National Aeronautics and Space Administration

FY 2022 VOLUME OF INTEGRATED PERFORMANCE

FY 2020 Annual Performance Report

FY 2021 Annual Performance Plan Update

FY 2022 Annual Performance Plan

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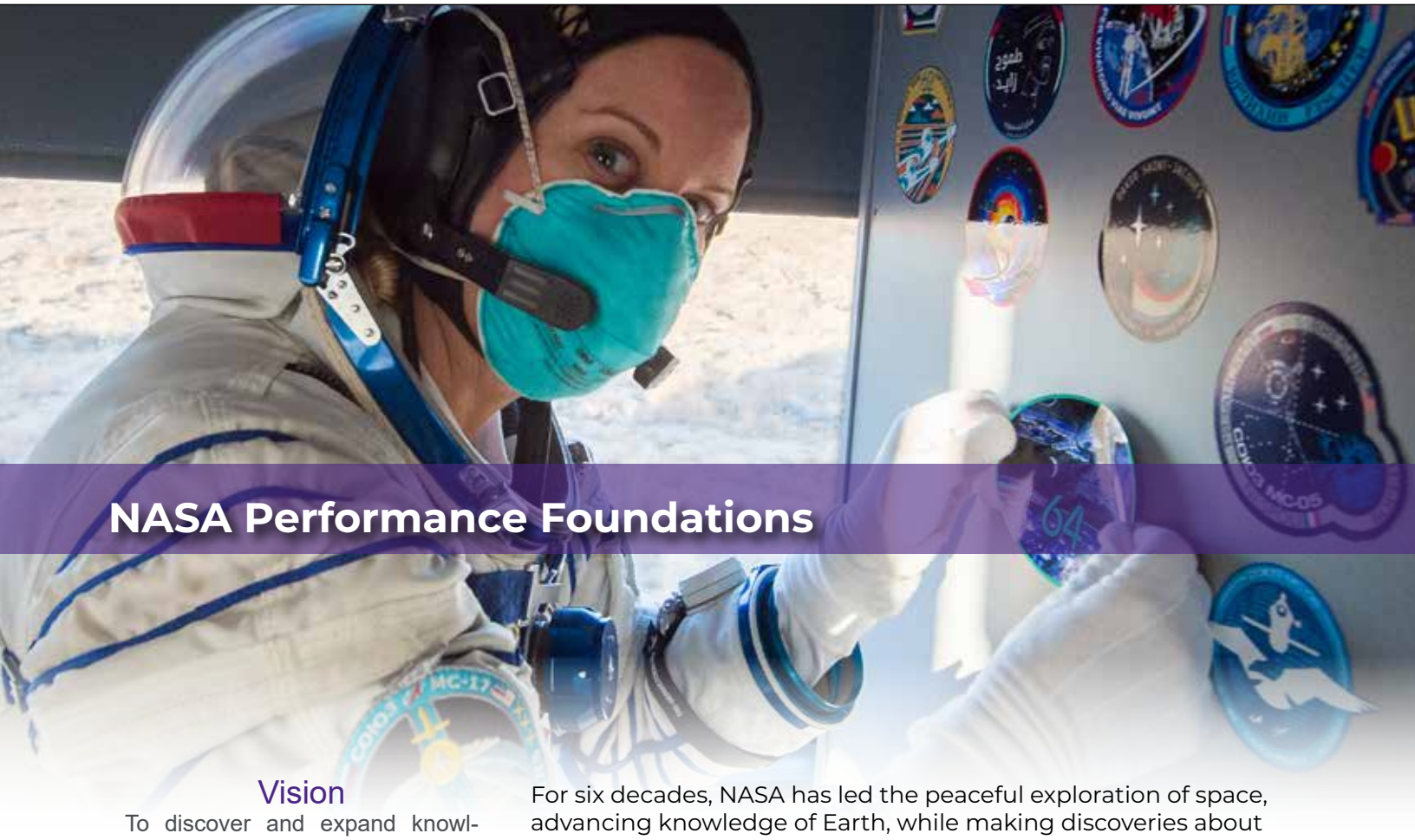
Above: NASA astronauts Barry "Butch" Wilmore, left, and Sunita "Suni" Williams visit the Commercial Crew and Cargo Processing Facility at Kennedy Space Center in Florida on December 17, 2020. The astronauts are at Kennedy to prepare for their flights to the International Space Station on Boeing's CST-100 Starliner, as part of the agency's Commercial Crew Program. Wilmore and Williams will command the Crew Flight Test and the Starliner-1 mission, respectively. Photo Credit: Boeing/ John Proferes

PART 1

Performance Management at NASA

The samples Apollo 11 brought back to Earth from the Moon were humanity's first from another celestial body. NASA's Mars 2020 Perseverance rover mission will collect the first samples from another planet (Mars) for return to Earth by subsequent missions. In place of astronauts, the Perseverance rover will rely on the most complex, capable and cleanest mechanism ever to be sent into space, the Sample Caching System. In this photo taken on May 20, 2020 ,at the Kennedy Space Center, engineers and technicians insert 39 sample tubes into the belly of the rover. Each tube is sheathed in a gold-colored cylindrical enclosure to protect it from contamination. The Perseverance rover will carry 43 sample tubes to the Red Planet's Jezero Crater. Photo Credit: NASA/JPL-Caltech



NASA Performance Foundations

Vision

To discover and expand knowledge for the benefit of humanity.

Mission

Lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and bring new knowledge and opportunities back to Earth. Support growth of the Nation's economy in space and aeronautics, increase understanding of the universe and our place in it, work with industry to improve America's aerospace technologies, and advance American leadership.

Above: NASA astronaut Kate Rubins affixes an Expedition 64 sticker inside the bus carrying her and fellow crewmates, Russian cosmonauts Sergey Kud-Sverchkov and Sergey Ryzhikov of Roscosmos, to the launch pad on October 14, 2020 at the Baikonur Cosmodrome in Kazakhstan. The trio launched at 1:45 a.m. EDT to begin a six-month mission aboard the International Space Station. Photo Credit: NASA/GCTC/Andrey Shelepin

For six decades, NASA has led the peaceful exploration of space, advancing knowledge of Earth, while making discoveries about the furthest reaches of the universe. NASA research has advanced aeronautics, helped develop the commercial space industry, and strengthened the U.S. economy.

NASA's continued success is predicated on a solid foundation of performance. The Agency uses common business and development practices to proactively establish expectations and assess and improve performance on an ongoing basis. These practices are strengthened by the Agency's diversity in technical and operational expertise. NASA uses data and evidence to inform investment decisions at all levels, from day-to-day operations to selecting major missions and establishing the necessary infrastructure to pursue goals that may take a generation, or longer, to realize.

NASA is transparent in these efforts, complying fully with requirements on performance reporting and accountability, in accordance with the Government Performance and Results Act (GPRA) Modernization Act of 2010. NASA's commitment to performance reaches further than compliance. The Agency has an ingrained culture of self-evaluation and continuous improvement, using findings from these studies and assessments to improve the Agency in the short term, and position NASA for long-term success.

The NASA 2018 Strategic Plan outlines NASA's plans for the future, provides a clear and unified direction for all of its activities, and sets the foundation on which the Agency can build and mea-

sure the success of its programs and projects. This direction is captured in NASA's Vision and Mission statements—why NASA exists, what it aspires to achieve, and how it expects to make a difference that benefits all Americans.

The information reported in this document is aligned with the *NASA 2018 Strategic Plan* and the FY 2022 Budget Estimates, in accordance with the requirements of the GPRA Modernization Act. The Agency currently is developing its strategic plan for the 2022 through 2026 timeframe. This new strategic plan will continue many of NASA's efforts to expand understanding of Earth, other worlds, and the cosmos as a whole; conduct human and robotic space exploration; and develop and advance technologies in exploration and aeronautics that allow American industry to increase market share and new markets, both on Earth and in the near-Earth region of space.

Strategic Plan Framework

The *NASA 2018 Strategic Plan* created a framework that consists of NASA's priorities, top-level objectives, and strategies for making progress toward these priorities at varying levels throughout the Agency (see the figure below). At the top of the framework are strategic goals that describe NASA's Mission. Strategic objectives present the strategies for achieving these goals. Progress towards these strategic objectives is measured through performance goals. Annual targets allow NASA to measure and track incremental progress towards achieving the performance goals. A performance goal may also include key milestones or activities that are part of the annual target.

Annual Performance Plan

The Annual Performance Plan consists of multi-year, outcome oriented performance goals and measurable targets that align to NASA's budget. The plan is aligned to program and project commitments in the fiscal budget request and is released to the public concurrently with the Budget Estimates document. As part of the 2022 through 2026 strategic planning process, NASA will review its performance goals for alignment with the new strategic plan framework and priorities. See Part 2, starting on page 21, for NASA's performance goals and fiscal year targets.

A subset of performance goals are also agency priority goals, highlighting high-priority, high-profile activities the Agency plans within a two-year timeframe.

In January 2021, the Office of Management and Budget suspended reporting for the FY 2020-2021 agency priority goals. NASA transitioned its four agency priority goals [m-dash] James Webb Space Telescope, Low Earth Orbit Economy, Artemis, and Lunar Surface Capabilities — to performance goals to track performance through the planned completion

of the goals. NASA may continue tracking some of the performance goals beyond FY 2021.

Every fiscal year, NASA reevaluates and updates the existing performance goals and targets to ensure they still accurately reflect NASA's budget, priorities, and programmatic plans. This is an opportunity for NASA to revise performance goal descriptions as needed, add new measures, delete performance goals that are no longer valid, revise targets submitted the previous fiscal year, and submit new targets consistent with the fiscal year's budget request.

Part 2 on page 21 of this document includes updated targets for FY 2021.

Performance Management in Action

NASA is committed to remaining a good steward of the taxpayer's numerous investments entrusted to its care. This includes maintaining a culture of data-driven performance management that continually improves its performance management systems, increasing accountability, transparency, and oversight. This approach leads to more consistent performance reporting across NASA's missions, and ensures the optimal use of Agency resources.

NASA plans and evaluates its performance in a continuous cycle, spanning fiscal years, in conjunction with the annual planning, programming, budgeting, and execution process used to ensure that resource alignment supports mission and operational needs. This ongoing feedback loop ensures that plans reflect performance expectations, and, in return, those performance results inform decisions on planning.

The GPRA Modernization Act provided an update to the Government Performance and Results Act of 1993. The GPRA Modernization Act requires agencies to set long-term goals and objectives as well as near-term performance goals. The GPRA Modernization Act also builds upon a performance management leadership structure that begins with the Agency Administrator, the Chief Operating Officer, the Performance Improvement Officer, and the goal leaders. The GPRA Modernization Act's performance framework must translate across and cascade down the organization to all Agency managers and team leaders.

Annual Strategic Reviews

The annual Strategic Review process encompasses a comprehensive analysis of each of NASA's strategic objectives. Agency leaders assess progress on executing the strategies and goals stated in the *NASA 2018 Strategic Plan*. The assessment considers different indicators the Agency tracks for each strategic objective, as well as challenges, risks, external factors, and other events that may have affected the outcomes. The review also looks at what current or future evaluations or evidence-building activities are needed to make better assessments of the Agency's progress.

Based on this self-assessment, NASA determines that each strategic objective demonstrates noteworthy progress, satisfactory performance, or is a focus area for improvement. NASA's Chief Operating Officer reviews the summary of the self-assessments and the crosscutting assessment, then decides on final ratings for the strategic objectives and next steps for the Agency. NASA uses Strategic Review inputs, findings, and results throughout the Agency's budget process and as an input to the annual performance planning process. A summary of progress and assessment results for each strategic objective is included in Part 2, beginning on page 21.

Cross-Agency Priority Goals

The Trump Administration's President's Management Agenda, released on March 20, 2018, set a plan for modernizing and reforming the Federal Government. It consisted of 14 cross-agency performance goals centered around three key areas for improvement: modern information technology; data, accountability, and transparency; and the workforce for the 21st century. Cross-agency priority goals drive cross-government collaboration to implement the President's Management Agenda and address these three key areas. Due to the presidential transition, external reporting on these areas was discontinued in January 2021. Work in key reform areas has continued and will likely be incorporated into cross-agency priority goals for the Biden Administration.

Beginning in FY 2020, NASA updated performance goals to consist of an outcome-based statement and measurable targeted level of performance to be achieved each year. The final level of achievement for those targets are assigned a color rating of Green (achieved), Yellow (below target), Red (significantly below target), or White (unable to assess for the fiscal year due to missing data). NASA internal success criteria determine the levels of performance for a Yellow or Red rating.

Agency Priority Goals

NASA leadership identified four agency priority goals for the FY 2020–2021 reporting cycle. Progress toward achieving agency priority goals is reported on quarterly through Performance.gov. Due to the presidential transition, OMB discontinued reporting for the FY 2020–2021 agency priority goals as of January 2021 and has moved the FY 2020 quarterly reports to the Trump Archive on Performance.gov. NASA is developing new agency priority goals for the FY 2022–2023 cycle.

Below are the final FY 2020 ratings for NASA's four agency priority goals. Detailed FY 2020 performance information for the agency priority goals also is provided in Part 2 on page 21. NASA will not have an opportunity to pursue these agency priority goals through completion in FY 2021. However, NASA has transitioned them to performance goals, with revisions to focus and milestones where needed, to complete the performance areas for FY 2021. For example, revised the performance statement for James Webb Space Telescope to reflect the new FY 2022 launch date and Lunar Surface Capabilities has been revised to focus on the Space Technology Mission Directorate's (STMD's) milestones. The remaining Commercial Lunar Payload Services milestone has been moved to Performance Goal 1.1.10.

FY 2020–2021 Agency Priority Goals

	Agency Priority Goals and Statements	Responsible Program	Rating
Discover	1.1.11: Complete shipment of the James Webb Space Telescope in preparation for launch in FY 2022. Revolutionize humankind's understanding of the cosmos and humanity's place in it. 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, 2021, NASA will launch the James Webb Space Telescope, complete on-orbit checkout, and initiate observatory commissioning.	James Webb Space Telescope Program, Science Mission Directorate (SMD)	Yellow Three of four milestones completed.
Explore	2.1.2: Enable a robust commercial low Earth orbit economy in which transportation, habitation, and on-orbit services are available for purchase by NASA and other customers. Enable a robust commercial low Earth orbit economy in which transportation, habitation, and on-orbit services are available for purchase by NASA and other customers. By September 30, 2021, NASA will support the development of commercial services, including through releasing new business opportunities, supporting demonstration flights, beginning certification activities, and demonstrating commercial capabilities.	Commercial Spaceflight Development and International Space Station, Human Exploration and Operations Mission Directorate (HEOMD)	Red Two of four milestones completed.

Explore	2.2.1: Advance America's goal to land the first woman and the next man on the Moon by demonstrating the necessary capabilities that advance lunar exploration. Advance America's goal to land the first woman and the next man on the Moon by 2024 and pursue a sustainable program of exploration by demonstrating capabilities that advance lunar exploration. By September 30, 2021, NASA will launch Artemis I and make significant progress for Artemis II, and have multiple companies under contract to develop systems to land humans on the Moon.	Exploration Systems Development, Human Exploration and Operations Mission Directorate (HEOMD)	Yellow Three of four milestones completed.
	2.2.2: Commence lunar surface technology demonstrations to enable a sustainable lunar surface exploration strategy. Commence lunar surface science investigations, technology, and exploration demonstrations to enable a sustainable lunar surface exploration strategy. By September 30, 2021, deliver NASA science and technology payloads to the awarded Commercial Lunar Payload Services (CLPS) provider(s) for delivery to the surface of the Moon.	STMD, SMD, HEOMD	Yellow Three of four milestones completed.

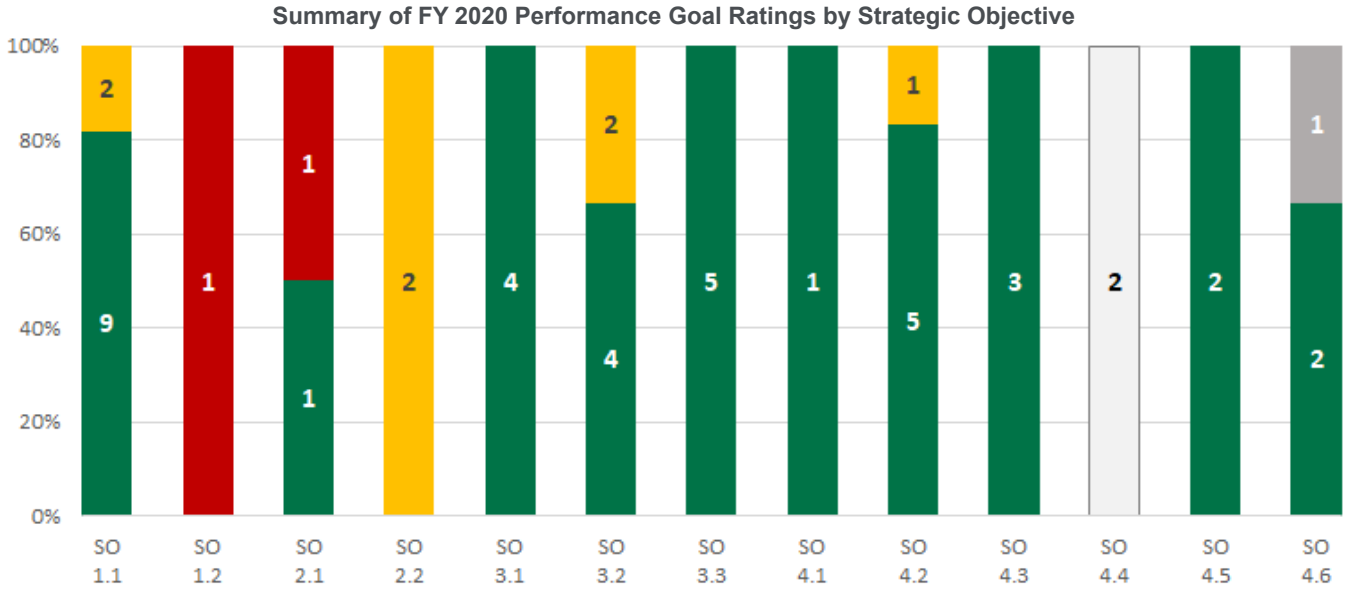
* Agency priority goal reporting has been suspended for FY 2021. NASA has transitioned the above agency priority goals performance goals for FY 2021.

Annual Performance Assessments

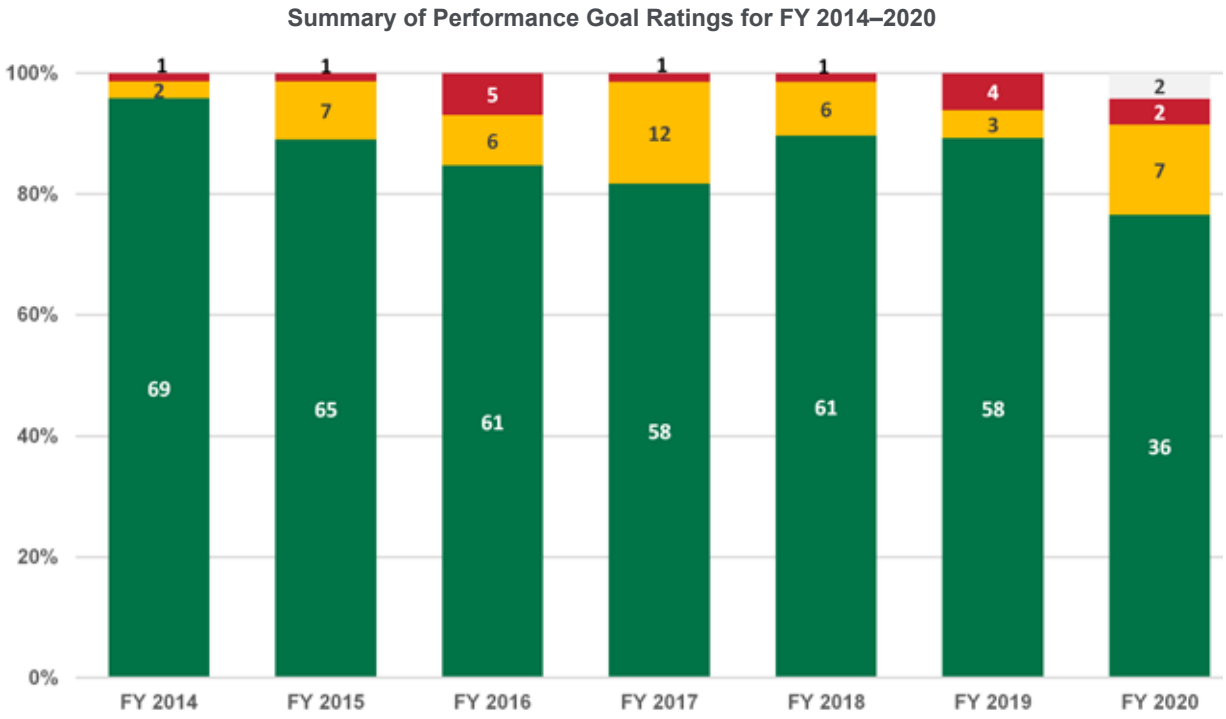
During the third and fourth quarters of each fiscal year, program officials assess progress towards achieving the performance goals listed in the Annual Performance Plan. They determine whether targets or milestones were met as anticipated, assign the appropriate color rating, and provide an explanation to support the rating. NASA's Chief Operating Officer and the Performance Improvement Officer review the performance assessment results and provide feedback, determine final ratings when needed, and recommend course corrections.

Every year, NASA publishes a summary of preliminary fiscal year performance ratings in the annual Agency Financial Report, in accordance with Circular A-136 guidance, using available fourth quarter data. NASA publishes the final fiscal year performance ratings in the Annual Performance Report, which becomes part of the Volume of Integrated Performance.

Below are FY 2020 ratings for NASA's 48 performance goals organized by NASA's 13 strategic objectives, as well as performance goal ratings for FY 2014 through FY 2020. While COVID-19 and severe weather slowed some performance progress, NASA's civil servant and contractor workforce overwhelmingly kept the Agency's performance goals on track or slightly below target. NASA adheres to the value of safety-first, and mandated telework Agency-wide during FY 2020. On-site work was limited to mission-essential work and conducted in accordance to Centers for Disease Control and Prevention guidelines. Part 2 on page 21 presents the individual FY 2020 ratings, organized by NASA's 13 strategic objectives and with supporting performance explanations. This information is reprinted from NASA's FY 2020 Annual Performance Report, published in January 2021, and includes updates to previously incomplete data and unrated performance goals.



Below are the performance goal ratings for FY 2014 through FY 2020. Part 2 presents the individual FY 2020 ratings, organized by NASA's 13 strategic objectives and with supporting performance explanations.



Performance Management Goals and Mandates

Several pieces of legislation have been passed over the years that have informed the implementation of management strategies and objectives. The key pieces of legislation that have impacted performance reporting are OMB Circular No. A-123, the Foundations for Evidence-Based Policymaking Act of 2018 (Evidence Act), and the Program Management Improvement Accountability Act of 2016 (PMIAA). Together this legislation informs all aspects of performance management goals and mandates.

Enterprise Risk Management

The enterprise risk management process provides insights on how to effectively prioritize and manage risks to mission delivery while also providing an enterprise-wide, strategically aligned portfolio view of organizational risks, challenges, and opportunities. NASA's governing councils serve as the Agency's risk management platform and the Chief Operating Officer serves as the senior official accountable for risk management. While NASA cannot mitigate all risks related to achieving its strategic goals and objectives, the Agency is using these risk-management strategies to identify, measure, and assess challenges related to mission delivery to the greatest extent possible. Enterprise risk management is integrated with the Strategic Review process to provide an analysis of the risks and opportunities NASA faces in achieving its strategic objectives.

Using Evidence for Decision-Making

NASA uses evidence to inform investment decisions at all levels, from day-to-day operations to selecting major missions and establishing the necessary infrastructure to pursue goals that may take a generation, or longer, to realize. The Evidence Act formalized requirements for agencies to utilize evidence, evaluation, and data as a planning tool for policy and decision-making. NASA will report planned evaluations from the Annual Evaluation Plan and findings from evidence-building activities from the Learning Agenda in future Volumes of Integrated Performance.

Annual Evaluation Plans will feature significant evaluations to support the performance planning process and provide evidence to decision-makers. The Learning Agenda is a four-year plan to build evidence across several priority areas for NASA to cultivate interagency collaboration, establish pathways for dissemination and data sharing, and identify gaps that exist across the Agency's vibrant performance and planning culture. Both the Annual Evaluation Plan and Learning Agenda will help NASA determine if the Agency has accomplished what it set out to do and inform future priorities.

Program and Project Management for Executive Agencies

PMIAA formalized requirements to strengthen program and project management within Federal agencies. As a research and development agency, NASA uses the core concept of cost, schedule, and program and project management to assess performance during the development phase. NASA established a Program Management Improvement Officer and a permanent program management working group to address PMIAA requirements and develop implementation plans. NASA is currently carrying out a five-year PMIAA strategic implementation plan, that includes performing periodic portfolio assessments to examine and determine focused improvements to the Agency's program management practices, guidance, and trainings that strive to improve performance overall.

Oversight and Accountability

In setting goals and establishing plans to achieve mission success, NASA leaders rely on information from multiple sources. Rigorous independent assessments, both internal and external to the Agency, are an essential tool in ensuring the integrity of data necessary to make well-informed investment decisions. Independent verification and validation in planning and executing work provides greater confidence in performance during development and execution, and improves expected outcomes. In many cases, these assessments include a routine measure of progress against a predetermined set of indicators or other targets that effectively establish an "early warning system" so that deviations can be more quickly and easily addressed.

Governance Councils

NASA has four Agency-level councils that establish strategic direction and provide oversight of Agency activities. The Executive Council focuses on major Agency-wide decisions by providing strategic guidance and top-level planning. The Mission Support Council is a functional council focused on mission-enabling decisions, threshold operational decisions, internal controls, and liability. The Program Management

Council is an integral part of NASA's program and mission decisions, ensuring programs and projects maintain acceptable performance as they progress through the phases of their life cycle. The Acquisition Strategy Council supports obtaining, or advancing the development of, the systems, research, services, construction, and supplies to fulfill the Agency's mission. The Senior Management Council, a fifth council comprised of NASA senior leaders, provides advice and counsel to the Executive Council on Agency issues and input on the formulation of Agency strategy.

Technical Authorities

The technical authority process is part of NASA's system of checks among key organizations to ensure that decisions have the benefit of different points of view and are not made in isolation. Selected senior officials, called technical authorities, have direct lines of reporting to the Administrator, ensuring work on critical performance areas adheres to Agency policy and performance standards. NASA's technical authorities are responsible for safety and mission assurance, engineering, and health and medical issues. Approval from NASA's technical authorities is required at each phase of major mission development or project implementation.

Baseline Performance Reviews

The Chief Operating Officer conducts a monthly internal assessment and reporting forum where NASA's leadership tracks and assesses performance of the Agency's work against established plans. The baseline performance review is a bottom-up review of how well the Agency has performed against its strategic goals and other performance metrics, such as cost and schedule estimates, contract commitments, and technical objectives. Periodically, each mission directorate provides a performance assessment of the activity it oversees. Analysts outside of the performing organization provide independent assessments. NASA's technical authorities provide oversight and an additional level of control.

Technology Readiness Reviews and Investment Reviews

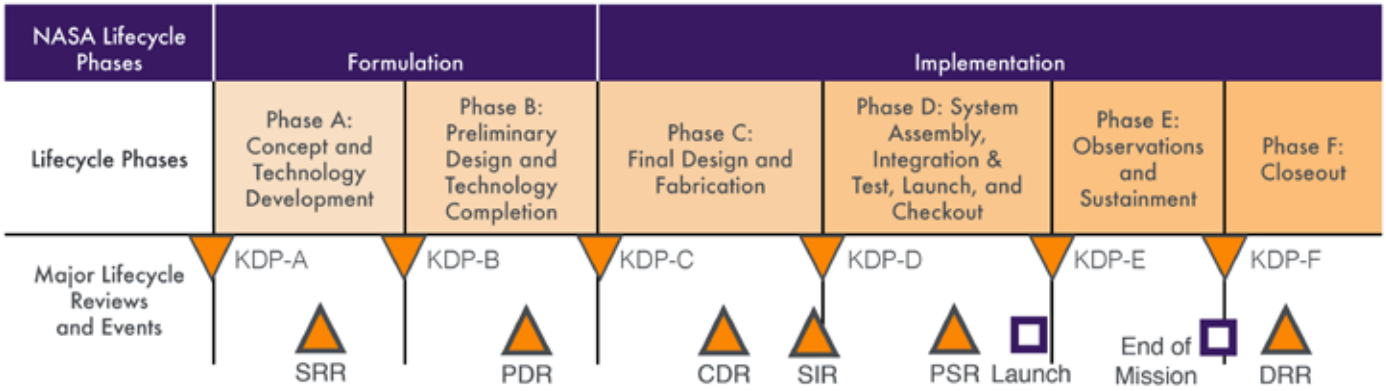
Experts in technology development use technology readiness levels—a set of progressively sophisticated criteria and milestones—to assess the maturation of a technology or capability, from early concept, through testing, to integration and use. NASA conducts routine progress reviews to measure the advancement of the work, but also to ensure that the technology or capability remains relevant and beneficial to its missions. NASA conducts an annual assessment of its technology development portfolio to ensure that investments continue to align to future Agency needs and that a balance of desirable technologies remain in the pipeline.

Program and Project Key Decision Point Reviews

As stated above, NASA requires internal independent assessments on the progress of programs and projects through their life cycles. Senior leaders convene a series of formal gatekeeping key decision point reviews, requiring managers to provide assessments of how the programs and projects are performing in key areas. Such key decision points are specific milestones at which managers must provide Agency leadership with information about the program's maturity and readiness to progress to the next stage of the life cycle (see the figure below).

The mandatory reviews at key decision point milestones focus on the program or project's assessment of status, as well as that of the Standing Review Board or mission directorate independent review team. Multiple stakeholder organizations also have the opportunity to weigh in on the information presented. Other reviews may be scheduled, in accordance with the lifecycle schedule of that project and depending on the formulation, development implementation, or construction plan. Additionally, NASA senior leaders monitor overall performance monthly through the Baseline Performance Review. NASA provides Congress, the Office of Management and Budget, and the Government Accountability Office with cost and schedule updates for major projects with an estimated lifecycle cost of $250 million or greater.

NASA Flight Project Lifecycle Phases, Key Decision Points, and Milestones*



Key Decision Point (KDP) is an event where NASA determines whether a project is ready to move to the next phase of its life cycle and establishes content, cost, and schedule commitments for that phase

System Requirements Review (SRR) evaluates whether the functional and performance requirements for the system meet the needs of the project and represent achievable capabilities

Preliminary Design Review (PDR) evaluates completeness/consistency of the planning, technical, cost, and schedule baselines developed during Formulation

Critical Design Review (CDR) evaluates the project design and its ability to meet mission requirements with appropriate margins and acceptable risk

System Integration Review (SIR) evaluates whether the projects is ready for integration and test, can be completed with available resources, and is ready for Phase D

Pre-Ship Review (PSR) ensures the completeness of any item of hardware or software before it is released to another facility for integration with a larger system or the spacecraft

Disposal Readiness Review (DRR) evaluates the readiness of the project and system for a disposal event, such as deorbiting

*Project lifecycle phases, key decision points, and milestones are established by and defined in NASA Space Flight Program and Project Management Requirements (NASA Procedural Requirements 7120.5E) and NASA Research and Technology Program and Project Management Requirements (NASA Procedural Requirements 7120.8A).

NASA Office of Inspector General and the Government Accountability Office

Two independent organizations, the NASA Office of Inspector General and the Government Accountability Office, conduct both broadly- and narrowly-focused evaluations of how well the Agency is achieving outcomes and performing to expectations. Evaluations cross all types of NASA work, from planning new initiatives, managing major programs, implementing necessary infrastructure modernization, to the potential impact of legislation and policy. The Office of Inspector General and contracted independent auditors are also employed to review the Agency's financial record keeping systems, compliance with requirements, and financial controls. NASA reviews the resulting reports and provides feedback on how the Agency will improve on identified management challenges.

Organized for Success and Sustainability

NASA is organized for success, with a leadership model that optimizes strategic direction at the Agency level, facilitates management at the functional levels in the mission directorates and mission support offices, and enables a wide range of activities at centers and facilities. The distributed and diverse nature of NASA's work is unified by an integrated performance culture that engages employees and stakeholders at all levels.

The innovative, responsive, and dynamic nature of NASA's work benefits from the Agency's highly leveraged relationships within and between mission directorates, mission support offices, and centers. This organizational model ensures that Agency leaders can take both a holistic and more narrowly focused approach to programmatic, operational, business, and safety management.

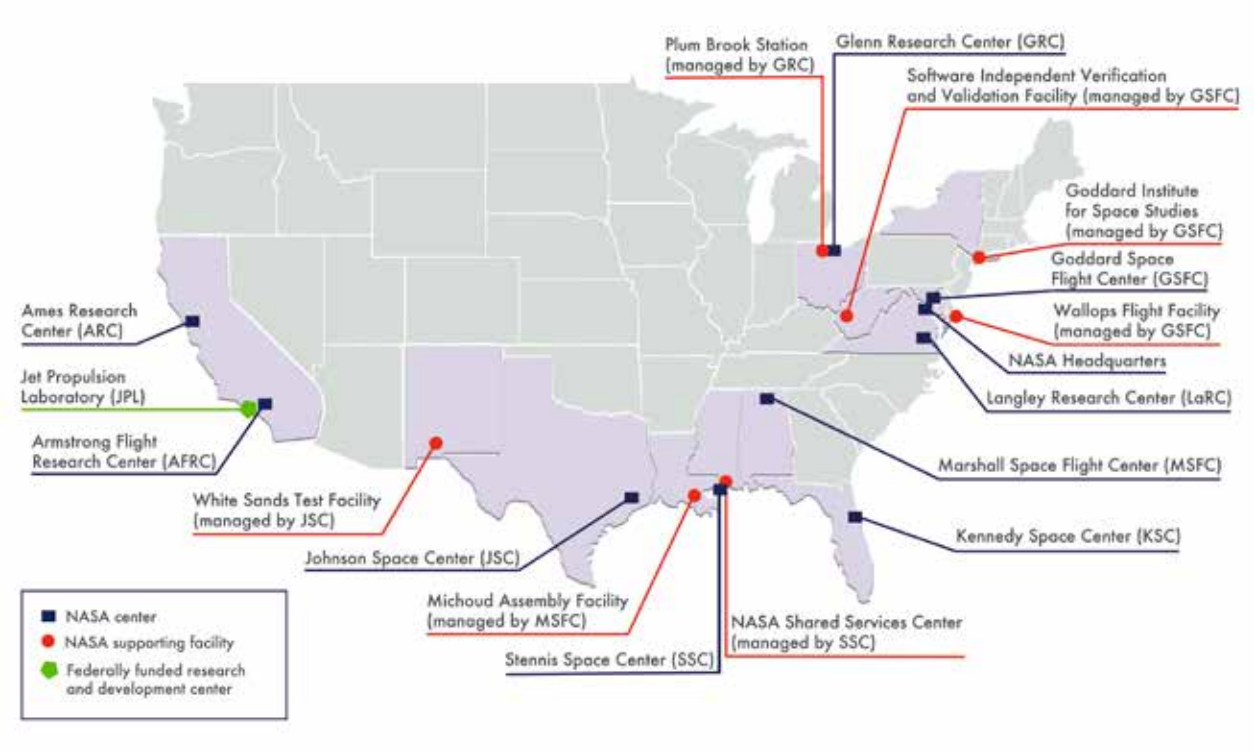
The NASA workforce of about 17,723 civil servants in 2020 is distributed among its centers, facilities, and Headquarters. NASA's centers and facilities manage and execute the mission work—engineering, operations, science, and technology development—and mission-enabling activities. Each location is supported by a contractor workforce providing technical and business operations services.

The Administrator and senior officials lead the Agency by providing top-level strategy, policy, and direction. Headquarters offices lead the Agency's budget development, execution, and organization-wide performance management activities. Mission directorates and mission support offices at Headquarters manage decisions on programmatic investments and guide operations of the centers. NASA's organizational structure is set in NASA Policy Directive 1000.3E.

Provided below are brief descriptions of NASA's mission directorates and select offices.

