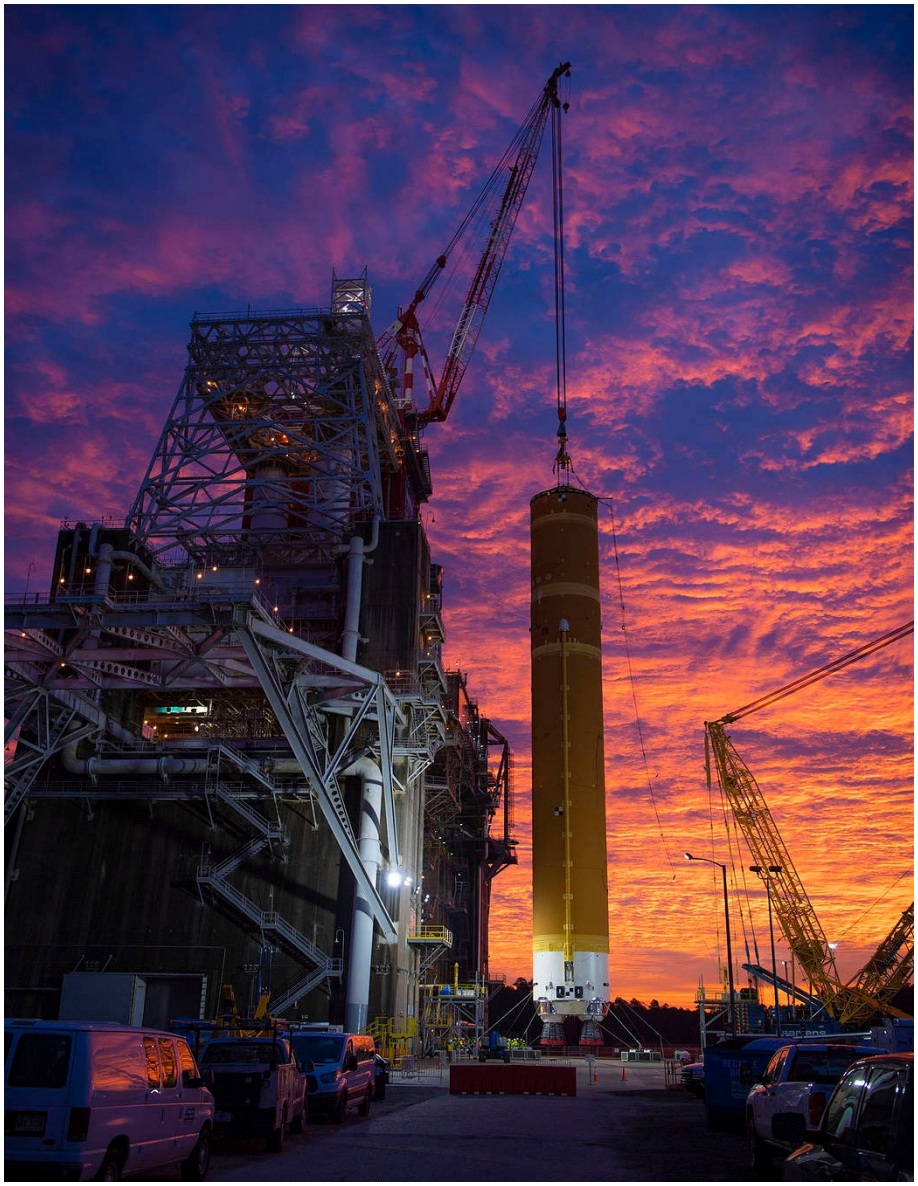
National Aeronautics and Space Administration

FY 2020 Annual Performance Report



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NASA's FY 2020 Annual Performance Report

NASA published a summary of preliminary fiscal year performance ratings in the *FY 2020 Agency Financial Report* using available fourth quarter data. This FY 2020 Annual Performance Report provides NASA's final, but incomplete, detailed performance progress for FY 2020 in accordance with the Government Performance and Results Act (GPRA) Modernization Act of 2010. The document includes:

- 2020 Summary of Progress Update by strategic objective
- NASA's performance towards achieving the performance goals and annual targets in the FY 2020 Annual Performance Plan
- Explanations of annual performance

NASA's *FY 2022 Volume of Integrated Performance* will include additional FY 2020 performance results, as well as its FY 2022 Annual Performance Plan, FY 2021 Annual Performance Plan Update, and Annual Evaluation Plan that describes the evaluation activities NASA plans to conduct during FY 2021 in support of the Foundations of Evidence-Based Policymaking Act of 2018. The *FY 2022 Volume of Integrated Performance* will be published concurrently with NASA's FY 2022 President's budget request (to be available on nasa.gov/budget/index.html).

