear, unified, and long-term direction for NASA's activities. It is available [on NASA's website](#).

## Centers and Facilities Nationwide

The NASA workforce of 17,814<sup>1</sup> civil servants is distributed among its Centers, facilities, and Headquarters, as shown in Figure 1. A contractor workforce supports each location by providing technical and business operations services.

Figure 1: NASA's Centers and Facilities



## NASA's Organizational Structure

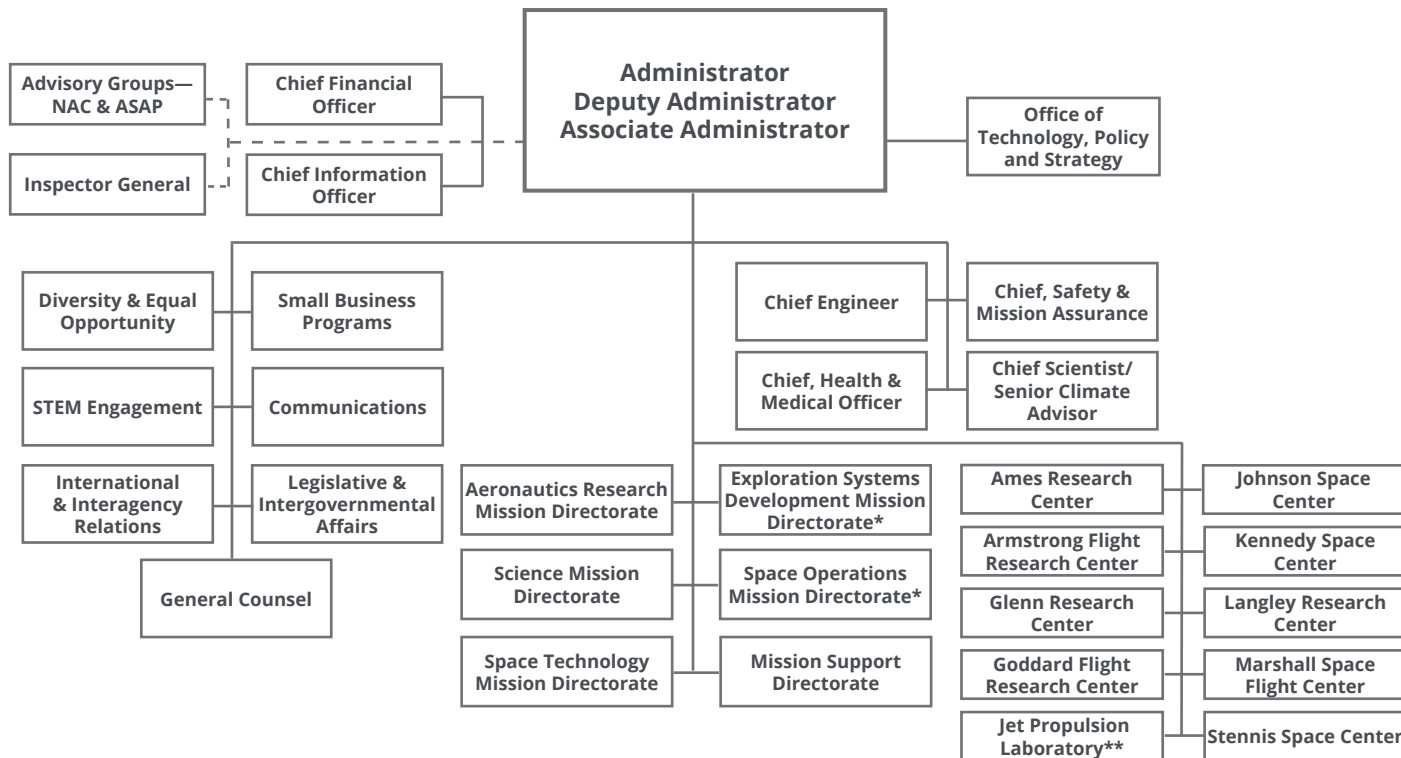
The innovative, responsive, and dynamic nature of NASA's work benefits from our highly leveraged relationships with and between Mission Directorates, Mission Support Offices, and Centers. This organizational model ensures that our leaders can take both a holistic and more narrowly focused approach to programmatic, operational, business, and safety management. The Administrator and senior officials lead NASA by providing top-level strategy, policy, and direction. NASA's Office of the Chief Financial Officer leads the Agency's budget development, execution, and organization-wide performance management activities.

<sup>1</sup> NASA Workforce Profile, Workforce Information Cubes for NASA ([WICN](#)). Last updated February 12, 2022.



Mission Directorates and Mission Support Offices at Headquarters manage decisions on programmatic investments and guide operations of the Centers. Provided below are brief descriptions of NASA's Mission Directorates and select offices (see Figure 2).

**Figure 2. NASA's Organizational Structure**



\*The Human Exploration and Operations Mission Directorate reorganized into two Mission Directorates at the beginning of FY 2022  
 \*\*JPL is a Federally Funded Research and Development Center (FFRDC) managed by the NASA Office of JPL Management and Oversight  
 Dotted lines indicate independent advisory or oversight organizations  
 NASA Advisory Council (NAC)  
 Aerospace Safety Advisory Panel (ASAP)

The [Aeronautics Research Mission Directorate \(ARMD\)](#) conducts research to advance the safety, capacity, and efficiency of the air transportation system, reduce emissions, and sustain U.S. technological leadership in the aviation industry.

The [Space Technology Mission Directorate \(STMD\)](#) invests in transformational technologies that help offset future mission risk, reduce cost, advance capabilities that enable NASA's missions, and support space industry growth and high-quality job creation. STMD identifies and promotes research and technology development, demonstrates applicability, and supports the infusion of these technologies into NASA's exploration and science missions as well as commercial space activities.

The [Science Mission Directorate \(SMD\)](#) conducts scientific exploration enabled by observatories that view Earth from space, observe, and visit other bodies in the solar system, and gaze out into the galaxy and beyond. NASA's science programs focus on three interdisciplinary objectives: discovering the secrets of the universe, searching for life in the solar system and beyond, and safeguarding and improving life on Earth.

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The [Exploration Systems Development Mission Directorate](#) (ESDMD)<sup>2</sup> defines and manages the systems development for programs critical to the Artemis lunar exploration initiatives. ESDMD is responsible for developing the Space Launch System, the Orion spacecraft, and Exploration Ground Systems. ESDMD also is responsible for developing technologies and capabilities to support sustainable human deep space exploration.

The [Space Operations Mission Directorate](#) (SOMD) focuses on launch and space operations, including launch services, space communications and navigation, and eventually, sustaining operations on and around the Moon. SOMD also manages the International Space Station (ISS) and commercial space capability development and on-going operations, such as commercial crew and cargo flights and the program to develop the commercial space stations that will replace the ISS.

The [Mission Support Directorate](#) (MSD) enables the Agency's missions by managing institutional services, capabilities, and critical mission support resources. MSD is actively reducing institutional risk to NASA's current and future missions by improving processes, stimulating efficiency, and providing consistency and uniformity across institutional standards and practices.

NASA's best asset for achieving mission success is a diverse, multidisciplinary, and skilled workforce across all centers and facilities. NASA's approach to performance management is based on the premise that each team member brings unique experience and important expertise to projects. NASA is committed to nurturing an organizational culture in which individuals make full use of their time, talent, and opportunities to pursue the highest standards in engineering, research, operations, and management.

# Achieving our Vision and Mission

NASA inspires the world through exploration and discovery, leading scientific and technological advancements that benefit Americans and all humanity. Our efforts in space help to further the national economy, including through innovative commercial partnerships with American businesses. With the increasing threat of climate change, NASA's efforts to study and understand the Earth are of critical global significance. In addition, NASA's partnerships with academic institutions support a robust Science, Technology, Engineering, and Mathematics (STEM) workforce and promote diversity, equity, and inclusion in the fields of science and technology.

We embrace the challenge of furthering global scientific and technological achievement and expanding the realm of what is possible in aeronautics and space. This challenge is our passion, our purpose, and is reflected in our Vision and Mission.

## Vision

**Exploring the secrets of the universe  
for the benefit of all.**

## Mission

**NASA explores the unknown in air and space,  
innovates for the benefit of humanity,  
and inspires the world through discovery.**

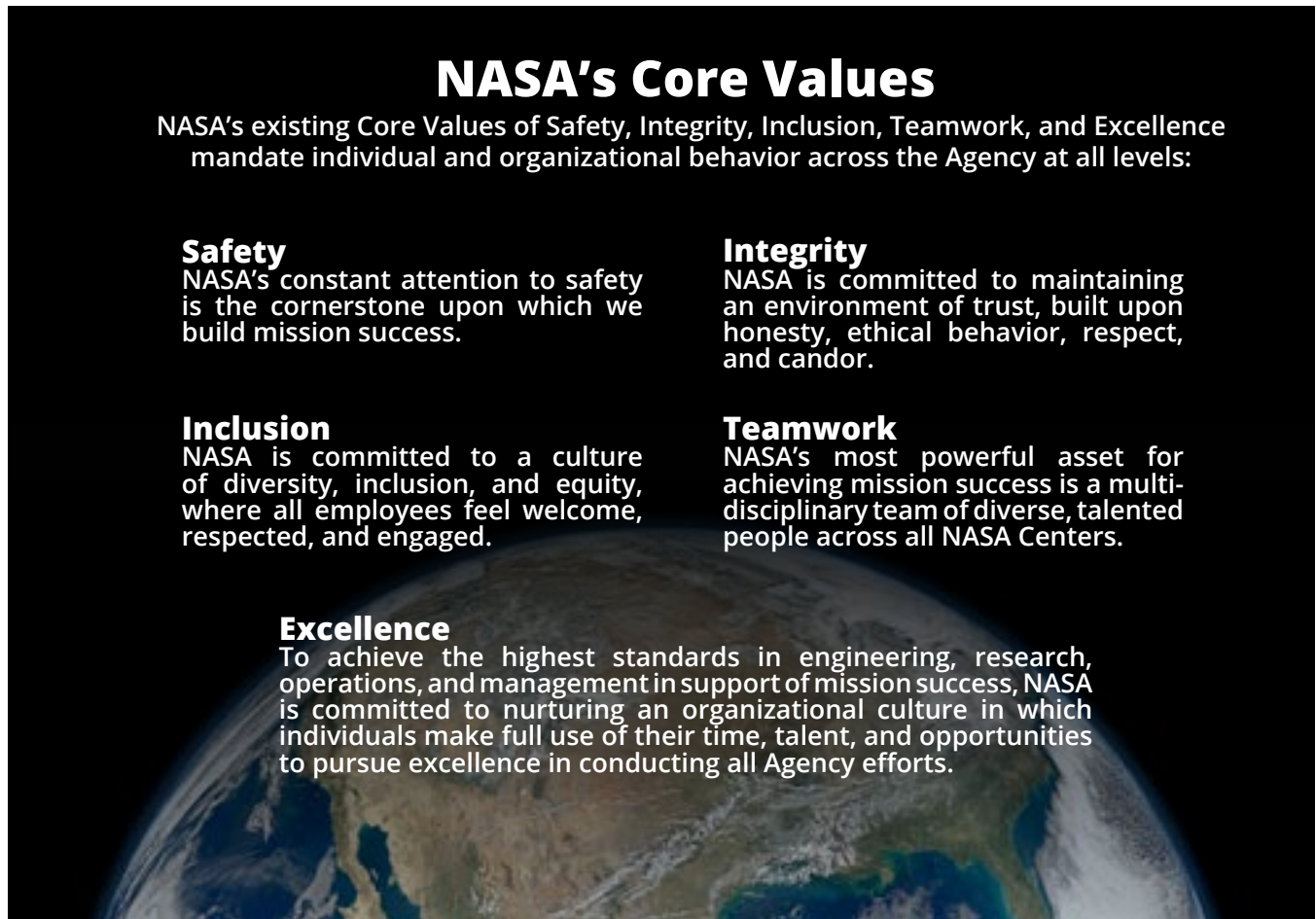
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<sup>2</sup> At the beginning of FY 2022, the Human Exploration and Operations Mission Directorate was divided into the Exploration Systems Development Mission Directorate and the Space Operations Mission Directorate.

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## Core Values

NASA's long-term success will be largely determined by the strategic decisions and investments we make today, as well as constant adherence to our five guiding Core Values, shown below.



### NASA's Core Values

NASA's existing Core Values of Safety, Integrity, Inclusion, Teamwork, and Excellence mandate individual and organizational behavior across the Agency at all levels:

**Safety**  
NASA's constant attention to safety is the cornerstone upon which we build mission success.

**Integrity**  
NASA is committed to maintaining an environment of trust, built upon honesty, ethical behavior, respect, and candor.

**Inclusion**  
NASA is committed to a culture of diversity, inclusion, and equity, where all employees feel welcome, respected, and engaged.

**Teamwork**  
NASA's most powerful asset for achieving mission success is a multi-disciplinary team of diverse, talented people across all NASA Centers.

**Excellence**  
To achieve the highest standards in engineering, research, operations, and management in support of mission success, NASA is committed to nurturing an organizational culture in which individuals make full use of their time, talent, and opportunities to pursue excellence in conducting all Agency efforts.

## Overarching Approach

NASA will lead a new era of space exploration that will advance our understanding of climate change, inspire the Nation and the world, promote equitable opportunities in NASA's engagements, and support the creation of jobs in the growing space economy, increasing the flexibility of the hybrid workplace for NASA employees to provide their best support to the Mission. These changes will give NASA employees more options for how they work and support the NASA Mission. Our Strategic Goals and Objectives are underpinned by Government-wide efforts including:

- Maintaining America's global standing;
- Driving economic growth;
- Addressing climate change; and
- Promoting racial and economic equity.

These national efforts are reflected in numerous Executive Orders (see Appendix E), U.S. National Space Policy, Congressional mandates, and independent advisors such as the National Academies of Sciences, Engineering, and Medicine (also known as the National Academies). Please refer to Appendix C for more information on NASA's strategy development and implementation.

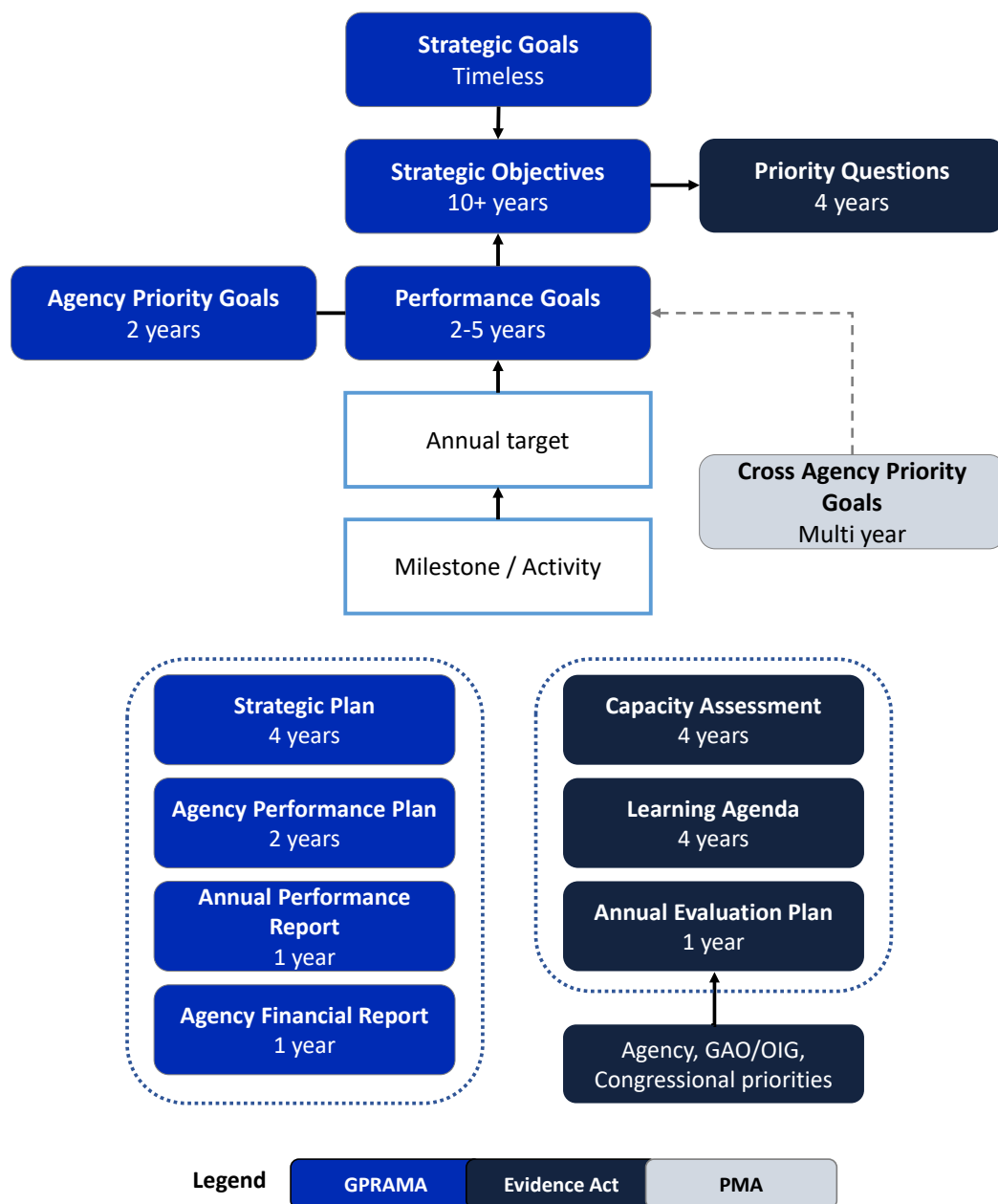
The Strategic Plan also reflects additional space-specific policy guidance as communicated by the U.S. Space Council. The Vice President announced the United States Space Priorities Framework on December 1, 2021. Through this framework, NASA will support a robust U.S. space enterprise while preserving and maintaining

space for future generations, focusing on three key priorities:

- Strengthening STEM education through inspirational missions and collaboration with the academic community;
- Addressing the climate crisis through space-based observation equipment, international partnerships, and data-sharing; and
- Promoting rules and norms that govern space, create stability, and preserve and protect the space environment for the future.

NASA's 2022 *Strategic Plan* defines a framework that consists of Strategic Goals aligned to our Mission; Strategic Objectives describing our strategies for achieving the Strategic Goals; and multiyear, outcome-oriented Performance Goals. Annual targets and milestones allow NASA to measure and track incremental progress towards achieving the Performance Goals.

**Figure 3. NASA's Performance-Evidence Framework**



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Congress signed the [Foundations for Evidence-Based Policymaking Act of 2018](#) (Evidence Act) into law in January of 2019. The Evidence Act establishes a framework for agencies to organize evidence building, data management, and data access functions to ensure an integrated connection to data and evidence. The 2022 *Strategic Plan* includes NASA's first-ever Learning Agenda and Capacity Assessment, which support this new requirement.

The Learning Agenda (Appendix A), Capacity Assessment (Appendix B), and Annual Evaluation Plan demonstrate NASA's commitment to evidence-based decision-making and provide a roadmap for the Agency's learning efforts and capacity-building. These documents align with the Strategic Plan and intend to produce outcomes that tie together the Strategic Objectives and their results. We are committed to maturing the integration of evidence into the performance framework in the early implementation of the Evidence Act and will continue to evolve the Agency's evidence-building capabilities in future products and processes.

- The Learning Agenda is a roadmap for NASA to systematically plan evidence-building activities that will allow the Agency to make evidence-based policy decisions. The Learning Agenda identifies a set of broad questions NASA sees as urgent to moving our operations and Mission forward over the next four years. When answered, these questions will help us work more effectively and efficiently, using evidence to make decisions relating to missions, programs, and investments.
- The Capacity Assessment provides an overview of evidence-building activities across the Agency that are appropriate to achieve NASA's Mission. The Capacity Assessment reviews NASA's ability to conduct evidence-building activities and identifies where resources are needed to develop and improve our capacity. This process supports the Agency's needs for learning and management, performance and strategic management, interagency and private sector coordination, and oversight and accountability.
- The Annual Evaluation Plan identifies evaluations the Agency plans to undertake over the next fiscal year. This plan cultivates data sharing and resources between NASA organizations and provides information to help support our evidence-driven culture. Progress will be reported to NASA's Office of the Chief Financial Officer (OCFO) and OMB, including relevant contributions to the NASA Volume of Integrated Performance and other performance documents.

These plans capture the priorities and capacity of NASA to build evidence that will inform our decision-making, promote transparency, and hold us accountable for developing systematic evidence-building capacity. As part of evidence-building, the Learning Agenda, Capacity Assessment, and Annual Evaluation Plan allow us to further expand our capabilities and integrate our performance, evidence, and data management capabilities that will shepherd evidence-based decision-making.

## Our Strategic Plan

We strive to accomplish our Vision and Mission with the utmost care — recognizing that we are stewards of taxpayer dollars, critical human capital, and one-of-a-kind facilities.

NASA has **identified four Strategic Goals** that will strengthen our ability to accomplish our Mission and contribute to maintaining American leadership in space, aeronautics, climate research, and innovation while driving economic growth in the civil space sector. The Strategic Goals, as well as their corresponding Strategic Objectives, are outlined below and discussed in detail in the following section of this plan.

Four major themes, each characterized by a single word, reflect the focus of NASA's four Strategic Goals:

- **DISCOVER** references NASA's enduring purpose of scientific discovery
- **EXPLORE** references NASA's push to expand the boundaries of human presence in space
- **INNOVATE** references NASA's broad mandate to promote the technologies of tomorrow
- **ADVANCE** references the capabilities, workforce, and facilities that allow NASA to achieve our Mission

## Strategic Goals and Strategic Objectives

Theme	Goal Statement	Objective Statement
<b>Discover</b>	Expand human knowledge through new scientific discoveries	1.1: Understand the Earth system and its climate
		1.2: Understand the Sun, solar system, and universe
		1.3: Ensure NASA's science data are accessible to all and produce practical benefits to society
<b>Explore</b>	Extend human presence to the Moon and on towards Mars for sustainable long-term exploration, development, and utilization	2.1: Explore the surface of the Moon and deep space
		2.2: Develop a human spaceflight economy enabled by a commercial market
		2.3: Develop capabilities and perform research to safeguard explorers
		2.4: Enhance space access and services
<b>Innovate</b>	Catalyze economic growth and drive innovation to address national challenges	3.1: Innovate and advance transformational space technologies
		3.2: Drive efficient and sustainable aviation
<b>Advance</b>	Enhance capabilities and operations to catalyze current and future mission success	4.1: Attract and develop a talented and diverse workforce
		4.2: Transform mission support capabilities for the next era of aerospace
		4.3: Build the next generation of explorers



NASA's Aqua satellite captured this true-color image in September 2020, showing the fires in the West, the smoke from those fires drifting over the country, several hurricanes converging from different angles, and Hurricane Sally making landfall. Image Credit: NASA Worldview, Earth Observing System Data and Information System.

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# STRATEGIC GOAL 1

## EXPAND HUMAN KNOWLEDGE THROUGH NEW SCIENTIFIC DISCOVERIES.

### **Goal Statement**

NASA's enduring purpose is scientific discovery and exploration for the benefit of the United States and all of humanity. NASA seeks to discover the secrets of the universe, search for life elsewhere, and protect and improve life on Earth and in space. Finding answers to these profound science questions requires support for national priorities in science and exploration, enhancing new opportunities for cross-disciplinary science, and expanding the societal benefits of our science programs. It also requires continued progress on the scientific priorities, including those identified by the National Academies of Sciences, Engineering, and Medicine through their decadal surveys.

We will extend our 60-year history of scientific achievements, make groundbreaking discoveries, and transform knowledge of humanity, our home planet, the solar system, and the universe. NASA's missions have not only changed what we know, but also how we think as a society—truly civilization-scale science. NASA's missions and sponsored research provide access to the farthest reaches of space and time and deliver essential information about our home planet, directly improving life here on Earth.

We are undertaking new work that builds on our past successes in individual disciplines to enable a more collaborative environment at the forefront of science and science applications. We are applying those lessons learned and best practices in support of other national needs, including climate change, space weather prediction, and planetary defense. We embrace and thrive on this iterative process that is supportive of evolving national and user needs.

NASA has an open data policy that makes its science data available to all. Current data systems are focused on disseminating data to the science community to support research in five science disciplines: Earth Science, Astrophysics, Planetary Science, Heliophysics, and Biological and Physical Sciences. We plan to undertake investments and initiatives that will make our data more accessible and accelerate its use by the science community. In Earth Science, we are exploring new ways to work with the social science community to integrate NASA data and information with socioeconomic and other kinds of data to provide insights on environmental challenges that disproportionately impact communities of color.

Finally, NASA acts as a global champion of free and open access to scientific data. We collaborate with our partners in a spirit of global engagement and science diplomacy. As more nations seek to use space for scientific investigation, the body of knowledge grows for the benefit of all.

### **Maintaining America's Global Standing**

The activities undertaken within Strategic Goal 1 directly leverage existing and emerging international and domestic partnerships to maintain and expand U.S. leadership in Earth and space science, advancing America's global standing in science and innovation. With over 400 active international partnerships, NASA Science missions are a valuable tool for projecting soft power and for global engagement. In addition to those mission-related agreements,

NASA's Global Learning and Observations to benefit the Environment (GLOBE) program and Aerosol Robotic Network programs have a presence in over 100 countries.

These existing NASA partnerships offer an excellent foundation for strengthening and expanding alliances across the world, continuing to model the importance of open and transparent science that benefits all. Further, NASA's continuing leadership in open data and open science serves to champion free and open access to scientific data so that the body of knowledge grows for the benefit of all humankind. NASA also supports and leads international diplomatic efforts in developing global norms of behavior to ensure a safe, secure, and sustainable space environment.

### **Driving Economic Growth**

NASA-funded research, contracts, and Small Business Innovative Research initiatives provide economic benefits across the United States. Likewise, addressing climate change and enabling climate forecasting will contribute to economic growth across the United States.<sup>1</sup>

### **Addressing Climate Change**

NASA's Earth science activities are focused on increasing our understanding of the Earth and its changing climate. NASA's ability to view Earth from the unique vantage point of space provides a broad and integrated set of uniformly high-quality data covering all parts of the planet. These data help inform decision makers across all levels of Government—as well as industry, disaster prevention and response, and agriculture—to make policy and operational decisions to address climate change.

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<sup>1</sup> <https://openknowledge.worldbank.org/handle/10986/35178>



# Strategic Objective 1.1

## Understand the Earth system and its climate.

Integrate and advance knowledge of Earth as a system to meet the challenges of environmental change, strengthen our Nation, and improve life for all people.

### Lead Office

Science Mission Directorate (SMD)

### Objective Overview

Earth's changing environment impacts every aspect of life on our planet and has profound implications on society and our Nation's well-being. Studying Earth as an integrated, complex system is essential to understanding the causes and consequences of climate change and other global environmental concerns. Based on the increasing body of Earth observation data and corresponding research, we know now that our planet and its climate are profoundly changing. While much remains to be understood about the natural and human-induced processes and the complex coupling at the heart of these changes, one thing is clear: NASA's measurements are critical to their understanding.

Climate adaptation and mitigation efforts cannot succeed without these robust climate observations and research. As the impacts of global climate change become more numerous and acute, the demand for accurate, timely, and actionable

knowledge about the Earth system is more pressing than ever. NASA is a world leader in the production of data necessary to understand, model, monitor, and ultimately predict climate and environmental change. NASA is the only organization in the world with an integrated end-to-end program in Earth-observing mission development, launch, operations, technology, research, data systems, and applications.

NASA's measurements and predictive models provide information for decision makers and organizations that work with communities affected by the impacts of changing climate, including information regarding the efficacy of policies and decisions that help the United States and others adapt and thrive on our changing planet. NASA also works with international partner satellites; data from airborne, ship-based, and ground network instrumentation; and outputs from operational weather models from National Oceanic and Atmospheric Administration (NOAA) and other meteorological agencies. NASA integrates and harnesses these disparate data sources, enabling scientists to investigate and solve large questions

Below: Inside the Integrated Processing Facility at Vandenberg Space Force Base in California, United Launch Alliance (ULA) technicians prepare to remove the contamination barrier and access door from the two ULA Atlas V rocket payload fairings for the joint NASA-U.S. Geological Survey Landsat 9 satellite on June 24, 2021. Image credit: NASA/Randy Beaudoin



that cannot be addressed using data from only a single mission or spaceborne instrument.

NASA Earth Science projects explore our rapidly changing world, where natural and human factors interact, following an interdisciplinary, Earth systems approach that examines the interplay among the atmospheric, ocean, land, and ice systems. Using the recommendations of the National Academies' 2017-2027 decadal survey for Earth science and applications from Space<sup>1</sup> as a compass, and informed by Government-wide priorities, NASA Earth Science is developing the observing systems that will answer the most important science and application questions of the next decade across the following focus areas:

- Atmospheric Composition
- Weather and Atmospheric Dynamics
- Climate Variability and Change
- Water and Energy Cycle
- Carbon Cycle and Ecosystems
- Earth Surface and interior

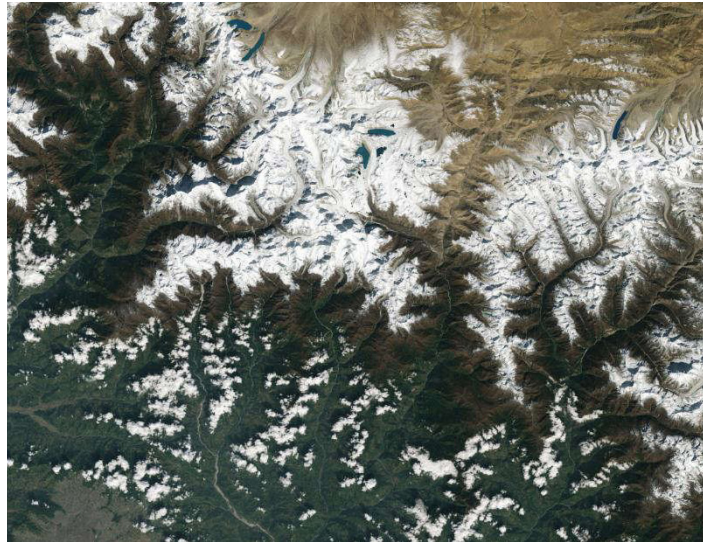
Implementation is achieved through a balanced portfolio of programs as articulated in the SMD's Science Strategy<sup>2</sup>, and engages various commercial, interagency, and international partnerships.

### Objective Strategy

NASA's Earth science activities utilize observations from the vantage points of space, air, and in-situ to advance our scientific understanding of the Earth in service to the United States and the world. We lead the world in the production of data necessary to understand, model, monitor, and ultimately predict climate change, and we are expanding our efforts in the years ahead. In May 2021, NASA announced the implementation of the Earth System Observatory in response to the 2017-2027 Decadal Survey, consisting of a new set of Earth-focused missions to provide key information to understand the Earth's systems and processes, as well as interactions between the processes on the land, ocean, and in the atmosphere. We use our understanding of natural processes and their interactions to provide objective information on changes happening now, as well as estimates of how our environment might evolve in the future.

<sup>1</sup> *Thriving on Our Changing Planet: A Decadal Survey for Earth Observation from Space*, National Academies of Science, Engineering, and Medicine, Space Studies Board (2018)

<sup>2</sup> *Science 2020-2024: A Vision for Scientific Excellence*, NASA Science Mission Directorate (2020)



Recently received Landsat 9 photos provide a preview of how the mission will help people manage vital natural resources and understand the impacts of climate change on the Earth's landscapes and coastlines, adding to Landsat's unparalleled data record that spans nearly 50 years of space-based Earth observation.

Our pursuit of answers to fundamental science questions about the Earth system benefits humanity in many ways. NASA's unique ability to view Earth from the perspective of space allows for the collection of broad, high-quality data from all parts of the planet. Only from space can we make the observations of the complex Earth system that can illuminate connections between short and long time scales, fine and global spatial scales, and chemical, physical, and biological processes. NASA shares this unique knowledge and data freely and openly with the global community, including members of the Government, commercial, and academic communities. For example, in the agriculture sector alone, NASA's Earth science observations have proven helpful with crop area estimates, productivity assessments, and yield models across a range of time scales, water planning, and irrigation management. Likewise, NASA observations and models serve many other economic sectors and industries, disaster management, and community planning.

To complete innovative Earth science missions, NASA will effectively manage a diverse portfolio while balancing innovation with successful program execution. Specifically, NASA will:

- Measure mission success against clearly written top-level measurement requirements;
- Develop objective criteria to enable

unequivocal measurement of success or failure in meeting each requirement;

- Establish a budget for each new mission that funds the mission’s complete lifecycle cost, based on detailed engineering studies and independent cost estimates;
- Obtain tactical-level community advice on portfolio adjustments via the NASA Advisory Council, Science Committee, and the science advisory committees; and
- Implement effective partnerships—commercial, international, interagency, academic, and others—that leverage NASA resources and extend scientific results.

As an example, NASA’s [Commercial Smallsat Data Acquisition \(CSDA\)](#) program evaluates and procures data from commercial vendors that complement NASA’s measurements and help advance NASA’s Earth science research and applications activities.

NASA’s commitment to equity is based on the understanding that the use of NASA data, products, and personnel can and should inform the just treatment and meaningful involvement of all people—regardless of race, color, national origin, income, or ability—with respect to development, implementation, and evaluation of programs, practices, and activities that affect human health and the environment.

## How NASA Engages and Works with Partners

NASA improves national capabilities to predict climate, weather, and natural hazards, to manage resources, and to develop environmental policy by leveraging our partnerships with other agencies that maintain forecast and decision support systems, such as NOAA, USGS and EPA. Most notably, NASA develops, builds, tests, and launches weather satellites that are operated by NOAA, as well as Earth observation satellites operated by USGS.

NASA also works with our international partners to jointly develop or coordinate our Earth observation activities. NASA and the European Space Agency (ESA) have a long and successful history working together to understand our changing planet. For example, in 2020, NASA, NOAA, and our European partners, launched the Sentinel-6 Michael Freilich satellite, which is collecting the most accurate data yet on global sea level rise. The mission also measures atmospheric temperature and humidity that will help improve climate models and weather forecasts.

Most recently, NASA and ESA have formed a first-of-its-kind strategic partnership to observe Earth and its changing environment. Recognizing that climate change is an urgent global challenge, the timing is right for NASA and ESA, as partners in space, to join forces to lead and support a global response to climate change. The partnership is an effort to help address and mitigate climate change through monitoring Earth with combined efforts of both agencies in Earth science observations, research, and applications. This partnership was formalized through a joint statement of intent, signed in July 2021, which outlines how the agencies will collaborate to ensure continuity of Earth observations; advance understanding of the Earth system, climate change and application of that knowledge; and collaborate on an open data policy that promotes open sharing of data, information, and knowledge within the scientific community and the wider public.

## Contributing Programs and/or Program Activities for Strategic Objectives

Earth Science Research; Earth Science Technology; Earth System Explorers; Earth System Science Pathfinder; Earth Systematic Missions.

# Strategic Objective 1.2

## Understand the Sun, solar system, and universe.

Conduct scientific studies of the Sun and solar system, use space as a laboratory, peer out into the vast reaches of the universe, and play a catalyzing role in lunar robotic exploration. These efforts are guided by National priorities and recommendations from the National Academies' decadal surveys and implemented through a balanced portfolio of programs.

### Lead Office

Science Mission Directorate (SMD)

### Objective Overview

The success criteria for SMD are progress in answering fundamental science questions, implementing the decadal survey priorities, and responding to direction from the Executive Branch and Congress. Four of NASA's science areas contribute directly to this Strategic Objective.

Astrophysics is humanity's scientific quest to discover the origin of the universe and of life itself. How does the universe work? How did we get here? Are we alone? Progress is advanced through the combination of basic research and flight missions. Astrophysics is guided by the *Pathways to Discovery in Astronomy and Astrophysics for the 2020s* ([Astro2020](#)) Decadal Survey, which identifies science goals and recommendations for astrophysics planning and investment for the next

decade. Basic research uses the data from our missions to create new knowledge and advance our understanding of the universe. The research program includes competed programs in data analysis, theory, technology development, and suborbital projects. Small missions are undertaken as competitively selected, Principal Investigator-led Explorers missions. Large and medium strategic missions are directed to NASA Centers for implementation and are managed within the Strategic Missions Program.

Heliophysics embraces arguably the original "first light" of scientific wonder (the Sun), and how it influences the very nature of space. Our nearest star sends out a steady outpouring of particles and energy (the solar wind), which forms an extensive and dynamic solar atmosphere impacting all the planets. This solar atmosphere extends to the edge of the heliosphere, shaping the protective bubble in which our solar system travels

Below: Using its Wide Angle Topographic Sensor for Operations and eNginEering (WATSON) camera, NASA's Perseverance Mars rover took this selfie over a rock nicknamed "Rochette," on September 10, 2021, the 198th Martian day, or sol, of the mission. Two holes can be seen where the rover used its robotic arm to drill rock core samples for potential return to Earth as part of a future mission. Image Credit: NASA/JPL-Caltech/MSSS



around the Milky Way. Guided by the 2013 *Solar and Space Physics: A Science for a Technological Society* decadal survey, the goal of heliophysics is to understand the Sun and its interactions with Earth, the solar system and the interstellar medium, including space weather. Heliophysics incorporates studies of the interconnected elements into a single system that produces dynamic space weather. Studying this system allows us to discover the fundamental physics governing how the universe works and helps protect our technology and people from the impacts of space weather. The study of the coupled solar-terrestrial system can also teach us more about the habitability of planets in other stellar systems throughout the universe.

Space weather directly affects the safety of humans in space and on Earth by influencing the operation of electrical power grids, communications and navigation systems, gas and oil pipelines, and spacecraft electronics and orbital dynamics. NASA develops instrumentation, technology, models, and research tools to understand space weather. NASA also collaborates with agencies such as the National Science Foundation and NOAA to improve space weather predictive capabilities.

Through the observation and discovery of complex planetary worlds and objects, we seek to understand our solar system and the distribution of life within it. The focus of Planetary Science is to advance scientific knowledge of the origin and history of the solar system, the potential for life elsewhere, and the hazards and resources present as humans explore space. The scientific foundation of this endeavor is the 2011 Vision and Voyage for planetary science in the Decade 2013-2022 [decadal survey](#). NASA manages a diverse portfolio of research and technology development and unique mission investigations. NASA is operating spacecraft at Mars, Jupiter, and the Moon, and preparing to launch two missions to asteroids. NASA is also undertaking flagship missions to Jupiter's moon Europa and to return samples from Mars, and selected two missions to explore Venus. Knowledge gained by future human missions to the Moon will be utilized to visit Mars and possibly other solar system bodies, in concert with continued robotic missions.

Advances in planetary science, coupled with leading efforts to detect, track, and characterize near-Earth objects, will continue to improve planetary defense. NASA's Near-Earth Objects Observations Program funds research activities to increase our understanding of the motions, compositions, and nature of near-Earth objects. This includes using optical



Tomato plants growing under LED lights in a growth chamber inside a laboratory at the Kennedy Space Center. These plants are growing in units equipped with features designed to mitigate the effects of microgravity on water distribution, oxygen exchange, and root growth when aboard the International Space Station. Image credit: NASA

and radar techniques to better understand objects' orbits, shapes, sizes, and other relevant characteristics. These planetary defense activities enable the science community to understand the nature of near-Earth objects, information that could be leveraged to mitigate a possible Earth impact.