Above: A Northrop Grumman Antares rocket carrying a Cygnus resupply spacecraft rolls out of the Horizontal Integration Facility to the Mid-Atlantic Regional Spaceport's Pad-0A on September 26, 2020, at NASA's Wallops Flight Facility in Virginia. Northrop Grumman's 14th contracted cargo resupply mission with NASA to the International Space Station delivered about 8,000 pounds of science and research, crew supplies, and vehicle hardware to the orbital laboratory and its crew. The CRS-14 Cygnus spacecraft was named after the first female astronaut of Indian descent, Kaplana Chawla. Photo Credit: NASA/Patrick Black

NASA's Centers and Facilities

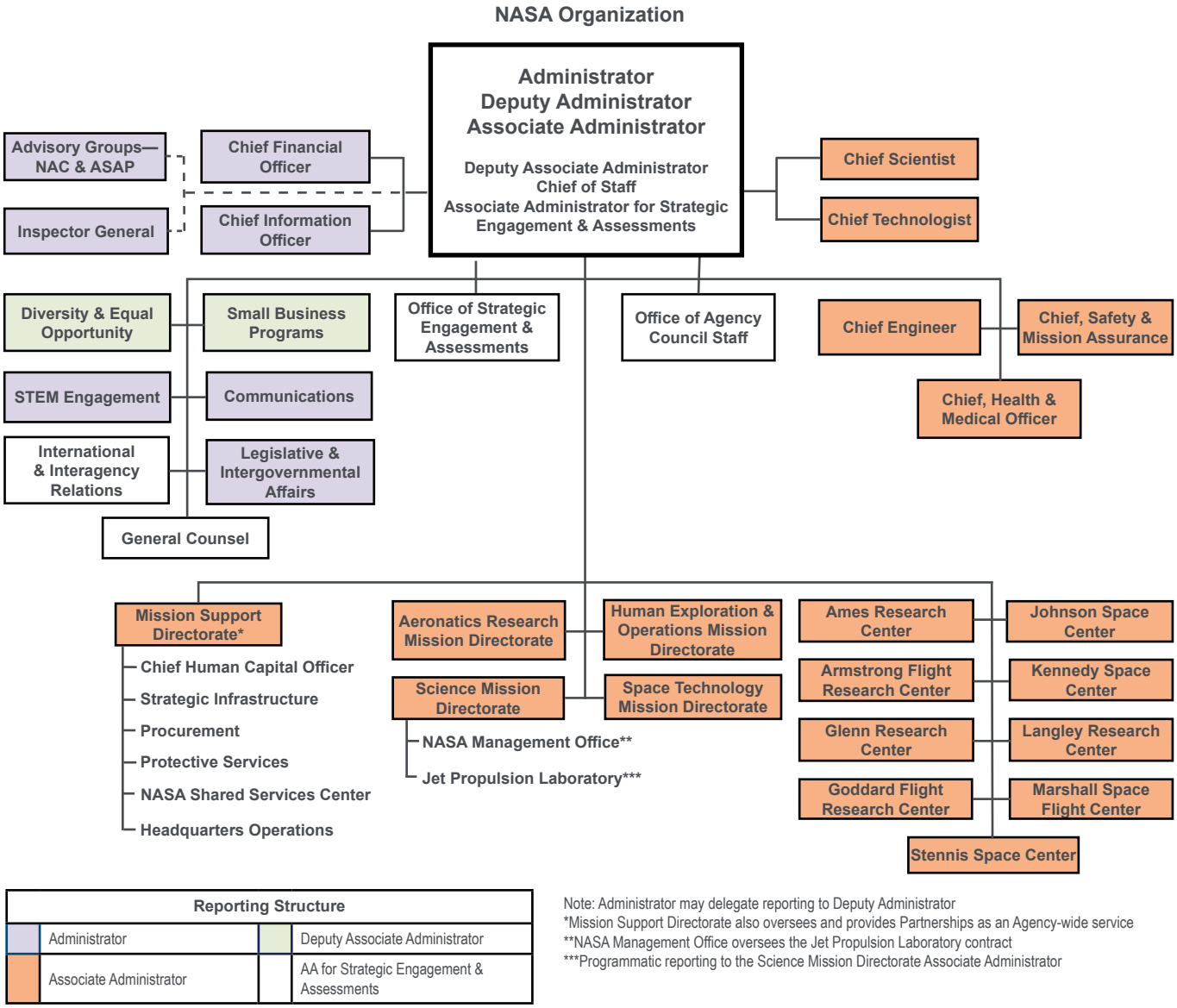


- **The Administrator's Staff Offices** lead the Agency by providing guidance and direction that cuts across all of NASA's work. These offices represent the Administrator with respect to safety and mission assurance, managing the workforce and its diversity, overseeing the acquisition and use of information technology, conducting financial and procurement operations, as well as coordinating STEM [science, technology, engineering, and mathematics] engagement activities, international partnerships, and legislative affairs.
- 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 **Human Exploration and Operations Mission Directorate (HEOMD)** leads and manages NASA space operations related to human exploration in and beyond low Earth orbit. HEOMD oversees requirements development, policy, and programmatic oversight across its numerous programs. HEOMD's activities include Artemis, the International Space Station (ISS), commercial space transportation, low Earth orbit spaceflight operations, launch services, and space communications.
- 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.
- The **Space Technology Mission Directorate (STMD)** invests in transformational technologies that may offset future mission risk, reduce cost, advance capabilities that enable NASA's Missions, and support space industry growth. STMD has used merit-based competition to identify and promote research and technology development, demonstrate applicability, and infuse these technologies into NASA's aeronautics, exploration, and science missions.
- The **Mission Support Directorate (MSD)** enables the Agency's missions by managing institutional services and

capabilities. 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 **Office of Inspector General (OIG)** promotes economy, effectiveness, and efficiency within the Agency by conducting independent and objective audits, investigations, and evaluations of Agency programs and operations. The OIG safeguards taxpayer dollars and the integrity of the Agency by detecting and preventing fraud, waste, and abuse.

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 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.



Strategies for Improvement

NASA's commitment to good governance and stewardship of taxpayer funds requires that the Agency routinely conducts internal assessments and evaluations to aid in maintaining, managing, and improving operations. In addition, periodic external assessments focus management attention on areas of high risk or potential difficulty. The Government Accountability Office (GAO) and the NASA Office of Inspector General (OIG) conduct such external assessments, identifying trouble spots and recommending how to address them. Issues raised by the GAO and OIG represent high-priority areas for management attention.

High Risk Areas Identified by the GAO

The GAO assesses management activities across the Federal Government and identifies practices and vulnerabilities that put agencies at risk of fraud, waste, abuse, and mismanagement. The GAO's High Risk List updated every two years, has included NASA's acquisition management since the list was established in 1990. To assist in corrective action planning, the GAO established five criteria that, if addressed, would substantively improve operations and clear the GAO's concern about high-risk activity:

- **Leadership Commitment:** Demonstrated strong commitment and top leadership support.
- **Capacity:** Agency has the capacity (i.e., people and resources) to resolve the risk(s).
- **Action Plan:** A corrective action plan exists that defines the root cause, solutions, and provides for substantially completing corrective measures, including steps necessary to implement recommended solutions.
- **Monitoring:** A program has been instituted to monitor and independently validate the effectiveness and sustainability of corrective measures.
- **Demonstrated Progress:** Ability to demonstrate progress in implementing corrective measures and resolving high-risk areas.

Above: From left, Mission Specialist Shannon Walker, Pilot Victor Glover, Crew Dragon Commander Michael Hopkins – all NASA astronauts – and Japan Aerospace Exploration Agency (JAXA) astronaut and Mission Specialist Soichi Noguchi were seated in SpaceX's Crew Dragon spacecraft during crew equipment interface training. Walker, Glover, Hopkins, and Noguchi are scheduled to launch to the International Space Station on the Agency's SpaceX Crew-1 mission. This will be the first operational mission to the orbiting laboratory under NASA's Commercial Crew Program following the Agency's certification of SpaceX's crew transportation system. Photo Credit: SpaceX

As part of the 2019 update for NASA, High-Risk Series: Substantial Efforts Needed to Achieve Greater Progress on High-Risk Areas (GAO-19-157SP), the GAO included a scorecard detailing which of these criteria for improving acquisition management have been met, partially met, or have not been met. NASA has fully met the criterion for a corrective action plan and has partially met the criteria for leadership, monitoring, capacity, and demonstrated progress.

NASA's responses to these challenges have yielded more credible cost and schedule baselines, and both the GAO and OIG have observed that NASA's management of its small- and medium-class major flight projects has improved. The effectiveness of these tools is particularly evident for the smaller (under $1 billion lifecycle cost) projects. However, NASA needs to improve management of its larger, more complex projects, which typically involve the development of a significant number of new technologies, greater integration risk, and early cost and schedule estimation challenges. The GAO observed that risks remain for NASA's largest flagship-type projects, such as the James Webb Space Telescope (Webb) (see Agency Priority Goal/Performance Goal 1.1.11 on page 41), the Space Launch System (SLS), and Orion (see the Artemis Agency Priority Goal/Performance Goal 2.2.1 on page 53).

A Corrective Action Plan for Acquisition Management Improvements

NASA released an updated high-risk corrective action plan in August 2020 in response to the continued inclusion of NASA's acquisition practices in GAO's 2019 high-risk report, as well as recent challenges in cost schedule growth experienced by several of NASA's highest profile missions. The overall goal of the plan is to strengthen the Agency's cutting-edge program and project management efforts across the board and improve transparency to stakeholders.

In September 2018, NASA senior leadership determined that a new corrective action plan was necessary to continue driving improvements in the Agency's program and project management policies and processes. The plan was comprised of seven initiatives to implement, one initiative to pilot, and one initiative to research.

Between the start of the 2018 plan in December 2018 and approval of the 2020 plan in July 2020, six initiatives were completed, one (Improve Human Exploration and Operations Mission Directorate (HEOMD) Portfolio Insight and Status) was closed and rewritten to better align to GAO's open priority recommendations and to clarify tracking and closure requirements, and two longer-term initiatives remained in process. The two ongoing initiatives—Enhanced Earned Value Management (EVM) Implementation and Program Planning and Control (PP&C) Training Curriculum—are intended to be longer-term initiatives. The initiative to pilot an agency schedule repository was deemed a success and a new initiative to fully implement the schedule repository was put into place.

The August 2020 CAP update also included two new initiatives. One initiative will be to implement enhancements to NASA's Cost Analysis and Data Requirements (CADRe) data collection process to better capture critical data from Category III/Class D missions. The other will see that major acquisitions (contracts greater than $500 million) include an evaluation of the financial health, stability, and outlook of organizations under consideration prior to contract award in order to enhance competitive and sole-selection procurement processes.

Management Challenges Identified by the OIG

Each fiscal year, NASA's OIG issues a letter summarizing what the Inspector General considers to be NASA's most serious management and performance challenges, as well as a brief assessment regarding the Agency's progress in addressing those challenges. NASA leverages the results of OIG audits to improve the overall efficiency and effectiveness of its programs, projects, and functional activities. NASA also is committed to ensuring timely and responsive final management decisions, along with timely and complete final management action, on all audit recommendations issued the NASA OIG.

To this end, NASA has implemented a comprehensive program of audit follow-up intended to ensure that audit recommendations issued by the OIG are resolved and implemented in a timely, responsive, and effective manner.

NASA's audit follow-up program is a key element in improving the overall efficiency and effectiveness of NASA's programs, projects, and operations. The requirements for managing the OIG's recommendations are detailed in NASA's FY 2020 Agency Financial Report.

The OIG's 2020 Report on NASA's Top Management and Performance Challenges, below, continues the seven challenges identified in 2019.

Landing the First Woman and the Next Man on the Moon by 2024[1]

The development of a deep-space human exploration capability to reach the Moon and then Mars is NASA's most ambitious and costliest ongoing activity. In March 2019, the White House directed NASA to accelerate its plans for a lunar landing. NASA requested an additional $1.6 billion in its FY 2020 budget as initial funding to help meet the program's new timetable. In FY 2021, requested over $7 billion for Artemis and estimated that it will cost ultimately cost approximately $28 billion between 2021 and 2025 to realize its lunar ambitions.

The Agency is currently developing the SLS and the Orion Crew Vehicle, launch infrastructure that includes two mobile launchers (ML-1 and ML-2), and supporting technologies, such as spacesuits and a robotic lunar rover for long-duration operations. In addition, NASA is using commercial partnerships to develop new systems, including the Human Landing System and the Lunar Gateway.

While SLS, Orion, and Exploration Ground System (EGS) programs are making progress, each has experienced significant cost increases and schedule delays. Further, each of the major contracts for building the SLS for Artemis I have experienced technical challenges, performance issues, and requirement changes that have resulted in $2 billion of overall cost increases and at least 2 years of schedule delay. The Artemis mission has experienced a series of challenges exacerbated more recently by COVID-19's impact on Agency facilities and operations. Beginning in April 2020, 12 of the Agency's 18 major facilities were closed except to protect life and critical infrastructure. As a result, key development activities for SLS and Orion had to be delayed or suspended. In August 2020, NASA alerted Congress of development cost increases of 30 percent for both SLS and EGS. Specifically, NASA aligned the development costs for SLS and EGS through Artemis I and established revised cost commitments placing the new development baseline cost for SLS at $9.1 billion, and the commitment for the initial ground systems capability to support the mission at $2.4 billion. Concurrently, plans for the Gateway and lunar lander need to be finalized to meet NASA's goal of landing on the Moon by 2024.

Given the multiple challenges outlined above, the OIG believes that the Agency will be hard-pressed to land astronauts on the Moon by the end of 2024. At the very least, achieving any date close to this ambitious goal—and reaching Mars in the 2030s—will require strong, consistent, sustained leadership from the President, Congress, and NASA, as well as stable and timely funding. For its part, NASA must determine the true long-term costs of its human exploration programs, set realistic schedules, define system requirements and mission planning, form or firm up international partnerships, and leverage commercial space capabilities.

See Agency Priority Goal/Performance Goal 2.2.1 on page 53 for more information on NASA's efforts in this area. Information on supporting efforts is available in Strategic Objective 2.2 on page 51.

Improving Management of Major Projects

As the OIG notes, NASA has developed some of the world's most complex systems and major projects in the areas of Earth science, human exploration, planetary science, astrophysics, aeronautics, and technology demonstration. However, NASA also has historically experienced cost overruns and schedule delays for its projects in development. The GAO's 2020 assessment of NASA's major projects found that cost performance had deteriorated over the past three years, with cost growth increasing from 27.6 percent to approximately 31 percent. The average schedule delay decreased.

1 The FY 2022 President's Budget Request updated this objective to send the first woman and first person of color to the Moon as a step toward the ultimate goal of the human exploration of Mars.

The OIG states that contributing factors listed in the 2019 Report on NASA's Top Management and Performance Challenges—understanding a project's technical complexity, funding instability, flawed estimating assumptions, poor project management, and a "too big to fail" mentality—have been compounded by the impacts of the COVID-19 pandemic. The OIG notes that NASA has taken corrective actions to strengthen project management, improve monitoring of contractors, and expand use of earned value management, a management tool that integrates cost, schedule, and technical information. As a result, cost and schedule performance has improved for several projects, including the Surface Water and Ocean Topography (SWOT) project and the NASA–Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR). NASA also is adding additional points during the project's lifecycle when cost and schedule are assessed and potentially updated. NASA also is updating the training for its programmatic analysts to promote best practices and strengthen the Agency's programmatic capabilities.

See Performance Goal 1.1.10 on page 39 and Agency Performance Goal/Performance Goal 1.1.11 on page 41 for performance information on the development of NASA's major science flight programs.

Sustaining a Human Presence in Low Earth Orbit

In recent years, and under the direction of Congress, NASA has sought opportunities to commercialize low Earth orbit by transitioning from being the sole operator of the International Space Station (ISS) to serving as one of many customers for a privately owned and operated platform. The Agency has relied on commercial partners to successfully transport cargo to and from the ISS since 2012 and had a recent first success in the long road to development of a commercial crew transportation capability when the Space Exploration Technologies Corporation (SpaceX) launched two American astronauts to the ISS and safely returned them 64 days later. However, NASA's other commercial partner—The Boeing Company (Boeing)—has experienced significant additional delays related to an aborted uncrewed test flight in December 2019. Given the need to re-fly that test mission, Boeing will not be ready to launch a crewed mission to the ISS until summer 2021 at the earliest. Leading up to this point, both companies experienced years-long delays which, in 2020, resulted in the U.S. segment of the ISS twice operating with a single crew member instead of the typical three or more.

NASA's broader plans for increasing commercialization of low Earth orbit are contingent on the Agency's ability to increase and sustain commercial activity on the ISS. Similar to findings in prior NASA OIG reports, in February 2020 a NASA-initiated independent review found significant issues with the effectiveness of the Center for the Advancement of Science in Space, Inc. (CASIS), which manages commercial, non-NASA research activities on the U.S. segment of the ISS. Given the important role CASIS plays in increasing commercialization of the ISS and low Earth orbit, proper management and oversight of the organization is key to creating and sustaining a commercial market for low Earth orbit. NASA and CASIS are reexamining the organization's board of directors and creating a User Advisory Committee to provide input on how the National Laboratory's resources should be managed. NASA also appointed the Agency's Chief Economist as the Program Executive of the National Laboratory.

To spur interest in commercial activity in low Earth orbit, NASA announced several initiatives in recent years. Most recently, in June 2020 the Agency created the Suborbital Crew office within the Commercial Crew Program to enable astronauts, principal investigators, and other Agency personnel to fly on commercial suborbital space transportation systems, which are expected to be more accessible and affordable alternatives to the ISS. Furthermore, in July 2019 the Agency issued the Next Space Technologies for Exploration Partnerships Broad Agency Announcement, which will allow commercial entities to enter into public-private partnerships to develop commercial destination technologies—including habitable modules, external platforms, and deployable structures—for low Earth orbit. Although these initiatives are a positive step, the OIG is concerned that the Agency's new commercialization policy does not include performance metrics for evaluating NASA's development of commercial markets. Further, NASA may need to clarify how to manage commercial missions and private astronaut requests with respect to their impact on the

Agency's commercial crew missions and ISS crew capacity. Moving forward, the OIG notes, NASA will need to continue to support opportunities for private operators to sustain private platforms in low Earth orbit. This includes working with other federal agencies to ensure that the adoption of regulations for the commercial use of space promote economic growth while minimizing uncertainty for taxpayers, investors, and private industry.

See Strategic Objective 2.1 on page 46 for more information about NASA's efforts to sustain a human presence in low Earth orbit.

Attracting and Retaining a Highly Skilled Workforce

NASA's work relies on attracting and retaining a highly skilled, diverse workforce. Both the OIG and the GAO have reported that the performance of multiple large-scale projects, including Europa Clipper and Low-Boom Flight Demonstrator, have been impacted by not having the staff with the appropriate skills. Of the 11,000 employees who fall under the occupation category "science and engineering," more than half are over 50 years old and almost 30 percent will be eligible for retirement in 2020, with an additional 2,000 employees becoming eligible within the next 5 years. This loss of critical skills and institutional knowledge is an additional risk for NASA's goal of returning humans to the Moon by 2024.

As the OIG states, a number of external factors has contributed to NASA's workforce challenges. Federal employment has decreased while expectations for government to solve major issues has increased. The government has had difficulty recruiting and retaining millennials to the aging workforce. Furthermore, NASA is competing to attract talent during a nationwide shortage of science, technology, engineering, and mathematics (STEM) workers in the aerospace community.

NASA has taken different approaches to address these issues. In 2012, the Technical Capabilities Assessment Team assessed the Agency's technical capabilities and needs and made recommendations for investing in, consolidating, or eliminating unneeded capabilities. Subsequent and related efforts focused on mission support functions. The ongoing Mission Support Future Architecture Program is reorganizing the mission support organization to create enterprise workforce structures that will more efficiently use employee skills across the Agency and meet evolving mission needs. NASA is partnering with non-profit and educational institutions, conducting competitions, and providing undergraduate opportunities to help attract the next generation of employees to aerospace and STEM professions. NASA also has increased the use of special hiring authorities to address workforce gaps in highly specialized, critical skill areas.

See Strategic Objective 4.4 on page 101 for performance towards maintaining a diverse and innovative workforce.

Improving Oversight of Contracts, Grants, and Cooperative Agreements

Under Section 3610 of the pandemic relief legislation known as the CARES Act, agencies are permitted to reimburse contractors for work stoppages caused by the pandemic to keep employees and subcontractors in a ready state given the closure of NASA Centers. This provision is particularly relevant to an agency like NASA that relies so heavily on private contractors for its science and space exploration projects. It is imperative that NASA ensure these Section 3610 funds are appropriately identified, recorded, and segregated, since the reimbursement may be paid not only from NASA's $60 million in CARES Act funding, but also from its annual appropriations. Furthermore, it will be incumbent upon NASA contracting officers to oversee contractor activity and obtain appropriate documentation to identify contractors that qualify for this relief.

NASA's acquisition management and contract oversight has been a long-standing challenge. NASA's grants and cooperative agreements are also at risk of mismanagement and fraud. Key areas of concern include ensuring grant investments achieve intended results, overseeing the use of grant funds, and obtaining timely and accurate financial and performance information from grantees. The OIG has found repeated cases where NASA and award recipients lacked an adequate system of controls to ensure proper administration and management of awards, and as a result funds were not used for

their intended purposes. Over the past 3 years, the OIG has conducted 8 grant fraud investigations resulting in 4 indictments, 1 prosecution, $740,000 in direct recoveries to NASA, $2.6 million in civil settlements, and 5 debarments.

While NASA has made several enterprise-wide changes to address challenges related to its procurement oversight and acquisition management, progress remains slow. In what the OIG views as a positive trend, NASA's use of award-fee contracts has diminished as a percentage of procurement dollars paid to businesses from 56 percent in FY 2014 to 47 percent in FY 2019. NASA has also made efforts to increase its efficiency in closing expired grants. Over the past 5 years, the Agency has revised its Grants and Cooperative Agreement Manual—including updating procedures regarding pre-award risk reviews and closeout of awards—in response to OIG recommendations and its own initiatives, which has strengthened the Agency's grants management and oversight.

See Performance Goal 4.1.2 on page 86 for information on NASA's efforts to achieve procurement efficiencies.

Managing and Mitigating Cybersecurity Risk

The OIG expresses concern about gaps between NASA's threat exposure and its ability to effectively manage and mitigate cyber risk, particularly during the COVID-19 pandemic, when the number of cyber threats has increased exponentially. The OIG states that the Agency's ability to detect and recover from cyberattacks are hampered by incomplete and inaccurate system security plans that categorize systems and data; prescribe formal techniques for protecting information systems from unauthorized users, viruses, and other events; and specify the actions needed to respond to these threats. As a result of resource constraints and conflicting operational priorities, more than 1,800 corrective actions to address the Agency's security vulnerabilities remained open as of May 2020.

The OIG points to NASA's expansive web presence of nearly 3,000 web domains as presenting an additional, significant cyber risk. The Office of the Chief Scientist has begun an effort to review NASA's web footprint and digital presence, reduce the overall footprint, and recommend ways to reduce cyber vulnerabilities by strengthening digital security. However, until the project is complete, vulnerabilities remain. In November 2019, NASA counterintelligence officials identified the improper access of an Internet-facing server containing personally identifiable information at a NASA center.

The OIG identifies several areas where NASA has taken positive steps to improve its overall information security and posture, including implementing Department of Homeland Security directives and legislative requirements. For NASA requires 100 percent of privileged users to sign in with Personal Identity Verification (PIV) credentials before using IT assets. Privileged users are given wider access and more authority than non-privileged users. In addition, NASA met the 90 percent Risk Management Assessment target of unprivileged users required to use PIV identified by the Federal Information Security Modernization Act (FISMA). In September 2019, NASA updated its IT Strategic Plan, which guides the direction, mission alignment, investments, and accountability for the IT efforts. A major change is to the IT operating model, which includes integrating mission processes across organizational boundaries and moving to enterprise computing model that is centralized and uses standardized products and systems.

See Strategic Objective 4.5 on page 106 for more information on NASA's efforts to manage and mitigate cybersecurity risk.

Addressing Outdated Infrastructure and Facilities

The OIG expresses concern that over 75 percent of NASA's more than 5,000 facilities are beyond their design life. The backlog of deferred maintenance has resulted in expensive unscheduled maintenance, which the OIG estimates as costing approximately three times more than it would have to repair or replace the equipment with on-time maintenance. In addition, NASA infrastructure portfolio includes 155 abandoned properties that are a safety and maintenance liability.

Efforts to update ground support infrastructure for the Artemis program, including modernization of Pad 39B and modification of the Vehicle

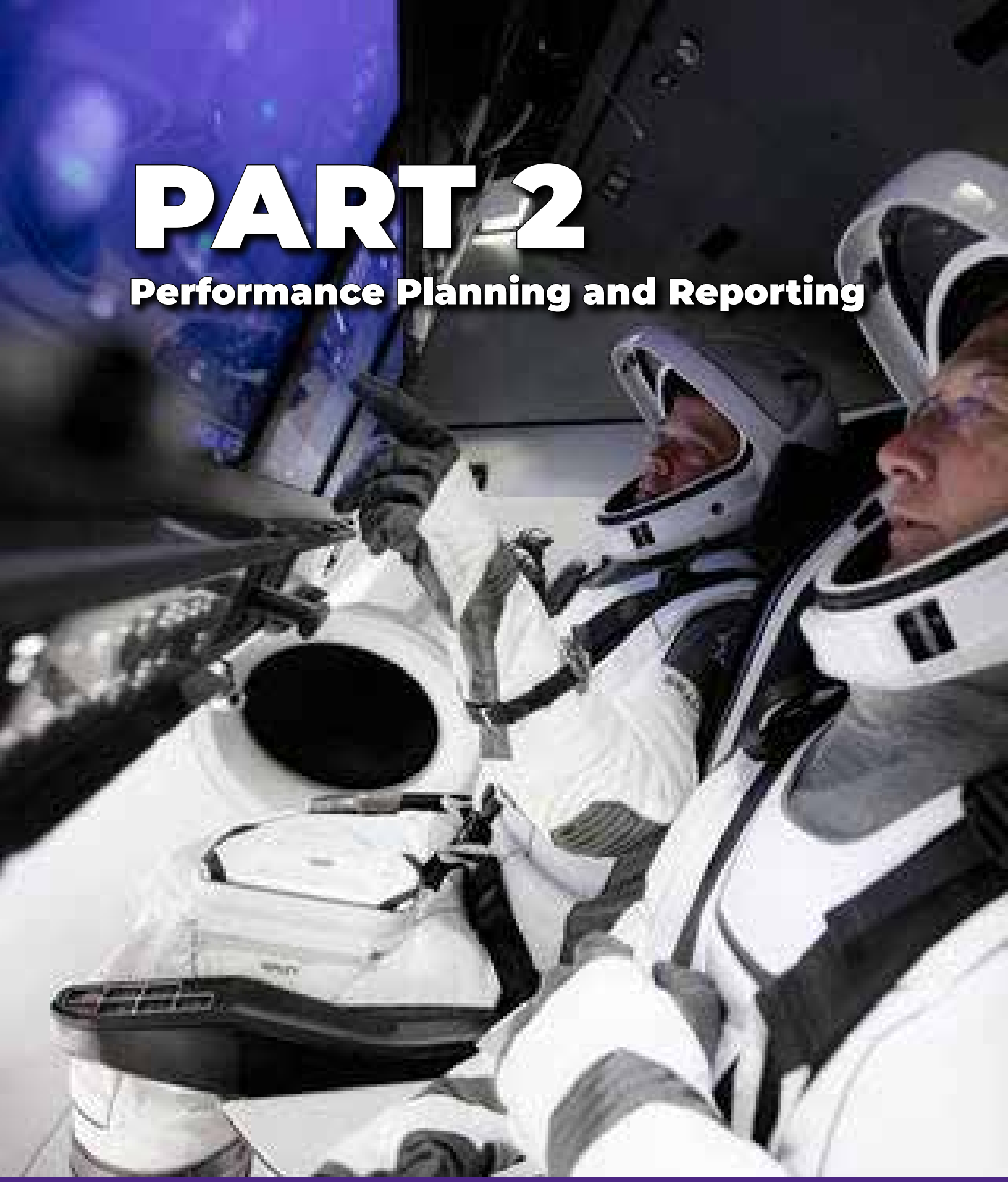
Assembly Building to accommodate the SLS rocket and Orion spacecraft, have faced cost and schedule target overruns. Construction projects were impacted by pandemic-related facility closures. Additionally, as facilities were re-opened for mission critical work, NASA obligated $3.8 million for building cleaning to protect the health of the on-site workforce.

The OIG states that the Agency is making progress on modernizing its infrastructure by demolishing old facilities, repairing failing facilities, and replacing old buildings with new, more sustainable facilities. The OIG also reports that the Agency is using $18 million in historic property lease proceeds at Ames Research Center to maintain facilities, including the Unitary Planned Wind Tunnel, Arc Jet Complex, and Vertical Motion Simulator. To support the Artemis program, NASA is refurbishing old facilities, such as Kennedy Space Center's Launch Complex 39B to support launch of the SLS rocket and constructing a new Modular Supercomputing Facility at Ames Research Center.

See Performance Goal 4.2.6 on page 95 for more information on NASA's efforts to ensure reliable, on-time facility availability. See Strategic Objective 4.6 on page 110 for information on NASA's efforts to efficiently manage, operate, and sustain NASA's infrastructure.

PART 2

Performance Planning and Reporting



In March 2020, SpaceX teams at NASA's Kennedy Space Center in Florida, the company's Mission Control in Hawthorne, California, and NASA flight controllers in Mission Control Houston, Texas, executed a full simulation of launch and docking of the Crew Dragon spacecraft, with NASA astronauts Bob Behnken and Doug Hurley participating in SpaceX's flight simulator. Photo Credit: NASA

DISCOVER

STRATEGIC GOAL 1

Expand human knowledge through new scientific discoveries.

A United Launch Alliance Atlas V rocket with NASA's Mars 2020 Perseverance rover onboard launches from Space Launch Complex 41, July 30, 2020, at Cape Canaveral Air Force Station in Florida. The Perseverance rover is part of NASA's Mars Exploration Program, a long-term effort of robotic exploration of the Red Planet. Photo Credit: NASA/Joel Kowsky

Strategic Objective 1.1: Understand the Sun, Earth, solar system, and universe.

LEAD OFFICE

Science Mission Directorate (SMD), with support from the Human Exploration and Operations Mission Directorate

GOAL LEADER

Karen Flynn, Deputy Associate Administrator for Management, SMD

Since NASA's inception, scientific discovery regarding Earth, the Sun, the solar system and the universe beyond has been an enduring purpose of the Agency. NASA 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 protecting and improving life on Earth.

NASA uses the recommendations of the National Academies' decadal surveys as an important input in planning and prioritizing the future of its science programs. For almost 50 years, decadal surveys have proven vital in establishing a broad consensus within the national science community on the state of science, the highest priority science questions to address, and actions that can be undertaken to answer those questions. NASA uses these recommendations to prioritize future flight missions, as well as technology development and proposals for theoretical and suborbital supporting research. In determining the content of the science portfolio,

NASA also considers national priorities and policies, appropriations, existing technological capabilities, partnership opportu-

Above: The James Webb Space Telescope has the largest mirror of its kind that NASA has ever built — so big that it can't fit inside a rocket without folding up. In early March, testing teams deployed Webb's 21 feet 4-inch (6.5 meter) primary mirror into the same configuration it will have when in space. Like the art of origami, Webb is a collection of movable parts that have been specifically designed to fold to a compact formation that is considerably smaller than when the observatory is fully deployed or extended. This allows it to just barely squeeze within a 16-foot (5-meter) payload fairing or cargo bay of a rocket, with little room to spare. Once in space, it will blossom and unfold into the world's premier space science observatory. Photo Credit: Northrop Gruman/NASA

nities, and other programmatic factors.Since NASA's inception, scientific discovery regarding Earth, the Sun, the solar system and the universe beyond has been an enduring purpose of the Agency. NASA 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 protecting and improving life on Earth.

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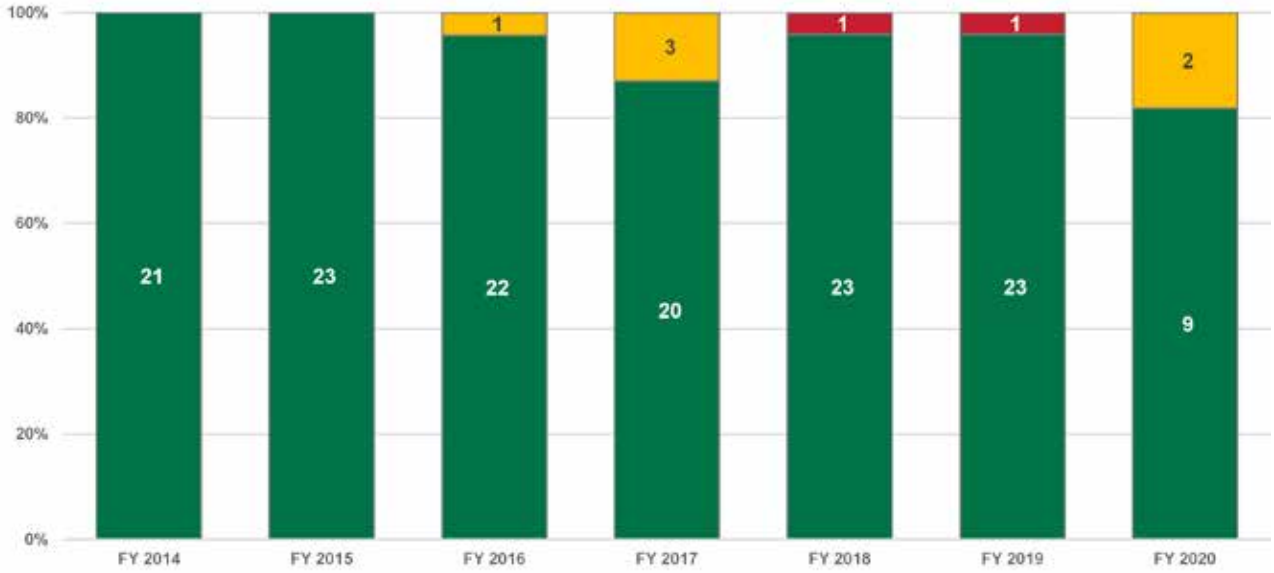
In spring 2020, NASA found that it continued to make satisfactory progress toward Strategic Objective 1.1, with clear strategies for achievement. NASA is conducting missions to maintain continuity of climate data records, explore the physical processes within our solar system's space environment, advance our understanding of Earth's natural exchanges of carbon between the land, atmosphere and ocean, study the dynamic zone high in our atmosphere where Earth weather and space weather meet, study the Sun's poles, advance understanding of the potential for life on other worlds, and better understand the worlds in our solar system.

Progress on near-term priorities includes the launch of the Mars 2020 Perseverance rover and the Solar Orbiter mission, a collaboration with the European Space Agency. Progress continued on several missions scheduled for launch in 2021, including Sentinel-6 Michael Freilich, Landsat 9, Lucy, and the James Webb Space Telescope (Webb). NASA also awarded contracts and task orders for deliveries of instruments and technology demonstrations to the lunar surface and selected four Discovery Program mission concepts.

NASA announced the selection of Libera, a new space-based instrument that represents an innovative and cost-effective approach to maintaining the 40-year data record of the balance between the solar radiation entering Earth's atmosphere and the amount absorbed, reflected, and emitted. Libera is the first mission selected in response to the 2017 Earth Science decadal survey. Implementing a high-priority recommendation of the most recent Solar and Space Physics decadal survey, NASA also announced initial selections for its DRIVE (Diversity, Realize, Integrate, Venture, Educate) Science Centers, a Heliophysics program supporting science that cannot effectively be done by individual investigators or small teams, but instead requires the synergistic, coordinated efforts of a research center.

While Strategic Objective 1.1 has a clear strategy for success, there have been impacts due to the COVID-19 pandemic. NASA is experiencing disruptions to missions in this objective due to COVID-related restrictions, whether from reduced efficiency at work sites, travel restrictions, reduced availability of facilities, or disruptions to the supply chain for current and future procurements. The Agency has implemented a series of short- and medium-term actions to mitigate impacts in order to ensure mission success and the overall health of the portfolio and continues to consider others as circumstances warrant. For the James Webb Space Telescope, for which COVID-19 impacted the Northrop Grumman work schedule significantly from March to May, NASA performed a schedule assessment and established a new Launch Readiness Date (LRD) of October 31, 2021. The new LRD incorporates delays to date, anticipated impacts moving forward, and completion of additional risk-reduction tasks/technology, as well as appropriate schedule margin.

Summary of Progress for Performance Goals Contributing to Strategic Objective 1.1, FY 2014—2020



Note: FY 2018—FY 2020 contribute to Strategic Objective 1.1, as established by the NASA 2018 Strategic Plan. For FY 2014 through FY 2017, individual performance goals were assigned to a strategic objective based on contributing work.

1.1.1: Demonstrate progress in exploring the physical processes in the space environment from the Sun to Earth and throughout the solar system.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	Significant progress demonstrated		
Achieved	Demonstrated as planned		

NASA's **Science Mission Directorate** is organized into four areas of scientific study—**Astrophysics**, **Earth Science**, **Heliophysics**, and **Planetary Science**—to seek answers to profound questions, such as why Earth's climate and the environment are changing, how and why the Sun varies and the affect it has on Earth and the solar system, how planets and life originate, how the universe works and what is its origins and destiny, and is there life elsewhere in the universe.

FY 2020 Performance Progress

NASA achieved the FY 2020 target for this multi-year performance goal, as determined by the assessment of progress led by the Heliophysics Advisory Committee in September 2020. Below are examples of scientific progress reported in FY 2020.

The selected results demonstrate significant progress in our understanding of the interconnections shaping the space environment. During break-up of the polar vortex in the Earth's middle atmosphere, the Global-scale Observations of the Limb and Disk (GOLD) mission observed a change in the composition of the thermosphere hundreds of kilometers above. Numerical simulations demonstrate that acoustic waves at the interface between the ocean and the atmosphere produced by offshore earthquakes can reach as far as the upper atmosphere, potentially providing a new approach for tsunami early warning systems. In the Earth's magnetosphere, data from the Van Allen Probes mission along with theoretical calculations provide further evidence that human-generated radio waves from high-powered, ground-based transmitters propagate into space and scatter electrons out of the radiation belts.

The Magnetospheric Multiscale (MMS) mission in conjunction with the Japanese Arase satellite showed that oxygen ions flowing out of the ionosphere reach the near-Earth plasma sheet during a geomagnetic storm main phase, intensifying the storm. Parker Solar Probe (PSP), which has gotten closer to the Sun than any previous human-made object, found a solar wind environment that is much more impulsive and unstable than what is seen closer to Earth. In this environment, the dynamic coupling between solar wind plasma and magnetic fields produces unusual new signatures called switchbacks. Switchbacks are formed as the magnetic field bends back on itself until it is pointing almost directly back at the Sun.

In other planetary environments, observations from the Mars Atmosphere and Volatile Evolution (MAVEN) mission showed that the most significant contribution to the loss of material from Mars' moon Phobos came from ions that previously escaped the atmosphere of Mars. At Earth's Moon, high reflectance regions called "lunar swirls" were found to be associated with plasma interacting with magnetic anomalies. Maps of the flow patterns of protons from the solar wind around lunar craters were produced, important for the study of weathering of the lunar surface.

This illustration shows the MAVEN spacecraft and the limb of Mars. Image Credit: NASA's Goddard Space Flight Center.