The FY 2020 Annual Performance Report performance content was provided by NASA's mission directorates and mission support offices and was produced by NASA's Office of the Chief Financial Officer, with support from Deloitte Consulting, LLP.

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Welcome to NASA

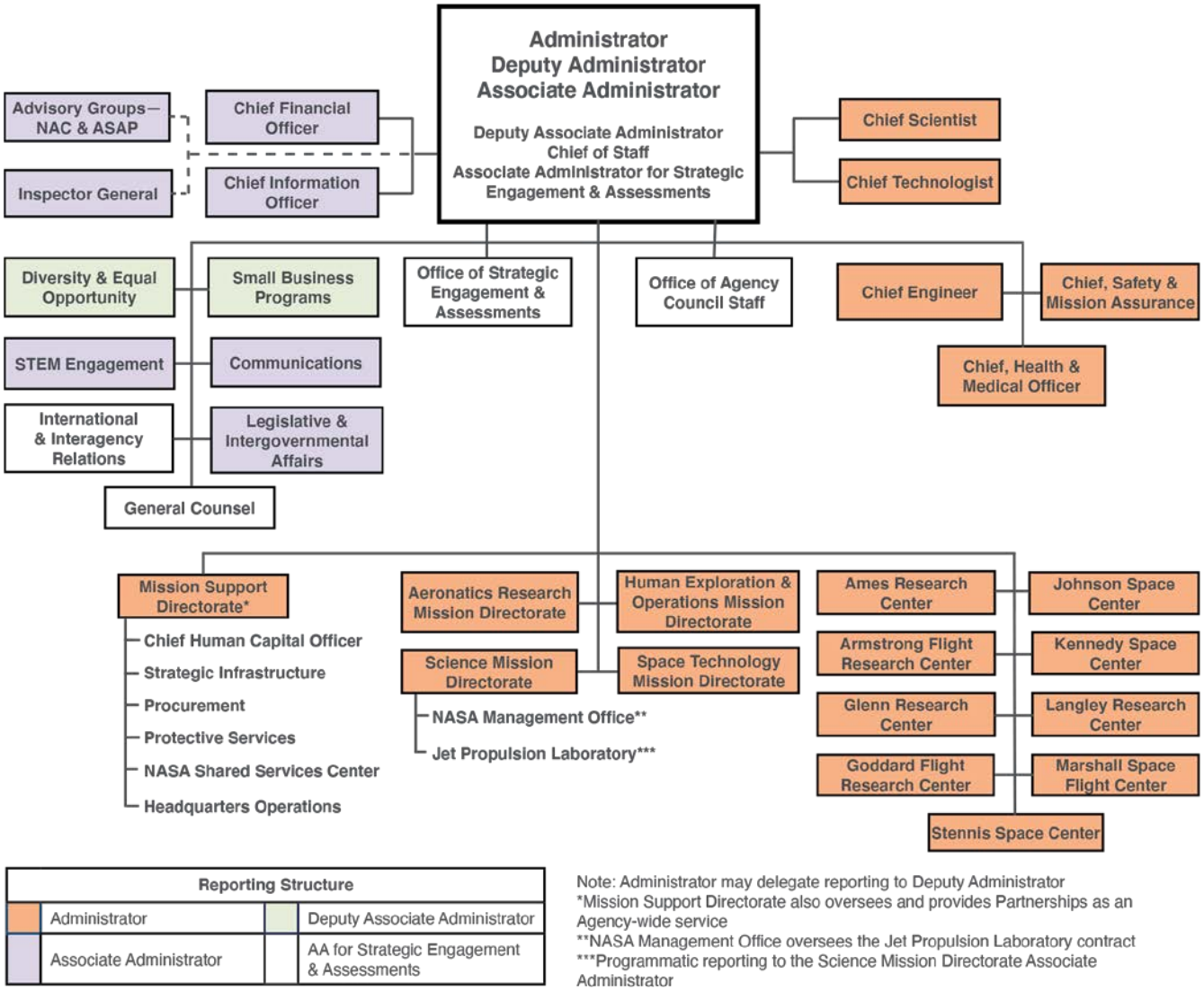
For six decades, NASA has led the peaceful exploration of space, advancing knowledge of Earth, while making discoveries about the furthest reaches of the universe. NASA research has advanced aeronautics, helped develop the commercial space industry, and strengthened the U.S. economy.

