National Aeronautics and
Space Administration

Headquarters
Washington, DC 20546-0001

January 25, 2022

Science 2020-2024: A Vision for Scientific Excellence in 2021 was designed to capture the four cross-cutting priorities of the Science Mission Directorate (SMD) and accompanying strategies that reflect our shared values and directly respond to changes in the broader ecosystem in which we work. We intentionally set these priorities and strategies to focus attention on those areas where we can have the greatest impact. Designed to be a living plan, providing an overarching framework for how we would work, we also recognized our implementation approach would evolve over time as new opportunities and developing conditions arise. Furthermore, we committed to providing transparency to our stakeholders on the progress we make towards achieving our goals.

I am pleased to share with you the first major update to the plan, reflecting several important changes. This past year we welcomed the Biological and Physical Sciences Division into SMD, and the plan now includes this community's important work. Our planet and its climate are profoundly changing, and this plan emphasizes the contributions of NASA's Earth Science program to understanding climate change and providing information to decision-makers and other agencies. Additionally, we've placed a stronger emphasis on inclusion, a new NASA core value and a focus across all priority areas.

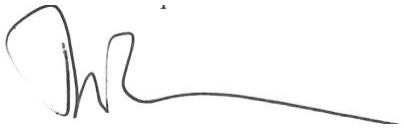
The plan, arranged by priority areas, provides a brief description of our intentions and high-level objectives associated with each, and speaks to new cross-cutting opportunities, such as SMD's role to accelerate open data and open-source science. While implementation of the strategies continues to look different between our divisions, we are excited to share the tremendous progress being made across all elements of the portfolio.

We continue to measure success by our ability to:

- Implement recommendations of Decadal Surveys in concert with national priorities and needs through creative partnership models that go beyond traditional ways of developing and executing missions
- Challenge assumptions about what is technically feasible and enable revolutionary scientific discovery through a deliberate focus on innovation, experimentation, and cross-disciplinary research
- Create a more collaborative culture within the Science Mission Directorate and across the science community, encouraging diversity of thought, sharing best practices, and informed risk-taking to improve operations
- Develop future leaders and inspire learners of all ages through new opportunities and hands-on experiences

Our priorities, like this plan, continue to evolve with close collaboration. The SMD leadership team, NASA Center Directors, advisory bodies at NASA and the National Academies of Sciences, Engineering and Medicine, will continue to work towards scientific strides as we move into this next year of science. Many thanks to all participants for their contributions.

Sincerely,



Thomas H. Zurbuchen, Ph.D. Associate Administrator, Science Mission Directorate

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Who We Are

NASA VISION

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

NASA MISSION

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

SMD VISION

To lead a globally interconnected program of scientific discovery that encourages innovation, positively impacts people's lives, and is a source of inspiration.

SMD MISSION

Discover the secrets of the universe. Search for life elsewhere. Protect and improve life on Earth and in space.

Since 1958, NASA has led the way in Earth and space science research with a team of world-class scientists and engineers dedicated to its mission. Success in the harsh, unforgiving environment of space requires an unwavering commitment to excellence to build and operate our missions and to develop cutting-edge technologies to further our fundamental research. In turn, investments in fundamental research enable new mission concepts and transform data into knowledge. Prioritization of these activities is guided by National Academies of Sciences, Engineering and Medicine (NASEM) Decadal Surveys and other national priorities, which provide effective focus to the programs.

From decades of experience, we have learned the importance of taking small steps to accomplish big goals. We seek to reach beyond our current knowledge by investigating our home the Earth, the Sun, the Moon, other worlds of our solar system, the stars, and the deep universe. As NASA's mission evolves, the Science Mission Directorate (SMD) continually strives to be innovative and drive discovery by studying biological and physical phenomena in space. SMD utilizes technological advances and new partnership opportunities, including public-private partnerships that leverage commercial investments to further NASA's science objectives. The key to our success is fulfilling our commitment to improve people's lives today and to inspire and engage the workforce of tomorrow.

As an organization, SMD incorporates the five NASA core values in all aspects of its work, as well as a sixth value of leadership. Through these values, we can drive towards a future in which we continue to expand the frontiers of human knowledge and our understanding of Earth and space.

SMD Core Values

LEADERSHIP

From studying the origin and evolution of the universe to seeking to understand the Earth as an interconnected system, SMD's leadership has advanced scientific knowledge and has had a direct positive impact on the quality of life on Earth. We know that scientific discovery is achieved through collaboration and diverse teams, and therefore we seek to create space for people to come together to continue expanding our understanding of Earth and space for the benefit of all.

EXCELLENCE

The work of SMD is at the forefront of scientific discovery and innovation. The questions we seek to answer affect humanity on a global scale and focus on our place in the universe—Where did we come from? Are we alone? Achieving excellence by tackling such difficult questions requires courage and dedication. It requires a culture where there is a willingness to learn and change and to take risks in the interest of science. We do not identify these opportunities in a vacuum; rather, the science community guides our prioritization through decadal surveys, competitive processes, and peer review. Our commitment to excellence requires us to challenge ourselves and learn from both our successes and our failures. We must dig deep for lessons, be willing to adjust, and continually expand our knowledge.

INTEGRITY

SMD is committed to ensuring that all decisions are made with integrity and transparency, believing in the importance of living up to our commitments. To be successful, we must establish clear guidelines and criteria for decision-making processes and communicate these expectations in a timely manner to all stakeholders so that there is a common understanding. Such processes should allow us to make timely, appropriate decisions to reduce unnecessary administrative burden.

TEAMWORK

SMD believes in the importance of diverse teams to tackle strategic problems and maximize scientific return most effectively and innovatively. Internally, we seek to grow our workforce by providing opportunities for personal and professional development and cross-divisional collaboration. Externally, we are working to promote opportunities for collaboration across and between disciplines, as well as to develop and inspire the next generation of science and engineering leaders to carry our work into the future.

SAFETY

NASA has a strong safety culture which extends to all aspects of SMD's work. Not only are we concerned about protecting life and property, but we also recognize the importance of psychological health and safety. We strive to create an environment where everyone can contribute to our work. People must feel comfortable bringing up issues and concerns without fear of retribution or reprisal. This extends to all members of the science community who work with us.

INCLUSION

SMD is committed to fostering an inclusive environment of belonging where diversity of thought, backgrounds and perspectives are welcomed and celebrated. SMD recognizes that success is only achieved through full participation of inclusive and diverse teams, belonging, and contributing as organizations and individuals. We are committed to inclusion for SMD-funded teams, and not just within SMD, but more broadly. We are dedicated to creating a multi-pronged approach that brings systemic and lasting change in this area by fostering inclusion, diversity, equity, and accessibility across all elements of our work through dedicated activities and sustained engagement.

Introduction

Since the successful launch of Explorer 1 in January 1958, research in and from space has broadened our view of the world we live in and has created public value. Our impact has been two-fold: *we discover the secrets of the universe,* and we *protect and improve life on Earth and in space*. Whether near our home in space or all the way to the deepest reaches of the universe, we explore the world around us, constantly questioning what we know; we have learned how to make missions successful both at Earth and traveling into deep space.

Photo Credit: ***NASA/ESA/J. Olmsted (Space Telescope Science Institute)***
Using the unique capabilities of the Hubble Space Telescope, scientists have discovered a quasar emitting large amounts of energy generated by a supermassive black hole fueled by infalling matter. The blistering radiation pressure from the vicinity of the black hole pushes material away from the galaxy's center at a fraction of the speed of light.

In 2023 we look forward to the 65th anniversary of NASA and its Science program. NASA's strategy for the future builds on this legacy, recognizing that we can and must continually modernize and improve how we operate, while still being good stewards of the resources made available by the United States of America and its taxpaying citizens. This vision outlines the major drivers of our program over the next five years. As leaders, we continuously compare our achievements against our potential and our opportunities, and it is in that sense that this strategy is looking towards the future. SMD has the responsibility to continue delivering the most compelling and highest impact science program to the American public while inspiring the next generation of explorers.

NASEM sets high-level science priorities through their decadal surveys. Not only does SMD support scientific discovery for the sake of new knowledge, but it also advances fundamental science that improves life on Earth and serves as the foundation for future exploration, and the technology innovations that will enable it.

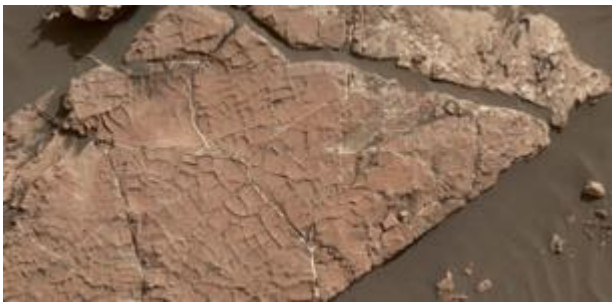

Photo Credit: ***NASA/JPL-Caltech/MSSS***
NASA's Curiosity rover has found evidence of an ancient Martian oasis where streams of water may have once flowed. Mars missions, like the Curiosity rover, look to unravel the mystery of how the Martian climate changed and search for evidence of conditions that might have supported ancient Martian life.

Some of the most important questions we address cut across the traditional boundaries of the decadal surveys. The fundamental science quest to search for life elsewhere is one that requires advances in each scientific division. Astrophysics requires an understanding of how planets form and how to find and study them around other stars. Studying biological and physical systems in the extreme environment of space enables us to make scientific breakthroughs not possible on Earth. Earth Science provides the understanding of measurements of atmospheric emissions so these can be used to search for signs of life on other worlds. Understanding how stellar activity and stellar magnetospheres affect planetary atmospheres and climate is addressed by Heliophysics, and Planetary Sciences requires an understanding of how geologic processes on Mars and on ocean worlds in our solar system might give rise to habitable environments.

SMD does not perform its research in isolation, and it is important to assess the meaning of partnerships through leadership in this context. Partnerships enable new approaches to do research and enable us to build on past success. Consequently, SMD enters into strategic partnerships that can influence the unique strengths of each contributor to drive scientific progress on behalf of the greater good. By partnering with other space agencies, universities, industry, and others, we can generate diverse ideas, technology, research and scientific processes, and support the development of a diverse workforce.

SMD actively looks for opportunities to build on private sector investments and to utilize innovative public-private partnerships to advance SMD objectives. Building an entrepreneurial ventures-based perspective not only enables us to achieve a fundamentally new understanding of our home planet and the star that sustains us, but also propels significant improvements in predictive capability that protects life, health, and property. Our strategy, combined with closely working with international partners, drives both innovative technology and science to synergistically address global challenges that no one nation or organization can address alone. Additional opportunities are unlocked through the engagement of our cross-agency partners, as well as private sector partners within the United States and other governments.