1.1.2: Demonstrate progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	Significant progress demonstrated		
Achieved	Demonstrated as planned		

NASA's **Science Mission Directorate** is organized into four areas of scientific study—**Astrophysics, Earth Science, Heliophysics,** and **Planetary Science**—to seek answers to profound questions, such as why Earth's climate and the environment are changing, how and why the Sun varies and the affect it has on Earth and the solar system, how planets and life originate, how the universe works and what is its origins and destiny, and is there life elsewhere in the universe.

FY 2020 Performance Progress

NASA achieved the FY 2020 target for this multi-year performance goal as determined by the assessment of progress led by the Astrophysics Advisory Committee in October 2020. Below are examples of scientific progress reported in FY 2020.

Magnetic fields play a strong role in shaping spiral galaxies, according to research from the Stratospheric Observatory for Infrared Astronomy (SOFIA). Observing celestial dust grains, which align perpendicular to magnetic field lines, with SOFIA's newest instrument using far infrared light, astronomers could infer the shape and direction of the otherwise-invisible magnetic field.

Using the Chandra X-ray Observatory, astronomers have seen, for the first time, evidence of a single black hole boosting star birth in more than one galaxy at a time.

Using Hubble Space Telescope, SOFIA, and the Solar and Terrestrial Relations Observatory (STEREO), scientists traced in real time how a dying star, Betelgeuse, loses its mass.

In FY 2020, Voyager 2 left the solar system, traveling beyond the Sun's sphere of influence, called the heliosphere. The Voyagers are the first spacecraft to leave the heliosphere, providing in-place observations of the interaction of a star—the Sun—with the interstellar medium. This is fundamentally important to understanding of how all stars interact with their environments and will inform future NASA ventures beyond the solar system.

Planet formation is thought to happen within protoplanetary disks by aggregation of small solid particles of dust. This is expected to happen in the mid-region of the disk at the same time as surface regions are being evaporated by the radiation of the host star. At present, it is unclear how these millimeter-sized aggregates can turn into large 100 kilometer-sized planetesimals, and ultimately planets, before most of the disk dissipates. New high-resolution numerical computer simulations provide a detailed theoretical framework to understand how planetesimal formation occurs under globally turbulent disk conditions. This framework will be able to help researchers estimate how long it takes for planetesimals to grow, as well as enable more detailed numerical experiments in the future.

An artist concept depicting one of NASA's twin Voyager spacecraft. Humanity's farthest and longest-lived spacecraft celebrated 40 years in August and September 2017. Image Credit: NASA/JPL-Caltech

1.1.3: Demonstrate progress in exploring, observing, and understanding objects in the solar system in order to understand how they formed, operate, interact, and evolve.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	Significant progress demonstrated		
Achieved	Demonstrated as planned		

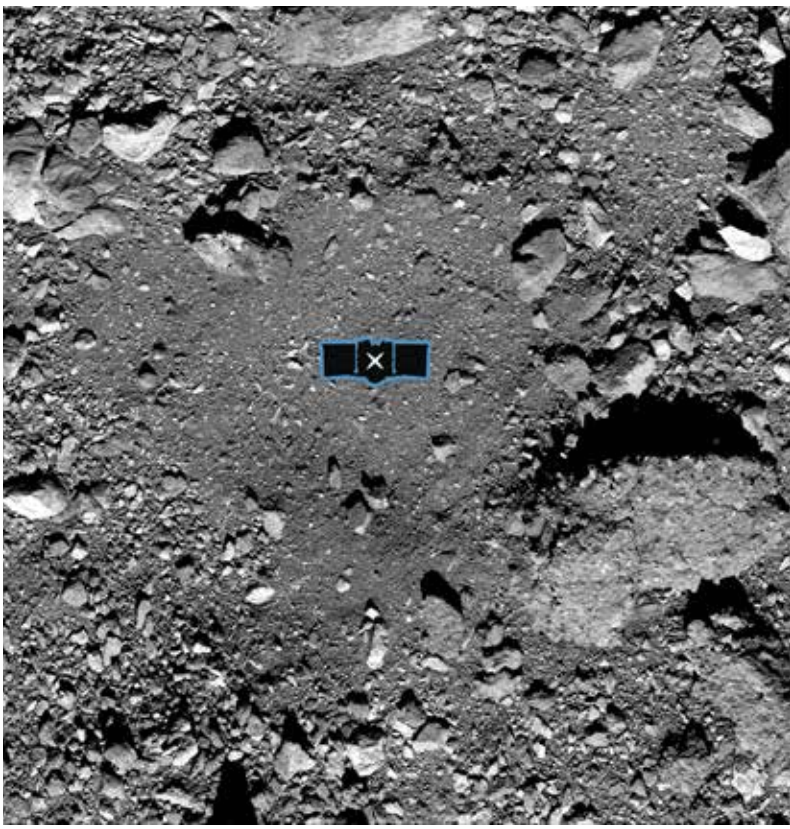
NASA's **Science Mission Directorate** is organized into four areas of scientific study—**Astrophysics, Earth Science, Heliophysics,** and **Planetary Science**—to seek answers to profound questions, such as why Earth's climate and the environment are changing, how and why the Sun varies and the affect it has on Earth and the solar system, how planets and life originate, how the universe works and what is its origins and destiny, and is there life elsewhere in the universe.

FY 2020 Performance Progress

NASA achieved the FY 2020 target for this multi-year performance goal as determined by the assessment of progress led by the Planetary Science Advisory Committee in August 2020. Below are examples of scientific progress reported in FY 2020.

The selected results represent a breadth of accomplishment in exploring, observing and understanding objects in the solar system and how they formed, operate, interact, and evolve. Analysis of fragments from Asteroid 2008 TC3, which disintegrated in the atmosphere and landed as more than 700 individual stones, revealed contact between chondritic (meteorite material that has not been modified from its original, parent form) and achondritic (meteorite material that has melted and recrystallized) lithologies. The study provided new information about composition and formation of TC3, as well as information about surrounding asteroids and insight into asteroid Bennu, target of the Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS-REx) mission.

Meanwhile, in the outer planets, a simulation of icy crevasse and cycloid formation on Jupiter's frozen moon, Europa, suggested that crevasses could evolve in a relatively short amount of time by a series of nearly instantaneous fracturing events (hundreds of meters per second), followed by long periods of dormancy/inactivity (hundreds of years). The modeled behavior provides better understanding of surface processes and will help improve knowledge about the rotation state of Europa and the secular motion of the crust, setting the stage for future exploration missions, including the Europa Clipper mission.



This image shows sample site Nightingale, OSIRIS-REx's primary sample collection site on asteroid Bennu. The image is overlaid with a graphic of the OSIRIS-REx spacecraft to illustrate the scale of the site. Image Credit: NASA/Goddard/University of Arizona

1.1.4: Demonstrate progress in discovering and studying planets around other stars.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	Significant progress demonstrated		
Achieved	Demonstrated as planned		

Area for external review panel determination in FY 2020

1. *Annual external expert review determination of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.4.*

Areas for external review panel determination in FY 2021

1. Annual external expert review determination of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.4.
2. Complete Transiting Exoplanet Survey Satellite (TESS) mission success criteria.

Area for external review panel determination in FY 2022

1. Annual external expert review determination of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.4.

NASA's **Science Mission Directorate** is organized into four areas of scientific study—**Astrophysics, Earth Science, Heliophysics,** and **Planetary Science**—to seek answers to profound questions, such as why Earth's climate and the environment are changing, how and why the Sun varies and the affect it has on Earth and the solar system, how planets and life originate, how the universe works and what is its origins and destiny, and is there life elsewhere in the universe.

FY 2020 Performance Progress

NASA achieved the FY 2020 target for this multi-year performance goal as determined by the assessment of progress led by the Astrophysics Advisory Committee in October 2020. Below are examples of scientific progress reported in FY 2020.

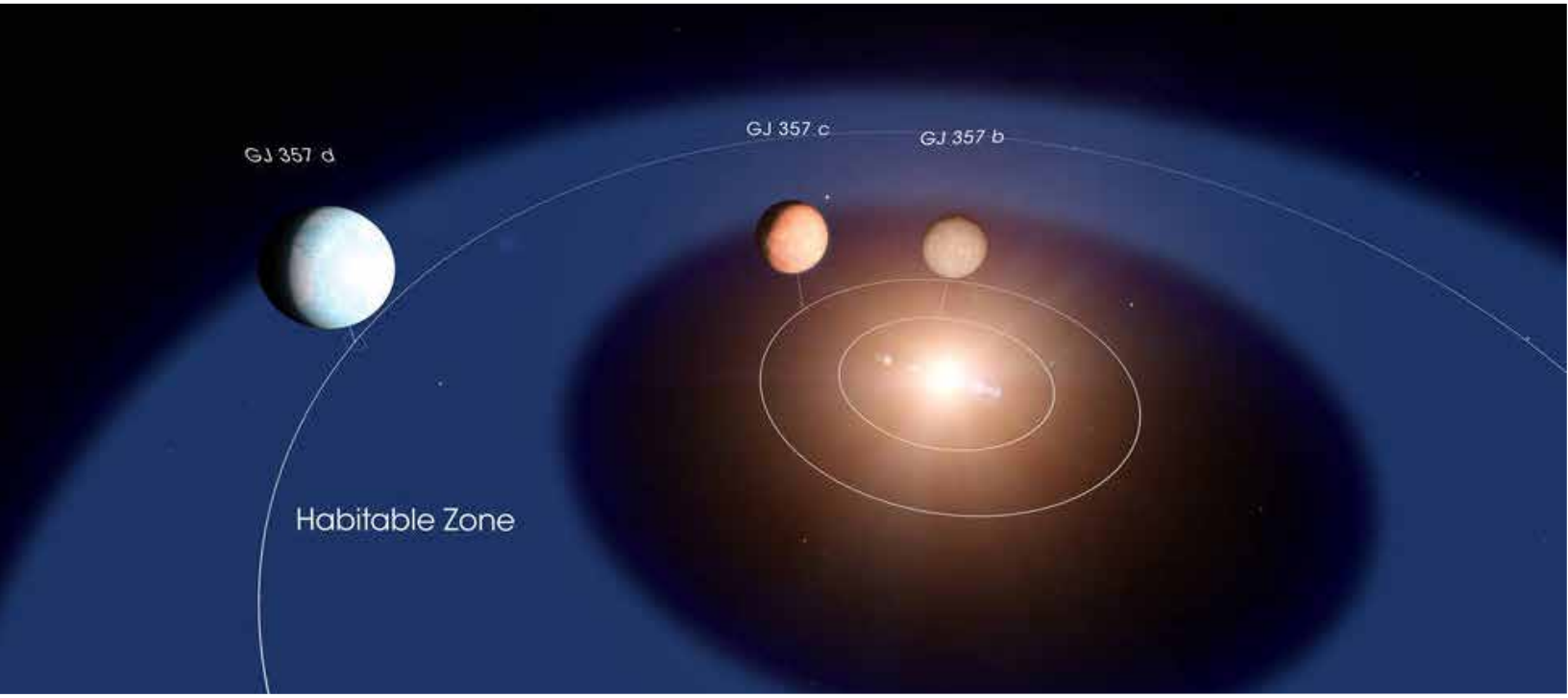
Scientists have used data from NASA's Transiting Exoplanet Survey Satellite (TESS) and Spitzer Space Telescope to report discoveries of extrasolar planets, including the first transiting planet candidate orbiting a white dwarf, the dense leftover of a Sun-like star. The Jupiter-sized object is about seven times larger than the white dwarf, named WD 1856+354, and at the end of its evolutionary path, posing many questions about how the planet candidate survived the white dwarf creation process, and how it came to be at its current location. Spitzer and TESS data also revealed a planet about as large as Neptune that circles the young star, AU Microscopii. The AU Mic system provides a one-of-a-kind laboratory for studying how planets and their atmospheres form, evolve and interact with their stars.

A piping hot planet discovered by TESS has pointed the way to additional worlds orbiting the same star, one of which is located in the

star's habitable zone. If made of rock, this planet may be around twice Earth's size. As one of the nearest transiting exoplanets known to date, it is a good target for transmission spectroscopy characterizing its atmosphere with the James Webb Space Telescope and other future NASA missions.

Observations from the Kepler mission have revealed frequent superflares on young and active solar-like stars. Superflares result from the large-scale restructuring of stellar magnetic fields and are associated with the eruption of coronal material (a coronal mass ejection, CME) and energy release that can be orders of magnitude greater than those observed in the largest solar flares. There is growing appreciation that the space environment around exoplanets and the interaction with the stellar wind of the host star has a significant impact on planetary atmospheric chemistry, and even the retention of an atmosphere. This has led to a number of increasingly sophisticated modeling efforts, as the information they yield will help to redefine the extent of habitable zones around Sun-like stars.

Above: An illustration of WD 1856 b, a potential Jupiter-size planet, orbits its much smaller host star, a dim white dwarf. Image Credit: NASA's Goddard Space Flight Center



This diagram shows the layout of the GJ 357 system. Planet d orbits within the star's so-called habitable zone, the orbital region where liquid water can exist on a rocky planet's surface. If it has a dense atmosphere, which will take future studies to determine, GJ 357 d could be warm enough to permit the presence of liquid water. Image Credit: NASA/Chris Smith

1.1.5: Demonstrate progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere, exploring and finding locations where life could have existed or could exist today, and exploring whether planets around other stars could harbor life.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	Significant progress demonstrated		
Achieved	Demonstrated as planned		

NASA's **Science Mission Directorate** is organized into four areas of scientific study—**Astrophysics, Earth Science, Heliophysics,** and **Planetary Science**—to seek answers to profound questions, such as why Earth's climate and the environment are changing, how and why the Sun varies and the affect it has on Earth and the solar system, how planets and life originate, how the universe works and what is its origins and destiny, and is there life elsewhere in the universe.

FY 2020 Performance Progress

NASA achieved the FY 2020 target for this multi-year performance goal as determined by the assessment of progress led by the Planetary Science Advisory Committee in August 2020. Below are examples of scientific progress reported in FY 2020.

Samples taken by the Cosmic Dust Analyzer (CDA) on the Cassini spacecraft were used to study the chemistry and potential habitability of Saturn's icy moon Enceladus by analyzing materials within icy plumes that were ejected from Enceladus. Researchers detected low-mass organic compounds within the ice grains, including oxygen-bearing, nitrogen-bearing, and aromatic compounds released through cracks in Enceladus's crust. These compounds are important on Earth as precursors to amino acids and other organic molecules. Hydrothermal activity in Enceladus' subsurface ocean, similar to what takes place on Earth, is believed to be an abiotic source of these organic molecules that are relevant to the origin or sustenance of life.

Closer to home, an analog study of lipids (a class of organic compounds that includes fats, oils, and hormones) in serpentine samples from an area in Oman set the stage for interpreting what lipids might look like on other terrestrial planets, like Mars. This study examined lipids in samples from the mantle of the Samail Ophiolite, an area actively undergoing the serpentinization process. The research team found lipids consistent with other serpentinite sites, indicating a common microbiome shared between areas containing sulfate-reducing and ammonia-oxidizing bacteria, methanogens (methane-producing bacteria), and methanotrophs (methane-using bacteria). This study provides more information on microbial habitability in analog environments on Earth to help with evaluating future rover landing sites and sample return from Mars.

One possible biosignature on distant worlds is the presence of oxygen in an exoplanet's atmosphere. In an astrophysics study, researchers identified a strong signal that oxygen molecules produce when they collide and developed a technique that could be used by NASA's James Webb Space Telescope to quickly identify promising nearby planets in the search for life. Researchers simulated this oxygen signature by modeling the atmospheric conditions of an exoplanet around an M dwarf, the most common type of star in the universe. The team modelled the impact of this enhanced radiation on atmospheric chemistry and used this to simulate how the component colors of the star's light would change when the planet would pass in front of it. The signal could help indicate the composition of M dwarf planets' atmospheres and provide clues about habitability, while providing new knowledge about star-planet interactions around highly active M dwarf stars.

1.1.6: Demonstrate progress in developing the capability to detect and knowledge to predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	Significant progress demonstrated		
Achieved	Demonstrated as planned in 2 areas		

Areas for external review panel determination in FY 2020

1. *Annual external expert review determination of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.6.*
2. *External expert review panel determination indicating whether expectations for research program have been fully met or exceeded in advancing scientific understanding of background solar wind, solar wind structures, and coronal mass ejections, which can be integrated into key models used to predict the arrival time and impact of space storms at Earth.*

Areas for external review panel determination in FY 2021

1. Annual external expert review determination of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.6.
2. External expert review panel determination indicating whether expectations for research program have been fully met or exceeded in advancing scientific understanding of background solar wind, solar wind structures, and coronal mass ejections, which can be integrated into key models used to predict the arrival time and impact of space storms at Earth.

The **Heliophysics Division**, part of the **Science Mission Directorate**, studies the nature of the Sun and how it influences the nature of space and, in turn, the atmospheres of planets and the technologies that exist there.

Planned areas for external review panel determination in FY 2022

1. Annual external expert review determination of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.6.
2. External expert review panel determination indicating whether expectations for research program have been fully met or exceeded in advancing scientific understanding of background solar wind, solar wind structures, and coronal mass ejections, which can be integrated into key models used to predict the arrival time and impact of space storms at Earth.

FY 2020 Performance Progress

NASA achieved the FY 2020 target for this multi-year performance goal as determined by the assessment of progress performed by the Heliophysics Advisory Committee in September 2020. Below are examples of scientific progress reported in FY 2020.

Understanding the nature of solar flare trigger mechanisms is key to improving space weather prediction capabilities. Hinode and Solar Dynamics Observatory (SDO) observations provide strong evidence for the onset mechanism of flares. The intrusion of flux at the Sun's surface leads to instabilities in the overlaying coronal magnetic fields, resulting in a rapid release of energy through magnetic reconnection. A unique and creative technique was developed utilizing acoustic wave information derived from the SDO and Solar Terrestrial Relations Observatory (STEREO) missions, as well as ground-based observations to infer far-side solar structures. This new technique enables far-side mapping of the Sun without the necessity of deploying satellites to that area, facilitating early detection of potential extreme events that impact Earth. There has also been a significant improvement in our ability to identify precursors to solar flares. By utilizing a deep

neural network analysis of Interface Region Imaging Spectrograph (IRIS) high resolution spectral data, researchers are now able to identify pre-flare spectra approximately 35 minutes prior to the flare onset with 80 percent accuracy, a major step forward in forecasting flares. These results demonstrate significant progress in understanding drivers and sources and their influence on solar wind structures.

Through observations from Time History of Events and Macroscale Interactions during Substorms (THEMIS), with support from Geostationary Operational Environmental Satellite(s) (GOES) and other observations from the NASA Heliophysics fleet, new insights were obtained into how and where energy is released during intense geomagnetic storms—closer to Earth with reconnection events more frequent than previously thought. Magnetic reconnection converts magnetic to particle energy and drives space currents, which in turn can disrupt electrical power line transmission. The knowledge gained will enable improved modeling of these effects.

The Geostationary Operational Environmental Satellites (GOES)-T lifted to the 29' x 65' thermal vacuum chamber on September 29, 2020. Photo Credit: Lockheed Martin

1.1.7: Demonstrate progress in identifying, characterizing, and predicting objects in the solar system that pose threats to Earth or offer resources for human exploration.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	Significant progress demonstrated		
Achieved	Demonstrated as planned in 2 areas		

Areas contributing to performance goal in FY 2020

1. *Annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.7.*
2. *Identify and catalogue 9250 near-Earth asteroids that are 140 meters in diameter or larger.*

Areas contributing to performance goal in FY 2021

1. Annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.7.
2. Identify and catalogue 9,750 near-Earth asteroids that are 140 meters in diameter or larger.

Planned areas contributing to performance goal in FY 2022

1. Annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.7.
2. Identify and catalogue [number to be based on FY 2021 actual] near-Earth asteroids that are 140 meters in diameter or larger.

FY 2020 Performance Progress

NASA achieved the FY 2020 target for this multi-year performance goal as determined by the assessment of progress performed by the Planetary Science Advisory Committee in August 2020. Below are examples of scientific progress reported in FY 2020.

In FY 2020, asteroid search teams found another two near-Earth asteroids (NEAs) larger than one kilometer in size, 2,862 NEAs less than one kilometer in size, and three Earth-approaching comets. As of September 30, 2020, the total known population of near-Earth objects (NEOs) was 23,813 NEAs and 113 Earth-approaching comets. JPL's Center for NEO Studies computes that none is likely to strike Earth in the next century. However, there were 2,124 NEAs (157 larger than one kilometer in size), with 113 found in FY 2020, in orbits that could become a hazard in the distant future and warrant monitoring.

The **Planetary Science Division**, part of the **Science Mission Directorate**, studies and explores the solar system to better understand its history, composition, and the distribution of life within it. The division also identifies and characterizes objects in the solar system that pose threats to Earth or offer resources for human exploration.

The Mission Accessible Near-Earth Object Survey (MANOS) team funded by the Near-Earth Object Observations Program studied the physical properties of near-Earth asteroids that could also be targets of spacecraft missions and reported in the literature on how spectral type depends on the sizes of near-Earth asteroids and identified a common origin for two separate pairs of near-Earth asteroids.

A powerful and unexpected meteor shower outburst occurred at high southern ecliptic latitude within the South Toroidal region in March 2020. Researchers utilized data from the Southern Argentina Agile MEteor Radar Orbital System (SAAMER-OS) to study the characteristics of this shower and to suggest a link to a parent body. The researchers noted after studying the orbital elements of the meteor shower that it appeared to resemble the **β** Tucanid and **δ** Mensid meteor showers (indicating a shared or common origin). The parent asteroid was also predicted to be asteroid (248590) 2006 CS, which is a large NEO. The study of these meteor showers can be useful for modeling dust evolution within the Solar System, while additionally preparing for future meteor showers by supplying researchers the strength of meteor shower activity and how it might change annually.

1.1.8: Demonstrate progress in characterizing the behavior of the Earth system, including its various components and the naturally-occurring and human-induced forcing that act upon it.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	Significant progress demonstrated		
Achieved	Demonstrated as planned in 2 areas		

Areas contributing to performance goal in FY 2020

1. *Annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.8.*
2. *Complete the mission success criteria for Ice, Cloud and land Elevation Satellite (ICESat)-2.*

Areas contributing to performance goal in FY 2021

1. Annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.8.
2. Complete Gravity Recovery and Climate Experiment Follow-On (GRACE-FO) mission success criteria.

Planned areas contributing to performance goal in FY 2022

1. Annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.8.

FY 2020 Performance Progress

NASA achieved the FY 2020 target for this multi-year performance goal as determined by the assessment of progress performed by the Earth Science Advisory Committee in October 2020. Below are examples of scientific progress reported in FY 2020.

Leveraging a time series of Landsat satellite data, researchers mapped deforestation and natural disturbance in the Amazon rainforest from 1995 to 2017. They found that the area of disturbed forest is 44–60 percent more than previously realized, indicating an unaccounted-for source of global carbon emissions and more pervasive damage to forest ecosystems.

The **Earth Science Division**, part of NASA's **Science Mission Directorate**, delivers the technology, expertise, and global observations that help researchers map the connections between Earth's vital processes and the effects of ongoing natural and human-caused changes.

Another study used Landsat time series to map the drivers of mangrove forest loss, one of the most carbon dense ecosystems. The scientists estimated that 62 percent of global mangrove losses between 2000 and 2016 resulted from land-use change, primarily through conversion to aquaculture and agriculture, and that up to 80 percent of these human-driven losses occurred within six Southeast Asian nations, reflecting regional policy of enhancing aquaculture to support economic development.

Using data from the ICESat and ICESat-2 laser altimeters, scientists precisely measured how much ice has been lost from ice sheets in Antarctica and Greenland between 2003 and 2019. The Antarctic Peninsula, seen here, was one of the fastest changing regions of the continent. Photo Credit: NASA's Goddard Space Flight Center/K. Ramsayer

Researchers used Ice, Cloud and land Elevation Satellite (ICESat)-2 data for insight into trends of ice sheets, such as unified estimates of grounded and floating ice mass change from 2003 to 2019. Their analysis reveals patterns likely linked to competing climate processes: ice loss from coastal Greenland (increased surface melt), Antarctic ice shelves (increased ocean melting), and Greenland and Antarctic outlet glaciers (dynamic response to ocean melting) was partially compensated by mass gains over ice sheet interiors (increased snow accumulation). Losses outpaced gains, with grounded-ice loss from Greenland (200 billion tons per year) and Antarctica (118 billion tons per year) contributing 14 millimeters to sea level. Mass lost from West Antarctica's ice shelves accounted for more than 30 percent of that region's total. Quantifying changes in ice sheets and identifying the climate drivers is central to improving sea level projections.

Researchers showed reductions in satellite measurements of nitrogen dioxide pollution over China before and after the Lunar New Year. The observed reduction in 2020 was approximately 20 percent larger than the typical holiday-related reduction and was related to changes in human behavior due to the outbreak of COVID-19. Nitrogen dioxide is a measure of economic activity, as nitrogen dioxide is primarily emitted from fossil fuel consumption, and the authors related this nitrogen dioxide reduction not only to the imposition of provincial lockdowns, but also to the reporting of the first of COVID-19 cases in each province that preceded the lockdowns. Both actions were associated with nearly the same magnitude of reductions.

In 2002, the Río Cauto Delta, pictured here in a January 2020 Landsat 8 image, was named a Ramsar site – an internationally recognized wetland of importance. The delta is home to numerous species of mangroves. Image Credit: NASA Earth Observatory/Lauren Dauphin

Denis Macharia leads a group of Tanzanian government officials through vulnerability mapping on issues like water availability and the selection of hotspot communities for adaptation interventions. Photo Credit: Water Resources Integration Development Initiative (WARIDI)/Erneus Kaijage

Below: The shores of a refreezing lake on the surface of Zachariae Isstrom in northeast Greenland. Photo Credit: NASA/Jeremy Harbeck

1.1.9: Demonstrate progress in enhancing understanding of the interacting processes that control the behavior of Earth system, and in utilizing the enhanced knowledge to improve predictive capability.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	Significant progress demonstrated		
Achieved	Demonstrated as planned in 3 areas		

Areas for external review panel determination in FY 2020

1. *Annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.9.*
2. *40% of Earth science applications projects advance one Applications Readiness Level (ARL), with 3 projects advancing to ARL 8 or 9.*
3. *Customer satisfaction rating for the Earth Observing System Data and Information System (EOSDIS) exceeds the most recently available Federal Government average rating of the American Customer Satisfaction Index.*

List of areas contributing to Performance Goal 1.1.9 in FY 2021

1. Annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.9.
2. 40% of Earth science applications projects advance one Applications Readiness Level (ARL), with 3 projects advancing to ARL 8 or 9.
3. Customer satisfaction rating for the Earth Observing System Data and Information System (EOSDIS) exceeds the most recently available Federal Government average rating of the American Customer Satisfaction Index.

List of areas contributing to Performance Goal 1.1.9 in FY 2022

1. Annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.9.
2. 40% of Earth science applications projects advance one Applications Readiness Level (ARL) with 3 projects advance to ARL 8 or 9.
3. Customer satisfaction rating for the Earth Observing System Data and Information System (EOSDIS) exceeds the most recently available Federal Government average rating of the American Customer Satisfaction Index.

The **Earth Science Division**, part of NASA's **Science Mission Directorate**, delivers the technology, expertise, and global observations that help researchers map the connections between Earth's vital processes and the effects of ongoing natural and human-caused changes.

FY 2020 Performance Progress

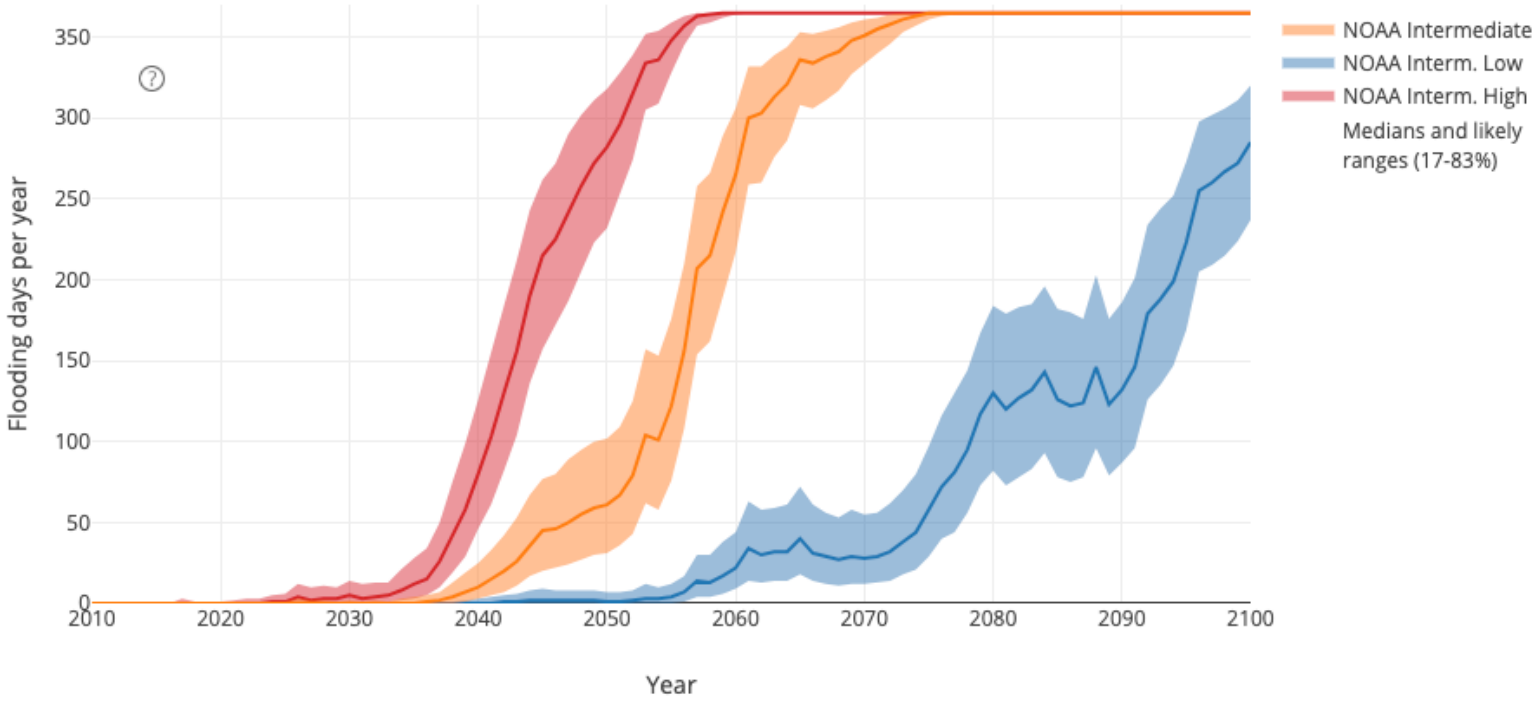
NASA achieved the FY 2020 target for this multi-year performance goal as determined by the assessment of progress performed by the Earth Science Advisory Committee on October 22, 2020. Below are examples of scientific progress reported in FY 2020.

The increase in high-tide flooding has been attributed to both global warming tendencies and sea level rise, as well as inter-annual and decadal climate and ocean fluctuations. Scientists developed a probabilistic projection model, which formed the basis of the NASA Flooding Days Projection Tool ,to allow decision makers to assess how sea level rise and other factors will affect the frequency of high-tide flooding in coming decades on a location-specific basis. The projections are based on an analysis of astronomical tides and other natural fluctuations in tide gauge data in combination with sea level rise projections based on climate models and climate assessments. The tool is designed to be flexible and adapt to the user's needs by allowing for results to be viewed for multiple sea level rise projections across a range of flooding thresholds.

Nitrogen oxide (NO_x) are a family of gases that play a major role in air pollution. They are emitted by vehicle engines and industrial processes. Scientists used Aura Ozone Monitoring Instrument (OMI) observations of nitrogen diox-

ide (NO_2) from a new high-resolution product to show that NO_x lifetime in approximately 30 North American cities has changed between 2005 and 2014. They saw significant changes in NO_x lifetime in North American cities that are of the same order as changes in NO_x emissions over the same time periods. The pattern of these changes suggests that NO_x-limited chemistry dominates North American urban plumes and also demonstrates that the change in NO_x lifetime must be accounted for when relating NO_x emissions and concentrations.

A new study applied machine learning—in particular, a clustering algorithm that filtered through a vast quantity of data—to identify patterns in the ocean that have similar physics. The results show that there are five clusters that compose 93.7 percent of the global ocean, such as those driven by the balance between the wind pressure on the surface of the ocean and the bottom torques. This consistency allowed guiding and testing of the machine learning algorithm using classical ocean physics principles, building a helpful bridge between machine learning and oceanography.



The graph above shows the number of days per year that sea level in Honolulu, HI is projected to exceed 52cm above MHHW. Image Credit: University of Hawaii Sea Level Center

1.1.10: Achieve critical milestones of Science Mission Directorate major projects.

2015	2016	2017	2018	2019	2020
Green	Green	Yellow	Green	Green	Yellow

Number of critical milestones completed.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	10	12	12
Achieved	8		

List of major projects critical milestones FY 2020

1. *Complete Interstellar Mapping and Acceleration Probe (IMAP) Key Decision Point (KDP)-B review.*
2. *Complete the 2016 Medium Explorer (SPHEREx) Announcement of Opportunity Key Decision Point (KDP)-C review.*
3. *Complete the Europa Clipper mission Critical Design Review (CDR).*
4. *Complete the Lucy mission Critical Design Review (CDR).*
5. *Launch the Mars 2020 mission.*
6. *Complete the Psyche mission Critical Design Review (CDR).*
7. *Complete the Double Asteroid Redirection Test (DART) mission Key Decision Point (KDP)-D review.*
8. *Award the second Commercial Lunar Payload Services (CLPS) mission task order.*
9. *Complete the Landsat 9 Key Decision Point (KDP)-D review.*
10. *Complete the Sentinel-6A satellite Flight Acceptance Review.*
11. *Complete the Surface Water and Ocean Topography (SWOT) System Integration Review (SIR).*
12. *Complete the NASA-Indian Space Research Organization (ISRO) Synthetic Aperture Radar (NISAR) System Integration Review (SIR).*

List of major projects critical milestones FY 2021

1. Launch Sentinel-6A.
2. Complete the Landsat 9 Pre-Ship Review (PSR).
3. Initiate Surface Water and Ocean Topography (SWOT) mission Observatory Integration and Testing (I&T).
4. Initiate the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission spacecraft element Integration and Testing (I&T).

NASA's **Science Mission Directorate** conducts scientific exploration that is enabled by observatories in Earth orbit and deep space, spacecraft visiting the Moon and other planetary bodies, and sample return missions.

5. Land the Mars 2020 rover in the Jezero Crater, complete checkout, and begin surface operations.
6. Complete the Mars Sample Return mission Key Decision Point (KDP)-A review.
7. Complete the Double Asteroid Redirection Test (DART) mission Pre-Ship Review (PSR).
8. Complete the Europa Clipper mission Critical Design Review (CDR).
9. Complete the Psyche mission System Integration Review (SIR).
10. Complete the Lucy mission Pre-Environmental Review (PER).
11. Complete one Dragonfly Mobility radar and lidar performance characterization tests.
12. Complete the Interstellar Mapping and Acceleration Probe (IMAP) Preliminary Design Review (PDR).
13. Complete the Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer (SPHEREx) Key Decision Point (KDP)-C review.
14. Complete the two Nancy Grace Roman Space Telescope instrument Critical Design Reviews (CDRs).
15. Complete the Volatiles Investigating Polar Exploration Rover (VIPER) mission Key Decision Point (KDP)-C review.

List of planned major projects critical milestones FY 2022

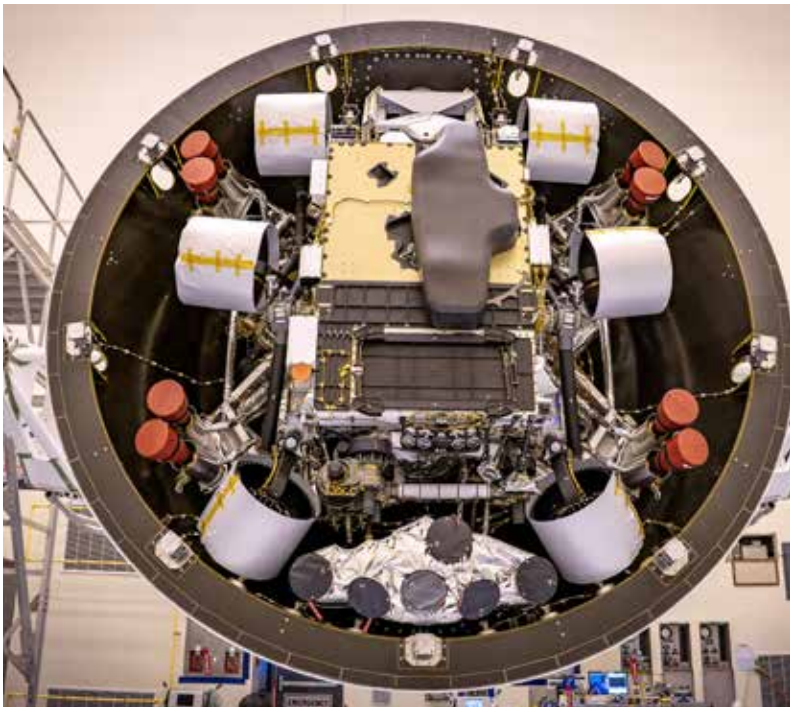
1. Complete Sentinel-6B launch vehicle award.
2. Complete Geospace Dynamics Constellation (GDC) mission instrument selections.
3. Complete the Surface Water and Ocean Topography (SWOT) mission Operational Readiness Review (ORR).
4. Complete the Surface Biology and Geology (SBG) Mission Confirmation Review (MCR).
5. Complete the Mars Sample Return mission Key Decision Point (KDP)-B review.
6. Launch the Double Asteroid Redirection Test (DART) mission.
7. Complete the Europa Clipper mission System Integration Review (SIR).