Biological and physical sciences pioneers scientific discovery and enables space exploration by using the spaceflight environment, in and beyond low Earth orbit, to conduct experiments that cannot be done on Earth. This work focuses on transformative science to contribute to advances in science, technology, and space exploration. This research also enables human spaceflight exploration to expand the frontiers of knowledge, capability, and opportunity in space. Implementation requires both scientific research and technology development. Strategic priorities in this area are informed by the National Academies of Sciences' decadal survey and research is currently guided by the first decadal survey (2011). Recommendations for the second, the decadal survey on biological and physical sciences research in space 2023-2032, are expected to be delivered during the summer of 2023. NASA partners with the research community and a wide range of organizations (e.g., academic, commercial, and Government laboratories) to do this work. Partnerships with other NASA organizations, other Government agencies, industry and international partners also provide access to a broad range of experimental platforms (e.g., ISS, un-crewed space-

craft, ground-based analogs for spaceflight, drop towers, aircraft) and a diverse set of experts. NASA strives for broad involvement of the research and technology development communities in the formulation and dissemination of its work.

## Objective Strategy

NASA's success in science discovery across these core contexts is based on a balanced program that involves a number of critical and enabling elements: laying the scientific and technical foundation for space-based missions through Research and Development; inventing and using new space-based observing and sampling capabilities; creating the context and capabilities to interpret the resulting data; and maximizing the return on investment in the acquisition of data. SMD's suborbital and ground-based programs are conducted to enable or complement space-based observations and train future mission scientists and engineers.

To complete innovative space missions NASA will effectively manage a diverse portfolio while balancing innovation with successful program execution. Like our approach in Strategic Objective 1.1, NASA will:

- Measure mission success against clearly written top-level measurement requirements
- Develop objective criteria to enable unequivocal measurement of success or failure in meeting each requirement
- Establish a budget for each new mission that funds the mission's complete life-cycle cost, based on detailed engineering studies and independent cost estimates
- Obtain tactical-level community advice on portfolio adjustments via the NASA Advisory Council, Science Committee, and the science advisory committees
- Implement effective partnerships—commercial, international, interagency, academic, and others—that leverage NASA resources and extend scientific results

NASA will implement missions only after focused development has matured required technologies. A balanced science program proactively identifies potential technologies required to meet future mission requirements, conduct trade studies, assess development risks, and invest in new technologies well in advance of mission implementation. NASA is also expanding the use of lower-cost CubeSats and SmallSats to accomplish our science goals.

NASA engages the science advisory committees

annually to rate scientific progress. In addition, the National Aeronautics and Space Administration Authorization Act of 2005 directed that the performance of each science division shall be reviewed and assessed by the National Academy of Sciences at five-year intervals.

## Searching for Life Elsewhere

The search for life in the solar system and beyond is guided by the ability to understand how life originated on Earth and by the quest to find habitable environments outside of Earth. To improve the knowledge of environmental requirements for habitability, NASA will develop tools for detecting life, develop tools for determining the relative habitability of present or ancient environments, and explore analog environments on Earth. This will facilitate target selection for further robotic, and ultimately human, exploration. Observations from SMD's astrophysics missions have made it clear that habitable planets exist around stars other than the Sun and that such planets are plentiful. Improving techniques and ideas for discovering and characterizing habitable and/or inhabited environments on these planets, coupled with an understanding of the potential false positives for habitability or life, will enable prioritization of exoplanets for targeted follow-up observations. In the coming decades, this will help to push frontiers of discovery and enable the search for signs of life on worlds that may be capable of harboring life, both within our own solar system and within the galaxy.

NASA's strategy relies on applying the lessons learned about the origin, evolution, and distribution of life on Earth to other bodies in our solar system and beyond. There is no single measurement or experiment that will definitively reveal the presence of extant or past life on a body in our solar system or a planet around another star. NASA will utilize many measurement results in a "[Ladder of Life Detection](#)" that will inform any certainty of the discovery of past or present life elsewhere.

## How NASA Engages and Works with Partners

NASA will extend partnerships domestically and internationally. Science is a broad national and international enterprise and SMD partners with U.S. Federal agencies and more than 60 nations and international research organizations to leverage ideas, capabilities, and resources. NASA's constellation of Sun, Earth, solar system, and distant universe spacecraft and observatories are models of international and interagency cooperation and serve to further common scientific interests; about

two-thirds of all of NASA's science missions have at least one international partner, and many missions have multiple interagency or international partners.

NASA's science is uniquely positioned among Federal agencies to transfer content and expertise to an informative environment to support learning across all age groups. Data are accessible through multiple channels, which allows NASA to benefit from partners actively engaged in learning communities and emerging citizen-based science.

### **Contributing Programs and/or Program Activities for Strategic Objectives**

Astrophysics Explorer; Astrophysics Research; Cosmic Origins; Exoplanet Exploration; Physics of the Cosmos; Biological and Physical Sciences; Heliophysics Explorer Program; Heliophysics Research; Heliophysics Technology; Living with a Star; Solar Terrestrial Probes; Discovery; Lunar Discovery and Exploration; Mars Exploration; Mars Sample Return; New Frontiers; Outer Planets and Ocean Worlds; Planetary Defense; Planetary Science Research; Radioisotope Power; Space Weather.

# Strategic Objective 1.3

## Ensure NASA's science data are accessible to all and produce practical benefits to society.

In order to ensure NASA's science data are accessible to all and produce practical benefits to society, SMD plans to undertake investments and initiatives that will accelerate the accessibility and use of SMD data by its user community by investing in the following: 1) capabilities to enable open-source science; 2) continuous evolution of data and computing systems; and 3) community and strategic partnerships for innovation.

### Lead Office

Science Mission Directorate (SMD)

### Objective Overview

SMD's missions and research activities inspire curiosity and increase the understanding of our planet, the solar system, and the universe. One of our core capabilities is the ability to collect, store, manage, analyze, and distribute data and information for scientists, international partners, learners of all ages, decision-makers, and industry to further science, improve modeling, increase knowledge, and spur economic innovation.

The science divisions within SMD generate, analyze, activate, and archive large amounts of data to support science objectives and deliver data and scientific results to users around the world. Over

the next 5 years, SMD divisions will substantially increase the size of data archives as the volume of data generated by new missions increases from approximately 10 petabytes per year today to over 100 petabytes per year in 2026. This growth of NASA's science archives presents unique opportunities for new scientific discovery and partnerships, as well as significant challenges for data management, curation, access, analysis, computing, and computational modeling.

As part of this effort, we plan to undertake investments and initiatives that will accelerate the accessibility and use of SMD data by its existing and new user communities. NASA's data initiatives are focused on making actionable data accessible to other Federal agencies, relevant decision-makers, stakeholders, and the public.

Below: University of Florida team members conduct thermal-vacuum testing of the European Space Agency (ESA)-NASA Laser Interferometer Space Antenna observatory's Charge Management Device. From left to right: Ph.D. students Samantha Parry Kenyon and Benjamin Letson, and Postdoc, Dr. Taiwo Olatunde. Image Credit: NASA





This will be done by investments in three key areas: 1) capabilities to enable open-source science; 2) continuous evolution of data and computing systems; and 3) community and strategic partnerships for innovation.

### Objective Strategy

NASA is working on several initiatives to invest in the three key areas identified above. Open-source science is the collaborative culture enabled by technology that empowers the open sharing of data, information, and knowledge within the scientific community and with the wider public to accelerate scientific research and understanding. Open-source science builds on concepts from open-source software that expanded participation in the developing code and applies these to the scientific process to accelerate discovery by openly conducting science from project initiation through implementation. Data and computing programs play a critical role in enabling open-source science through thoughtfully-designed software systems that are initiated as open-source software projects, are easy to use, and support the wide variety and high volume of data generated by NASA's scientific missions. Specifically, this initiative will allow open development of software and models, and better enable researchers to perform computational experiments that are constrained or verified by observations.

Community and strategic partnerships will accelerate the modernization of various modeling efforts. The adoption of machine learning and artificial intelligence technologies will greatly speed up the data analysis and computational performance of the models. Our commercial partners will access our science data and integrate it into models and service offerings, while our interagency partners benefit from improved data system services through easier access to data and the software used to generate the products.

NASA is also leveraging strategic and commercial partnerships to drive technological innovation. For example, NASA has piloted programs that use unsupervised learning and anomaly detection to explore the extreme conditions associated with superstorms. The more we understand what causes such space weather, the more we can improve our ability to forecast and mitigate the effects. Finally, expansion of citizen science initiatives through the use of volunteers in the pursuit of knowledge, con-



#### OPEN (TRANSPARENT) SCIENCE

scientific process and results should be visible, accessible, and understandable



#### OPEN (INCLUSIVE) SCIENCE

process and participants should welcome participation by and collaboration with diverse people and organizations

#### OPEN (ACCESSIBLE) SCIENCE

data, tools, software, documentation, and publications should be accessible to all (FAIR)



#### OPEN (REPRODUCIBLE) SCIENCE

scientific process and results should be open such that they are reproducible by members of the community



Open-source science requires a culture shift to a more inclusive, transparent, and collaborative scientific process, which will increase the pace and quality of scientific progress. To help build a culture of open science, NASA is championing the Open-Source Science Initiative, focused on data transparency, accessibility, inclusivity, and reproducibility.

sistent with the 2017 America INNOVATES Act,<sup>1</sup> continues beyond the current 23 projects to countless more with the open-source science approach.

NASA recognizes that Earth's changing climate disproportionately influences environmental exposures and vulnerabilities of the world's poorest and marginalized communities, and that NASA data, products, and personnel can and should inform the just treatment and meaningful involvement of all people. Through collaboration with the Office of Diversity and Equal Opportunity, SMD will identify current barriers to and opportunities for advancing equity for underserved communities and expand partnerships with organizations currently working

<sup>1</sup> America Implementing New National Opportunities To Vigorously Accelerate Technology, Energy, and Science Act (America INNOVATES Act), S.1187, 2017.

directly with such communities. Likewise, NASA with our grantees to make data more accessible to organizations and explore across science disciplines (e.g., with social scientists) to ensure the more effective use of NASA data for furthering environmental justice.

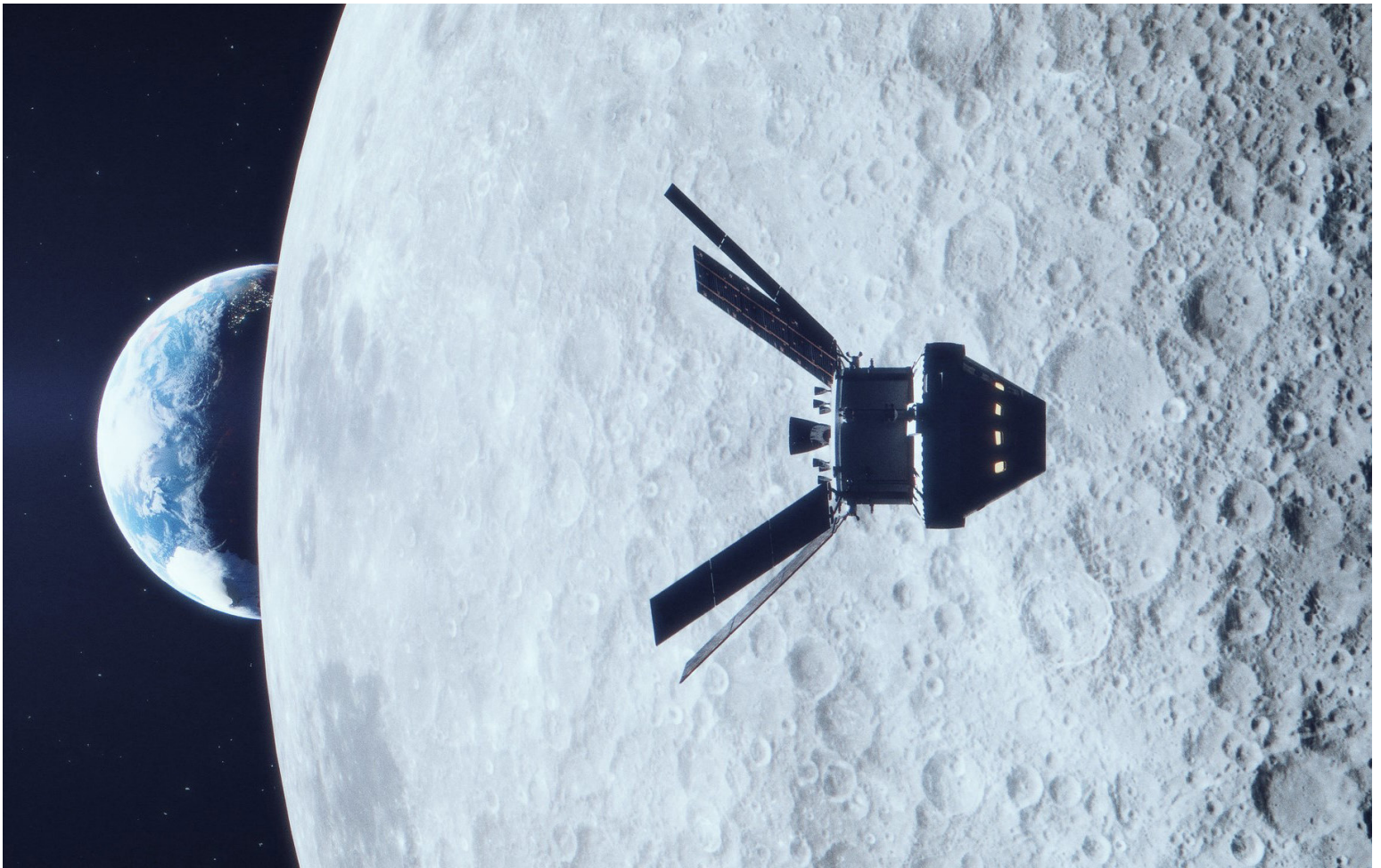
### **How NASA Engages and Works with Partners**

NASA works with a broad range of users and stakeholders in furthering our understanding of climate and its impacts through the collected data, analysis, and modeling; these communities include all levels of government (Federal, state, and local), international governments, domestic and international consortia, think tanks and philanthropies, academia, and industry. Using Earth observation data, we work with a number of state and local agencies in responses to disasters from wildfires to hurricanes. NASA has also partnered with local government entities to help plan for climate change and sea level rise in urban environments.

NASA also partners with members of the interagency community, through agreements with specific agencies, as well as interagency working groups, to further the use of relevant data. Internationally, NASA partners with space agencies across the world to develop, build, launch, and maintain platforms and instruments for long-term climate data, including satellite altimetry. Likewise, NASA partners with organizations around the world to provide data to support sustainable, climate-resilient decision-making.

### **Contributing Programs and/or Program Activities for Strategic Objectives**

Earth Science Data Systems; Applied Sciences.



A strong commitment to maintain U.S. leadership in space is required to establish a lasting human presence at the Moon. NASA will continue to lead a bold coalition into deep space, uniting international exploration goals with private-sector ambitions for a peaceful human endeavor beyond Earth. (Artist Illustration) Image Credit: NASA

# STRATEGIC GOAL 2

EXTEND HUMAN PRESENCE TO THE  
MOON AND ON TOWARDS MARS FOR  
SUSTAINABLE LONG-TERM EXPLORATION,  
DEVELOPMENT, AND UTILIZATION.

## **Goal Statement**

NASA's rich history of human spaceflight provides the foundation for today's exploration vision: to maintain U.S. leadership in space, establish a lasting presence on and around the Moon, and pave the way forward to Mars and beyond. This strategy begins with the Artemis, a series of missions that will land the first woman and the first person of color on the lunar surface, marking the first time in nearly 50 years that humans have landed on the Moon. Along the way, we will develop and inspire a diverse national science, technology, engineering, and mathematics (STEM) workforce, and inspire new generations to join our ranks.



The Moon is the ideal location to revive human activities in deep space and develop the orbital and surface infrastructure needed to support repeated missions in a campaign that will evolve in complexity and duration as we prepare for Mars. Building on more than two decades of operations in low Earth orbit aboard the International Space Station, and leveraging our wealth of experience with groundbreaking exploration, we will explore farther to ensure U.S. leadership in global space exploration, build back better through innovation and collaboration with industry, strengthen our global partnerships, and empower NASA to develop technologies to solve challenges here on Earth.

Establishing a long-term human presence at the Moon and conducting the first human mission to the surface of Mars will be among the most challenging technical enterprises in human history. This era of human exploration will require innovative technologies and systems—some of which have not yet been demonstrated—to explore new and more challenging locations, like the lunar South Pole. Developing these capabilities will spur advancements in critical fields like medicine, energy, materials science, manufacturing, and climate science.

Artemis mission success will require the continuation of existing partnerships and the development of new ones. Working with commercial partners enables NASA to focus its attention forward, while creating jobs and stimulating the economy. An emerging space economy will create new jobs and industries and empower countless future generations while benefitting life on Earth.

Our Nation is not alone in making plans to explore the Moon. Pursuing human exploration missions to the Moon and Mars ensures continued American preeminence in science, technology, and exploration, and encourages others to join us. Our existing international partners have expressed great interest in collaboration on Artemis. NASA is pursuing opportunities for collaboration with several emerging space nations interested in joining us on the Moon via the Artemis Accords. NASA also contributes to other nations' science missions, leveraging their skills and interests to conduct scientific research, develop and demonstrate technology, and train international crews to operate farther from Earth for longer periods of time than ever before.

Over the next several decades, NASA will establish long-term footholds in cislunar space and on the lunar surface and deploy complex crew-rated transportation and habitation systems to the Moon

and Mars. All of these elements are necessary to establish the surface infrastructure that will enable humans to live at and explore new, scientifically rich locations.

Throughout this century, NASA has focused on increasing private-sector involvement in space, laying a foundation for long-term exploration where Government agencies are one of several customers in a vibrant space economy. NASA has successfully implemented programs where the Government funds and supports key technologies such as advanced space communication technologies to enable higher data volume and reliability for communications between spacecraft and Earth as well as between astronauts on the lunar surface. NASA's investments in the global space economy and in the next-generation STEM workforce will ensure that people around the world can participate in a great vision of long-term human life in cislunar space. By making this vision a reality, we will improve life on Earth and extend U.S. leadership farther than ever before.

### **Maintaining America's Global Standing**

NASA is focused on addressing the challenges of taking humanity toward the Moon and deeper into space, enabling future discoveries, and providing knowledge to improve life on Earth. We remain the partner of choice for human exploration missions, and through Artemis and exploration of Mars, NASA and America will maintain leadership among spacefaring nations, building on decades of successful multinational partnerships.

Building on successful multinational partnerships in low Earth orbit, NASA will extend its leadership role into deep space, continuing many of its partnerships at the Moon, while growing new partnerships with emerging spacefaring nations. Through the [Artemis Accords](#), NASA has established a practical set of principles to guide cooperation among nations participating in the Agency's 21st century lunar exploration plans. The Accords implement the principles of the 1967 Outer Space Treaty and reinforce commitment by the United States and partner nations to the Registration Convention, the Agreement on the Rescue of Astronauts, and other norms of behavior, including the public release of scientific data, that NASA and our partners have supported. As of March 2022, the following countries have announced their signing of the Accords: Australia, Bahrain, Brazil, Canada, Israel, Italy, Japan, Luxembourg, Mexico, New Zealand, Poland, Romania, South Korea, Ukraine, the United Arab Emirates, the United Kingdom, and the United



States. Discussions with many other nations that wish to join the Artemis program and sign the Artemis Accords are ongoing.

Developing a lasting and effective exploration campaign requires the energy, expertise, and innovation of the world's top minds. Under NASA's leadership, Artemis is designed to leverage and maximize the ambitions and expertise of our international partners. These efforts will ensure U.S. international leadership while inspiring and benefitting the global public and strengthening our global partnerships while also easing the cost burden to the American taxpayer.

### **Driving Economic Growth**

NASA supports the development of a robust low Earth orbit economy in which many stakeholders on Earth can participate. The new space economy benefits U.S. industry, promotes technological discovery, improves life on Earth, and allows NASA to focus on the challenges of exploring the Moon and Mars. NASA's activities follow the direction of Congress and the White House, recognizing that it is in the national security and economic interests of the United States to encourage the development of a healthy and robust commercial sector in low Earth orbit, in which the Government is one of many customers.

In the last decade, NASA has proven that a service-based model for access to space can successfully spur new, non-Government, space-based revenue streams for American companies. Following success with the Commercial Crew Program in low Earth orbit, NASA is acquiring human landing systems, logistics deliveries to the Moon, and advanced spacesuits for ISS and Artemis as services.

Public-private partnerships, like those formed under NASA's Next Space Technologies for Exploration Partnerships model (NextSTEP), provide the impetus for industry to invest in the space economy. Competition spurs innovation, reduces cost, and ensures NASA's economic impact is spread across a range of business types and sizes.

NASA understands the importance of promoting economic growth through tangible and measurable goals and activities. NASA initiatives and programs—along with the development of technologies required to make NASA missions possible—represent a significant investment in our Nation's industrial base and manufacturing capabilities, research and education endeavors, and advanced technology sectors. NASA's keen interest in promot-

ing economic growth focuses on fostering competition and innovation for society's benefit. We will continue to partner with the U.S. private sector to push the economic frontier deeper into space and build on what we've already established in low Earth orbit.

# Strategic Objective 2.1

## Explore the surface of the moon and deep space.

Extend human presence into cis-lunar space to allow for sustained operations on the lunar surface and then on towards Mars to unlock mysteries of the universe.

### Lead Office

Exploration Systems Development Mission Directorate (ESDMD)

### Objective Overview

Artemis missions, and future human exploration of Mars, will expand opportunities for Americans, increase our global standing, and inspire the next generation of leaders in STEM. Long-term exploration and scientific utilization present unique opportunities for major discoveries impacting critical fields like medicine, energy, and manufacturing that will benefit society worldwide.

The Orion spacecraft will carry humans beyond low Earth orbit, provide emergency capability, sustain the crew in transit, and provide safe re-entry from deep space. The Space Launch System will send crew via Orion, as well as supplies to the Gateway space station around the Moon. NASA's Exploration Ground Systems team develops and

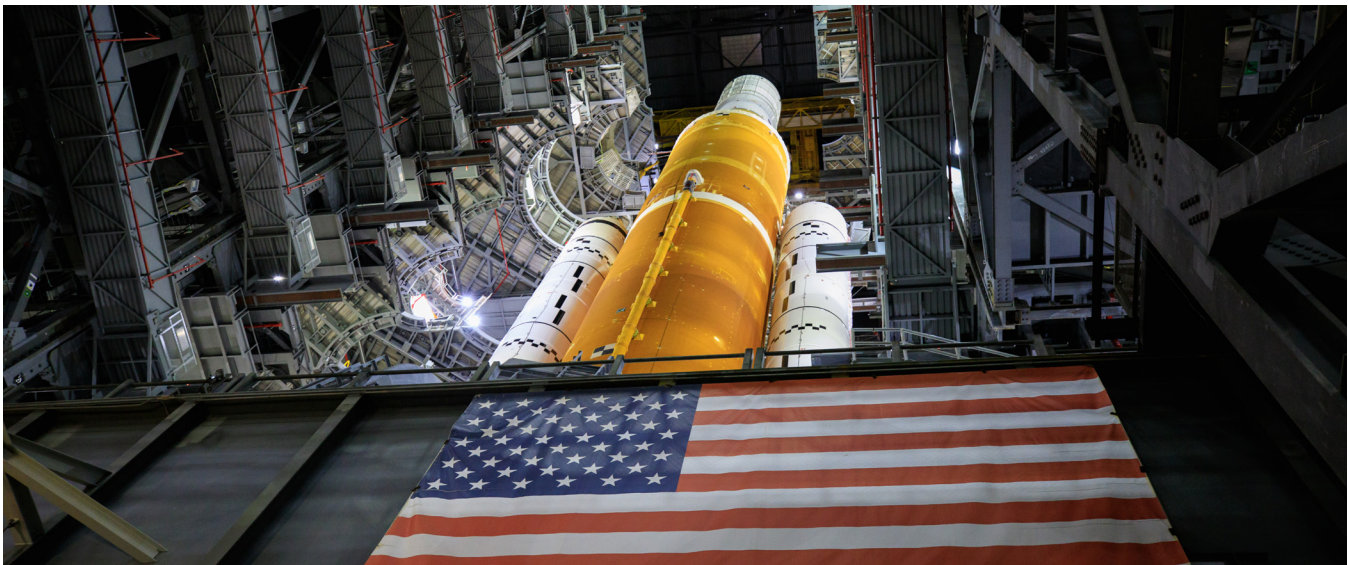
operates the systems and facilities needed to process and launch rockets and spacecraft during assembly transport and launch.

The Human Landing System (HLS) will be the first commercially developed vehicle to transport humans to and from the surface of the Moon. NASA is encouraging innovation through competition to find the best possible systems for taking astronauts to the Moon on increasingly frequent and longer duration missions.

NASA will develop an Artemis Base Camp near the Moon's South Pole. The base camp is envisioned to include an unpressurized rover, a pressurized rover, a fixed surface habitat and a surface power system to keep the elements powered during the lunar night and dormant periods.

NASA will work closely with international partners to achieve Artemis objectives and grow the global space economy. These relationships will reinforce

Below: In this view looking up inside High Bay 3 of the Vehicle Assembly Building at NASA's Kennedy Space Center in Florida, the work platforms have been retracted from around the Artemis I Space Launch System on September 20, 2021. All 10 levels of platforms were extended and retracted as part of an umbilical test. Artemis I will be the first integrated test of the Space Launch System (SLS) and Orion spacecraft. In later missions, NASA will land the first woman and the first person of color on the surface of the Moon, paving the way for a long-term lunar presence and serving as a steppingstone on the way to Mars. Image credit: NASA/Frank Michaux





America's position as the global leader in space exploration and provide new avenues for partnership with nations around the world. NASA's deep space exploration efforts will continue to act as a beacon of peace and scientific partnership around the globe.

Artemis missions will be driven by scientific objectives like collecting new information on planetary processes and the character and origin of volatiles. NASA will uncover the history of our Earth-Moon system and new information about our Sun. The human data collected as mission durations increase will make future work in deep space safer and more efficient. What we learn will also help us protect our home planet and improve daily life for people around the world.

### Objective Strategy

Exploring beyond low Earth orbit requires a space transportation system that can safely transport crew and cargo to deep space. Artemis includes a crew vehicle, heavy-lift launch vehicle, the Gateway in lunar orbit with logistics resupply, Human Landing Systems, and lunar surface systems to support astronaut expeditions, as well as supporting Earth-based ground facilities and systems.

As NASA establishes infrastructure at the Moon, a long-term orbiting platform will be necessary to support increasingly lengthy surface expeditions. The Gateway will also host some science experiments and provide additional data on the impacts of deep space flights on humans and systems.

NASA and its partners are preparing for a robust human return to the Moon, with an incremental buildup of capabilities in orbit and on the surface that will help prepare for the first human missions to Mars. Viewed as a deep space planetary laboratory, the Moon offers many opportunities to unlock new discoveries about the Earth-Moon system origins and the deep history of our solar system. Artemis systems have dual purposes, to explore the Moon and to demonstrate key capabilities for Mars. The rovers and power systems on the surface, HLS hazard avoidance and navigation systems, and even ascent capabilities could have direct applications to human missions to Mars. The orbit-to-surface operations involving astronauts ferrying between gravity fields will explore new challenges and techniques to mitigate them. Increasing surface duration stays and extravehicular activities on a planetary surface will provide crucial data in making surface exploration safer and more effective.



Artist's illustration of the Gateway at the Moon. Built and outfitted by NASA, commercial, and international partners, the Gateway will be humanity's first deep space exploration and research outpost. Image Credit: NASA/Alberto Bertolin

### How NASA Engages and Works with Partners

Establishing a sustained human presence on the Moon and conducting the first human mission to the surface of Mars will be among the most challenging endeavors in human history. NASA will engage with other Government agencies for collaborative efforts (e.g., Department of Energy, Department of Commerce, National Science Foundation, United States Geological Survey), and to ensure compliance with national and international policies and obligations (e.g., Federal Aviation Administration, Department of State).

International partners are critical to Artemis and the Moon towards Mars plan. The [Artemis Accords](#) established in 2020 set common principles for the peaceful exploration and use of outer space. The Accords are grounded in the Outer Space Treaty of 1967. To date, more than a dozen countries have signed the Artemis Accords, including both established and new partners, and NASA anticipates many more to join in the months and years ahead.

The NASA-led Gateway, that will be located in lunar orbit, is a multinational collaboration with many of our established partners in low Earth orbit. We have already signed agreements with three partners to provide modules and critical capabilities: the Canadian Space Agency (CSA), European Space

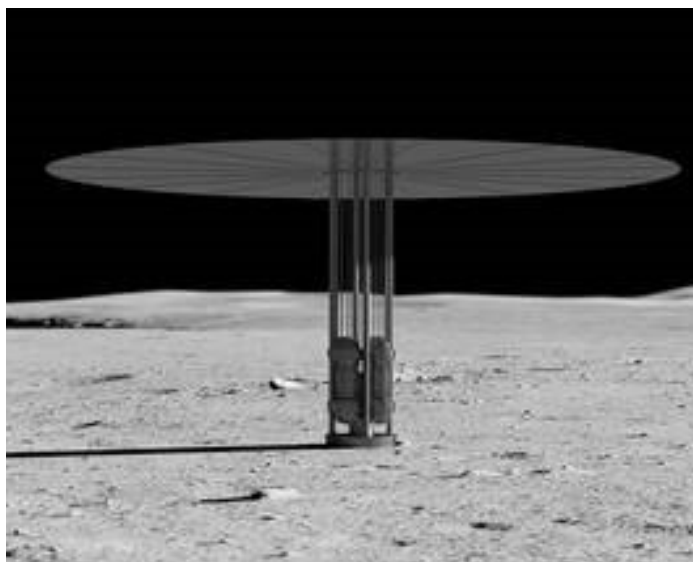


Agency (ESA), and Japan Aerospace Exploration Agency (JAXA). ESA and JAXA will also contribute early Gateway science instrument suites that will study the deep space radiation environment.

Following success with NASA's Commercial Crew Program in low Earth orbit, NASA is acquiring HLS, logistics deliveries to the Moon, and advanced spacesuits for ISS and Artemis as services. A services approach allows companies to engage other customers in addition to NASA and introduce new revenue streams into their business models. Competition leads to innovation, and these partnerships will ease the financial burden on NASA so our highly skilled workforce can focus on advanced technology development and research while solving the future challenges of exploration.

### **Contributing Programs and/or Program Activities**

Exploration Capabilities; Exploration Operations; Space Launch System (SLS); Orion; Orion Production & Sustainment; Exploration Ground Systems (EGS); Advanced Cislunar and Surface Capabilities (ACSC); Gateway; Human Landing System (HLS); xEVA and Human Surface Mobility Program; Moon & Mars Architecture.



Fission Surface Power - To keep Artemis surface elements continuously powered, regardless of environmental conditions, NASA is developing a small, lightweight fission surface power system to demonstrate on the Moon. Expanding on the agency's former Kilopower project, NASA's Space Technology Mission Directorate has partnered with the Department of Energy and industry to make this concept a reality. In the coming years, NASA will design, fabricate, and test a system that provides up to 40 kilowatts of electrical power – enough to run 30 average households – continuously for at least 10 years.





# Strategic Objective 2.2

## Develop a human spaceflight economy enabled by a commercial market.

Expand the space economy by leveraging the ISS and stimulating the growth of human spaceflight commercial activities.

### Lead Office

Space Operations Mission Directorate (SOMD)

### Objective Overview

A robust human spaceflight economy ensures national interests for research and development in space are fulfilled while allowing NASA to focus Government resources on the challenges of deep space exploration through Artemis.

NASA will maintain access to a human-rated platform in low Earth orbit (LEO) to continue U.S. human presence and expand the American foothold in space. The continuous operation of a research and technology demonstration platform in space is critical to achieving NASA's and the Nation's

goals in science, technology, and human space flight. As such, we are investing resources to foster a robust human spaceflight economy.

Since its inception, industry, academia, and our international partners have used the International Space Station (ISS) as a testbed for research and the development and maturation of state-of-the-art systems that increase access to space. NASA is supporting new space stations from which we and other customers can purchase services and stimulate the growth of commercial human spaceflight activities. As commercial LEO destinations become available, we intend to implement an orderly transition from current ISS operations to these new commercial destinations.

Below: Two U.S. cargo ships are pictured attached to the International Space Station, as the orbital complex flew 260 miles above the Laccadive Sea south of India in 2019. In the right foreground, the Northrop Grumman Cygnus space freighter, with one of its prominent cymbal-shaped UltraFlex solar arrays is attached to the Unity module. At top rear, the SpaceX Dragon commercial resupply ship is attached to the Harmony module. Image Credit: NASA



The ISS is the prime example of American leadership in global space exploration, enabling a U.S.-led multinational partnership to advance shared goals in space. The ISS supports a robust commercial marketplace, with more than 20 commercial facilities operating and generating revenue, including in-space manufacturing facilities and a commercial airlock. As NASA increases the opportunities for business on the ISS, the number and types of companies taking advantage of those opportunities will likely increase, which will in turn create more demand.

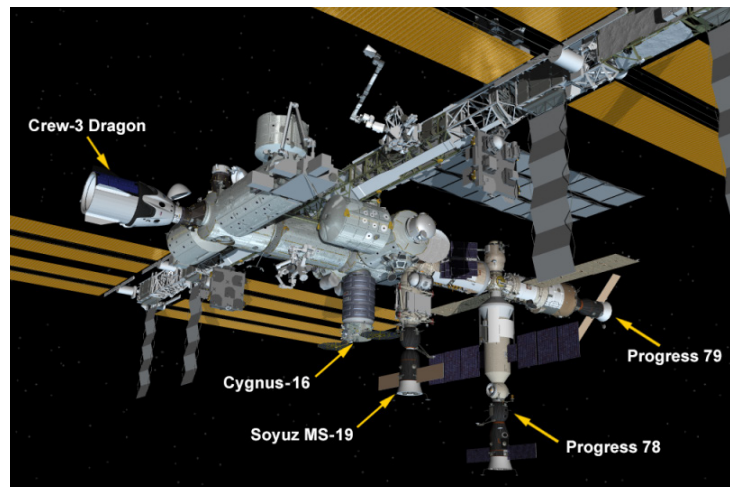
### Objective Strategy

NASA is committed to the development of both the supply side of the future human spaceflight economy (i.e., future platforms providing services for a fee) and the demand side (i.e., need for on-orbit services for Government requirements or to produce products of commercial value).

NASA pursues several avenues to enable the supply side of the human spaceflight economy. The ISS has entered an era of robust commercial use, taking advantage of our capacity to develop the technologies that industry needs to move from being dependent on NASA for access to space to providing the access we need to continue our mission in LEO after the lifetime of the ISS. These avenues include offering the use of an ISS port to a private company to deploy a new commercial element on the ISS; supporting the development and use of free-flying commercial LEO destinations; and offering the use of the ISS for private astronaut missions. NASA's expectation is that one or more of these development and demonstration efforts will prove commercially viable, allowing U.S. and international customers to purchase human spaceflight services in LEO while also providing us with the platforms and capabilities we require in LEO.

Creating a robust human spaceflight economy depends on bringing many new businesses and people into space and requires the development of not only the supply of services, but also the demand for those capabilities. NASA will soon see the [first private astronaut mission](#) to the ISS. Private astronaut missions are dedicated missions that are privately funded, fully commercial spaceflights on commercial launch vehicles for a variety of potential commercial purposes utilizing ISS.

Simultaneously, NASA's Commercial LEO Development and ISS programs are developing and maturing the demand side of the human spaceflight economy. NASA issued a preliminary "[LEO Demand](#)



On November 11, 2021, five spaceships were parked at the space station including Northrop Grumman's Cygnus space freighter; the SpaceX Crew Dragon vehicle; and Russia's Soyuz MS-19 crew ship and Progress 78 and 79 resupply ships. (Artist Illustration) Image Credit: NASA

[Forecast](#)," which describes NASA's long-term needs for microgravity services. NASA also provides support for sustained demand focus areas, such as industrial biomedicine and manufacturing. NASA also offers marketing and advertising opportunities aboard ISS on a fully reimbursable basis.

Through the successful implementation of similar commercialization strategies, such as the [Commercial Resupply Services](#) and [Commercial Crew Program](#), NASA demonstrates that companies can develop and operate the next generation of spacecraft and launch systems to serve the ISS. This success brought the commercial launch industry back to the United States, demonstrating that U.S. industry is more than capable of competing on the global stage. This commercial capability also fuels the growing U.S. share of the global launch market and provides expanded utility, additional research time, and broader opportunities for discovery and space exploration. An important goal of this commercialization strategy is to encourage the development of new industry capabilities, enabling these companies to sell future services to all customers, not just NASA.

Today, commercial crew and cargo transportation services provide a vital lifeline from Earth to the ISS for technology demonstrations. There are 21 commercial facilities operating onboard ISS today, including a 3-D printer, a bioprinter, and an airlock,



which are available for use by both NASA and other paying customers.

NASA is committed to using the ISS and its capabilities to aid in the development of the U.S. industry's ability to provide the necessary platforms and services in LEO. NASA is also committed to continued Government utilization of LEO beyond the ISS for basic research and development, Earth and deep space observations, and astronaut training. Our commitment includes providing Government funding to private industry via contracts and partnerships to ensure that future capabilities fulfill Government requirements.

These partnerships will enable private industry to assume roles that have been traditionally Government-only by creating new opportunities for economic growth through new markets and industries in LEO. They will potentially yield long-term cost savings to the Government by leveraging industry innovation and commercial market incentives. These activities will create a market environment in which commercial LEO destination services are available to both Government and private-sector customers. Commercial LEO destinations, along with commercial launch services, will provide the backbone of that the human spaceflight economy after the life of ISS.

### **How NASA Engages and Works with Partners**

When NASA returns to the Moon, we will go in a way that reflects the world today, with Government, industry, and international partners working together in a global effort to build and test the sustainable systems needed for successfully executing challenging missions on towards Mars . The advent of a robust commercial space economy has introduced new partners to the world of human space exploration and shifted the way we do business. To remain the world leader in human space exploration, we will continue to evolve.

The emphasis on public-private partnerships as the preferred program acquisition approach to extend human presence deeper into space will continue to change, with a new focus on embedded teams with mutually agreed upon support and outcomes. We continue to engage industry and academia early to build trusted relationships during the program definition and solution creation process, providing NASA competencies through people, processes, tools, and facilities to help in the management of risks encountered during the execution of our partner's proposed approach.

NASA relies on partnerships with academia and industry where we are developing American-led space infrastructure enabled by a commercial market, enhancing space access for both Government and commercial entities. These activities are catalysts for economic development, including those related to space tourism. Together, NASA and our partners will help ensure the well-being of future space explorers and support existing and future space operations for both NASA and non-NASA missions.

### **Contributing Programs and/or Program Activities**

Commercial LEO Development Program; International Space Station; Commercial Crew Program; Crew and Cargo Program.