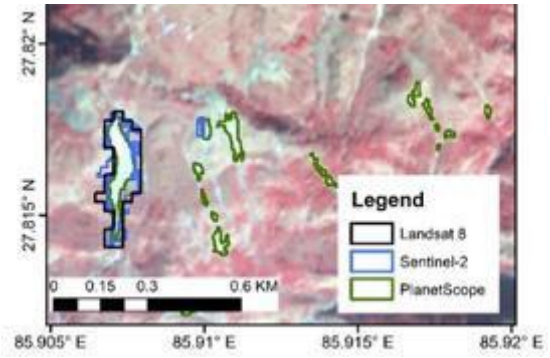

Photo Credit: ***PlanetScope/RapidEye/NASA***
The Commercial Small Satellite Data Acquisition Program enables the purchase of Earth science observation data from commercial small satellite constellations (e.g., PlanetScope) to provide a cost-effective means to augment and complement NASA observations. For example, data purchased from the PlanetScope constellation was overlaid with NASA & ESA data to better map smaller landslides areas in Nepal during 2018.

The challenge to any successful enterprise like SMD is to continually test its own assumptions and create new opportunities. Collaboration, within SMD and across our community, promotes open science and more effectively optimizes resources. We push to make leaps of progress, and test new approaches to answer the aspirational questions we ask; by applying such innovative approaches, we truly can realize our full potential.

Science Leadership Priorities

To achieve our goals, SMD relies on four cross-cutting priorities: Exploration and Scientific Discovery, Innovation, Interconnectivity and Partnerships, and Inspiration. Our core purpose is to explore and make scientific discoveries on behalf of the world, making innovation and collaboration essential for success in our pursuit. Our work inspires and encourages future leaders to contribute their ideas in pursuit of new science questions and means of discovery.

The following sections detail the strategies associated with each priority area and the high--level implementation approach. These strategies are designed to be ambitious new pursuits for SMD, going above and beyond the current program of record to drive action and make progress in specific directions over the next five years.

PRIORITY 1
EXPLORATION AND SCIENTIFIC DISCOVERY

STRATEGY 1.1: Execute a balanced science program based on discipline-specific guidance from the National Academies of Sciences, Engineering, and Medicine, Administration priorities, and direction from Congress.

STRATEGY 1.2: Participate as a key partner and enabler in the agency's exploration initiative, focusing on scientific research of, on, and from the Moon, lunar orbit, Mars, and beyond.

STRATEGY 1.3: Advance discovery in emerging fields by identifying and exploiting cross-disciplinary opportunities between traditional science disciplines

STRATEGY 1.4: Develop a Directorate-wide, target-user focused approach to applied programs, including Earth Science Applications, Space Weather, Planetary Defense, and Space Situational Awareness.

SMD seeks to discover the secrets of the universe, to search for life elsewhere in the Universe, and to protect and improve life on Earth and in space. To be successful, we have a balanced portfolio approach that includes flight missions, research and analysis, technology development, and applications as critical components of our work. The relative balance across these efforts is informed by NASEM through their Decadal Surveys and is responsive to Administration priorities and direction in the law.

Photo Credit: *Johnson Space Center*
NASA astronaut Jessica Meir waters plant pillows where Mizuna mustard greens are raised as part of the Veg-04B experiment. This investigation is part of a phased research project addressing the need for a continuous fresh food production system in space, focusing on the effects of light quality and fertilizer on a leafy crop. Taste is assessed by the crew

We are undertaking new work that builds on our past success in individual science disciplines to enable a more collaborative environment at the forefront of science and science applications. For example, NASA's Astrobiology Program collaborates across astrophysics, biological and physical sciences, heliophysics, and planetary sciences to further the search for life beyond Earth. We have also established new interdivisional grant programs that enable researchers in astrophysics and planetary science to study the formation and characterization of extrasolar planets. These programs are now being expanded to include heliophysics research on the impact of different stellar types on orbiting planets and applying Earth science climate models to extrasolar planets.

To go farther and stay longer in space, the Biological and Physical Sciences Division is focusing on fundamental research that will be instrumental in ensuring the health, safety, and productivity of humans during long-duration missions. Through our open science databases, critical insights from this research could be used by other government agencies, academic researchers, international partners, and commercial industry in ways that could benefit humanity as well.

Closer to home, our Science program pioneered the use of SMD data to inform decision-makers and has expanded data usage to support other national needs, including climate change, space

weather prediction, and planetary defense. As SMD data is used in support of such capabilities, new users and user needs will be identified, which will drive fundamental research that is likely to yield even more advances in modeling and new tools.

Finding answers to these profound science questions requires continued progress on the scientific priorities identified by NASEM through their Decadal Surveys. Furthermore, support for national priorities in science and exploration will enable new opportunities for cross-disciplinary science. In addition to responding to guidance provided by the scientific community, national priorities can also be defined by the Administration and Congress.

STRATEGY 1.1

Execute a balanced science program based on discipline-specific guidance from the National Academies of Sciences, Engineering, and Medicine, Administration priorities, and direction from Congress.

The 2021 U.S. Space Priorities Framework states, "The United States will maintain its leadership in space exploration and space science. The United States will remain a global leader in science and engineering by pioneering space research and technology that propels exploration of the Moon, Mars, and beyond." NASEM provides guidance that helps SMD achieve a balanced portfolio built on the pillars of scientific and technical excellence. Through the Decadal Survey process, the scientific community provides input on key science drivers and recommends the balance between strategic-scale missions, competitively selected small and mid-scale missions, technology programs, and research and analysis programs. This guidance is designed to lead the science community by focusing on the highest priority science questions the Nation should be addressing and highlighting areas of opportunity to grow the scientific community’s capabilities, helping SMD execute the strategy. Each division director within SMD is responsible for managing their own portfolio in accordance with this guidance, and progress against the Decadal Surveys is assessed by NASEM as part of NASEM’s mid-term reviews. Implementation of Decadal Survey recommendations is modified to reflect existing budgets, particularly when funding for new missions is different from that assumed in the Decadal Surveys.

Astrophysics

Photo Credit:
Composite image of Centaurus A. Magnetic fields are shown as streamlines over an image of the galaxy taken at X-ray (blue, Chandra, R. Kraft), visible (white, European Southern Observatory wide field imager), infrared (red, Spitzer, J. Keene) and submillimeter wavelengths (orange, Atacama Pathfinder Experiment, A. Weiss).

Astrophysics is humankind's scientific quest to discover the origin of the universe and of life itself. Three questions — how does the universe work? how did we get here? are we alone? — form the basis of the three astrophysics science themes: Physics of the Cosmos (PCOS), Cosmic Origins (COR), and Exoplanet Exploration (ExEP). Basic research and flight missions combined advance the progress in these three areas. In this quest, astrophysics is guided by NASEM's *Pathways to Discovery in Astronomy and Astrophysics for the 2020s*, which identifies the science goals and technology priorities informing our investment decisions.

Basic research synthesizes the data from our missions to create new knowledge and advance our understanding of the universe; leading to new questions, which motivate new measurements and new missions. The Astrophysics Research Program includes competed programs in data analysis, theory, technology development, and suborbital projects. Small and medium missions are undertaken as competitively selected, Principal Investigator-led Pioneers, Explorers, and Probe missions. Large strategic missions are directed to NASA Centers for implementation and are managed within the Astrophysics Strategic Missions Program.

Biological and Physical Sciences

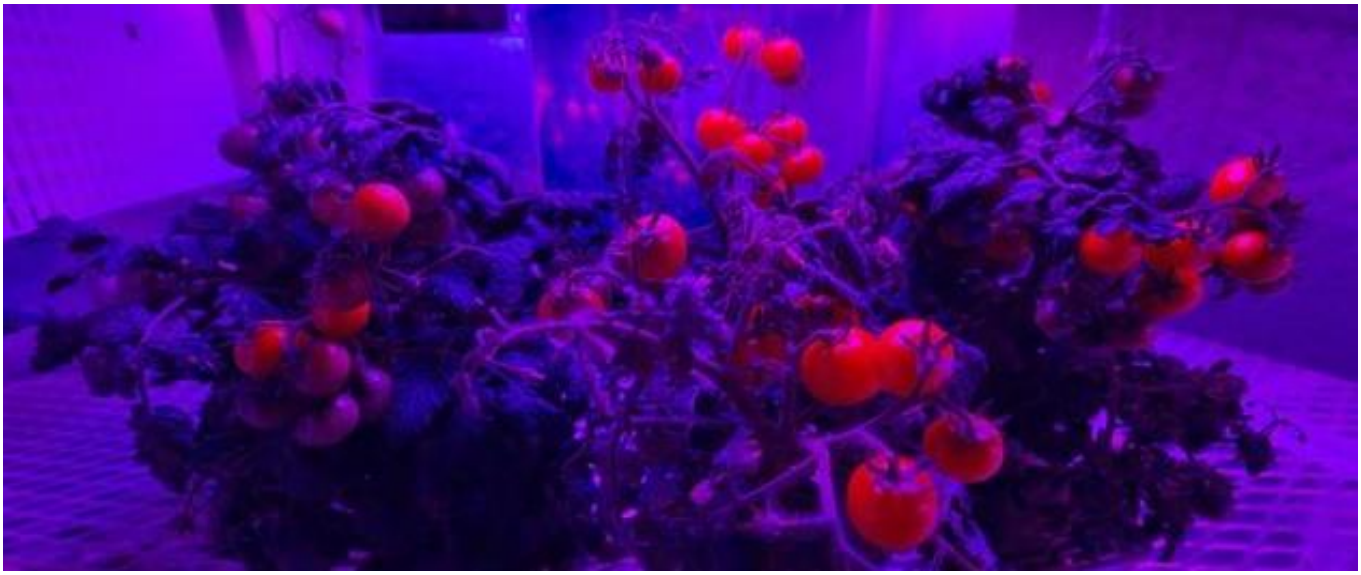

Photo Credit: *NASA/Cory Huston*

Tomato plants are growing under red and blue LED lights in a growth chamber inside a laboratory at the Space Station Processing Facility at NASA's Kennedy Space Center in Florida. The plant growth is being tested in the Veggie Passive Orbital Nutrient Delivery System (PONDS).

The Biological and Physical Sciences Division pioneers scientific discovery and enables space exploration by using space environments to conduct investigations not possible on Earth. Many of the results also benefit life on Earth. Examples include:

- Studying how prolonged exposure to extreme conditions, such as reduced gravity and space radiation, affects living things sheds light on human disease and aging
- Performing high-precision tests of General Relativity and Quantum Mechanics in near-absolute zero temperatures to inform the development of quantum technologies
- Studying dynamic colloidal systems—substances consisting of particles dispersed through another substance (such as gels, foams, etc.)—to aid the development of novel materials ranging from consumer products to computers that use light instead of electricity

To go farther and stay longer in space, we must understand the combined effects of deep space- stressors on humans, plants, and animals to protect life on long-duration missions. We must also be able to make, not take, supplies while probing the far reaches of our solar system. These endeavors can lead to advancements in biomedicine, agriculture, power sources, and construction, among others. We also frequently partner with academic institutions, commercial industry, international organizations, and other government agencies to conduct research, share facilities, data, materials, and knowledge. BPS's broad range of research platforms spans ground-based facilities, suborbital, low Earth orbit (including the International Space Station and emerging commercial platforms), and eventually the lunar orbit and surface. This breadth of platforms allows investigators to progress technology development and refine experimental design. BPS research is currently guided by the National Academies of Sciences' 2011 Decadal Survey; recommendations from a second decadal are expected to be delivered in 2023. The upcoming decadal is expected to reflect a shift towards focused areas where transformative science can best be achieved, which could include: Thriving in Deep Space, which enables fundamental biological discoveries of human/animal and plant systems; Quantum Science, which pushes the frontiers of the fundamental science of unique states of matter; and Soft Matter, which seeks to understand, control, and use complex dynamical systems, contributing to fundamental knowledge and advanced materials. Thus, BPS has built in the flexibility to refine or change direction.