The NASA workforce of about 16,435 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.

- 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)** designs, develops, and tests advanced technologies that will make aviation much more environmentally friendly, maintain safety in increasingly crowded skies, and ultimately transform the way the United States, air passengers, and these world-wide, travel between destinations. Research conducted by ARMD directly benefits today's air transportation system, the aviation industry, and the passengers and businesses who rely on aviation every day.
- 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 the International Space Station (ISS), commercial space transportation, low Earth orbit spaceflight operations, deep space exploration systems, 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, and advance capabilities that enable exploration. STMD has used merit-based competition to identify and promote research and technology development, demonstrate applicability, and infuse these technologies into NASA's exploration 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 Performance Foundations

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 measure 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.

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.

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 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 this report.

This document includes the Summary of Progress Update for each of NASA's 13 strategic objectives, describing the progress that programs and projects have made in support of their strategic objective since the 2020 Strategic Review.

Annual Performance Assessments

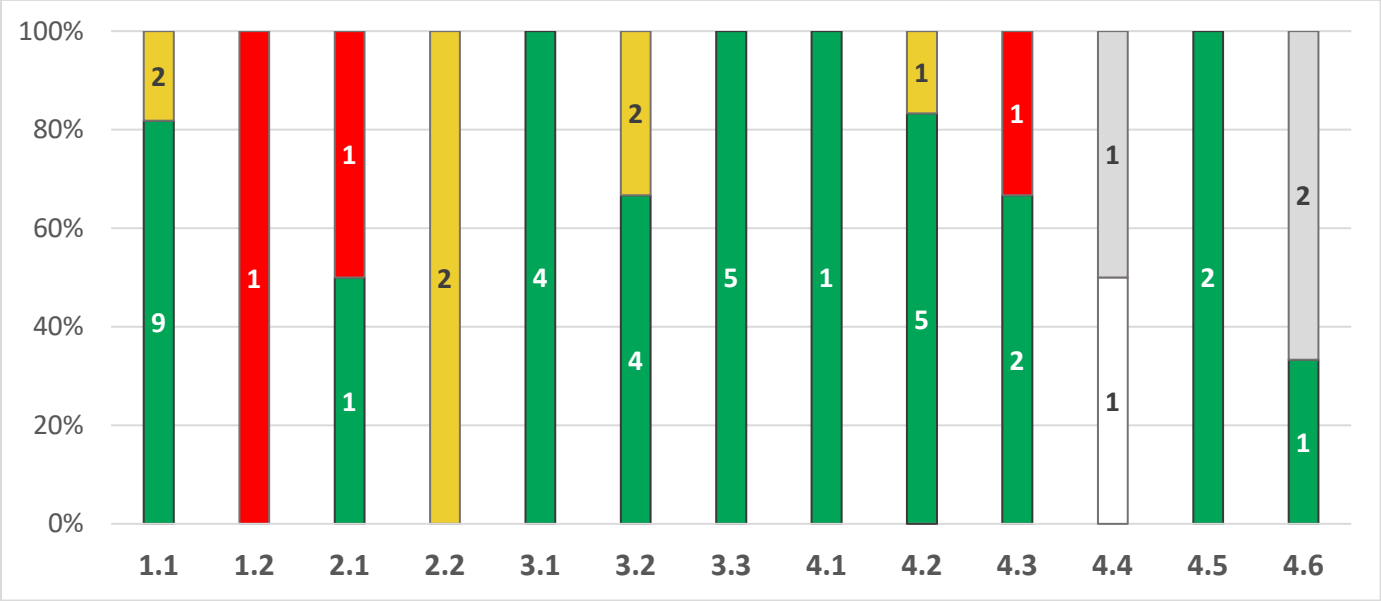
During the third and fourth quarters of FY 2020, program officials assessed progress towards achieving the performance goals listed in the FY 2020 Annual Performance Plan. They determined whether targets or milestones were met as anticipated, assigned the appropriate color rating, and provided an explanation to support the rating. NASA's Chief Operating Officer and the Performance Improvement Officer reviewed the performance assessment results and provided feedback and approved the final ratings.