8. Complete the Psyche mission Pre-Ship Review (PSR).
9. Launch the Lucy mission.
10. Complete one Dragonfly mission instrument Preliminary Design Review (PDR).
11. Complete the Interstellar Mapping and Acceleration Probe (IMAP) Critical Design Review (CDR).
12. Complete the telescope for the Nancy Grace Roman Space Telescope.
13. Complete the Volatiles Investigating Polar Exploration Rover (VIPER) Critical Design Review (CDR).
14. Deliver the NASA-Indian Space Research Organization (ISRO) Synthetic Aperture Radar (NISAR) Radar payload to ISRO.
15. Award Payloads and Research Investigations on the Surface of the Moon (PRISM)-2A Commercial Lunar Payload Services (CLPS) mission task order.

FY 2020 Performance Progress

NASA achieved 8 of the 12 milestones planned for FY 2020. Beginning in April 2020, NASA and its partners limited hands-on work to prioritized projects, following health guidance from the Centers for Disease Control and Prevention, to help protect the workforce from COVID-19 impacts. As a result of the change of operations, some projects did not achieve their milestones. NASA delayed the SPHEREx KDP-C review to the first quarter of FY 2021 due to COVID-19 impacts and the loss of the originally selected telescope vendor. The SIRs for SWOT and NISAR also were delayed until FY 2021 due to COVID-19 impacts. In addition, the Europa Clipper CDR was postponed to December 2020 due to delays in finalization of the launch vehicle selection for the mission and the associated uncertainties in the design of launch vehicle-specific mission elements.

The Lucy CDR was completed in October 2019 and the KDP-B review for IMAP was completed in January 2020. NASA awarded the second CLPS mission task order in April. The Psyche CDR and Landsat-9 KDP-D review were completed in May, and the KDP-D review for the DART mission and the Flight Acceptance Review, now referred to as the Qualification and Acceptance Review, for Sentinal-6 Michael Freilich were in July. Mars 2020 Perseverance launched on July 2020 on its way to the Red Planet. (Watch the launch on YouTube.)



Inside the Payload Hazardous Servicing Facility at NASA's Kennedy Space Center in Florida, the Backshell-Powered Descent Vehicle and Entry Vehicle assemblies were prepared to be attached to the Mars Perseverance rover on May 4, 2020. The cone-shaped backshell contains the parachute, and along with the mission's heat shield, provides protection for the rover and descent stage during Martian atmospheric entry. The Mars Perseverance rover was scheduled to launch in mid-July atop a United Launch Alliance Atlas V 541 rocket from Pad 41 at nearby Cape Canaveral Air Force Station. The rover is part of NASA's Mars Exploration Program, a long-term effort of robotic exploration of the Red Planet. The rover will search for habitable conditions in the ancient past and signs of past microbial life on Mars. The Launch Services Program at Kennedy is responsible for launch management. Photo Credit: NASA/Christian Mangano

Wheels are installed on NASA's Mars Perseverance rover inside Kennedy Space Center's Payload Hazardous Servicing Facility on March 30, 2020. Photo Credit: NASA

1.1.11: Complete shipment of the James Webb Space Telescope in preparation for launch in FY 2022.

2015	2016	2017	2018	2019	2020
Green	Yellow	Yellow	Green	Green	Yellow

Complete development milestones.

	Execution	Planned	
Fiscal Year	FY 2020 Agency Priority Goal	FY 2021	FY 2022
Target	4	4	4
Achieved	3		

List of major projects critical milestones FY 2020

1. *Complete second sunshield membrane deployment and folding.*
2. *Complete deployment #2 of telescope deployable tower assembly.*
3. *Complete observatory pre-environmental test review.*
4. *Complete observatory vibration and acoustics testing.*

List of major projects critical milestones FY 2021

1. Initiate observatory post-environment testing deployments.
2. Complete final comprehensive system test.
3. Complete sunshield folding in preparation for final stow for shipment.
4. Complete shipment of observatory to launch site.

List of development milestones for FY 2022

1. Launch observatory.
2. Complete main observatory deployments.
3. Complete commissioning.
4. Initiate prime mission science program.

FY 2020 Performance Progress

NASA achieved three of the four FY 2020 milestones focused on testing Webb prior to its launch.

NASA completed the deployment and re-folding of the second sunshield on January 2, 2020. In parallel, preparations continued for the replacement of the spacecraft Traveling Wave Tube Amplifier (TWTA), the command and telemetry processor (CTP), and for the observatory environmental testing.

The **James Webb Space Telescope**, a program under the **Science Mission Directorate,** will be the premier observatory of the next decade. The large infrared telescope is an international collaboration between NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA).

COVID-19 impacted the Northrop Grumman work schedule, causing delays to observatory testing in March 2020. The work schedule was limited to one shift per day for integration and test (I&T) touch labor and one shift for planning and documentation. Several key observatory tests, including a second test deployment of the telescope deployable tower assembly, were delayed. In June 2020, the work schedule returned to two full shifts and the team was able to complete key milestones. NASA then completed the observatory environmental testing, consisting of acoustics and sine-vibration testing on October 2, 2020.

NASA planned to assess the program's progress in April 2020 as Webb schedule margins grew tighter in fall 2019. However, NASA postponed the April assessment due to the COVID-19 pandemic. Based on a risk assessment completed in July, NASA determined that—due to facility closures, reduced shifts to protect the workforce, and the ongoing impacts of COVID-19—a launch during the second quarter in FY 2021 was no longer feasible and moved the launch readiness date to the first quarter in FY 2022, with no requirement for additional funds. (Read NASA's July 16, 2020, announcement.) NASA has revised the goal statement and the FY 2021 milestones to reflect this new launch readiness date. On-orbit checkout and observatory commissioning, part of the original goal statement, will take place in FY 2022.

For more information about NASA's progress toward achieving this agency priority goal is available at the Trump Archive on Performance.gov.

Strategic Objective 1.2: Understand the responses of physical and biological systems to spaceflight.

LEAD OFFICE
Human Exploration and Operations Mission Directorate (HEOMD) with support from the Science Mission Directorate (SMD)

GOAL LEADER
Karen Flynn, Deputy Associate Administrator for Management, SMD

The International Space Station (ISS), a laboratory in low Earth orbit where crew members have lived and worked for almost 20 continuous years. The ISS is a platform for allows for research on the role of gravity in physical and biological systems, Earth and space observation, and technology development. As a research and technology development facility, the ISS provides the capability for human-tended, long-duration space-based research, which is critical to the research and development of technologies supporting Artemis and future deep space exploration. ISS research also supports investigations in human physiology and biotechnology. As NASA's only current long-duration, crewed orbital testbed, the ISS is used by researchers to study the effects of long-duration exposure to the space environment on the crew and devise and test countermeasures to offset health risks. NASA's strategy for prioritizing and enabling fundamental physical and biological systems research is guided by several studies released by the National Academies over the past two decades, including the 2011 Decadal survey.

In spring 2020, NASA determined that it was showing satisfactory progress in its efforts to achieve this strategic objective. In the near term, NASA has funded and is performing research studies that address the known risks as defined by the current human exploration plan. The Agency has well established outreach to industry, academia, and international agencies and

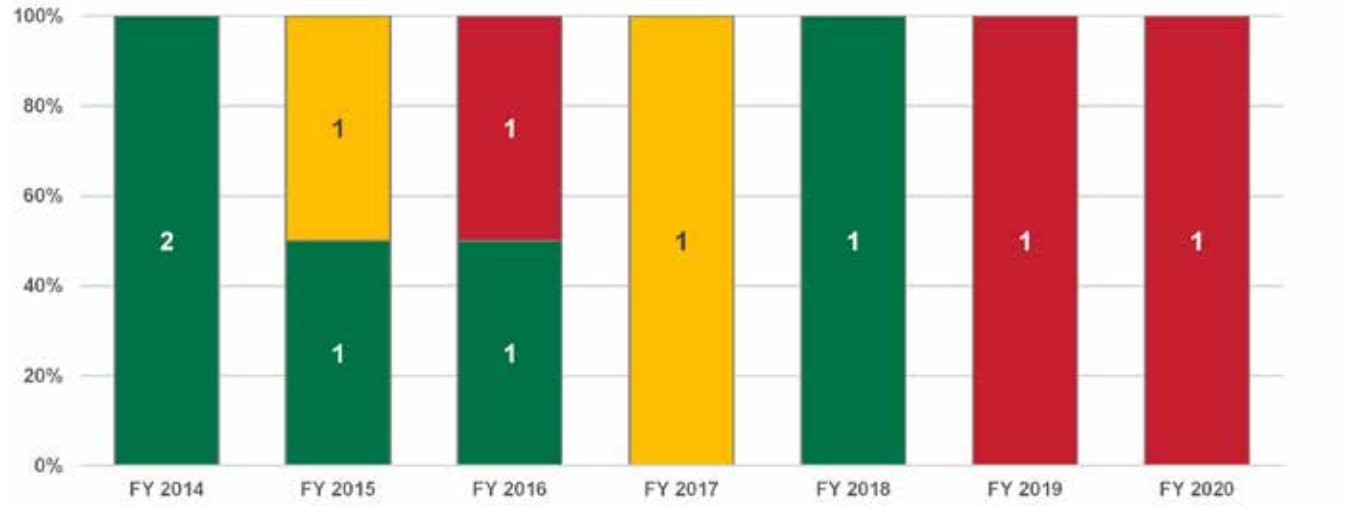
Above: A prototype of Organic Processor Assembly (OPA) – technology capable of treating mixed organic wastes – arrives at the Neil Armstrong Operations and Checkout Building at NASA's Kennedy Space Center in Florida on August 19, 2020. At the heart of the OPA is an anaerobic membrane bioreactor, a hybrid technology that couples anaerobic digestion with membrane filtration. Photo Credit: NASA/Cory Huston

will continue to leverage these partnerships to advance physical and biological studies. This fiscal year, NASA will establish nearly a dozen broad-based partnerships with other U.S. government agencies, private industry, and international partners to advance scientific research. NASA continues to develop the parameters of the next Decadal study on physical and life sciences; the outcome of the Decadal report will inform future research priorities.

NASA's future strategy for this objective will include commercialization of low Earth orbit and new Space Act Agreements for testing the marketplace for commercially viable low Earth orbital platforms to advance human subject, biological, and physical science research beyond the ISS program. NASA's plans for human exploration beyond low Earth orbit include investigating biological responses of living organisms (yeast) to the increased radiation environment of deep space with the BioSentinel cubesat launch on Artemis 1. Once established, the cislunar Gateway will provide a deep space platform to complement ground-based and ISS research.

Strategic Objective 1.2 activities have been impacted due to the COVID-19 pandemic, including delays in development of hardware scheduled to launch to ISS, with associated cost impacts. Extensions of grant funding to the research community will be required to accommodate the delays in the execution of the investigations on ISS.

Summary of Progress for Performance Goals Contributing to Strategic Objective 1.2, FY 2014—2020



Note: FY 2018—FY 2020 contribute to Strategic Objective 1.2, as established by the NASA 2018 Strategic Plan. For FY 2014 through FY 2017, individual performance goals were assigned to a strategic objective based on contributing work.

1.2.1 [Ends in FY 2021]: Advance scientific research with the potential to understand the responses of physical and biological systems to spaceflight.

2015	2016	2017	2018	2019	2020
Yellow	Red	Yellow	Green	Red	Red

Number of peer reviewed published studies.

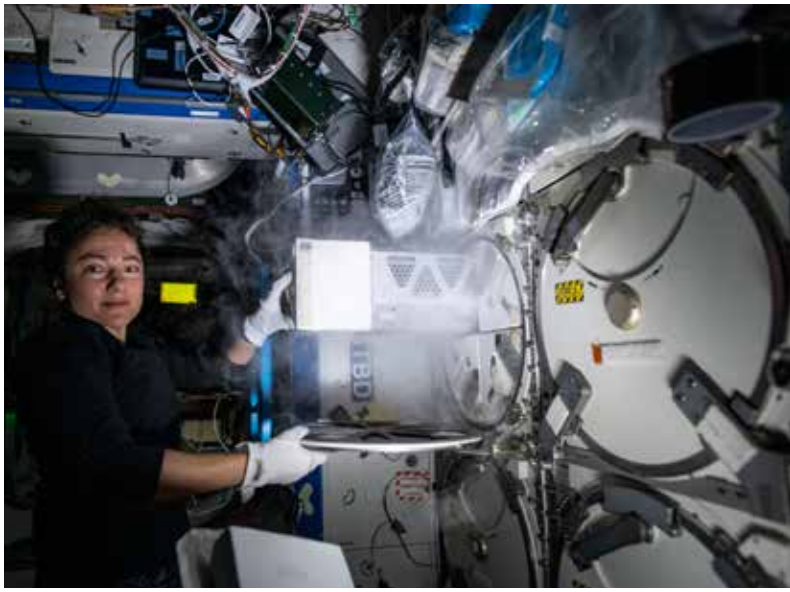
	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	500	360	Discontinued
Achieved	360		

*NASA is developing a new strategic plan and anticipates replacing this objective.

The **Division of Biological and Physical Sciences**, part of the **Science Mission Directorate**, administers the Space Biology Program and Physical Sciences Program. The **Human Research Program**, part of the **Human Exploration and Operations Mission Directorate**, studies the best methods and technologies to support safe, productive human space travel.

FY 2020 Performance Progress

During FY 2020, significantly fewer than anticipated studies by NASA-supported investigators were published or accepted for publication in peer-reviewed journals. The pace of research slowed starting in April as facilities closed and institutions shifted to remote operations to protect staff during the COVID-19 pandemic. Research dependent on laboratory access was stopped or delayed. As a result, investigators submitted fewer studies to peer-reviewed journals.



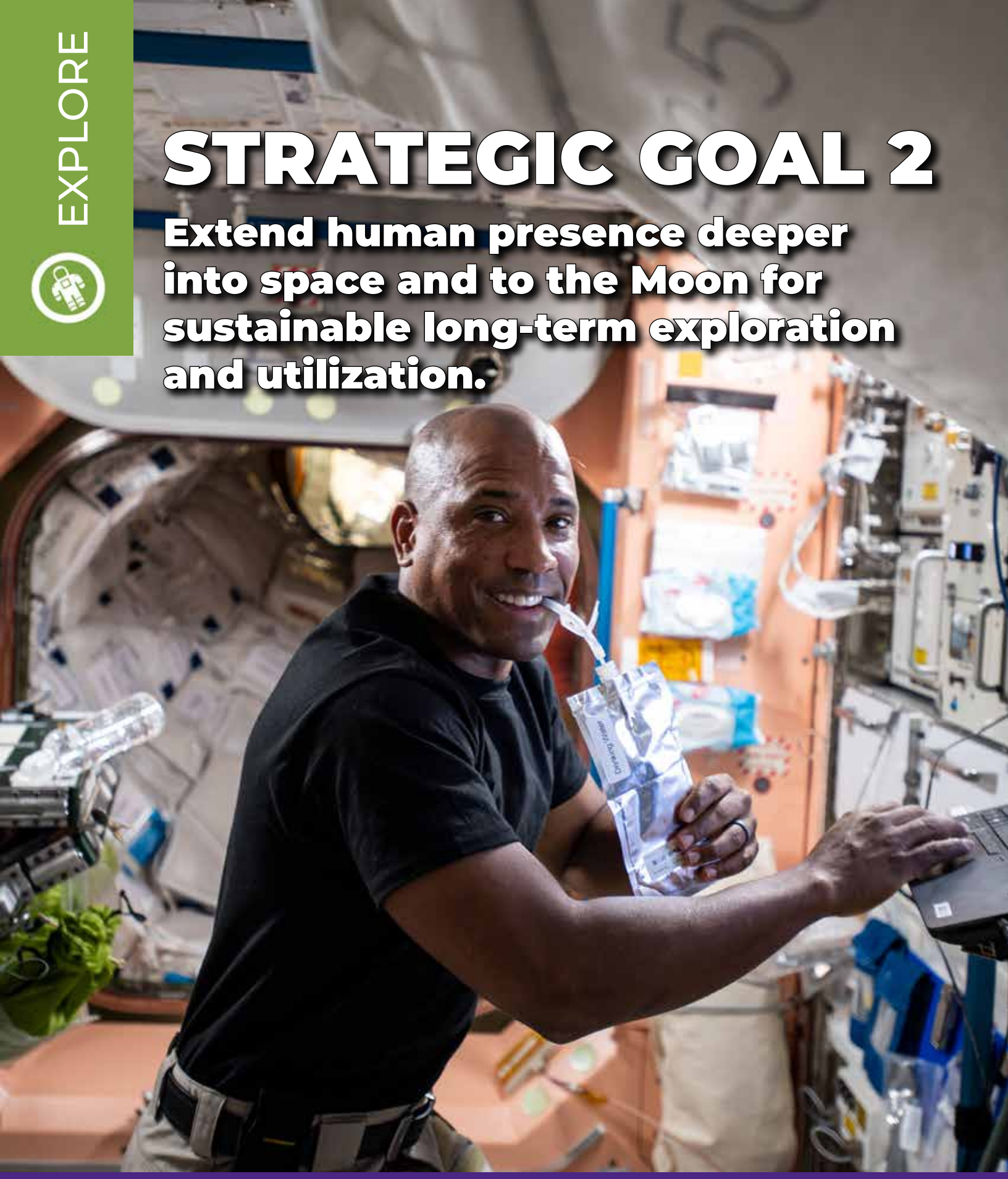
NASA astronaut and Expedition 62 Flight Engineer Jessica Meir gathers frozen research samples stowed in an International Space Station science freezer for loading inside the SpaceX Dragon resupply ship and return to Earth for scientific analysis. Photo Credit: NASA

NASA astronaut Shane Kimbrough sets up hardware for the SUBSA physics investigation that examines the mechanisms behind solidification of brazing alloys in microgravity inside the Microgravity Science Glovebox. Photo Credit: NASA

EXPLORE

STRATEGIC GOAL 2

Extend human presence deeper into space and to the Moon for sustainable long-term exploration and utilization.



SpaceX Crew-1 Pilot and Expedition 64 Flight Engineer Victor Glover of NASA sips on a water bag while familiarizing himself with systems and procedures during his first week aboard the International Space Station International Space Station (ISS). NASA is using the ISS to demonstrate technologies and capabilities for long-term exploration of the Moon and other destinations. Photo Credit: NASA

Strategic Objective 2.1: Lay the foundation for America to maintain a constant human presence in low Earth orbit enabled by a commercial market.

LEAD OFFICE
Human Exploration and Operations Mission Directorate (HEOMD)

GOAL LEADER
Altonell (Toni) Mumford, Deputy Associate Administrator for Management, HEOMD

NASA is enabling the development of a space-based low Earth orbit economy by establishing the infrastructure necessary for a transition from operations aboard the International Space Station (ISS) to one or more future commercial platforms, while continuing to leverage ISS for research and technology development. NASA is maximizing ISS utilization and throughput, using diverse commercial acquisition strategies, and offering customers research capacity in both space and Earth-similar laboratories. NASA is also working to develop a healthy commercial supplier base for low Earth orbit activities and looking for ways to eliminate barriers to commercialization. All aspects of crew health are holistically managed, including implementation of a comprehensive health care program for astronauts, and the prevention and mitigation of negative, long-term health consequences of space flight.

In spring 2020, NASA determined that there was satisfactory progress for this strategic objective. NASA's strategy for this objective is to implement an ISS commercial use and pricing policy; quantify NASA's long-term needs for activities in low Earth orbit; encourage and accommodate private astronaut missions to the ISS; partner with industry to both begin developing commercial low Earth orbit destinations and leverage ISS capabilities; and stimulate the growth of sustainable demand for products and services in the low Earth orbit economy.

Above: The Canadarm2 with the Dextre robotic hand attached, seemingly protrudes from the side of the International Space Station as the orbiting complex soared 263 miles above the South Pacific Ocean. Photo Credit: NASA

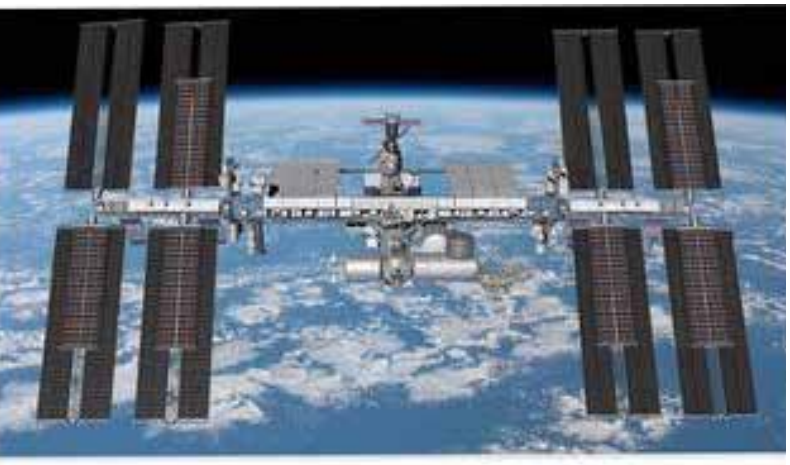
NASA will also continue providing cargo and crew transportation capabilities that support ISS operations and the establishment of a commercial low Earth orbit economy. In FY 2020, NASA completed activities against each of these strategy elements.

In support of NASA's strategy to open the ISS for commercial use, NASA selected a commercial partner to provide at least one habitable commercial module. The module will attach to the ISS and will demonstrate the beginning of the ability to provide products and services that are purchased by NASA and other customers. NASA is providing seed money to eight proposals with the potential to stimulate sustainable demand for low Earth orbit products and services and has allocated five percent of NASA's ISS resources for commercial use.

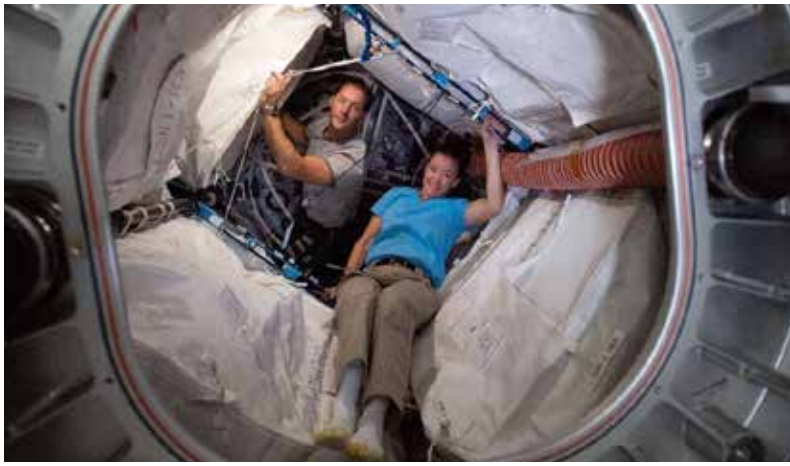
There have been impacts to Strategic Objective 2.1 due to the COVID-19 pandemic. While NASA's response to COVID-19 restricted access to some NASA and contractor facilities, mission specific work continued to be performed in support of the successful SpaceX Demo-2 launch, mission operations, and safe return of the crew. (Watch highlights of Demo-2 on YouTube.)

Summary of Progress for Performance Goals Contributing to Strategic Objective 2.1, FY 2014—2020

Note: FY 2018—FY 2020 contribute to Strategic Objective 2.1, as established by the NASA 2018 Strategic Plan. For FY 2014 through FY 2017, individual performance goals were assigned to a strategic objective based on contributing work.



This image shows the planned configuration of six iROSA solar arrays intended to augment power on the International Space Station. The roll-up arrays arrive on the SpaceX-22 resupply mission. Image Credit: NASA/Johnson Space Center/Boeing



Expedition 65 Flight Engineers, Thomas Pesquet from ESA, and Megan McArthur from NASA, are pictured inside BEAM, the Bigelow Expandable Activity Module. Photo Credit: NASA

2.1.1: Initiate technology demonstrations on the International Space Station to advance deep space exploration.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Yellow	Green

Number of research and technology demonstrations conducted.

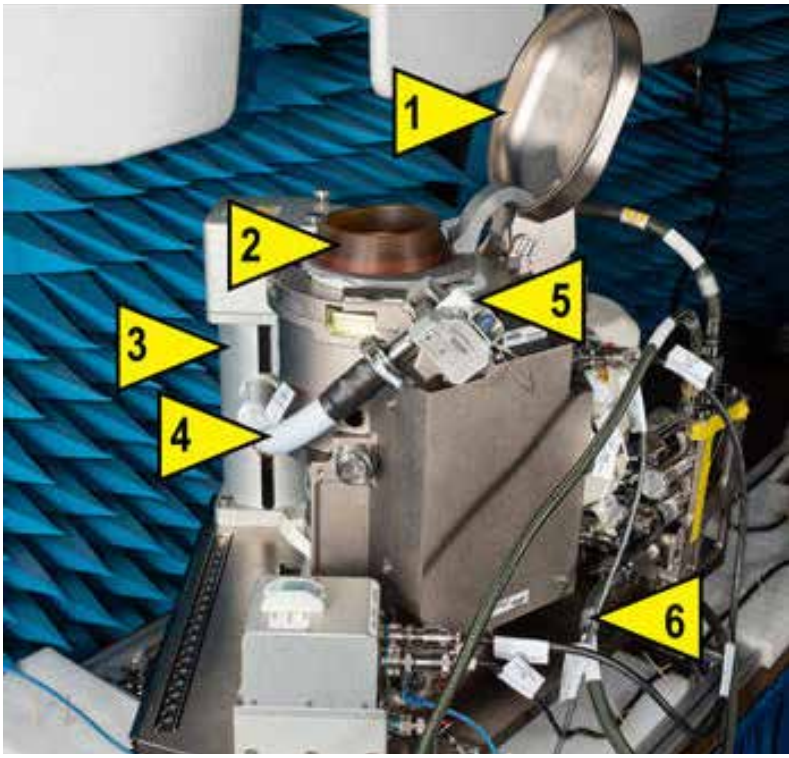
	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	5	5	5
Achieved	5		

The **International Space Station (ISS) Program**, part of NASA's **Human Exploration and Operations Mission Directorate**, plans, develops, and manages the capabilities that support the expanding commercial use of the ISS.

FY 2020 Performance Progress

NASA met the FY 2020 target by demonstrating five technologies aboard the ISS:

- Spacecraft Fire Safety IV (Saffire IV) studied how fires spread in space
- Charcoal HEPA Integrated Particle Scrubber (CHIPS) filters tested to scrub the air in Node 3
- Urine Transfer System, which is part of a new toilet system, helps automate waste management and storage
- BioMole Facility tested a possible replacement for current microbial monitory systems
- Water Processor Assembly (WPA)—part of the Environmental Control and Life Support System—Multi-Filter (MF) single bed operation



Universal Waste Management System (UWMS), NASA's new space toilet. 1. Lid, 2. Seat, 3. Urine pretreat tank, 4. Urine hose, 5. Urine funnel attaches here (funnel not shown), 6. Urine Transfer System (UTS) attaches here. Photo Credit: NASA

2.1.2: Enable a robust commercial low Earth orbit economy in which transportation, habitation, and on-orbit services are available for purchase by NASA and other customers.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Red

Number of milestones met.

	Execution	Planned	
Fiscal Year	FY 2020 **Agency Priority Goal**	FY 2021	FY 2022
Target	4	4	4
Achieved	2		

List of development milestones for FY 2020

1. *Make awards for the port solicitation – NextStep 2 Broad Agency Announcement (Appendix I).*
2. *Make awards for the free-flyer solicitation – NextStep 2 Broad Agency Announcement (Appendix K).*
3. *Initiate astronaut training for initial private astronaut mission under a reimbursable space act agreement.*
4. *Both commercial crew industry partners complete demonstration missions.*

List of development milestones for FY 2021

1. Update and release the commercial pricing policy.
2. Release the Request for Proposal (RFP) for Commercial LEO Destinations Phase 1.
3. Finalize mission order for the first private astronaut mission to the International Space Station (ISS).

List of development milestones for FY 2022

1. Complete required partnership agreements with other government agencies for commercial activities.
2. Initialize the free-flyer project milestones.
3. Successfully complete the second provider commercial test flight launch.
4. Commercial LEO Development program milestone TBD.

FY 2020 Performance Progress

NASA completed two of the four FY 2020 milestones for this agency priority goal.

In January 2020, NASA awarded a contract through the Next Space Technologies for Exploration Partnerships (NextSTEP)-2 Broad Agency Announcement (Appendix I) to Axiom Space to provide at least one habitable commercial module to be attached to the ISS. The module will be attached to the ISS's Node 2 forward port to demonstrate its ability to provide products and services as NASA transitions the ISS to commercial and marketing opportunities.

The International Space Station (ISS), **Commercial Crew**, and **Low Earth Orbit Commercialization**, programs under Human Exploration and Operations Mission Directorate, are committed to continuing the sustained human presence in low Earth orbit by through a robust low Earth orbit economy.

During the second quarter of FY 2020, NASA selected eight awards to stimulate demand under the ISS Utilization NASA Research Announcement and NextSTEP-2 Appendix J. The awards are designed to help the selected companies raise the technological readiness level of their products and move them to market, enabling U.S. industry to develop sustainable, scalable, and profitable non-NASA demand for services and products in low Earth orbit. The awards for the free-flyer solicitation (NextSTEP-2 Appendix K), the third milestone for this agency priority goal, has been delayed until FY 2021.

NASA signed a reimbursable Space Act Agreement with a commercial company that will provide astronaut training for private astronaut missions.

In May 2020, the SpaceX Crew Dragon Endeavor spacecraft successfully delivered astronauts Doug Hurley and Bob Behnken to the ISS. In August, the spacecraft carrying the two astronauts safely splashed down into the Gulf of Mexico. (Watch highlights of Demo-2 on YouTube.) While SpaceX successfully completed their commercial crewed demonstration flight to the ISS, Boeing did not complete a crewed demonstration of their CST-100 Starliner spacecraft. During an uncrewed orbital test flight conducted in December 2019, the spacecraft experienced some anomalies, including intermittent space-to-ground communication issues. A joint NASA-Boeing independent

review team recommended corrective and preventive actions to address in preparation for a second uncrewed orbital flight test, which will occur in the first half of FY 2021. Boeing plans to conduct a crewed orbital flight test in summer 2021. More information about NASA's progress toward achieving this agency priority goal is available in the Trump Archive on Performance.gov.

A United Launch Alliance Atlas V rocket, topped by the Boeing CST-100 Starliner spacecraft, stand on Space Launch Complex 41 at Florida's Cape Canaveral Air Force Station on December 4, 2019. The vehicle was placed on the launch pad for Boeing's wet dress rehearsal ahead of the Orbital Flight Test, an uncrewed mission to the International Space Station for NASA's Commercial Crew Program. Photo Credit: Boeing

The SpaceX Crew Dragon spacecraft is seen aboard SpaceX's GO Navigator recovery ship shortly after splashing down in the Gulf of Mexico off the coast of Pensacola, Florida, on August 2, 2020. NASA astronauts, Robert Behnken and Douglas Hurley, spent 62 days aboard the International Space Station for NASA's SpaceX Demo-2 mission, becoming the first astronauts to launch to the orbiting laboratory from U.S. soil since the end of the shuttle program in 2011. The final flight test for SpaceX, Demo-2 will pave the way for the Agency to certify the company's transportation system for regular, crewed flights to the orbiting laboratory. Photo Credit: NASA/Mike Downs

Strategic Objective 2.2: Conduct human exploration in deep space, including to the surface of the Moon.

LEAD OFFICE
Human Exploration and Operations Mission Directorate (HEOMD)

GOAL LEADER
Altonell (Toni) Mumford, Deputy Associate Administrator for Management, HEOMD

NASA's Artemis program has a goal to return American astronauts to the Moon. NASA will use innovative technologies to explore larger areas of the Moon and for longer durations than ever before. Artemis is a collaborative effort with commercial and international partners to establish a sustainable lunar exploration capability for long-term exploration of the Moon, followed by human missions to other destinations.

NASA is designing mission capabilities that will support this objective in deep space and enable increasingly complex missions to build knowledge and gain a lasting foothold onto Earth's nearest celestial body. Current planned capabilities in this architecture include exploration ground systems, a launch system for crew transportation, a deep-space human-rated crew module, a lunar gateway around the Moon, lunar landers, surface mobility systems and a new generation of spacesuits, and U.S. commercial launch vehicles for cargo transportation and to deploy other capabilities in the architecture. NASA will leverage these technical, operational, and human physiology lessons learned on and around the Moon to prepare for the next giant leap.

In spring 2020, NASA's Strategic Review determined that, overall, this was a focus area for improvement. NASA has made signif-

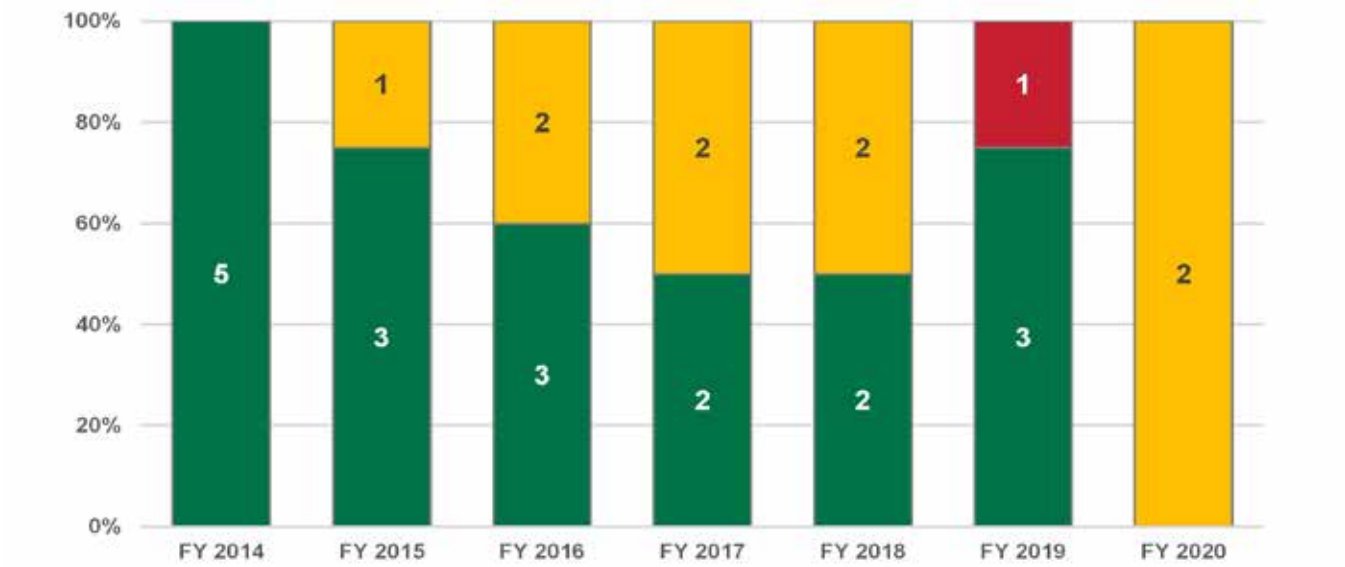
Above: At NASA's Michoud Assembly Facility in New Orleans on January 19, 2021, technicians weld together three cone-shaped panels on Orion's crew module for the Artemis III mission that will use innovative technologies to explore larger areas of the Moon and for longer durations than ever before. The crew module's primary structure, the pressure vessel, is comprised of seven machined aluminum alloy pieces that are welded together through a weld process that produces a strong, airtight habitable space for astronauts during the mission. The pressure vessel is designed to withstand the harsh and demanding environment of deep space, and is the core structure upon which all the other elements of Orion's crew module are integrated. Photo Credit: NASA

icant progress in developing future lunar and deep space systems; however, the programs developing the Space Launch System (SLS), Orion, and Exploration Ground Systems (EGS) have experienced challenges with cost and schedule. NASA continues to make progress on Artemis and to execute the required design, development, and testing of technologies and systems necessary for deep space activities. NASA has also made progress on the Artemis programs required to support a human lunar landing and lunar surface operations for long-term exploration and utilization necessary to enable future human missions to Mars. The design and development of the Gateway architecture has progressed via the completion of several element design reviews and the Human Landing System (HLS) procurement milestones have been completed as scheduled.

The Artemis I crew and service module continued final assembly, integration, and test operations at Kennedy Space Center, where the EGS utilized technology/new approaches to enable Launch Control Center firing room testing to accomplish critical work utilizing appropriate COVID-19 protocols. The HLS Program completed execution of 11 NextSTEP-2 contracts with industry. These contracts were designed to inform HLS lunar lander requirements, mature lander designs, and develop component prototypes focused on functions such as cryogenic fluid management, precision landing, and using technologies. In May 2020, NASA awarded 10-month base period firm-fixed price contracts to three companies. The HLS Program worked with the three companies to finalize requirements and standards for design, construction, and safety for the proposed human lander systems. NASA will review each of the HLS partners designs through the end of 2021 as the next step toward refining the human landing system returning Americans to the lunar surface.

There have been impacts to Strategic Objective 2.2 due to the COVID-19 pandemic. Development activities with hardware at the Kennedy Space Center and Michoud Assembly Facility continued, with appropriate COVID-19 protocols in place. The delay of the Core Stage Green Run Hot Fire Test until early 2021, is later than anticipated principally due to COVID-19 stand-down and subsequent work constraints, schedule impacts due to historical severe weather in the areas (six hurricanes), and technical issues.

Summary of Progress for Performance Goals Contributing to Strategic Objective 2.2, FY 2014—2020



Note: FY 2018—FY 2020 contribute to Strategic Objective 2.2, as established by the NASA 2018 Strategic Plan. For FY 2014 through FY 2017, individual performance goals were assigned to a strategic objective based on contributing work.

2.2.1: Advance America's goal to land the first woman and the next man on the Moon by demonstrating the necessary capabilities that advance lunar exploration.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Yellow	Red	Yellow

Number of critical milestones met.

	Execution	Planned	
Fiscal Year	FY 2020 **Agency Priority Goal**	FY 2021	FY 2022
Target	4	4	3
Achieved	3		

Development milestones for FY 2020

1. *Ship the Artemis I Orion spacecraft to Plum Brook Station for testing.*
2. *Integrated Human Landing System contract Awards. (NextSTEP-2, Appendix H)*
3. *Award Gateway Logistics Contract.*
4. *Perform Green Run Hot Fire Test.*

Development milestones for FY 2021

1. Complete Artemis I booster segment installations on the Mobile Launcher.
2. Complete the Space Launch System (SLS) Core Stage Green Run hot fire testing.
3. Complete SLS Core Stage mate at the Kennedy Space Center.
4. Award the Human Launch System (HLS) Option A.