Earth Science

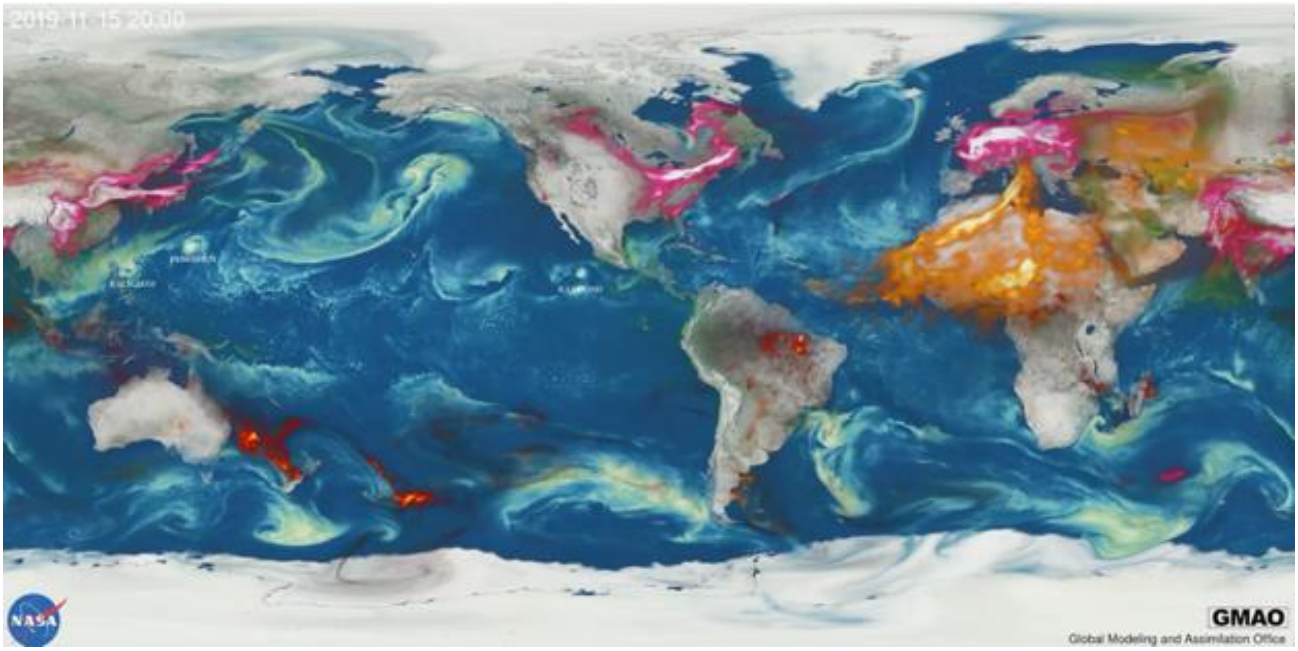

Photo Credit: *NASA's Goddard Space Flight Center*

NASA's Global Modeling and Assimilation Office used Earth science data gathered from multiple missions to visualize several high impact events across the globe between August 2019 and January 2020, including Hurricane Dorian (August to September 2019), major fire events in South America and Indonesia (August to September 2019), and extreme wildfires in Australia (December 2019 to January 2020). The model helps demonstrate how different events interact and the environmental impacts they can have around the globe.

NASA Earth Science explores our rapidly changing world, where natural and human influences interact, following an interdisciplinary, Earth systems approach that examines the interplay among the atmospheric, ocean, land, and ice systems. Studying the Earth in an integrated way is essential to understanding the cause and consequences of climate change and other global environmental concerns. NASA's Earth Science program makes substantial contributions to the growing body of Earth observation data and research that tells us our planet and its climate are profoundly changing. While much remains to be understood about the natural and human induced- processes and the complex coupling at the heart of these changes, one thing is clear: NASA's measurements are critical to their understanding. As the impacts of global climate change become more numerous and acute, the demand for accurate, timely, and actionable knowledge about the Earth system is more pressing than ever. NASA's measurements provide information for decision-makers and intermediary organizations that work with communities affected by the impacts of a changing climate, including information regarding the efficacy of policies and decisions that help the us thrive on our changing planet.

Using the recommendations of the 2017 NASA Earth Science Decadal Survey, *Thriving on Our Changing Planet: A Decadal Strategy for Earth Observation from Space,* as a compass, NASA Earth Science is developing the observing systems that will answer the most important science and application questions of the next decade across the following areas identified by the decadal survey:

- Coupling of the water and energy cycles
- Ecosystem change
- Extending and improving weather and air quality forecasts
- Reducing climate uncertainty and informing societal response
- Sea-level rise
- Surface dynamics, geological hazards, and disasters

Heliophysics

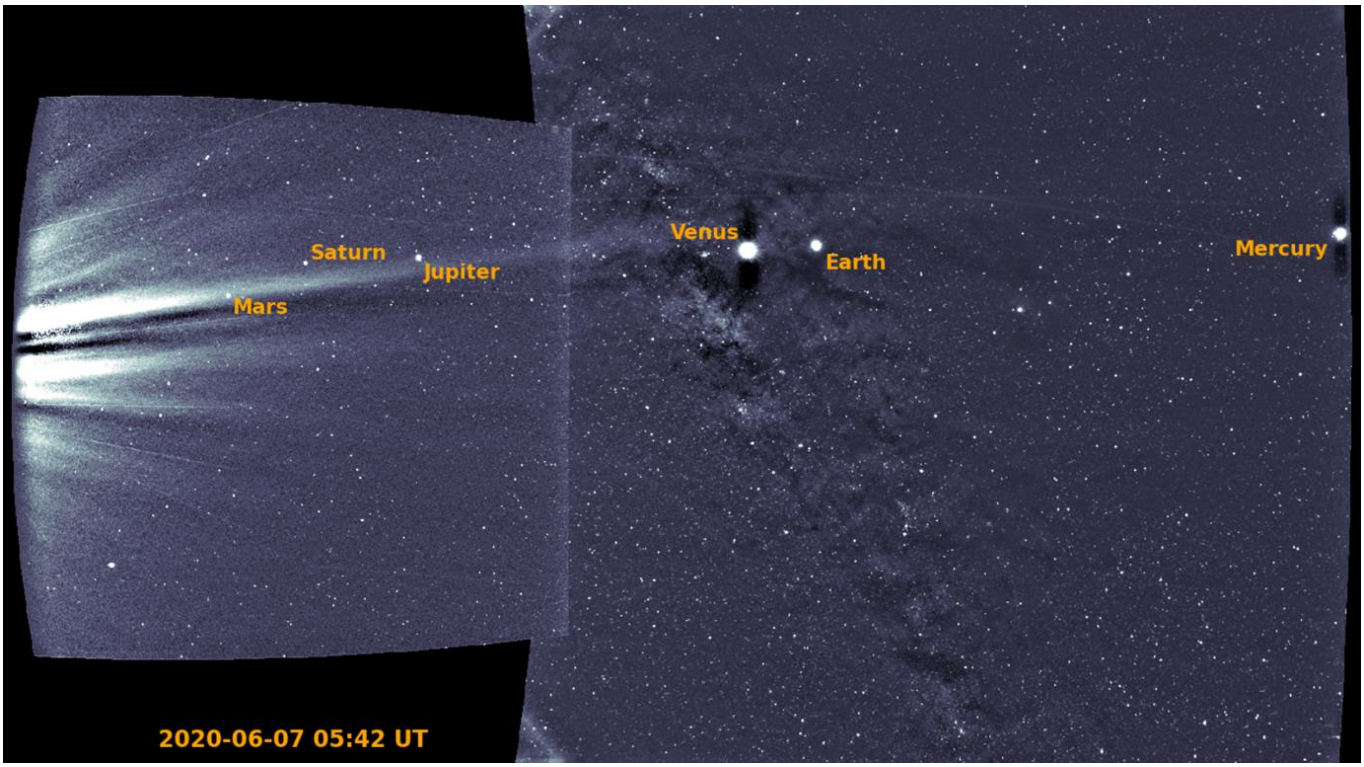

Photo Credit: *NASA/Johns Hopkins APL/Naval Research Laboratory/Guillermo Stenborg and Brendan Gallagher*

Parker Solar Probe was making a close approach to the Sun on June 7, 2020, when its Wide-field Imager for Solar PRobe (WISPR) captured the planets Mercury, Venus, Earth, Mars, Jupiter and Saturn in its field of view.

NASA's Heliophysics program embraces the original "first light" of scientific wonder - the Sun, and how it influences the very nature of space. Our nearest star sends out a steady outpouring of particles and energy, the solar wind, which forms an extensive and dynamic solar atmosphere impacting all the planets. This solar atmosphere extends far out to the edge of the heliosphere, shaping the protective bubble in which our solar system travels around the Milky Way. The scope of heliophysics is vast, spanning from the Sun's interior to Earth's upper atmosphere, throughout interplanetary space, to the edges of the heliosphere, where the solar wind interacts with the local interstellar medium.

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

Planetary Science

Photo Credit: *NASA/JPL-Caltech*

NASA's Perseverance Mars rover took a selfie with the Ingenuity helicopter, seen here about 13 feet (3.9 meters) from the rover. This image was taken by the WATSON camera on the rover's robotic arm on April 6, 2021, the 46th Martian day, or sol, of the mission.

Planetary science is a grand enterprise undertaken for the benefit of all humanity. Through the observation and discovery of complex planetary worlds and objects, we seek to understand our solar system and the distribution of life within it. The NASA Planetary Science strategic objective is to advance scientific knowledge of the origin and history of the solar system, the potential for life elsewhere, and the hazards and resources present as humans explore space. The scientific foundation of this endeavor is NASEM's 2011 planetary science decadal survey, *Vision and Voyages for Planetary Science in the Decade 2013-2022*. NASA pushes the limits of spacecraft as well as robotic engineering design and operations to implement this vision and manages a diverse portfolio of research and technology development that secures maximized science return for resources invested.

The excitement of venturing further with planetary science exploration is coupled with unique mission investigations. NASA's New Horizons spacecraft in 2019 completed the first in human history fly-by of a Kuiper Belt object, Arrokoth, and continues onward. The OSIRIS-REx mission successfully completed sample collection at asteroid Bennu in 2020 and is now on its return journey to deliver those samples back to Earth. NASA currently is operating spacecraft at Mars, Jupiter, and the Moon, including the Ingenuity helicopter that demonstrated the first ever powered controlled flight on another world in 2021; and is undertaking a flagship mission to Jupiter's moon Europa, as its subsurface ocean has great potential to harbor extraterrestrial life. The mission to return the first samples from the surface of another planet is underway, with the successful landing of Perseverance and the initiation of the collection of scientifically selected samples. The Mars Sample Return campaign will recover these samples and return them safely to Earth to enable decades of science analysis. Our Moon holds important information about the formation of our planet, resources for living and working in space, traveling farther into space, and strategic and economic opportunities. Knowledge gained by future human missions to the Moon will be utilized to visit Mars and possibly other solar system bodies, in concert with continued robotic missions. Advances in planetary science, coupled with leading efforts to detect, track, and characterize near-Earth objects, will continue to improve planetary defense.