NASA uses a stoplight color rating system to indicate whether a performance goal's target was achieved, and if not, by how much based on internal success criteria. For FY 2020, NASA also has one performance goal that is rated White, indicating that information was not available to assess progress for FY 2020. Three performance goals are unrated in the FY 2020 Annual Performance Report, due to late availability of the data needed to assess progress.

Green	Yellow	Red	White	Unrated
FY 2020 target achieved	Below FY 2020 target	Significantly below FY 2020 target	Unable to assess for FY 2020	Currently unrated due to delay in data availability

Below is a summary of the FY 2020 ratings for NASA's 48 performance goals organized by the 13 strategic objectives. Detailed performance information is provided in the next section. Additional information will be available in NASA's *FY 2022 Volume of Integrated Performance*, to be published concurrently with NASA's FY 2022 President's budget request (to be available on nasa.gov/budget/index.html).

FY 2020 Performance Goal Ratings by Strategic Objective



Detailed Performance Information

Strategic Goal 1: Expand human knowledge through new scientific discoveries.

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

LEAD OFFICE
Science Mission Directorate (SMD)

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 opportunities, and other programmatic factors.

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.

Below are the FY 2020 performance results for performance goals supporting Strategic Objective 1.1.

Performance Goal 1.1.1: Demonstrate progress in exploring and advancing understanding of the physical processes and connections of the Sun, space, and planetary environments throughout the solar system.

Annual Measurement	NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research
FY 2020 Target	Significant progress demonstrated
Achieved	Significant progress demonstrated as determined
Rating	Green

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.

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.

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

Annual Measurement	NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research
FY 2020 Target	Significant progress demonstrated
Achieved	Significant progress demonstrated
Rating	Green

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.

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.

Performance Goal 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.

Annual Measurement	NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research
FY 2020 Target	Significant progress demonstrated
Achieved	Significant progress demonstrated
Rating	Green

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.

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 TC_3, 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 TC_3, 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.

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

Annual Measurement	NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research
FY 2020 Target	Significant progress demonstrated
Achieved	Significant progress demonstrated in 1 area
Rating	Green

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.

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.

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.

Performance Goal 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.

Annual Measurement	NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research
FY 2020 Target	Significant progress demonstrated
Achieved	Significant progress demonstrated
Rating	Green

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.

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.

Performance Goal 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.

Annual Measurement	NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research
FY 2020 Target	Significant progress demonstrated
Achieved	Significant progress demonstrated for 2 areas
Rating	Green

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.

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.

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.

Performance Goal 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.

Annual Measurement	NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research
FY 2020 Target	Significant progress demonstrated
Achieved	Significant progress demonstrated in 2 areas
Rating	Green

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.

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 9,250 near-Earth asteroids that are 140 meters in diameter or larger.

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 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.

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

Annual Measurement	NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research
FY 2020 Target	Significant progress demonstrated
Achieved	Significant progress demonstrated in 2 areas
Rating	Green

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.

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.

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.

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.

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.

Performance Goal 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.

Annual Measurement	NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research
FY 2020 Target	Significant progress demonstrated
Achieved	Significant progress demonstrated in 3 areas
Rating	Green

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.

List of 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 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.

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 dioxide (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.

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

Annual Measurement	Number of critical milestones completed
FY 2020 Target	10-12
Achieved	8
Rating	Yellow

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.

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).

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.)

Performance Goal 1.1.11: Launch the James Webb Space Telescope, complete on-orbit checkout, and initiate observatory commissioning. (Agency Priority Goal)

Annual Measurement	Complete development milestone
FY 2020 Target	4
Achieved	3
Progress	Yellow

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).

List of development milestones for 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.

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.

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.

More information about NASA's progress toward achieving this agency priority goal is available at Performance.gov/NASA/APG_nasa_4.html.

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
Altonell (Toni) Mumford, Deputy Associate Administrator, HEOMD

The International Space Station (ISS), a laboratory in low Earth orbit that has been crewed for almost 20 continuous years, 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 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 be informed and based on the new Decadal survey, as well as the remaining known risks to human spaceflight and technology demonstration needs for human spaceflight missions beyond low Earth orbit including life support and biological systems and will be prioritized and executed as supported by the budget. These 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 limited research with ground-based and ISS studies.

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.

Below is the FY 2020 performance result for the performance goal supporting Strategic Objective 1.2.

Performance Goal 1.2.1: Advance scientific research with the potential to understand the responses of physical and biological systems to spaceflight.

Annual Measurement	Number of peer reviewed published studies
Fiscal Year	FY 2020
Target	500
Actual	To be determined
Rating	Red

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.