# Strategic Objective 2.3

## Develop capabilities and perform research to safeguard explorers.

Provide enhanced capabilities, maintain crew health and performance, and conduct research to ensure safe space exploration.

### Lead Office

Space Operations Mission Directorate (SOMD)

### Objective Overview

Humans worked briefly on the Moon 50 years ago and have pioneered technological advances in low Earth orbit for the past 40 years. The activities that NASA leads that will return humans to the Moon, and from there on towards Mars, are focused on “buying down” risk through research and the development of tools and techniques to protect humans during deep space exploration. NASA is working to overcome radiation, crew isolation, and deep space communications delays, as well as food, medicines, and shelf-life constraints.

Each of these challenges must be solved to ensure crew members are safe and healthy as we move beyond low Earth orbit.

NASA is pursuing new technologies that will help manage the effects of extended stays in space on human health and performance. Each advance in our knowledge can provide basic human needs, including oxygen and water, along with the ability to maintain and repair critical systems. NASA will demonstrate the performance of emergent technologies in an environment where the risk to the safety of human or vehicle operations can validate the performance of the technology without risking the crew or mission, and prior to their use in an operational environment.

Below: NASA astronaut Kate Rubins works inside the Life Sciences Glovebox in late 2020, conducting research for the Cardinal Heart study. Biomedical research seeks to help scientists understand the aging and weakening of heart muscles to provide new treatments for humans on Earth and astronauts in space. Image Credit: NASA





NASA emphasizes partnering with industry and academia to develop new technologies that will enable future space travel that is less reliant on resupply and communications from Earth. The resultant reduction in logistics costs and increase in system capabilities and reliability are designed to safeguard humans on missions beyond low Earth orbit. The knowledge gained through research on the effects of reduced gravity on the systems in the body—including studying research areas that are unique to the Moon, Mars, and other destinations—will help quantify the best methods and technologies to support safe and productive human missions in deep space.

### Objective Strategy

NASA is developing capabilities, necessary countermeasures, and technologies in support of human space exploration, focusing on those capabilities that will mitigate the highest risks to crew health and performance. Some of these technologies will reduce medical and environmental risks and ensure effective human-system integration with the exploration mission systems necessary to safely explore in deep space.

New approaches are necessary to rapidly develop prototype systems, demonstrate key capabilities, and validate operational concepts to safeguard explorers during future human missions beyond low Earth orbit. NASA will continue to invest in exploration research and development and testing in both terrestrial and space environments. Most significantly, we will continue to use the ISS as a steppingstone to expand human presence farther into the solar system. The International Space Station (ISS) continues to expand our knowledge and experience in long-duration spacecraft operations and serves as an irreplaceable testbed for technology demonstrations of new capabilities and upgraded vehicle systems.

NASA enables space exploration by reducing the risks to astronaut health and performance using ground research facilities, the ISS, and analog environments. The performance of research in this combination of settings facilitates the development of procedures and furthers research areas that are unique to the Moon, Mars, and other destinations. Our portfolio is built around an architecture that uses evidence to identify a risk to the human system, gaps in our knowledge about characterizing or mitigating the risk, and the activities necessary to produce the knowledge necessary to close the gaps and reduce the risk.



NASA astronaut and Expedition 66 flight engineer Megan McArthur is seen with a taco made using fajita beef, rehydrated tomatoes and artichokes, and chile peppers. The chile peppers were grown as part of the Plant Habitat-04 investigation aboard the International Space Station. Image Credits: NASA/Megan McArthur

NASA supports the astronaut corps, space flight readiness training, and the health of crew members before, during, and after each spaceflight mission to the ISS. From Apollo through the Space Shuttle and to the ISS, crew members undergo rigorous preparation, which is critical to mission success. To pave the way to the Moon and onto Mars, NASA will partner with academia and commercial industry to prepare crewmembers for living and working for extended periods in space. Key activities include the identification of new training regimes to prepare crews for extended periods of space travel, including the identification of protocols for medical or technical problems that might arise when returning to Earth will take days, not hours.

## How NASA Engages and Works with Partners

For decades, NASA has demonstrated world-wide leadership across a broad spectrum of life sciences research communities, where we work with our international partners, other Federal agencies, and the academic and private sector to develop the knowledge that supports safe and healthy space travel. Formal agreements between NASA, other Federal agencies, academia, and our international partners form the basis of decades-long joint research activities on quantifying and mitigating the effects of space travel on humans. The knowledge gained with our partners will continue to inform our design for safer deep-space exploration systems.

NASA will continue to focus on preparing humans for the stresses of living and working for extended periods in the hostile environment of space. As humans explore further from Earth, many different issues will arise and require investigation. NASA will continue to study multiple human system challenges, including bone and muscle loss, vision, health, and wellness monitoring, and physical and mental function maintenance. These activities have led us to develop an exploration biomedical program focused on several goals: informing human health, performance, and habitability standards; developing countermeasures and risk-mitigation solutions; and advancing habitability and medical-support technologies. The 2021 report by the National Academies of Science, Engineering, and Medicine for managing cancer risks associated with radiation exposure during crewed space missions<sup>1</sup> will help inform future crew health and safety.

## Contributing Programs and/or Program Activities

Human Research Program; Human Space Flight Operations.

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<sup>1</sup> Space Radiation and Astronaut Health: Managing and Communicating Cancer Risks, National Academies of Science, Engineering, and Medicine, 2021.



# Strategic Objective 2.4

## Enhance space access and services.

Meet the communication, launch service, and strategic capabilities needs of NASA's programs.

### Lead Office

Space Operations Mission Directorate (SOMD)

### Objective Overview

The ability to provide cost-effective, mission-essential services provides a stable foundation for America's human and robotic missions. These capabilities range from acquiring launch vehicles for U.S. Government civil sector and robotic missions, to communicating with both crewed missions such as the International Space Station (ISS) in low Earth orbit, the Artemis lunar missions, and uncrewed, scientific missions such as planetary rovers on the surface of Mars.

NASA provides safe, reliable, and cost-effective launch services for NASA and NASA-sponsored payloads seeking access to space on U.S. commercial launch vehicles. As the launch agent of the U.S. civil space sector, NASA relies on the Launch Services Program (LSP) to certify new commercial launch vehicles for readiness to fly high-value spacecraft, and direct vital launch

mission assurance efforts to ensure the greatest probability of launch mission success. LSP's primary responsibility is to meet the needs of a diverse customer base spanning our Mission Directorates, a wide range of educational organizations, and other customers. LSP is the Agency's recognized expert in all aspects of commercial launch services, including acquisition, certification, and mission management.

NASA provides the critical communications and navigation services to our operational missions, and we will continue to invest in critical technologies that will increase reliable communications capabilities. NASA engages with the satellite communications industry to develop communications capabilities that supports U.S. needs, are globally competitive, and advance U.S. leadership in the generation of new markets. Today, commercially provided satellite communications continues to mature, and NASA envisions a commercial communications market where near-Earth customers will have access to suitable commercial services and where NASA is one of many customers.

Below: A SpaceX Falcon 9 rocket carrying NASA's Imaging X-ray Polarimetry Explorer (IXPE) spacecraft is seen at sunset on the launch pad at Launch Complex 39A, December 8, 2021, at NASA's Kennedy Space Center in Florida. The IXPE spacecraft is the first satellite dedicated to measuring the polarization of X-rays from a variety of cosmic sources, such as black holes and neutron stars. Image Credit: NASA/Joel Kowsky



Developing and testing rocket propulsion systems is foundational to spaceflight. Whether the payload is a robotic science experiment or a crewed mission, the propulsion system used to launch it must be safe and reliable. Utilizing unique test facilities, NASA ensures the safe and effective execution of a rigorous engine test program, critical to any rocket propulsion development activity.

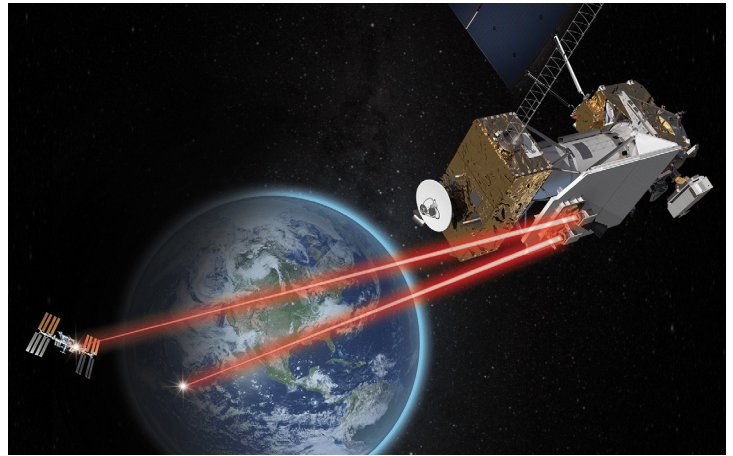
### Objective Strategy

NASA has an important role as a valued partner and advisor to the U.S. commercial launch industry. To ensure the U.S. launch industry continues to grow and maintain a competitive posture, NASA certifies new commercial launch vehicles for readiness to fly high value spacecraft, performs key mission design and launch integration activities, and directs launch mission assurance efforts to ensure the greatest probability of launch mission success.

The National Space Policy directs that we make use of, rather than duplicate, commercially provided services. NASA has a diverse set of users and communications needs against which commercial capabilities will be evaluated, such as launch vehicle support, visiting vehicles to ISS, human space flight, and science missions in Earth orbit, which range from flagship observatories to SmallSats and CubeSats. NASA will systematically migrate near-Earth missions from communications and navigation services provided by Government-owned networks to commercial networks. NASA will continue to provide support to our users and envisions transitioning future space-relay users to commercial providers over the next decade.

NASA is investing in critical technologies that will increase reliable communications capabilities and transform NASA mission technology. Our strategy is guided by the ability to acquire and utilize advanced space capabilities to the maximum extent possible. NASA's efforts in the continued development of communications technologies will enable, improve, and mature available communication and navigation technologies for both ground and space-based use. NASA will continue to leverage investments, experience, and accomplishments in many areas, including optical communications, building the initial technologies and capabilities required for future space-based communications networks.

NASA manages testing facilities across the Nation, where both our programs and U.S. industry conduct rocket engine and component tests under controlled conditions. Our decades of experience in rocket propulsion testing ensures the delivery of



Launched in December 2021, the Laser Communications Relay Demonstration will demonstrate optical communications capabilities for future missions. Most spacecraft use radio frequency technology to communicate with Earth. Optical communications could increase bandwidth 10-100 times more than radio frequency. (Artist Illustration) Image Credit: NASA

desired outcomes while minimizing test time and costs. NASA has a keen focus on streamlining facility usage and eliminating redundant capabilities that keep this national asset available, as required, by multiple customers and users.

### How NASA Engages and Works with Partners

NASA continues to work with industry and academia through a variety of partnerships, including numerous Space Act Agreements, focusing on rocket propulsion testing, space-based communications, launch system risk reduction, and other strategic capabilities. For example, executing a robust and proven strategy, NASA achieves assured access to space through a competitive "mixed fleet" approach that utilizes the breadth of U.S. industry's capabilities. LSP provides expertise to NASA payload missions who are using launch services through other Government agencies, the launch industry, or contributed by a foreign partner. NASA collaborates extensively with the U.S. Space Force and other agencies in the areas of mission assurance, fleet surveillance, and acquisition strategy, and is an invaluable source of technical expertise and insights across the U.S. commercial space industry.

NASA's Rocket and Propulsion Test (RPT) program is responsible for managing and sustaining the Agency's expertise and facilities for ground testing of rocket engines. RPT provides vital propulsion data to validate initial designs, increase confidence





in technical performance, reduce risks, and ensure launch readiness in preparation for Artemis I and Artemis II, as well as supporting the Commercial Crew Program's milestones.

### **Contributing Programs and/or Program Activities**

Communications Services Program; Launch Services; Rocket Propulsion Test; Space Communications and Navigation.



NASA astronaut and Expedition 63 Commander Chris Cassidy poses with two Astrobeer robotic assistants during visual and navigation tests inside the Kibo laboratory module from Japan Aerospace Exploration Agency (JAXA) Image Credit: NASA

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# STRATEGIC GOAL 3

## CATALYZE ECONOMIC GROWTH AND DRIVE INNOVATION TO ADDRESS NATIONAL CHALLENGES.

### **Goal Statement**

NASA drives economic development and growth through technological innovation. The National Aeronautics and Space Act of 1958 specifically calls out this important theme, and since its inception NASA's investments have driven innovation, benefitting the U.S. economy and the American people. It was Apollo and other U.S. space programs, with their need for large quantities of integrated circuit components, that led to lower-cost production and provided a critical early boost to the growth of the American semiconductor industry. Similarly, NASA's early role in the development of satellite communications and remote sensing

eventually led to the emergence of the robust space-based market, spanning a broad range of commercial communication and data services.

Originally tied to keeping the Nation secure and advancing U.S. leadership in aeronautics, communications satellites, and Earth remote sensing, NASA's mandate is broader today. The challenges NASA addresses relate to gathering climate change data; driving American innovation through aerospace research and development; developing commercial and human space launch, transportation, and exploration capabilities; understanding cosmic phenomena as wide-ranging as space weather, asteroids, and exoplanets; supplying technological solutions that could also apply to terrestrial problems; and improving the Nation's innovation capacity.

Today, NASA invests in a broad portfolio of both space technology and aeronautics research, development, and demonstration. We invest more than 80 percent of our funds in U.S. industry and academia. Where possible, the Agency leverages public-private partnerships, reducing development costs, accelerating infusion of new technologies, meeting national needs, and potentially enabling new markets. Each year, NASA creates over 1,000 new technologies, and the Agency works diligently to ensure that the American people receive maximum benefit from those advancements through patent licenses, software usage agreements, and other commercialization efforts.

### **Maintaining America's Global Standing**

In solving some of the most difficult technological challenges our Nation faces in space and flight, NASA serves as an innovation leader, sourcing ideas from a broad, diverse base of organizations and transferring technology into the aerospace economy. NASA's technology investments help grow the U.S. industrial and academic base, continuing the Nation's economic leadership and strengthening our national security.

In the coming years, NASA will advance space technologies that enable rapid, safe, and efficient transportation, as well as expanded access to diverse surface destinations. We seek to enable a vibrant space economy with technological advancements that foster U.S. innovation and competitiveness, drive economic growth and the creation of high-paying U.S. jobs, and ensure national leadership in space. Similarly, NASA is making significant contributions to keep U.S. aviation the global leader in safety, efficiency, and innovation. We explore early-stage concepts, develop new technologies and

air traffic operational procedures, and demonstrate their potential to transform aviation into an economic engine at all altitudes. The Agency is committed to cutting-edge research and technology to assure U.S. competitiveness in space and in flight.

NASA embraces competition and external partnerships to spur innovation and entrepreneurship. We partner with universities, small businesses, industry, emerging commercial entities, individual innovators, and other Government agencies. With a focus on reducing technology risks through research, transitioning promising concepts, and infusing NASA technologies into commercially viable products and services, NASA furthers American technological leadership through active engagement with a diverse U.S. innovation community.

### **Driving Economic Growth**

Technology drives the aerospace economy. Through its space technology and aeronautics portfolios, NASA proactively works to drive U.S. economic growth and job creation in the U.S. space industry by reducing research and development risks for U.S. companies; stimulating new business creation and maturation; removing barriers to entry for new businesses to enter the market; supplying small businesses with training and expertise to grow in the marketplace; providing opportunities for businesses to test and mature technologies in relevant environments; and building bridges for industry to access technologies through licensing technology and serving as an early customer to help jumpstart new markets.

### **Addressing Climate Change**

NASA research is directly contributing to the long-term sustainability of aviation, including reduction of greenhouse gas emissions and noise by developing and testing new green technologies for next-generation aircraft, new automation tools for greener and safer airspace operations, and sustainable energy options for aircraft propulsion. We partner with industry, academia, and other Government agencies through the Sustainable Flight National Partnership to accomplish the aviation community's aggressive international carbon reduction goals. For example, through our work in advanced vehicle technologies, efficient airline operations, and sustainable aviation fuels, we aim to potentially achieve net-zero aviation carbon emissions by 2050. We also invest in technologies that can reduce greenhouse gases, provide new clean energy alternatives, and improve climate observations and climate adaptation decision support.

# Strategic Objective 3.1

## Innovate and advance transformational space technologies.

Develop revolutionary, high-payoff space technologies driven by diverse ideas to transform NASA missions and ensure American leadership in the space economy.

### Lead Office

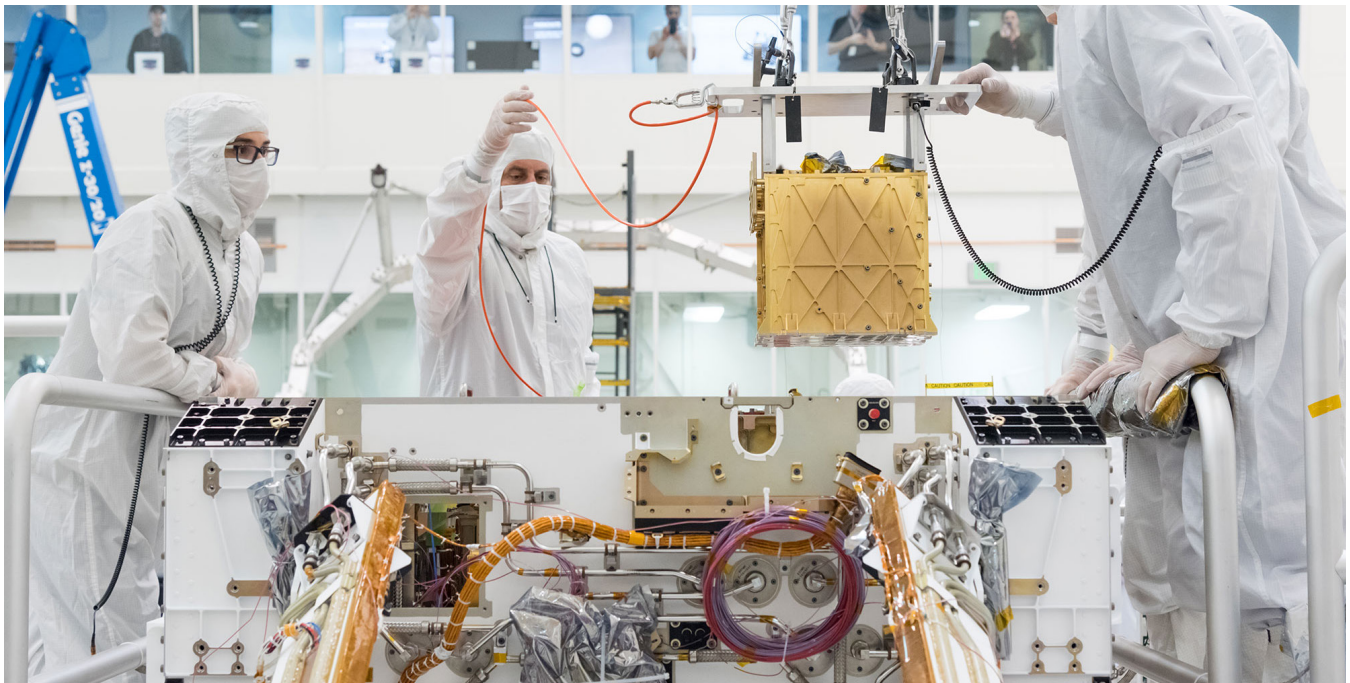
Space Technology Mission Directorate (STMD)

### Objective Overview

Technological leadership remains vital to our national security, economic prosperity, and global competitiveness. The Nation's continued economic leadership is due in part to the technological investments made over time that enabled our country to emerge as a global technological leader. That commitment accelerated the economy with the creation of new industries, products, and services that yielded lasting benefits. Moving forward, a technology-driven NASA will continue to help fuel our Nation's economic engine and support the creation of jobs for decades to come, while also providing valuable breakthroughs for NASA's missions and the commercial space industry. In short, technology drives the space economy.

As NASA embarks on its next era of discovery and exploration, the advancement of transformational space technologies help guide the journey ahead. We invest in crosscutting and transformational technologies that have high potential for offsetting mission risk, reducing cost, and advancing existing or creating new capabilities. Our technology investments enable NASA's science and human exploration missions and foster growth and job creation in domestic industries. We harness innovation and entrepreneurship through partnerships with universities, small businesses, and other Government agencies, while also engaging the broader public. Through leadership in space technology, NASA will contribute to growing the U.S. industrial and academic base by transferring space technology into the space economy, continuing the Nation's global economic leadership, and strengthening our national security.

Below: Members of NASA's Mars 2020 project install the Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE) into the chassis of NASA's next Mars rover. MOXIE will demonstrate a way that future explorers might produce oxygen from the Martian atmosphere for propellant and for breathing. The car-battery-sized instrument does this by collecting carbon dioxide from the Martian atmosphere and electrochemically splitting the carbon dioxide molecules into oxygen and carbon monoxide molecules. The oxygen is then analyzed for purity before being vented back out to the Martian atmosphere along with the carbon monoxide and other exhaust products. Image credit: NASA/JPL-Caltech



In the coming years, NASA will advance technologies that enable rapid, safe, and efficient transportation as well as expanded access to diverse surface destinations. We seek to enable a vibrant space economy with supporting utilities and commodities through investments in in-situ resource utilization, sustainable power systems, and autonomous construction. NASA will invest in technologies to enable long duration human exploration missions and those that transform our missions and discoveries by investing in high performance computing, advanced robotics, satellite servicing and assembly, in-space manufacturing, and new vehicle platform technologies that are more rapid, affordable, and capable. These technological advancements will foster U.S. innovation and competitiveness, drive economic growth and the creation of good-paying jobs, and ensure national leadership in space.

NASA also continues to advance climate and clean energy technology innovations. We emphasize reducing greenhouse gas emissions (including carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons); production of clean energy; sustainable aviation; climate science observations; and harnessing data for climate research. We will formulate new prizes, topics within the Small Business Innovation Research and Small Business Technology Transfer programs, and grant opportunities to address climate challenges and the clean energy economy. In addition, NASA will be supporting Earth-observing capabilities for Small Spacecraft platforms to support breakthrough science and National efforts to address climate change.

In addition, NASA will be supporting Earth-observing capabilities for small spacecraft platforms to support breakthrough science and national efforts to address climate change.

### Objective Strategy

Working closely with stakeholders, enlisting partnerships, utilizing evidence-based decision making, and promoting diversity, equity, inclusion, and accessibility are all key to our strategy.

To balance near-, mid-, and long-term technology requirements we employ a merit-based competition model, with a portfolio approach spanning a range of discipline areas and technology readiness levels. Integration across programs is key to identifying and successfully transitioning and transferring new capabilities. By working with potential stakeholders up front and continuously engaging through conception, maturation, and demonstra-



A NASA technology that could one day help land humans on Mars is under development and will be tested in 2022. The Low-Earth Orbit Flight Test of an Inflatable Decelerator (LOFTID) will demonstrate entry of an aeroshell from low-Earth orbit. This technology enables a variety of proposed NASA missions to destinations such as Mars, Venus, Titan as well as return to Earth.

tion, we are more effective in transferring new transformative technologies and capabilities within NASA, the U.S. Government, and throughout industry and academia.

NASA's technology portfolio has grown significantly in recent years, and enhancements in portfolio management processes and functions are required to continue effective and efficient operations. We focus on evidence-based decision making as part of our success strategy. Continuous improvement of data management enables us to have a more complete understanding of the vast array of projects within our portfolio, allowing for the investigation of technology development history to inform future investment decisions. Strategic implementation planning remains an integral component of meeting our objectives. Moving forward, focused, outcome-based requirements and documentation will inform quantitative analysis of technology gaps and provide guidance for future investments.

NASA promotes diversity, equity, inclusion, and accessibility, guided by Executive Orders 13985 and 14041, through supporting participation by underserved communities in its technology programs. A key element of our strategy is inspiring and

developing a diverse and powerful U.S. aerospace technology workforce. We remain focused on increasing the diversity of our innovation community. Accordingly, our space technology programs participate in the NASA Science, Technology, Engineering, and Mathematics (STEM) Engagement Minority University Research and Education Project (MUREP) to engage and support Minority Serving Institutions (MSIs), including Historically Black Colleges and Universities (HBCUs). Through MUREP, NASA reaches scientists, engineers, and students from underserved and underrepresented communities. For example, in 2021, NASA awarded grants, up to \$50,000 each, to 11 MSIs to foster partnerships between those institutions and U.S. small businesses while also potentially lowering the barriers of entry to participation in NASA's Small Business Technology Transfer program. We also recently launched a pilot initiative with the MSI STEM Research and Development Consortium aimed at increasing MSI participation in Federal research. Additionally, our annual "Technology Infusion Road Tour" reached representatives from MSIs to share insight and strategies on how to pursue procurement and technical opportunities with the Agency. Moving forward, our Early-Stage Innovation and Partnerships, Technology Maturation, and Technology Demonstration portfolios will continue to explore new approaches to increase participation by underserved communities.

### **How NASA Engages and Works with Partners**

To ensure American leadership in the space economy, NASA aggressively pursues critical technology gaps and global space technology leadership. We embrace competition and external partnerships that spur innovation and entrepreneurship. We create partnerships with universities, small businesses, industry, emerging commercial entities, individual innovators, and other Government agencies to meet NASA mission needs and support commercial expansion in space. We also welcome opportunities to work with our international partners on shared priorities. With a focus on infusing NASA technologies into commercial products and services, we actively engage our stakeholders to help define investment content and identify opportunities where technological advances can enable a commercially viable product or service. We utilize multiple mechanisms to partner with industry, including public-private partnerships through contracts and Space Act Agreements. By sharing the risk and financial stakes with the private sector, other Government agencies and internal stakehold-

ers, NASA encourages future commercial markets in the process of developing new capabilities. NASA invests in high-risk, high-reward activities across the technology development spectrum through our partnerships.

NASA understands the future of American leadership in space depends on a national aerospace technology workforce comprised of inventors and innovators across a wide spectrum of disciplines in addition to technologists and engineers that tackle the hard problems that space presents, and our partnerships spur growth in these disciplines. We also recognize that diversity of thought and background, and cross-disciplinary perspectives are critical to the Nation's success and that working to attain equity must include building better bridges to underserved and underrepresented communities, so no talent is missed in achieving our national space technology objectives.

### **Contributing Programs and/or Program Activities**

Early-Stage Innovation and Partnerships; Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Program ; Technology Demonstration; Technology Maturation.

# Strategic Objective 3.2

## Drive efficient and sustainable aviation.

Lead aviation innovation to enable safe and sustainable air transportation through revolutionary vehicle advances and efficient flight operations.

### Lead Office

Aeronautics Research Mission Directorate (ARMD)

### Objective Overview

Air transportation is an integral part of modern life, providing safe, affordable, and convenient travel to the public. Consequently, it has become an integral part of the U.S. and global economy. In a 2020 economic impact report<sup>1</sup> published by the Federal Aviation Administration, air transportation<sup>2</sup> provided \$78 billion of positive trade balance for the U.S. manufacturing sector, 10.9 million direct and indirect jobs and 21.3 billion tons of freight by the U.S. airlines culminating in \$1.8 trillion of total U.S. economic activity (8.6 percent of the 2018 U.S. Gross Domestic Product). Of the 10.9 million jobs, over one million were high-quality manufacturing jobs. Nearly every

product created and purchased today (from toys to groceries) is touched by aviation in some way. Speed, convenience, and economic benefits from air transportation are the primary factors in its rapid growth; benefits that have been even more important during the COVID-19 pandemic.

NASA's research contributes significantly to the aviation sector in improving its safety, efficiency, and resulting economic well-being of the Nation. Our role is to reduce the risk inherent in innovative concepts. We explore early-stage concepts and ideas, develop new aviation technologies and air traffic operational procedures, and demonstrate their potential in a relevant environment. The Agency is steadfast in its commitment to cutting-edge research and technology development and demonstration to assure U.S. competitiveness in the aviation sector.

1 [2020 Economic Impact Report](#)

2 Pre-Covid-19

Below: An ultra-efficient aircraft shape called the “transonic truss-braced wing” undergoes testing in NASA's 14'x22' wind tunnel at Langley Research Center in Virginia. The unique design of its wing reduces drag during flight, which in turn reduces fuel consumption by up to 10 percent. Further development and testing of this concept are taking place under NASA's Sustainable Flight National Partnership, which is expanding research to enable more sustainable aviation. Image credit NASA



## Objective Strategy

To continue NASA's leadership in aviation innovation and enable a revolutionary transformation of the aviation system, NASA is focused on six major research areas, or Thrusts, for the long-term future of aviation. These research Thrusts utilize the full capability of our in-house aeronautics expertise. Through high-risk, high-reward research and technology development, NASA seeks to enable:

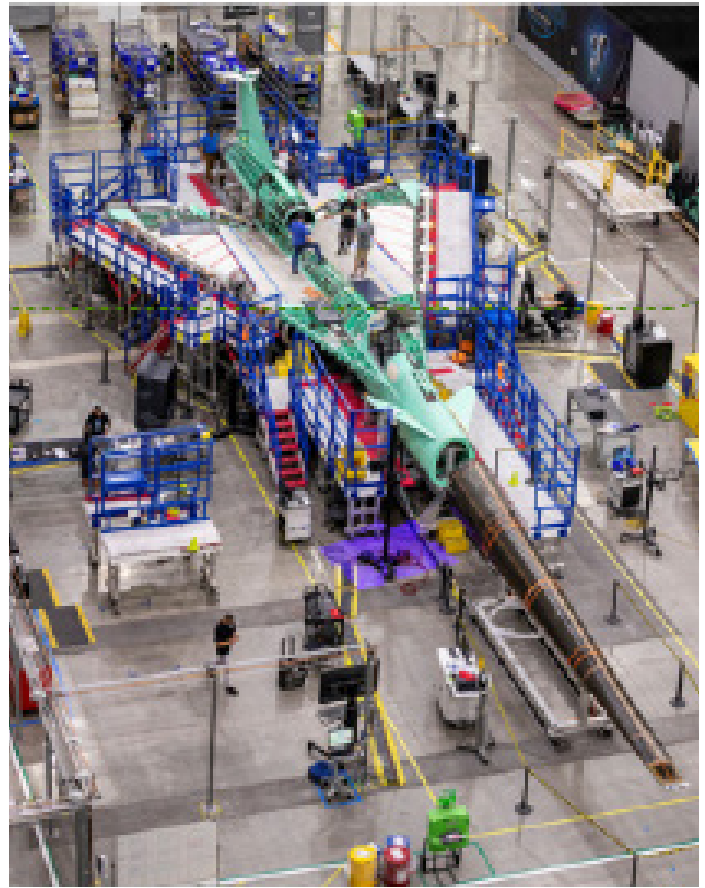
- Safe and efficient growth in global operations;
- Innovation in commercial supersonic aircraft;
- Ultra-efficient subsonic transports;
- Safe, quiet, and affordable vertical lift air vehicles;
- In-time system-wide safety assurance; and
- Assured autonomy for aviation transformation.

Each Thrust is designed to address an important area of research and technology development that will further U.S. leadership in the aviation industry and enhance global mobility. This research is performed with an emphasis on multi-disciplinary collaboration focused on the critical, integrated challenges aligned to the six research Thrusts—what NASA refers to as convergent research. Together, these research Thrusts combine to enable safe, sustainable growth in the overall global aviation system, while pioneering transformative capabilities that will create revolutionary opportunities.

NASA works with partners in other Government agencies, industry, and academia to support innovative concepts and technologies, and with international counterparts to leverage complementary investments.

## How NASA Engages and Works with Partners

NASA is committed to increasing diversity and broadening representation in the Nation's aeronautics research and development enterprise, both internal and external to NASA. We engage with the private sector and academia in research activities through solicitations such as the NASA Research Announcements. We encourage participation by academic institutions that serve underrepresented and minority groups through active outreach to professional organizations for women and to Minority Serving Institutions (MSIs) and Historically Black Colleges and Universities (HBCUs) informing them about NASA's portfolio and upcoming opportunities. ARMD's University Leadership Initiative (ULI) is one notable example of our efforts in this



The X-59 QueSST (Quiet SuperSonic Technology) aircraft will fly at supersonic speeds above communities during the Low-Boom Flight Demonstration mission, generating sonic "thumps" instead of booms. Image credit: NASA/Lockheed Martin

regard. ULI represents a new type of interaction with the university community, where universities take the lead, build their own teams, and set their own research path. Under this initiative, we explicitly require proposing university teams to include MSIs and HBCUs and continue to encourage women faculty members to apply. We also leverage Minority University Research and Education Project (MUREP) funded by NASA Office of Science, Technology, Engineering and Mathematics.

Partnerships with other Government, industry, academia, and foreign aeronautics agencies leverage ARMD's investments through joint efforts that complement NASA's internal capabilities, provide access to a wide range of technologies beyond the traditional aeronautics portfolio, and facilitate technology transfer to more mature states of development and eventual implementation. Integrated technology demonstrations typically include selected industry or Government partners who contribute their

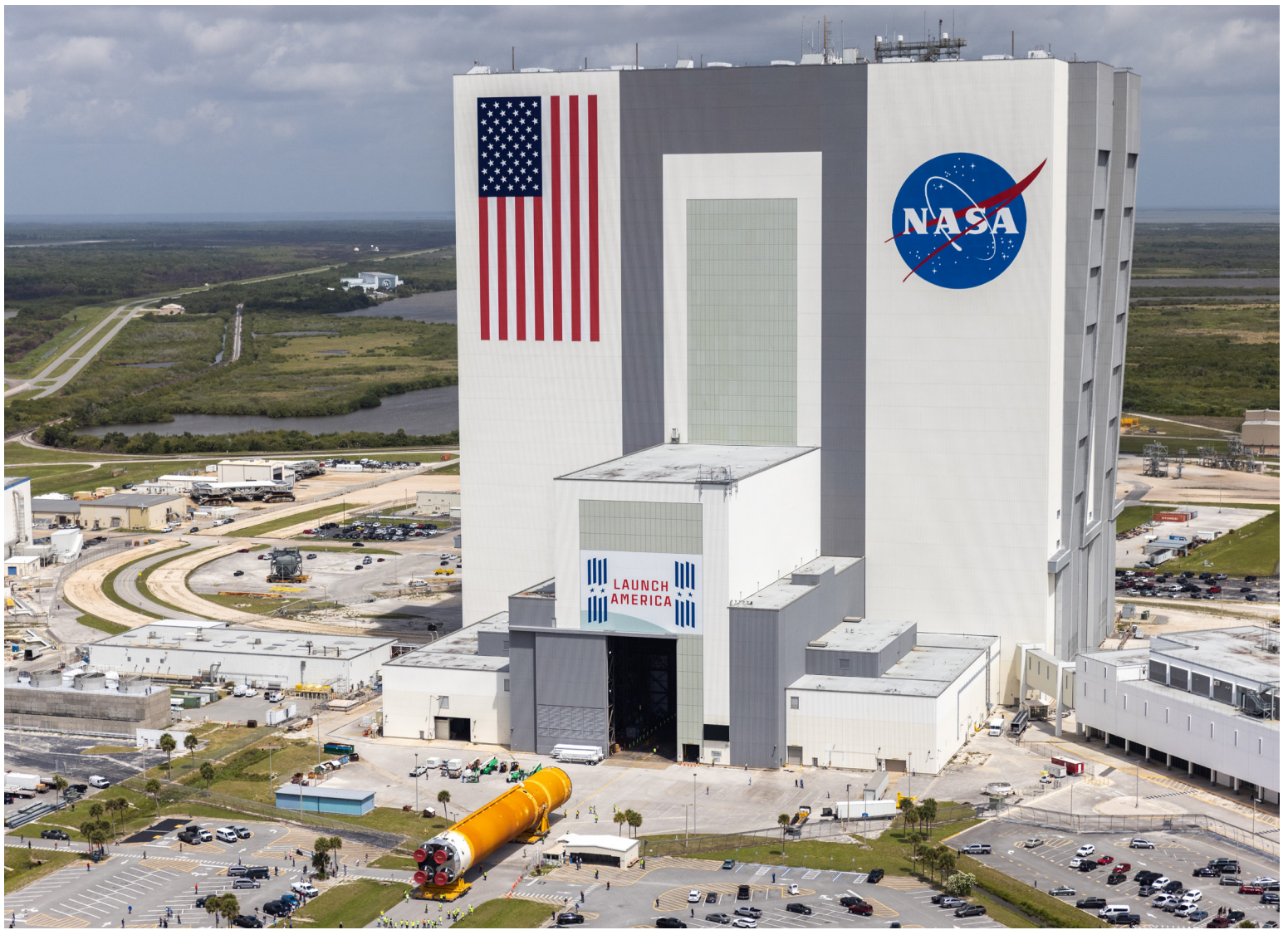


own funding or knowledge. These partnerships also give ARMD deep insight into the goals and needs of the aviation community, as well as providing user feedback and facilitating industry engagement early in the technology development cycle.

ARMD collaborates closely with the Federal Aviation Administration to support their decision making and to improve the performance of the National Airspace System (NAS), as well as with the Department of Defense and other Government agencies to leverage technology investments. Industry partnerships allow rapid insertion of NASA aeronautics research results into air vehicles and subsystems, and NAS operations, tools, and processes. Partnerships with domestic academic institutions support cutting-edge research on emerging aviation technologies and on the education of new researchers in various fields of study. To help address the global nature of air transportation, ARMD also forges partnerships with a wide range of international Government entities, such as the International Forum for Aviation Research.

### **Contributing Programs and/or Program Activities**

Advanced Air Vehicles Program; Transformative Aero Concepts Program; Integrated Aviation Systems Program; Airspace Operations and Safety Program; and Aerosciences Evaluation and Test Capabilities.



The Kennedy Space Center's Vehicle Assembly Building (VAB) is one of the largest buildings in the world. The high bay is big enough to hold the massive Space Launch System rocket boosters stacked on top of the mobile launcher. The high bay doors are 456 feet high. Image credit: NASA/Kim Shiflett

# STRATEGIC GOAL 4

## ENHANCE CAPABILITIES AND OPERATIONS TO CATALYZE CURRENT AND FUTURE MISSION SUCCESS.

### **Goal Statement**

NASA's complex and bold missions require modern, adaptable technical and professional support capabilities to enable mission readiness, resilience, and our continued leadership in science, exploration, discovery, and innovation. The pace of change and innovation in aerospace is increasing, and NASA must deliver critical support capabilities for mission success. We will pursue the goal of enhancing capabilities and operations to ensure that NASA has the right people, infrastructure, technology, and technical excellence and oversight needed to advance the Agency into the Artemis era and beyond.

A diverse workforce, empowered in an equitable, inclusive, and accessible environment, is a key requirement for ensuring Agency success in the era of commercialized space. Diversity encourages new thought, inclusion ensures engagement, and accessibility creates a platform where all can participate. Together, these are key elements that spark innovation and ensure the Agency's ability to generate the best ideas and solutions to novel and unprecedented challenges. To support our Core Value of Inclusion, we will implement a robust and systematic strategy to ensure diversity, equity, inclusion, and accessibility (DEIA) for the benefit of all, internal and external to NASA. In addition to fulfilling presidential directives and executive orders, NASA will continuously promote the incorporation and transformation of DEIA into our culture and business practices at all levels of the Agency.