STRATEGY 1.2

Participate as a key partner and enabler in the Agency's exploration initiative, focusing on scientific research of, on, and from the Moon, lunar orbit, Mars, and beyond.

Exploration is a NASA staple. Space Policy Directive-1 calls on NASA to "lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities. Beginning with missions beyond low- Earth orbit, the United States will lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars and other destinations." As its next step in human space exploration, NASA's Artemis program is preparing to send the first woman and first person of color to the Moon by 2024. By 2028, the program plans to establish sustainable lunar exploration that will eventually lead to human missions to Mars. SMD is a direct contributor to this national priority through ongoing investments in fundamental research and science and technology payloads, support for commercial landers and payloads, and lunar samples. Our active collaboration with commercial and international partners opens new opportunities of scientific exploration of the Moon.

SMD is leading NASA's Commercial Lunar Payload Services (CLPS) initiative to enable rapid, frequent, and affordable access to the lunar surface and cislunar space. In addition to science investigations, early CLPS deliveries will include valuable technology demonstration payloads to inform the development of future exploration systems needed for humans to return to the lunar surface. Future payloads will include rovers, power sources, and science experiments, including NASA's Volatiles Investigating Polar Exploration Rover (VIPER), and technology demonstrations to be infused into the Artemis program. NASA is currently using the commercial providers to deliver over 40 payloads to five lunar surface destinations for under $500M in the next 2 years. Future annual solicitations will provide PI-led science payload suites for deliveries in 2024 and beyond. Starting in 2022, NASA will maintain a cadence of approximately two CLPS deliveries per year, providing ample opportunities not only for SMD, but ESDMD, SOMD, STMD and our international partners for years to come.

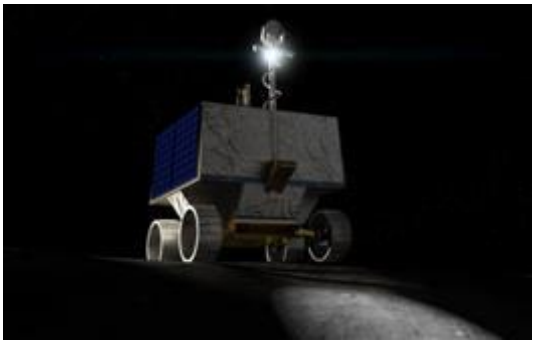

Photo Credit: *NASA Ames/Daniel Rutter*
NASA's VIPER will go to the South Pole of the Moon to get a close-up view of the location and concentration of water ice that could eventually be harvested to sustain human exploration on the Moon, Mars — and beyond.

SMD will continue to seamlessly collaborate with the Exploration Systems Development (ESDMD), Space Operations (SOMD), and Space Technology (STMD) Mission Directorates, as well as their partners, to further these mutual national objectives:

- Robotically assess environmental constraints that could impact crew safety and resource availability at the Moon, Mars, and beyond;
- Develop opportunities across all science disciplines that leverage investments in human exploration towards performing high-priority science, using novel platforms, and robotic and human-assisted research paradigms; and
- Engage across the Agency to ensure that its technological approaches are aligned with Agency investments in platform technologies, and feed forward towards science and human exploration goals, where appropriate.

STRATEGY 1.3

Advance discovery in emerging fields by identifying and exploiting interdisciplinary opportunities between traditional science disciplines

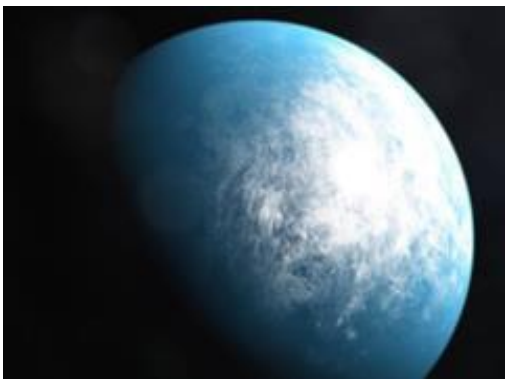

Photo Credit: *NASA's Goddard Space Flight Center*
NASA's TESS has found its first earth sized exoplanet in the habitable zone, TOI 700d. In the future, the James Webb Space Telescope may be able to identify whether the planet has an atmosphere, which could provide insight into if TOI 700 d is a life-bearing world.

SMD has traditionally operated within the disciplines identified in Strategy 1.1. We recognize that there is tremendous potential to make revolutionary scientific advances, not just within these disciplines, but also at the interfaces between and among disciplines. SMD therefore seeks to provide opportunities for integrated, interdisciplinary research that encourages collaboration. To be successful, SMD must balance the ownership of these opportunities to ensure consistency and alignment to the program of record. For example, SMD has restructured its Exoplanet Research Program to better function as a cross-divisional program involving personnel and funding from all science divisions. SMD has also adopted a new process to evaluate these proposals by topic, with panels that are agnostic to the common funding sources of the Principal Investigators (PI).

There are many cross-cutting opportunities between disciplines within SMD, as well as across the agency. Within the directorate, synergies exist between astrophysics, biological and physical sciences, heliophysics, planetary science, and Earth science that could result in both fundamental and applied advancements.

The Exoplanet Research Program serves as a model for how other disciplines work together. For example, emerging opportunities exist to use Earth as a laboratory in support of habitability and to answer questions from the heliophysics domain. SMD surveys the scientific community for feedback on suggested research areas for cross-divisional collaboration not currently solicited by the existing grants programs.

STRATEGY 1.4

Develop a broadly applicable, target-audience focused approach to SMD's applied programs, including Earth Science Applications, Space Weather, Planetary Defense, and Space Situational Awareness.

One of SMD's goals is to protect and improve life on Earth. To accomplish this, we will build on our long-standing work on Earth Science Applications and expand our approach to providing applied information in the areas of Space Weather, Planetary Defense, and Space Situational Awareness. It is our intent to develop a NASA-wide strategy across these different research areas, engaging directly and through our partnerships with operational agencies and user communities, to influence best practices that meet the needs of the communities our data can positively affect. As these capabilities mature, there may be opportunities for commercialization that would increase the return on investment of NASA research and foster commercial innovation.

PRIORITY 2
INNOVATION

STRATEGY 2.1: Foster a culture that encourages innovation and entrepreneurship across all elements of the SMD portfolio.

STRATEGY 2.2: Foster a culture that encourages collaboration in pursuit of common goals.

STRATEGY 2.3: Enhance our focus on high intellectual risk/high impact research investments.

STRATEGY 2.4: Drive innovation in focused technology areas to capitalize on the rapid evolution of commercial capabilities.

STRATEGY 2.5: Ensure NASA's science data are accessible to all and produce practical benefits to society.

Excellence is achieved through continuous innovation and learning. SMD recognizes that innovation and measured risk-taking are the cornerstones of a forward-looking program of scientific discovery. This boldness in vision must be coupled with tailored management processes. To answer the science questions defined in Priority 1, we must rely on innovation. We currently have programs in place to identify and mature technologies in support of future missions, but we must also be ready to take advantage of revolutionary new capabilities as they are developed. Therefore, we have identified four innovation strategies to enable both incremental steps and giant leaps in knowledge.

As research has shown, diversity is a key driver of innovation and more diverse organizations are more innovative. Creating an inclusive culture that cultivates diverse teams internally and externally to SMD is an essential foundation for innovation to succeed. We will address this important aspect in Priority 4.

STRATEGY 2.1

Foster a culture that encourages innovation and entrepreneurship across all elements of the SMD portfolio.

Measured risk-taking is a necessary part of progress and SMD seeks to create an environment in which risk-taking is encouraged and transparently managed. To do this, SMD operates a coherent and strategic directorate-wide innovation ecosystem, including early-stage technology identification, technology development and maturation, and ultimately transition to flight. We recognize that not all innovation will be successful, and that room for experimentation and failure should be allowed during the developmental process.

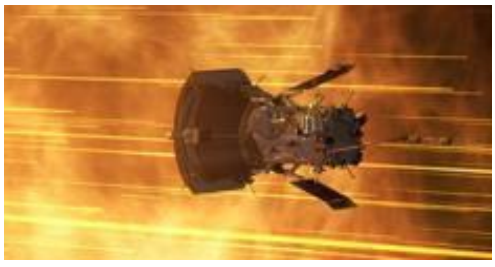

Photo Credit: ***NASA's Goddard Space Flight Center***
For the first time in history, a spacecraft has touched the Sun. NASA's Parker Solar Probe employs a revolutionary heatshield capable of withstanding temperatures of nearly 2,500° F. This innovation enabled the probe to fly within the Sun's inner corona, sampling particles and fields that are still bound to the Sun's atmosphere.

While the importance of innovation and experimentation is significant, proactive communication about the risks associated with a particular mission concept, early investments in technology development, and other risk reduction efforts are key components of this strategy.

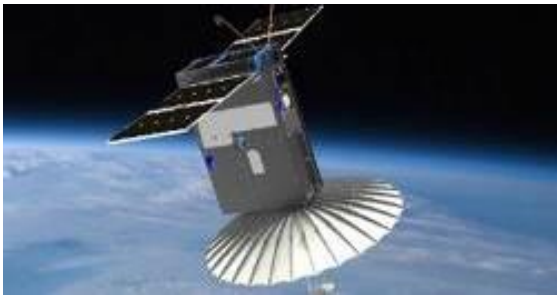

Photo Credit: ***Tyvak/Jonathan Sauder/NASA/JPL-Caltech***
In-space technology demonstrations such as NASA's Radar in a CubeSat (RainCube) allow SMD to increase technology readiness and supports risk reduction for future missions.

We often think about risk-management in the context of a single project rather than the overall risk posture of the entire SMD enterprise. In the future, SMD seeks to grow innovation through both its competed and directed work by using a portfolio-level approach, allowing SMD to take varying risk postures between missions, depending on their scale, and tailor management processes accordingly. For competitive opportunities, SMD must encourage and reward proposers for novel approaches towards scientific discovery, when they are accompanied by realistic risk maturation processes. SMD recognizes that taking risks means accepting occasional failures. In addition, clear lines of authority and accountability for risk-related activities are necessary for proper management.

SMD is also committed to foster a sense of entrepreneurialism in its research community. To this end, SMD will join with STMD to make the i-Corps program available to its research communities. This nationally recognized scheme is designed to catalyze the translation of fundamental research into the commercial marketplace, as well as provide researchers training in entrepreneurship skills.

STRATEGY 2.2

Foster a culture that encourages collaboration in pursuit of common goals.

Innovative management of an executable, compelling and exciting portfolio is accomplished by balancing both large and directed missions with medium to small-sized and competed missions. The selection of missions with a determined cadence and cost-cap engages the scientific community to present impactful and diverse ideas to meet emerging priorities. Sound planning prevails as missions exist in various stages of formulation—development, prime operations, and extended operations—wherein high return on investment has been proven. Finally, effort is promoted between missions, research and analysis, technology and supporting infrastructure.