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.

Strategic Goal 2: Extend human presence deeper into space and to the moon for sustainable long-term exploration and utilization.

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, 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 comprehensively 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. 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.)

Below are the FY 2020 performance results for the performance goal supporting Strategic Objective 2.1.

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

Annual Measurement	Number of research and technology demonstrations conducted
FY 2020 Target	5
Achieved	5
Rating	Green

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.

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

Performance Goal 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. (Agency Priority Goal)

Annual Measurement	Number of milestones met
FY 2020 Target	4
Achieved	2
Rating	Red

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.

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.

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 International Space Station (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.

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.

For more information about NASA's progress toward achieving this agency priority goal is available at Performance.gov/NASA/APG_nasa_1.html.

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, HEOMD

NASA's Artemis program has a goal to return American astronauts to the South Pole of the Moon by 2024. Using innovative technologies, the landing will include first woman and next man on the lunar surface 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 Mars and 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—sending astronauts to Mars.

In spring 2020, NASA's Strategic Review determined that, overall, this was a focus area for improvement. NASA has made significant 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 2024 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, while 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. HLS 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 in 2024.

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, currently 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.

Below are the FY 2020 performance results for the performance goal supporting Strategic Objective 2.2.

Performance Goal 2.2.1: Advance America's goal to land the first woman and the next man on the Moon by 2024 by demonstrating the necessary capabilities that advance lunar exploration. (Agency Priority Goal)

Annual Measurement	Number of milestones met
FY 2020 Target	4
Achieved	3
Rating	Yellow

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.

FY 2020 milestones:

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*

During FY 2020, NASA made notable progress towards the Artemis I, Artemis II, and Artemis III missions despite challenges associated with COVID-19. (Find out more about the Artemis program.)

In November 2019, NASA shipped the Orion Artemis I Crew and Service Module to Plum Brook in Sandunsky, Ohio, to undergo testing in the Thermal Vacuum Chamber, which simulates the space environment. When completed, Orion was transported to Kennedy Space Center, Florida, and prepared for final assembly and test operations.

NASA awarded the first Gateway Logistics Service contract to SpaceX on March 25, 2020, designating the company as a U.S. commercial provider to deliver cargo, experiments, and other supplies to lunar orbit. On April 30, NASA announced that it had selected three U.S. companies—Blue Origin, Dynetics, and SpaceX—to design and develop human landing systems for the Artemis program, one of which will be selected to land the first

woman and next man on the surface of the Moon. The HLS awards were made under the NextSTEP-2 partnership with industry.

NASA began the fiscal year on track to complete the Space Launch System (SLS) Core Stage Green Run testing, an eight-part test to ensure that all components operate together to power the 212-foot tall core stage. Although testing was halted by more than two months due to COVID-19, NASA completed six out of eight test objectives by the end of the fiscal year. However, due to the impacts of COVID-19, as well as an unprecedented hurricane season, NASA did not achieve the fourth quarter milestone of conducting the Hot Fire test of the four RS-25 engines. The final two Green Run tests were delayed until early FY 2021.

For more information about NASA's progress toward achieving this agency priority goal is available at Performance.gov/NASA/APG_nasa_2.html.

Performance Goal 2.2.2: Commence lunar surface science investigations, technology, and exploration demonstrations to enable a sustainable lunar surface exploration strategy. (Agency Priority Goal)

Annual Measurement	Number of critical milestones met
Fiscal Year	*FY 2020*
Target	4
Achieved	3
Rating	Yellow

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).

List of development milestones for FY 2020

1. Plan strategy for APG coordinated with the President's Budget Release.
2. Complete on-ramp 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.

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 no 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 have been put in place at JPL which has 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.

For more information about NASA's progress toward achieving this agency priority goal is available at Performance.gov/NASA/APG_nasa_3.html.

Strategic Goal 3: Address societal challenges and catalyze economic growth.

Strategic Objective 3.1: Develop and transfer revolutionary space technologies to enable transformative 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 technology 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.

Below are the FY 2020 performance results for the performance goal supporting Strategic Objective 3.1.

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

Annual Measurement	Number of new early stage technologies and concepts invested in
FY 2020 Target	210
Achieved	253
Rating	Green

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.

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.

Performance Goal 3.1.2: Mature technology projects that offer significant improvement to existing solutions or enable new space exploration capabilities.