NASA and the Nation need a diverse and skilled science, technology, engineering, and mathematics (STEM) workforce today and in the future. We are committed to engaging, inspiring, and attracting future generations of explorers and building a diverse future STEM workforce through a broad set of programs, projects, internship opportunities, activities, and products that connect students to NASA's mission, work, and people, whether in-person or virtually.

Competition for top STEM talent, along with other business and professional skillsets needed at NASA, is increasing, and an ever-increasing portion of our current civil service workforce is retirement eligible. Meanwhile, top talent expects hybrid work experiences that allow flexibility around where, when, and how they work best. To address these factors, we will equip our people for the growing exploration, science, and aerospace economy through a focus on innovation, digital skill set development, and increased team agility (through hybrid collaboration tools and other innovations). We will also implement modern human capital solutions and policies to attract, hire, and retain our talented workforce.

NASA also recognizes that a modern physical infrastructure that will foster innovation is key in attracting, retaining, and supporting top talent to meet mission needs and be an employer of choice for years to come. NASA's physical infrastructure and technology support our missions. However, much of NASA's physical infrastructure dates back to the Apollo era and is well beyond design life. We will utilize a mission-driven, technology-enabled approach to ensure critical capabilities and assets

are mission-ready, reliable, and affordable. NASA will also rebuild and right-size our infrastructure and technical capabilities to support hybrid work environments, accessibility, environmental stewardship, and sustainability.

NASA will transform and modernize our mission support capabilities to address rapidly changing information technology (IT), tools, expanding data collection, analysis and dissemination, and evolving cybersecurity threats. Digital technologies will improve the way that we work and collaborate internally and with our partners, increasing the effectiveness of our business processes and delivering better experiences and more value to our customers. NASA will continue pursuit of robotic process automation, data-driven decision lenses, enhanced cloud offerings and artificial intelligence at scale where possible while ensuring security, credentialing, and privacy standards are maintained. Improvements to NASA's cybersecurity measures, including new applications, encryption, and IT infrastructure, will protect vital assets against threats from malicious actors. As technology's role in the workplace continues to expand with a hybrid workforce, NASA's IT services are vital to enabling and protecting the Agency's work.

NASA already published tens of thousands of [data-sets](#), numerous open-sourced code [projects](#), and [data](#) in other forms, including imagery, that is readily accessible for application developers. NASA will work to provide equitable access to datasets and other NASA-developed information, including addressing barriers and biases that may make access difficult for people from underserved groups and users that have not traditionally used NASA data . Democratizing data enables teachers, students, researchers, and other Government agencies to promote data literacy, data driven decision making, and the sharing of best practices.

In alignment with our Core Values, assuring safety, security, and mission success remains an Agency priority, especially as mission complexity and integration with industry increases, and as the aerospace environment in which we operate rapidly changes. We will focus on evolving our safety, health and medical, and engineering oversight policies and practices to protect the Agency, public, and orbital and planetary environments from potential harm, while reaching mission success through innovative technical excellence.

NASA will maintain and enhance our mission support capabilities that enable us to engage in mu-

tually beneficial partnerships with other Federal agencies, U.S. industry, academia, nonprofit organizations, state and local Governments, and international entities that contribute to and support the Agency's Strategic Objectives and Mission.

Finally, NASA is committed to inspiring an informed society by engaging the broadest audience possible, connecting with audiences outside of our traditional space community to expand the awareness of space, and effectively tell the stories that bring focus to our work, people, and value in everyday life.

### **Maintaining America's Global Standing**

NASA's contributions to the Nation's leadership in science, exploration, discovery, and innovation have been enabled by the foundation of mission support services and infrastructure created by NASA.

### **Addressing Climate Change**

NASA will continue to implement and improve sustainable best practices and outcomes in the management of our facilities, fleet, and cross-cutting operations, as well as our compliance with environmental laws. The NASA Mission Support Directorate and Office of Strategic Infrastructure will play key roles in the implementation of the [NASA Climate Action Plan](#). NASA is developing an Agency Resilience Framework that will include adaptation to climate change. The framework will be integrated into the Agency Master Plan and Center Master Plans. The Agency Resilience Framework will provide guidance for development of Center Resilience Plans that will include a process for identifying threats, vulnerabilities, and risks; developing adaptation strategies; and prioritizing adaptation actions.

NASA will continue to invest in data management and collaboration capabilities to support collection, storage, processing, and appropriate sharing of information internally and externally to enable climate change analysis. We are dedicated to minimizing our mission and operational impacts on the environment and our use of natural resources. To ensure we uphold these high standards, share best practices, and promote transparency, we will continue to publish and implement NASA's annual [Sustainability Report and Implementation Plan](#) and other climate data.

### **Promoting Racial and Economic Equity**

The NASA Office of Diversity and Equal Opportunity will work with all NASA Mission Directorates to help identify current barriers to and opportunities

for advancing environmental justice, as well as potential partnership opportunities with organizations currently working on environmental issues. Through these efforts, we seek the fair treatment and meaningful involvement of all people regardless of race, color, ethnicity, gender, national origin, or income with respect to the development, implementation, and advancement of policies, knowledge, solutions, collaborations, partnerships, and the mitigation where possible of the effects of climate change on all people to which people are entitled under Title VI of the Civil Rights Act of 1964.

Through our [STEM Engagement strategy](#), NASA will support student learning experiences and dedicated competitive opportunities for climate research capacity building at minority-serving institutions. Additionally, the STEM Engagement Internship program will support NASA climate change researchers through mentor-guided student intern experiences.



# Strategic Objective 4.1

## Attract and develop a talented and diverse workforce.

Cultivate a diverse, motivated, and highly qualified workforce through modernizing our Human Capital processes and systems, increasing our workforce agility and flexibilities, and implementing a robust Diversity, Equity, Inclusion, and Accessibility (DEIA) approach to ensure systematic and sustainable fairness, impartiality, and equity in our business practices.

### Lead Office

Mission Support Directorate (MSD) and the Office of Diversity and Equal Opportunity

### Objective Overview

NASA will modernize how we attract, hire, support, lead, and retain the quality, diversity, and depth of talent necessary for mission success. Recent experiences and lessons from the pandemic, as well as nationwide workforce and workplace trends, will inform and help NASA institutionalize and improve our hybrid work practices. NASA's modernization strategy will also address other factors such as an increasing number of retire-

ment-eligible civil servants over the next five years and increasing competition for highly qualified science, technology, engineering, and mathematics (STEM) talent, especially as more commercial entities enter the field.

While NASA has long enjoyed a reputation of attracting top talent; we recognize the value of recruiting and employing a diverse workforce cannot be understated. The Agency is better positioned to fulfill its current and future missions when we intentionally invite people with different backgrounds, who show promise and potential, into spaces to inspire and challenge us to think and work differently.

Below: Diana Trujillo, an aerospace engineer, is Technical Group Supervisor for Sequence Planning and Execution and a Tactical Mission Lead for the Mars Perseverance rover. Born and raised in Colombia, Trujillo immigrated to the United States at the age of 17 to pursue her dream of working for NASA. In this photograph, Trujillo celebrates the completion of a successful shift as flight director. She is pointing at an image taken by the Perseverance Rover on the surface of Mars of the successful deployment of Ingenuity, the first helicopter ever delivered to the surface of another planet. Image Credit: NASA





In 2020, NASA added Inclusion to our Core Values, recognizing that inclusion is intrinsic to our work, our relationships, and our achievements. Inclusion increases collaboration and productivity. Additionally, it encourages employees to go above-and-beyond to achieve our goals. Also, all people want to feel a sense of inclusion and belonging. Inclusion happens when people can have psychological safety in being their authentic selves, sharing their ideas, knowledge, creativity, and innovation. The combination of all our values and the emphasis on Inclusion lets NASA strive to have a healthy culture and be an employer of choice.

### Objective Strategy

NASA will continue to instill DEIA and other human capital best practices to modernize how we hire, retain, and develop our distributed and digitally enabled workforce. NASA will continuously improve our hiring and onboarding processes to enable our managers and human capital professionals to employ the right people, when and where they are needed to meet mission needs today and in the future. We will develop our people to meet evolving mission needs through increasing partnership opportunities with academia, and others, as well as through experiential rotations and meaningful leadership development assignments.

NASA will cultivate a workforce that is more agile and responsive to changing skill demands and requirements. Through effective and strategic workforce planning we will align workforce requirements directly to the Agency's Strategic Plan. In addition, we will identify gaps between competencies the workforce currently possesses and future requirements. Lastly, we will identify and implement gap reduction strategies such as: continuing to use contractors and term-limited appointments, leveraging NASA Excepted Employment appointments or temporary workers to meet current specific mission requirements, and ensuring we maintain a stable workforce to meet future demands. We will use Agency-specific direct hiring and term appointment authorities for the civil servant workforce to provide us the flexibility to optimally align competency and skill requirements to future mission needs.

We will transform our culture, policies, and tools to foster productive hybrid work environments that help NASA attract and retain a diverse, motivated, and highly qualified workforce. Informed by lessons learned from the pandemic and nationwide workforce and workplace trends, our remote work and telework options will be balanced now and in the future, to promote inclusive teams that incorporate



In support of the Administration's Executive Orders concerning DEIA, NASA will enhance our capabilities to identify barriers and mitigate their negative impacts on increasing diversity and inclusion, engaging underserved populations, and advancing environmental justice.

multiple gender and racial identities, include diverse professional and education experiences, and lead to a greater diversity of thought which enables our workforce to provide premier support to our aerospace, science, technology, and exploration missions.

NASA enthusiastically supports the Administration's emphasis on DEIA to address social and political issues that need national and local attention and solutions. NASA is committed to inspiring and facilitating an environment in which DEIA standards are expected in our operations. To that end, our multi-prong strategy includes:

- Committing the Agency to action that fulfills Presidential directives (e.g., Executive Orders (see Appendix E), memoranda, etc.) and other Federal guidance and/or policies;
- Sustaining creative engagement to inspire and promote incorporation and transformation of DEIA in our culture and customary business practices at the Agency, Center, organization, and individual levels;
- Continuing our cross-collaborations with other agencies, such as the Equal Employment Opportunity Commission, Department of Justice, and the Office of Personnel Management for DEIA policy guidance, and reaching out to the

Department of Homeland Security and the Department of Defense to benchmark best practices in DEIA, and;

- Updating performance goals beginning in FY 2022 to align with this Strategic Objective.

### **Alignment with Federal Workforce and DEIA Priorities, and Related Executive Orders**

NASA will align human capital practices to support the strategies outlined in the President's Management Agenda, place DEIA as a central norm of the workplace, and support Executive Orders concerning DEIA. Our programs seek to address under-representation based on race, ethnicity, gender identity, sexual orientation, tribal affiliation, and socioeconomics.

The Agency has already begun revising and updating its internal policies and guidelines, including a NASA Policy Statement on DEIA will enable NASA to achieve several objectives, including:

- Reinforcing NASA's historical commitment to improve DEIA;
- Providing notification to NASA employees of their DEIA rights and responsibilities;
- Taking proactive steps to prevent discrimination, retaliation, and harassment in order to avoid and mitigate legal liability; and
- Complying with the U.S. Equal Employment Opportunity Commission's Management Directive 715 requirement for the annual issuance of an equal employment opportunity policy statement by the head of each agency.

NASA will evaluate the current state of DEIA across the Agency and the workforce, and subsequently prepare an Agency DEIA Plan. This will also be followed by annual reports on the status of Agency efforts as required in Executive Order 14035 and includes efforts to incorporate guidance set forth by OMB. Working in concert with OMB, other Government agencies, and councils organized by the Administration, we seek to be a leading partner with other Government counterparts. A cornerstone of this planning will be collecting and analyzing comprehensive data, or leveraging existing data, related to diversity in overall workforce composition, senior workforce composition, employment applications, hiring decisions and applicant flow, promotions, pay and compensation, professional development programs, and attrition.

NASA believes that focusing a portion of recruitment efforts on early careerists and offering more remote and telework options will attract new, diverse applicant markets. We will also seek to understand the expectations and needs across our five generations of workers to maximize the use of programs such as term-limited employment that can tap part time, job-sharing options for those not seeking full-time employment, and our phased retirement and Emeritus programs to maximize knowledge transfer and mentoring from our senior careerists more fully. In addition, we are expanding internal job rotation and detail assignments by creating more "virtual/remote" opportunities that do not require physical relocation to provide broader career development opportunities across all Centers. Finally, we will expand our ability to understand workforce perspectives in real time by implementing ongoing pulse surveys, analyzing data from new-hire, Federal Employee Viewpoint Survey, and exit surveys, and piloting new techniques such as chatbots.

NASA will also implement or increase the availability and use of DEIA training programs for employees, managers, and leadership. Such training programs should enable knowledge of systemic and institutional racism and bias against underserved communities, provide support in building skillsets to promote respectful and inclusive workplaces and eliminate workplace harassment, and increase understanding of implicit and unconscious bias, the effects and impact of privilege, historic discrimination, and misrepresentation.

### **Contributing Programs and/or Program Activities**

Mission Enabling Services.

# Strategic Objective 4.2

## Transform mission support capabilities for the next era of aerospace.

Re-build, modernize, and right-size NASA's mission enabling capabilities to ensure mission readiness and cultivate a reliable foundation for the future innovations in aerospace and science.

### Lead Office

Mission Support Directorate (MSD)

### Objective Overview

As NASA's missions evolve and increasingly integrate with industry, and hybrid workforces and workplaces become the norm, mission support requirements will change. In alignment with NASA's Core Values, mission support's top priority is ensuring mission success—safely and securely. This is increasingly challenging with the growing complexity of our missions. Much of NASA's infrastructure is from the Apollo-era. It is time to re-build, modernize, and right-size NASA's mission-enabling capabilities.

To advance an environment of inclusion, integrity, teamwork, and excellence required for the Arte-

mis era, we must strengthen our technical authorities and modernize our physical and information technology (IT) infrastructure. NASA will focus on the following three priority areas:

- Strengthen NASA's Agency Technical Authorities
- Modernize infrastructure and technical capabilities
- Support our workforce and programs with secure, innovative technology

### Objective Strategy

**Strengthen NASA's Agency Technical Authorities** - *Protect the Agency, public, and orbital and planetary environments from potential harm, while reaching mission success through innovative technical excellence.*

Below: Chief of the Test, Launch and Recovery Operations Branch within the Exploration Ground Systems Program Jeremy Graeber, (left) and Artemis I Launch Director Charlie Blackwell-Thompson (right), along with civil servant and contractor members of the Artemis I launch team, monitor activities during the ninth formal terminal countdown simulation inside Firing Room 1 in the Launch Control Center at NASA's Kennedy Space Center in Florida on June 24, 2021. This is part of a series of simulations to help the team prepare for the launch of Artemis I, the uncrewed first flight of the Space Launch System rocket and Orion spacecraft. Image credit: NASA/Kim Shiflett







With increasing mission complexity and a rapidly changing aerospace industry, NASA must evolve policies and practices that continue to protect the health and safety of our workforce and the public. NASA must also mitigate the technical risk to our missions and the space environment. NASA's Agency Technical Authorities advise Agency leaders and partners on programmatic and technical readiness and risk to ensure mission success. They must have the tools to ensure safety, security, and technical excellence objectives are met. The Agency Technical Authority role remains crucial and will play an important role in NASA's future missions, partnerships, and status as a leader in aerospace.

NASA is evolving mission enabling and oversight capabilities to successfully implement our missions in human exploration, climate research, and other objectives. Specifically, NASA will:

- Advance our ability to identify and mitigate new risks to personnel, both on the ground and in flight, as we continue to provide innovative support capabilities in aerospace, science, technology, and exploration to both protect and enhance performance across our entire workforce and our partners.
- Modernize our policies, standards, tools, and expertise to ensure that health and safety, security, and mission assurance practices are adaptable and woven into the design and development of increasingly complex missions and operations by NASA and its partners.
- Increase organizational resilience by assuring success through independent assessments and evaluations of mission threats through the development and dissemination of mitigation strategies.
- Continue to foster relationships with other Government agencies, such as the Federal Aviation Administration and Space Force, industry leaders, and international partners through interagency, Government-industry, and international working groups and committees aimed at the advancement of space industry practices, reduction of risk by implementing medical policy related to spaceflight, and state-of-the-art advances in aviation and spaceflight health and performance.

**Modernize infrastructure and technical capabilities** - *Rebuild and right-size NASA's infrastructure and technical capabilities to advance the Nation's science and aerospace leadership, while supporting environ-*



A Marshall Space Flight Center transportation specialist stands alongside two new, fully electric cars using Marshall's 240-volt charging station. NASA is acquiring zero emission vehicles (ZEV) and charging infrastructure to reduce greenhouse gas emissions in our fleet operations and align with the President's goal of achieving a fully ZEV Federal fleet.

*mental stewardship, sustainability, and enhancing resource conservation efforts.*

Resilient and ready infrastructure is critical for mission success. Much of NASA's current infrastructure dates back to Apollo-era space exploration, with 83 percent of facilities beyond design life. The demands on the NASA infrastructure continue to increase as our commercial partnerships increase and our missions become more complex. NASA will prioritize and transform our asset management to ensure that our mission critical infrastructure and facilities are available and reliable in the Artemis era and beyond.

Guided by our Agency Master Planning process, we are taking an Agency-wide and mission-driven approach to ensure critical capabilities and assets are mission-ready, reliable, and affordable. At the same time, we are investing in the long-term asset health, sustainability, and physical footprint reductions that ensure NASA's future mission success. This mission-driven approach, utilizing data-driven and risk-informed methodologies, will ensure that NASA prioritizes sustainment and investment in mission critical infrastructure, divestment of unneeded infrastructure, and the leasing of assets to commercial partners where practical. We will continue our right-sizing efforts by demolishing and eliminating obsolete facilities to reduce our overall physical footprint, resource consumption, maintenance costs, and aging infrastructure risk, as well as enable our ability to re-new and rebuild modern



and sustainable infrastructure to support future mission success.

We will also continue to implement and improve sustainable best practices and outcomes in the management of our facilities, fleet, and cross-cutting operations, as well as our compliance with environmental laws. NASA is committed to sustained (year-over-year) reduction of our overall energy and water consumption. By identifying and quantifying facilities which are significant energy users and developing initiatives to reduce energy and water consumption in these facilities, eliminating unneeded and redundant facilities, and reducing our carbon footprint as we transform to increasingly hybrid work environments and fully transition to a zero-emission vehicle Federal fleet.

NASA will establish, implement, and manage an Agency-level plan to better align aircraft operational capabilities with NASA mission requirements across the Agency, strategically manage our aircraft capabilities to meet long-term Agency needs, and support NASA's leadership in aerospace and science. The domain of this plan includes NASA aircraft, associated infrastructure, support equipment, Unmanned Aircraft Systems, and the acquisition of Commercial Aircraft Services. This more robust, responsive, and agile approach to aircraft capability management and development will enable the Agency to optimally deploy aircraft capabilities and resources when and where needed, prioritize sustainment of current NASA aircraft capabilities, and support investment and divestment decisions. It will also empower the Agency to better leverage commercial and other Government aircraft capabilities to support achievement of NASA strategic goals and objectives.

**Support our workforce and programs with secure, innovative technology** - *Address rapidly changing IT, expanding data collections, and increasing cybersecurity threats*

NASA depends heavily on secure digital processes, technology, and accessible data to achieve mission success. The Agency will transform business processes, IT, and data management to effectively meet our mission needs, while keeping pace with evolving technologies and threats. Strengthened engagement between our IT organization and our customers will lead to a shared understanding of IT needs, and evaluation of customer satisfaction will determine if those needs were met. NASA will focus on consistent IT service delivery, reliable operations, expanded digital capabilities, and pro-

active and resilient cybersecurity, all supported by engaged, customer-focused IT teams.

This transformation will depend on the harmonization of business practices across NASA's centers to reach effectiveness and efficiency goals. Timely, secure data sharing and support for the Agency's partnerships with industry remain critical to the success of NASA's missions. Modernization of the Agency's IT infrastructure will enable seamless, reliable, and secure collaboration across NASA's workforce and partners and will foster innovation in our expanding digital environment.

As IT evolves globally, cybersecurity threats are increasing in frequency and sophistication. This trend has the potential to exploit the complexity and interconnectedness of NASA's systems and data, placing the Agency's missions at risk. We will reinforce our operational resilience through strategic cybersecurity risk management and by modernizing IT capabilities. We will support our geographically hybrid workforce seamlessly and securely while strengthening the security and privacy of our data. NASA's transition to an enterprise operating model for IT will amplify these outcomes by strengthening customer engagement, service planning and delivery, and cost-effective management.

### **Contributing Programs and/or Program Activities**

Priority Area 1: Agency Technical Authority; Center Engineering, Safety, & Operations

Priority Area 2: Infrastructure & Technical Capabilities; Exploration Construction of Facilities (CoF); Institutional CoF; Science CoF; Space Operations CoF; Environmental Compliance and Restoration

Priority Area 3: Information Technology

Contributing Support Program: Mission Enabling Services



# Strategic Objective 4.3

## Build the next generation of explorers.

Engage students to build a diverse future STEM workforce.

### Lead Office

Office of Science, Technology, Engineering, and Mathematics (STEM) Engagement (OSTEM)

### Objective Overview

NASA makes vital investments toward building a diverse STEM workforce. The scope of our STEM engagement comprises all endeavors to attract, engage, and educate students and to support educators and educational institutions.

Given the Nation's need for a skilled STEM workforce and projected demand, NASA clearly has a vested interest in attracting, engaging, and preparing its future STEM professionals. The national STEM ecosystem will benefit from NASA contributions to attract and retain students on STEM pathways, with increased attention on underserved and underrepresented students. Recent national and international tests show that in the last decade, U.S. students have demonstrated little or no

growth in mathematics and remain ranked in the middle of advanced economies on international science and mathematics assessments.<sup>1</sup>

NASA will implement strategies to broaden student participation to increase diversity, equity, inclusion, and accessibility (DEIA) in STEM through NASA opportunities and activities. While the number of women and underrepresented minorities earning STEM degrees has grown in broad science and engineering occupations over the last decade, significant underrepresentation remains in areas critical to NASA like engineering and computer and mathematical sciences.<sup>2</sup> NASA is committed to building a diverse, skilled future STEM workforce—our next generation of explorers with the technical skills needed to carry forward our Nation's vital mission and work in aeronautics and space into the future.

<sup>1</sup> Science Board, National Science Foundation. 2020. Science and Engineering Indicators 2020: The State of U.S Science and Engineering. NSB-2020-1. <https://nces.nsf.gov/pubs/nsb20201/>

<sup>2</sup> National Science Foundation, National Center for Science and Engineering Statistics. 2019. Women, Minorities, and Persons with Disabilities in Science and Engineering: 2019. [Special Report NSF 19-304](#).

Below: Student Launch provides a research-based, competitive experiential exploration opportunity for university, middle and high school student teams across the nation. One of NASA's Artemis Student Challenges aimed to engage students in NASA's work in science and exploration, Student Launch challenges student teams to design, build and fly a high-powered rocket containing a science or engineering payload. Image Credit: NASA



## Objective Strategy

NASA is committed to engaging students in its mission, with the aim to immerse students in NASA's work and inspire the next generation to explore. To that end, NASA will continue to make vital contributions in STEM engagement. NASA's work in STEM Engagement is a collaborative endeavor which encompasses efforts across the OSTEM, the Mission Directorates, and the Field Centers.

We will sustain our track record of inspiring, attracting, and engaging students through a strategy that will support Federal STEM education priorities and drive Agency efforts to:

- Attract diverse groups of students to STEM through learning opportunities that spark interest and provide connections to NASA's mission and work;
- Create unique opportunities for a diverse set of students to contribute to NASA's work in exploration and discovery; and
- Build a diverse future STEM workforce by engaging students in authentic learning experiences with NASA's people, content, and facilities

This strategy is also centered on five design principles to guide the planning and execution of the Agency's efforts: (1) developing and deploying mission-driven authentic STEM experiences, (2) using evidence-based practices, (3) driving scalability, (4) measuring outcomes, and (5) focusing on DEIA.

NASA will implement STEM engagement initiatives, programs, and activities that serve students, and provide unique support to educators and educational institutions. NASA's STEM engagement efforts are ultimately focused on attracting, retaining, and supporting students on STEM pathways. Recognizing that attracting students to STEM is the foundation of a successful model to build a diverse future STEM workforce, we will place a focus on evidence-based opportunities that attract students, leveraging our unique and exciting mission and work. We will provide mission-driven student opportunities and activities along the continuum of STEM pathways; immersive, experiential learning experiences that lead to STEM academic pursuits; and extra-curricular and work experiences that support higher education students in preparation for successful workforce entry. The scope of student opportunities includes challenges and competitions, NASA-unique learning opportunities, educational products, and work experiences including internships and fellowships.



Hawaii Space Flight Laboratory undergraduate students, summer interns and engineers integrating the Neutron-1 3-U CubeSat in a cleanroom. NASA Space Grant, MUREP, and EPSCoR will continue to fund a wide spectrum of competitive student and institutional research opportunities to enable contributions to NASA's work in science and exploration. Image Credit: University of Hawaii at Manoa

Moving ahead, NASA will drive progress to expand student work experiences, anchored to the Agency's missions and programmatic work with mentors from the technical workforce. This includes enhancing the internships program, with objectives to broaden and enrich student participation.

In addition to a broad portfolio of efforts dedicated to students, NASA will support educators and educational institutions. This includes providing mission-unique content, resources, and support to educators; contributing to classroom and out-of-school learning experiences; building capacity at minority-serving institutions (MSIs) and within jurisdictions that have not participated equitably in competitive aerospace and aerospace-related research activities; creating informal educational opportunities for learning and programs; and enabling mission-driven research for students and institutions.

NASA will continue to magnify reach and impact through strategic partnerships. To facilitate intentional design of opportunities that meet needs and to scale distribution, we will leverage networks and build connections within the national STEM education ecosystem. We will also develop educational tools and platforms to significantly enhance the digital footprint to better reach students and educators.

NASA is placing an intense focus on broadening student participation, with concerted efforts toward engaging more underserved and underrepresented students in NASA STEM engagement programs and activities. To accomplish this, NASA will:

- Enhance communications and stakeholder engagement to build networks and relationships;
- Strengthen practices and systems;
- Build a solid foundation for a focus on metrics and evaluation to effectively measure progress, and;
- Create a culture and drive a collective focus across NASA's STEM engagement community on broadening student participation, and foster a commitment to DEIA in student opportunities and programs.

NASA is committed to an evidence-driven model and will continue to engage in evidence-building activities specifically focused on underserved and underrepresented students and communities using a comprehensive performance assessment and evaluation framework. The framework includes a learning agenda and an evidence-based decision-making process that engages both internal and external stakeholder audiences.

NASA is well positioned within the Nation's STEM ecosystem to collaborate with other Federal agencies, state and local Government, industry, institutions, and the non-profit sector to contribute to a shared goal of a globally competitive workforce. Our unique contributions are vital to attract and build a vibrant and diverse next generation STEM workforce that will continue the Nation's legacy of exploration and discovery. To execute our STEM engagement efforts, we will leverage our community of talented and dedicated education professionals and its technical workforce, who together can inspire and engage youth and students in STEM.

NASA conducts STEM engagement efforts through a diverse portfolio of opportunities, activities, products, and resources for students, educators, and educational institutions. OSTEM is responsible for the strategic direction, operational integration, and assessment and evaluation of STEM engagement. OSTEM implements the STEM Engagement Program, consisting of four projects: the National Space Grant College and Fellowship Project (Space Grant); Minority University Research and Education Project (MUREP); Established Program to Stimulate Competitive Research (EPSCoR); and Next Generation STEM project (Next Gen STEM). NASA Mission

Directorates create opportunities for students to actively engage in NASA's work. These include mission-driven learning opportunities, challenges and competitions, work experiences, and competitive student research opportunities.

NASA will continue to make strategic investments in STEM engagement. NASA implements Space Grant, a national network of colleges and universities with over 1,000 affiliate institutions and organizations working to expand opportunities for students to participate in NASA's aeronautics and space projects. Space Grant is made up of 52 consortia located in all 50 states, the District of Columbia, and Puerto Rico. Moving forward, Space Grant will continue to provide valuable learning experiences for undergraduate and graduate students and build delivery of experiential opportunities for middle and high school students.

NASA EPSCoR establishes partnerships with Government, higher education, and industry that are designed to drive sustainable improvements in research and development capacity and competitiveness in eligible jurisdictions.

MUREP provides support via competitive opportunities and awards to MSIs. MUREP investments enhance the research, academic, and technology capabilities of MSIs through multiyear cooperative agreements, bolstering their capacity in educating and preparing students for STEM careers. MUREP will continue to expand competitive opportunities to address specific gaps needs while building capacity at institutions.

Next Gen STEM develops and deploys evidence-based STEM learning opportunities that provide a platform for students to learn via NASA's endeavors in exploration and discovery. Through Next Gen STEM, NASA makes vital investments in K-12 and informal education. This includes competitive awards to the Museum and Informal Education Alliance, comprised of more than 2,000 member organizations, including museums, science centers, parks, libraries, planetariums, nature centers, and after-school groups. Looking ahead, Next Gen STEM will strengthen efforts to engage K-12 students, build networks within the formal education ecosystem, engage educators through the NASA CONNECT community of practice, train NASA STEM experts to expand work with students, and expand challenges and competitions to broaden student participation.

NASA will continue to build collaborative efforts and facilitate connections to better serve stu-



dents and educators. The Mission Directorates will continue to create mission-centered learning opportunities and drive student contributions to NASA's work. The Aeronautics Research Mission Directorate in collaboration with MUREP, will offer unique research opportunities in critical challenges facing aviation, while efforts with Space Grant will increase award opportunities to university students proposing entrepreneurial solutions to make aviation more sustainable. Partnership efforts between the Earth Sciences Division and MUREP will foster MSI contributions and build capacity in climate change research. NASA will cultivate broadened participation from underserved communities through connections between existing networks to programs such as Science Mission Directorate's Science Activation, which supports a cooperative network of competitively selected teams that work together to connect NASA science experts, unique content, and authentic experiences with diverse communities across the Nation. In addition, efforts to build connections between the Global Learning and Observations to Benefit the Environment Program and NASA STEM engagement networks will broaden student contributions to understanding the Earth system and climate change. Finally, OSTEM and the Mission Directorates will expand collaborations to enable student contributions to NASA's missions, building upon Artemis Student Challenges, the Breakthrough, Innovative and Game-Changing Idea Challenge, and the University Student Research Challenge.

NASA's STEM workforce demonstrates a unique level of dedication to building the next generation of explorers. In addition to OSTEM, NASA Mission Directorates and their programs, as well as the STEM disciplinary organizations, provide exciting student opportunities and access to NASA's STEM professionals and their expertise.

NASA's compelling and exciting STEM engagement opportunities and efforts will inspire students to reach for the stars and build our Nation's next generation of explorers.

### How NASA Engages and Works with Partners

NASA has a rich history of collaborating across the Nation's STEM ecosystem to foster innovative student learning experiences that leverage our unique mission, people, and facilities. NASA collaborates with partners to:

- Engage students across the United States in opportunities connected to our missions,

themes and STEM engagement efforts;

- Foster innovative models, methods, or approaches tied to national and Agency STEM education goals; and
- Broaden participation of students from groups traditionally underrepresented in STEM.

We conduct strategic partnerships with a wide range of external STEM engagement stakeholder organizations through formal Space Act Agreements. Generally, these provide unfunded collaborators with access to NASA mission data and imagery, subject matter expertise in scientific and technical disciplines connected to our Mission, and support with curation of NASA education resources, products, and materials. Through these efforts, we coordinate with industry, educational institutions, and non-profit organizations to support development of high-quality opportunities for both youth outside of the classroom and students in pre-kindergarten through graduate school.

NASA also works in partnership with other Federal agencies to coordinate efforts and to collaborate on specific initiatives. For example, NASA works with the U.S. Department of Education to provide students with access to scientific and technical mentors and equip educators with STEM resources that can be used both inside and outside of the classroom. We also collaborate with the National Science Foundation to advance diversity and inclusion goals through coordination of fellowship programming and undergraduate student engagements.

### Contributing Programs and/or Program Activities

STEM Engagement Program (NASA Space Grant; EPSCoR; MUREP; Next Gen STEM); Mission Enabling Services (Center STEM Engagement).

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# FIELD CENTERS AND FEDERALLY FUNDED RESEARCH AND DEVELOPMENT CENTER STRATEGIC GOAL CONTRIBUTIONS

## **Armstrong Flight Research Center (AFRC)**

### **Strategic Goal 1: Expand Human Knowledge Through New Scientific Discovery.**

AFRC provides specialized aircraft and capabilities to observe Earth's physical processes, test new observing technologies, and calibrate and validate Earth-observing satellites worldwide. AFRC enables improved understanding of our planet and ensures the success of the Science Mission Directorate's (SMD's) Earth Science research—particularly for its Airborne Science Program.

### **Strategic Goal 2: Extend Human Presence to the Moon and onto Mars for Sustainable Long-term Exploration, Development, and Utilization.**

AFRC tailors its risk-based integration, test, airworthiness, and flight safety processes to developmental space exploration projects for NASA in partnership with other Government agencies and industry. Using this process to assess, accept, and communicate the residual risk associated with atmospheric flight research, AFRC is participating in an assessment of suborbital flight providers for the Commercial Crew program. AFRC is also working on landing support of the CST-100 Starliner. AFRC participated in the Human Landing System (HLS) commercial source selection and supports the NASA Crew Office evaluation of HLS training requirements.

### **Strategic Goal 3: Catalyze Economic Growth and Drive Innovation to Address National Challenges.**

AFRC hosts the program management office for Flight Opportunities, which supports commercial space-flight industry maturation and validation of capabilities needed for NASA missions and commercial applications. The program awards flights and agreements to researchers from industry, academia, non-profit research institutes, and Government organizations. These investments advance technologies of interest to NASA, support commercial flight providers, and expand space-based applications and commerce.

AFRC also participates in NASA's Center Innovation Fund, which support emerging technologies and creative initiatives, led by NASA scientists and engineers, but often in partnership with other Centers, other agencies, research laboratories, academia, and private industry.

AFRC is a leader in atmospheric flight research, bringing decades of experience, complex systems integration expertise, unique infrastructure, flight test techniques, and flight test systems to support the demands of a various aeronautics initiatives that leverage flight to perform basic research and validate the results of analysis and ground-based testing.

AFRC enables efficient and sustainable aviation by developing electric aircraft, informing certification standards for advanced air mobility systems, participating in the development and flight tests of the world's first quiet supersonic aircraft to enable a new aviation market, and a new commercial subsonic configuration that will reduce the environmental impact of aviation.

AFRC's unique Dryden Aeronautical Test Range supports diverse missions with comprehensive resources for the control and monitoring of flight activities, including a flight test data portal to ensure retention and availability of critical data.

The Center's world-class airworthiness and flight safety review process enables NASA and partners to conduct high-risk flight activities safely and effectively across subsonic, supersonic, and hypersonic speed regimes.

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Additionally, the AFRC Technology Transfer Office ensures that innovations developed for aeronautics and space are made more broadly available to the public—boosting the U.S. economy and maximizing return on the Nation’s investment in NASA.

**Strategic Goal 4: Enhance Capabilities and Operations to Catalyze Current and Future Mission Success.**

AFRC analyzes potential future Mission Directorate, program, and mission requirements and optimizes Agency capabilities through rigorous flight safety processes. The Center continues to expand recruitment and workforce strategies to reach diverse candidates and build a workforce representative of all segments of society. AFRC’s Office of the Chief Human Capital Officer, in collaboration with the Office of Diversity and Equal Opportunity, Office of Science, Technology, Engineering, and Math (STEM) Engagement, and employee resource groups, develops and promotes training, academic programs, and rewards and recognition approaches that enhance the employee experience, while also building and retaining capabilities for mission success.

AFRC works with the Mission Support Directorate (MSD) to maintain the operating environment, support the locally assigned MSD workforce, and transform mission support operations by leveraging the skills and capacity of the enterprise workforce.

AFRC’s work in STEM engagement is focused on serving students. NASA invests in STEM engagement for students of all levels. AFRC will leverage its community of talented and dedicated education professionals and its technical workforce to inspire and engage youth and build the next generation of explorers.

**Ames Research Center (ARC)**

**Strategic Goal 1: Expand Human Knowledge Through New Scientific Discovery.**

ARC conducts research and technology development in aeronautics, astrobiology, astrophysics, and planetary, biological, and Earth sciences. ARC hosts the NASA’s Mars Climate Modeling Center, the NASA Earth Exchange, the Center for Life Detection, and the Space Biosciences Collaborative. ARC also leads a combined aeronautics and science activity focusing on research, detection, prediction, and mitigation of wildfires.

ARC’s core expertise in autonomy and robotics plays an integral role in the exploration of planetary bodies. ARC leads the development of the Volatiles Investigating Polar Exploration Rover, which will prospect for resources in the lunar South Pole region. ARC develops and tests vertical lift aircraft concepts, such as the Mars helicopter carried on the Mars 2020 Perseverance Rover mission, for operation in different planetary atmospheres.

ARC also manages the Small Spacecraft Technology Program and the Earth Science Project Office for airborne science investigations.

ARC develops, builds, and flies space missions and payloads to study the effects of the space environment on biological systems. The Center has further expertise in infrared, ultraviolet, and visible imaging, neutron spectrometers, X-ray diffraction and fluorescence instruments, biofluidic systems, exoplanet imaging technologies, airborne Earth science instruments, and environmental life support systems.

ARC hosts the Agency’s advanced supercomputing capability and systems, including leading disruptive technologies and data mining systems, with many scientific applications. ARC enables planetary scientific discovery through its aerothermodynamics, thermal protection materials, and arc jet testing capabilities.

**Strategic Goal 2: Extend Human Presence to the Moon and onto Mars for Sustainable Long-term Exploration, Development, and Utilization.**

ARC’s work in life, lunar, and planetary sciences, entry systems technologies, and robotic prospecting missions is crucial to NASA’s effort to send humans back to the Moon and on towards Mars. ARC incorporates microbiological science with spaceflight engineering for SmallSats and other missions to the International Space Station (ISS) and beyond. ARC supports life away from Earth and develops technologies to sustain astronauts on long-duration space travel and presence on the Moon or Mars. ARC hosts NASA’s Solar System Exploration Research Virtual Institute, which engages the scientific community in studying the Moon and other potential destinations.

ARC operates the NASA Arc Jet Complex, the largest and primary facility to test heatshield materials and spacecraft structures in hypervelocity flight conditions, supporting the safety of astronauts in flight. ARC



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operates the world's largest human-in-the loop motion simulator, the Vertical Motion Simulator, to evaluate handling quality and development of human landing systems.

ARC leads Data Systems Integration for Artemis and delivers mission planning systems for current and next-generation Mars surface missions. ARC provides testbeds for developing and validating robotics software that enables increasingly autonomous capabilities for crew support and uncrewed station-keeping and maintenance. ARC fault detection and recovery technologies should help improve the safety of the Space Launch System and Orion.