SMD is a learning organization that encourages best practices learned in one area to be rapidly shared and implemented across the entire organization and Agency. While each division within the organization has been established to align with the needs of the communities they serve, areas of mutual interest that overlap between divisions do exist. This creates opportunities for one division to pilot new ways of doing business, and for the other divisions to adopt them. To the extent possible, SMD uses cross-divisional teams to respond to strategic opportunities or issues that impact the entire organization and uphold its mission toward excellence.

STRATEGY 2.3

Enhance our focus on high intellectual risk/high impact research investments.

SMD invests in research that can have transformational impacts on our understanding of the world around us. Our research programs provide opportunities for the science community to offer new ideas and new approaches towards scientific discovery. We recognize that the peer review process used to make investment decisions may inadvertently discourage innovative concepts, and therefore we seek to be more proactive in encouraging high intellectual risk/high impact

research proposals. SMD established a Blue-Ribbon Panel to re-examine high-risk-/high-impact proposals that were not initially selected in disciplinary panels, and in FY22 launched a new funding line to catalyze and co-fund such potentially transformative research awards.

STRATEGY 2.4

Drive innovation in focused technology areas to capitalize on the rapid evolution of commercial capabilities.

While NASA invests heavily in new technologies to meet its needs, there are also opportunities to translate technologies from outside entities into NASA concepts. In some cases, these technologies present opportunities for NASA to capitalize on the investments of others to reduce mission costs and yield more advanced science capabilities. SMD must remain flexible in its mission design approach to enable enhanced collaborations with other government agencies and the commercial sector to best take advantage of these new modalities.

Photo Credit: ***NASA's Scientific Visualization Studio***
NASA's Global-scale Observations of the Limb and Disk (GOLD) instrument is hosted by a commercial communications satellite, operated by SES Government Solutions. GOLD is examining the response of the upper atmosphere to interactions with the Sun, magnetosphere, and the lower atmosphere.

SMD is actively pursuing opportunities to host science instruments on commercial satellites. These opportunities enable NASA to secure lower-cost access to space, such as Venture-Class Acquisition of Dedicated and Rideshare (VADR) missions, while leveraging existing commercial capacity, demand, and expertise. Similarly, SMD actively searches for opportunities where commercial entities enable different capabilities (new launches, research platforms, etc.) or new, service-based business models. The Commercial Lunar Payload Services (CLPS) initiative is one such endeavor that provides rapid, frequent, and affordable access to the lunar surface as the ultimate test bed for exploration and technology developments. In all cases, the criteria for collaboration include "enabling new science" or resulting in "more science per dollar". To find such novel partnerships, experimentation is key. Notably, SMD is building upon the success of NASA's sounding rocket and balloon programs by making commercial suborbital platforms available to SMD-sponsored investigators alongside NASA-provided platforms starting in ROSES-22. This will allow investigators to propose a new class of nimble and innovative payloads to be flown on commercial suborbital platforms.

STRATEGY 2.5

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

To ensure NASA's science data are accessible to all and produce practical benefits to society, SMD plans to undertake investments and initiatives that will accelerate the accessibility and use of SMD data by its user community by investing in the following: 1) capabilities to enable open science; 2) continuous evolution of data and computing systems; and 3) community and strategic partnerships for innovation. As one example, NASA will enhance collection of greenhouse gas (GHG) data from aircraft and instruments, and expand existing activities including the legacy Carbon Monitoring System, competed research, and support for GHG measurement networks, to help assess the impacts of environmental change.

As communities around the world have changed their behavior in response to the spread of COVID-19, NASA satellites have observed changes in the environment. SMD, in collaboration with the European Space Agency (ESA) and the Japan Aerospace Exploration Agency (JAXA), have

created online data portals to provide an even richer picture of what is happening on our home planet during this time of crisis. The COVID-19 Dashboard reflects a rapid response to monitor, track and compare changes over time.

PRIORITY 3
INTERCONNECTIVITY AND PARTNERSHIPS

STRATEGY 3.1: Actively engage with the NASA Centers to make more informed strategic decisions that further NASA's scientific goals and are aligned with each Center's unique capabilities.

STRATEGY 3.2: Actively seek collaborations with international partners based on their unique capabilities and mutual scientific goals.

STRATEGY 3.3: Actively engage with other federal agencies to make more informed decisions, cooperate in scientific research, and pursue partnerships that further national interests.

STRATEGY 3.4: Provide increasing opportunities for research institutions, including academia and non-profits, to contribute to SMD's mission.

STRATEGY 3.5: Pursue public-private partnerships in support of shared interests with industry.

SMD directly supports researchers in their pursuit of knowledge because scientific discovery does not occur in isolation. SMD recognizes the important role that NASA Centers, other federal agencies, private industry, academia, non-profits, community- based organizations, and international partners play in helping make our scientific vision a reality.

Strategic partnerships that influence each contributor's strengths and interests can be an effective means of yielding advances in science and understanding for mutual benefit. Similarly, SMD has an opportunity to partner with other U.S. agencies to help further national interests in a coordinated and efficient manner. Building on this strong foundation, and under its new Engagement Strategy, SMD seeks to build new and meaningful relationships with underrepresented audiences, ultimately leading to more diverse partnerships to advance SMD and Agency goals.

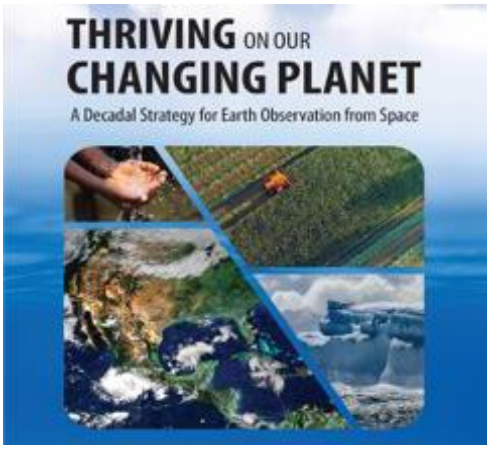

Photo Credit: ***National Academies of Sciences, Engineering, and Medicine***
Implementation of the 2017 Earth Science Decadal Survey encouraged the development of interagency, commercial and international partnerships.

STRATEGY 3.1

Actively engage with the NASA Centers to make more informed strategic decisions that further NASA's scientific goals and are aligned with each Center's unique capabilities.

SMD and NASA Center leadership will create a shared understanding of the important technical capability priorities for each center that are renowned within the community and work to implement SMD programs and projects, requiring knowledge of the health and capabilities at each NASA Center.

These prioritized capabilities will guide focused investment decisions at the portfolio level. SMD will ensure that roles and responsibilities are aligned with each NASA Center's unique strengths and ability to manage work. SMD is also engaged in activities that develop both talent and technical capabilities at the NASA Centers to ensure that future needs can be met. NASA Centers should be seen as "employers of choice" that attract recent graduates, mid-career scientists and engineers, and provide exchange and career growth opportunities for employees.

STRATEGY 3.2

Actively seek collaborations with international partners based on their unique capabilities and mutual scientific goals.

Photo Credit: ***NASA/ESA***
As a testament to the strength of the partnership between the U.S. and Europe, the first of two identical Sentinel-6 satellites in ESA's Sentinel mission, Sentinel 6-Michael Freilich, was named in honor of NASA's former Earth Science Division director.

Scientific discovery is a global endeavor and SMD empowers the scientific community worldwide. More than 2/3 of SMD's missions are international collaborations. The directorate has nearly 350 active international agreements involving nearly 140 countries and regions. With growing international interest in space exploration, the competition for partnerships among space agencies is increasing. We are aware of, and informed by, the context of economic competitiveness and national security concerns in the areas in which we work.

We seek to be the partner of choice in Earth and space science, and to contribute to the nation's diplomatic goals. For example, in 2021 SMD issued a Request for Information (RFI) seeking ideas for innovative programs that could help cultivate increased capacity in emerging partner nations and promote NASA best practices and values.

While demonstrating U.S. leadership in Earth and space science is vital for SMD, partner capabilities and resources should be weighed while mission leadership decisions are being made to advance scientific discovery. This strategic goal is assisted by SMD's policy to initiate international partnerships strategically. SMD's process for initiating NASA contributions to international partner-led missions are guided by a set of criteria contained in SPD-37, "Principles for Collaborations on Missions with International Partners."

STRATEGY 3.3

Actively engage with other federal agencies to make more informed decisions, cooperate in scientific research, and pursue partnerships that further national interests.

SMD continues to strategically evolve partnerships with other organizations across the federal government in pursuit of common interests and priorities. These partnerships can take different forms, from enabling new missions to improving our understanding of common areas of study to developing technology for each other's missions. These partnerships also facilitate the transfer of knowledge between agencies to enhance our overall contribution to the Nation. Our interests may evolve over time to ensure continued alignment to national and Agency priorities, and to capitalize on each partner's unique strengths.

Photo Credit: ***NASA***
The Landsat satellites, a partnership between NASA and the U.S. Geological Survey, have provided an uninterrupted space- based data record of the Earth's land surface since 1972 to help advance scientific research towards understanding our changing planet.

STRATEGY 3.4

Provide increasing opportunities for research institutions, including academia and non-profits, to contribute to SMD's mission.

NASA's missions and grants have reached the vibrant research community across the United States and are already making significant contributions to answer the science questions defined in Priority 1. The research community is the major source of new science questions and innovative mission concepts. We will adjust our calls for proposals in response to the science community's

feedback on alternative ways to make scientific measurements.

We will also continue to make improvements to the scientific competition process to be responsive to researcher needs. Initiatives like the No Due-Date (NDD) programs in Planetary Science launched with the release of ROSES 2021 resulted from researcher input into challenges faced during the COVID-19 pandemic. NDD seeks to allow individual PIs the opportunity to better achieve work-life balance and to give smaller institutions with a less-robust proposal support system greater flexibility in submitting proposals. As the results of this effort become clear over upcoming solicitation years, the hope is that the number of proposals from smaller institutions, including Primarily Undergraduate Institutions (PIUs) and Minority-Serving Institutions (MSIs), will increase, in turn expanding the pool of partner research institutions.

To continue making scientific progress in the future, we must recognize the important role that research institutions play in developing new talent and be supportive of these efforts. We will increase that support by actively encouraging students and early career researchers to take a more hands-on approach with our missions and research. We will also increase partnerships across institutions to provide additional opportunities for engagement and increasing diversity of thought. Listening sessions at MSIs and targeted activities in partnership with affinity groups will help broaden our footprint across the research and academic landscape. Together, these efforts align to support the development of a more diverse future workforce directly advancing SMD's mission.

STRATEGY 3.5

Pursue public-private partnerships in support of shared interests with industry.