List of development milestones for FY 2022

1. Launch Artemis I.
2. Complete the Artemis II interim Cryogenic Propulsion Stage.
3. Complete the Artemis II Module/Service Module mate.

FY 2020 Performance Progress

NASA had schedule delays during FY 2019 that resulted in it not achieving this agency priority goal. The green run hot-fire test for the SLS's core stage is now planned to be completed during the first quarter of FY 2021. First-time assembly challenges in constructing the engine section delayed completion of the core stage and shipment to NASA's Stennis Space Center, where the test will be conducted.

Artemis is led by the **Human Exploration and Operations Mission Directorate** and includes programs under Explorations Systems Development (see **HEO Programs**) and Advanced Exploration Systems. It is supported by the **Science Mission Directorate** and the **Space Technology Mission Directorate**.

On July 2, NASA successfully completed the Ascent Abort-2 test. The Launch Abort System's three motors fired, propelling a test version of Orion away from a booster. The abort system is designed to pull the crew vehicle away from a speeding launch vehicle in the unlikely event of an emergency during ascent. (Watch a video of the test taken from mid-air.)

NASA was delayed in rolling the mobile launcher from Launch Complex 39 to the Vehicle Assembly Building (VAB). Throughout the fiscal year, NASA conducted verification and validation testing on the Mobile Launcher, and in June 2019, the mobile launcher took the 10-hour trip from the VAB to Launch Complex 39 for additional verification and validation. This testing took longer than expected, and in August, NASA had to move the Mobile Launcher back to the Vehicle Assembly Building (before testing was complete) to protect it from hurricane Dorian. As a result of these schedule impacts, NASA will not complete testing until the first quarter of FY 2020.

More information about NASA's progress toward achieving this agency priority goal is available at the Trump Archive on Performance.gov.

The first solid rocket booster test for SLS missions beyond Artemis III is seen here during a two-minute hot fire test on September 2, 2020, at the T-97 Northrop Grumman test facility in Promontory, Utah. Photo credit: NASA/Northrop Grumman/Scott Mohrman

2.2.2 [Ends in FY 2021]: Commence lunar surface technology demonstrations to enable a sustainable lunar surface exploration strategy.

2015	2016	2017	2018	2019	2020
None before FY 2019					Yellow

Number of critical milestones met.

	Execution	Planned	
Fiscal Year	FY 2020 **Agency Priority Goal**	FY 2021	FY 2022
Target	4	2	PG Discontinued*
Achieved	3		

*NASA is developing a new strategic plan and anticipates replacing this objective.

List of development milestones for FY 2020

1. *Plan strategy for APG coordinated with the President's Budget Release.*
2. *Complete onramp of additional CLPS providers to enhance lunar delivery capability.*
3. *Complete Autonomous Mobility Field Test.*
4. *Conduct Exploration Extravehicular Mobility Unit (xEMU) Systems Requirements Review.*

List of development milestones for FY 2021

1. Complete Precision Landing suborbital demonstration.
2. Prepare hardware for flight demonstration for lunar polar water mining technology.

This agency priority goal is jointly led by the **Space Technology Mission Directorate (STMD)** and the **Science Mission Directorate (SMD)**, with support from the **Human Exploration and Operations Mission Directorate (HEOMD)**.

FY 2020 Performance Progress

NASA fell short of achieving the FY 2020 target for this two-year agency priority goal, completing three of the four milestones due to the impacts of the COVID-19 pandemic.

In November 2019, NASA added five companies to the Commercial Lunar Payload Services (CLPS) contract to perform commercial deliveries of payloads to the surface of the Moon, bringing the total number of companies on the CLPS contract to 14. All 14 companies are now eligible to compete on future task orders for the delivery of payloads to the lunar surface. This on-ramp to CLPS not only expanded the competitive pool, but also enhanced the landing performance capabilities.

In December, the NASA Executive Council approved the Agency's strategy for meeting this agency priority goal, in coordination with the President's Budget Release. The approval included NASA's approach to managing and coordinating across three mission directorates—the Space Technology Mission Directorate, Science Mission Directorate, and Human Exploration and Operations Mission Directorate—and three strategic elements: gradual capability buildup, scientific exploration, and commercial partnerships.

On December 19-20, NASA also conducted the Systems Requirements Review (SRR) for the xEMU, a next-generation spacesuit to support the Artemis program.

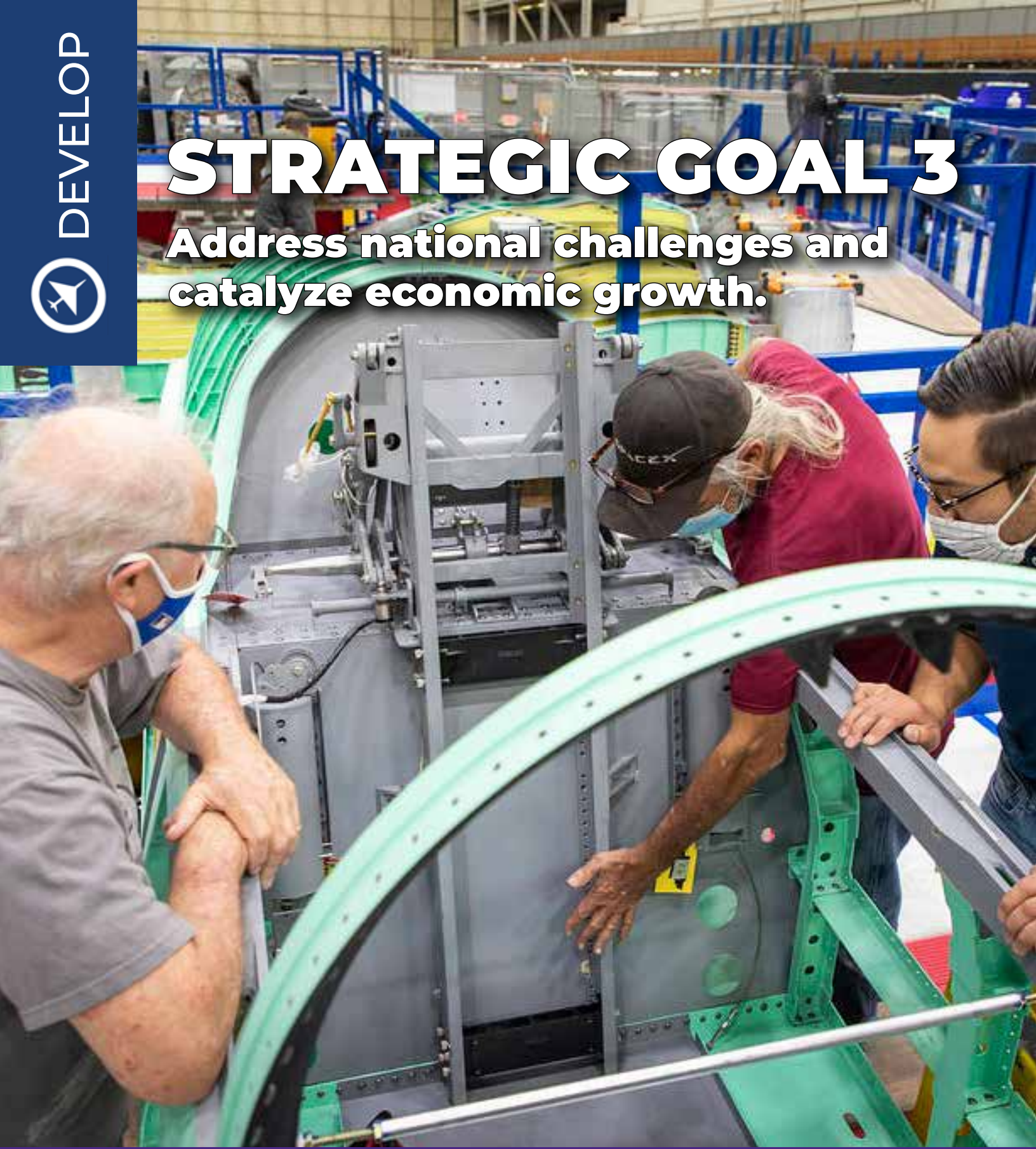
NASA did not complete the autonomous mobility field tests of the Autonomous Pop-Up Flat Folding Explorer Robot (A-PUFFER) during FY 2020. The A-PUFFER team conducted the first set of field tests during the second quarter of the fiscal year. Additional testing was scheduled for May 2020, but was delayed due to the pandemic-related closure of the Jet Propulsion Laboratory (JPL), in Pasadena, California. When JPL began partial reopening, the team submitted a request to conduct additional testing in July, with an operations safety plan describing how the testing could be conducted outside while maintaining social distance. The team remained on a waiting list; however, additional COVID restrictions were put in place at JPL which further delayed the final A-PUFFER demo. The project has been granted a no-cost extension and hopes to have the final demo completed by early next year.

More information about NASA's progress toward achieving this agency priority goal is available at the Trump Archive on Performance.gov.

DEVELOP

STRATEGIC GOAL 3

Address national challenges and catalyze economic growth.



Technicians at Lockheed Martin's Skunk Works factory in Palmdale, California, examine the cockpit section of NASA's X-59 Quiet SuperSonic Technology research airplane. In this view the camera is looking toward the rear of the aircraft. The yellow-green metal are the wing's internal structural ribs, while the gray metal in the foreground marks the cockpit's interior. An ejection seat from a retired NASA T-38 training jet will eventually be installed in the cockpit along with the airplane's avionics. Lockheed Martin is assembling the experimental aircraft for NASA in anticipation of its first flight some time in mid-2022. Designed to produce quiet sonic "thumps" when flying supersonic, the X-59 will be flown over select communities to measure public perception of the sound. Results will be given to regulators to use in determining new rules that could allow commercial faster-than-sound air travel over land. Photo Credit: Lockheed Martin

Strategic Objective 3.1: Develop and transfer revolutionary technologies to enable exploration capabilities for NASA and the Nation.

LEAD OFFICE
Space Technology Mission Directorate (STMD)

GOAL LEADER
Mike Green, Deputy Associate Administrator for Management, STMD

Technology drives exploration to the Moon, Mars and beyond. As NASA embarks on its next era of exploration, the Agency is advancing technologies and testing new capabilities at the Moon that will be critical for crewed missions to Mars. Investments in revolutionary, American-made space technologies also provide solutions on Earth. NASA makes its space tech available to commercial companies to generate real world benefits. NASA's success strategy for this strategic objective includes partnership, engaging and inspiring thousands of entrepreneurs, researchers and innovators. The Agency fosters a community of America's best and brightest working on the Nation's toughest challenges and closing technology gaps in multiple mission architectures. Additionally, NASA's strategy for this strategic objective, with guidance from external groups, includes a merit-based competition model with a portfolio approach spanning a range of discipline areas and technology readiness levels.

NASA's 2020 Strategic Review resulted in a continued rating of satisfactory performance. NASA continued to develop and transfer technologies, with a greater focus on supporting lunar landing goals. These technology investments continue to serve as a catalyst for the new technology required for the varied mission architecture needs of multiple stakeholders. NASA remains focused on building partnerships to identify and close technol-

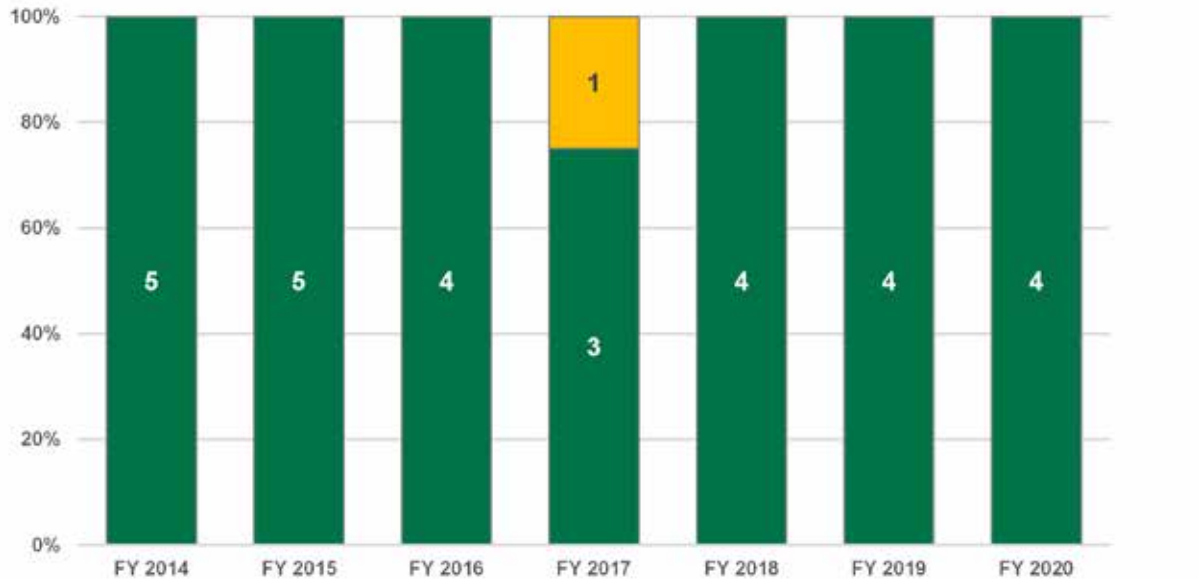
Above: The 109th CubeSat (small satellite) selected through NASA's CubeSat Launch Initiative deployed July 13, 2020. The Technology Education Satellite 10 (TechEdSat-10) deployed from the International Space Station via the commercially developed Nanoracks CubeSat Deployer. TechEdSat-10 (pictured above) is a 6U CubeSat that flew as a payload aboard Northrop Grumman's 13th (NG-13) Commercial Resupply Mission, which launched February, 15, 2020. This small satellite mission will test radio communication ('Lunar' and 'Mars' radios, wireless sensor technologies and internal Wi-Fi), precision deorbit technologies, radiation-tolerant electronics, and hardware for future artificial intelligence space experiments. It has seven transmitters, eight microprocessors, and the largest capacity power system of all similarly sized NASA CubeSats. Photo Credit: NASA

ogy gaps in multiple mission architectures as well as to establish public-private partnerships with the U.S. aerospace industry to leverage private investment. NASA continues to invest in a portfolio approach to space technology, spanning a range of discipline areas and technology readiness levels. Specific examples of recent accomplishments under this strategic objective include three on-orbit technology demonstrations (i.e., Deep Space Atomic Clock (DSAC), Green Propellant Infusion Mission (GPIM), and Robotic Refueling Mission 3 (RRM3)); four more technology demonstrations successfully launched on the Mars 2020 mission (i.e., Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE), Terrain Relative Navigation (TRN), Mars Entry, Descent, and Landing Instrumentation 2 (MEDLI2) and Mars Environmental Dynamics Analyzer (MEDA)); 14 Tipping Point partnerships for Moon and Mars technologies, with more planned; and ongoing development of lunar surface capabilities, including tests of Autonomous Pop-Up Flat Folding Explorer Robot (A-PUFFER).

While Strategic Objective 3.1 has a clear strategy for success, there have been impacts due to the COVID-19 pandemic. Some technology maturation and demonstration projects are experiencing cost and schedule impacts due to facility closures, supply chain disruptions, and testing delays. Some early stage projects, as well as commercial sector partnerships, have experienced disruptions due to the inability to access research facilities. Also, NASA's small business partners find it increasingly difficult to secure matching funds, further adding strains and impacts to the small business community. Additional delays could impact projects' abilities to secure partnerships with industry and academia, as well as partnerships for the Oxygen Generation Assembly (OGA), thereby further eroding schedule and deliveries.

While some of NASA's projects are experiencing cost, schedule, technical, and/or programmatic challenges, overall NASA's space technology portfolio is on track and includes several technology demonstrations planned for the next few years. Examples include Laser Communications Relay Demonstration (LCRD) and the Pathfinder Technology Demonstrator (PTD)-1, CubeSat Proximity Operations Demonstration (CPOD), and Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) small spacecraft demonstrations. In the mid- to long-term, NASA has identified 12 technology capabilities as priorities for development, each of which addresses anticipated technology gaps across multiple stakeholder architectures.

Summary of Progress for Performance Goals Contributing to Strategic Objective 3.1, FY 2014—2020



Note: FY 2018—FY 2020 contribute to Strategic Objective 3.1, as established by the NASA 2018 Strategic Plan. For FY 2014 through FY 2017, individual performance goals were assigned to a strategic objective based on contributing work.

3.1.1: Encourage creative and innovative solutions to space technology challenges by investing in early stage technologies and concepts from U.S. innovators.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

Number of new early stage technologies and concepts invested in.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	210	210	210
Achieved	253		

NASA's **Space Technology Mission Directorate** nurtures innovative and high-risk/high-payoff technologies and concepts, including early stage ideas, that could transform future NASA missions, as well as the aerospace industry.

FY 2020 Performance Progress

NASA achieved the FY 2020 target for this multi-year performance goal as the Agency continues to advance early stage innovation. In FY 2020, NASA invested in 253 new early stage technologies and concepts, exceeding the target of 210. These investments ensure a healthy base of promising early stage solutions for further future development by other programs and organizations.

NASA leveraged the country's spectrum of academic researchers to foster groundbreaking research in advanced space technology. This included selecting nine Early Career Faculty awards, 14 Early Stage Innovation awards, and 63 NASA Space Technology Graduate Research Opportunities.

The Agency continued to engage America's innovators and entrepreneurs to nurture visionary ideas with the goal of transforming future NASA missions with the creation of breakthroughs through NASA Innovative Advanced Concepts (NIAC). The Agency selected 23 new concept studies in FY 2020, comprised of 16 Phase I projects, six Phase II projects, and one Phase III project.

NASA encouraged creativity and innovation within NASA centers by supporting emerging technologies and creative initiatives, selecting 137 Center Innovation Fund (CIF) projects. The Agency also encouraged its brightest early career technologists to experience hands-on technology development opportunities through seven Early Career Initiative awards.

Technicians wearing protective equipment perform work for a future mission on flight hardware for NASA's Orbital Syngas Commodity Augmentation Reactor, or OSCAR, at the Neil Armstrong Operations and Checkout Facility at the agency's Kennedy Space Center in Florida on August 10, 2020. OSCAR began as an Early Career Initiative project at the spaceport that studies technology to convert trash and human waste into useful gasses such as methane, hydrogen, and carbon dioxide. By processing small pieces of trash in a high-temperature reactor, OSCAR is advancing new and innovative technology for managing waste in space that is now being flight tested. Photo Credit: NASA/Cory Huston

3.1.2: Mature technology products that offer significant improvement to existing solutions or enable new capabilities.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Yellow	Green	Green

Percentage of key performance parameters completed for Technology Maturation projects.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	60%	60%	60%
Achieved	64%		

FY 2020 Performance Progress

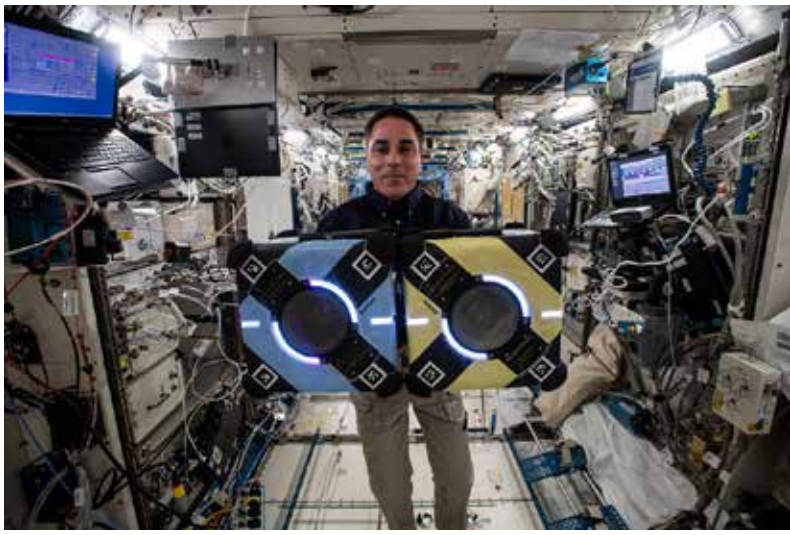
NASA achieved the FY 2020 target for this multi-year performance goal by completing 64 percent of planned key performance parameter (KPP) events for Technology Maturation projects, exceeding the 60 percent target. These completed KPPs represent technology advancement that may lead to entirely new mission approaches and provide solutions to national needs.

The Agency met KPPs in projects such as Astrobee, Extreme Environment Solar Power (EESP), and Autonomous Medical Operations (AMO). Astrobee is a new free-flying robotic system that will work alongside International Space Station astronauts to assist in routine duties, both autonomously and via remote control. EESP technologies will benefit missions to destinations with low sunlight intensity, low temperature, and high radiation (e.g. general vicinity of Jupiter). The AMO project is developing an onboard software system to enable astronauts on long-duration exploration missions to respond to medical scenarios independent of Earth contact.

In addition, NASA launched MEDLI2 and MEDA with the 2020 Mars Perseverance Rover in July 2020 and both technologies are currently on their way to Mars. MEDLI2 will allow investigators to study the safety and reliability of current entry vehicles, helping to ensure the safety of future Mars missions. MEDA will provide information about Mars' dust cycle and its impact on the planet's weather. This work could lead to daily Mars weather reports, as NASA prepares for human exploration of the Red Planet.

NASA's **Game Changing Development program**, part of the **Space Technology Mission Directorate**, guides innovative, high-impact technologies and capabilities from proof of concept through component or breadboard testing in a relevant environment.

NASA also selected 15 Tipping Point partnerships whose technologies will help enable the Agency's Moon to Mars exploration approach. This investment of over $40 million in the U.S. space industry, including small businesses, will help bring these technologies to market and ready them for NASA use.



NASA astronaut and Expedition 63 Commander Chris Cassidy poses with two Astrobee robotic assistants during visual and navigation tests inside the Kibo laboratory module from JAXA (Japan Aerospace Exploration Agency) on September 4, 2020. Photo Credit: NASA Photo Credit: NASA.

3.1.3: Demonstrate new technology and capabilities to support NASA's missions and space industry growth.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

Critical activities completed for two programs supporting the performance goal.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	6	2	2
Achieved	13 milestones for Small Spacecraft; 7 milestones for Tech Demo		

Critical milestones for FY 2020

1. *Achieve 6 key milestones for the Small Spacecraft program.*
2. *Achieve 6 key milestones for the Technology Demonstration program.*

Critical milestones for FY 2021

1. Achieve a key milestone in 6 Small Spacecraft Technology projects.
2. Achieve 6 key milestones for the Technology Demonstration program.

Planned Critical milestones for FY 2022

1. Achieve a key milestone in 6 Small Spacecraft Technology projects.
2. Achieve 6 key milestones for the Technology Demonstration program.

FY 2020 Performance Progress

NASA achieved the FY 2020 target for this multi-year performance goal by exceeding its target for milestones in demonstrating new technology and capabilities. NASA completed a total of 21 targeted milestones and key decision points (KDP), major reviews that serve as gateways to the next lifecycle phase. The Agency continues to foster and mature for demonstration new crosscutting space technology capabilities that meet NASA and industry needs by enabling new missions or greatly enhancing existing ones.

The **Small Spacecraft Technology Program** and **Technology Demonstration Missions** are part of the **Space Technology Mission Directorate**. The Small Spacecraft Technology Program develops and demonstrates new small spacecraft technologies and capabilities for NASA's missions in science, exploration, and space operations. Technology Demonstration Missions bridge the gap between laboratory-proven and final infusion by providing ground- and flight testing for promising technologies.

NASA's FY 2020 achievements in small spacecraft technology included two milestones towards launch of the CAPSTONE lunar mission. CAPSTONE will reduce risk for future spacecraft by validating innovative navigation technologies and verifying the dynamics of a halo-shaped orbit. NASA also met milestones for Lunar Flashlight, PTD 2, PTD 3, PTD 4, CubeSat Laser Infrared Crosslink (CLICK) A, CLICK B/C, Advanced Composites Based Solar Sail (ACS3), and the Starling distributed mission demonstration.

The technology demonstration mission On-Orbit Servicing, Assembly and Manufacturing (OSAM)-2 mission (formerly called Archinaut One) completed three milestones including its Preliminary Design Review (PDR). In addition, other technology demonstration achievements included: completion of a KDP for the LCRD and delivery to Northrop Grumman; completion of the Critical Design Review (CDR) for the DSOC; and KDP completion for OSAM-1 (satellite servicing and in-space robotic assembly technologies).

NASA also conducted three on-orbit technology demonstrations—the DSAC, GPIM, and RRM3—and launched the MOXIE and the TRN to Mars. MOXIE will demonstrate a way that future explorers might produce oxygen from the Martian atmosphere for propellant and for breathing, and TRN will enable the Mars 2020 Perseverance Rover to avoid large scale landing hazards during entry, descent, and landing on the Red Planet.

3.1.4: Spur technology development through engagement with the commercial sector and the general public.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

Critical milestones achieved for two programs supporting the performance goal.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	3	3	3
Achieved	3		

Critical milestones for FY 2020

1. *Conduct 42 NASA challenges, prize competitions, and crowdsourcing activities.*
2. *Advance 45 Small Business Innovative Research/ Small Business Technology Transfer (SBIR/STTR) technologies beyond Phase II.*
3. *Manifest 16 payloads on commercial suborbital flights for testing.*

Critical milestones for FY 2021

1. Conduct 42 NASA challenges, prize competitions, and crowdsourcing activities.
2. Advance 45 Small Business Innovative Research/ Small Business Technology Transfer (SBIR/STTR) technologies beyond Phase II.
3. Manifest 16 payloads on commercial suborbital flights for testing.

Planned Critical milestones for FY 2022

1. Conduct 42 NASA challenges, prize competitions, and crowdsourcing activities.
2. Advance 55 Small Business Innovative Research/ Small Business Technology Transfer (SBIR/STTR) technologies beyond Phase II.
3. Manifest 16 payloads on commercial suborbital flights for testing.

FY 2020 Performance Progress

NASA achieved the FY 2020 target for this multi-year performance goal by exceeding its targets for all three critical activities including conducting prize and challenge competitions, advancing technologies with small businesses and research institutions, and selecting of flight opportunity payloads.

NASA's **Space Technology Mission Directorate (STMD)** offers prizes for meeting key technology challenges, while reaching out to non-traditional NASA partners. STMD also provides an opportunity for small businesses and research institutions to participate in government-sponsored research and development efforts in key technology areas.

NASA provided opportunities for small, highly innovative companies and research institutions through the SBIR/STTR program. NASA created 125 post-Phase II opportunities (the prototype development phase), compared to the targeted 45 opportunities, including 32 Phase II-E/X (which requires matching funds), eight Civilian Commercialization Readiness Pilot Program opportunities, four Phase II Sequential awards, and 81 Phase III awards (preparing the technology for infusion/commercialization). The Agency's SBIR program also funded eight technologies that are represented on the Mars 2020 Perseverance Rover.

NASA started 61 new prize challenges in FY 2020, as well as continuing six prize challenges that started prior to FY 2020. Of the new challenges started, 25 of them were through the NASA@WORK platform, which provides NASA employees an unconventional and inventive way to share knowledge and advance projects. Other exciting public challenges started in FY 2020 include Exploring Hell: Avoiding Obstacles on a Clockwork Rover, the Lunar Loo Challenge, as well as the Watts on the Moon Challenge.

NASA also competitively selected 50 payloads, exceeding the target of 16, from industry and academia for flight on commercial flight vehicles to achieve agency priorities.

Strategic Objective 3.2: Transform aviation through revolutionary technology research, development, and transfer.

LEAD OFFICE
Aeronautics Research Mission Directorate (ARMD)

GOAL LEADER
William Harrison, Portfolio Analysis & Management Office, Director, ARMD

NASA is advancing U.S. global leadership in aviation through the application of new concepts and technologies throughout aviation design, development, production, and operations. Technologies pioneered by NASA and developed in partnership with U.S. industry have led and will continue to lead to transformative improvements in mobility, efficiency, sustainability, and safety. NASA focuses its high-risk, high-reward aviation research and technology development in areas identified by its trend and gap analyses. In understanding fundamentals and delivering solutions, the Agency applies a strategy of convergent research, integrating multi-disciplinary work across its focus areas of research and development. NASA leverages its in-house aeronautics resources with partners in other government agencies, industry, and academia to support innovative concepts and technologies, and with international counterparts to leverage complementary investments.

NASA's 2020 Strategic Review determined that progress for the strategic objective is noteworthy. NASA's strategy for this objective is focused on strategic thrusts that address aeronautic global trends/drivers. The six strategic thrusts are: Thrust 1–Safe, Efficient Growth in Global Operations to achieve safe, scalable, routine high tempo airspace access for all users, Thrust 2–Innovation in Commercial Supersonic Aircraft to achieve practical, affordable commercial supersonic air transport, Thrust 3–Ultra-Efficient Subsonic Transports to realize revolutionary improvements in economics and environmental performance

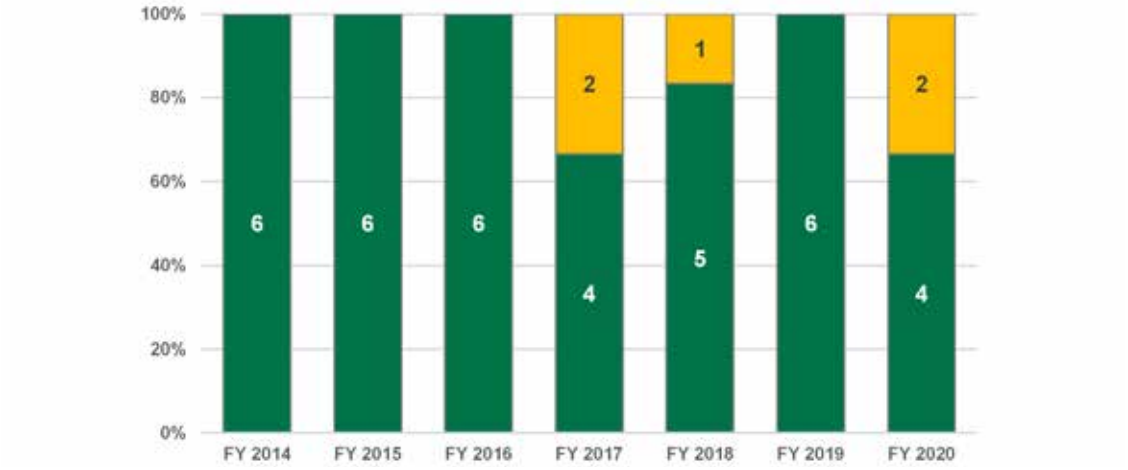
Above: Telemetry testing begins on the X-57 Maxwell Mod 2, NASA's first all-electric X-plane, as the operations crew at NASA's Armstrong Flight Research Center records the results. Telemetry testing is a critical phase in the X-57's functional test series. In addition to confirming the ability of the X-57 aircraft to transmit speed, altitude, direction, and location to teams on the ground, telemetry testing also confirms the ability to transmit mission-critical data, such as voltage, power consumption, and structural integrity. The goal of the X-57 is to help set certification standards for emerging electric aircraft markets. Photo Credit: NASA

for subsonic transports with opportunities to transition to alternative propulsion and energy, Thrust 4–Safe, Quiet, and Affordable Vertical Lift Air Vehicles to realize extensive use of vertical lift vehicles for transportation and services including new missions and markets, Thrust 5–In-Time System-Wide Safety Assurance to predict, detect and mitigate emerging safety risks throughout aviation systems and operations, and Thrust 6–Assured Autonomy for Aviation Transformation to Safely implement autonomy in aviation applications. (See the *NASA Aeronautics Strategic Implementation Plan 2019 Update* for more information on the six strategic thrusts.)

NASA continues to make progress on its near-term success criteria completing 7 out of 23 of its near-term criteria by end of FY 2020. The agency is also demonstrating progress against its mid- and long-term measures. NASA continues to strategically focus on its six thrusts while continuing to seek feedback from the aviation community. Historically, from FY 2014–FY 2019, NASA successfully met 67–100 percent of its aeronautics-focused performance metrics.

While Strategic Objective 3.2 has a clear strategy for success, there have been impacts to some projects due to the COVID-19 pandemic.

Summary of Progress for Performance Goals Contributing to Strategic Objective 3.2, FY 2014—2020



Note: FY 2018—FY 2020 contribute to Strategic Objective 3.2, as established by the NASA 2018 Strategic Plan. For FY 2014 through FY 2017, individual performance goals were assigned to a strategic objective based on contributing work.

3.2.1: Develop solutions that will advance decision-making ability for improving air traffic management to accommodate future growth in air travel, and for increasing aviation safety under hazardous conditions.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Yellow

Annual performance activities completed.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	2	1	2
Achieved	1		

Development milestones for FY 2020

1. *Evaluate a service-oriented architecture, intended to improve safety and efficiency, for traditional operations in a relevant airspace.*
2. *Conduct an operational assessment of the Integrated Arrival/Departure/Surface (IADS) metroplex departure management prototype.*

Performance activities for FY 2021

1. Transfer knowledge and technology (i.e., digital services) that enable broad adoption of a NASA-developed Trajectory Option Set (TOS) based digital re-routing concept.

Performance activities for FY 2022

1. Develop a community-supported vision for the National Airspace System of 2045.
2. Conduct National Campaign-1 (NC-1) testing, perform demonstration of NC Operational Scenarios, and collect data from flight demonstrations and simulations.

The **Airspace Operations and Safety Program**, part of the **Aeronautics Research Mission Directorate**, is working with partners to conceive and develop the Next Generation Air Transportation, or NextGen, technologies to further improve safety, capacity, and efficiency in the national airspace.

FY 2020 Performance Progress

NASA partially achieved this performance goal for FY 2020 by demonstrating, through simulation, the use of service-oriented technologies for improving operations for high complexity airspace.

NASA is developing advanced decision-making capabilities for improving air traffic management to accommodate future growth in air travel. In FY 2020, NASA successfully completed a simulation that modeled airline decision support tools that would allow airline dispatchers to easily propose in-flight reroutes by selecting from a set of system-generated options. Once accepted by air traffic control, the reroute would be issued via the FAA's Airborne Reroute system. The demonstration was conducted as a remote cognitive walk-through due to restrictions to NASA laboratory usage during the COVID-19 pandemic.

The IADS Metroplex Coordinator is a tool designed to provide benefits when the aircraft demand exceeds the capacity of an airport. An operational field evaluation of this tool was scheduled for April-August 2020. Despite COVID-19 constraints, NASA and field demonstration partners were prepared to conduct the evaluation in April: the software development was completed on schedule, the system was deployed, training was conducted, and airline as well as FAA partners were committed to participating in the evaluation. However, the COVID-19 pandemic dramatically reduced air traffic volume such that the number of scheduled flights seldom exceeded capacity during the evaluation period. Thus, insufficient data was collected to fully satisfy this portion of the success criteria during FY 2020.

3.2.2: Demonstrate the ability to reduce the perceived loudness of sonic booms and enable future industry innovation in commercial supersonic aircraft.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

Annual performance activities completed.

	Execution		Planned
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	1	2	Transitioning to APG
Achieved	0		

Development milestone for FY 2020

1. *Complete final assembly of the Low Boom Flight Demonstrator (LBFD) aircraft.*

Performance activities FY 2021

1. Low Boom Flight Demonstrator (LBFD) aircraft ready to ship from Palmdale to Lockheed Martin Fort Worth.
2. Deliver a validated F-15-based test capability that enables precise, near-field probing of the LBFD shock wave structure.

Performance activities FY 2022

1. First flight of the Low Boom Flight Demonstrator (LBFD) aircraft.
2. Deliver a validated F-15-based test capability that enables in-flight Schlieren images of the LBFD shock structure.

FY 2020 Performance Progress

NASA achieved this performance goal by continuing progress toward the Low Boom Flight Demonstrator aircraft acceptance and acoustic validation, and Community Response Test Plan approval. While the final assembly of the Low Boom Flight Demonstrator aircraft will be delayed beyond the first quarter of FY 2021, there is still margin in the schedule for aircraft acceptance and completion of acoustic validation before the end of FY 2024.

Delays for the final assembly were largely due to prime contractor manufacturing and performance issues ultimately resulting in the approved baseline to be non-reflective of actual execution. Consequently, NASA and the prime contractor agreed to collaboratively re-plan tasks and schedules required to complete final assembly and checkouts of the X-59 Quiet SuperSonic Technology (QueSST) aircraft. Thereafter, the project conducted a schedule risk assessment to re-establish key milestone dates and needed reserves.

The **Integrated Aviation Systems** and **Advanced Air Vehicles** programs, part of NASA's **Aeronautics Research Mission Directorate**, are working together to validate design approaches for quiet supersonic aircraft and develop data to support the definition of a standard for acceptable noise.

Additional delays from the COVID-19 pandemic have also impacted schedules and progress. The prime contractor has also experienced multiple production shutdowns, critical parts shortages, as well as delays from critical subcontractors.

Based on SRA results, re-plan adjustments, and known COVID-19 impacts have been incorporated into a new integrated master schedule to facilitate a more accurate assessment of programmatic performance of the X-59 aircraft fabrication and assembly effort. In addition, NASA conducts Low Boom Flight Demonstration Mission quarterly meetings to ensure ongoing integration of contributing Mission activities. This ensures readiness to fully conduct the Low Boom Flight Demonstration Mission to inform a certification standard for supersonic overland flight.