Annual Measurement	Percentage of key performance parameters completed for Technology Maturation projects
FY 2020 Target	60%
Actual	64%
Rating	Green

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 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 Mars Entry, Descent, and Landing Instrumentation 2 (MEDLI2) and Mars Environmental Dynamics Analyzer (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 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.

Performance Goal 3.1.3: Demonstrate new technology and capabilities for space exploration.

Annual Measurement	Critical milestones achieved for two programs supporting the performance goal
FY 2020 Target	6 milestones for each of two contributing programs
Achieved	Small Spacecraft Technology: 13 Technology Demonstration Missions: 8
Rating	Green

Small Spacecraft Technology develops and demonstrates new small spacecraft technologies 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 test for promising technologies. Both programs are part of the Space Technology Mission Directorate.

FY 2020 critical milestones

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

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.

NASA's FY 2020 achievements in small spacecraft technology included two milestones towards launch of the Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (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, Pathfinder Technology Demonstrator (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 Laser Communications Relay Demonstration (LCRD) and delivery to Northrop Grumman; completion of the Critical Design Review (CDR) for the Deep Space Optical Communications (DSOC); and KDP completion for OSAM-1 (satellite servicing and in-space robotic assembly technologies).

NASA also conducted three on-orbit technology demonstrations—the Deep Space Atomic Clock (DSAC), Green Propellant Infusion Mission (GPIM), and Robotic Refueling Mission 3 (RRM3)—and launched the Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE) and the Terrain Relative Navigation (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.

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

Annual Measurement	Critical activities completed for three programs supporting the performance goal
FY 2020 Target	3
Achieved	3
Rating	Green

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 researcher institutes and small businesses to participate in government-sponsored research and development efforts in key technology areas.

FY 2020 critical activities

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

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 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, Director, Portfolio Analysis & Management Office, 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 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 due to the COVID-19 pandemic. Impacts include the following:

- Wind tunnel and other test facility closures have delayed schedules (including significant milestones).
- Computational research is slowed due to reduced remote connection speeds, access restrictions, and software licensing issues.
- Due to limitations on facility access and decreased levels of air traffic in the National Airspace System, the projects of the Airspace Operations and Safety Program have been unable to conduct demonstration of their technologies in relevant environments.
- The Boeing ecoDemonstrator flight trial is delayed at least one month resulting in minimum schedule reserves.

- In the Low Boom Flight Demonstrator (LBFD) project, facility closures/production shutdowns have contributed to assembly/first flight delays. While COVID-19 is not the primary contributor to LBFD risk, COVID-19-related manufacturing delays have exacerbated pre-existing cost and schedule overruns.
- In the X-57 Maxwell focus area, NASA has experienced delays in Modification (Mod) II development, ground test, and flight test. As with the LBFD project, delays attributable to COVID-19 compounded pre-existing cost and schedule overruns. As a result, Mods III and IV schedules are also slipping.
- In the University Innovation project, limited access to campus buildings and experimental facilities has impacted some activities. However, work involving modeling/simulations is being performed remotely off-site.

Below are the FY 2020 performance results for the performance goal supporting Strategic Objective 3.2.

Performance Goal 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.

Annual Measurement	Development milestone(s) completed
FY 2020 Target	2
Achieved	1
Rating	Yellow

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.

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.

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 Federal Aviation Administration's (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.

Performance Goal 3.2.2: Demonstrate the ability to reduce sonic booms, enabling future industry innovation in commercial supersonic aircraft.

Annual Measurement	Development milestone(s) completed
FY 2020 Target	1
Achieved	0
Rating	Green

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

Development milestone for FY 2020

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

NASA achieved this performance goal by continuing progress toward the LBFD aircraft acceptance and acoustic validation, and Community Response Test Plan approval. While the final assembly of the LBFD 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.

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 schedule risk assessment 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.

Performance Goal 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.

Annual Measurement	Development milestone(s) completed
FY 2020 Target	5
Achieved	2
Progress	Yellow

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

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).

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.

Performance Goal 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.

Annual Measurement	Development milestone completed
FY 2020 Target	1
Achieved	1
Rating	Green

The Advanced Air Vehicles, Integrated Aviation Systems, and Transformative Aeronautics Concepts 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.

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.

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.

Performance Goal 3.2.5: Significantly increase the ability to anticipate and resolve potential safety issues, and to predict the health and robustness of aviation systems.

Annual Measurement	Development milestone(s) completed
FY 2020 Target	2
Achieved	2
Rating	Green

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.