SMD seeks to foster an environment that allows for more cost-effective approaches to enable new scientific discovery and innovation. Consistent with the principles for commercial partnerships outlined below, we are committed to partnering with the U.S. aerospace industry and will continually assess partnership models, including traditional contractor relationships and emerging public-private partnerships, to advance important science objectives as well as to engage the public in our efforts. For example, we have recently undertaken several initiatives to leverage new commercial capabilities, such as expanded use of SmallSats and CubeSats, in all science disciplines via focused mission and constellations, commercial Earth Science data buys, rideshare opportunities, and commercial lunar payload transport services. Earth Science also engages with non-traditional partners in the commercial and NGO sectors, such as Conservation International, Google, Mercy Corps, and Microsoft. New partnership models will require opportunities for commercial providers to demonstrate their capabilities through targeted experiments that provide a more in-depth understanding of alternative mission architectures, data acquisition approaches, and data licensing agreements.

Beyond influencing industry's expertise to meet the Agency's goal, SMD is also committed to working in tandem with private sector partners to address shared challenges, such as orbital debris mitigation and spaceflight safety coordination.

SMD Principles for Commercial Partnerships

1. Develop strategic partnerships that leverage the unique strengths of each contributor to drive scientific progress.
2. Actively pursue partnerships that innovate both in *what* we do with commercial partners as well as in *how* we do it.
3. Continually assess and evolve partnership models, recognizing that experimentation is key and that some experiments may fail.
4. Evaluate the success of traditional and nontraditional partnerships by determining if these result in “enabling new science” and in “more science per dollar.”
5. Encourage and assess potential obstacles to Principal Investigator adoption of commercial solutions to illustrate market demand from the science community.
6. Leverage existing commercial capacity, demand, and expertise, while exploring emerging business areas where early adoption can support domestic growth and competitiveness.
7. Build on investments in partnerships across NASA and other parts of the government, sharing NASA best practices.
8. Accept some additional risk responsibly in the interest of establishing affordable, high-value domestic capabilities.

PRIORITY 4
INSPIRATION

STRATEGY 4.1: Increase the diversity of thought and backgrounds represented across the entire SMD portfolio through a more inclusive environment.

STRATEGY 4.2: Advance equity in the scientific competition process to develop a scientific community that reflects the diversity of the Nation.

STRATEGY 4.3: Purposefully and actively engage with audiences and learners of all ages to share the story of NASA's integrated science program.

SMD inspires the learners of today and develops the leaders of tomorrow. The success of these efforts not only benefits NASA, but also strengthens our partners identified in Priority 3. We understand that diverse teams create better, faster, and more innovative solutions and breakthroughs. To that end, we are dedicated to identifying and eradicating systemic obstacles that impede or dissuade underrepresented groups from joining and rising through NASA's ranks or from participating in NASA's programs. We expect the learning and effort in this space to be challenging—and we plan to co-develop solutions with those we wish to serve better as we install viable solutions across our processes. Internally, we are committed to creating an environment of belonging that is undergirded by an inclusive, psychologically safe culture. Further, we are working continuously to broaden access and equity to our external projects, offerings, and developing opportunities to foster diversity and inclusion throughout NASA's science portfolio. We are intentional about realizing our commitment that all people, across ages and backgrounds, see NASA as their scientific home in the Nation we share together.

STRATEGY 4.1

Increase the diversity of thought and backgrounds represented across the entire SMD portfolio through a more inclusive, equitable, and accessible environment.

Photo Credit: *NASA*
SMD interns tour the NASA Centers to learn more about the groundbreaking innovative programs taking place across the Agency.

SMD believes in the importance of cultivating diverse and inclusive teams to tackle strategic problems and maximize scientific impact. SMD is using a deliberate and measured approach to increase the inclusion, diversity, equity, and accessibility (IDEA) of its teams, both internal and external to NASA. Further, SMD is striving to develop a truly inclusive, equitable, and accessible environment through intentional efforts that increase internal dialogue, awareness, transparency, and introduce policies, and practices that further inclusion.

To this end, SMD is implementing an IDEA-specific strategy with key milestones, goals, and performance indicators. This strategy embeds principles of IDEA across the SMD portfolio (internal/external projects and activities), identifies priority areas of work, and provides clear measurable outcomes to track progress. SMD will continue to leverage internal, agency level, and external expertise in the community to co-create its IDEA strategy with diverse stakeholders. SMD's IDEA strategy is informed by agency-level DEIA strategic goals and developed in alignment with broader agency plans.

For the past several years, SMD has led an unprecedented series of initiatives to strengthen diversity and equity in the scientific community. For example, SMD now leads the federal scientific enterprise in its use of dual-anonymous peer review for research proposal evaluation. This approach has quantitatively strengthened equity in access to research funding since its inception in 2020. In 2021, NASA piloted the use of required inclusion plans with research proposals to ensure that NASA-sponsored research teams are positive and inclusive working environments. In 2022, SMD will launch a new Bridge program, a signature initiative designed to stimulate collaborative partnerships between Minority Serving Institutions, very high research activity (R1) universities, and NASA Centers.

SMD is taking a strategic approach to managing its workforce, strengthening recruitment practices, and identifying leadership development and mentoring opportunities as ways to grow an inclusive and more diverse and stronger organization. To strengthen SMD's internal IDEA efforts, numerous organizational structures are being implemented to increase collaboration and catalyze action through all facets of SMD. Such interventions include the chartering of the IDEA Working Group which serves as a centralized point for communicating IDEA-related challenges, advocates internally, and implements IDEA initiatives that span divisions. The IDEA Working Group is responsible for tangible inroads such as a monthly conversation series, broad strokes learning curriculum, mechanisms to elicit ongoing feedback from the workforce, and a job shadowing program for SMD staff to forge relationships and experiences across positions. The working group champions SMD-wide education efforts and adoption of inclusive language. IDEA advocates throughout SMD work in tandem to spearhead initiatives, projects, and specific goals within their portfolio.

SMD is a strong supporter of programs that provide students and recent graduates with opportunities to work with and learn from leaders in their chosen fields. Such programs not only benefit SMD but strengthen the overall community in which we work. More information about SMD's strategic engagement approach with Minority Serving Institutions (MSI's) is enumerated in Strategy 3.4.

STRATEGY 4.2

Advance equity in the scientific competition process to help develop a scientific community that reflects the diversity of the Nation.

SMD recognizes that its influence and reach go well beyond its missions, and that its efforts to encourage healthy behavior through action are part of the broader national journey towards a more equitable society. The SMD scientific competition process, which funds a national community of external researchers through grants and other competed opportunities, is one of NASA's most direct and visible mechanisms to impact the broader scientific community. With the recognition that we have influence over this process as well as an opportunity to model inclusive and equitable behavior, SMD has undertaken concerted efforts to examine the scientific competition process to identify and, in collaboration with underserved communities, co-develop solutions to address barriers to entry and meaningful participation.

With these goals in mind, SMD is actively building on ongoing efforts to improve existing policies, procedures, and guidance. Recent reforms have sought improvements in the proposal submission phase, as well as in the evaluation phase, to improve both the diversity of individual and/institutions participating in the process as well as to identify and address the potential obstacles to their success. These changes will continue to be informed by feedback from the community, as well as best practices adopted by other leading scientific institutions.

SMD is investing in students and early career faculty to help them grow into leaders of the future. SMD has been particularly focused on developing a new cadre of mission Principal Investigators through workshops and hands-on training as part of existing mission teams. Long-duration missions, such as Hubble and Chandra missions, provide a unique opportunity to develop future leaders from within the team, and are assessed on the robustness of teams over the lifetime of the mission.

Photo Credit: ***Erika Hamden***
2019 PI Launchpad Workshop Participants gather before discussing the proposal process. SMD has partnered with the Heising-Simons Foundation, and the University of Arizona teamed up to organize workshops, share presentations, and panels, to make the proposal process more transparent and accessible.

SMD recognizes the importance of creating inclusive environments so that everyone can participate equitably. People must feel safe, valued, and included before they are comfortable contributing to the team. We have therefore initiated several efforts designed to address the problem of harassment within the scientific community. These include Codes of Conduct for SMD-sponsored conferences, review panels, and mission teams; as well as adding inclusion requirements to proposals submitted in response to mission Announcements of Opportunity.

STRATEGY 4.3

Purposefully and actively engage with audiences and learners of all ages to share the story of NASA's integrated science program.

Photo Credit: ***NASA/Aubrey Gemignani***
SMD coordinated space and ground observations of the August 21, 2017 total solar eclipse, allowing scientists to safely take advantage of a research opportunity. Eighty-eight percent of all U.S. adults shared in the experience of the first total solar eclipse to cross the continental United States in almost 100 years.

SMD creates value by transforming taxpayer investments into knowledge, about the many worlds around us, and our place in them. This knowledge is used to solve problems and create a better future. But knowledge is only advanced when it is shared using the rigorous processes that science affords – replicability, peer-evaluation, publication, civil discourse, and the creation of new questions. The public should have confidence in NASA's findings, particularly when that information concerns them, their families, communities, and the world at large.

SMD's achievements inspire learners of all ages. NASA's Science Activation program's vision is for learners across the United States to become architects of their own life-long learning pathways. All learners. In fact, in 2021, 50% of the Program funded efforts were in communities not traditionally served. Through collaborations with community-based partnerships and using transdisciplinary, digital tools and real-world experiences, we enable learners to actively participate in the advancement of knowledge. For example, over 450 community engagement sites have been initiated across the United States in anticipation of the James Webb Space Telescope mission. For launch, these sites hosted 614 events—including star parties and hands-on arts and educational events—and provided feedback on innovative ways NASA can support their community's learners for Webb's first images.

SMD reaches the American public and beyond by sharing its science and encouraging greater public understanding of its missions, research, and related activities. We disseminate science results to elevate awareness, excitement, and understanding. We do these using techniques such as storytelling to help connect the work that NASA does to people's everyday lives. We recognize that communication channels change and evolve with time, and thus our communication—just like

our research—needs to be innovative and incorporate lessons learned into current practice and future plans. SMD is undertaking a website modernization effort to consolidate our public websites into an experience that not only shares our science but encourages visitors to actively participate in the excitement of discovery.

SMD also encourages opportunities for new engagements, as in citizen science projects. Volunteers can directly participate in data analysis, observations, and problem solving, thereby contributing to NASA's science mission and the overall advancement of knowledge.

Implementation

SMD's deliberate focus on excellence is supported by governing processes and behaviors across the entire portfolio. As highlighted throughout this document, implementation efforts are ongoing and will continue to be evaluated for their success in advancing the priorities described. It is our intention to identify owners and implementation timelines to provide accountability and transparency for each of the strategies detailed in this vision. Internal processes will be used to help prioritize the strategies for implementation and a dashboard of major milestones will be developed and posted publicly on the SMD website to share both implementation details and our progress in meeting them. The dashboard is intended to evolve over time in response to changing opportunities and needs.