Images captured at the beginning and end of 2020 show the progress made in assembling the X-59 Quiet SuperSonic Technology airplane. This positive headway mirrors the many accomplishments achieved by NASA's aeronautical innovators despite a difficult year that included a global pandemic. Photo Credit: Lockheed Martin

3.2.3: Advance airframe and engine technologies to enable the development of future generations of ultra-efficient air vehicles that minimize environmental impact including electric aircraft propulsion concepts.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Yellow	Yellow

Annual performance activities completed.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	5	2	4
Achieved	2		

Development milestones for FY 2020

1. *Design, fabricate, assemble, and test components and sub-systems for a small core, high-pressure compressor concept engine, intended to improve operational efficiency.*
2. *Develop and flight test a flexible, deployable vortex generator system for cost-effective fuel reduction on transport aircraft using passive-shape, low-temperature shape memory alloys.*
3. *Complete detailed analysis of turbulent heat flux data obtained from NASA's Turbulent Heat Flux (THX) experiment to enable better computational tools for prediction and design of future air vehicle propulsion systems.*
4. *Provide test capability for MW-scale powertrain (electrical) at altitude.*
5. *Complete system integration and verification and validation testing and begin flight testing of the X-57 Maxwell electric aircraft (Mod II).*

Performance activities for FY 2021

1. Design and fabricate a low-noise variant of the High-Lift Common Research Model and conduct a wind tunnel experiment to perform acoustic measurements of innovative slat noise reduction concepts entailing realistic materials and component sizes.
2. Award industry contract(s) for 1 MW powertrain flight demonstrations.

Performance activities milestones for FY 2022

1. Establish feasibility for megawatt, kilovolt fault management devices for electrified aircraft propulsion (TRL-4).

The **Advanced Air Vehicles** and **Transformative Aeronautics Concepts** programs, part of NASA's **Aeronautics Research Mission Directorate**, evaluate, develop, and test technologies and capabilities for ultra-efficient aircrafts.

2. Design and fabricate a semi-span model of an advanced Transonic Truss Braced Wing (TTBW) configuration, conduct a wind tunnel test to further investigate the buffet boundary of the configuration, and compare experimental results with the computational predictions of structural response and buffet boundary to improve (or calibrate) methods for this non-traditional wing architecture.
3. Complete screening of materials and manufacturing technologies to be considered under the HiCAM effort; requirements definition for a full-scale component-level test article; and evaluate high-rate materials and manufacturing concepts at the coupon and element levels.
4. Preliminary design complete for at least one integrated, 1 MW class electric powertrain flight demonstration.

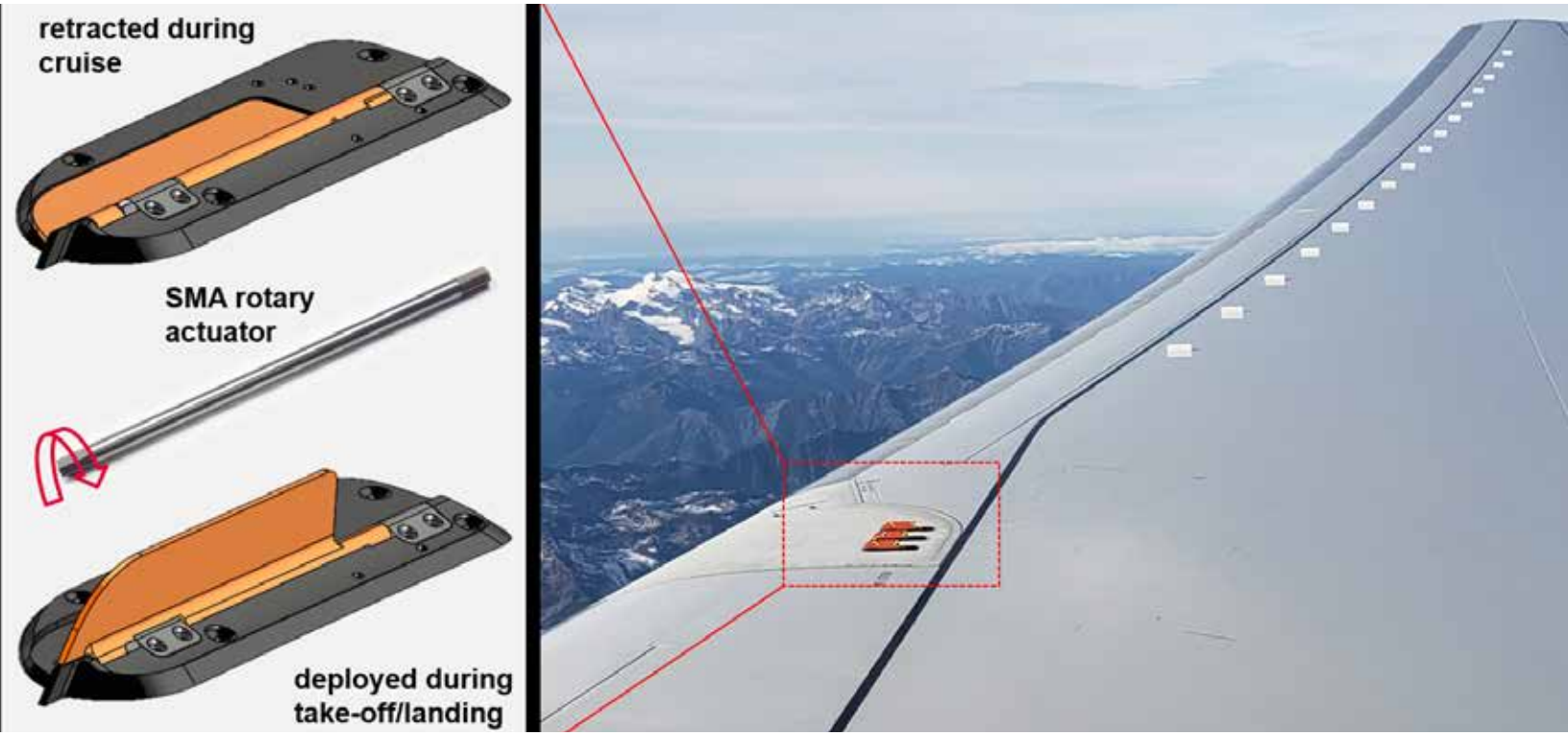
FY 2020 Performance Progress

NASA partially achieved this performance goal for FY 2020 by advancing airframe and engine technologies through specific research activities.

In FY 2020, NASA investigated Transonic Truss-Braced Wing and other ultra efficient wing technologies and completed a multi-year Technical Challenge on Higher Aspect Ratio Optimal Wing. This effort has promoted technologies to Technology Readiness Level 4 that offer significant fuel burn reduction relative to existing aircraft technology. Also in FY 2020, NASA continued to advance both High Overall Pressure Ratio Compressor technology and Megawatt-Class Electrified Aircraft Powertrain technology despite delays in testing in both areas due to COVID-19. Both technologies areas offer reduced aircraft fuel burn and progress continues toward the ultimate objectives with a 6 month slip in testing.

NASA also demonstrated a deployable vortex generator system using low temperature shape memory alloys which was flight tested on a Boeing 777 EcoDemonstrator aircraft. Four dedicated flight test days were conducted demonstrating successful deployment and retraction of the vortex generator system developed with a partnership between NASA, Boeing and Aerotec. Drag reduction analysis of shape memory actuators was performed and quantified as expected up to 42,000 feet.

Right: A technician works inside a Boeing 787-10 Dreamliner completing installation of equipment that will be used to support a NASA research project being flown during Boeing's 2020 ecoDemonstrator program. Wires from an array of 214 microphones installed on the airplane's exterior were snaked through a pair of passenger windows to recorders loaded on the racks seen here. Photo Credit: Boeing



The figure shows the integration of a deployable vortex generator system, which uses a shape memory alloy (SMA) rotary actuator, on the Boeing 777 EcoDemonstrator aircraft. Image credit: NASA

3.2.4: Advance airframe and propulsion technologies to enable the development of vertical take-off and landing (VTOL) vehicles that minimize noise and maximize safety.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Yellow	Green	Green

Annual performance activities completed.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	1	1	1
Achieved	1		

Development milestone for FY 2020

1. *Develop the theory for, and implement and assess the functionality of, Broadband Acoustic Rotor Codes for application to VTOL Urban Air Mobility (UAM) vehicles.*

Performance activities for FY 2021

1. Complete conceptual design and sizing trade studies for Vertical Take Off and Landing (VTOL) Urban Air Mobility (UAM) configurations.

Performance activities for FY 2022

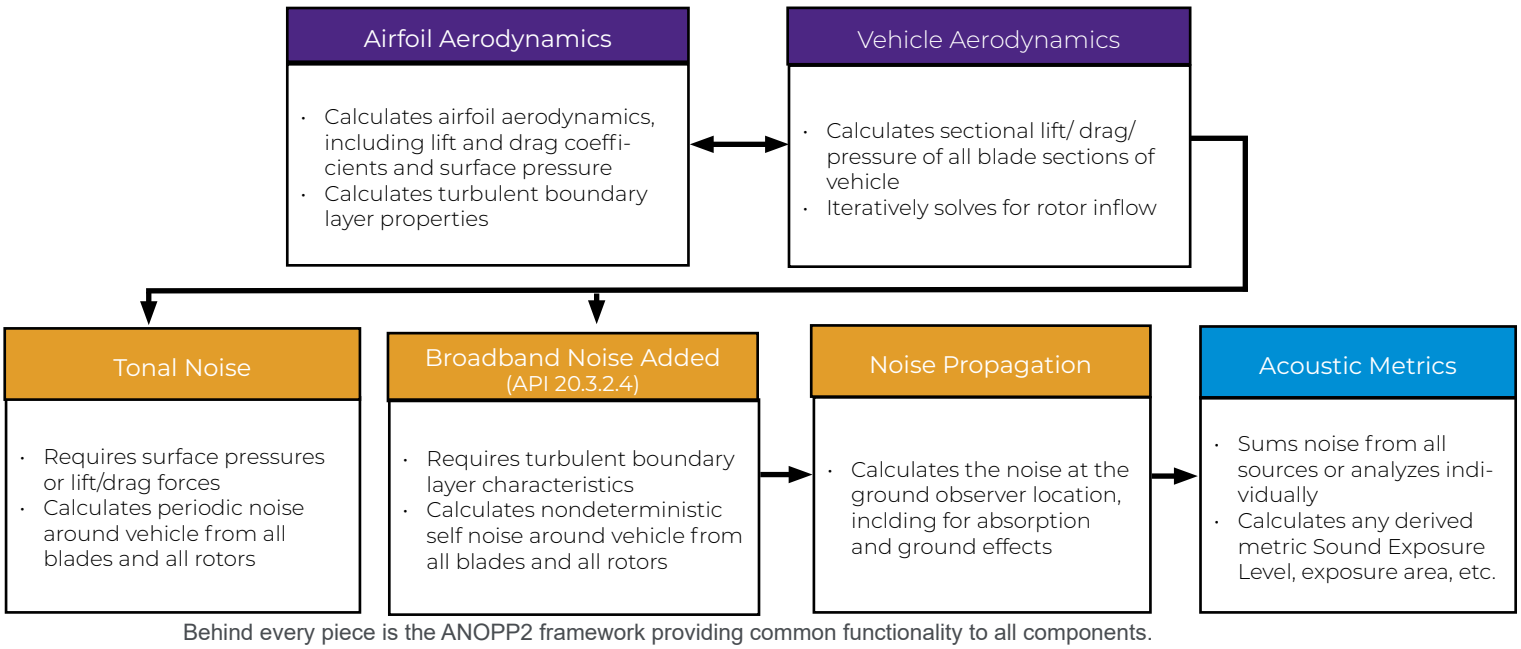
1. Assessment of Urban Air Mobility vehicle noise operating in realistic trajectories with a second generation (Gen-2) noise-power-distance database that includes loading, thickness, and broadband noise for a mix of vehicles.

The **Advanced Air Vehicles** and **Integrated Aviation Systems** programs, part of NASA's **Aeronautics Research Mission Directorate**, demonstrate and deliver tools, technologies, and flight operations methods for safe, quiet, and affordable vertical lift air vehicles.

FY 2020 Performance Progress

In FY 2020, NASA investigated propeller and rotor broadband noise prediction for Urban Air Mobility vehicles, identified gaps in validation data and methodology for prediction of broadband self-noise, and executed improvements to the capability of existing analysis tools. A new module to capture this unique noise was developed and implemented in NASA's Aircraft Noise Prediction Program 2 (ANOPP2). The capability was validated through comparison to experimental data and was released to users as part of the production release of ANOPP2v1.3.0.21586 in April 2020. Over 200 industry, academia, and government users have downloaded the updated analysis to date. This improvement is a significant advancement in the ability to design for minimal noise for VTOL future configurations.

ANOPP2 Component Interactions



Behind every piece is the ANOPP2 framework providing common functionality to all components.

3.2.5 [Ends in FY 2021]: Significantly increase the ability to anticipate and resolve potential safety issues, and to predict the health and robustness of aviation systems.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

Annual performance activities completed.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	2	1	PG Completed
Achieved	2		

Development milestones for FY 2020

1. *Demonstrate the use of formalizable requirements in order to reduce errors, improve traceability to verification and validation data, and mitigate safety risks.*
2. *Assess performance of initial safety-related monitoring services, protocols, and supporting architecture as tested in simulations and in flight.*

Performance activities for FY 2021

1. Evaluate costs and benefits given a demonstrated automated evaluation of safety risk over multiple simultaneous events utilizing non-traditional data.

The **Airspace Operations and Safety Program**, part of the **Aeronautics Research Mission Directorate**, develops real-time safety monitoring and assurance system technologies and capabilities to enhance air transportation safety, capacity, and efficiency.

FY 2020 Performance Progress

NASA achieved the FY 2020 targets for this performance goal, which focuses on developing tools to support in-time terminal area risk identification, notification, and hazard mitigation. For FY 2020, NASA conducted demonstrations of the use of formalizable requirements in order to reduce errors, mitigate safety risks, and improve traceability to verification and validation data.

Errors in requirements have been identified by industry and regulatory partners as one of our largest overall safety risks. NASA is conducting research on how formalizable requirements can impact verification and validation during the entire product lifecycle. NASA has successfully developed and demonstrated the integration of the NASA-developed Formalized Requirement Elicitation Toolset with the CoCoSim, a tool that performs model checking of formal safety properties on Simulink models.

NASA also delivered a prototype for corrections and improvement to the Automatic Dependent Surveillance-Broadcast (ADS-B) Compact Position Reporting algorithm. The algorithm is a safety-critical function that enables aircraft to share their current position and speed with other aircraft in their vicinity. All of NASA's recommended changes were adopted and are intended to be incorporated in revision C of the RTCA DO-260 Minimum Operational Performance Standards.

3.2.5 [Begins in FY 2022]: Define and demonstrate solutions that predict, identify, and mitigate emerging safety risks and address the national need to safely transform the National Airspace System.

Annual performance activities completed.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	N/A	N/A	1
Achieved	N/A		

Performance activities for FY 2022

1. Complete simulations and flight tests of automated in-flight safety/risk assessment with alternate proactive and fail-safe mitigation methods.

The **Airspace Operations and Safety Program**, part of the **Aeronautics Research Mission Directorate**, develops real-time safety monitoring and assurance system technologies and capabilities to enhance air transportation safety, capacity, and efficiency.

3.2.6 [Ends in FY 2020]: Support transformation of civil aircraft operations and air traffic management through the development, application, and validation of advanced autonomy and automation technologies, including addressing critical barriers to enabling urban on-demand air mobility and unmanned aircraft systems (UAS) operations in low-altitude airspace.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

Annual performance activities completed.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	1	PG Completed	PG Completed
Achieved	1		

Development milestones for FY 2020

1. *Develop, conduct, and validate through simulation increasingly autonomous and automated technologies to support transformation of civil aircraft operations and air traffic management and address critical barriers to enabling on-demand urban air mobility operations in low-altitude airspace.*

The **Integrated Aviation Systems** and **Advanced Air Vehicles** programs, part of NASA's **Aeronautics Research Mission Directorate**, are developing technologies and capabilities to enable autonomous aircraft and urban air mobility.

FY 2020 Performance Progress

NASA achieved the FY 2020 target for this multi-year performance goal by completing analysis of the performance data of the UAS traffic management (UTM) system and related technologies, which demonstrated that a highly automated, cloud-based architecture that safely enables low-altitude UAS operations is feasible. Over the previous four years, the project followed a risk-based approach to develop and test the UTM system and matured it through successively more capable Technical Capability Levels (TCLs). This culminated in the TCL 4 testing in the highly complex urban environments of Reno, Nevada, and Corpus Christi, Texas, as well as focused in-board technology evaluations at NASA centers in FY 2019.

The results from those tests confirmed the concept and provided new insights into industry's ability to develop and provide traffic management services for UAS operations, and to interface with new FAA systems that can integrate into the traditional air traffic management infrastructure. Through technology transfers, the UTM results are now informing the FAA in their testing in this year's UTM Pilot Program, as well as the longer-term UTM implementation plan for the Nation. Industry standards bodies, such as American Society for Testing and Materials (ASTM) and Joint Authorities for UAS Rulemaking on Unmanned Systems (JARUS), are also incorporating the UTM results. Additionally, the UTM service-based architecture is serving as the foundation for enabling advanced air mobility solutions in urban environments and high-altitude UAS traffic.

As part of project closeout, the UTM project has completed an extensive lessons-learned collection and archived key documentation that will benefit current and future projects and research efforts.

3.2.6 [Begins in FY 2021]: Contribute toward the safe introduction of on-demand Urban Air Mobility (UAM) by developing, applying, demonstrating, and validating advanced autonomy and automation technologies and providing methods or research results that support certification of autonomous systems.

Annual performance activities completed.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	N/A	3	2
Achieved	N/A		

Performance activities for FY 2021

1. Develop an initial Urban Air Mobility airspace management system.
2. Evaluate the use of run-time monitoring as a tool for the assurance of untrusted components in a system.
3. Conduct National Campaign (NC) Developmental Testing (or NC-DT), perform demonstration of NC operational scenarios, and collect data from flight demonstrations and simulations in preparation for NC-1.

Performance activities for FY 2022

1. Enable informed investment decisions for future development of increasingly automated vehicles and airspace operations.
2. Delivery of draft evidence and recommendations for the robustness of failover plans; and the use of run-time monitoring to the FAA, Unmanned Aircraft Safety Team, and Flight Safety Foundation that can be used in regulatory guidance to industry and in standards committees.

The **Integrated Aviation Systems** and **Advanced Air Vehicles** programs, part of NASA's **Aeronautics Research Mission Directorate**, are developing technologies and capabilities to enable autonomous aircraft and urban air mobility.

Strategic Objective 3.3: Inspire and engage the public in aeronautics, space, and science.

LEAD OFFICES
Missions Support Directorate and Office of Communications

GOAL LEADER
Johnny Stephenson, Associate Administrator, Office of Communications

NASA's multi-faceted approach to this goal is to inspire and engage the public and provide unique science, technology, engineering, and math (STEM) opportunities for diverse audiences. By increasing public knowledge about NASA's work, the Agency can contribute to science literacy and an improved national understanding and appreciation of the value of STEM work and careers. The Agency also believes that it can help strengthen diversity in STEM fields by ensuring that grantee universities comply with Federal requirements for minimizing and addressing issues related to discrimination and harassment. NASA is employing a strategy that seeks to inspire, engage, educate, and employ the next generation of explorers through NASA-unique STEM learning opportunities. NASA engages the public and students in its mission by creating unique opportunities that: provide authentic learning experiences with NASA's people, content, and facilities; build a diverse future workforce; and contribute to exploration missions. NASA's education and outreach functions each play a critical role in increasing public knowledge of NASA's work, fostering an understanding and appreciation of the value of STEM, and enhancing opportunities to teach and learn.

Above:Team Kulia I Ka Nuu from Kapi'olani Community College in Hawaii participates in the 2019 Moon Challenge of the Wisconsin Space Grant Consortium's First Nations Launch National High-Power Rocket Competition. As part of the challenge, the team had to design and construct a warning sensor system and mount it inside the high-powered rocket they built to record two flight events during ascent – a nominal separation event and an air frame anomaly. The rocket was launched at the Richard Bong State Recreational Area in Wisconsin. Photo Credit: Christine Bolz/WSGC

The 2020 Strategic Review determined that NASA's progress continued to be satisfactory for this strategic objective. NASA is integrating metrics and using data to inform decisions on better reaching the public, engaging stakeholders, evaluate outcomes, and safeguard against unlawful practices. NASA continues to use data to refine content and social media distribution platforms, targeted to audience preferences. The Agency is also assessing its higher education challenges, competitions, and internships. This will enable NASA leaders to understand how and to what extent these activities are contributing to NASA's missions and result in participant engagement and achieving programmatic outcomes.

NASA is designing and implementing an integrated Agency communications team through the Mission Support Future Architecture Program (MAP). Under this program, the Agency is successfully realigning communications resources to enable the communications enterprise to operate more efficiently and sustainably. The newly established communications enterprise management office is instituting business process improvements that will better enable the enterprise to keep the public informed about NASA's activities. The Agency also partners with public universities and nonprofit institutions to advance equal opportunity in NASA-funded programs and activities. NASA also is rolling out an Agency Unity Campaign for employees emphasizing mission success through increased collaboration, connection and communication. NASA also continues using performance assessment and evaluation-driven processes to enhance the effectiveness of STEM engagement investments.

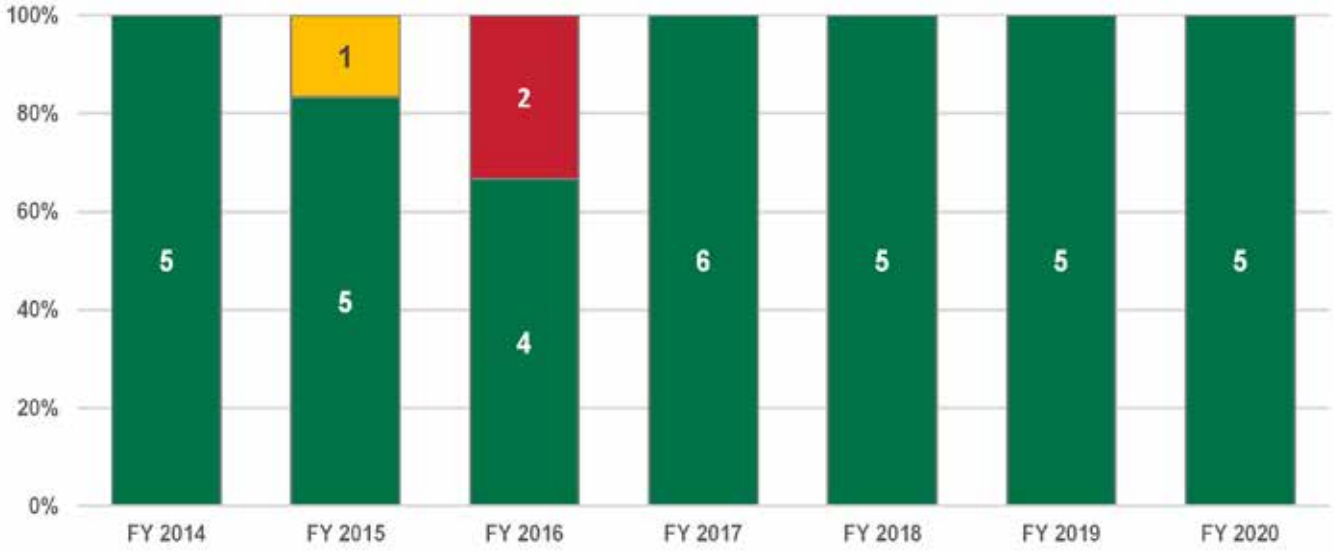
The pandemic has limited the execution of planned STEM engagement activities. The modification or cancellation of NASA's Office of STEM Engagement's in-person student opportunities at NASA centers, in public settings, and at universities affects OSTEM's ability to reach participants. Institutional closures and transitions to virtual instruction limit partner's abilities to execute planned programs and contribute to mission-driven research, which in turn affects their ability to generate peer-reviewed publications and paper presentations. Because performance data is reported one year in arrears, the full impacts of the reduction in both student participants and the production of mission-driven research products will not be fully realized until FY 2021 performance reports and beyond. Despite these challenges, the NASA STEM engagement community rallied together to rapidly develop and implement innovative virtual opportunities for students, training experiences for educators and parents/caregivers, and conduct performance assessment and evaluation activities to reveal evidence to demonstrate NASA STEM engagement investments' outputs, outcomes, and benefits to students, educators, and educational institutions. The Office of STEM Engagement executed a performance assessment strategy, an evaluation strategy, and a learning agenda in order to: monitor performance accomplishments; assess program and project effectiveness and outcomes; and systematically identify data to collect and evidence-building activities to facilitate the use of evidence in programmatic decisions and policymaking.

Notwithstanding the current challenges the nation is facing as a result of the global health crisis, NASA forges forward in its efforts to strengthen diversity in the STEM fields through assessment of NASA grant recipients' compliance with Federal civil rights laws and efforts to ensure that grantees are addressing discrimination, harassment, and accessibility issues, as well as reporting on grantee promising practices. COVID-19 has a significant impact not only on grantees' efforts to execute NASA's corrective actions and recommendations, but also on the Agency's capability to execute external civil rights requirements. The current environment poses a challenge in monitoring corrective actions and recommendations as well as in conducting new compliance reviews because many of the reviewed grantees, such as science centers and museums, have had to reduce their operations and, in some cases, cease operations completely and place staff on leave. Nonetheless, NASA continues to conduct and monitor civil rights compliance efforts to ensure that grantees are advancing equal opportunity and diversity in their programs and activities by adjusting current compliance models making NASA processes responsive to our current environment and limited capabilities. During FY 2020, NASA conducted reviews of four university STEM programs and two science centers, located in various regions across the country and U.S. territories. In the program on which NASA has been able to conduct monitoring on civil rights corrective actions and recommenda-

tions despite COVID-19 challenges, the grantee, a science center, has completed 80 percent of corrective actions within six months of review, and is expected to complete the other 20 percent within nine months.

Restrictions on person-to-person interaction during the pandemic challenged the communications enterprise to devise a new strategy for engaging with NASA's stakeholders and the public. The Office of Communications met the challenge quickly and expertly by increasing digital engagement on social media and the internet. New content includes virtual exhibits and participation in online events with NASA speakers, as well as the NASA at Home section of NASA.gov, which features family-focused content to entertain and educate the Agency's audiences in quarantine. Additionally, NASA created a virtual guest experience for the recent launch that allowed members of the public to participate via a calendar of mission information, mission highlights, and virtual tours. Amid the pandemic and simultaneous civil unrest, the Office of Communications also has expanded its role in internal communications, providing NASA's workforce with more frequent and more in-depth leadership messages regarding Agency operating status and renewed emphasis on diversity and inclusion.

Summary of Progress for Performance Goals Contributing to Strategic Objective 3.3, FY 2014—2020



Note: FY 2018—FY 2020 contribute to Strategic Objective 3.3, as established by the NASA 2018 Strategic Plan. For FY 2014 through FY 2017, individual performance goals were assigned to a strategic objective based on contributing work.

3.3.1: Increase NASA's public engagement through social media.

2015	2016	2017	2018	2019	2020
Green	Yellow	Green	Green	Green	Green

Percentage of annual social media audience growth as measured by the number of total followers across all flagship platforms. This metric is tracked on a recurring basis month-over-month.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	10%	10%	10%
Achieved	19.5%		

NASA's **Office of Communications** develops and implements outreach strategies to communicate NASA's activities, priorities, and achievements to a wide audience. The Office of Communications is an Administrator Staff Office.

FY 2020 Performance Progress

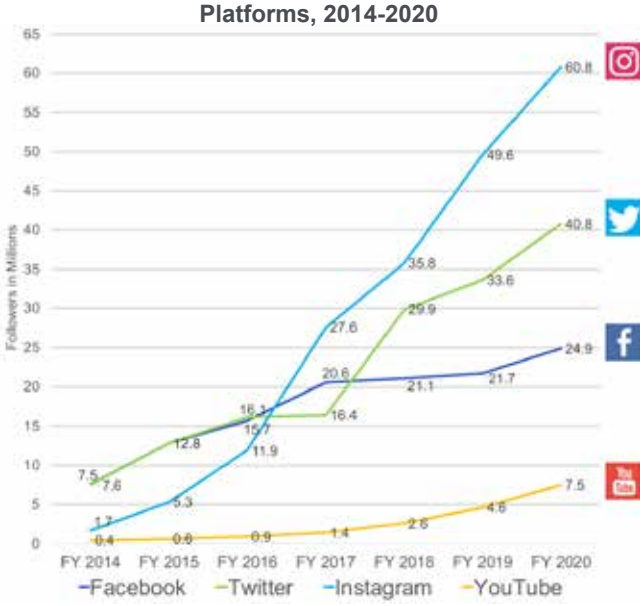
Throughout the course of FY 2020, NASA's flagship social media accounts for Facebook, Instagram, Twitter, Tumblr, YouTube, and LinkedIn showed robust growth. Overall, NASA's flagship social media followers increased by 19.5 percent during FY 2020, exceeding the FY 2020 target growth of 10 percent for this multi-year performance goal.

Large, popular events and major activities—including the all-woman spacewalk (watch the video on YouTube), the SpaceX commercial crew Demo-2 mission launch and landing events, and the Mars Perseverance rover launch—continue to drive the flagship account growth. Additionally, digital consumption of virtual events has increased growth. This rise in followers across the majority of the Agency's social media platforms may not be a concrete trend and is expected to adjust as the pandemic state changes across the globe.

Below are the FY 2020 year-end follower numbers per platform:

- Facebook – 24.9 million
- Instagram – 60.8 million
- Twitter – 40.8 million
- Tumblr – 952.7 thousand
- YouTube – 7.5 million
- LinkedIn – 4.9 million

Follower Growth for NASA's Four Largest Flagship Platforms, 2014-2020



Over the past 6 years, NASA has shown steady growth for it's four flagship social media accounts (likes for Facebook and followers for Twitter, Instagram, and YouTube). In particular, the following for NASA's flagship Instagram account increased from 1.7 million followers in FY 2014 to 60.8 million in FY 2020. Social Media at NASA

3.3.2 [Ends after FY2021]: Promote equal opportunity compliance and encourage best practices among NASA grant recipient institutions.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

Percentage of Agency civil rights recommendations/corrective actions to grant recipient institutions reviewed for compliance that are implemented within one year.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	90%	90%	PG Discontinued*
Achieved	90%		

*NASA is developing a new strategic plan and anticipates replacing this objective.

The **Office of Diversity and Equal Opportunity** leads diversity and civil rights policies, programs, and services, enabling the universe of available talent to contribute inclusively and equitably to NASA. ODEO is an Administrator Staff Office.

FY 2020 Performance Progress

NASA achieved its FY 2020 target for this performance goal. NASA reviewed the Virginia Air and Space Center, a grant recipient institution, and determined that it was 90 percent compliant with NASA's equal opportunity recommendations and corrective actions.

In addition, NASA has been working to improve complaints processing procedures and timeliness. It has decreased average processing times from 353 days in FY 2019 to less than 92 days in FY 2020 for Final Agency Actions for procedural dismissals, Final Agency Dismissals based on merits, and Final Agency Actions. This FY 2020 average processing time for Final Agency Actions includes the closure of backlog of old complaints awaiting adjudication. NASA also decreased the average processing time for FAAs for complaints in which a hearing was not requested from 468.3 days in FY 2019 to just over 143.8 days in FY 2020.

3.3.3 [Ends in FY 2020]: Provide opportunities for students, especially those underrepresented in STEM fields, to engage with NASA's aeronautics, space, and science people, content, and facilities in support of a diverse future NASA and aerospace industry workforce.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

Percentage of higher education significant awards in four categories of student diversity for NASA STEM enrollees compared to the national average.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	At least 2 of 4 categories meet or exceed national average	PG Discontinued*	PG Discontinued*
Achieved	2 categories met or exceeded national average		

*To be based on national averages obtained from the U.S. Department of Education's Center for Education Statistics Integrated Postsecondary Education Database for the most recent academic year available.

NASA **STEM Engagement** encompasses all endeavors Agency-wide to attract, engage and educate K-12 and higher education students and to support educators, educational institutions and professional organizations in STEM fields.

FY 2020 Performance Progress

NASA achieved the FY 2020 target for this performance goal by providing higher education significant awards in two of four categories, meeting or exceeding national STEM higher education enrollment target percentages for racial and ethnic categories underrepresented in STEM. Of the total 6,412 awards made during the during the 2018–2019 academic year**, NASA provided awards to 6,066 higher education students.

Some students received multiple awards, resulting in 6,412 significant awards and over $35 million in direct financial support to higher education students. Awards were provided by the National Space Grant College and Fellowship Project (68.8 percent/4,413 awards), Minority University Research and Education Project (MUREP) (10.2 percent/653 awards), Next Gen STEM (0.7 percent/7 awards), and NASA's mission directorates and mission support offices (20.9 percent/ 1,339 awards). Significant awards were provided to students across all institution categories defined by the U.S. Department of Education (i.e., Asian American and Native American Pacific Islander-Serving Institutions, Alaskan Native-Serving and Native Hawaiian-Serving Institutions, Historically Black Colleges and Universities, Hispanic-Serving Institutions, Native American-Serving Nontribal Institutions, Predominantly Black Institutions, Predominantly White Institutions, and Tribal Colleges and Universities) and levels (at least two but less than four years, and four or more years).

*Based on national averages obtained from the U.S. Department of Education's Center for Education Statistics Integrated Postsecondary Education Database for the most recent academic year available.

**Note: NASA rates this performance goal using data reported on the academic calendar. The FY 2020 rating is based on data from the 2018–2019 academic calendar.

NASA's MUREP Institutional Research Opportunity selected the Navajo Technical University and Sitting Bull College as cooperative agreement recipients to conduct education and research. Photo Credit: NASA

3.3.3 [Begins in FY 2021]: Provide opportunities for students, especially those underrepresented in STEM fields, to engage with NASA's aeronautics, space, and science people, content, and facilities in support of a diverse future NASA and aerospace industry workforce.

Percentage of higher education significant awards in four categories of student diversity for NASA STEM enrollees for both virtual and in-person higher education engagement activities.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	N/A	Baseline is measured for 4 categories	At least 2 of 4 categories meet or exceed the FY 2021 baseline
Achieved	N/A		

*To be based on national averages obtained from the U.S. Department of Education's Center for Education Statistics Integrated Postsecondary Education Database for the most recent academic year available.

NASA **STEM Engagement** encompasses all endeavors Agency-wide to attract, engage and educate K-12 and higher education students and to support educators, educational institutions and professional organizations in STEM fields.

3.3.4: Enhance the effectiveness of education investments using performance assessment and evaluation-driven processes.

2015	2016	2017	2018	2019	2020
None before FY 2018				Green	Green

Milestone achieved in the implementation of performance assessment and evaluation of STEM engagement investments.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	1	PG Discontinued	PG Discontinued
Achieved	1		

Milestone for FY 2020

1. *Award a competitive agreement to conduct a multi-year, third-party, project-level evaluation of the National Space Grant College and Fellowship Project.*

FY 2020 Performance Progress

NASA achieved this performance goal by completing the FY 2020 milestone. The NASA Office of STEM Engagement National Space Grant College and Fellowship (Space Grant) Program: Program-Level Independent Evaluation Opportunity Solicitation (NNH20ZHA006C) was released on April 29, 2020. A pre-proposal webinar was held for interested proposers on May 28, 2020. Proposers were asked to submit Notices of Intent by June 5, 2020, and proposals were due on July 16, 2020. Through this competitive solicitation, NASA successfully awarded two cooperative agreements to Space Grant Consortia to conduct two-year, independent program-level evaluation pilots of the NASA Office of STEM Engagement Space Grant. These pilot evaluations will be representative of the Space Grant Program offerings across multiple states that can be scaled to assess the entire Space Grant Program (based upon the findings and recommendations of the pilot studies).

Right: In partnership with NASA's Space Grant project the Arizona Space Grant Consortium, will provide funding for the Arizona STEM Challenges to Educate New Discoverers (ASCEND) program, which will allow students to participate in designing, building, and flying entry-level balloon payloads. Through each payload and launch, students will collect and study data while building excitement for careers in STEM. The ASCEND program will promote NASA and Space Grant to underrepresented student populations. Photo Credit: NASA

NASA **STEM Engagement** encompasses all endeavors Agency-wide to attract, engage and educate K-12 and higher education students and to support educators, educational institutions and professional organizations in STEM fields.

From left to right, students Austin Pritts, Taia Saurer, and Amanda Gutierrez have been named the winners of the Moon Pod Essay Contest for their creative visions of a journey to the Moon. The contest was a collaborative effort between NASA's Office of STEM Engagement and the Human Exploration and Operations Mission Directorate in partnership with the online platform Future Engineers. Photo Credit: NASA

3.3.5: Provide opportunities for students to contribute to NASA's aeronautics, space, and science missions and to work in exploration and discovery.

2015	2016	2017	2018	2019	2020
None before FY 2018				Green	Green

Number of paper presentations, peer-reviewed research publications, and (beginning in FY 2021 to include student-proposed solutions and products) resulting from STEM engagement investments.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	1,300	PG Discontinued*	PG Discontinued*
Achieved	2,015		

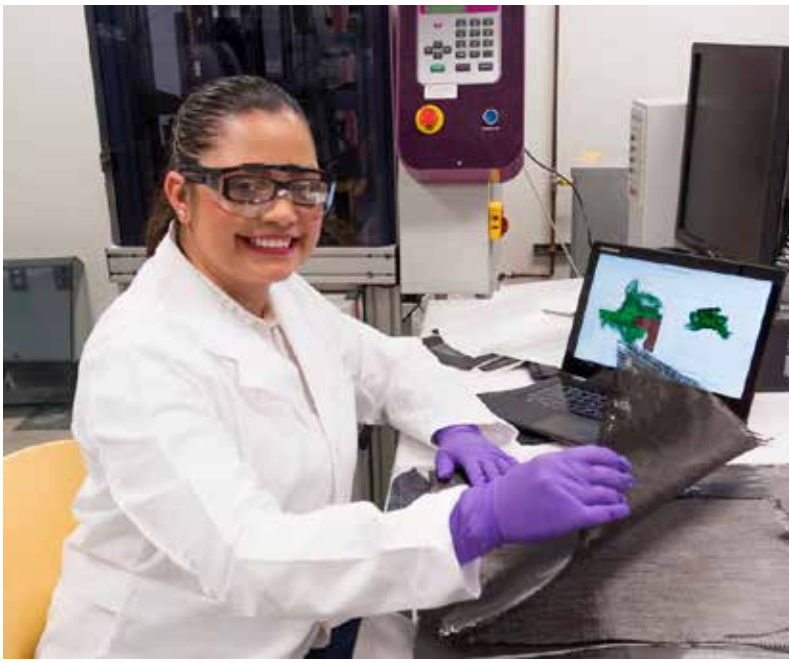
*NASA is developing a new strategic plan and anticipates replacing this objective.