**Strategic Goal 3: Catalyze Economic Growth and Drive Innovation to Address National Challenges.**

ARC hosts the program management offices for both Small Spacecraft Technology (SST) and Small Business Innovative Research & Small Business Technology Transfer (SBIR/STTR). SST develops and demonstrates new small spacecraft technologies and capabilities for NASA's missions in science, exploration, and space operations. SBIR/STTR funds the research, development, and demonstration of innovative technologies that fulfill NASA needs and have significant potential for successful commercialization.

In addition, ARC supports space technology maturation projects within NASA's Game Changing Development (GCD); participates in the Center Innovation Fund (CIF), supporting emerging technologies and creative initiatives, led by NASA scientists and engineers; and hosts the ARC Technology Transfer Office, ensuring that innovations developed for aeronautics and space are broadly available to the public.

ARC's 30 years of experience in advanced air traffic management systems improves the efficiency and safety of commercial aviation, reducing delays, fuel burn, and greenhouse gas emissions. ARC leverages expertise in system-wide safety, autonomy, artificial intelligence, and transforms the National Airspace Systems to accommodate all vehicle types and complex operations from low altitude to upper atmosphere flight regimes. ARC develops airspace tools to support aerial wildfire suppression.

The Center also conducts research and development of large-scale simulations for sustained atmospheric flight, including aerodynamic performance prediction, vehicle design and shape optimization, noise prediction, fluid-structure interaction, propulsion-airframe integration, and safety analysis. Through the Sustainable Flight National Partnership, ARC serves in a critical vertical flight research role for Advanced Air Mobility systems analysis and testing capabilities.

ARC operates the Transonic Wind Tunnels, used for evaluating new aircraft configurations for commercial and military applications as well as the launch abort systems for the Artemis program, and the Unitary Plan Wind Tunnel. Additionally, ARC operates the Vertical Motion Simulator, Air Traffic Control Laboratory, Airspace Operation Laboratory, and Future Flight Central to provide realistic environments for air traffic and airspace management research and to study human systems performance, human and machine interactions, and future aviation safety challenges.

ARC hosts the NASA Aeronautics Research Institute (NARI) that was established by NASA ARMD in 2012 to promote innovation in aeronautics to address challenges in the Nation's air transportation system, facilitate partnerships with the Federal Aviation Administration, other agencies, academia, and the commercial and emerging aviation industry, and inspire cross-Center activities. NARI advances the future of aeronautics by listening to stakeholders and recommending opportunities for game-changing technologies.

**Strategic Goal 4: Enhance Capabilities and Operations to Catalyze Current and Future Mission Success.**

ARC manages and operates several unique research and testing facilities, including the Arc Jet Complex for simulating hypervelocity flight conditions and the NASA Advanced Supercomputing Facility, which hosts several eco-friendly, multi-petaflop supercomputers to meet NASA's high-performance computing needs.

ARC serves as the nerve Center for securing NASA's information technology infrastructure. It co-hosts the NASA Security Operations Center with Johnson Space Center to protect more than 100,000 devices and users.

ARC provides support and resources to educators and institutions to effectively engage students. ARC leverages its community of talented and dedicated education professionals and its technical workforce to inspire and engage students in STEM and build the next generation of explorers.

ARC strives to ensure mission success by enabling a positive environment that values diversity, equity, inclusion, and accessibility. ARC aims to attract, fully utilize, and retain the best talent to achieve its mission.

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ARC must be viewed as an employer of choice with a diverse workforce.

ARC hosts the NASA Research Park, which includes tenants from other Government agencies, academia, and innovative private-sector entities, enabling a research and development ecosystem and partnership for current and future NASA missions.

## **Glenn Research Center (GRC)**

### **Strategic Goal 1: Expand Human Knowledge Through New Scientific Discovery.**

GRC's contributions to power and propulsion systems, materials and structures, and space environment research ensure that NASA maximizes the scientific knowledge gained from robotic missions and advances new capabilities for future exploration.

GRC provides radioisotope power and electric propulsion systems, including the development of a next-generation radioisotope thermal generator, to ensure the success of current and future robotic planetary science missions. The Center's expertise in materials and structures, as well as unique space environment test facilities, are applied to develop and test electronics, scientific instruments, and other payloads for operation in the extreme environments of space.

As a global leader in microgravity research, GRC collaborates with academia, other Government agencies, and industry to drive research in microgravity combustion, fluid physics, and soft matter dynamics. This research spans new concepts, testing in unique environmental test facilities, and conducting experiments on the ISS.

### **Strategic Goal 2: Extend Human Presence to the Moon and on towards Mars for Sustainable Long-term Exploration, Development, and Utilization.**

GRC leads the development of electric propulsion and power systems technology for exploration of the Moon and on towards Mars, including the Power and Propulsion Element, a key component of the Gateway, which will serve as a multi-purpose outpost for Lunar exploration. GRC is also leading the integration of the European Service Module, the primary power and propulsion component for the Orion crew vehicle, to ensure the success of Artemis missions.

GRC is also developing technologies that will enable sustained exploration of the Lunar surface, human missions to Mars, and other deep space destinations. Space nuclear power is one essential capability, including nuclear electric propulsion for in-space transportation, and fission surface power technology for operation on the surface of the Moon and Mars.

The Center is also leading NASA efforts to evaluate and integrate commercially provided satellite communications capabilities for future missions in low Earth orbit and beyond.

To support the growing commercial space economy, GRC collaborates with industry, academia, and other Government agencies to commercialize NASA technology and form public-private partnerships for mutual benefit. Unique, full-scale space environment test facilities at Lewis Field and Armstrong Test Facility are supporting both Government and commercial systems development.

### **Strategic Goal 3: Catalyze Economic Growth and Drive Innovation to Address National Challenges.**

GRC conducts research and technology development for aerospace power, propulsion, and communications technologies from the conceptual stage through flight demonstration in collaboration with industry, academia, and other partners.

GRC is developing in-situ resource utilization concepts and technologies that will enable the use of natural resources in space for sustainable human exploration. GRC leads the demonstration of cryogenic fluid management technologies that will enable future deep space exploration architectures.

With an emphasis on these technology areas, GRC supports maturation projects within NASA's GCD. In addition, GRC leads the Solar Electric Propulsion Project and the Fission Surface Power Project for NASA's Technology Demonstration Missions (TDM). GRC also participates in NASA's CIF, which supports emerging technologies and creative initiatives led by NASA scientists and engineers.

GRC collaborates with industry to address the challenges of next-generation commercial aviation, including the next single-aisle aircraft and emerging Advanced Air Mobility markets. This work includes hybrid-electric power and propulsion systems, components, and technologies, to meet sustainable aviation goals and de-

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velop electrified propulsion systems. GRC provides expertise and capabilities to demonstrate these technologies through extensive ground testing and flight demonstrations.

GRC leads research and technology development for advanced airbreathing propulsion systems of supersonic and hypersonic aircraft. The Center is also developing communications technologies to integrate future advanced vehicles into the airspace to transform the aviation industry.

GRC continues its long history of delivering innovative technologies and concepts to enable a pathway towards zero-emission aircraft, including materials and structures, sustainable fuels, advanced manufacturing, and power generation and storage.

Additionally, the GRC Technology Transfer Office ensures that innovations developed for aeronautics and space are made more broadly available to the public.

**Strategic Goal 4: Enhance Capabilities and Operations to Catalyze Current and Future Mission Success.**

GRC develops and sustains integrated unique capabilities (expertise, laboratories, test facilities, and digital platforms) in propulsion, power, communications, materials and structures, cryogenic fluids, physical and biological sciences to support current and future science missions, human exploration space technology development, and aeronautics research. These capabilities support a broad portfolio of work including early-stage research, technology development, demonstrations, and aerospace flight system development. The GRC capabilities will increasingly integrate and leverage new digital capabilities and platforms to transform the way that NASA designs, develops, tests, and evaluates new technologies and flight systems.

GRC takes action to attract, develop, and retain a diverse workforce that reflects societal demographics and emphasizes equity, inclusion, and accessibility. The Center will continue to evolve with increased workforce flexibility and agility, including enhanced capabilities to work across different office, laboratory, and remote work environments to meet current and future NASA mission needs.

GRC leverages NASA mission support capabilities to ensure integration of efficient operations, communications, financial management, procurement, infrastructure management, legal services, occupational safety and health programs, information technology, and other services to deliver on current and future commitments.

## **Goddard Space Flight Center (GSFC)**

**Strategic Goal 1: Expand Human Knowledge Through New Scientific Discovery.**

GSFC enables and conducts science research from space. The Center's measurements, modeling, and theoretical investigations in the areas of Earth science, planetary and lunar science, heliophysics, and astrophysics expand knowledge, national capability, and opportunities for collaboration on a variety of flight missions and field campaigns. GSFC teams work with other NASA Centers, academia, and industry to conceptualize, design, build, test, integrate, and operate space-based, airborne, and ground-based missions, spacecraft, and state-of-the-art instruments.

The Center's renowned, in-house space and Earth scientists work closely with the engineers, project managers, and safety and mission assurance professionals to develop and refine scientific requirements for missions; provide operations for those missions; and collect and disseminate mission data to partners and the public. Using data from Center-led and partner missions, GSFC creates and hosts authoritative models of Earth and space phenomena used by scientists worldwide for analysis and advancement of the understanding of Earth and space science phenomena, including climate, weather, space weather, and star and galaxy formation.

**Strategic Goal 2: Extend Human Presence to the Moon and onto Mars for Sustainable Long-term Exploration, Development, and Utilization.**

GSFC supports NASA's goal of extending humanity's presence in space in several ways. The GSFC-managed Space and Near-Earth Networks provide space communications for all human spaceflight programs as well as other Agency programs. The Center's launch range, vehicle processing, and payload processing capabilities at Wallops Flight Facility resupplies the ISS with experiments and life support. GSFC also develops technology that improves crew safety today and enables the exploration concepts of tomorrow, such as advanced robotic and in-space assembly systems. The Center enhances exploration by identifying and guiding scientifically significant research activities, training explorers in scientific techniques, developing models

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of observed phenomena, and conducting research that characterizes the exploration locales, identifying threats to explorers and their support systems.

**Strategic Goal 3: Catalyze Economic Growth and Drive Innovation to Address National Challenges.**

GSFC's science and innovation enable economic growth on a national scale, and GSFC's missions drive technologies that affect people every day. The Center's climate models inform senior Government and industry policy makers. Worldwide weather reports are possible because of GSFC satellites and weather models. GSFC's search and rescue technology saves lives on Earth while GSFC's space weather detection models help protect astronauts and satellites in orbit and communications and power infrastructure on the ground. Further, GSFC transfers innovations to industry for commercial applications such as advanced laser and X-ray systems for communications, medical imaging systems, and robotics for safer mining and drilling. The Center's cryogenic systems, component miniaturization, new sensors and instruments, and robotics systems are influencing the next generation of consumer and industrial systems and creating new capabilities for the space industry.

GSFC developed the Laser Communications Relay Demonstration, for NASA's TDM, which successfully launched in December 2021. GSFC also supports maturation projects within NASA's GCD. In addition, GSFC participates in NASA's CIF, which supports emerging technologies and creative initiatives led by NASA scientists and engineers.

Additionally, the GSFC Technology Transfer Office ensures that innovations developed for aeronautics and space are made more broadly available to the public.

**Strategic Goal 4: Enhance Capabilities and Operations to Catalyze Current and Future Mission Success.**

GSFC relies on, recognizes, and nourishes the diversity of its workforce, and commits to diversity, equity, inclusion, and accessibility throughout the organization and among its suppliers and partners. Physical and digital accessibility is integrated into missions, products, and the Center's infrastructure plans.

The GSFC-managed Independent Verification and Validation (IV&V) facility in West Virginia provides software assurance services Agency-wide. The Center manages electrical, electronic, and electromechanical parts services for NASA.

Students apply each year for internships and other work opportunities at the Center, and GSFC involves university faculty, students, and researchers as principal partners in all phases of its work. GSFC's STEM learning activities, internships, fellowships, and post-doctoral opportunities are used to translate core missions into experiences that motivate and inspire students and educators at all levels.

GSFC consistently reaches across Federal agency, commercial, and academic boundaries to execute NASA's Mission, creating innovative partnership arrangements for nearly every project. As a result, the Center manages one of the Agency's largest portfolios of cooperative and reimbursable agreements with industry, academia, other Government agencies, and international partners. These include relationships with the U.S. Space Force and longstanding agreements to provide weather and terrestrial observing satellites to the National Oceanic and Atmospheric Association (NOAA) and the U.S. Geological Survey.

## **Jet Propulsion Laboratory (JPL)**

**Strategic Goal 1: Expand Human Knowledge Through New Scientific Discovery.**

Scientific discovery is a driving force for humankind. JPL develops and operates robotic missions that contribute to the scope of human knowledge and improve the human condition. JPL enhances technology, creates new industries, and fosters peaceful connections with other nations. JPL continues to create opportunities and missions that contribute to the expansion of scientific knowledge.

Earth science missions, built by JPL for NASA, reveal the dynamic interactions between natural and human components to manage Earth's changing climate. JPL supports implementation of the Earth Science Observatory. JPL collaborates with Federal, state, and commercial organizations to convert datasets into applications to care for our planet. JPL plans to increase access and use of datasets by embracing data technologies, including artificial intelligence, to better enable data-driven science with an increasing emphasis on climate change.

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Beyond Earth, NASA's Perseverance rover caches samples from Mars as the first step of a future Mars Sample Return mission. Europa Clipper will begin a new era of exploration through NASA's Ocean Worlds program, while the VERITAS mission (which stands for Venus Emissivity, Radio Science, InSAR [Interferometric Synthetic Aperture Radar], Topography, and Spectroscopy) (VERITAS) mission will unveil Venus to pinpoint future missions to our sister planet. JPL is building the coronagraph technology demonstration for the Roman Space Telescope, which will image nearby exoplanets that are a billion times fainter than their stars. Public access to JPL's mission data begins by providing seamless transfer from spacecraft with NASA's Deep Space Network through NASA's Advanced Multi-Mission Operations System to NASA's Planetary Data System. JPL also operates multiple mission and science archives to make data accessible and enable new discoveries by researchers.

**Strategic Goal 2: Extend Human Presence to the Moon and onto Mars for Sustainable Long-term Exploration, Development, and Utilization.**

JPL advances technologies for communications, navigation, and surface operations at and around the Moon designed to ensure robust operations in cislunar space. To prepare for future landed exploration, Lunar Trailblazer will investigate water on the Moon and characterize resources. In addition, the Farside Seismic Suite, which will receive a ride to the lunar surface as part of the Commercial Lunar Payload Services (CLPS) initiative, will reveal the interior structure of the Moon and demonstrate the capability to survive the night for long-term operations.

JPL also develops capabilities for advanced commercial deep space communication and navigation. JPL works directly with a range of startup and innovative small businesses to guide their development, supplying direction and objectives for NASA needs. These businesses will be well positioned to contribute to the emerging space economy as suppliers of unique, innovative, and cost-effective products that serve NASA and the broader community.

JPL enables enhanced access to space by providing and developing advanced navigation, communication, and security capabilities to ensure that crewed spacecraft, and their robotic precursors, can reach their exploration targets and robustly communicate with Earth.

**Strategic Goal 3: Catalyze Economic Growth and Drive Innovation to Address National Challenges.**

To advance future NASA missions, JPL will address challenges across a range of technology fields, including communications, autonomy, artificial intelligence, machine learning, robotics, data science, nanotechnology, quantum sensing, and advanced manufacturing, design, and materials. Leveraging these technologies in space vehicle systems will enable transformational missions, whether they are small spacecraft or complex landing, in-situ systems, and sample return.

JPL advances cutting edge technologies that support national needs in climate, quantum information systems, commercial space, transportation, and cybersecurity. JPL will execute technology demonstrations of capabilities that enable new discoveries and exploration. These include flying an optical communications system that increases the data volume from deep space missions, an atomic clock that enables robotic spacecraft to operate without near-continuous connection to Earth, landing systems that enable pinpoint landings on extreme terrain, and a coronagraph instrument that will pave the way toward finding life outside of our solar system.

With an emphasis on these technology areas, JPL supports maturation and demonstration projects through NASA's GCD and Technology Demonstration Missions, respectively. JPL also participates in NASA's CIF, which supports emerging technologies and creative initiatives led by NASA scientists and engineers.

JPL collaborates with other Government agencies and private-sector partners to address problems of national significance and catalyze economic growth. JPL also develops and transfers technologies that enable reliable high-speed communication, data transfer, processing, visualization, access, and encryption capabilities within the national sphere of influence around Earth and out to the Moon. The JPL Technology Transfer Office ensures that innovations developed for aeronautics and space are made more broadly available to the public.

**Strategic Goal 4: Enhance Capabilities and Operations to Catalyze Current and Future Mission Success.**

JPL maintains a diverse talent pipeline that attracts and engages the brightest minds across the STEM community. To further diversify this pipeline and increase retention and promotion rates among underrepre-

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sented groups, JPL is focusing on increasing engagement with Historically Black Colleges and Universities, fostering career opportunities for underrepresented groups, and launching an accessibility taskforce. JPL strives to create an environment where employees feel included, represented, and valued while providing flexibility around where, when, and how they work best.

JPL transforms the enterprise to better support flight projects by thinking about the enterprise as a system comprised of people, processes, tools, data, facilities, and other resources that work together to accomplish NASA's Mission. JPL and the Infrared Processing and Analysis Center are innovating in mission and science operations to match future concepts and smaller missions enabled by easier access to space. JPL is also pursuing and infusing advanced capabilities in communication, navigation, and mission operations to enable the next generation of robotic missions.

JPL develops future principal investigators through various experiential workshops that increase participants' capabilities to ideate, collaborate, and communicate compelling science-driven missions. To bring space down to Earth for all, JPL is also leading engagement activities and will continue making connections with the public through engaging learning activities to inspire the next generation of explorers.

## **Johnson Space Center (JSC)**

### **Strategic Goal 1: Expand Human Knowledge Through New Scientific Discovery.**

JSC manages the ISS, which provides long-duration microgravity for continuous and interactive research while revolutionizing technologies and capabilities that will reveal the universe. The ISS is a unique platform for scientists and researchers to monitor climate change, map natural resources, predict and assess natural disasters, monitor urban growth, and support agriculture and wildlife management.

JSC curates all extraterrestrial sample collections, ensuring astromaterials sample integrity and planetary protection. The Center applies orbital debris modeling and risk analysis for human spacecraft systems and robotic satellites. JSC leads NASA's initiative to deliver science and technology to the lunar surface through CLPS, where companies of varying sizes bid on delivering payloads for NASA including integration and operations, launching from Earth and landing on the surface of the Moon.

### **Strategic Goal 2: Extend Human Presence to the Moon and onto Mars for Sustainable Long-term Exploration, Development, and Utilization.**

JSC leads mission design, development, and execution for crewed exploration missions, sending humans into the solar system faster and farther. The ISS provides innovative ways to fly and test hardware that will be required for deep space exploration, including advanced environmental control and life support systems that will be tested using streamlined processes for flight hardware development. JSC's advanced technology experiments on the ISS, such as the sensing of hurricanes, advanced medical diagnostic techniques, and pharmaceutical investigations, improve life on Earth. JSC expands partnerships with entities outside the aerospace sector to increase space flight expertise and innovation capabilities.

Orion is equipped with advanced technologies and backup capabilities to ensure its mission performance is safe, reliable, and successful. JSC leads development of Gateway, a crew-tended spaceport in lunar orbit that will serve as a multipurpose outpost orbiting the Moon and a staging area for deep space exploration.

JSC is standing up the extravehicular activities (EVA) and Human Surface Mobility Program that includes ISS EVA support, exploration EVA development, and the Lunar Terrain Vehicle. The Center also maintains architecture and mission planning capabilities.

JSC is the home to the Human Research Program, which develops advanced life science capabilities to protect the health, safety, and performance of astronauts as well as provide benefits to medical science on Earth. JSC expands frontiers by leading development of future deep space missions on Orion. This crew vehicle will support deep space missions to the Moon and eventually towards Mars.

White Sands Test Facility, managed by JSC, serves as a preeminent resource for testing and evaluating hazardous materials and rocket propulsion systems. JSC continues to explore space to benefit humanity and maintains a focus on solving challenges that both advance human productivity in space and unite the Center with partners from other agencies, industry, and academia to complete bold missions.

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### **Strategic Goal 3: Catalyze Economic Growth and Drive Innovation to Address National Challenges.**

Programs such as ISS, Orion, Gateway, Human Research Program, Commercial Low Earth Orbit (COMM-LEO), Commercial Lunar Payload Services, Extravehicular Activities and Human Surface Mobility, along with the Center's support of Commercial Crew and Human Landing System activities, provide billions of dollars of development activity across the country. NASA is working with both commercial and international partners to establish the Gateway as a cislunar outpost for human explorers. JSC incorporates new technologies and available commercial solutions to develop alternative components and broaden the supplier base. Additionally, the COMM-LEO program, which supports Strategic Goal 2, strengthens the high-tech industrial base and supports further development of a commercial marketplace in low Earth orbit through commercial and academic partnerships and technology transfer.

JSC supports technology maturation projects within NASA's GCD. JSC also participates in NASA's CIF, which supports emerging technologies and creative initiatives led by NASA scientists and engineers. Additionally, the JSC Technology Transfer Office ensures that innovations developed for aeronautics and space are made more broadly available to the public.

### **Strategic Goal 4: Enhance Capabilities and Operations to Catalyze Current and Future Mission Success.**

JSC collaborates with the Commercial Crew Program on development and certification process for getting U.S. astronauts to and from the ISS. The ISS program and JSC's Flight Operations Directorate are reducing operational costs and developing new capabilities, while increasing science utilization and commercial access to low Earth orbit. JSC promotes mission success by delivering reliable, adaptable, and streamlined technical and professional support infrastructure and capabilities. The Center engages the public in NASA projects through robust public outreach and social media programs, including opportunities for interaction with astronauts. JSC also focuses on lowering barriers to collaboration with both existing and emerging partners. The Center does this by developing critical expertise, serving as champions for innovation, and proactively recruiting as well as developing a diverse pool of highly motivated employees that propel the frontiers of space exploration. JSC actively promotes diversity, equity, inclusion and equal opportunities via our Inclusion and Innovation Council, ten Employee Resource Groups, and the Inclusive Leadership Cadre. Lastly, JSC is intentional about partnering with academia to promote STEM activities with a broad and diverse community of students.

## **Kennedy Space Center (KSC)**

### **Strategic Goal 1: Expand Human Knowledge Through New Scientific Discovery.**

KSC procures commercial launch services for NASA's science and robotic missions, ranging from Venture Class for the smallest and lightest CubeSat satellites to Heavy Class for the largest and most massive space telescopes. The Center also leads plant research and production in a microgravity environment and supports biological sciences for NASA's Biological and Physical Sciences Program.

### **Strategic Goal 2: Extend Human Presence to the Moon and onto Mars for Sustainable Long-term Exploration, Development, and Utilization.**

KSC provides program and project management support for NASA's exploration missions in several ways. The Center leads processing, assembly, integration, and test of payload and flight science experiments bound for the ISS and low Earth orbit. KSC's Commercial Crew Program acquires and manages commercial transportation services, including development and human certification of integrated commercial crew systems and flight certification for each crew transportation mission to and from the ISS. KSC's Launch Services Program acquires and manages commercial launch services, including certification and technical insight and approval on commercial launch vehicles for NASA's science and robotic small, medium, and large class missions.

The Center designs, develops, operates, sustains, integrates, and tests flight systems and ground systems, and support infrastructure, including lander ground operations. KSC's Exploration Ground Systems Program leads launch processing for the integrated launch vehicle and spacecraft to advance human exploration. This includes vehicle and spacecraft processing, servicing, maintenance, command, control, and telemetry; launch, landing and recovery; and crew support. KSC's Deep Space Logistics provides the logistics services capabilities for NASA's deep space exploration plan supporting the Space Launch System (SLS), HLS, and Orion.

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KSC leads partnership development strategies and operations for the Nation's pre-eminent multi-user spaceport, supporting Government and commercial operations. KSC offers commercial services for ground operations and services that can accommodate different vehicles, systems, and commercial launch providers. It operates and maintains a multiuser spaceport with infrastructure, systems, and processes to support flight and ground hardware for crewed and uncrewed launch vehicles and payloads. KSC enables NASA mission success and makes the space enterprises of NASA, other Government agencies, and the commercial sector more capable and affordable.

**Strategic Goal 3: Catalyze Economic Growth and Drive Innovation to Address National Challenges.**

KSC supports research, development, testing, and demonstration of advanced flight and surface systems and transformational technologies to advance exploration systems, human and cargo landers, and deep space systems. KSC also supports environmental control and life support systems technology development, habitation space systems development, and operations and in-situ resource utilization.

KSC works with commercial industry to encourage new opportunities and develop partnership agreements that further commercial investment to enhance the multi-user spaceport, enable innovation, and increase diverse access to space.

KSC supports technology maturation projects within NASA's GCD Program. KSC also participates in NASA's CIF, which supports emerging technologies and creative initiatives led by NASA scientists and engineers. Additionally, the KSC Technology Transfer Office ensures that innovations developed for aeronautics and space are made more broadly available to the public.

**Strategic Goal 4: Enhance Capabilities and Operations to Catalyze Current and Future Mission Success.**

KSC collaborates with partners, including other Centers and external entities, to advance and share technology, promote STEM learning, and engage with the public regarding NASA's Mission.

KSC safely and strategically optimizes its diverse workforce and provides innovative, cost-effective, and efficient Center services to support the Agency's Mission. KSC continually evaluates and aligns its highly-valued people and programmatic and institutional capabilities to implement rigorous and innovative safety, facility and systems engineering and integration, IT, and other services to ensure reliable and quality products.

## **Langley Research Center (LaRC)**

**Strategic Goal 1: Expand Human Knowledge Through New Scientific Discovery.**

Researchers at LaRC work to understand air quality, radiation and climate, and atmospheric composition. They also develop active remote sensing techniques to boost the quality of atmospheric data. This research balances advanced instrument development, field and space-borne experiments, and data retrieval, analysis, and archival.

LaRC houses the world's most comprehensive collection of atmospheric data in its Atmospheric Science Data Center and provides this data to the global public. Additionally, LaRC hosts the National DEVELOP program that addresses environmental and public policy issues through collaborative research projects connecting NASA data to regional concerns around the globe.

**Strategic Goal 2: Extend Human Presence to the Moon and onto Mars for Sustainable Long-term Exploration, Development, and Utilization.**

LaRC develops concepts and tools to extend human presence in space, particularly innovations needed to safely live and work on the Moon and Mars. LaRC designs architecture solutions for humans and equipment to reach the Moon and Mars; leads development of new high-mass entry, descent, and landing (EDL) technologies to allow precision landing of needed equipment and vehicles; and develops tools and innovations for the autonomous construction, assembly, deployment, and manufacturing of structures need for long duration space missions.

LaRC is committed to supporting partners with EDL technologies for Human Landing Systems, such as Navigational Doppler Lidar. Partnering with MSFC and GSFC, LaRC provides assembly expertise for the Agency's initiatives, which will lead to precision-assembled space structures. After arriving on the Moon, LaRC will contribute to lunar surface construction efforts with insights on landing pads and advanced berms, vertical solar arrays, lunar surface manipulator systems, and safe-haven habitats.



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### **Strategic Goal 3: Catalyze Economic Growth and Drive Innovation to Address National Challenges.**

LaRC research helps the Nation meet fundamental challenges that arise from the rapid evolution of aviation and space exploration. The Center's work fuels economic growth in traditional commercial aviation and space technologies and emerging markets. LaRC is a major contributor to the Agency's current experimental flight demonstrators (also known as X-planes), including the X-59 Low Boom Flight Demonstrator, to enable overland supersonic flight, and to future flight efforts as part of the Sustainable Flight National Partnership. LaRC continues to push the boundaries for high-speed (supersonic and hypersonic) commercial flight and contributes vehicle and airspace technologies to enhance the emerging Advanced Air Mobility market.

LaRC also leads and supports activities including manufacturing initiatives in composite structures and materials. The Center promotes public-private partnerships with in-space manufacturing and assembly and supports industry partners developing commercial space transportation systems for access to low Earth orbit and beyond. LaRC ensures that NASA leverages the burgeoning autonomy technology area to benefit a variety of NASA missions.

LaRC hosts the program management office for NASA's GCD. GCD advances space technologies that may lead to entirely new approaches for the Agency's future space missions and provide solutions to significant national needs. LaRC also leads the Low-Earth Orbit Flight Test of an Inflatable Decelerator (LOFTID) project for NASA's TDM. LaRC also participates in NASA's CIF, which supports emerging technologies and creative initiatives, led by NASA scientists and engineers.

Additionally, the LaRC Technology Transfer Office ensures that innovations developed for aeronautics and space are made more broadly available to the public.

### **Strategic Goal 4: Enhance Capabilities and Operations to Catalyze Current and Future Mission Success.**

LaRC continues to transform the way it provides capabilities and conducts operations. Following the new Agency-wide enterprise support model, LaRC works with the Office of Strategic Infrastructure and mission directorate infrastructure groups, such as Aerosciences Evaluation and Test Capability, to fund and support capabilities required by the Agency and the Nation to conduct NASA missions.

LaRC is committed to a diverse workforce, actively engaging and recruiting from underrepresented and underserved groups and universities to find the best and brightest talents to solve NASA's challenges. Additionally, LaRC supports the Agency's STEM efforts by providing leadership and contributions to STEM engagement opportunities and activities.

## **Marshall Space Flight Center (MSFC)**

### **Strategic Goal 1: Expand Human Knowledge Through New Scientific Discovery.**

MSFC leverages expertise in science, engineering, and project management to conduct scientific missions and develop instruments, leading transformative discovery in core science and technology areas. MSFC's expertise in developing applications and utilizing data informatics from space-based Earth-observing instruments delivers responsive disaster analysis, lightning imaging, and weather forecasting products across the United States, as well as global human benefit through the SERVIR program. MSFC scientists study the Sun's dynamics to improve forecasts and study the "X-ray universe" of hot gases and X-rays emitted from objects like black holes with the Chandra and Imaging X-ray Polarimetry Explorer (IXPE) observatories, along with other high-energy instruments. MSFC develops state-of-the-art optics and instruments to understand the origins of our universe. MSFC planetary scientists support the development of lunar surface processes and the understanding of lunar habitability, as well as developing payloads and instruments for NASA's CLPS program. The Planetary Missions Program Office manages a portfolio of robotic missions canvassing our solar system, from the continuing Lunar Reconnaissance Orbiter to larger missions like Europa Clipper that will help us explore the possibility of life.

### **Strategic Goal 2: Extend Human Presence to the Moon and onto Mars for Sustainable Long-term Exploration, Development, and Utilization.**

MSFC serves as the space transportation design, development, and manufacturing leader for NASA. MSFC leverages its expertise with large-scale, complex systems to develop the vital capabilities that will enable humanity to return to the Moon to stay and explore on toward Mars. MSFC's systems engineering and integration expertise plays an important role in bringing together the work of the Agency and industry.

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MSFC is responsible for the SLS and its continued evolution to serve as a cornerstone for human deep space exploration for decades to come. MSFC also manages NASA's human and large cargo landing transportation systems, working with commercial partners to provide sustained access to the lunar surface. Additionally, MSFC deploys new technologies on the ISS that will inform next-generation life support and research hardware for Artemis. MSFC also partners with industry to develop concepts for the lunar habitat for a sustained human presence on the Moon's surface and a transit habitat for the journey to Mars.

MSFC's Payload Operations Center coordinates all U.S., European, Japanese, and Canadian scientific and commercial experiments aboard the ISS, synchronizes payload activities of international partners, and directs communications between crew members and researchers from around the world who have onboard experiments. Drawing on more than two decades of experience serving as "Science Central" for the ISS, MSFC will provide payload and mission operations support for a new generation of human spaceflight and scientific exploration at the Moon and beyond.

### Strategic Goal 3: Catalyze Economic Growth and Drive Innovation to Address National Challenges.

MSFC's leadership in human space exploration ignites economic growth opportunities while inspiring, educating, and improving life on Earth. MSFC partnerships with industry and academia advance and incorporate Advanced Manufacturing Technologies (e.g., additive, welding, composites) for use on Earth and in space, while establishing standards and qualifications for use in space flight. Additive manufacturing technology developments are paving the way for future lunar and Mars in-situ surface construction.

MSFC's chemical propulsion expertise is at the forefront of innovation and development of advanced ascent, in-space, and lander propulsion systems. The development of these systems and related technologies, including the development of long-term cryogenic fluid management for nuclear propulsion systems, are essential to deep space human exploration. MSFC sustains current human presence in space through the environmental control and life support systems aboard the space station and is advancing those systems for long term and deep space exploration.

MSFC hosts the program management office for NASA's TDM. TDM focuses on ground and flight-testing crosscutting technologies with strong customer interest that meet the needs of NASA and industry by enabling new missions or greatly enhancing existing ones. MSFC also leads the Space Nuclear Propulsion Project for TDM as well as several maturation projects for NASA's GCD. In addition, MSFC participates in NASA's CIF, which supports emerging technologies and creative initiatives led by NASA scientists and engineers. MSFC also stimulates technological innovation through technology transfer and innovative Centennial Challenge competitions. Collectively, these activities provide business opportunities for industry and academia, while also improving life on Earth.

### Strategic Goal 4: Enhance Capabilities and Operations to Catalyze Current and Future Mission Success.

MSFC inspires the next generation of explorers through STEM activities and other outreach events such as the Human Exploration Rover Challenge and Student Launch Initiative. MSFC's outreach extends to secondary and post-secondary education institutions alike, with a specific focus on inclusion of traditionally underserved and underrepresented populations and institutions of learning. MSFC engages in education outreach campaigns and routinely hosts interns each academic semester. These inclusionary activities serve as a pipeline for recruitment of a talented and representatively diverse population that allows the Center to shape the workforce to meet the demands of the evolving space industry. Just as MSFC seeks to inspire today's next generation, it also continually seeks to develop its current workforce through technical, programmatic, and personal training in an effort to prepare tomorrow's leaders to address the challenges they will face as they inspire future generations.

By leading and providing key enterprise information technology systems, services, and infrastructure, MSFC is enabling NASA's transformation to a new work paradigm that supports the needs of the Agency and the employee alike. In this mission support role, MSFC enables the Agency's future while providing cybersecurity, network and application services, and secure data communications.

## **Stennis Space Center (SSC)**

### Strategic Goal 1: Expand Human Knowledge Through New Scientific Discovery.

SSC created and continues to enhance the Remote Sensing Toolkit, applying knowledge of remote sensing

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applications and digital transformation to lower barriers to access NASA's Earth science data and the tools to apply that data to benefit society.

**Strategic Goal 2: Extend Human Presence to the Moon and onto Mars for Sustainable Long-term Exploration, Development, and Utilization.**

SSC leverages expertise in the design, development, operation, and sustainment of large-scale, complex systems to provide unique facilities and expertise that enable research and development of current and emerging propulsion systems and launch vehicles. SSC tests the RS-25 engine and SLS Exploration Upper Stage for NASA, as well as propulsion system components, engines, and stages for industry, to enable the exploration and commercialization of space.

SSC develops innovative and transformational technologies that enable efficient, safe, deep-space exploration and ground operations, and adapts commercial technology to enhance propulsion testing. SSC creates intelligent, autonomous systems supporting the development of Gateway, lunar surface systems, in-situ resource utilization, space suits, and small satellites.

**Strategic Goal 3: Catalyze Economic Growth and Drive Innovation to Address National Challenges.**

SSC is a catalyst for growth of the propulsion industry and the commercialization of space. SSC supports development of the U.S. launch industry by testing the latest designs and transferring generations of experience to emerging companies. SSC accelerates development of the industry by leasing existing, underutilized facilities or greenspaces for industry propulsion development, reducing development time and costs.

The SSC technology development program creates innovative, mission-ready solutions. Through public-private and academic partnerships, SSC strengthens the U.S. industrial base in fields such as autonomous systems, digital twins, integrated systems health management, predictive and condition-based maintenance, artificial intelligence and machine learning, embedded systems, and computational fluid dynamics.

The Autonomous Systems Lab (ASL) continually enhances the NASA Platform for Autonomous Systems, the first platform for the development of Class A autonomous systems. The ASL provides best-in-class tools and expertise to help NASA and industry develop robust, safety-critical, human-rated autonomous systems for space missions and ground operations. The ASL works with NASA and other agencies to establish requirements for trusted autonomous space systems.

SSC participates in NASA's CIF, which supports emerging technologies and creative initiatives, led by NASA scientists and engineers. SSC also enhances access to NASA technology by maintaining multiple technology transfer processes for the Agency to drastically reduce licensing time while increasing process security.

**Strategic Goal 4: Enhance Capabilities and Operations to Catalyze Current and Future Mission Success.**

SSC works diligently with the MSD to transform local delivery of support services through the new enterprise models. SSC provides significant cost savings to NASA through the consolidated contract for base operations at both SSC and the Michoud Assembly Facility, as well as administering the Multiple Award Construction Contract (MACC)-II regional construction contract. Similarly, SSC's unique facility operations cost-sharing model with its Federal City tenants provides additional efficiency.

SSC supports a STEM portfolio with a diverse set of activities, education products, internships, challenges and competitions, informal and formal education and out-of-school student learning activities, and educator support. Robust face-to-face and virtual opportunities attract and retain students on STEM pathways with significant attention on underserved and underrepresented students.

SSC's talent recruitment plan leverages the Office of the Chief Human Capital Officer's talent strategy by utilizing LinkedIn and Talent Marketplace to reach new and diverse candidates. SSC builds constructive relationships with schools and universities, community-based organizations, small businesses, and professional associations to expand outreach to underrepresented communities and to create and maintain an inclusive workplace culture.

# Appendix A: Learning Agenda

## A Culture of Evidence

NASA has long held a culture of using evidence to inform its endeavors. As an Agency at the cutting edge of exploration, scientific discovery, and technological development, NASA believes that frequently and thoroughly examining and evaluating its programs, missions, and projects leads to future success. NASA is committed to strong evidence-building practices, and the Learning Agenda is one of NASA’s tools to identify the priorities we believe will strengthen the Agency’s policymaking through systematic evidence-building.

## Establishing a Learning Agenda

NASA undertook a multi-year process to develop the first Learning Agenda as the Agency began to implement the Evidence Act and build the 2022 Strategic Plan. Under the leadership of NASA’s Evaluation Officer, the Agency set about planning for the Learning Agenda in 2019 to identify the learning priorities for the Agency. The Evaluation Officer led an Evidence Act Working Group made up of representatives from NASA’s Mission Directorates and Centers, as well as technical and program experts to identify Agency priorities and where evaluations would have the most impact for policymaking decisions.

Membership of the Evidence Act Working Group	
Evaluation Officer / Performance Improvement Officer	Rep., Office of Strategic Infrastructure
Statistical Official	Rep., Office of STEM Engagement
Chief Data Officer	Rep., Office of the Chief Human Capital Officer
Deputy Performance Improvement Officer	Rep., Glenn Research Center
Rep., Office of the Chief Information Officer	Rep., Kennedy Space Center
Rep., Office of the Chief Financial Officer	Rep., Aeronautics Research Mission Directorate
Rep., Office of the Chief Economist	Rep., Space Technology Mission Directorate
Rep., Office of Procurement	Rep., Science Mission Directorate

Table 1: Evidence Act Working Group

The Working Group initially identified nearly 70 priority questions, which were reviewed with stakeholders to ensure the questions would provide the necessary evidence to make informed policy decisions. These stakeholders included leadership from a diverse subset of divisions and directorates, who consistently engage with academia, small business, and industry partners to inform our processes. In addition, Office of Management and Budget (OMB), evaluation consultants from the General Services Administration (GSA), and other Federal science agencies provided input on the Agency’s identified priority questions. Once the Priority Questions were solidified, the Working Group collected foundational data, refined the scope of each question, and created an approach to answer the questions in the Learning Agenda.