Appendix A: Acronym List

BPS	Biological and Physical Sciences Division
CLPS	Commercial Lunar Payload Services
COR	Cosmic Origins
ESA	European Space Agency
ESD	Earth Science Division
ExEP	Exoplanet Exploration
GOLD	Global-scale Observations of the Limb and Disk
GPS	Global Positioning System
HEOMD	Human Exploration and Operations Mission Directorate
MRO	Mars Reconnaissance Orbiter
NASA	National Aeronautics and Space Administration
NASEM	National Academies of Sciences, Engineering, and Medicine
NSF	National Science Foundation
PCOS	Physics of the Cosmos
PI	Principal Investigator
PSD	Planetary Science Division
R&A	Research and Analysis
RainCube	Radar in a CubeSat
ROSES	Research Opportunities in Space and Earth Science
SMD	Science Mission Directorate
STScI	Space Telescope Science Institute
STMD	Space Technology Mission Directorate
TESS	Transiting Exoplanet Survey Satellite
USGS	United States Geological Survey
VIPER	Volatiles Investigating Polar Exploration Rover

Appendix B: Accomplishments

Deputy Associate Administrator for Research

Section	Brief title	Description	Status	Progress	Outcome/ Current Impacts
2.1	Accelerating Entrepreneurship Through i-Corps	Starting in 2022, SMD will join I-Corps. This nationally recognized program is designed to catalyze the translation of fundamental research into the commercial marketplace, as well as provide researchers training in entrepreneurship skills.	Ongoing		
2.3	Catalyzing High-Risk/High-Impact research	SMD already selects high-risk/high-impact (HR/HI) proposals at a higher rate than other types of proposals. However, to underscore the importance of HR/HI work, SMD established a Blue-Ribbon panel to examine HR/HI research proposals that were not initially selected for funding through disciplinary research panels. As a result, SMD made numerous awards to research that would have a potentially transformative impact in their respective fields. Going forward, SMD will introduce a new fund — the Research Catalyst Fund — designed to act as a focal point and partial funding source for HR/HI research.	Ongoing		
2.4	Embracing Commercial Suborbital Capabilities	SMD is excited by the emergence of new commercial suborbital platforms that complement NASA's existing capabilities. Beginning in ROSES-22, SMD plans to make commercial platforms available for all programs that fly suborbital payloads. These capabilities will be offered alongside NASA-provided platforms.	Ongoing		
4.1	Dual-Anonymous Peer Review	SMD leads the federal scientific enterprise in the use of dual-anonymous peer review to evaluate research proposals, which has quantitatively strengthened equity in access to research funding and directly boosted the diversity in NASA's science ecosystem. Approximately 20 ROSES programs now use dual-anonymous peer review, and SMD plans to expand its use in the future.	Ongoing		
4.1	Work-Life Balance Resources	SMD recognizes the importance of balancing research and life commitments and established a series of resources to inform SMD-funded researchers about the various wellness resources, award flexibilities, and leave options that are available to the research community (https://science.nasa.gov/researchers/work-life-balance)	Complete		
4.1	SMD Bridge Program	SMD is committed to building diverse and inclusive research environments that are essential to the vitality of the scientific enterprise. In 2022, SMD will launch a new Bridge program, which is designed to stimulate collaborative research partnerships between Minority Serving Institutions, very high research activity universities, and NASA Centers, thereby boosting equity and excellence in the space, Earth and biological and physical sciences.	Future		

4.1	Codes of Conduct for Sponsored Meetings	SMD now requires all meetings that we sponsor through the Topical Workshops, Symposia, and Conferences ROSES solicitation to explicitly include codes of conduct that strive to create an environment that is free of harassment and discrimination.	Complete		
4.1	Mission PI Workshops	Beginning in 2019, SMD began offering lectures and workshops on becoming a mission Principal Investigator. For very early career researchers, the one-to-two hour "So you think you want to be a Principal Investigator..." lecture provides basic information on the role of the mission Principal Investigator and the processes SMD uses to solicit, evaluate, and select Principal Investigator-led missions. For researchers who have already begun thinking about proposing a mission, SMD has developed the "PI Launchpad" — a small, intensive workshop experience focused on a small number of skills key to writing successful mission proposals. Attendees at PI Launchpads are chosen through a highly competitive application process that focuses on leadership experiences, including recognition of the role of power dynamics and diversity and inclusion in team leadership.	Ongoing		
4.1	Grant Term and Condition	All SMD grants now include a term and condition that requires institutions receiving NASA grant funding to provide NASA with information when the grantee institution has made a finding of harassment or has placed a NASA PI or Co-I on administrative leave pending a harassment investigation.	Complete		
4.1	Pre-Reviews of Mission Review Panels	Before the membership of a panel reviewing mission proposals is finalized, the Deputy Associate Administrator for Research convenes a small group of exceptionally experienced scientists to examine the processes used to recruit the panel. This review is focused on ensuring that a diverse, inclusive and unconflicted panel is in place.	Complete		
4.1	Review Panel Code of Conduct	SMD is strongly committed to ensuring that our peer-review panels are conducted with the highest possible levels of integrity, inclusion, and professional respect. Beginning with ROSES-21 reviews, SMD instituted Codes of Conduct that all panelists and panel chairs must abide by.	Complete		
4.1	Mission Team Code of Conduct	SMD is committed to building safe, inclusive, accessible, and equitable environments for mission science teams, and accordingly will require that all science teams adopt clear and actionable codes of conduct for research and publication.	Future		
4.1	AO requirements	SMD will add requirements to its Standard Announcement of Opportunity Template to require proposals to contain descriptions of the inclusive and equitable processes employed in the initial creation of mission proposal science teams as well as a plan to maintain diversity and inclusivity throughout the lifetime of the proposed mission. SMD is also exploring approaches to incentivize the participation of Minority Serving Institutions in mission proposals in an equitable and capacity-building manner.	Future		
4.1	Inclusion Pilot in R&A	The ROSES-21 Astrophysics Theory program element piloted an inclusion plan, whereby all proposals must address plans for creating a positive and inclusive environment for those carrying out the investigation, as well describe the contributions the proposed investigation will make to the training of a diverse and inclusive scientific workforce. Based on the outcome of this pilot, SMD is making inclusion plans an element of other ROSES-22 programs.	Ongoing		

Deputy Associate Administrator for Programs

Section	Brief title	Description	Status	Progress	Outcome/ Current Impacts
1.2	SMD - STMD MOU	The purpose of this MOU is to formalize a process for executing the technology programs of the two Mission Directorates in concert, such that collaboration is made possible, and duplication is avoided. Effective communication across the Mission Directorates is key to the success of executing the framework. Both Mission Directorates strive to invest in technologies that support their mission years in advance of mission implementation in order to retire risk, reduce cost, and increase the likelihood of success. Effective technology development requires careful analysis of technology gaps, identification of technologies to fill those gaps, prioritization of those gaps, sustained investment to advance the chosen technologies, and successful infusion into missions or other products benefitting society and the US economy. Technology development in each Mission Directorate is distinguishable: STMD's primary responsibility is to enable new spacecraft platform capabilities while SMD's is to mature new science instruments. When overlaps occur, proper coordination between SMD and STMD is essential to avoid duplication and ensure programmatic success.	Complete	MOU signed by SMD AA and STMD AA	
2.1	Entrepreneurs Challenge	The purpose of the Entrepreneurs Challenge is to identify fresh ideas and new partners (especially small start-up companies) to support development of instruments and technologies to advance the Agency's science exploration goals.	2nd year of a 3-year effort	Completed 2020 and 2021 Challenges.	In 2021, seven companies were each awarded $90,000 for their innovative ideas
2.1	Class D Implementation	Institutionalized Class D policies: Class D Compliance Matrix, Class D Mission Assurance Requirements (MAR), Class D Implementation Plan, and updated SMD SRB Handbook, changing the approach to acceptance of risk and managing projects. Execution of SMD Class D policy within SMD, allowing for the reduction of organizational requirements while maintaining the technical and programmatic integrity of low-cost missions.	Ongoing	Class D MAR was signed and implemented. Completed the Class D Compliance Matrix which aligns with NPR 7120.5F.	
2.2	Large Missions Implementation Plan	To ensure that SMD is more successful at delivering large strategic missions on time and within budget, the SMD Associate Administrator (AA) chartered a Large Mission Study (LMS) to examine how NASA makes critical decisions that either impede or support mission and programmatic success. At the conclusion of the study, a plan was developed and implemented. This effort will help inform SMD's leaders to improve decision making, management, and review processes across SMD, with emphasis on establishing and keeping more achievable commitments when large missions are confirmed.	Ongoing	Implementation plan has been briefed and published.	Implementation plan is already being applied to Mars Sample Return, and is in place to inform responses to the Astro2020 Decadal Survey

2.2	Portfolio Performance Management Integrated Approach	Ongoing activities for the improvement of programmatic oversight and management of the SMD flight missions portfolio. Ongoing activities for the development and implementation of NASA and SMD policies and practices. Working closely with SMD Divisions, NASA Centers, FFRDCs, OCE, OCFO, OSMA, and other NASA mission directorates.	Ongoing		
2.3	Technology Federation Board	The Technology Federation is an information exchange and discussion forum to air issues of importance and to craft policy relating to the planning, execution and infusion of technologies by and for SMD. The Technology Federation enables the coordination, planning, execution, and infusion of technologies across SMD; advises the SMD Associate Administrator on relevant technology issues; provides insight to the Centers regarding SMD priorities and plans; and assesses the effectiveness of SMD's technology programs. The Technology Federation is comprised of the Technology Council and the Full Council. The Technology Council is comprised of representatives from each of SMD's research divisions, while the Full Council consists of the Council members plus technology program managers from across the Directorate.	Ongoing	Prioritization of technology investments for enabling future science missions. SMD co-chair of STMD STAR process (trilateral - SMD, STMD, HEOMD).	
2.4	SmallSat/ CubeSat Initiative	SmallSat coordination serves an essential function within SMD and the Agency. We conducted a survey of SMD Divisions and centers on SmallSat priorities, challenges, and strategies. Engaging internal NASA entities, academia and commercial industry to understand industry capabilities for future partnering efforts to enable science through the utilization of SmallSats.	Ongoing	Held 2nd Annual NASA SmallSat Virtual Forum, March - May 2021	
3.1	Monthly, Quarterly, and Key Decision Points Meetings	Actively engages NASA Centers in the program and project management of SMD missions through monthly Flight Program Reviews (FPR), quarterly meetings for overseeing technical, cost, schedule, and programmatics of missions, and for key decision points in the life cycle of flight missions.	Ongoing	Held 31 (27 decisional and 4 informational) DPMCs and processed 5 out-of-board DPMC decisions in FY21. [comment: readers may not understand "out-of-board DPMC"	
4.1	Standing Review Board Engagement	Expanding and diversifying Standing Review Board (SRB) candidate pools for SRB chair and deputy chairs for purpose of growing future SRB chairs and to increase the diversity of panels. Implemented the SMD policy for adding deputy chairs to boards and having smaller boards for Class D missions. Initiated bi-annual dialogues with SRB chairs, deputy chairs, and review managers. Established kick-off meetings with newly formed SRB leaders to communicate expectations for serving on a SRB for a SMD mission.	Ongoing		
4.2	Outreach Activities	Keynote speaker at the MUREP Institutional Research Opportunity Principal Investigator (PI) Meeting 2021. Inspired PIs representing 19 minority serving institutions across the US and territories. Speaker at SmallSat Symposium, IEEE Aerospace Conference, Small Satellite Conference, AGU, KASI "Talk Concert", etc.	Ongoing		