FY 2020 Performance Progress

NASA achieved this performance goal by reporting a total 2,015 peer-reviewed publications and technical papers and presentations, exceeding the FY 2020 target. NASA's performance in providing opportunities for students to contribute to NASA's aeronautics, space, and science missions and work was assessed across peer-reviewed publications and technical paper presentations directly resulting from research funded by NASA STEM Engagement grants and awards to higher education institutions. As a direct result of NASA STEM Engagement investments, the Establish Program to Stimulate Competitive Research (EPSCoR), Space Grant, and MUREP grantee and awardee institutions published 550 peer-reviewed papers and 6 books, delivered 282 invited paper presentations, and published or presented 1,177 technical papers. Notably, 50 percent of the peer-reviewed publications were authored or coauthored by students. Additionally, nine patents were awarded to higher education institutions as a direct result of their NASA STEM Engagement grants or cooperative agreements.

*Note: NASA rates this performance goal using data reported on the academic calendar. The FY 2020 rating is based on data from the 2018–2019 academic calendar.

NASA **STEM Engagement** encompasses all endeavors Agency-wide to attract, engage and educate K-12 and higher education students and to support educators, educational institutions and professional organizations in STEM fields.



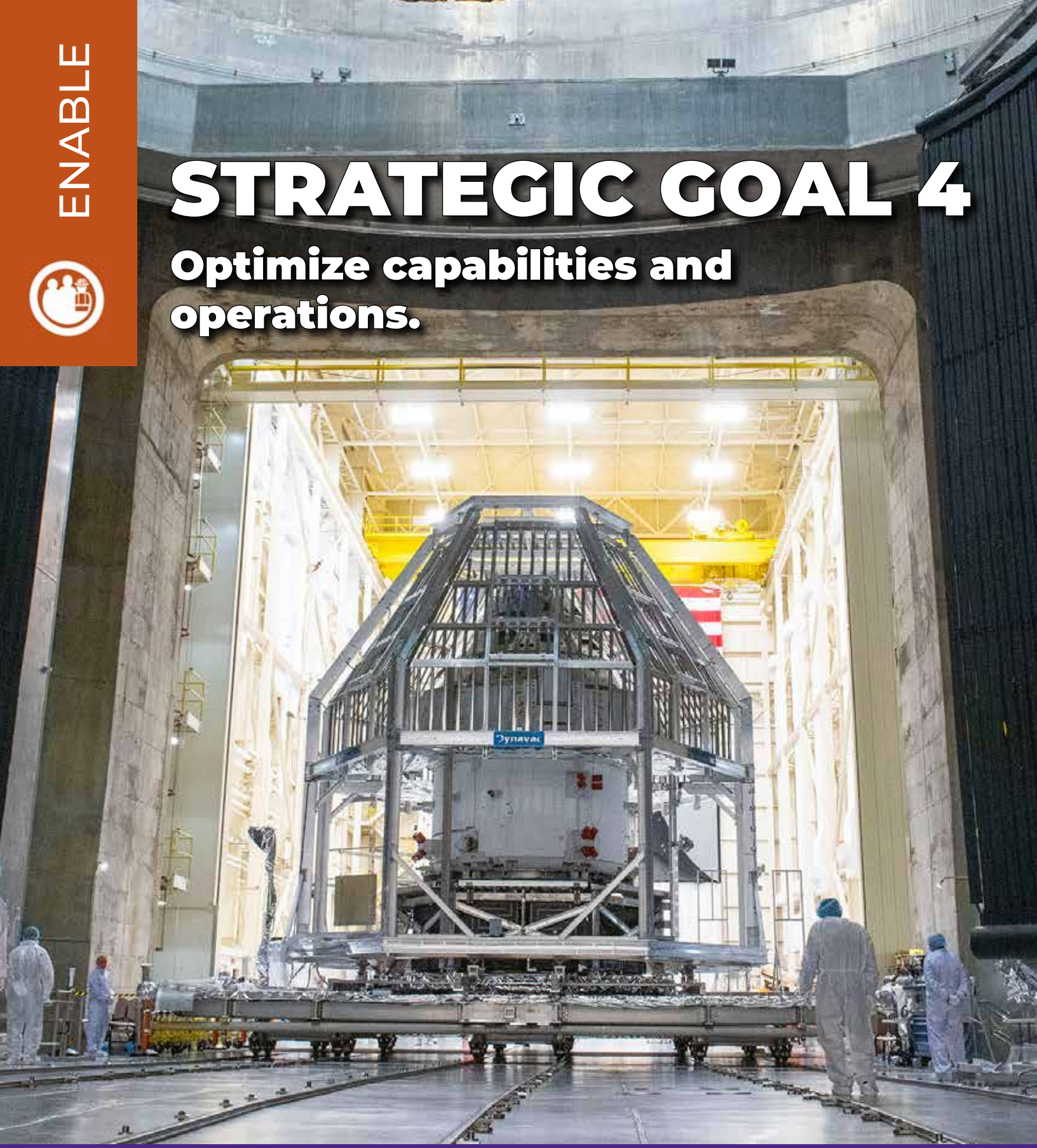
Through a cooperative agreement with NASA, the University of Texas at El Paso (UTEP), a Hispanic-serving institution, developed the Center for Space Exploration and Technology Research. Former UTEP student and now faculty member, Alejandra Castellanos, measures a laminate using woven, carbon-fiber layers to test low-velocity impact. The photo was taken when she was a Center for Space Exploration and Technology Research student at UTEP in 2017 in the university's Challenger-Columbia Structures and Materials Lab. Photo Credit: College of Liberal Arts at UTEP / Andy Castellanos

California State University student Jazmyne Bartee holds a plane she had built learning about the three axes and control surfaces for aircraft. Photo Credit: NASA / Lauren Hughes

ENABLE

STRATEGIC GOAL 4

Optimize capabilities and operations.



The Orion spacecraft for Artemis I is prepared for testing at NASA's Plum Brook Station on December 14, 2019. In this photo, the spacecraft (crew module and European-built service module) is installed in a vacuum chamber where it will be subjected to temperatures ranging from -250 to 300 degrees Fahrenheit to ensure it can withstand the extreme temperatures it may experience flying in-and-out of sunlight and shadow during a mission. The spacecraft is surrounded by a thermal cage, called Heat Flux, which is a specially-designed system that heats specific parts of the spacecraft at any given time. Orion will also be surrounded on all sides by a set of large panels, called a cryogenic-shroud, that will provide the cold background temperatures of space. NASA's testing capabilities help reduce mission risk and protect humans, vehicles, and the gear on which they rely. Photo Credit: NASA/ Bridget Caswell

Strategic Objective 4.1: Engage in partnership strategies.

LEAD OFFICE
Mission Support Directorate (MSD)

GOAL LEADER
Robert Gibbs, Associate Administrator, MSD

NASA is establishing appropriate partnerships to achieve the Agency's Mission using contracts to acquire property or services and/or partnership agreements using other statutory authorities to implement mutually beneficial activities to NASA and its partner. The strategy for the success of this objective focuses in four areas: 1) Execute innovative, effective, and efficient procurement solutions and contracts that enable NASA's mission; 2) Conduct education with and outreach to small businesses on how to partner with NASA and its commercial partners; 3) Enable NASA's international and interagency partnerships through identification of strategic opportunities and management of agreements, engagements, guidance on the applicability of U.S. regulations, and policies; and 4) Enable domestic, non-federal partnerships that are strategic and beneficial for NASA through transparency, education, awareness, and outreach opportunities, and identify partnership resources and capabilities for the public.

NASA's 2020 Strategic Review determined that this strategic objective shows satisfactory progress. NASA continues to establish appropriate collaborations and acquisitions to achieve the Agency's Mission. Innovative procurement strategies jointly developed with mission directorates have led to acquisition efficiencies by consolidating mission requirements under fewer contracts. NASA has several control measures in place to

Above: The sun sets at Boeing's research facility near Glasgow, Montana, where this 787-10 Dreamliner on loan from Etihad Airways served as the aircraft for the 2020 edition of Boeing's ecoDemonstrator program. NASA flew a pair of research projects to gather data on aircraft noise and test an air traffic management digital data communications tool. Results from these flights, which took place during late August and early September, will help develop technology to enable future aircraft designs and flight operations that will be quieter, more fuel efficient, and result in fewer delays. NASA has collaborated with Boeing on its ecoDemonstrator program almost every year since 2014. Photo Credit: Boeing

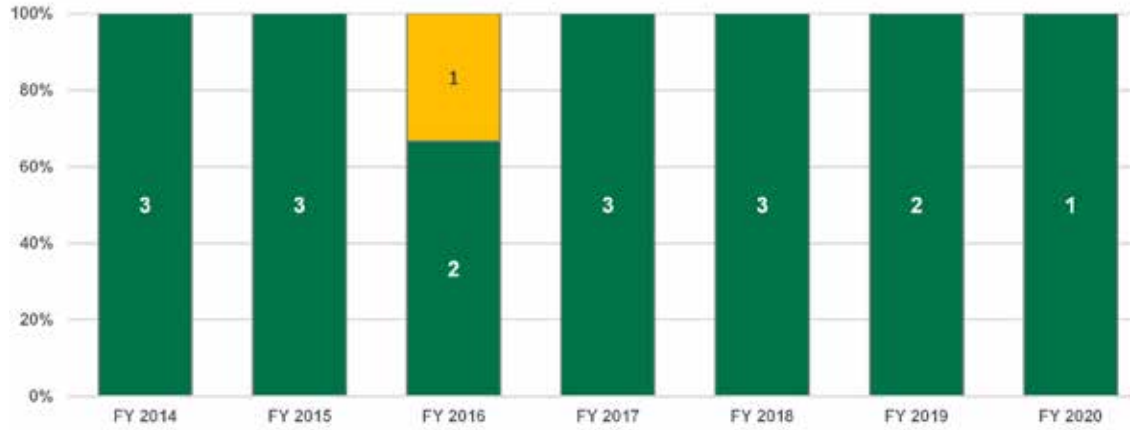
ensure that the Agency receives value from its partnerships and that these activities align to NASA's Mission. NASA provides standardized guidance and training to stakeholders, and potential partnerships are reviewed at several levels in advance of being finalized. Once completed, the Agency assesses those partnerships that used NASA resources to determine how beneficial the agreement was to advancing the Agency's objectives. Results inform future partnership decisions.

NASA annually spends approximately 81 percent of its budget on acquiring goods and services and procurements totaled over $19.5 billion with over 36,000 procurement actions. Additionally, NASA's Office of Procurement conceptualized, designed, and implemented the Enterprise Service Delivery Model that embraces concepts of Category Management principles by actively managing spending and utilizing Office of Management and Budget (OMB)-identified Best in Class Contracts (BICs) through the creation of 25 Product Service Lines, with specific procurement assignments, for institutional and a subset of program/project (e.g., engineering, propellants) lines of business. Procuring increasingly more goods/services using enterprise approaches will enable the Agency to reduce redundancies and meet or exceed the annual targets (i.e., Spend Under Management, Spend Using BIC, etc.) established by OMB. The Agency expanded its strategic (non-procurement) partnerships by increasing the number of new partners with whom NASA does business. In FY 2020, the Agency established partnerships with 52 new domestic, non-Federal partners—partners with whom the Agency has not had previous agreements. In addition, the Agency established 80 new international agreements in FY 2020. NASA's small business outreach program has evolved to target industry sectors rather than socioeconomic categories. The total agency dollars obligated to small business, as a sum of prime and subcontract dollars, increased an average of five percent annually.

In 2020, some partners were reluctant to enter into new non-procurement partnership agreements with NASA given the Agency's inability to commit to firm milestone schedules for on-site activities that do not qualify as "essential work." Concerns with meeting milestones for existing agreements will require extensions to complete work. A number of major meetings and events where international collaboration is formed were cancelled held virtually or postponed until 2021.

Impacts from COVID included the cancelation of all scheduled small business outreach events for the remainder of the fiscal year and were replaced with several virtual outreach events have already taken place. These have included the participation of various U.S. senators and congressmen along with the NASA Administrator. While these events have been successful thus far, the nature of a virtual platform limits the two-way exchange of information. Additionally, businesses are not able to network with each other in a virtual format. This is a key component of in-person events, particularly as it pertains to NASA's small business subcontracting program.

Summary of Progress for Performance Goals Contributing to Strategic Objective 4.1, FY 2014—2020



Note: FY 2018—FY 2020 contribute to Strategic Objective 4.1, as established by the NASA 2018 Strategic Plan. For FY 2014 through FY 2017, individual performance goals were assigned to a strategic objective based on contributing work.

4.1.1: Maintain the number of active partnership agreements with domestic, interagency, and international partners that support and enable NASA's mission.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

Number of milestones met.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	2,404	2,404	2,404
Achieved	2,872		

NASA's **Partnership Office** and the **Office of International and Interagency Relations (OIIR)** engage in non-procurement partnerships with international, intergovernmental, academic, industrial, and entrepreneurial entities, recognizing them as important contributors of skill and creativity to NASA missions. The **Mission Support Directorate (MSD)** oversees services provided by the Partnership Office.

FY 2020 Performance Progress

NASA achieved the FY 2020 target for this multi-year performance goal for partnership agreements. NASA managed 2,183 domestic and 689 international active partnership agreements, for a total of 2,872 agreements.

To facilitate strategic partnerships and mission objectives, NASA focused on outreach efforts to attract new, non-traditional organizations, while continuing to expand partnerships with existing partners. NASA personnel across the Agency conducted numerous outreach meetings and participated in external forums and conferences identifying and engaging with potential partners. Before COVID-19-related restrictions were in place in the United States, NASA partnerships and OIIR representatives met with potential partners at the 70th International Astronautical Congress and SpaceCom. Under COVID-19 health guidelines, NASA expanded outreach using webinars by teaming with the Office of Small Business Programs to reach the small business community and the Technology Transfer Office to identify partners at the SmallSat Conference.

Due largely to these and other similar outreach initiatives, NASA entered into partnership agreements with 43 new (first-time) non-Federal partners during FY 2020. Further, the number of page views/hits to the NASA Partnerships website during FY 2020 were up 33 percent over FY 2019. Reaching new audiences regarding NASA partnership opportunities and increasing the number and types of new partners benefits the Agency by cultivating new and innovative collaboration opportunities to help advance NASA's missions.

Flight Tested Tech to Enable Precision Landing on the Moon. Photo Credit: NASA/Lauren Hughes

Masten Employees Prepare Rocket for Flight Test of Lunar Landing Technology. Photo Credit: NASA/Lauren Hughes

4.1.2 [Begins in FY 2021]: Procure common goods and services as an enterprise to eliminate redundancies, increase efficiency, and deliver more value and savings.

NASA's **Office of Procurement** provides innovative, effective, and efficient acquisition solutions, optimizing Agency capabilities and operations and enabling NASA's missions.

Percentage of NASA's total common spending obligated on Agency, government-wide, or best-in-class (BIC) contracts consistent with NASA's Category Management Plan and the Spend Under Management (SUM) key performance indicator.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	N/A	SUM = $4.8B BIC = $1.7M	SUM = 65% BIC = 5%
Achieved	N/A		

Strategic Objective 4.2: Enable space access and services.

LEAD OFFICE
Human Exploration and Operations Mission Directorate (HEOMD)

GOAL LEADER
Altonell (Toni) Mumford, Deputy Associate Administrator for Management, HEOMD

NASA uses private and government capabilities to ensure that people, payloads, and data can be delivered to and from space. NASA achieves this through a portfolio of services and strategic capabilities, including launch services for robotic missions, commercial space transportation for crew and cargo, ground- and space-based communications, and specialized test facilities.

The 2020 Strategic Review determined that NASA's progress for this strategic objective was satisfactory. NASA's strategy is to maintain a minimum capability to achieve mission requirements for all space access and services elements. A primary responsibility in this portfolio, NASA continues to serve as the launch agent for the civil space sector. This includes satellite and robotic planetary mission launches, access to space for human exploration and cargo to and from the International Space Station (ISS) and other low Earth orbit destinations, providing access to responsive and reliable space communication and tracking services for NASA missions, and maintaining the capabilities necessary to execute customer requirements.

NASA's partners for commercial crew have achieved significant milestones with the first launch into orbit from American soil with a crew since the Space Shuttle Orbiters were retired in 2011. The May 30 launch of the SpaceX Demo-2 test flight carried two NASA astronauts to the ISS. The subsequent successful docking

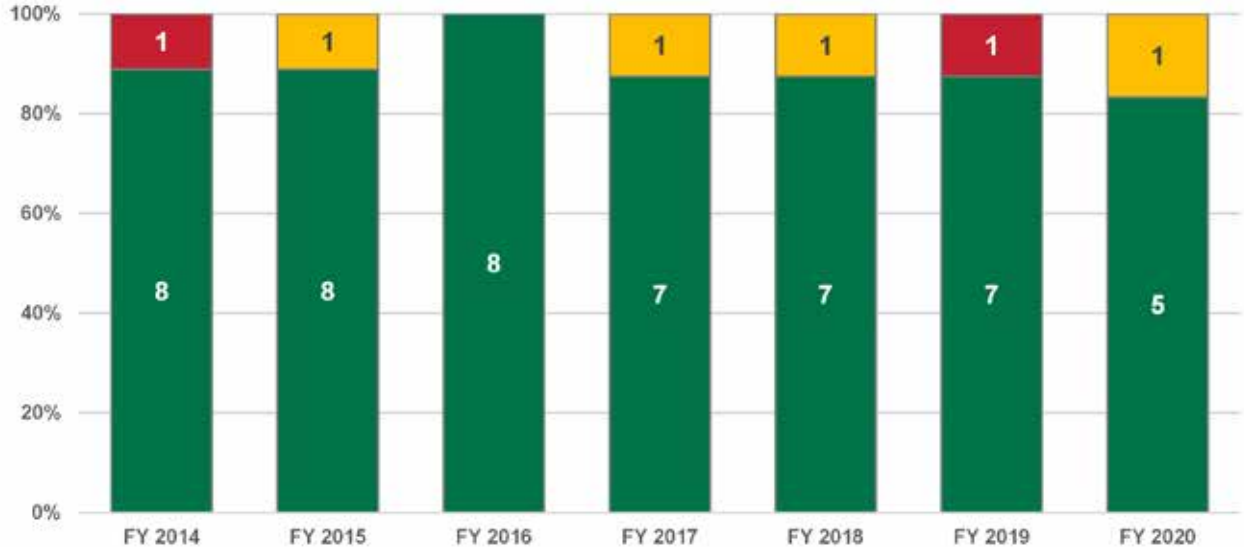
Above: NASA astronaut Douglas Hurley is helped out of the SpaceX Crew Dragon Endeavour spacecraft onboard the SpaceX GO Navigator recovery ship after he and NASA astronaut Robert Behnken landed in the Gulf of Mexico off the coast of Pensacola, Florida, on August 2, 2020. The Demo-2 test flight for NASA's Commercial Crew Program was the first to deliver astronauts to the International Space Station and return them safely to Earth onboard a commercially built and operated spacecraft. Behnken and Hurley returned after spending 64 days in space. Photo Credit: NASA/Bill Ingalls

operations and splashdown completed many of the test objectives of the SpaceX Demo-2 mission. Boeing's December 2019 Orbital Flight Test encountered several anomalies that, among other things, prevented it from demonstrating it could dock with the ISS. On April 6, Boeing announced that it has decided to re-fly the uncrewed test flight of its CST-100 Starliner commercial crew spacecraft. The Boeing CST-100 Starliner re-flight is expected in FY 2021.

NASA provided launch services, test services, and communications support to internal and external customers throughout FY 2020. NASA is successfully managing launch service capabilities across the civil space sector and acquired three launches in FY 2020. The Mars 2020 Perseverance launch campaign was conducted during the COVID-19 pandemic (watch the launch on YouTube), and NASA also managed multiple commercial launch services contract awards, and conducted additional launch service acquisitions for NASA and other civil sector customers. The NASA communications networks continued to perform well above their 95 percent requirement in FY 2020. The Space Communications and Navigation (SCaN) program is aligning upgrades and development activities with both the new SCaN Architecture Study and the Artemis program plans. SCaN is preparing an acquisition strategy that will allow future NASA missions to rely on end-to-end communications services provide by the commercial communications industry. Finally, prior to the COVID-19 pandemic, the rocket propulsion testing capability was successfully utilized at multiple test sites throughout FY 2020, performing nearly 400 tests with a 100 percent facility readiness rating. In early FY 2020, NASA supported over 650 hours of Thermal Vacuum tests on the Artemis I Capsule at the Glenn Research Centers' Plum Brook Station.

Strategic Objective 4.2 programs are implementing their strategies while managing COVID-19 pandemic impacts. Within the portfolio, SCAN's communications networks have maintained nominal operations during the COVID-19 pandemic, with reduced staff; to keep site staff safe, on-site development projects stopped until safety plans and procedures were created, reviewed and implemented. Schedule impacts to NASA FY 2021 launch campaigns remain under evaluation. Finally, five of NASA's rocket propulsion testing facilities were either partially or completely closed in response to localized COVID-19 outbreaks; however, specific mission-essential work was performed with added COVID safety requirements.

Summary of Progress for Performance Goals Contributing to Strategic Objective 4.2, FY 2014—2020



Note: FY 2018—FY 2020 contribute to Strategic Objective 4.2, as established by the NASA 2018 Strategic Plan. For FY 2014 through FY 2017, individual performance goals were assigned to a strategic objective based on contributing work.

4.2.1: Provide cargo transportation through commercial partners to support the International Space Station (ISS).

2015	2016	2017	2018	2019	2020
Green	Yellow	Green	Green	Green	Green

Number of commercial cargo missions launched/delivered to ISS.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	4	4	4
Achieved	4		

The **International Space Station Division**, part of the **Human Exploration and Operations Mission Directorate**, manages commercial resupply services for ISS.

FY 2020 Performance Progress

During FY 2020, NASA executed four Commercial Resupply Services (CRS) missions to support the ISS: Northrop Grumman (NG)-12 berthed to ISS on November 4, 2019; SpaceX (SpX-19) berthed on December 8, 2019; NG-13 berthed on February 18, 2020; and SpX-20 berthed March 9, 2020.

The Northrop Grumman Antares rocket, with Cygnus resupply spacecraft onboard, launches from Pad-0A on February 15, 2020 at NASA's Wallops Flight Facility in Virginia. Photo Credit: NASA/Aubrey Gemignani

The Nanoracks Bishop Airlock is packed in the Dragon spacecraft's trunk on October 12, 2020, inside SpaceX's processing facility at NASA's Kennedy Space Center in Florida for its ride to the International Space Station aboard the company's 21st Commercial Resupply Services (CRS-21) mission. Photo Credit: SpaceX

Mission engineers receive and prepare science and research and food items for the final cargo load into the Cygnus resupply spacecraft onboard the Northrop Grumman Antares rocket on February 8, 2020 at the Horizontal Integration Facility (HIF) of NASA's Wallops Flight Facility in Virginia. Photo Credit: NASA/Aubrey Gemignani

4.2.2: Provide NASA crew transportation through commercial partners to low Earth orbit.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Yellow	Yellow	Yellow

Number of commercial crew missions launched.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	2	2	2
Achieved	1		

The **Commercial Crew Program**, part of the **Human Exploration and Operations Mission Directorate**, is partnering with U.S. industry to fly human space transportation systems.

FY 2020 Performance Progress

In May 2020, for the first time in history, NASA astronauts launched from American soil in a commercially built and operated American crew spacecraft on its way to the ISS on NASA's SpaceX Demo-2 mission. The SpaceX Crew Dragon Endeavor spacecraft successfully delivered astronauts Doug Hurley and Bob Behnken to the ISS 19 hours later. In August, the spacecraft carrying the two astronauts safely splashed down into the Gulf of Mexico.

Successful completion of the FY 2020 target for this performance goal called for both commercial partners conducting their crewed demonstration flight during the fiscal year. While SpaceX successfully completed their crewed flight to the ISS, Boeing did not complete a crewed demonstration of their CST-100 Starliner spacecraft. During an uncrewed orbital test flight conducted in December 2019, the spacecraft experienced some anomalies, including intermittent space-to-ground communication issues. A joint NASA-Boeing independent review team recommended corrective and preventive actions to address in preparation for a second uncrewed orbital flight test in late FY 2021. Boeing plans to conduct a crewed orbital flight test in FY 2022.

Boeing's CST-100 Starliner's four launch abort engines and several orbital maneuvering and attitude control thrusters ignite in the company's Pad Abort Test, pushing the spacecraft away from the test stand with a combined 160,000 pounds of thrust. The test, conducted November 4, 2019, was designed to verify that each of Starliner's systems will function not only separately, but in concert, to protect astronauts by carrying them safely away from the launch pad in the unlikely event of an emergency prior to liftoff. Photo Credit: NASA JSC/Boeing

4.2.3: Maximize the availability of propulsion test facilities that support NASA's test requirements.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

Percentage availability.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	90%	90%	90%
Achieved	99.7%		

NASA's **Rocket Propulsion Test program**, part of the **Human Exploration and Operations Mission Directorate**, manages rocket propulsion test facilities, activities, and resources.

FY 2020 Performance Progress

NASA exceeded the FY 2020 target of 90 percent availability for this performance goal, with over 700 tests conducted. Only two facility delays occurred, resulting in 99.7 percent availability for the fiscal year. All on-site work was conducted according to health and safety guidance.

Below: Delivery and installation of NASA's Space Launch System (SLS) rocket's first core stage to Stennis Space Center for a milestone Green Run test series prior to its Artemis I flight. The SLS core stage, the largest rocket stage ever built by NASA, stands 212 feet tall and measures 27.6 feet in diameter. Crews upgraded the B-2 test stand's high-pressure sound suppression water system to dump hundreds of thousands of gallons on the test stand during the hotfire test. The B-2 test stand is located at Stennis Space Center in southern Mississippi. Photo Credit: NASA/SSC

4.2.4 [Ends in FY 2020]: Complete Launch Services Program (LSP) objectives for NASA-managed expendable launches.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

Percentage of expendable launch objectives successfully completed.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	100%	PG Discontinued	PG Discontinued
Achieved	100%		

FY 2020 Performance Progress

NASA effectively managed launch service capabilities across the civil space sector, as evidenced by three successful launches from Cape Canaveral Air Force Station, Florida, in FY 2020:

- The Ionospheric Connection Explorer (ICON) mission on October 10, 2019, on a Pegasus XL rocket
- The Solar Orbiter spacecraft on February 10, 2020, on an Atlas V rocket
- The Mars 2020 Perseverance Rover mission on July 30, 2020, on an Atlas V rocket, during the COVID-19 pandemic

NASA is also managing multiple awarded commercial launch services and conducting additional launch service acquisitions for NASA and other civil sector customers.

NASA's **Launch Services Program**, part of the **Human Exploration and Operations Mission Directorate**, is responsible for acquiring and launching expendable launch vehicles.

Both halves of a United Launch Alliance Atlas V payload fairing come together around the Solar Orbiter spacecraft inside the Astrotech Space Operations facility in Titusville, Florida, on January 20, 2020. The fairing provides a protective, aerodynamic cover to the payload inside during the early minutes of ascent. Solar Orbiter is an international cooperative mission between ESA (European Space Agency) and NASA. The mission aims to study the Sun, its outer atmosphere and solar wind. The spacecraft will provide the first images of the Sun's poles. NASA's Launch Services Program based at Kennedy Space Center in Florida is managing the launch. Solar Orbiter launched aboard an Atlas V rocket on February 10, 2020, from Space Launch Complex 41 at Cape Canaveral Air Force Station in Florida. Photo Credit: NASA/Ben Smegelsky

4.2.4 [Begins in FY 2021]: Complete Launch Services Program (LSP) commercial launch services objectives for NASA-managed science, exploration, U.S. Government, and Government-sponsored missions.

Commercial launch services objectives successfully completed.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	N/A	100% of primary manifested missions successfully launched	100% of primary manifested missions successfully launched
Achieved	N/A		

NASA's **Launch Services Program**, part of the **Human Exploration and Operations Mission Directorate**, is responsible for acquiring and launching expendable launch vehicles.

4.2.5: Maintain the delivery of Space Communications network services.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

Percent of delivery.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	96%	96%	96%
Achieved	96%		

Space Communications and Navigation, part of the **Human Exploration and Operations Mission Directorate**, manages NASA's ground-based communications facilities and services and the Tracking and Data Relay Satellites.

FY 2020 Performance Progress

NASA's communications networks—the Deep Space Network, the Space Network, and the Near Earth Network—have maintained nominal operations during the COVID-19 pandemic, despite reduced staff. NASA stopped on-site development projects until safety plans and procedures were created, reviewed, and implemented.

4.2.6: Maximize the availability of the Space Environment Testing Management Office (SETMO) portfolio of assets to meet NASA's current and future test facility needs.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

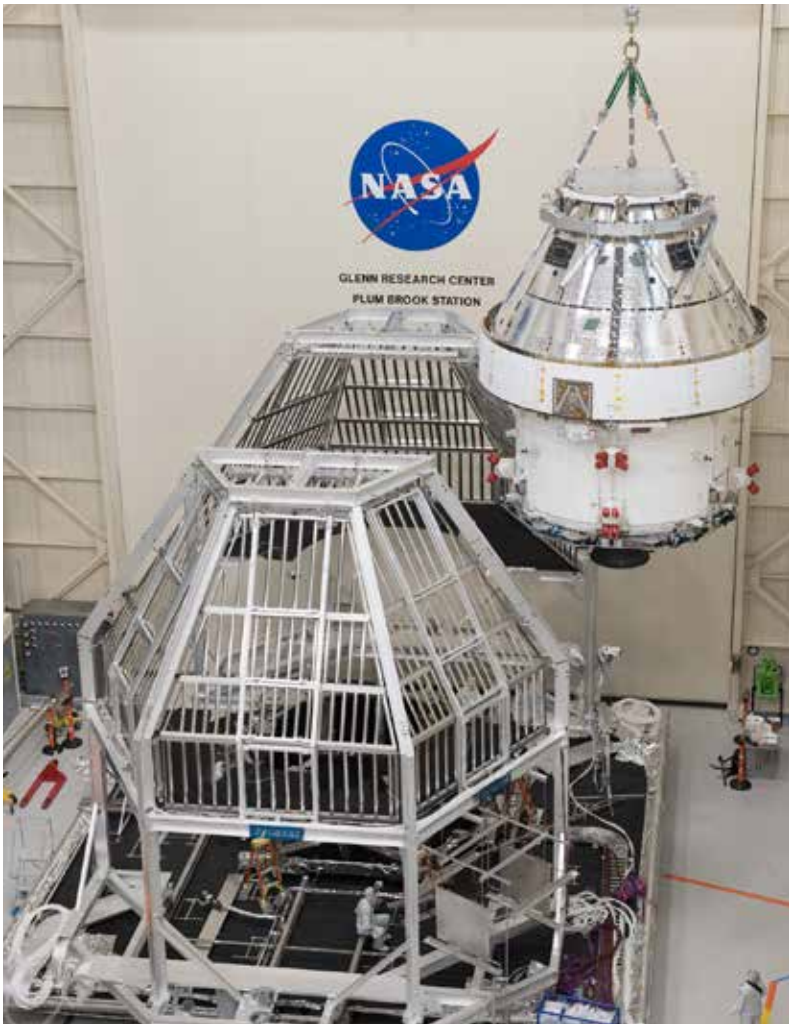
Percent overall availability of SETMO portfolio assets.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	90%	90%	90%
Achieved	98%		

The **Space Environments Testing Management Office**, part of the **Mission Support Directorate**, manages NASA's shared capabilities and assets used to conduct testing in a simulated space environments.

FY 2020 Performance Progress

NASA accomplished 98.2 percent overall availability of its SETMO portfolio assets, exceeding the FY 2020 target of 90 percent. NASA's workforce performs essential preventive maintenance to ensure that its key capabilities and critical assets will continue to be available in the future to support the missions that require them. Core capabilities include thermal vacuum chambers, simulators, and the Arc Jet Complex, located at NASA's Ames Research Center in California. NASA implements strategic investment decisions to sustain, enhance, replace, modify, or dispose of facilities based on NASA's and national needs.



NASA's Orion spacecraft, the crew module and European-built service module, is lifted into a thermal cage and readied for its move into the vacuum chamber at NASA's Plum Brook Station for testing. Testing began with a 60-day thermal test, where the spacecraft was subjected to temperatures ranging from -250 to 300-degrees Fahrenheit to ensure it can withstand the harsh environment of space during Artemis missions. Photo Credit: NASA/Marvin Smith

Strategic Objective 4.3: Assure safety and mission success.

LEAD OFFICE

Technical Authorities: Office of the Chief Engineer (OCE), Office of the Chief Health and Medical Officer (OCHMO), and Office of Safety and Mission Assurance (OSMA)

GOAL LEADER

Mark Weyland, Director, Medical Policy and Ethics

NASA uses discipline experts, known as Technical Authorities, to provide authoritative and independent decisions on application of requirements across the Agency's programs and projects. This includes evaluating hardware, software, environmental conditions, and human performance expectations. Technical Authorities identify hazards, including the impacts of new requirements and departures from existing requirements, and evaluate risk acceptability. NASA uses these decisions to assure that risks are addressed or mitigated to an acceptable level, improving the likelihood that missions, programs, and operations will be completed safely and successfully. NASA's Technical Authorities are increasing awareness and reducing risk across the Agency through their roles and are at a satisfactory performance rating.

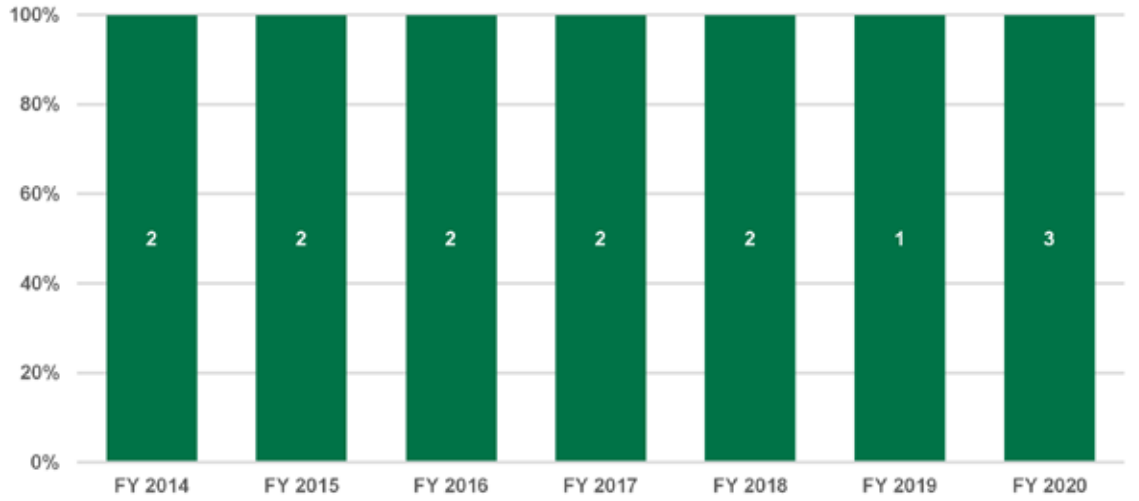
In 2019, NASA rated this strategic objective as a Focus Area for Improvement. The 2020 Strategic Review determined that NASA's performance in this area was satisfactory. The technical authorities continued to provide sound, relevant, and independent advice to NASA's programs, projects, and leadership.

NASA's Technical Authorities increased awareness and reduced risk across the agency through their roles and are at a satisfactory performance rating. During 2019, NASA established applicable safety, engineering, and health policy directives and

Above: The James Webb Space Telescope has the largest mirror of its kind that NASA has ever built. So big that it can't fit inside a rocket without folding up. In early March 2020, testing teams deployed Webb's 21 feet 4-inch (6.5 meter) primary mirror into the same configuration it will have when in space. NASA worked with its contractors to identify mission-critical, schedule-sensitive work that required on-site operations and to ensure staff followed safety and health guidance. OCHMO has provided critical input to the NASA COVID-19 Response Plan and Guidelines for a Safe Workplace. Photo Credit: Northrop Grumman

procedural requirements, and assured that the directives and requirements were appropriately implemented. NASA continued to enhance training programs, knowledge sharing events, and communications to expand Safety and Mission Assurance awareness and technical expertise, while updating NASA guidance on orbital debris mitigation, planetary protection, and nuclear safety in accordance with presidential direction and advisory panel recommendations. The Agency also continued to establish early, consistent and proper level of engagement (Standards Development, Requirements Definition, Design, Development, Test and Evaluation) with NASA programs and commercial space industry to advise, advocate, and ensure the health and performance of astronauts and pilots.

Summary of Progress for Performance Goals Contributing to Strategic Objective 4.3, FY 2014—2020



Note: FY 2018—FY 2020 contribute to Strategic Objective 4.3, as established by the NASA 2018 Strategic Plan. For FY 2014 through FY 2017, individual performance goals were assigned to a strategic objective based on contributing work.

4.3.1: Acheive zero fatalities or permanent disabling injuries to the public resulting from NASA activities.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

Number of fatalities or permanent disabling injuries.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	0	0	0
Achieved	0		

The **Office of Safety and Mission Assurance**, **Office of the Chief Health and Medical Officer**, and **Office of the Chief Engineer** ensure safety and mission success by providing independent oversight of NASA's programs and projects. They are supported by the **NASA Safety Center** and the **Katherine Johnson IV&V Facility**.

FY 2020 Performance Progress

There were zero fatalities or disabling injuries to the public or NASA employees during FY 2020 as a result of NASA activities. There was extensive planning and execution of risk mitigation controls prior to all aerospace flight operations and potentially hazardous operations to achieve this performance goal.