## NASA’s Vision for Learning

NASA’s Learning Agenda process is a continuous cycle of identifying priority areas for evidence and continuous learning. Over the next four years, NASA will embed learning activities within the Agency’s planned evidence-building efforts. The Learning Agenda process establishes a formal tool for NASA to prioritize evidence-building activities that advance the Agency’s mission and operations in alignment with strategic initiatives.

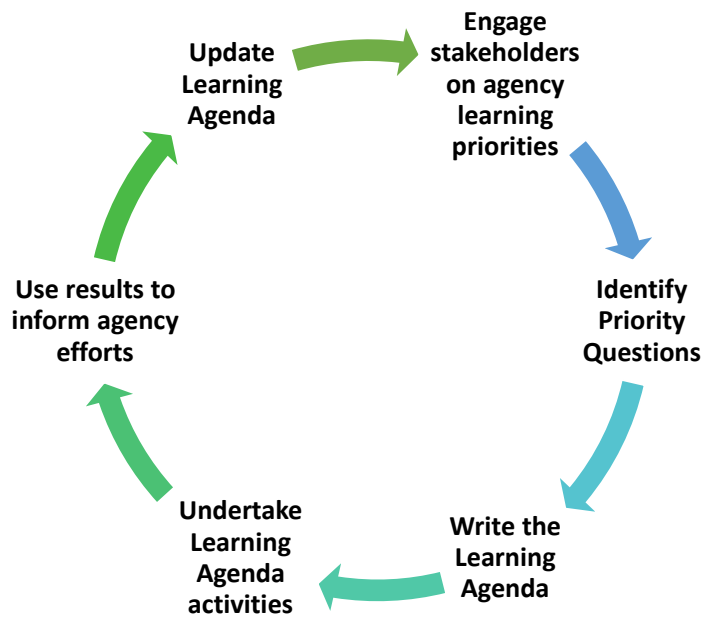


Figure 1: Learning Cycle: Developed from [M-19-23](#)

The multi-year process of creating and responding to the Learning Agenda coincides with the four-year timeframe for performance management set forth in the NASA Strategic Plan, itself developed every four years. By developing each plan in tandem, NASA aligns the Agency’s Strategic Objectives, management priorities, and the evaluations it will undertake to answer Priority Questions into a single framework. NASA’s Learning Agenda is transparent and promotes interest in and support for the studies, evaluations, and other evidence that will follow.

NASA will leverage its many resources for evaluation, analysis, and other evidence-building activities to answer the Learning Agenda Priority Questions. The Agency will use its established capacity to conduct evidence-building activities both internally and externally and use the results for continuous learning and to make better informed policy decisions. In the case where NASA may not have the tools available within the Agency, NASA has an extensive network of Federally

Funded Research and Development Centers (FFRDCs), academic institutions, industry partners, and citizen science to support evidence-building. We will leverage this additional knowledge base to further improve our Learning Agenda process in future years.

## NASA’s FY 2022-2026 Priority Questions

NASA’s Learning Agenda includes five Priority Questions that cover cost and schedule, digital and data analytics, early-stage technology innovation and partnership investment, improved access to opportunities, and broadening participation. The Priority Questions address mission-critical areas for NASA that will require evidence to improve Agency outcomes. In the development of the Priority Questions, NASA looked to both strategic and operational needs as well as questions that could be answered in the near- and long-term.

Priority Question Categorization	
Strategic (S)	Focus on how the Agency meets its mission
Operational (O)	Focus on the efficacy of the Agency’s operations, such as human resources, grant-making procedures, financial systems, and internal processes
Short-term (ST)	Evaluation will occur between 1-18 months
Long-term (LT)	Evaluation will occur over 18+ months

Table 2: Priority Question Categories

The Priority Questions cover focus areas of strategic or operational importance to the Agency with the potential to impact the way NASA operates and carries out its mission. NASA will build evidence and data that supports its Strategic Objectives, Corrective Action Plan (CAP) initiatives stemming from Government Accountability Office (GAO) reports, and Management Challenges stemming from Office of Inspector General reports. This information will provide senior leadership with evidence to inform future policymaking. The table below outlines NASA’s 5 priority questions.

PQ#	Priority Question	Focus	Expected Results
PQ1	How can NASA enhance its early-stage innovation and partnership investment strategies to support American leadership in space technology?	S	LT
PQ2	To what extent do NASA's cost and schedule models, when used early in spaceflight project development, accurately predict final costs and schedules?	S	LT
PQ3	To what extent has the Enterprise Data Platform (EDP) been adopted and used to drive decision making?	O	ST
PQ4	How do NASA's procurement and grant practices advance equity for improved access to opportunities for underserved communities?	O	LT
PQ5	How do NASA Internships broaden participation of underrepresented and underserved students to advance equity and build a diverse future STEM Workforce?	O	ST

Table 3: Priority Question Outline

As previously mentioned, NASA aligns the Agency's Strategic Goals and Objectives to its Learning Agenda. These Goals and Objectives, as defined in the Agency's Strategic Plan, have been restated in Table 4 below. Table 5 demonstrates how each priority question correlates to these Goals and Objectives.

Theme	Goal	Statement
Discover	Expand human knowledge through new scientific discoveries	1.1 Understand the Earth system and its climate
		1.2 Understand the sun, solar system, and universe
		1.3 Ensure NASA's science data are accessible to all and produce practical benefits to society
Explore	Extend human presence to the Moon and on towards Mars for sustainable long-term exploration, development, and utilization	2.1 Explore the surface of the moon and deep space
		2.2 Develop a space economy enabled by a commercial market
		2.3 Develop capabilities and perform research to safeguard explorers
		2.4 Enhance space access and services
Innovate	Catalyze economic growth and drive innovation to address national challenges	3.1 Innovate and advance transformational space technologies
		3.2 Drive efficient and sustainable aviation
Advance	Enhance capabilities and operations to accelerate current and future mission success	4.1 Attract and develop a talented and diverse workforce
		4.2 Transform mission support capabilities for the next era of aerospace
		4.3 Build the next generation of explorers

Table 4: NASA's Strategic Goals and Objectives

NASA Priority Questions/Strategic Goals & Objectives Crosswalk					
Strategic Goals and Strategic Objectives	PQ1	PQ2	PQ3	PQ4	PQ5
Strategic Goal 1, Strategic Objective 1.1	X		X	X	
Strategic Goal 1, Strategic Objective 1.2	X		X	X	
Strategic Goal 1, Strategic Objective 1.3	X	X	X	X	
Strategic Goal 2, Strategic Objective 2.1	X	X	X	X	
Strategic Goal 2, Strategic Objective 2.2	X	X	X	X	
Strategic Goal 2, Strategic Objective 2.3	X		X	X	
Strategic Goal 2, Strategic Objective 2.4	X	X	X	X	

Strategic Goal 3, Strategic Objective 3.1	X	X	X	X	X
Strategic Goal 3, Strategic Objective 3.2	X	X	X	X	X
Strategic Goal 4, Strategic Objective 4.1				X	X
Strategic Goal 4, Strategic Objective 4.2	X		X		X
Strategic Goal 4, Strategic Objective 4.3				X	X

Table 5: NASA Priority Questions/Strategic Goals & Objectives Crosswalk

## Priority Question #1

How can NASA enhance its early-stage innovation and partnership investment strategies to support American leadership in space technology?

### Alignment to Strategic Goals and Objectives

Strategic Goal 1	Strategic Goal 2	Strategic Goal 3	Strategic Goal 4
SO 1.1: Understand the Earth system and its climate	SO 2.1: Explore the surface of the moon and deep space	SO 3.1: Innovate and advance transformational space technologies	SO 4.2: Transform mission support capabilities for the next era of aerospace
SO 1.2: Understand the sun, solar system, and universe	SO 2.2: Develop a space economy enabled by a commercial market	SO 3.2: Drive efficient and sustainable aviation	
SO 1.3: Ensure NASA's science data are accessible to all and produce practical benefits to society	SO 2.3: Develop capabilities and perform research to safeguard explorers SO 2.4: Enhance space access and services		

### Theory of Change

If NASA can identify strategies that broaden our base of innovators, facilitate effective transition and transfer of promising innovations for mission infusion and commercialization, and strengthen the community with whom we work, then we will help ensure American leadership in space technology.

### Context

Through its Space Technology Mission Directorate (STMD), NASA provides a robust national space technology engine to meet agency and national aspirations and builds a foundation for a self-sustaining U.S. space economy. As one part of this strategy, NASA invests in innovative early-stage technology concepts that could lead to future breakthrough capabilities, enable new mission paradigms, and foster growth of the U.S. space economy. We recognize that the “high-payoff” promise of early-stage innovation is most often accompanied by higher risk. Accordingly, we anticipate that most early-stage investments may not advance for further development beyond the initial investigation. Nonetheless, those that do may eventually change what’s possible in aerospace.

NASA will assess its current strategy for investments in early-stage innovation and partnerships with the intention of implementing policy and process improvements or pilots that increase the likelihood of creating the technology breakthroughs of tomorrow. We will take stock of what is working well and what could benefit from improvement. NASA will consider alternative approaches, especially those that have proven successful within other organizations. We may conduct specific evaluations and/or small-scale pilot studies

to assess potential new policies and procedures. NASA will continue to assess its progress and strive for continual improvement, refining and developing new quantitative and qualitative success measures accordingly. Together, these activities will provide a foundation of evidence to better inform NASA’s investment in early-stage innovation.

While other areas of focus may surface during NASA’s assessment of its current strategies, we initially anticipate focusing on a few key elements of early-stage and partnership investment strategy:

- Sourcing ideas from a broad base of innovators, including those from underserved and underrepresented communities. We theorize that a broad base of innovators helps ensure new perspectives and more comprehensive capture of promising ideas.
- Ushering technologies through the “valleys of death.” In R&D, the “valley of death” is a commonly used metaphor to describe an inherent gap between adjacent stages of development, requiring technology transition. For the purposes of this learning agenda, we will place particular emphasis on the transition of early-stage innovation to the technology maturation phase of development.
- Transferring space technology into the space economy. In addition to creating technological breakthroughs, STMD is committed to transferring technologies beyond NASA, fostering commercialization opportunities, and growing the U.S. space economy.

## Approach

NASA will address this priority question through a combination of fact finding, analysis of programs and existing policies, evaluations of proposed policy and process improvements or pilots, and related performance measurement improvements. We plan to conduct these activities during the period of FY 2022 – FY 2026. However, we recognize the need for a low-level of continual assessment beyond that period, particularly due to the often-longer term timeframe for impact – often 10-20 years or more – of early-stage concepts. We elaborate on this approach in the subsequent sections.

## Evidence-building activities

To address this priority question, NASA will employ a variety of evidence-building activities spanning the categories of fact-finding research, policy analysis, program evaluations, and performance measurements.

Evidence-Building Activity	Evidence Category	Timeline
Review prior studies for relevant data	Foundational Fact Finding	FY 2022-2026

**Description:** Investment in early-stage technology development and transfer, along with basic research, remains a cornerstone of U.S. technology advancement and leadership. NASA’s current strategy for early-stage investment is already built upon evidence gained from decades of prior experience within and beyond NASA. It employs acquisition strategies that leverage various sources of innovation and encourage continued development of promising ideas.

That said, measuring the effectiveness of specific strategies and approaches to early-stage investment is particularly difficult, even within the context of other research and development programs, partly because of the long development times necessary to recognize the benefit and impact of early-stage concepts. The often complicated development paths to ultimate implementation make it difficult to even trace breakthroughs to originating research. Nevertheless, in exploring potential enhancements to our current strategies, NASA has at its disposal a wide range of studies and analyses from which to draw evidence. In 2017, for example, NASA STMD commissioned a benchmarking study conducted by the Science and Technology Policy Institute (STPI) that examined NASA investment in early-stage innovation as compared to several other U.S. Government agencies and organizations. NASA’s Small Business Innovation Research (SBIR) program has also supported a number of National Academies studies focused on impact evaluation and improvement. In 2019, SBIR also commissioned a [report](#) to establish an initial understanding of the role the U.S. Government has played in supporting an entrepreneurial approach to space. We shall revisit these and other studies for relevant evidence and with particular focus on the aforementioned key elements of this priority question learning agenda. Similarly, we will review other relevant studies from within NASA and beyond.



Fact-finding could also occur through data collection from the NASA innovation community, including previous proposers to STMD’s Early-Stage Innovation and Partnerships (ESIP) on their experience with the programs. STMD has two methods available for clearing surveys through OMB related to customer experience for external communities:

1. NASA received a Section 280 clearance Nov 4, 2020.
2. NASA also has access to a Fasttrack process for customer experience surveys.

STMD will choose one or the other primarily based on the way we intend to use the data and secondarily on administrative concerns (e.g., burden-hours remaining, clearance durations). Data collected under a Fasttrack clearance *cannot* be published (e.g., to performance.gov) or used to make *material* policy changes, while data collected under a Section 280 clearance can. Surveys conducted under Section 280 provide more flexibility with how we can use the incoming data—even allowing us to make material programmatic and policy changes based on the survey’s data. NASA STMD has developed a strong relationship with the Office of Information and Regulatory Affairs desk officer who clears these customer experience surveys. In fact-finding to understand potential barriers and adjustments from the vantage point of our external partners and stakeholders, STMD may also leverage this data collection approach.

**Potential Methods:** Assessment of existing studies, reports, and metrics:

- 2019 NASA-commissioned Space Angels report: *U.S. Government Support of the Entrepreneurial Space Age*
- 2017 NASA-commissioned STPI early-stage innovation benchmarking study
- 2010 *Capabilities for the Future: An Assessment of NASA Laboratories for Basic Research*, National Academies Press
- Other NASA studies and National Academies reports
- Extended literature searches to include relevant studies conducted by other Government agencies, academic institutions, etc.
- Customer experience surveys (Section 280 or Fasttrack)

Evidence-Building Activity	Evidence Category	Timeline
Analysis of existing programs and project data	Policy Analysis	FY 2022-2026

**Description:** With approximately 10 years of experience across multiple early-stage innovation and partnership programs, STMD has at its disposal a wide array of information and data with which we continue to assess the effectiveness of our programs and policies. Individual STMD ESIP programs have already implemented internal performance measures relevant to the key elements of this priority question learning agenda, including those related to diversity, equity, inclusion, and accessibility (DEIA) and transition of promising concepts and technologies. Also, the recently appointed STMD Program Director for Early-Stage Innovation and Partnerships is tasked with addressing measures of success and other policy analysis across the entire STMD ESIP portfolio.

In exploring potential adjustments/improvements to our current strategies, NASA will conduct analyses of existing STMD program and project data regarding DEIA, technology transition rates, patterns of STMD technology transition both within and beyond other STMD programs, analyses of technology transfer data, and other relevant analyses of available data. Wherever possible, we also will leverage other concurrent initiatives that may help inform this learning agenda, including STMD’s ongoing strategic framework and acquisition planning activities.

**Potential Methods:** Analysis of STMD information and data may include:

- Analysis of existing STMD program data on DEIA and current transition rates
- Analysis of patterns of transition and transfer within and beyond STMD programs, including any policy, etc. barriers within STMD

- Leveraging relevant insights from STMD’s ongoing strategic architecture activities
- Leveraging relevant insights from STMD’s ongoing acquisition benchmarking study

Evidence-Building Activity	Evidence Category	Timeline
Engagement with researchers	Program Evaluation	FY 2022-2026

**Description:** As we clarify areas of focus through fact finding and policy analysis activities, we will continue to define specific evaluations and pilot studies to assess the effectiveness of proposed policy and procedural adjustments related to one or more of the aforementioned focus areas within the priority question: broadening the innovation base, transitioning promising technologies, and transferring technology into the space economy.

NASA STMD has identified its first evaluation as part of this priority question learning agenda. Planned for execution in FY 2022 and detailed in NASA’s FY 2022 Annual Evaluation Plan (AEP), this initial evaluation addresses the key elements of broadening NASA’s innovation community and focuses specifically on NASA engagement with researchers from Minority Serving Institutions (MSIs) and Historically Black Colleges and Universities (HBCUs) through the Small Business Technology Transfer (STTR) program. This evaluation will be conducted by NASA’s SBIR/STTR program.

**Potential Methods:** Design and execution of evaluations in cooperation with GSA Office of Evaluation Sciences:

- FY 2022 evaluation design and evaluation implementation of potential improved engagement with MSIs/HBCUs, conducted by STMD’s SBIR/STTR program
- Other evaluations, particularly those surrounding broadening the innovation community, facilitating effective technology transition, and transferring technology into the space economy.

Evidence-Building Activity	Evidence Category	Timeline
Reporting on goals, objectives, and outcomes	Performance Measurement	FY 2022-2026 (Annually)

Description: NASA, including programs within STMD’s Early-Stage Innovation and Partnership (ESIP) portfolio, continues to plan, assess, and report on its performance toward goals, objectives, and outcomes. This includes public reporting in compliance with Government Performance and Results Act Modernization Act of 2010 (GPRAMA) and OMB guidance, but also extends to all levels of activity from the Mission Directorate level to individual programs to projects. In fact, STMD is currently in the process of expanding ESIP-related performance measures to be publicly reported under NASA’s FY 2022 and FY 2023 Annual Performance Plans.

As part of this priority question learning agenda, NASA will incorporate findings into its performance measurement framework throughout the learning agenda timeline. We consider this one part of our commitment to continual improvement. Such enhancements to performance measures will help provide more insight into NASA’s ESIP portfolio moving forward.

**Potential Methods:** Continued systematic performance tracking. Emphases may include:

- Improving / expanding relevant program-level metrics
- Improving / expanding GPRAMA-related reporting
- Coordinating preliminary design level early-stage measures across programs
- Exploring success measures beyond transitions
- Continued emphasis on outcome-focused measures

## Anticipated challenges and mitigation strategies

There are several anticipated challenges for this priority question learning agenda. Examples, along with associated mitigation strategies, include:

Challenge	Mitigation
Limited resources and time availability	Include resources for evaluation in budget requests. Leverage existing efforts wherever possible
Long development time to realize eventual early-stage investment benefits	Develop interim success measures for nearer-term impacts of policy changes.
The inherent difficulty in measuring early-stage success	Leverage previous findings from other organizations wherever possible
Access to and sharing of data due to proprietary and policy restrictions	Work with other Government agencies experienced in evaluation to mitigate data sharing concerns. Include resources for data quality improvements in budget requests
The learning agenda concept is new to the Government, including NASA	Work closely with OMB to understand and implement process guidance. Work closely with other Government agencies experienced in evaluation
Reliance on external entities to advance promising early-stage innovation	Continue to work closely with our partners to foster transition. Include performance measures that specifically assess progress within NASA's control
Engaging with underrepresented communities	Incorporate investigation of approaches to mitigate this challenge directly into the learning agenda (e.g., our FY 2022 annual evaluation plan)

Table 6: Priority Question 1 Challenges and Mitigation Strategies

## Communicating Results

STMD will report on progress to NASA's Office of the Chief Financial Officer (OCFO) and OMB, including relevant contributions to the NASA Volume of Integrated Performance (VIPer) and other performance documents which we anticipate will include Evidence-Act-related progress in future years. Additionally, we anticipate that findings from this learning agenda may result in updates to STMD's communication with the community of potential innovators, including improved guidance during the solicitation process. Results of this process may inform communications with similar programs within other agencies, including collaboration across SBIR/STTR programs. Analyses and evaluations conducted through this learning agenda also may result in published papers and/or presentations at conferences and workshops.

## Priority Question #2

To what extent do NASA's cost and schedule models, when used early in spaceflight project development, accurately predict final costs and schedules?

## Alignment to Strategic Goals and Objectives

Strategic Goal 1	Strategic Goal 2	Strategic Goal 3
SO 1.3: Ensure NASA's science data are accessible to all and produce practical benefits to society	SO 2.1: Explore the surface of the moon and deep space SO 2.2: Develop a space economy enabled by a commercial market SO 2.4: Enhance space access and services	SO 3.1: Innovate and advance transformational space technologies SO 3.2: Drive efficient and sustainable aviation

## Theory of change

If NASA can improve its ability to make better predictions early in program and project development in or-

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der to bound cost and schedule more appropriately, the Agency will be better able to deliver on its commitments.

## Context

NASA is on the cutting edge of scientific discovery and space exploration and develops large projects that span multiple years or decades. A major management challenge for NASA is managing cost and schedule given the technical complexity of these projects. Improving cost and schedule models should help NASA better deliver on its commitments.

For NASA spaceflight projects, NASA utilizes three general techniques in helping inform Agency management and external stakeholders with regards to predicting development cost and schedules.

1. Early in formulation, the Agency requires projects to produce probabilistic cost and schedule estimates.
2. As a prerequisite to approval for implementation, the Agency requires projects to produce a probabilistic model of its baseline plan to help inform Agency commitments
3. Lastly, within the implementation phase of development, the Agency utilizes earned value management to measure projects' performance against that plan.

Given a project's lack of maturity during formulation, the probabilistic cost and schedule estimate incorporates the broad uncertainties regarding the project's scope, technical approach, safety objectives, acquisition strategy, implementation schedule, and associated costs. The project team develops its cost and schedule estimates using many different techniques. These include, but are not limited to, bottoms-up estimates where specific work items are estimated by the performing organization using historical data or engineering estimates; vendor quotes; analogies; and parametric cost and schedule models.

In addition to the requirement for projects to produce probabilistic cost and schedule analysis in formulation, the Agency also conducts independent assessments on the probabilistic analysis. Independent assessments of cost and schedule in early formulation often utilize agency parametric models as cross checks.

This priority question primarily deals with the Agency's in-house parametric capability to help inform early formulation probabilistic cost and schedule estimates.

Parametric cost and schedule models utilize relationships between historic program costs/schedules and technical parameters to predict future costs/schedules. Cost and Schedule Estimating Relationships (CERs/SERs) are used to capture these relationships and are developed using statistical techniques – including regression analysis. These models are a solid foundation for probabilistic cost and schedule estimating and will generally do a good job of estimating unless: a project has major cost drivers not modeled by the CERs (probably the source of outliers); the model does not contain data analogous to estimate; or the programmatic content and approach are not defined properly (test hardware, development approach, funding availability, etc.).

## Approach

NASA will continue to improve its cost and schedule model capability. NASA continually improves its modeling capability annually through:

1. **Data Collection:** NASA collects programmatic and technical data for every space flight project 5 times through its lifecycle (Cost Analysis Data Requirement).
2. **Data Normalization and Analysis:** NASA conducts statistical analysis (e.g. regression analysis) to find what technical information drives both cost and schedule. Analysis is conducted annually but Agency strives to update cost and schedule models on an 18-month cadence.
3. **Model Development and Deployment:** Analysis is packaged in models for the NASA cost and schedule community to utilize. Model development allows analysts to use technical uncertainty and historical variation to drive probabilistic cost and schedule analysis.

## Evidence-building activities

Evidence-Building Activity	Evidence Category	Timeline
Investigate technical drivers that drive cost and to what extent they do so	Foundational Fact Finding	FY 2022-2026 (Conducted every 12-18 months)

**Description:** Conduct statistical analysis of technical drivers that drive cost and to what extent. Analysis will be updated as additional data is collected from completed NASA projects.

**Potential methods:** Various, but historically, principle component analysis and step-wise regression are utilized.

Evidence-Building Activity	Evidence Category	Timeline
Normalize new data and add to historic data set; historic data will be examined to determine relevance	Foundational Fact Finding	FY 2022-2026 (Conducted every 12-18 months)

**Description:** New data will be normalized and added to historic data set that drives analysis while existing historic data will be examined to determine if it is still relevant.

**Potential methods:** Methods include normalizing for mission externalities, inflation, and block buys/builds.

Evidence-Building Activity	Evidence Category	Timeline
Stratification of data will be examined for refined CERs/SERs	Foundational Fact Finding	FY 2022-2026 (Conducted every 12-18 months)

**Description:** Further stratification of data will be examined for refined CERs/SERs.

**Potential methods:** Principle Component Analysis, Step-wise Regression, and Multivariable Regression are anticipated potential methods.

## Anticipated challenges and mitigation strategies

Challenge	Mitigation
Limited resources and time availability	Include resources for evaluation in budget requests. Leverage existing efforts wherever possible
The learning agenda concept is new to the Government, including NASA	Work closely with OMB to understand and implement process guidance. Work closely with other Government agencies experienced in evaluation

Table 7: Priority Question 2 Challenges and Mitigation Strategies

## Communicating Results

Data analysis results for all NASA cost and schedule models are available to all NASA personnel. Analysis statistical fits and descriptive statistics are available to broad distribution with each model's supporting documentation material.

## Priority Question #3

To what extent has the Enterprise Data Platform (EDP) been adopted and used to drive decision making?

## Alignment to Strategic Goals and Objectives

Strategic Goal 1	Strategic Goal 2	Strategic Goal 3	Strategic Goal 4
SO 1.1: Understand the Earth system and its climate	SO 2.1: Explore the surface of the moon and deep space	SO 3.1: Innovate and advance transformational space technologies	SO 4.2: Transform mission support capabilities for the next era of aerospace
SO 1.2: Understand the sun, solar system, and universe	SO 2.2: Develop a space economy enabled by a commercial market	SO 3.2: Drive efficient and sustainable aviation	
SO 1.3: Ensure NASA's science data are accessible to all and produce practical benefits to society	SO 2.3: Develop capabilities and perform research to safeguard explorers  SO 2.4: Enhance space access and services		

## Theory of Change

If NASA implements enterprise-wide transformative digital and data analytics capabilities, then the agency will be able to modernize its operations to make more informed mission, operational, research, and investment decisions that leverage the following six strategic thrusts:

- 1. Data:** Better management and use of data makes mission execution easier and difficult goals more attainable. NASA embraces a “One Data” culture that’s free of siloes and promotes consistent management and metadata strategies across the agency, allowing NASA to pursue data-enabled insights and decisions.
- 2. Collaboration:** Collaboration across the agency is key to getting the most out of NASA’s vast and valuable data collections. We need a platform that allows us to efficiently and collaboratively create, modify, analyze, visualize, and share data and data products using simple, integrated tools.
- 3. Model-based Everything (MBx):** NASA is already a proponent of Model-based Engineering, which is the application of formal modeling to support system requirements, design, analysis, and verification and validation activities through the life of a project. Applying these principles more broadly will bring key tenets of the Evidence Act into everything NASA does.
- 4. Process transformation:** NASA’s data consumers need the ability to efficiently use and share data across the agency. Developing and promoting integrated process workflows ensures that NASA’s data is findable, accessible, understandable, secure, trusted, interoperable, and reusable.
- 5. Machine learning and artificial intelligence:** Areas of effort include rote automation and semi-autonomous systems focused on mission and scientific support and business operations. NASA is also fostering a culture that is committed to ethical research, development, and application of machine learning and artificial intelligence that is accountable, explainable and transparent, scientifically robust, and societally beneficial.
- 6. Culture and workforce:** NASA’s Enterprise Data Platform promotes a culture of data transparency, fair and equal access, and collaboration across organizations. In addition, the EDP has applications beyond NASA’s scientific and mission organizations; workforce development and equity, finance, and other infrastructure areas are early adopters.

## Context

Before the Evidence Act was signed, NASA was a champion of free and open access to scientific data. NASA’s work incorporates and builds upon the work of others in a spirit of global engagement and diplomacy. The growing culture of digital and data analytics allows NASA to build out a data-centric platform that supports

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not only growing the foundations of our space-based missions, but also creates an environment where we are able to better understand the context of our institutional data and interpret the data in different ways for different results, maximizing on the return on investment of the data acquired.

In an attempt to maximize the return on investment of our data, NASA is constructing an Enterprise Data Platform – easing the constraints NASA engineers, researchers, scientists, and technicians encounter when they attempt to find, access, and share data. This platform, managed and operated by the Office of the Chief Information Officer (OCIO), will build out an ecosystem of NASA’s data enabling users to begin to use information as a strategic asset.

NASA’s data ecosystem is a massive source of untapped power, as NASA has as many pieces of data and information as there are stars and planets in the sky. Data are distributed across many platforms and organizations, a situation that adds complexity in leveraging data as a strategic asset. Firewalls and access controls create siloed data systems, which lead to incomplete data inventories, non-comprehensive search capabilities, and no common enterprise approach to data governance. In many cases, current tooling often requires a programming component and, in most cases, has a steep learning curve. NASA’s workforce needs simple and intuitive tools to locate, mine, harness, and translate NASA’s data into timely actionable insights; common and non-resource-intensive ways to fast-track data sharing; and a culture of “default to share” for data. We imagine a future in which NASA’s more than 17,000 employees can get the data they need, when they need it, wherever they need it.

## Approach

To address these data challenges facing the Agency, in FY 2021, OCIO and the Agency Business Innovation Office (Digital Transformation Program) teamed to roll out an Enterprise Data Platform (EDP), which is a suite of data management and analytics services to solve many common data management and analytics problems using an enterprise approach. This “one-stop shop” consists of industry-leading products for data virtualization and management, data modeling and analytics, and data visualization. These tools are securely hosted in the cloud and give users the ability to tap into the full power of NASA data while lowering the barrier of entry for data storytelling. The EDP will contain a comprehensive data catalog or Yellow Pages of NASA datasets to greatly increase data discoverability. Combined with a cultural shift in data sharing and normalized data-sharing policies, data access can be accomplished in a more reusable manner as the EDP will provide our Agency’s data stewards with an enterprise platform to govern key NASA datasets. By working in this manner, the months and weeks that were previously required to find and gain access to data can be drastically reduced to days and hours, enabling an agile data-analytics platform for Agency users. With the EDP’s suite of tools, the workforce will be empowered with low-code tooling to gain hindsight, insight, and foresight into NASA’s data.

## Evidence-building activities

The Enterprise Data Platform is only as powerful as the data that feed it and the behaviors that drive it. NASA will promote an open and collaborative data culture to enable more experimentation and discovery while working with Agency data stewards to identify and contribute high-value datasets. We are working with organizations to become early adopters by bringing use cases to test, learn, and evolve the platform.

To evaluate the extent of data-driven decisions made from the EDP, NASA will conduct the following activities:

Evidence-Building Activity	Evidence Category	Timeline
Track and measure how early adopters are using the EDP	Performance Management	FY 2022-2023

**Description:** The Enterprise Data Platform is a multi-faceted tool with an iterative development and design process. Understanding how early adopters are using the EDP helps drive development strategies and priorities for future dashboards, visualizations, and other analytical tools, and informs communication strategies for expanding use beyond the core group of early adopters.

**Potential methods:** Track and measure how early adopters are using the EDP. Freeform sessions such as focus groups or “office hours” will allow users to provide feedback to development and/or communication teams and also share best practices with one another. Additional methods for assessing the success of the EDP include sending out general user surveys, implementing a communications plan that includes the collection of “before and after” metrics, and collecting and analyzing usage statistics directly within the platform itself

Evidence-Building Activity	Evidence Category	Timeline
Evaluate the implementation of the EDP in the day-to-day use cases of the early adopters	Program Evaluation	FY 2022-2023

**Description:** In addition to tracking and measuring general usage of the Enterprise Data Platform, it’s critical to confirm that the platform is meeting specific use cases that were documented during the requirements gathering phase. Understanding if and how use cases have been addressed – and if any new use cases have emerged post-adoption – will inform future iteration on the EDP as we incorporate new tools, data sets, and workflows specifically targeted to the way people are using the platform.

**Potential methods:** Evaluate the implementation of the EDP and its adoption into day-to-day business processes. Gather data and feedback through targeted user surveys focused specifically on previously identified use cases and any new use cases which emerged post-adoption.

Evidence-Building Activity	Evidence Category	Timeline
Track and measure the quantity of data sets on-boarded throughout the implementation of the EDP	Performance Management	FY 2022-2025

**Description:** NASA has a very large number of data sets, with new data sets being created all the time. For the Enterprise Data Platform to be as useful and successful as possible, the data sets that feed into it must be high quality both internally and externally. The data contained in the sets must be reliable, accurate, and robust, and the data sets themselves must be the most relevant of their kind and comprise a broad library of data from across the agency.

**Potential methods:** NASA is already developing an inventory of its high-quality data sets. This work, which will be ongoing as new data sets are created and/or identified, ensures that the initial pool of data sets for the EDP, while possibly not large, will be high quality and immediately useful and usable. As new data sets are added to the EDP, their numbers will be tracked; the quantity of data sets, as well as access and usage trends, will be analyzed by the development team throughout the roll-out and implementation of the EDP.

Evidence-Building Activity	Evidence Category	Timeline
Evaluate the implementation and benefits after several years of EDP use	Program Evaluation	FY 2024-2025

**Description:** After several years of adoption, the impacts of the Enterprise Data Platform will be felt beyond the day-to-day activities of its primary users. The EDP will have created opportunities for organizations within NASA, and NASA as a whole, to make more efficient use of time and resources and to ensure that programs, missions, science, and workforce management are avoiding duplication of cost and effort with respect to data modeling and analytics.

**Potential methods:** Assess the individual day-to-day use and benefits of the EDP, using both general and targeted user surveys, and at an organizational level the extent that the EDP has led to data-driven decision making at NASA. Comparative “before and after” analysis of infrastructure costs in areas such as licensing, data storage and processing, platform administration, and network and security will demonstrate direct ef-



fects on budgetary resources; secondary benefits and advantages will be identified and measured through analysis of high-level decision-making trends within the agency.

### Anticipated challenges and mitigation strategies

There are several anticipated challenges for this priority question learning agenda. Examples, along with associated mitigation strategies, include:

Challenge	Mitigation
Obtaining buy-in from owners of current visualization/ analytics tools that are locally maintained and will need to be migrated into the EDP	Work directly with data stewards and platform owners to communicate agency priorities and coordinate project timeline and migration schedules
Prioritizing data sets for inclusion in initial/early release	Work with data stewards to identify key structured data sets, leverage Memoranda of Agreement to encourage participation and buy-in
Maintaining key core functionalities in face of technology creep and budget fluctuations	Identify and prioritize key core platform structure, develop a funding model for additional requested services over and above the core service stack
Improving access to and sharing of data while abiding by proprietary and policy restrictions and improving data security	Leverage AI and machine learning to analyze data sets for insufficient or overly restrictive access controls
Implementing enterprise-level instances of analytics tools and services and simplifying the ecosystem such that duplicative functionality is reduced, without interrupting current data analytics capabilities	Develop a Decommission Plan to coordinate independent instances of tools and services. Decommission activities will begin only after the cutover to the EDP has been fully executed

Table 8: Priority Question 3 Challenges and Mitigation Strategies

### Communicating Results

OCIO will regularly report on progress on the Enterprise Data Platform to NASA’s IT Strategic Board, and to OMB. In addition, demonstrations and other information sessions targeted to the broader audience of agency data stewards and other day-to-day users will be held, possibly modeled as a series of “Ask Me Anything” sessions. As the EDP is rolled out to early adopters, the results of performance and experience measurement will be communicated to OMB through the appropriate channels related to Evidence Act activities. Additionally, we anticipate that findings from the early adopter cohort may result in updates to OCIO’s communication with the broader community of potential users, including improved guidance during the data tagging and access management processes. The EDP intends to inform communication and collaboration with similar programs within other agencies where data sharing is necessary and appropriate.

### Priority Question #4

How do NASA’s procurement and grant practices advance equity for improved access to opportunities for underserved communities?

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## Alignment to Strategic Goals and Objectives

Strategic Goal 1	Strategic Goal 2	Strategic Goal 3	Strategic Goal 4
SO 1.1: Understand the Earth system and its climate	SO 2.1: Explore the surface of the moon and deep space	SO 3.1: Innovate and advance transformational space technologies	SO 4.1: Attract and develop a talented and diverse workforce
SO 1.2: Understand the sun, solar system, and universe	SO 2.2: Develop a space economy enabled by a commercial market	SO 3.2: Drive efficient and sustainable aviation	SO 4.3: Build the next generation of explorers
SO 1.3: Ensure NASA's science data are accessible to all and produce practical benefits to society	SO 2.3: Develop capabilities and perform research to safeguard explorers  SO 2.4: Enhance space access and services		

## Theory of Change

If NASA can understand what favorable procurement and grants practices provide more equitable opportunities to underserved communities, then NASA can establish new practices and policies and/or transform its existing practices and policies to break down barriers that underserved communities may face in taking advantage of agency procurement/contracting and grants/cooperative agreement opportunities.

## Context

In January 2021, President Biden issued Executive Order 13985 on Advancing Racial Equity and Support for Underserved Communities through the Federal Government. To meet the priorities of the memo, NASA will explore how its procurement and grants practices advance equity for underserved communities. As described below, these activities and processes are managed by three organizations across the Agency: the Office of Procurement (OP), the Office of Small Business Programs (OSBP), and the Science Mission Directorate (SMD).

The NASA Headquarters Office of Procurement oversees the acquisition process and ensures Agency compliance with the Federal Acquisition Regulation (FAR) and the NASA FAR Supplement. The FAR guidelines require Federal agencies to ensure that certain underserved communities have opportunities to compete for Government contracts. FAR Part 19 covers small disadvantaged, Historically Underutilized Business Zone (HUBZone), veteran-owned small business, service-disabled veteran-owned small business, and women-owned small business concerns. Subpart 8.700 outlines procurement guidelines when purchasing from Nonprofit Agencies Employing People Who Are Blind or Severely Disabled. NASA is committed to continuously improving the ways it procures services and issues grants from all types of communities. The NASA FAR Supplement, 1826.302, includes an HBCU/MSI goal which implements the Agency-wide 1 percent HBCU/MSI goal.

NASA's OSBP promotes and integrates all small businesses into the competitive base of contractors that pioneer the future of space exploration, scientific discovery, and aeronautics research for NASA. OSBP has a very proactive outreach program to promote small business awareness and participation, utilizing innovative techniques at nontraditional venues in geographically targeted areas, to enhance all categories of small business. Due to the pandemic, OSBP participates in and hosts outreach events virtually. OSBP also has an active small business mentor-protégé program, aggressive communication, and an outreach plan that targets all of the aforementioned categories of small businesses. The goal of these activities is to educate, inform and instruct small businesses on how to successfully compete for and win Government contracts, prime and subcontracts and how to partner with large businesses for subcontracting opportunities as well as joint ventures.

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Consistent with the cross-cutting priorities and strategies in the NASA Science Plan (“[Science 2020-2024: A Vision for Scientific Excellence](#)”), SMD is committed to developing a scientific community that reflects the diversity of the nation and instilling a culture of inclusion across its entire portfolio. This includes the competed research opportunities that lead to the award of over a thousand grants a year NASA firmly believes that success in these efforts will benefit not only NASA but also the entire scientific community and will help bring the best minds and talent to understand, innovate, and tackle challenging issues like climate change.