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.

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.

Performance Goal 3.2.6: 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.

Annual Measurement	Development milestones completed
FY 2020 Target	1
Achieved	1
Rating	Green

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.

Development milestone 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.

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.

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
Bettina Inclán, 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.

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 non-profit 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 STEM engagement 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. OSTEM 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 recommendations 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 work force with more frequent and more in-depth leadership messages regarding agency operating status and renewed emphasis on diversity and inclusion.

Below are the FY 2020 performance results for the performance goals supporting Strategic Objective 3.3.

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

Annual Measurement	Percentage of annual social media audience growth across all flagship platforms
FY 2020 Target	10%
Achieved	19.5%
Rating	Green

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.

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 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

Performance Goal 3.3.2: Promote equal opportunity and encourage best practices among NASA grant recipient institutions.

Annual Measurement	Percentage of Agency civil rights recommendations/ corrective actions to grant recipient institutions reviewed for compliance that are implemented within one year
FY 2020 Target	90%
Achieved	90%
Rating	Green

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.

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.

Performance Goal 3.3.3: 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.

Annual Measurement	Percentage of higher education significant awards in four categories of student diversity for NASA STEM enrollees compared to the national average*
FY 2020 Target	At least 2 of 4 categories meet or exceed national average
Achieved	2 categories met or exceeded national average
Rating	Green

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.

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.

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

Annual Measurement	Milestone achieved in the implementation of performance assessment and evaluation of STEM engagement investments
FY 2020 Target	1 met or exceeded
Achieved	1 met
Rating	Green

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.

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.

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).

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

Annual Measurement	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
FY 2020 Target	1,300
Achieved	2,015
Rating	Green

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.

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.

Strategic Goal 4: Optimize capabilities and operations.

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) Education 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 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 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 80 international agreements and partnerships with 43 new domestic, non-Federal partners—partners with whom the Agency has not had previous agreements. 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. The virtual meetings and events have been successful, although not optimal, and caused delayed rollout of major initiatives to foster international partnerships in support of Artemis, Gateway, and other Agency programs.

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.

Below is the FY 2020 performance result for the performance goal supporting Strategic Objective 4.1.

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

Annual Measurement	Number of active partnership agreements with domestic, interagency, and international partners
Target	2,671
Achieved	2,872
Rating	Green

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.

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.

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, 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 where 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 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.

Below are the FY 2020 performance results for the performance goals supporting Strategic Objective 4.2.

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

Annual Measurement	Number of commercial cargo missions launched/ delivered to ISS
FY 2020 Target	4
Achieved	4
Rating	Green

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.

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.

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

Annual Measurement	Number of commercial crew missions launched
FY 2020 Target	2
Achieved	1
Rating	Yellow

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.

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, which will occur in the first half of FY 2021. Boeing plans to conduct a crewed orbital flight test in summer 2021.

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

Annual Measurement	Percent availability
FY 2020 Target	90%
Achieved	99.7%
Rating	Green

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

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.

Performance Goal 4.2.4: Complete Launch Services Program (LSP) objectives for all NASA-managed expendable launches.

Annual Measurement	Percentage of expendable launch objectives successfully completed
FY 2020 Target	100%
Achieved	100%
Rating	Green

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

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.

Performance Goal 4.2.5: Maintain the delivery of Space Communications network services.

Annual Measurement	Percent of delivery
FY 2020 Target	96%
Achieved	96%
Rating	Green

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.

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.

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

Annual Measurement	Percent overall availability of SETMO portfolio assets
FY 2020 Target	90%
Achieved	98%
Rating	Green

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 environment.

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.

Strategic Objective 4.3: Assure safety and mission success.

LEAD OFFICE
Office of the Chief Health and Medical Officer

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

GOAL LEADER
Mark Weyland, Director, Medical Policy and Ethics/Office of the Chief Health and Medical Officer

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 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.

Below are the FY 2020 performance results for the performance goals supporting Strategic Objective 4.3.

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

Annual Measurement	Number of Fatalities or permanent disabling injuries
FY 2020 Target	0
Achieved	0
Rating	Green

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.

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.

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

Annual Measurement	Level less than 5-year running average
FY 2020 Target	3.85 million
Achieved	4.73 million
Rating	Red

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.

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.

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

Annual Measurement	Number of non-concurrence determinations and percentage of program variances
FY 2020 Target	Zero non-concurrence determinations and five percent or fewer program variances
Achieved	Zero non-concurrence determinations; zero program variances
Rating	Green

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.