4.3.2: Reduce damage to NASA assets (excluding launched flight hardware).

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Red

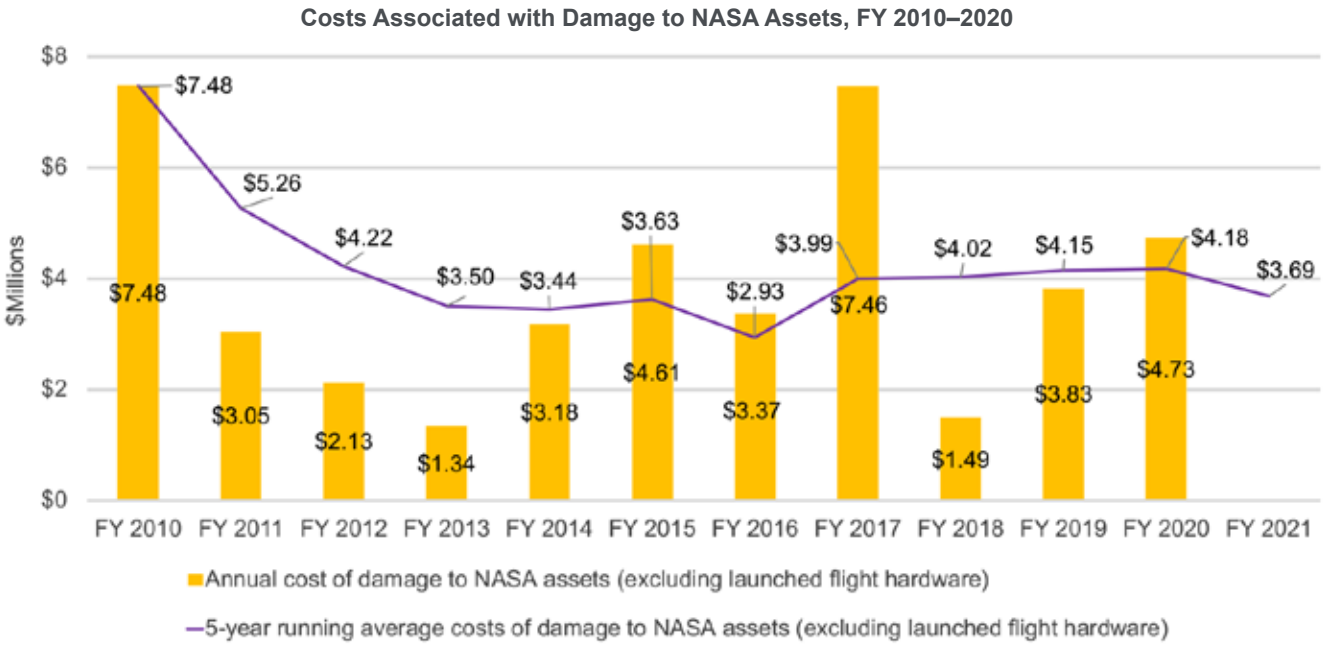
Level less than 5-year running average.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	$3.85M	$3.69M	TBD
Achieved	$4.73M		

The **Office of Safety and Mission Assurance**, **Office of the Chief Health and Medical Officer**, and **Office of the Chief Engineer** ensure safety and mission success by providing independent oversight of NASA's programs and projects. They are supported by the **NASA Safety Center** and the **Katherine Johnson IV&V Facility**.

FY 2020 Performance Progress

In FY 2020, NASA's non-mission-related damage costs were $4.727 million, primarily due to a transformer fire at Glenn Research Center in May 2020. This was above the historical average of $3.8 million.



4.3.3: Ensure the health, safety, and performance of NASA astronauts and pilots.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

Number of non-concurrence determinations and percentage of program variances.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	0 non-concurrence determinations; 5% or fewer program variances	0 non-concurrence determinations; 5% or fewer program variances	0 non-concurrence determinations; 5% or fewer program variances
Achieved	0 non-concurrence determinations; 0% or fewer program variances		

*Performance goal under review for alignment with draft 2022 Strategic Plan.

The **Office of Safety and Mission Assurance**, **Office of the Chief Health and Medical Officer**, and **Office of the Chief Engineer** ensure safety and mission success by providing independent oversight of NASA's programs and projects. They are supported by the **NASA Safety Center** and the **Katherine Johnson IV&V Facility**.

FY 2020 Performance Progress

In FY 2020, the Health and Medical Technical Authority (HMTA) issued no non-concurrences with respect to major program milestones. In addition, the HMTA issued no program variances from the technical standards.

Meeting these targets enables NASA to accomplish all of its missions safely and in the most cost-effective ways. Given the cadence of NASA's human spaceflight missions, the FY 2021 budget increases resources for the HMTA to improve its ability to develop the appropriate standards, assess and advise programs on implementation, prioritize amongst and between programs, or evaluate requests for waiver or risk mitigations for all NASA programs that are in development, in a time-critical manner. However, this increase does not provide full baseline funding.

As current programs (e.g., International Space Station, Orion, and Space Launch System) become more heavily invested and more programs and projects (e.g., Mars Architecture Team, Lunar Hab, Commercial Programs) come online, HMTA will need to expand to fully cover all required areas. Budget challenges in FY 2022 will derail the progress made in FY 2021.

In addition, all measures to prevent COVID-19 infection as directed by NASA's Office of the Chief Health and Medical Officer were carefully implemented by essential center civil service and contractor employees.

Strategic Objective 4.4: Manage human capital.

LEAD OFFICE
Mission Support Directorate (MSD) and Office of the Chief Human Capital Officer (OCHCO)

GOAL LEADER
Robert Gibbs, Associate Administrator, MSD

NASA is cultivating a diverse and innovative workforce with the right balance of skills and experience to provide an inclusive work environment in which employees that possess varying perspectives, life experiences, and backgrounds can work together and remain fully engaged in the Mission. NASA strategy for this objective is to equip NASA for mission success by supporting mission workforce planning, acquiring top talent quickly, enhancing how people work, and growing employees and leaders, and to create an inclusive environment for all NASA employees to feel engaged and safe to raise concerns.

The 2020 Strategic Review determined that NASA made satisfactory progress. In July 2020, NASA announced that Inclusion would be added as one of its core values. This new core value will be incorporated into NASA's 2022 Strategic Plan. NASA is rolling out its strategy on creating an inclusive environment for all employees through its Unity Campaign. A survey was conducted to assess how the roll-out is going. Over 50 percent of responding employees were familiar with the campaign and 45 percent stated that their supervisor supported the campaign. Overall, NASA views the results positive at this stage of the early campaign rollout. NASA also had over 10,000 employees participate in over 500 facilitated Diversity Dialogues. They allowed candid discussion of social issues, and a safe place for employees to

Above: In celebration of Women's History Month, the "Women of Launch Control" working in Exploration Ground Systems take time out of their Artemis I launch planning to pose for a photo in Firing Room 1 of the Launch Control Center at NASA's Kennedy Space Center in Florida on March 4, 2020. NASA's diverse and innovative workforce are fully engaged in NASA's Mission. Photo Credit: NASA/Glenn Benson

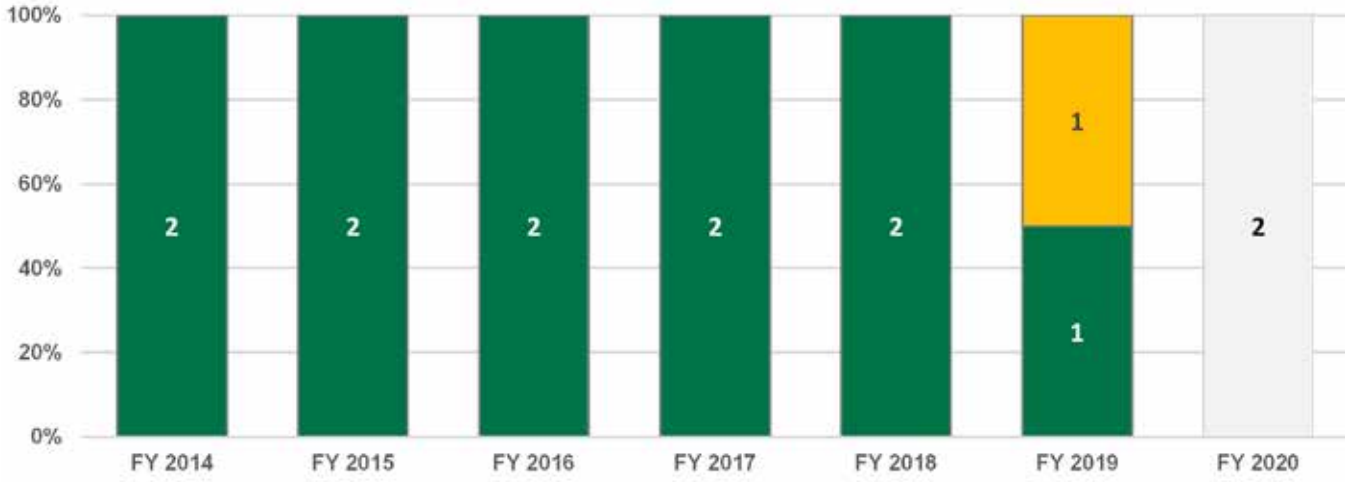
express themselves and increase collaboration, connection and communication.

Beginning in 2019, NASA experienced an increase in the average "time to hire," and the number of open hiring requests that had not issued a certificate. These increases occurred during a migration of staffing services to the NASA Shared Services Center, a temporary pause in new hiring requests, and a large increase in demand. In 2020, the Agency was at a five-year low in the Human Capital Customer Satisfaction rating (as measured by the General Services Administration's Mission Support Survey). NASA took steps to reduce the "time to hire" and hiring backlog by taking advantage of several new hiring authorities. These measures, along with process improvements, helped eliminate its hiring backlog. By the end of 2020, NASA was exceeding staffing production targets and issuing certificates within 25 days of receipt on a consistent basis.

In October 2019, NASA established a new Agency Position Description classification process, reducing the time required to classify positions by more than 90 percent. NASA's new strategic workforce planning process emphasized the development of center strategic workforce plans to improve workforce agility.

While Strategic Objective 4.4 has a clear strategy for success, there were adverse impacts due to the COVID-19 pandemic. NASA's learning and development strategy required a large-scale transition from in person classes to virtual learning. The Federal Employee Viewpoint Survey was delayed six months and shortened, affecting OCHCO's ability to evaluate several performance metrics. OCHCO experienced a large increase in requests for virtual collaboration, organizational development support, and training for supervisors on managing a virtual workforce. There was also an increased workload in data analytics, including COVID-19 dashboards and employee surveys. Virtual onboarding for new NASA employees was successful and allowed NASA to continue regular hiring activities for critical positions.

Summary of Progress for Performance Goals Contributing to Strategic Objective 4.4, FY 2014—2020



Note: FY 2018—FY 2020 contribute to Strategic Objective 4.4, as established by the NASA 2018 Strategic Plan. For FY 2014 through FY 2017, individual performance goals were assigned to a strategic objective based on contributing work.

4.4.1 [Ends in FY 2021]: Sustain NASA's employees' perceptions of innovation climate, as measured by the Innovation-related questions on the Federal Employee Viewpoint Survey (FEVS), through Human Capital Programs and tools that support NASA employees.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	White

Agency FEVS Innovation score.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	84%	84%	Discontinued*
Achieved	Unable to assess		

*NASA is developing a new strategic plan and anticipates replacing this objective.

The **Office of the Chief Human Capital Officer**, part of the **Mission Support Directorate**, helps NASA maintain an adaptable and skilled workforce through strategic workforce planning, management services, and staff training and development. Visit **NASAPeople** for more information about the Human Capital Program, careers at NASA, and other workforce information.

FY 2020 Performance Progress

NASA was unable to assess progress toward achieving this performance goal in FY 2020 due to lack of data resulting from changes to the 2020 FEVS. In June 2020, the Office of Personnel Management (OPM), which conducts the survey, announced that it had reworked the survey—a measurement of Federal employees' perceptions of workplace experiences, leadership, and culture—to cut some of the standard questions and add questions related to the COVID pandemic. Among the questions cut were the innovation-related questions used to assess this performance goal.

NASA Deputy Administrator, Jim Morhard (through January 2021), left, poses for a photo with Max Stier, president and chief executive officer of the Partnership for Public Service, after accepting the Best Place to Work award for large federal government agencies for NASA on January 10, 2020. NASA received the award based on civil servant responses to the FY 2019 FEVS. Photo Credit: NASA/Aubrey Gemignani

4.4.2: Sustain NASA employees' perceptions of inclusion, as measured by the New Inclusion Quotient (New IQ) index scores on the annual Federal Employee Viewpoint Surveys (FEVS), through Diversity Equal Opportunity programs and tools that support NASA employees.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	White

Agency FEVS New IQ Index score.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	70%	70%	70%
Achieved	Unable to assess		

The **Office of Diversity and Equal Opportunity (ODEO)** leads diversity and civil rights policies, programs, and services, enabling the universe of available talent to contribute inclusively and equitably to NASA. ODEO is an Administrator Staff Office.

FY 2020 Performance Progress

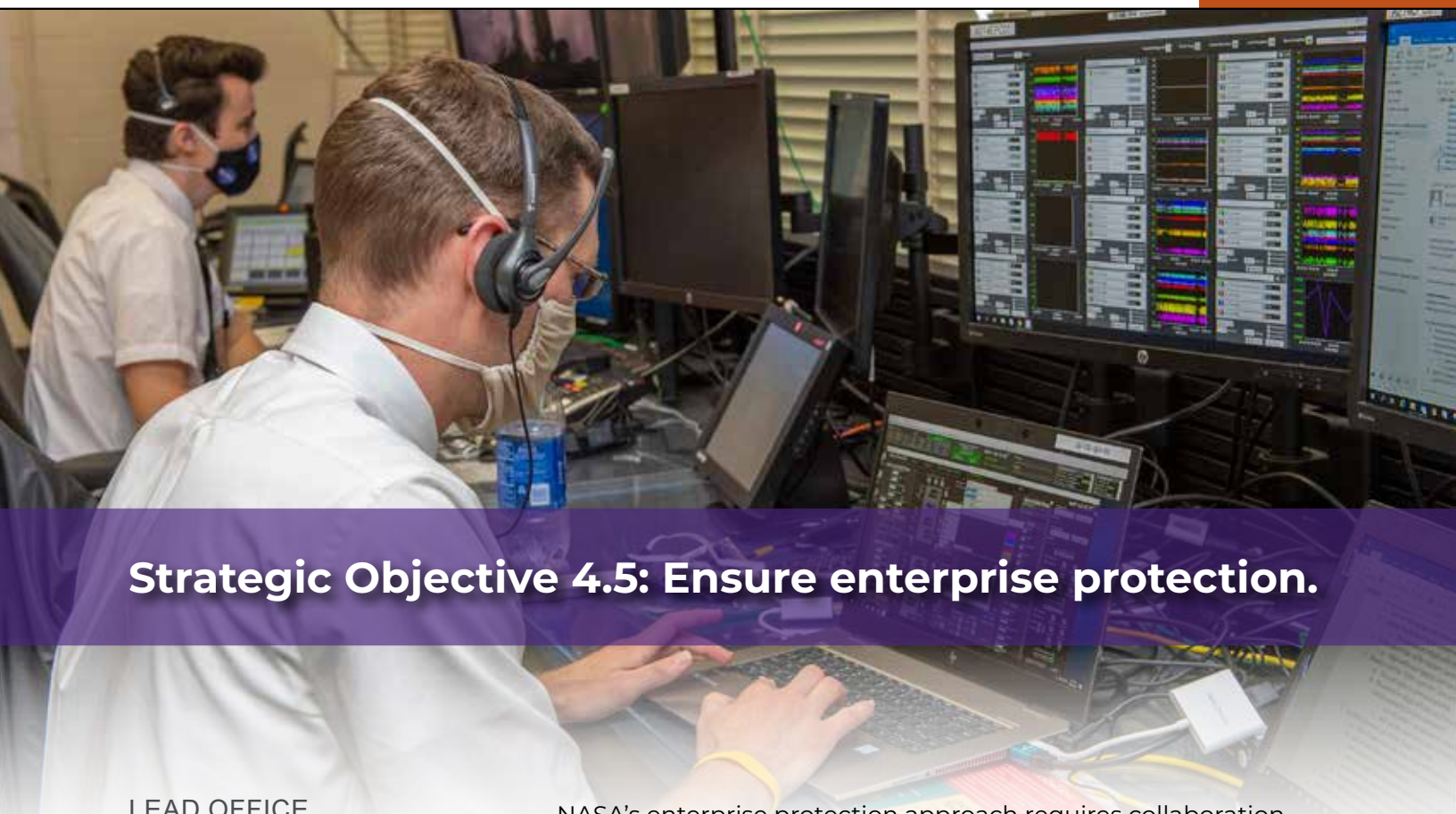
NASA was unable to assess progress toward achieving this performance goal in FY 2020 due to lack of data resulting from changes to the 2020 FEVS. In June 2020, OPM, which conducts the survey, announced that it had reworked the survey to cut some of the standard questions and add questions related to the COVID pandemic. Of the 20 questions that normally comprise the New IQ index score, only 9 questions were included in the shortened 2020 survey.

4.4.3 [Begins in FY 2021]: Improve employees' perception of NASA as an equal opportunity and anti-harassment workplace, as measured by the Federal Employee Viewpoint Survey (FEVS) questions focused on equal employment opportunity (EEO) and anti-harassment compliance, through customer service scores, and completion of NASA/MAP deliverables for EEO compliance.

Percentage of NASA FEVS EEO and anti-harassment compliance scores.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	N/A	75%	75%
Achieved			

The **Office of Diversity and Equal Opportunity** leads diversity and civil rights policies, programs, and services, enabling the universe of available talent to contribute inclusively and equitably to NASA.



Strategic Objective 4.5: Ensure enterprise protection.

LEAD OFFICE
Office of the Chief Information Officer (OCIO) and Enterprise Protection Program (EPP)

GOAL LEADER
Jeff Seaton, Acting Chief Information Officer and David Adams, Principal Advisor for Enterprise Protection

NASA's enterprise protection approach requires collaboration across all parts of the Agency, as well as with NASA's Federal and commercial partners. The Agency established a periodic cross-cutting dialogue for information sharing, and the Enterprise Protection Board addresses emerging protection topics that require strategic collaboration. NASA is partnering with the Department of Homeland Security to modernize, and consolidate where appropriate, the Agency's cybersecurity infrastructure in alignment with the National Institute of Standards and Technology (NIST) cybersecurity framework.

The 2020 Strategic Review determined that NASA made satisfactory progress on this strategic objective. NASA maintained an overall rating of "Managing Risk" based on its quarterly Federal Information Security Modernization Act (FISMA) Assessment reports, the highest score for federal agencies to demonstrate progress toward implementing fundamental cybersecurity requirements. The Agency continued implementing a strategy to increase visibility into the security posture of NASA's enterprise systems and data, manage enterprise protection risk by maintaining a comprehensive risk management process, and to enable an adaptable resilience process that proactively ensures enterprise protection requirements are addressed throughout the life cycle of NASA's programs, projects, and activities.

Above: Stewart Whaley, Cameron Muelling, foreground, and teams at NASA's Marshall Space Flight Center help monitor launch conditions for the Demo-2 mission from the Huntsville Operations Support Center. This Alabama-based, multi-mission facility is capable of distributing secure mission voice, video, and data anywhere in the world. NASA's enterprise protection approach helps reduce risks, such as cybersecurity threats, that would interfere with this vital mission support. Photo Credit: NASA/Emmett Given.

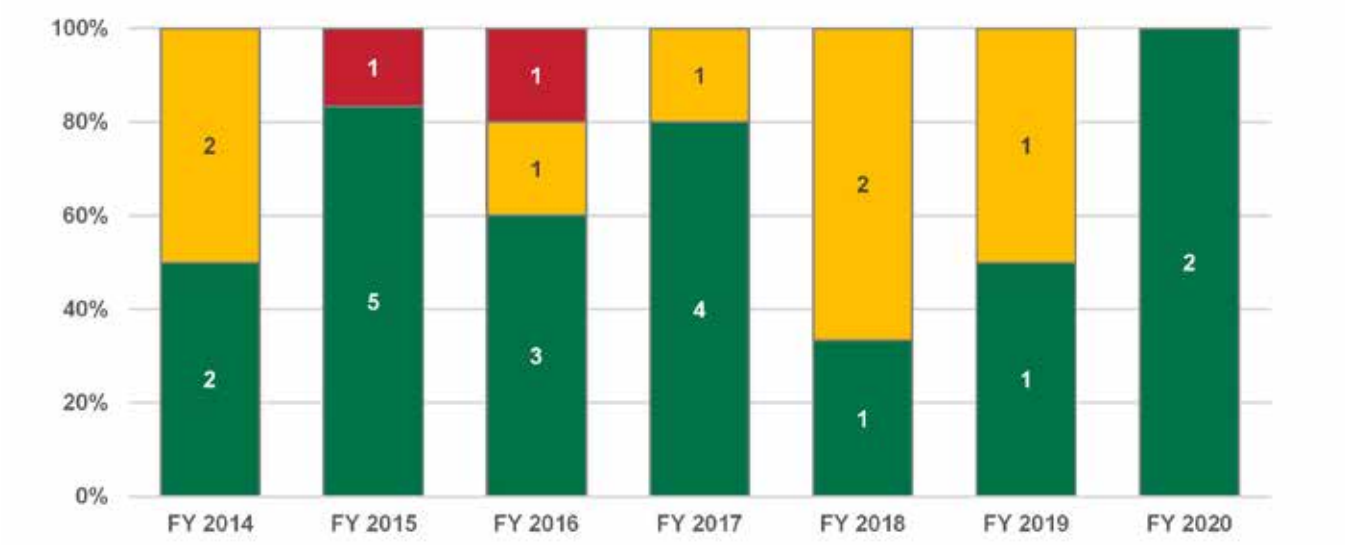
NASA continued to ensure Agency-wide resilience. EPP implemented new policies and updated existing ones, chartered the Enterprise Protection Board, and issued standards for space system protection. Four classified meetings enabled raising threats and risks from malicious sources and determined cross-Agency mitigation approaches. A classified threat portal provided a single location for curated threat information from other agencies. NASA established a cross-Agency Cybersecurity Task Team that benchmarked four external space organizations, and seven internal organizations. The Team made recommendations to the Enterprise Protection Board to improve mission cybersecurity culture and risk posture by instilling cybersecurity risk management into all aspects of mission work to support mission success, safety, and security.

The Agency strengthened its operational technology security posture and closed all remaining operational technology security recommendations from the Office of Inspector General (OIG) in its 2017 report, *Audit of Industrial Control System Security within NASA's Critical and Supporting Infrastructure*. By the end of FY 2020, more than 50 percent of operational technology systems that are part of NASA's critical infrastructure were assessed and granted an Authorization to Operate (ATO) in accordance with the Risk Management Framework as outlined in NIST 800-37 and NASA policies and requirements.

To identify assets on the network and cybersecurity vulnerabilities to remediate, NASA continued to deploy continuous diagnostics and mitigation (CDM) technologies across the Agency. By the end of FY 2020, NASA increased its software asset management to 100 percent and hardware asset management remained at 67 percent, increasing central visibility into all assets on NASA's network. OCIO is working with mission directorates and the Jet Propulsion Laboratory to consistently deploy sensors that detect and alert on unauthorized hardware and software on NASA's networks. OCIO partnered with the Human Exploration and Operations Mission Directorate to embed a cybersecurity executive in the Artemis program to evaluate applicable cybersecurity requirements.

While Strategic Objective 4.5 has a clear strategy for success, there have been impacts due to the COVID-19 pandemic. In response to the pandemic, NASA expanded its collaborative work environment to enable secure, remote work. Cybersecurity threats and risks increased across the Agency, necessitating fortification of enterprise protection methods while delaying some of the planned 2020 efforts to increase cybersecurity resiliency.

Summary of Progress for Performance Goals Contributing to Strategic Objective 4.5, FY 2014—2020



Note: FY 2018—FY 2020 contribute to Strategic Objective 4.5, as established by the NASA 2018 Strategic Plan. For FY 2014 through FY 2017, individual performance goals were assigned to a strategic objective based on contributing work.

4.5.1: Safeguard NASA's data and IT assets by implementing cybersecurity and privacy capabilities.

2015	2016	2017	2018	2019	2020
Yellow	Green	Red	Yellow	Yellow	Green

Percentage of cybersecurity capability Cross-Agency Priority (CAP) goals met from performance.gov

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	100%*	100%	100%
Achieved	70%		

*Target represents the long-term exemplar for this performance goal. NASA assesses annual progress based on an interim target.

The **Office of the Chief Information Officer (OCIO)** manages the information technology (IT) and data that enable NASA's missions. Through strategic partnering across NASA and with the Department of Homeland Security (DHS), the OCIO is ensuring that critical mission and infrastructure systems have resilient cybersecurity, back-up, and disaster recovery capabilities.

FY 2020 Performance Progress

NASA achieved the incremental progress expected in FY 2020 for the multi-year performance goal target of 100 percent of CAP goals met. NASA currently meets seven of ten (70 percent) of cybersecurity CAP goal targets on Performance.gov, exceeding its target of meeting at least 60 percent in FY 2020. NASA achieved this performance through 100 percent deployment of DHS CDM tools on the corporate network, as well as significantly increasing coverage on mission networks. These changes provide a holistic view of NASA's vulnerability profile and enterprise capabilities to secure its assets. Additionally, CDM tools and Agency initiatives enabled NASA to increase enforcement of personal identity verification (PIV) authentication and develop a variety of PIV solutions for unique Agency systems.

NASA is below target in Hardware Asset Management, High Value Asset (HVA) System Access Management, and Data Protection. The Agency's implementation of an enterprise-wide network access control solution, selected in 2020, will increase NASA's Hardware Asset Management score. Additionally, the Agency executed an HVA education initiative in 2020, which led to an increase in HVA System Access Management to 58 percent. NASA met the Data Protection target in FY 2019 but is below the FY 2020 target due to a reporting change by DHS and challenges related to cybersecurity tool implementation and the HVA documentation process.

4.5.2: [Ends in FY 2021] Improve the security of the NASA operational technology (OT) systems that are part of NASA Critical Infrastructure (NCI) in order to ensure they operate safely and securely in the face of the changing threat environment.

2015	2016	2017	2018	2019	2020
None before FY 2019				Green	Green

Percentage of OT systems that are part of NCI that have been assessed and granted an Authorization to Operate (ATO) in accordance with the Risk Management Framework (RMF), as outlined in National Institute of Standards and Technology (NIST) 800-37 and NASA policies and requirements.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	100%*	100%	Discontinued
Achieved	50%		

*Target represents the long-term exemplar for this performance goal. NASA assesses annual progress based on an interim target.

The **Enterprise Protection Program** is working with the **Office of the Chief Information Officer**, **Office of Protective Services**, **Office of Strategic Infrastructure**, **Office the Chief Engineer**, and mission directorates to ensure the security of NASA's operational technology.

FY 2020 Performance Progress

NASA achieved the incremental progress expected in FY 2020 for the multi-year performance goal target of 100 percent operational technology systems receiving an ATO. NASA made progress on improving the security and resiliency of the Agency's operational technology systems, but has not yet achieved the target for this multi-year performance goal to ensure safe and secure operation of NCI. The Agency completed a policy compliance data call for operational technology systems that are part of NCI assets to ensure that these types of systems have been assessed and granted an ATO in accordance with the Risk Management Framework as outlined in NIST 800-37 and NASA policies and requirements.

By the end of FY 2020, more than 50 percent of operational technology systems that are part of NCI were assessed and granted an ATO in accordance with RMF as outlined in NIST 800-37 and NASA policies and requirements.

Strategic Objective 4.6: Sustain infrastructure capabilities and operations.

LEAD OFFICE
Mission Support Directorate (MSD)

GOAL LEADER
Robert Gibbs, Associate Administrator, MSD

NASA is providing the facilities, tools, and services required to efficiently manage, operate, and sustain the infrastructure necessary to meet mission objectives. NASA has adopted a facilities maintenance and operation philosophy that proactively pursues and adopts the safest, most cost-effective blend of reliability-centered maintenance techniques, sustainability practices, and safety procedures. An Agency facilities master plan establishes priorities (over a 20-year projection) for construction, demolition, and maintenance. NASA uses a centralized approach in providing standardized, timely, and accurate business support for services.

In spring 2020, NASA's Strategic Review assessed this to be a focus area for improvement for the second year. While NASA has made significant improvement over the past year and continues to address issues and challenges related to its aging infrastructure, the Strategic Review still found that work needs to be done. NASA is working to make improvements for this objective through implementing a strategy to ensure NASA's infrastructure is available and affordable, guide Agency investments to mission critical assets to increase the facility condition, increase availability and reduce the risk of unplanned failures, and improve NASA's ability to operate facilities sustainably and

Above: The new Measurement Systems Laboratory building at Langley Research Center in Hampton, Virginia, receives some final touches as it nears the end of construction on September 11, 2020. It is the fourth new building constructed under the center's revitalization plan. Photo Credit: NASA

reduce overall resource demands through sustained (year-over-year) reduction of Agency energy/water use intensity.

NASA has made progress towards meeting its near-term success criteria for this objective which are essential for developing an Agency-wide infrastructure modernization plan, but the Agency continues to face looming issues and challenges with its extremely aging infrastructure and unplanned maintenance. Budget challenges have impacted the Agencies ability to meet its performance goals. NASA is currently striving to improve its ratio of unscheduled maintenance versus total maintenance. In an effort to increase facility reliability, NASA has implemented practices to help drive its ratio of unscheduled maintenance to total maintenance to 25 percent or lower and continue its goal to reduce its overall cost of ownership through the Agency's reduction of aging and unneeded infrastructure.

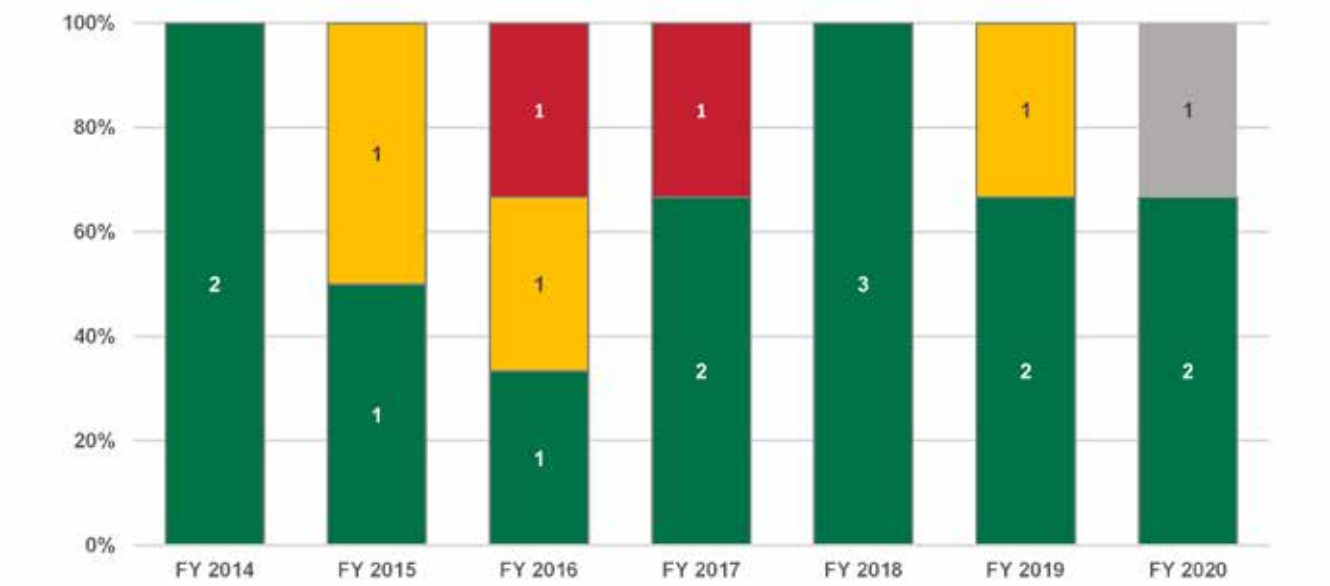
NASA is making progress towards updating its Mission Dependency Index (MDI) score for all of its facilities in an effort to identify the high MDI facilities and correlate them to the Facility Condition Index (FCI). MDI and FCI correlation will guide prioritization for capital repair and renewal projects. The Agency continues to demolish facilities with low MDI and low FCI and NASA's midterm goal is to use this information to inform repair and renewal investments, prioritize maintenance through a tiered maintenance system, and leverage Condition-Based Maintenance and Reliability Centered Maintenance.

NASA has had a challenge in meeting its energy and water reduction goals. In order to meet this challenge, the Agency will analyze Significant Energy Users that have not traditionally been included in energy conservation measures analyses due to their unique mission applications (e.g., wind tunnels, high pressure compressed air plants). The analysis will identify and prioritize energy/water consumption reduction investments.

While Strategic Objective 4.6 has a clear strategy for success, the following are impacts due to the COVID-19 pandemic. While energy and water use initially decreased at most centers due to closures during the beginning of the COVID-19 pandemic, NASA is expecting an increase in consumption as NASA personnel return to work. This increase is primarily caused by changes in facility heating, ventilation, and air conditioning (HVAC) operations. Centers are following Centers for Disease Control and Prevention and industry best practices for ensuring adequate ventilation, filtration and air changes to prevent the airborne spread of the novel coronavirus causing COVID-19. Increased HVAC run times, use of 100 percent outside air, and more efficient air filtration all increase energy and water use.

COVID-19 closures have reduced scheduled and preventative maintenance at all NASA centers; majority of routine inspections not performed. It is anticipated that maintenance backlog will persist beyond full reopening. Upon closure of the NASA centers due to the Coronavirus pandemic, a great majority of the ongoing NASA Construction of Facilities (CoF) projects were halted. Only a small number of projects that were deemed to be "mission essential" continued without interruption. To date, most of the CoF projects have restarted to some capacity. However, expenses continue to accrue for the CoF projects that were halted. In addition, these delays will impact annual progress on Sustainable Facilities, as well as implementation of projects improving energy/water efficiency.

Summary of Progress for Performance Goals Contributing to Strategic Objective 4.6, FY 2014—2020



Note: FY 2018—FY 2020 contribute to Strategic Objective 4.6, as established by the NASA 2018 Strategic Plan. For FY 2014 through FY 2017, individual performance goals were assigned to a strategic objective based on contributing work.

4.6.1: Demolish and eliminate obsolete and unneeded facilities to reduce the Agency's overall footprint.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

Square footage or facilities reduced.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	100k sq ft or 20 facilities	100k sq ft or 20 facilities	100k sq ft or 20 facilities
Achieved	51 facilities (68,250 sq ft)		

The **Office of Strategic Infrastructure**, part of the **Mission Support Directorate**, strategically manages NASA's assets and capabilities to meet mission needs and support Agency operations.

FY 2020 Performance Progress

NASA demolished 51 facilities or structures (a total reduction of 68,250 square feet) during FY 2020, exceeding the target of 20 facilities or structures, but representing less than the targeted reduction for square footage. For FY 2020, NASA's operating budget was reduced to $13 million from an initial plan of $25 million for demolition. This reduction resulted in fewer building demolished.

NASA's demolition program eliminates inactive and obsolete facilities, improves energy efficiency, reduces the Agency footprint, and eliminates safety and environmental liabilities. Demolishing these facilities also eliminates the deferred maintenance on assets in these facilities and saves operations and maintenance expenses. The constrained demolition plan for FY 2020 limited NASA's ability to further reduce operations and maintenance expenses by a proportional margin.

4.6.2: Improve NASA's ability to operate facilities sustainably and reduce overall resource demands.

2015	2016	2017	2018	2019	2020
Yellow	Yellow	Green	Green	Yellow	Unrated

Percentage of sustainability goals met annually in the OMB Scorecard for Efficient Federal Operations/Management.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	≥70%	≥70%	≥70%
Achieved	TBD		

The **Office of Strategic Infrastructure**, part of the **Mission Support Directorate**, strategically manages NASA's assets and capabilities to meet mission needs and support Agency operations.

FY 2020 Performance Progress

Performance towards achieving this performance goal is determined using the results of the annual OMB Scorecard for Efficient Federal Operations/Management. (Please note that the targets for FY 2020 and 2021 have been revised in accordance with the Office of Management and Budget (OMB) Scorecard for Efficient Federal Operations/Management.) The FY 2020 results are expected later in FY 2021.

4.6.3 [Ends in FY 2021]: Demonstrate increased facility reliability.

2015	2016	2017	2018	2019	2020
None	None	Red	Red	Green	Green

Percent reduction in unscheduled maintenance from previous year's actual unscheduled maintenance.

	Execution	Planned	
Fiscal Year	FY 2020	FY 2021	FY 2022
Target	1% below 23.7%*	1% below 21.34%	TBD based on FY 2021 actual
Achieved	21.34%		

*Note: The 2019 actual ratio of unscheduled maintenance was updated from 24.2 percent, reported in the FY 2021 Volume of Integrated Performance, to 24.7 percent to account for delayed data received. Therefore, the FY 2020 target was 23.7 percent, 1 percent from 2019 actual unscheduled maintenance.

The **Office of Strategic Infrastructure**, part of the **Mission Support Directorate**, strategically manages NASA's assets and capabilities to meet mission needs and support Agency operations.

FY 2020 Performance Progress

NASA performs scheduled maintenance on its equipment to keep it in good operating condition. When equipment fails, NASA must perform unscheduled maintenance to repair it. The percentage of unscheduled maintenance spending to total maintenance spending is an indicator of the overall condition of the equipment. More unscheduled maintenance indicates that the equipment has become unreliable, and unplanned failures and outages become more frequent, which can delay mission activities, such as manufacturing and testing.

For FY 2020, the ratio of unscheduled maintenance to total maintenance was 21.34 percent, which exceeded the targeted 1 percent reduction (23.7%*) from FY 2019 to FY 2020—despite the greatly reduced workforce at centers due to the COVID-19 pandemic—and met the long-term goal set by the Agency in 2015.