Understanding what effective strategies work to advance equity for NASA opportunities will help NASA advance its priorities in the diversity, equity, and inclusion space and plan for ways to best achieve agency priorities.

## Approach

OSBP uses the following tools to increase participation of underserved communities in procurement.

- [OSBP NASA Vendor Database](#) (NVDB) is open to all vendors, both large and small, who wish to do business with NASA. Interested businesses and HBCU/MSIs may register [here](#); the current vendor list is uploaded to the website at the end of each month. Members of the NVDB receive an easily navigable Microsoft Excel file containing a vendor registration list monthly, which enables them to conduct market research, a vendor search, MSI search and capability statement viewing. The current vendor list is viewable to all registered NASA users [here](#) and external agency users [here](#). All NASA civil servants and contractor employees have access to the NVDB to search for firms and universities with capabilities to support the Agency mission with an emphasis on locating small businesses, including all categories of small businesses and HBCU/MSIs.
- OSBP uses the United States Department of Education Accredited Postsecondary Minority Institutions [lists](#) and the White House Initiative on Historically Black Colleges and Universities through the United States [Department of Education](#) to identify MSIs.
- GSA Market Research [Tool](#) is used to seek businesses that represent underserved communities.
- The OP works with OSBP on the issuance of Request for Information when searching for small businesses and HBCUs/MSIs to meet agency requirements.

The [NASA Vendor Communication Plan](#) represents NASA’s commitment to continued and increased dialogue and exchanges of information with the vendor community from the earliest identification of a requirement through announcement of the award (see FAR subpart 15.2). The Plan outlines the communication framework for recurring vendor engagement with OP Senior Leadership and OP acquisition workforce during the acquisition cycle. OP uses the following events to engage audiences that can promote and solicit more interaction from underserved communities.

- Regular meetings with businesses to discuss their capabilities;
- Meetings with other agencies such as the Small Business Administration (SBA), U.S. Department of Veterans Affairs, Minority Business Development Agency Department of Defense Department of Defense, GSA and other Federal Government agencies to participate in their outreach efforts with small businesses;
- Quarterly industry forums with members of the underserved communities identified in EO 13985;
- Quarterly meetings with Council of Defense and Space Industry Associations; and
- Regular meetings with Source America-Ability One representatives to discuss opportunities for contractors that employ persons with disabilities.

OP plans to take the following additional outreach efforts to enhance equity in contracting:

- Convene targeted small group virtual forums with HBCUs/MSIs;
- Attend National HBCU Week; and host meetings with various minority-based associations and organizations, such as National Society of Black Physicists, National Society of Black Engineers, American Indian Science and Engineering Society, American Indian Higher Education Consortium, Great Minds in STEM, Society of Hispanic Professional Engineers, Society for Advancement of Chicanos/Hispanics

& Native Americans in Science, Society of Asian Scientists and Engineers, Women of Color, and Society of Women Engineers.

- OP plans to continue supporting OSBP’s meetings, outreach events and OSBP Learning Series with small businesses to share information on how to do business with NASA, NASA’s acquisition forecast, NASA enterprise delivery model, how to comply with new acquisition practices, etc.

The NASA Research Announcements SMD uses to solicit unique research programs that result in the award of grants, is one of the Agency’s most direct mechanisms to impact the scientific community and thus represents an invaluable opportunity to gauge and advance equity. SMD’s approach to advancing equity for underserved communities in the scientific competition process is based on the following:

- Identifying, understanding and co-developing solutions to addressing the obstacles underserved communities and individuals face when it comes to participating in the process;
- Piloting alternative approaches and modeling the success of other scientific organizations to inform new processes and policies; and
- Performing analysis of quantitative and qualitative assessment tools to measure impact of policy changes.

## Evidence-building activities

NASA is committed to improving research grant and procurement opportunities for underserved communities. A combination of evidence-building activities, detailed below, will help NASA inform its policies and procedures to answer the question, “How do NASA’s procurement and grant practices advance equity for improved access to opportunities for underserved communities?” NASA’s OP in partnership with OSBP will accomplish the evidence-building activities associated with procurement policies and practices and NASA’s SMD will accomplish the evidence-building activities associated with grant policies and practices.

### Science Mission Directorate

Evidence-Building Activity	Evidence Category	Timeline
Analysis of grant application and selection data.	Foundational Fact Finding	FY 2022-2026 (Annually)

**Description and Potential methods:** The analysis of grant application and selection data will inform the grant-related practices and process, which will advance equity for improved access to opportunities for underserved communities. The primary source of data to help SMD evaluate the impact on equity of grant policies and procedures is the ongoing analysis of grant application and selection data, including voluntary demographic data, collected by the Office of the Chief Scientist. Expanded analysis of this data will be paired with identifying relevant studies and continuing to model the successful practices of other leading scientific organizations such as the Space Telescope Science Institute and the National Academies of Science, Engineering and Mathematics.

SMD will also explore opportunities to expand the categories it uses to evaluate success based on available data. For instance, SMD can incorporate analysis of the different types of institutions that proposers belong to using benchmarks in research activity and expenditures as defined by the Carnegie Classification of Institutions of Higher Education. These other considerations, added to the analysis on a systematic basis, will expand the dimensions of diversity that SMD considers when assessing equity in the proposal review and selection process.

Evidence-Building Activity	Evidence Category	Timeline
Review results from adoption of DAPR to an expanded set of ROSES grant categories	Program Evaluation	FY 2022-2026 (Annually)

**Description and Potential Methods:** The annual review of grant selection data will support SMD’s evaluation of the dual-anonymous peer review process (DAPR) in advancing the equitability of male versus female research proposal selection under the Hubble Space Telescopic Program. Following the success of the process under the Hubble Space Telescopic observing program, SMD began evaluating proposals submitted to numerous grant awards in the Research Opportunities in Space and Earth Science (ROSES) program elements using DAPR in 2020. As a result of the pilot, SMD saw improvements, both in terms of the overall quality of the review process, as well as in the demographics of awardees. SMD will expand the use of DAPR across the gamut of grant programs to apply the lessons learned from this experience to inform and institutionalize the policies that will advance equity in the grant review process.

Evidence-Building Activity	Evidence Category	Timeline
Develop and analyze formal surveys or other qualitative feedback tools from targeted activities	Policy Analysis	FY 2022-2026

**Description and Potential methods:** SMD will put in place other mechanisms to identify areas of improvement to access to grants for underserved communities on a recurring basis. This may include data analysis of surveys or other qualitative feedback tools following proposal-writing workshops at national conferences, panel reviewer trainings on cognitive biases, and other targeted activities.

**Office of Procurement & Office of Small Business Programs**

Evidence-Building Activity	Evidence Category	Timeline
Analyze ability to meet small business goals	Performance Measurement	FY 2022-2023

**Description and Potential Methods:** OSBP, in partnership with the OP, serves as the lead organization managing NASA’s utilization of small businesses and underrepresented communities in support of the Agency mission through the direct award of prime dollars and subcontracted dollars to small businesses and underrepresented communities. Within NASA the center procurement offices are assigned small business goals to encourage and incentivize the utilization of small businesses in response to NASA procurement opportunities. OSBP works closely with the NASA end user communities and OP to help small businesses understand and be prepared to support NASA mission requirements.

The NASA Acquisition Forecast, OSBP Mobile App, and OSBP Active Contracts Lists provide information to the small business community to understand and prepare to support NASA. OSBP will also leverage the Office of Space Technology Mission Directorate (STMD) and the Office of STEM Engagement (OSTEM) programmatic activities in utilizing small businesses and underrepresented communities in support of the NASA mission. OSBP works with STMD and their management of the Agency’s Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs. These programs are highly competitive programs that encourage domestic small businesses to engage in Federal-funded Research and Development (R/R&D) with the potential for commercialization. OSBP leverages the activities and support that OSTEM provides to HBCUs, Hispanic Serving Institutions, Tribal Colleges, Asian American and Pacific Islander Serving Institutions (AAPISI), and Minority Serving Institutions (MSI) to increase these institution’s awareness, participation, and support of NASA programmatic mission needs and requirements.

Evidence-Building Activity	Evidence Category	Timeline
Develop and analyze formal surveys or other qualitative feedback tools from targeted activities	Policy Analysis	FY 2022-2026

**Description and Potential methods:** In an effort to advance equity and ensure improved access to contract

opportunities for underserved communities, OSBP and OP plan to engage underserved communities by soliciting feedback. This may include surveys or feedback tools following proposer or reviewer trainings and workshops. Data analysis from formal surveys or other qualitative feedback tools from targeted activities, such as the proposal-writing workshops at national conferences, and panel reviewer trainings on cognitive biases will provide data that can impact NASA’s procurement processes, policies and procedures.

OSBP and OP are preparing formal surveys to be issued at contractor engagement events as early as 4th quarter FY 2022; however, other qualitative feedback tools are still being researched. Therefore, the results of the analysis of the surveys and other qualitative feedback tools will be complete and ready for use by the 1st quarter of FY 2026.

Evidence-Building Activity	Evidence Category	Timeline
Assess the effectiveness of NASA’s current outreach efforts	Policy Analysis	FY 2022-2026

**Description and Potential Methods:** In an effort to advance equity and encourage greater participation of all categories of small business contractors in the Government contracting process, OP and OSBP will develop and establish new procurement policies and practices that incentivize contractors, through tailored evaluation criteria during the solicitation process to: 1) partner with members of underserved communities, including HBCUs/MSIs; 2) diversify its own workforce to add underrepresented employees; 3) identify and utilize small businesses in underserved communities; and 4) identify and utilize small business subcontractors that operate in historically underutilized populations – rural and/or urban areas. OP will also develop and enhance existing policies and practices to encourage use and support of the Ability One Program, one of the nation’s largest providers of jobs for people who are blind or have significant disabilities. NASA will continue to use its purchasing power to procure products and services from participating nonprofit agencies that train and employ workers with disabilities. Additionally, NASA will continue to use the allure of its unique, exciting, and inspiring mission to encourage agencies who train and employ workers with disabilities.

In order to do this, NASA has to obtain a better understanding of the effectiveness of its current outreach efforts in increasing awareness of procurement opportunities to small businesses and underserved and underrepresented communities. There could be opportunities to invest in IT data software and other resources to allow the collection and assessment of detailed vendor information and cloud marketing. However, the Agency cannot determine the best path forward without first assessing the effectiveness of its current strategies.

Policy analysis and development is an ongoing effort of continual improvement that will span the life of the learning agenda and beyond. OP and OSBP will initially leverage ongoing and planned analyses and assessments of solicitation practices and procurement policies during FY 2021. Policy development will begin in FY 2022 and be implemented by the 4th quarter of FY 2022. During FY 2022, OP will coordinate with OSBP and establish policies and practices regarding the solicitation process to accomplish the four items listed above.

## Anticipated challenges and mitigation strategies

Challenge	Mitigation
Data collection limitations. NASA can evaluate demographics of SMD’s proposing and awarded researchers gathered by SMD and the Office of the Chief Scientist. However, limitations exist on gathering the types of data that are consistent with the dimensions of diversity as outlined in EO 13985	The recommendations of the Equitable Data Working Group will be instrumental in understanding what additional information can be collected and how it should be used to evaluate these and other efforts. Formal surveys of the large community of proposers and reviewers would also be helpful but would require OMB approval per the Paperwork Reduction Act
Uncertainty due to voluntary nature of data collection. Currently, demographic data on SMD grant proposers/ awardees is collected on a fully voluntary basis via the grants proposal submission system. While this remains the intent, the need to consider response rate for any given category of analysis creates uncertainty in the results. As a consequence of these potentially large uncertainties, some analysis of the data will not yield helpful results if, for example, the response rate for a particular category was especially low	SMD will consider and acknowledge this uncertainty and pair analysis of this data with other qualitative assessment tools to evaluate the impact of specific policies
Limited resources and time availability	Include resources for increased outreach and IT resources in budget requests. Leverage existing efforts wherever possible
Category Management and NASA Product Service Lines reduce the number of procurement opportunities available to small businesses and underrepresented communities	Work with the Office of Procurement and the end user community early in the procurement process to make the requirements user friendly for small business and underrepresented communities’ participation
Development of business relationships with small businesses, underserved and underrepresented communities is a long-term process	Involve small businesses, underserved and underrepresented communities earlier in the procurement process. Reach out to these communities as the NASA requirements are being developed. Additionally, OSBP instructs small businesses, during outreach events and counselling sessions, on the importance of businesses doing their homework to understand the NASA mission needs and to come to the Agency with proposed solutions. This is a more proactive approach which tries to position small businesses to be in a better position to compete for NASA’s prime and subcontract awards
Practices and policy changes that are based on legislation/ statutes and Executive Orders (EO) will require a legislative proposal or EO change to delete or change those policies	Follow current practices and policies until legislation/statutes and EOs are changed

Table 9: Priority Question 4 Challenges and Mitigation Strategies

## Communicating Results

For its grant-related policies and processes, SMD will this work to inform internal and external stakeholders. SMD will share these results internally through its standard strategic planning efforts. This will be in the form of SMD-wide strategic planning and procedure documents, such as the Science Plan, and the SMD Management Handbook, as well as division-specific materials that will highlight progress made in the area of equity and serve as a building block for continuous improvement. As for external information sharing, SMD will continue to share progress in this area with OMB and other stakeholders, such as Congress, through formal briefings and in response to queries. These stakeholders will be briefed on updated procedures, guidance, and the success and challenges of these efforts. This also pertains to the scientific/research community that NASA engages with on a regular basis. SMD will work to continue the open dialogue with relevant scientific institutions and the scientific community at large to convey the progress NASA is making to advance opportunities for underserved communities, build accountability, and remain open to ideas for improvement.

OSBP reports the progress made to the United States Small Businesses Administration annually with the submission of the SBA Scorecard Report. The annual Scorecard is an assessment tool to 1) measure how well Federal agencies reach their small business and socio-economic prime [contracting and subcontracting goals](#), 2) provide accurate and transparent contracting data, and 3) report agency-specific progress. The prime and subcontracting component goals include goals for small businesses, small businesses owned by women, small-disadvantaged businesses, service-disabled veteran-owned small businesses, and small businesses located in HUBZones.

## Priority Question #5

How do NASA Internships broaden participation of underrepresented and underserved students to advance equity and build a diverse future STEM Workforce?

## Alignment to Strategic Goals and Objectives

Strategic Goal 3	Strategic Goal 4
SO 3.1: Innovate and advance transformational space technologies	SO 4.1: Attract and develop a talented and diverse workforce
SO 3.2: Drive efficient and sustainable aviation	SO 4.2: Transform mission support capabilities for the next era of aerospace
	SO 4.3: Build the next generation of explorers

## Theory of change

If NASA increases the number of interns from underrepresented and underserved communities who apply to and are accepted for a NASA internship, there will be an increase in contributions to NASA's work from diverse viewpoints and lead to full time employment that will strengthen the potential for a more diverse future Science, Technology, Engineering, and Mathematics (STEM) workforce across all industries.

## Context

NASA makes vital investments in STEM engagement toward building a future diverse workforce. Given the nation's need for a diverse, skilled STEM workforce and projected demands in order to meet future needs, NASA clearly has a vested interest in helping to prepare and attract its future STEM professionals. Also, the national STEM education ecosystem can benefit from NASA contributions toward attracting and retaining students on STEM pathways, with increased attention on underserved and underrepresented students. NASA Internships are competitive awards to support NASA's goal of building a diverse future workforce by providing unique NASA-related research and operational experiences for higher education students. These opportunities serve students by integrating interns with career professionals emphasizing mentor-directed, degree-related tasks and contributing to the operation of a NASA facility or the advancement of NASA's missions. Since 2019, NASA Office of STEM Engagement (OSTEM) has executed performance assessment and evaluation activities to assess the extent to which OSTEM investments have broadened participation of groups historically underrepresented in STEM. This priority setting has been guided by OSTEM's learning agenda question: How have NASA STEM Engagement investments broadened participation of historically underrepresented and underserved groups in STEM fields in NASA STEM Engagement activities?

In FY 2021, OSTEM is continuing its continuous improvement efforts by executing an outcome assessment to measure students' immediate outcomes of participating in NASA Internships and assess how and to what extent interns are contributing to NASA's missions. Additionally, this study will identify sources of group differences and address how NASA can continue to broaden participation of historically underrepresented



and underserved groups in STEM fields. Building on this effectiveness evaluation, OSTEM will expand its assessment of how internships have broadened participation of groups historically underrepresented in STEM. In alignment with the priority question: “How do NASA Internships broaden participation of underrepresented and underserved students to advance equity and build a diverse future STEM Workforce?”, OSTEM will conduct specific evidence activities to assess the effectiveness of NASA internships and identify practices that are advancing equity and building a diverse future STEM workforce. OSTEM will use its evidence-based decision-making process to assess what practices are working well and what practices could benefit from improvement. OSTEM will consider alternative approaches, especially those that are supported by research. These activities will provide a foundation of evidence that will inform NASA’s efforts to develop a diverse future workforce.

## Approach

OSTEM will address this priority question through a combination of policy analysis, program evaluation, and performance measurement activities. We plan to conduct these activities during the period of FY 2022–2026. We elaborate on this approach in the subsequent sections.

## Evidence-building activities

OSTEM will execute several key evidence-building activities that will build knowledge in support of the priority question. Using OSTEM’s evidence-based decision-making process, we will use each evidence-building activity to create a portfolio of evidence that will ultimately be used in support of the priority question.

OSTEM will serve as the lead organization for this priority question, although other NASA offices may contribute evidence if relevant and aligned to the priority question. OSTEM will oversee the planning and execution of evidence-building activities for this priority question. Evidence-building activities will begin in FY 2022 as part of OSTEM’s comprehensive performance assessment and evaluation strategy. OSTEM will leverage its current Learning Agenda and integrate the priority question as a key OSTEM learning question during FY 2022. Each evidence-building activity will be executed as an annual assessment, beginning in FY 2022. OSTEM will review the portfolio of evidence annually and make changes to evidence-building activities as needed.

Evidence-Building Activity	Evidence Category	Timeline
Internship Program DEIA efforts	Policy Analysis	FY 2022

**Description:** The Internship Program DEIA efforts focus on recruitment, awareness, applicant and participant analysis, etc. OSTEM plans to utilize the knowledge gained during this initiative to determine best practices for reaching underserved student populations for internships.

**Potential methods:** Data analysis of program-specific data (e.g., descriptive statistics and aggregate indicators)

Evidence-Building Activity	Evidence Category	Timeline
NASA Strategy for STEM Engagement	Policy Analysis	FY 2022-2023

**Description:** Through the policy analysis of NASA’s Strategy for STEM Engagement, OSTEM expects to gain valuable insights that will help determine what policies are in place that are currently leading to broadened participation by underrepresented students. This analysis will also help determine which policies and action plans are currently serving as barriers for participation for underrepresented students.

Evidence-Building Activity	Evidence Category	Timeline
NASA STEM Gateway performance data	Performance Measurement	FY 2022-2026 (annual reporting)

**Description:** NASA STEM Gateway is a universal registration and applicant data management system that

will collect non-traditional demographic information including geographic distribution (e.g., rural/urban status and congressional district) and MSI designations. OSTEM will use this data to generate meaningful performance metrics concerning underrepresented students in STEM internships.

**Potential methods:** Systematic tracking of performance data (e.g., program goals/objectives, participant demographics)

Evidence-Building Activity	Evidence Category	Timeline
Internship Outcome Assessment Year 2 Study	Program Evaluations	FY 2022-2023

**Description:** The Internship Outcome Assessment Follow-On Study will generate short-term outcomes associated with participation in the internship program. Further details can be found in the Agency’s FY 2022 and FY 2023 Annual Evaluation Plans.

**Potential methods:** Analysis of findings of key evaluation studies; likely to include studies with the following methodologies: quasi-experimental, pre-post design, implementation study, mixed method, etc.

Evidence-Building Activity	Evidence Category	Timeline
Career Readiness Follow-On Study	Program Evaluations	FY 2022

**Description:** The Career Readiness Assessment will investigate the career readiness of early career NASA STEM professionals who had a NASA internship prior to their employment as compared to those who did not. The study will include analysis of differences based on underrepresented group status.

**Potential methods:** Analysis of findings of key evaluation studies; likely to include studies with the following methodologies: quasi-experimental, pre-post design, implementation study, mixed method, etc.

Evidence-Building Activity	Evidence Category	Timeline
OSTEM Learning Agenda	Performance Measurement, Program Evaluations	FY 2022-2026 (annual reporting)

**Description:** The OSTEM Learning Agenda will include an analysis of portfolio of evidence created through performance and evaluation activities, which will help assess the extent to which OSTEM investments have broadened participation of groups historically underrepresented in STEM.

**Potential methods:** Analysis of findings of key evaluation studies; likely to include studies with the following methodologies: quasi-experimental, pre-post design, implementation study, mixed method, etc.

## Anticipated challenges and mitigation strategies

There are several anticipated challenges for this priority question learning agenda. Examples, along with associated mitigation strategies, include:

Challenge	Mitigation
Limited resources and time availability	Include resources for evaluation in budget requests. Leverage existing efforts wherever possible.
Transition to new universal registration/application and performance management system	Ensure performance and evaluation requirements are integrated into system development for performance reporting.
Longitudinal tracking of internships participants may be difficult	Develop interim success measures for nearer-term impacts of policy changes; leverage NASA STEM Gateway as a vehicle for data collection.
Schedule slippage	Create a schedule of tasks and milestones that can be used to monitor evidence-building activities.

Lack of reflection of DEIA efforts by the Office of Chief Human Capital Officer, Office of Diversity and Equal Opportunity, Office of Communications, and Missions	Ensure priority question is broad enough to reflect work of other NASA offices.
Limitations on data collection for individual participant demographics include necessary compliance with Paperwork Reduction Act requirements and self-reported/voluntary response, including the reluctance of some communities to respond to demographic questions.	Opportunities exist to find appropriate methods to collect other demographic data through the NASA STEM Gateway and leveraging other Federal datasets.

Table 10: Priority Question 5 Challenges and Mitigation Strategies

## Communicating Results

OSTEM will report on progress to the NASA STEM Engagement Council, NASA OCFO, and OMB, including relevant contributions to the NASA Volume of Integrated Performance (VIPer) and other performance documents. Additionally, we anticipate that findings from this priority question may result in updates to OSTEM’s Learning Agenda and will be shared with OSTEM leadership as part of OSTEM’s continuous improvement process. Analyses and evaluations conducted through this Learning Agenda also may result in published papers and/or presentations at conferences and workshops.

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# Appendix B: Capacity Assessment

## NASA's Capacity Assessment

Evidence-building capacity at NASA is wide and varied. Led by NASA's Evaluation Officer, in conjunction with the Statistical Officer and Chief Data Officer, five criteria guide NASA's evidence culture: coverage, quality, methods, effectiveness, and independence.

- Coverage at NASA ensures that evidence-building activities are conducted extensively across the Agency's Centers and Mission Directorates to maintain a distribution of capacity and to target those programs and operations at NASA that require greater analysis.
- Quality evidence-building efforts produce reliable and robust results that provide information useful for NASA leadership to make decisions.
- Methods or methodological approaches are carefully considered within NASA to ensure that the right quantitative and qualitative approach is chosen and tailorable to best collect and understand measurement data in each design and assessment.
- Effectiveness is a measure of outcomes to determine whether a policy or program achieved specific objectives and how efficiently resources were expended. NASA develops its evidence-building activities to drive impact across the Agency.
- Independence at NASA revolves around objectivity and requires that Agency staff and contractors uphold rigorous, ethical, and transparent research practices to ensure findings are externally valid and credible. NASA's commitment to independence means that statistics, evaluations, research, and analysis efforts across the Agency are performed impartially and free from undue influence.

In accordance with the requirements of the Evidence Act, NASA enacted the [NASA Policy Directive 1210.7](#), which establishes the standards of evaluation and statistical practices and the authority of the Evaluation Officer to oversee Agency-wide evidence-building activities. Further, NASA created an Evaluation Management Process Champion position, who leads an interagency working group across Centers and Mission Directorates to establish and maintain an evaluation management line of business.

To help identify the Agency's evidence-building activities and assess them, NASA designed a survey that was distributed across the Centers and Mission Directorates. The survey was used to understand what statistics, evaluation, and research and analysis activities were being conducted within the Agency and how to characterize them against the standards established by Office of Management and Budget (OMB). The details of this survey-based approach are described in the following sections.

### Assessment Scope and Method

The requirements for what to include in the Capacity Assessment are detailed in [M-19-23](#), which gave agencies the flexibility to identify how such an assessment can be conducted. Prior to identifying an assessment method, NASA defined how to properly scope this effort. The intent was to capture cross-portfolio activities that inform decision-making within the Agency. This cross-portfolio approach set parameters around the collection of evidence-building activities to ensure an extensive yet practical list.

Using OMB's definitions for statistics, evaluation, and research and analysis, it was important to understand how these terms translated and applied to NASA processes. NASA's programs and projects are organized by Mission Directorates and then governed by a Center. In order to get an accurate landscape of the Agency's capacity, identifying just a Mission Directorate and/or Center may not capture potential evidence-building activities. Therefore, it was important to identify representatives from each Mission Directorate and Center to ensure that the appropriate activities were included. Also, there is a Program Planning & Control (PP&C) function within the Agency that provides cost, schedule, risk, and resource support to programs and projects. These individuals are matrixed to various organizations to support any ongoing assessments. Including the PP&C community as participants in this assessment help ensure those additional analyses are being identified to help characterize the Agency's capacity. With representation from the Mission Directorates,

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Centers, and the PP&C community, NASA had identified where evidence-building domains occur across the Agency, and a comprehensive way to examine capacity criteria.

After identifying individuals who know of or perform statistical, evaluation, and research and analysis activities at NASA, the activities needed to be efficiently identified. NASA executed a two-phased approach to gather such data. Phase 1 consisted of a 17-question survey. Given the diverse staff roles and needing a mechanism to solicit Agency evidence-building activities, a survey method was selected to gather the initial information. A survey was used because 1) it allowed the participants the flexibility to provide responses within their availability, 2) it was more efficient than interviewing each individual, and 3) it served as a gateway to identify future methods for gathering data. This method was also the most efficient choice, at the time, due to resource limitations and clear guidance of what evidence-building activities are being conducted within the Agency. NASA was aware that using a self-reporting mechanism within a survey can introduce high levels of optimism and biased responses. Therefore, to offset the potential biases and attempt to validate the responses, the second phase of the approach included not only seeking input from the analysis practitioners but also from the senior leadership of the Mission Directorates and Centers to gain better insight into if the results from analyses influence policy and decision-making.

Phase 1 of the Capacity Assessment Survey concluded in Spring 2021. NASA received 47 completed surveys from the communities described above. The survey was initially sent to 35 persons and they had the ability to share the survey with other individuals in their division or center who may conduct evidence-building activities. The initial recipients were point of contacts within NASA's Performance/Evaluation and PP&C communities. These persons represented the practitioners that either conduct or know of individuals that conduct evidence-building activities. Since some of the surveys could have been forwarded repeatedly to individuals across the Agency, it is difficult to quantify the true response rate. NASA can comment that the individuals that received the survey took a careful approach in answering the questions and characterizing their evaluations, statistical and/or research analyses.

The objective of Phase 2 was to engage senior leadership of the identified evaluation communities and identify what type of evidence-building data is used towards their policy-making decisions. Phase 2 of the survey was distributed in Fall of 2021 with a response rate of approximately 71 percent. The results did verify the responses from Phase 1, concluding that the evidence-building analyses that is executed within the Agency is being utilized towards decision and policy making.

### Assessment Survey

The requirements outlined in M-19-23 helped guide which questions to include in the survey. The survey was comprised of 6 sections with a total of 17 questions. Along with open-ended questions, a 5-point Likert scale (Excellent, Good, Fair, Poor, Very Poor) was also used to evaluate capacity criteria related to coverage, quality, methods, effectiveness, and independence of the identified activities. The survey responders were to answer the questions based on the analysis that their office or organization conducted. For example, if a person worked for the PP&C branch of a certain mission directorate then their responses were to help understand the evidence-building activities within that mission directorate.

In addition to the capacity criteria described above, NASA developed a crosswalk to ensure the survey contained a mix of questions that addressed required elements A-F in the Evidence Act. This process ensured the survey was exhaustive of all information mandated by the legislation and of particular evidence-building relevance to the Agency. The open-ended questions were generated to support requirements outlined in M-19-23 and help NASA ascertain the level of appropriateness of the activities to:

- Support agency needs;
- Balance agency needs for learning and management, performance and strategic management, interagency and private sector coordination, and oversight and accountability; and
- Use appropriate methodologies.

Questions also helped determine if the Agency has the capacity to:

- Plan and implement evaluation activities, disseminate best practices and findings, and incorporate employee views and feedback; and
- Carry out capacity-building activities in order to use evaluation research and analysis approaches and data in day-to-day operations.

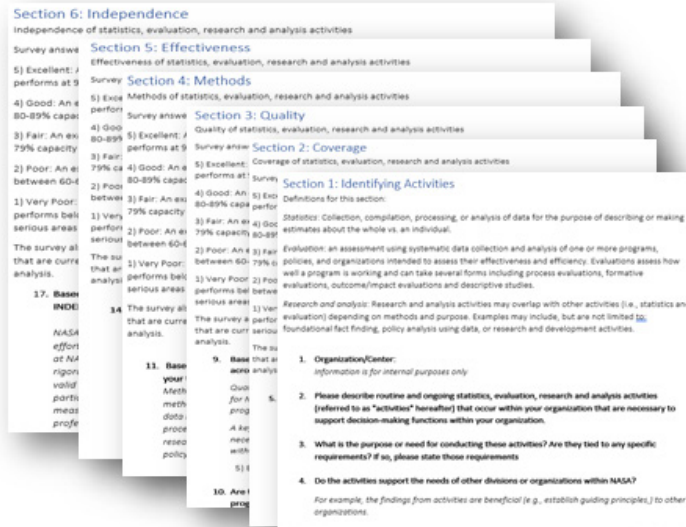


Figure 1: Capacity Assessment Survey

Phase 2 of the survey consisted of an open-ended question that stated, “What type of information, data, analysis, evaluation, and/or evidence is used to enable better decision making and/or policy making?” Recipients had the opportunity to list and describe those activities. The figure below illustrates the commonalities between the Phase 1 and 2 responses.

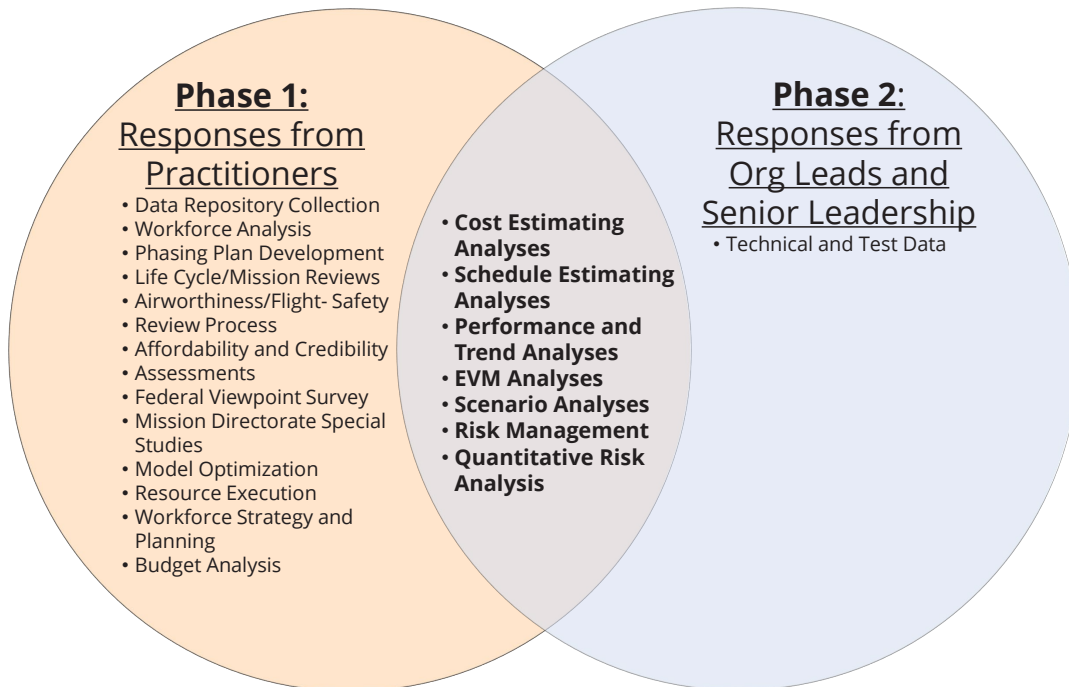


Figure 2: Capacity Assessment Phase 1 and Phase 2 Result Comparison

## Capacity Assessment Criteria

### Coverage

NASA has a robust internal and external evidence-building structure in place for its programs and missions, shown in the figure below. NASA’s governing bodies, Mission Directorates, and Centers identify evidence-building activities including statistics, evaluations, research, and analysis and maintain the tools and expertise needed to produce evidence. The Agency is structured to include research-focused organizations at NASA Headquarters, within Mission Directorates, at each of its Centers, and at the Federally Funded Research and Development Center levels. Phase 1 of survey distribution covered Mission Directorate, Center, and PP&C Community staff to properly capture a diverse subset of Agency staff and contractors across evidence-building domains. Research at NASA can be conducted entirely by Agency staff, augmented through contractor support, or through external research institutions and firms through a competitive Federal awards process.

<b>Internal</b>	Headquarters	<b>External</b>	Industry
	Mission Directorates		Universities
	Centers		National Academies
	FFRDCs		Citizen Science

Figure 3: NASA’s Internal and External Evidence-building Sources

Both the Office of Strategic Engagement and Assessments and the Strategic Investments Division (SID) are organizations within NASA that perform Agency-wide evidence activities. The Agency Investment Analysis (AIA) office, within SID, functions as NASA’s Statistical Unit to inform and advise NASA senior leadership on Agency-wide investment decisions to ensure affordable and achievable long-term strategies are effective and efficient for the Agency. The Branch Chief of AIA serves as NASA’s Statistical Official to ensure alignment between investments and evidence gathered for Agency strategy and resource allocation to enable informed decision-making through assessments, trending, and forecasting of budgets, mission content, workforce, mission performance, and other factors influencing the ability of NASA to achieve its mission. The Agency also leverages academia, industry, and the National Academies to utilize all available expertise in the aerospace community when conducting evidence-building activities. Citizen science projects also provide an integral source of evidence and discovery through the Agency’s open data portal. Policymakers at NASA can request and access evidence from all these resources through various council and external body reviews.

The Agency maintains a highly-skilled workforce comprised of scientists, engineers, nuclear and chemical engineers, and data and program analysts who have the expertise needed to conduct evidence-building activities across the Enterprise. In addition to the Federal workforce, NASA utilizes contracts to leverage the power and flexibility of academia and the private sector for additional insights into the Agency’s missions.

The results from the survey illustrated that analysts and practitioners have adequate personnel to plan and conduct evidence-building activities, and generally self-report high levels of full-time equivalent (FTE) and work-year equivalent staff (WYE) staff necessary to carry out vital Agency evidence-building functions. The future submissions of the Capacity Assessment will better highlight how the evidence-building activities support the development of skill sets to execute goals and objectives outlined in the Strategic Plan.

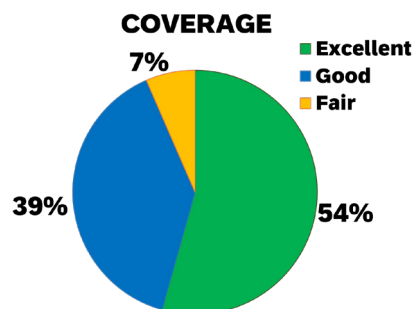


Figure 4: Agency Self Report of Coverage

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## Quality

NASA's evidence-building activities produce high-quality results due to its capable workforce, procedural requirements, and rigorous peer review processes. NASA has a structure of internal policies that dictate thorough research standards in line with the best standards and practices. The creation of NASA Policy Directive (NPD) 1210, NASA's Evaluation Policy, ensures that all evaluations meet the quality of standards established by the Evidence Act and the Federal evaluation community.

When NASA undertakes significant evidence-building activities for its programs and missions, a peer review process is in place to ensure that rigorous standards and quality are upheld. NASA's organization and diverse talent pool allows the Agency to utilize peer reviews so that findings are clear and thorough before results are disseminated to Agency leadership or the public.

The survey results indicate that Agency staff and contractors self-report high levels of quality necessary to produce reliable and robust results within their community and incorporate high levels of rigor needed to inform decision-making. Furthermore, respondents indicated in open responses that evidence-building quality standards are often codified as part of a specific NASA policy, objective or program requirement, including regular risk assessments and stipulations set forth in NASA Procedural Requirements and NPDs.

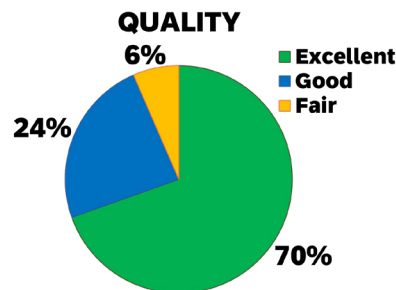


Figure 5: Agency Self Report of Quality

## Methods

As a world leader in aeronautics and space research, NASA is committed to using the right methodological approach to accommodate various research designs and data types. In many cases, NASA Centers or Mission Directorates conducting the analyses are responsible for developing an approach or research model that fits their needs and adopt evidence-based methodological approaches that produce verifiable findings. Other research efforts are smaller in scope and may include a targeted statistical analysis of a program, data set, or policy. Regardless of the research type or chosen methodology, NASA adheres to the highest standards of rigor and quality.

Leveraging the Capacity Assessment to gather a diverse inventory of evidence-building types was important to determine how NASA pairs these activities to specific methods and whether the Agency implements the appropriate quantitative and qualitative methodological approaches, techniques and strategies to collect and understand measurement data as part of each research design. Additionally, the survey sought inventory methods from across NASA's Mission Directorates, Centers, and PP&C Community, and determines how a methodological approach was decided.

The survey results indicate high levels of methodological appropriateness as self-reported, and that the strategies to collect and understand measurement data are strong. Additionally, the survey uncovered the myriad of historical approaches, industry standards (e.g., risk and schedule analysis, cost estimating, performance analysis and standard accounting) and other assessment criteria used to select a prevailing methodological type, tied to inventory of methods gathered in the survey.