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.

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: Strategically 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; Jane Datta, Assistant Administrator, OCHCO; and Steve Shih, Associate Administrator, ODEO

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. 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 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.

Below are the FY 2020 performance results for the performance goals supporting Strategic Objective 4.4.

Performance Goal 4.4.1: Sustain NASA 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.

Annual Measurement	Agency FEVS Innovation score
FY 2020 Target	84%
Achieved	N/A
Rating	White

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.

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.

Performance Goal 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 Survey (FEVS), through Diversity and Equal Opportunity programs and tools that support NASA employees.

Annual Measurement	Agency FEVS New IQ Index score
FY 2020 Target	70%
Achieved	To be determined
Rating	Unrated

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.

The FEVS—a government-wide survey used by NASA to gauge employees' perceptions of their workplace experiences, leadership, and culture—was delayed from May 2020 to September 2020. OPM delayed the survey to allow agencies to focus on mission-critical work during the COVID-19 pandemic. OPM used the delay to revise the survey to incorporate questions specifically about the pandemic and shorten the overall length. Of the 20 questions that normally comprise the New IQ index score, only 9 questions were included in the shortened 2020 survey.

OPM has collected the data for the 2020 FEVS and is compiling the results. NASA's anticipates receiving the results in January 2021.

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, Chief Information Officer, and David Adams, Acting 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. NASA is conducting comprehensive vulnerability, susceptibility, and mitigation assessments of existing and planned architectures, requirements and policies, technology, systems, workforce, and other relevant factors. Analysis of these assessments will result in strategic, actionable recommendations to reduce protection risk. 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 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.

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 Office of Inspector General recommendations. By the end of FY 2020, 80 percent of operational technology systems that are part of NCI were assessed and granted an Authorization to Operate (ATO) in accordance with the Risk Management Framework (RMF) as outlined in NIST 800-37 and NASA policies and requirements.

To manage assets and cybersecurity vulnerabilities, NASA deployed Continuous Diagnostic and Mitigation 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.

Below are the FY 2020 performance results for the performance goals supporting Strategic Objective 4.5.

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

Annual Measurement	Percentage of cybersecurity capability Cross-Agency Priority (CAP) goals met from performance.gov
FY 2020 Target	100%
Achieved	70%
Rating	Green

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.

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 Department of Homeland Security (DHS) continuous diagnostics and monitoring (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.

Performance Goal: 4.5.2: 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.

Annual Measurement	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
FY 2020 Target	100%
Achieved	80%
Rating	Green

The Enterprise Protection Program works with the Office of the Chief Information Officer and offices across the Agency to ensure the security of NASA's operational technology.

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, 80 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 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, etc.). 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. Energy and water consumption reporting has been delayed in FY 2020, as some centers do not have access to metering data when non-essential energy/utility management personnel are restricted from accessing the site. These delays may delay external reporting of energy/water performance metrics. 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. To date, a large number of these CoF projects have yet to restart. Only a small number of projects that were deemed to be "mission essential" continued without interruption. However, expenses continue to accrue for the halted CoF projects without corresponding progress toward project completion. In addition, these delays will impact annual progress on Sustainable Facilities, as well as implementation of projects improving energy/water efficiency.

Below are the FY 2020 performance results for the performance goals supporting Strategic Objective 4.6.

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

Annual Measurement	Square footage or facilities reduced
FY 2020 Target	100,000 square feet or 20 facilities
Achieved	51 facilities (total 68,250 square feet)
Rating	Green

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.

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.

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

Annual Measurement	Percentage of sustainability goals met annually in the OMB Scorecard for Efficient Federal Operations/Management
FY 2020 Target	100%
Achieved	To be determined
Rating	Unrated

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.

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 criteria for FY 2020 have been revised.) The FY 2020 results will not be available until approximately March 2021.

Performance Goal 4.6.3: Demonstrate increased facility reliability.

Annual Measurement	Percent reduction in unscheduled maintenance from previous year's actual unscheduled maintenance
FY 2020 Target	1% below FY 2019 actual unscheduled maintenance
Achieved	To be determined
Rating	Unrated

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.

For the first half of FY 2020, the ratio of unscheduled maintenance to total maintenance was 23.1 percent, which exceeded the targeted 1 percent reduction (23.7 percent*) from FY 2019 to the first half 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. The final FY 2020 data will be available in mid-January of 2021.

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.

*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.