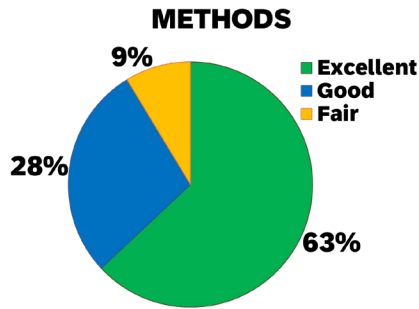
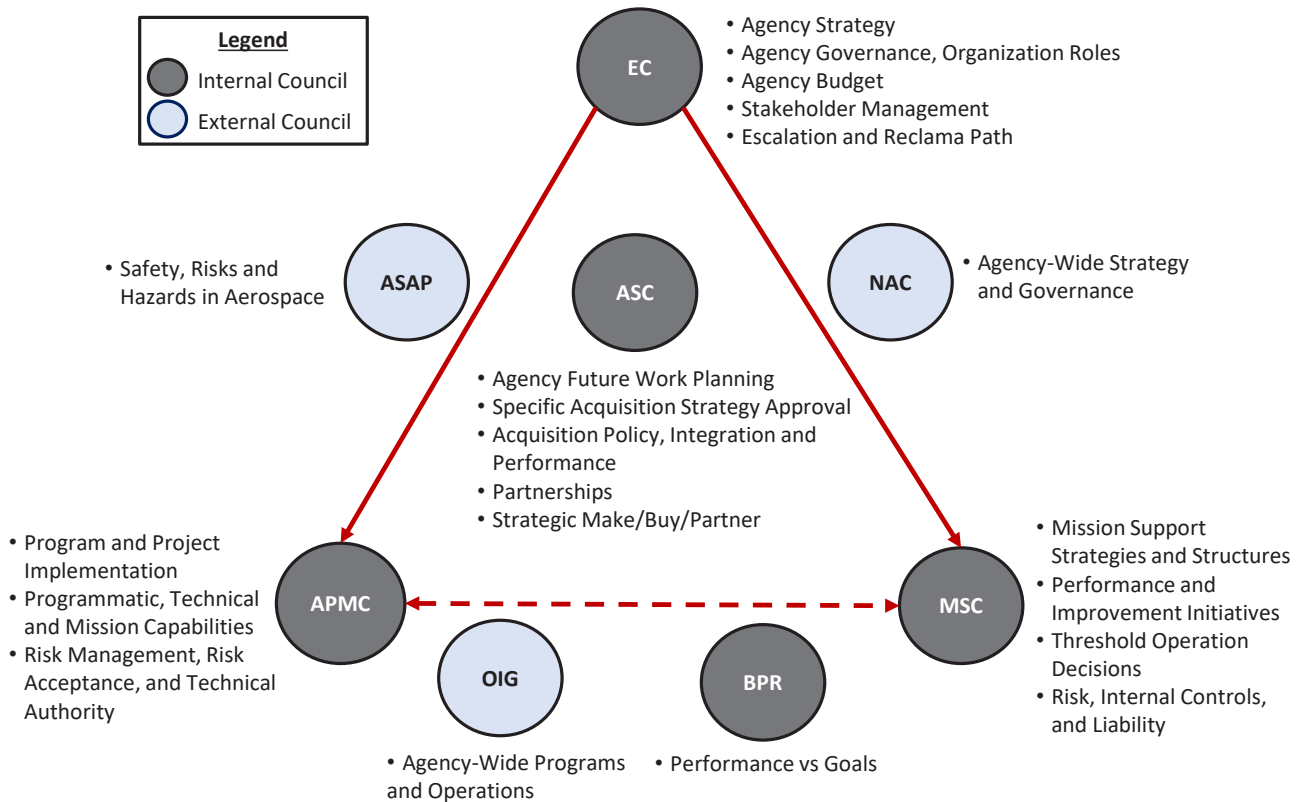


Figure 6: Agency Self Report of Methods

## Effectiveness

After the results from evidence-building activities have been internally reviewed, they are presented to one of several NASA management councils, which together comprise the decisional and governing bodies across the Agency. In addition to these governing bodies, a series of external councils and advisory groups play a support role to help provide oversight of Agency management and operations. Together, these internal and external councils, illustrated in the figure below, use these results to make better-informed policy decisions.



NASA's internal councils are led by the Executive Council (EC), which determines NASA's strategic direction and assesses progress toward achieving the Agency's vision. The EC depends on valid and robust research conducted across NASA's Centers and Mission Directorates to advise the Administrator. The Agency Program Management Council (APMC) provides oversight concerning the integrated Agency mission portfolio and uses performance reports and independent assessment models to ensure mission success and to enhance management accountability. The Acquisition Strategy Council (ASC) serves as the Agency's senior decision-making body regarding future work planning, specific acquisition strategy approval, and acquisition policy integration and performance. The Baseline Performance Review (BPR) is conducted monthly by the Associate Administrator and serves as a bottom-up review of how well the Agency is executing across per-

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formance metrics such as cost and schedule estimates, contract commitments, or technical objectives. The Mission Support Council (MSC) determines and assesses mission support requirements to enable successful accomplishment of the Agency's missions. To provide informed implementation strategies on vital support functions such as facility and infrastructure requirements and workforce projections, the MSC is tasked with evaluating research findings under the mission support portfolio to determine how efficiently funds are allocated and to measure the outcomes from these investments. Together, these decisional bodies depend upon and leverage NASA's vast evidence-building capacity and culture to make informed policy decisions across management, strategic, and operational lines.

External councils and advisory groups also play a role in interpreting NASA-produced statistics, evaluation, and research and analysis findings to assist senior officials in their governance capacity. The NASA Advisory Council is a longstanding body of external experts that convenes to address topics relevant to the Agency including human exploration, aeronautics, technology and innovation and uses NASA research to offer recommendations to the Administrator on the effectiveness of program safety and efficiency. The Aerospace Safety Advisory Council (ASAP) submits an annual report to both the Administrator and Congress detailing safety, risk and hazard data and findings across NASA's aerospace programs. Lastly, NASA's Office of the Inspector General (OIG) independently reports to the Administrator, Congress, and the public. The OIG promotes efficiency and effectiveness through audits, reviews, and investigations of NASA programs to detect waste, fraud, abuse, and mismanagement.

Figure 7: NASA's Council System. Developed from NPD 1000.0C

The survey results indicate high levels of effectiveness in that policies and programs achieve their intended program outcomes through efficient use of Agency resources. Furthermore, respondents indicated that NASA's Management Councils, external councils, and array of advisory groups serve an important oversight role to monitor Agency operations. Open-response survey answers indicated that most evidence-building activities followed a tracking and monitoring process to assess program/project milestones and that findings from these activities directly influence organizational planning and decision-making.

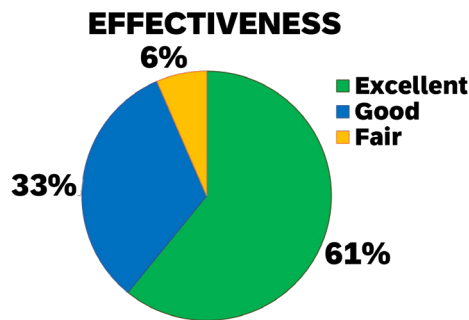


Figure 8: Agency Self-Report of Effectiveness

## Independence

NASA has the capability to undertake its own research efforts but also takes great strides to ensure its findings and methods are transparent, rigorous, and in-step with the broader scientific community and ethical standards. NASA research undergoes an independent peer review for publication in professional journals, and the Agency receives independent expert advice from the National Academies of Science, Engineering, and Medicine, which guide planning and help ensure the Agency's research and development priorities align with the needs of the larger exploration and science communities. The National Academies also lead a series of decadal surveys to help inform the balance of NASA portfolios while providing independent expert advice on areas such as aerospace technologies, space biology, and physics.

In addition to interagency outreach and consultation with the academic community, NASA also ensures research and program testing undergoes independent and impartial assessments when conducted within the Agency. Standing Review Boards (SRBs) are formal assessments across the lifecycle of a program or project

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to provide an objective review of design and development plans using staff outside of the programmatic or institutional authorities related to the program or project in question. SRBs also help keep applied research plans on track and help demonstrate to senior leadership that projects are ripe for a new stage of testing, while removing the pressures of self-imposed deadlines to push forward a project without the evidence to support its approval.

The survey results indicate that NASA teams and organizations self-report that evidence-building activities are undertaken impartially and free from undue influence. Agency staff and contractors submit that activities across each domain uphold rigorous, ethical, and transparent research practices to ensure findings are externally valid and credible.

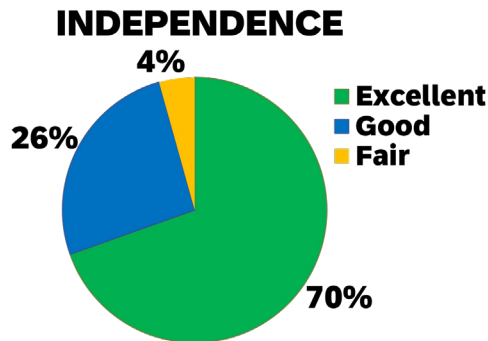


Figure 9: Agency Self Report of Independence

### NASA's Capacity for Evidence-Building Activities

The survey was distributed via email to the survey participants in Spring 2021 and a total of 47 responses were received with representation of 10 organizations. With the Likert scale establishing the standard towards assessing aspects of the identified activities, the level of detail provided with the open-ended questions was mixed.

Survey responses were reviewed to determine whether the activity could be either evaluation, statistics, and/or research and analysis. The definitions used were:

- **Statistics:** Collection, compilation, processing, or analysis of data for the purpose of describing or making estimates about the whole vs. an individual.
- **Evaluation:** an assessment using systematic data collection and analysis of one or more programs, policies, and organizations intended to assess their effectiveness and efficiency. Evaluations assess how well a program is working and can take several forms including process evaluations, formative evaluations, outcome/impact evaluations and descriptive studies.
- **Research and analysis:** Research and analysis activities may overlap with other activities (i.e., statistics and evaluation) depending on methods and purpose. Examples may include, but are not limited to foundational fact finding, policy analysis using data, or research and development activities.

There was some overlap in the placement of the activities, however, the results illustrated that the majority of NASA's evidence-building types are considered statistics.

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## Evidence Building Types

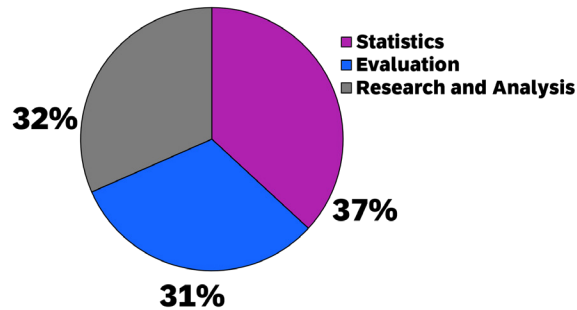


Figure 10: Agency's Evidence-Building Types

## Evidence-Building Activities Identified

It was apparent that the Agency conducts similar analyses within the Mission Directorates and at the Centers to better inform policies and aid in decision-making. The raw data from the survey was summarized at a high level to eliminate redundancy. The sections below provide further context on how NASA interprets statistics, evaluation, and research/analysis activities. Additionally, as required by A-11, these specific activities are identified and defined in terms of their use at NASA.

At NASA, statistical activities are comprised of collecting data from historical programs, projects, and processes to help determine how future programs/projects should function to achieve mission success. These statistical activities include looking at the range of data, identifying outliers and the circumstances as to why outliers exist. These analyses help determine Agency thresholds for cost and schedule estimates, determine acquisition requirements, and shape performance metrics. Centers also conduct strategic workforce analysis and financial assessments to ascertain whether there are sufficient resources to support a portfolio of programs and projects and/or Center needs Activities include:

- Cost Estimating and Analyses
  - Estimating and analysis activities including but not limited to creating cost models to estimate program, project, or directorate costs based on cost estimating relationships, analogous program/project data, and/or historical NASA data.
- Schedule Estimating and Analyses
  - Collecting historical NASA schedules to identify how to better estimate durations of future programs and projects.
- Data Repository Collection
  - Maintaining and collecting program and project cost, schedule, risk, and earned value management data to provide insight in the historical trends of the Agency.
- Workforce Analysis
  - Collecting historical data on the hiring and attrition of employees; conducting analyses on whether workforce needs are met
- Phasing Plan Development
  - Collecting historical program and project information to inform how to properly phase spend plans for successful execution of funds
- Performance and Trend Analysis
  - Determining if the program and/or project is executing within acceptable threshold levels based on collected programmatic data. Threshold levels are set from cost and schedule analyses
- Budget Analysis

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- Collecting budget data to define and establish budget requirements, controls, and guidelines to support agency priorities and strategies.

NASA Evaluation evidence-building types include assessing the efficiency and effectiveness of a Program, project and/or process. NASA conducts Lifecycle Reviews (LCRs) for key mission milestones or decision points. To support the LCR, the feasibility of the cost and schedule estimates are evaluated.

Activities include:

- Cost Estimating and Analyses
  - Conducting cost analyses to determine how well the program and project is executing their cost plan
- Schedule Estimating and Analysis
  - Conducting schedule risk analyses to determine how well the project is managing margin within acceptable threshold limits
- Risk Management and Quantitate Risk Analysis
  - Assessing possible impacts and outcomes of threats to program and project goals and objectives to help determine other areas of concern and be more reactive to perceived threats.
- Life Cycle and Agency Reviews
  - Determining if the program and/or project meets the intended objectives and executing within the pre-determined guidelines
- Earned Value Analyses
  - Conducting an integrated view of cost and schedule analyses to determine if the program and project is executing well within the pre-determined guidelines
- Airworthiness and Flight Safety Review
  - Conducting a process evaluation to determine if a project's team plans and hazard stance meets the requirements for aircraft operations.
- Affordability and Credibility Assessments
  - Conducting analysis to determine if a process or evaluation is useful to the agency's needs

NASA conducts various research and analysis activities to inform estimates, perfect model development, understand the possible impacts of varying scenarios, and provide context on newly-developed technologies/demonstrations. These types of activities provide foundational fact-finding towards executing evidence-building analysis. Once the Agency understands the context of the potential risk and/or question, action plans will be devised to address the gap and eliminate negative impacts. Activities include:

- Mission Directorate Special Studies
  - Performing various analyses and research to help determine why systematic issues may occur
- Scenario Analyses
  - Conducting research on several options to determine the most optimal alternative to identified problems within programs or projects.
- Risk Management and Quantitate Risk Analysis
  - Assessing possible impacts and outcomes of threats to program and project goals and objectives to help determine other areas of concern and be more reactive to perceived threats.
- Workforce Strategy and Planning
  - Using the historical workforce data, conducting analyses to determine how to optimize the cur-

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rent and future workforce

- Federal Viewpoint Survey
  - Consists of collecting data for the Federal Viewpoint Surveys and assessing improvements and degradation in employee morale.
- Resource Execution
  - Developing a plan for managing, analyzing, and reporting performance of resources based on researched and collected data
- Model Optimization
  - Improvement of program and project models by researching other possible methodological approaches and updating the models based on most recent collected data.

## Findings

Table 2 below summarizes assessment of each domain against coverage, quality, methods, effectiveness, and independence as required by A-11 (Requirements B-F). A list of the activities and operations, as required by Requirement A, were defined in the previous section.

Requirements B-F	Statistics	Evaluation	Research and Analysis
<p><b>Supports Agency Needs</b></p>	<ul style="list-style-type: none"> <li>• Activities support Agency's needs in terms of data collection for development of models and thresholds, forecast performance. Many analysis activities support adherence to NASA policy requirements. Strategic analysis also ensures alignment Strategic Plan</li> <li>• Survey responses indicate there are adequate personnel support to execute the identified activities, including for backfilling positions due to planned retirements</li> <li>• Activities are conducted across the Centers and Missions Directorates</li> </ul>	<ul style="list-style-type: none"> <li>• Identified activities support Agency needs and align to agency policy and requirements</li> <li>• Most of the capability resides with the Office of the Chief Financial Officer (OCFO), Strategic Development divisions within Centers, with some activities in the Office of Human Capital</li> <li>• Provide stakeholders with insight into performance of programs and their purpose. Successful execution of Programs/projects within Mission Directorates' support NASA's Strategic Plan and Objectives</li> <li>• Survey responses indicate there are adequate personnel support to execute the identified activities</li> </ul>	<ul style="list-style-type: none"> <li>• Agency needs are supported with the improvement of methods, tools, and practices that are used for some evaluation activities</li> <li>• Research and analysis efforts address immediate 'what if' scenarios of major Programs and projects</li> <li>• Capability of conducting analyses are distributed across the Centers and Mission Directorates</li> </ul>

Requirements B-F	Statistics	Evaluation	Research and Analysis
<p><b>Balancing Agency needs for learning and management, performance and strategic management, interagency and private sector coordination, and oversight and accountability</b></p>	<ul style="list-style-type: none"> <li>• Formal and informal training mechanisms are in place to help ensure that the personnel can execute activities based on established quality standards</li> <li>• The civil servant and contractor workforce collaborate well to ensure mission success. SOWs clearly identify what type of support is needed from the contracting workforce</li> <li>• Oversight into these activities are blurred across domains of Centers/Mission Directorates. Some may reside within specific Programs and projects, while others may be from an enterprise perspective</li> <li>• Statistical analyses help establish performance thresholds and provides guidance to decision makers when a Program or project is executing efficiently and meeting objectives.</li> </ul>	<ul style="list-style-type: none"> <li>• Professional development opportunities exist within NASA that are specific to the Evaluation activities (e.g., PP&amp;C Training Curriculum Enhancements). Formal training on how to conduct the identified evaluation activities can be accessed through learning management systems such as the Systems for Administration, Training, and Educational Resources and the Chief Financial Officer University</li> <li>• The contractors and other partners work alongside the civil servant workforce to ensure that these activities are being conducted when requested and needed</li> <li>• The OCFO SID has stewardship over the cost, schedule and earned value management functions within the Agency. These functions support multiple evaluations within NASA. The policies, methods, and processes are consistent and can be tailorable to meet the needs of specific evaluations</li> </ul>	<ul style="list-style-type: none"> <li>• Primarily informal training mechanisms are in place (e.g., mentoring, on the job training, etc.,) to conduct research and analysis efforts</li> <li>• An overarching question concerning flagship programs</li> <li>• There is support from the Enterprise perspective, however most research and analyses activities are germane to the civil servant workforce. Coordination from the contracting workforce is limited due to potential conflict of interest</li> <li>• Some Research and Analysis activities are organized based on specific need to address an overarching question for flagship programs. Centers and Mission Directorates are strategic in devising a plan to meet the new (e.g., special study teams), as they will oversight over those activities</li> <li>• Other Research &amp; Analysis activities include performing analyses to improve upon models and tools. Oversight into model improvement is led by the OCFO</li> </ul>
<p><b>Use of appropriate methods</b></p>	<ul style="list-style-type: none"> <li>• The application of methods and tools does vary with activities. However, methods do reflect of best historical approaches, along with industry and Agency best practices and guidelines</li> <li>• Analysts do benchmark methods against other agencies and capture lessons learned. Analysts network across directorates and Centers to help ensure appropriate use of methods for assessments and/or evaluations. Methodologies are supported by Agency policies and improved upon by historical data and research</li> </ul>		



Requirements B-F	Statistics	Evaluation	Research and Analysis
<p><b>Planning and implementing evaluation activities, disseminating best practices and findings, and incorporating employee views and feedback</b></p>	<ul style="list-style-type: none"> <li>• Results from analyses do drive how Program and projects plan and execute. For example, some of the cost and schedule analysis activities established Agency best practices that are outlined in governing policy and handbook documents</li> <li>• Results of the activities meets the needs of stakeholders</li> <li>• Collecting trends, past historical performances, and lessons learned enables the Agency to identify past challenges and know how to better respond to them in the future. These are incorporated by how Programs and project execute their processes and plans</li> </ul>	<ul style="list-style-type: none"> <li>• Results for Evaluation activities provide insight into performance of the Program to assess if the processes in place are effective and efficient</li> <li>• When variances arise, corrective actions are identified, evaluated and adhered to, where necessary, to minimize risk and ensure mission success</li> </ul>	<ul style="list-style-type: none"> <li>• Results from Research and Analysis activities can directly influence the how senior leadership engages and supports employees. For example, the View Point Survey allowed NASA to pinpoint the concerns of employees and devise an approach to address their needs</li> <li>• Analysis results have improved tool development to support cost and schedule estimates</li> </ul>
<p><b>Carrying out capacity-building activities in order to use evaluation research and analysis approaches and data in the day-to-day operations</b></p>	<ul style="list-style-type: none"> <li>• The capability to conduct evidence-building activities exists across the Centers and Mission Directorates. Sufficient data and resources are in place to conduct analysis of alternative and de-scope activities to ensure the successful execution of mission objectives without sacrificing technical and safety protocols</li> <li>• NASA’s Lifecycle Review process and Council System serves as a means to notify stakeholders on the effectiveness of analysis and if additional action is warranted</li> </ul>		

Table 1: Survey Results vs. Capacity Assessment Guidance

## Gap Analysis

Although NASA Mission Directorates, Centers, and PP&C staff self-assess these evidence-building types from fair to excellent across each capacity criteria along the Likert scale, gaps still exist in the evaluation process. Identifying these gaps is a necessary step toward informing Agency decision-makers about the current state of capacity, and where programs and processes could be improved.

Early in the Capacity Assessment process, it became clear that Evidence Act implementation was heavily concentrated within Agency OCFO functions in terms of staff and contractor resources. In order to properly diffuse these capabilities, NASA’s Evaluation Officer endeavored to broaden participation across the Agency by taking an enterprise approach. This led to the launch of the Evaluation Management Process Champion Working Group, comprised of members from across NASA’s Mission Directorates, Centers, and PP&C Community to directly report ongoing evidence-building activities within their organization or Center. This team was instrumental in identifying the appropriate working mix of survey respondents, and going forward, will be vital to execute an evaluation enterprise strategy, integrated and informed by the OCFO Leadership team. This will ensure the Agency is taking steps to increase visibility and participation of evidence-building functions beyond Headquarters and into all areas of NASA.

One drawback of using a survey, is that the timing of the survey can affect the responses received. Some

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of our respondents perform a relatively steady level of evidence-building activities throughout the years. However, many others experience peaks and valleys. This is similar to OMB or Agency Budget offices, who usually commit longer hours when budgets are being determined. These peaks in workload and requirements can increase even higher during Presidential administrative changes, as new focuses and initiatives are established. Therefore, it is imperative that we identify a mitigation strategy for this to negate any timing issues during the assessment of our evaluator's capabilities to perform analysis, especially related to coverage.

### **Capacity Assessment Path Forward**

With the inaugural submission of the NASA Capacity Assessment, a basis has been established on how to continuously improve upon capturing and understanding evidence-building activities within the Agency. Admittedly, as with any new endeavor, this initial assessment involved a learning curve and an understanding of how to collect and assess evidence-building data effectively and efficiently. This first submission can be considered a gateway to understanding the Agency's disconnects and gaps in terms of evidence-building. Ideally, with each subsequent Capacity Assessment submission, NASA will improve by better characterizing evidence-building activities and addressing how they impact policy and decision making. Ideally, the preferred future state of our Capacity Assessment would include:

- Further defining and categorizing evidence-building activities, more clearly;
- Expanding the scope from which data is collected;
- Streamlining how data is collected and assessed, utilizing support from process champion working groups from across the Agency;
- Achieving further alignment of evidence-building activities to support the execution of goals and objectives outlined in the Strategic Plan, Equity Action Plan, and other Agency initiatives;
- Reviewing technology capabilities more in-depth to determine opportunities to improve data gathering and data analytics; and
- Achieving further engagement with external stakeholders (i.e. colleges, universities, small businesses, industry partners, NASA Advisory Council).

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# Appendix C: Developing and Implementing NASA's Strategy

The 2022 Strategic Plan establishes NASA's framework of Strategic Goals and Objectives, which align with and support our Vision and Mission. The Strategic Plan reflects national policies and legislation, as well as the strategic direction set by the NASA Administrator. The strategic planning process included internal stakeholders from across the Agency and critical external stakeholders, including the Office of Management and Budget (OMB) and Congress.

NASA's strategic planning process began in September 2020 with executive-level guidance discussions. A Strategic Plan Working Group (SPWG) was charged with developing a new Strategic Plan built on this guidance. The SPWG was comprised of a core group of internal stakeholders representing our Mission Directorates, Centers, Office of STEM Engagement, and Office of Communications. It also included extended advisory members responsible for implementing the Strategic Plan in the areas of the Government Performance and Results Act Modernization Act of 2010 (GPRAMA); the Foundations for Evidence-Based Policymaking Act of 2018 (Evidence Act); enterprise risk management (ERM); planning, programming, budgeting, and execution (PPBE); and other areas. The Strategic Plan development process was co-led by a Senior Policy Advisor in the Office of the Administrator, and the Chief for the Strategic Planning, Performance Management, and Reporting Branch within the Office of the Chief Financial Officer.

The leads for the SPWG held regular informational and course-correction discussions with the NASA Administrator and other senior leaders throughout the development of the Strategic Plan. NASA's Executive Council, the governing council responsible for Agency-wide strategy, reviewed and approved the Strategic Planning framework at several formal touchpoints. Working with OMB, the SPWG refined content to ensure the Strategic Plan is consistent with national policy, sets an ambitious and lasting strategic direction for our ongoing activities, and builds a solid framework for implementation.

NASA's ability to deliver on the Strategic Goals and Objectives outlined in the Strategic Plan relies on a long-term strategic planning process that is ongoing and iterative, allowing for flexibility to respond to dynamic internal and external environments. We strive to be proactive in our strategy, reflecting the Agency's commitment to continued leadership in space exploration, development of new technologies, innovation, and scientific discovery. The NASA Administrator uses several formal internal mechanisms to ensure that Agency efforts align with our Strategic Plan and to identify potential changes in strategy:

- The Associate Administrator for Technology, Policy, and Strategy develops Agency-level strategy in consultation with internal and external stakeholders and works with senior leadership to implement it across the Agency, providing strategic alignment of mission areas.
- The Office of the Chief Financial Officer (OCFO) manages all external GPRAMA and Evidence Act reporting and is the compliance organization for the Strategic Plan. As a non-aligned organization, the OCFO provides independent guidance and support to the SPWG and senior leadership.
- The Executive Council, a forum comprised of senior leaders at NASA Headquarters, advises on high-level NASA strategy and reviews products that inform and/or are informed by the NASA Strategic Plan, such as our annual budget, Agency communication plan, and workforce decisions.
- The annual PPBE process uses long-term strategic planning as the basis for prioritizing our programmatic and institutional needs, as well as identifying potential Agency challenges and risks that could be potential barriers to success.
- The Strategic Review annually assesses whether NASA's programs and projects are successfully executing the strategy described for each Strategic Objective. The Strategic Review examines successes, risks, resources, and other areas that can impact implementation.
- The Annual Performance Plan provides the Performance Goals and Agency Priority Goals used to assess NASA's annual progress toward achieving the activities supporting each Strategic Objective. The Performance Goals and their annual targets are consistent with NASA's fiscal year budget re-

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quest. The annual results are incorporated into the Strategic Review.

- The Chief Operating Officer (COO), as well as other NASA senior staff, review Agency performance at a monthly data-driven Baseline Performance Review.
- Evaluations conducted through the Evidence Act seek to address Agency-level issues. Results to evaluations (identified in the Learning Agenda) may influence how we implement strategy—or guide new strategy.

The Mission Directorates and Centers incorporate our Agency-level strategy into their implementation plans to ensure we are all supporting the Vision and Mission. NASA holds its leadership fully accountable for meeting near-term performance standards and Performance Goals, as well as progress toward long-term Strategic Objectives. Program authorities and the Agency governance councils hold regular internal reviews to monitor and evaluate performance and use the results to support internal management processes and decision making. The COO is responsible for reviewing progress toward Agency program and project plans and addresses cross-cutting concerns that may impact mission performance against approved plans. Decisions are informed by leveraging evidence, evaluations, studies, and independent analysis to identify challenges, risks, and opportunities to ensure mission success.

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# Appendix D: Performance Goals, FY 2022-2023 Agency Priority Goals, and Cross-Agency Priority Goals

## Performance Goals

NASA's multiyear Performance Goals align with and contribute to Strategic Objectives in the *2022 Strategic Plan*. Each Performance Goal includes annual targets that reflect program and project budget. For a complete list of NASA's Performance Goals, please see the FY 2023 Agency Performance Plan, which will be published, in accordance with Office of Management and Budget guidelines, in the *FY 2023 Volume of Integrated Performance*.

## Agency Priority Goals (APGs)

NASA's FY 2022-2023 APGs are a subset of high-profile Performance Goals that have been selected for additional internal and external performance reporting. APGs reflect the top NASA and national performance priorities. The APGs are executed within a two-year timeframe, and therefore, do not reflect the full scope of the program or project. More information on APGs is available on <http://www.performance.gov>.

### Climate Change Research (Strategic Objective 1.1)

Use the global vantage point of space to advance our understanding of the Earth system, its processes, and changing climate. *By September 2023, NASA will advance climate change research by delivering two new observing systems and an upgrade to NASA's primary global Earth systems model.*

### James Webb Space Telescope (Strategic Objective 1.2)

After launch, deployment, and start of science operations, the James Webb Space Telescope will study every phase in the history of our universe, ranging from the first luminous glows after the Big Bang, to the formation of other stellar systems capable of supporting life on planets like Earth, to the evolution of our own solar system. *By September 30, 2023, NASA will complete commissioning of the James Webb Space Telescope, the most powerful and complex space telescope ever built, and begin Webb's Cycle 2 observations.*

### Artemis (Strategic Objective 2.1)

Advance America's goal to land the first woman and the first person of color on the Moon and pursue a sustainable program of exploration by demonstrating capabilities that advance lunar exploration. *By September 30, 2023, NASA will launch Artemis I, deliver the Core Stage for Artemis II to Kennedy Space Center for processing, and have multiple companies under contract to develop systems for sustainable human lunar exploration.*

### Space Technology Leadership (Strategic Objective 3.1)

Ensure American global leadership in space technology innovations through increased partnering with industry and demonstrating key lunar surface and deep space technologies. *By September 30, 2023: NASA will demonstrate leadership in space technology by:*

- *Enhancing partnerships with industry through delivery or completion of milestones for at least 4 Tipping Point opportunities, and at least 3 critical small business technology transitions to develop capabilities that support NASA and commercial needs;*
- *Delivering at least 3 new technologies that will be demonstrated on the lunar surface or in lunar orbit;*

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*and*

- *Completing at least 2 major milestones for projects that increase the nation's capabilities in deep space.*

### **Cross-Agency Priority (CAP) Goals**

CAP Goals are intended to accelerate progress on management priorities identified in the President's Management Agenda. The Government Performance and Results Act Modernization Act of 2010 (GPRAMA) requires agencies to address CAP Goals in their Strategic Plans, Annual Performance Plans, and Annual Performance Reports. Please refer to <http://www.performance.gov> for more information on the President's Management Agenda and the CAP Goals, including progress updates and NASA's contributions to the goals, where applicable.

To ensure effective leadership and accountability across the Federal Government, each CAP Goal typically has a named senior leader within the Executive Office of the President and another within one or more of the key delivery agencies. NASA is not a goal leader for any of the CAP Goals but does support CAP Goal implementation. NASA will provide additional information on its specific contributions to the CAP Goals, where appropriate, in its annual Volume of Integrated Performance.

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# Appendix E: Relevant Legislation and Executive Orders

## Overview

The following pages contain two tables of Executive Orders (EOs) and a mapping of these orders to the Strategic Objectives. The first table focuses on Workforce EOs and the second focuses on STEM and climate science. The tables are provided on separate pages and in landscape format in order to maximize readability.

The full text of each EO can be found online at <https://www.Federalregister.gov/presidential-documents/executive-orders/joe-biden/2021>.

<b>WORKFORCE EOS</b>	<b>EO 13985</b> <i>Racial Equity</i>	<b>EO 13988</b> <i>Gender Identity/Sexual Orientation</i>	<b>EO 14020</b> <i>Gender Policy Council</i>	<b>EO 14031</b> <i>Equity AAPJ and Native Hawaiians</i>	<b>EO 14035</b> <i>DEIA in the Federal Workforce</i>	<b>EO 14041</b> <i>Equity HBCUs</i>	<b>EO 14045</b> <i>Equity Hispanic Americans</i>	<b>EO 14049</b> <i>Equity Native Americans</i>	<b>EO 14050</b> <i>Equity Black Americans</i>
<b>SG1 DISCOVER</b>									
SO1.1 Earth and climate	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SO1.2 Solar system, universe	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SO1.3 Data accessibility	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/> L	<input type="radio"/>	<input type="radio"/> L	<input type="radio"/> L	<input type="radio"/> L	<input type="radio"/> L
<b>SG2 EXPLORE</b>									
SO2.1 Moon and deep space	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SO2.2 Space economy									
SO2.3 Safety									
SO2.4 Access and services									
<b>SG3 INNOVATE</b>									
SO3.1 Advanced technology	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SO3.2 Sustainable aviation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>SG4 ADVANCE</b>									
SO4.1 Workforce	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SO4.2 Mission support	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SO4.3 Next gen explorers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>KEY</b>									
<input checked="" type="radio"/>	<input type="radio"/>			<input type="radio"/>			<input type="radio"/>		
<b>EO NAME AND NUMBER ARE MENTIONED</b>	<b>ALIGNS WITH EO OR MENTIONS "EO," BUT NOT SPECIFIC EO NAME OR NUMBER</b>			<b>POTENTIAL LIMITED APPLICABILITY WITH EO IF CONTENT IS ADDED</b>			<b>NO IDENTIFIED APPLICABILITY WITH EO</b>		
	<b>BLANK BOXES</b>								



STEM EOS	EO 13990 Public Health and Climate	EO 14005 American Manu- facturing	EO 14007 Science and Technology Council	EO 14008 Climate Crisis	EO 14013 Climate Refugees	EO 14017 Supply Chains	EO 14027 Climate Change Support Office	EO 14028 Cyber- security	EO 14030 Climate Financial Risk	EO 14034 Data Protection	EO 14057 Clean Energy
<b>SG1 DISCOVER</b>											
SO1.1 Earth and climate	O	L	O	O	O	L	O	L	O		
SO1.2 Solar system, universe	O	L	O	O	O	L	O	L	O		
SO1.3 Data accessibility	O	L	O	X	O	L	O	L	O		
<b>SG2 EXPLORE</b>											
SO2.1 Moon and deep space		L	L			L		L			
SO2.2 Space economy		L	L			L		L			
SO2.3 Safety		L	L			L		L			
SO2.4 Access and services		L	L			L		L			
<b>SG3 INNOVATE</b>											
SO3.1 Advanced technology	O	O	L	X	L	O	L	L	L		L
SO3.2 Sustainable aviation	O	O	L	O	L	O	L	L	L		L
<b>SG4 ADVANCE</b>											
SO4.1 Workforce	L		L	O	L		L		L		L
SO4.2 Mission support	L	L	L	O	L	L	L	L	L	L	
SO4.3 Next gen explorers	L		O	L	L		L		L		
<b>KEY</b>											
	X		O			L					BLANK BOXES
EO NAME AND NUMBER ARE MENTIONED		ALIGNS WITH EO OR MENTIONS "EO," BUT NOT SPECIFIC EO NAME OR NUMBER			POTENTIAL LIMITED APPLICABILITY WITH EO IF CONTENT IS ADDED			NO IDENTIFIED APPLICABILITY WITH EO			

# Appendix F: Acronym List

Acronym	Definition
AAPISI	Asian American and Pacific Islander Serving Institutions
AEP	Annual Evaluation Plan
AFRC	Armstrong Flight Research Center, Edwards, CA
AI	Artificial Intelligence
AIA	Agency Investment Analysis
APG	Agency Priority Goals
APMC	Agency Program Management Council
ARC	Ames Research Center, Moffett Field, CA
ARF	Agency Resiliency Framework
ARMD	Aeronautics Research Mission Directorate
ASAP	Aerospace Safety Advisory Council
ASC	Acquisition Strategy Council
ASL	Autonomous Systems Lab
BPR	Baseline Performance Review
BPS	Biological and Physical Sciences
CAP	Cross-Agency Priority
CIF	Center Innovation Fund
CLPS	Commercial Lunar Payload Services
CoF	Construction of Facilities
COMM-LEO	Commercial Low Earth Orbit
COO	Chief Operating Officer
CSA	Canadian Space Agency
DAPR	Dual-anonymous Peer Review Process
DEIA	Diversity, Equity, Inclusion, and Accessibility
EC	Executive Council
EDL	Entry, Descent, and Landing
EDP	Enterprise Data Platform
EGS	Exploration Ground Systems
EO	Executive Order
EPA	Environmental Protection Agency
ESA	European Space Agency
ESDMD	Exploration Systems Development Mission Directorate
ESIP	Early-Stage Innovation and Partnerships
EVA	Extravehicular Activities
FAR	Federal Acquisition Regulation
FFRDC	Federally Funded Research and Development Center
FY	Fiscal Year
GCD	Game Changing Development
GPRAMA	Government Performance and Results Act Modernization Act of 2010
GRC	Glenn Research Center, Cleveland, OH
GSA	General Services Administration
GSFC	Goddard Space Flight Center, Greenbelt, MD

<b>Acronym</b>	<b>Definition</b>
HBCU	Historically Black Colleges and Universities
HLS	Human Landing System
HUBZone	Historically Underutilized Business Zone
ISS	International Space Station
IT	Information Technology
IXPE	Imaging X-ray Polarimetry Explorer
JAXA	Japan Aerospace Exploration Agency
JPL	Jet Propulsion Lab, Pasadena, CA
JSC	Johnson Space Center, Houston, TX
KSC	Kennedy Space Center, Titusville, FL
LCR	Lifecycle Review
LEO	Low Earth Orbit
LOFTID	Low-Earth Orbit Flight Test of an Inflatable Decelerator
LSP	Launch Services Program
LT	Long-term
MACC	Multiple Award Construction Contract
MOXIE	Mars Oxygen In-Situ Resource Utilization Experiment
MSC	Mission Support Council
MSD	Mission Support Directorate
MSFC	Marshall Space Flight Center, Huntsville, AL
MSI	Minority Serving Institutions
MUREP	Minority University Research and Education Project
NAC	NASA Advisory Council
NARI	NASA Aeronautics Research Institute
NAS	National Airspace System
NextSTEP	Next Space Technologies for Exploration Partnerships
NOAA	National Oceanic and Atmospheric Administration
NPD	NASA Policy Directive
NVDB	NASA Vendor Database
OCFO	Office of the Chief Financial Officer
OCIO	Office of the Chief Information Officer
OIG	Office of the Inspector General
OMB	Office of Management and Budget
OP	Office of Procurement
OSBP	Office of Small Business Programs
OSTEM	Office of STEM Engagement
PP&C	Program Planning and Control
PPBE	Planning, Programming, Budgeting, and Execution
PQ	Priority Question
ROSES	Research Opportunities in Space and Earth Science
RPT	Rocket and Propulsion Test
SBA	Small Business Administration
SBIR	Small Business Innovation Research
SID	Strategic Investments Division
SLS	Space Launch System

<b>Acronym</b>	<b>Definition</b>
SMD	Science Mission Directorate
SO	Strategic Objective
SOMD	Space Operations Mission Directorate
SPWG	Strategic Plan Working Group
SRB	Standing Review Board
SSC	Stennis Space Center, Kiln, MS
SST	Small Spacecraft Technology
ST	Short-term
STEM	Science, Technology, Engineering, and Mathematics
STMD	Space Technology Mission Directorate
STPI	Science and Technology Policy Institute
STTR	Small Business Technology Transfer
TDM	Technology Demonstration Missions
ULA	United Launch Alliance
ULI	University Leadership Initiative
U.S.	United States
USGS	United States Geological Survey
VERITAS	Venus Emissivity, Radio Science, InSAR, Topography, and Spectroscopy
WATSON	Wide Angle Topographic Sensor for Operations and eNginneering