Deputy Associate Administrator for Exploration

Section	Brief title	Description	Status	Quantifiable Progress	Outcome / Current Impacts
1.2	Progress in Commercial Lunar Payloads Services	NASA's process for Task Order awards allows for a quick proposal and evaluation process, while working to ensure mature technical and programmatic plans for deliveries. In FY21 and early FY22, NASA issued three additional task orders for a total of seven lunar surface deliveries totaling more than 40 payloads under the innovative CLPS acquisition approach. CLP-delivered payloads span science, technology, and exploration objectives. These awarded deliveries include payloads provided by STMD (PRIME-1 consisting of a TRIDENT drill and MSolo mass spectrometer, and an Electrostatic Dust Shield experiment) as well as ESDMD (LUGRe GNSS receiver experiment). ESSIO is on track to maintain its goal of two lunar deliveries per year.[comment: Does the FY21 sentence need to be updated?] Among the earlier awarded deliveries, the PSD-managed VIPER rover will land in late 2023 to the South Pole of the Moon, providing scientific measurements that can inform not only the decadal science objectives of lunar volatiles but the technology development and exploration objectives of ISRU for sustainable Artemis campaigns. Additionally ESSIO coordinates and/or creates collaboration opportunities with exploration and technology directorates to infuse science objectives into exploration activities and leverage science opportunities to inform exploration and technology objectives.	Ongoing	Awards for 7 deliveries of 40+ payloads in the next two years that include payloads provided by SMD, STMD, and ESDMD.	
2.1	Encouraging Commercial Business Practices, Reducing Costs	The CLPS initiative achieves rapid, frequent, and affordable access to the lunar surface through a streamlined firm fixed price acquisition approach that focuses on clear, concise, and complete definition of payload accommodation requirements while competitively fostering commercial innovation to implement those requirements in performance of an accommodation and operation service. With ESSIO and CLPS, efficient business models including low-overhead reporting and adaptive data-managed control of processes is a key to efficiency without the office. [comment: did you mean to say "without the office"?]	Ongoing	Demonstrated7 competitive award opportunities. 6 of 7 awards access the lunar surface for less than $100M. (The 7th being the 500kg VIPER delivery which is under $250M). By creating demand, spawned at least one CLPS provider to invest in a new lunar comm capability partnership bringing another American business into the lunar economy. [comment: not clear what you mean by "robustly" competitive]	

2.3	Science Instrument Selection Process	NASA's use of Commercial Lunar Payload Services to deliver instruments involves a higher level of risk than normal NASA activities, but with a potential payoff of establishing a lunar delivery service economy. While six deliveries are in development, NASA has been leaning forward to increase the level of scientific return from CLPS deliveries through the Payloads and Research Investigations on the Surface of the Moon (PRISM) solicitation process to achieve quality PI-led investigations with payload suites at lower cost, while staying compliant with time-honored peer-reviewed selection principles. PRISM made its first selections in FY2021, and they are being assigned to CLPS task order deliveries.	Ongoing	CLPS initiate is establishing a new high-volume capability to rapidly, affordably and frequently access the lunar surface. The risk tolerant approach of being a committed "first adopter" is key to achieving the high-impact of affordable lunar access. (Not including VIPER as out--of-family scope, 40+ payloads to 5 locations for under $500M is impactful.)	
2.4	CLPS Creates Demand for Technology Infusion and Opportunity for Technology Maturation	CLPS provides the opportunity for affordable access to the ultimate in-space platform for demonstration and maturation of enabling lunar exploration technologies as CLPS payloads. 2021 payloads include STMD and ESDMD technology maturation demonstrations. But in addition to that, ESSIO strategically pushes the boundaries of instrument accommodation capability to motivate commercial adoption and creation of technologies. This is includes creating the opportunities for other technology investments within and outside the agency, to find fusion opportunities, not as part of a CLPS delivery, but by the choice of commercial provider to leverage SBIR, STMD, or their internal and partnered investments to provide increasingly capable payload accommodations, such as precision delivery, far-side delivery, and night survival and operation.	Ongoing	Driven by CLPS-project "first adopter" demand for lunar access, participating contractors are realizing the value of STMD and SBIR investments, including NDL, RFMG, TALOS, and others. We are also seeing contractor investments and partnerships in high-payoff technologies that would otherwise not have had consumer opportunity. Many of these technology realizations are not due to direct NASA investment and direction, but rather are motivated by NASA's demand for capable lunar services. (Not listed until made public.)	
4.1	Frequent and Small Payload Deliveries Will Enable More Diverse Science Teams	As NASA continues to create opportunities for new payloads to fly to the Moon, LDEP offers an enhanced cadence of new opportunities for mission and flight teams. ESSIO will evaluate ways to increase the diversity and variety of ways for mission teams to grow and work including addition of a diversity plan requirement to future instrument solicitations. Additionally, the CLPS contract invokes NASA FAR Supplement 1852.219-77 NASA MENTOR-PROTÉGÉ PROGRAM and requires equal opportunity reporting under FAR 52.222-26. ESSIO and the CLPS project office are looking at future possibilities for incentivizing diversity and promoting a robust influx of STEM talent through encouraging mentorship and internship programs for underserved communities in future task orders and science/instrument teams.	Future	.	

Mars Sample Return Program

Section	Brief title	Description	Status	Quantifiable Progress	Outcome/ Current Impacts
1.1	Full Establishment of the Mars Sample Return (MSR) Program	The MSR Program was established in early 2021 after a successful pre-phase A. The program successfully passed its Key Decision Point A (KDP-A) and was granted authority to proceed as a program into its formulation phase. Staffing of the entire program, including leadership at NASA HQ, JPL, GSFC, and supporting centers, was fully accomplished by December 2021.	Complete	KDP-A passed. Formal program established. Staffing of all leadership positions completed.	Establishment of program completed.
3.2	Mars Sample Return Partnership with the European Space Agency	Based on the MOU signed with the European Space Agency in October 2020, MSR is partnering with ESA to provide significant hardware elements such as the Earth Return Orbiter, Sample Transfer Arm, and Sample Fetch Rover but also collaborating in the areas of program engineering and sample science planning. Discussions on details of additional collaboration areas are continuing as of December 2021.	Ongoing	Completed Earth Return Orbiter PDR and Capture Containment and Return System SRR in April 2022 with NASA and ESA participation [comment: suggest you spell out some of the acronyms]	Multiple areas of collaboration established. Positive impacts on viability of program due to shared programmatic burden.

Science Engagement & Partnerships Division

Section	Brief title	Description	Status	Quantifiable Progress	Outcome/ Current Impacts
1.3	Citizen science	There are 25 citizen science projects currently underway (https://science.nasa.gov/citizenscience).	2018 SMD Policy, 2020 New Initiative, Now Ongoing	Multiple new competitively selected projects added in 2021	These projects resulted in over 190 publications with citizen scientists as named co-authors (list updated annually).
2.1	Science Activation validated as an innovation model in 2019 by NASEM	Innovation is a key element of the Science Activation program, which relies on strategic partnerships with community-based organizations to meet mutual outcomes	Ongoing	~40 new partnerships added since 2016	In 2020, 23 million learner interactions

2.2	Collective impact approach in SciAct	Science Activation uses a collective impact model that fosters collaboration among its competitively selected projects. More than 90 cross-collaboration agreements have been signed among 27 projects and 14 NASA infrastructure activities.	Ongoing	Collaborations have matured in the past year with an emphasis on quality and impact over quantity	Magnifies the impact of the SciAct program
3.4	SciAct program	The SciAct program offers a different focus to leverage NASA science for learning, which can bring institutions who have not previously participated with NASA to the table.	Ongoing	5 new institutions received awards from ROSES-21	5 new institutions selected in ROSES-20 have projects well underway
3.5	SciAct program	Science Activation leverages a network of networks involving more than 268 partners in reaching learners of all ages with NASA science	Ongoing	~40 new partners added in SciAct 2.0	23 million learner interactions
4.1	Broadening Participation in Science Activation	Broadening participation is a core value for Science Activation since 2016	Ongoing	Currently 1/3 portfolio serves underserved audiences	By 2023, 40% of portfolio will server diverse audiences
4.2	SciAct program	$10M devoted in FY22 to combat social inequities.	Ongoing	8 new competitive awards selected	Awaiting FY22 approps to announce
4.3	SciAct program	This strategy guided the design of the SciAct program, which seeks to further enable NASA science experts and content into the learning environment more effectively and efficiently with learners of all ages	Ongoing	Revitalized the Division POCs this year to better connect the emerging SciAct collective to all aspects of NASA science.	Free, downloadable resources available at science.nasa.gov/learners e.g., development of lists of learning standards aligned to SMD divisions, which serve as a starting point for deeper discussions. https://science.nasa.gov/learners/learning-standards

Resource Management Division

Section	Brief title	Description	Status	Quantifiable Progress	Outcome/ Current Impacts
2.1	IT Survey Team	A small team formed within RMD to investigate innovative ways of using new technologies/ software/tools to do our work.	Ongoing	Creation of PPBE module in ScienceWorks to make all PPBE materials more accessible to HQ employees and to facilitate submission by Centers. Creation of a "bot" to complete funds distribution tasks; a pilot of this tool will be conducted in FY22	PPBE module successfully used in PPBE23 and improved access to materials significantly; will be fully implemented in PPBE24.
2.2	RMD Division Retreat	RMD held an in-person two day retreat in September 2021 in order to conduct team building exercises and strategic planning discussions.	Complete	Created an RMD mission statement which includes core values. Implemented changes to staff meetings and monthly training sessions to improve participation and value. Created a list of work to be done in the future in areas of strategic importance.	Teams have been created to address areas identified for improvement: workload/efficiency analysis, onboarding & training, subject matter expert model, and R&A support models

Inclusion, Diversity, Equity, and Accessibility (IDEA) Working Group

Section	Brief title	Description	Status	Quantifiable Progress	Outcome/ Current Impacts
4.1	IDEA Strategy	A measurable and action-oriented IDEA strategy specific to SMD that identifies strategic priorities and initiatives for the upcoming year.	Developed		Being socialized with divisions
4.1	IDEA Monthly Conversations	Internal learning series for SMD staff on a range of fundamental learning topics including bias, psychological safety, creating diverse science teams, cultural competency, and other key areas.	Ongoing	8 monthly conversations with an average participation of 45 attendees	Continuing learning curriculum with additional topics
4.1	Anonymous Comment Box	Anonymous comment box for SMD staff to provide their input on how to increase/further inclusion and belonging at SMD	Ongoing	10 anonymous comments submitted since launch in November 2021	
4.1	SMD Climate Survey	Establishing a baseline of internal climate and psychological safety at SMD for CS and contractor personnel to inform IDEA approach.	Ongoing	67% response rate to CS only survey. Joint CS/contractor survey to be administered in Spring 2022.	TBD 2022
4.1	Solicitation/AO Inclusion Language	Standard language for AOs that communicate SMD/NASA's values of IDEA.	Future		
4.1	HBCU Engagement Strategy	A new model for a co-created engagement strategy with HBCUs and SMD research centers to forge symbiotic and sustained relationships.	Just Started		

Astrophysics Division

Section	Brief title	Description	Status	Quantifiable Progress	Outcome/ Current Impacts
1.1	Strategic, Explorer, CubeSat mission launches and SR&T program	The Astrophysics Division strategy is to support a scientific balance of large, medium, and small missions, including CubeSat and suborbital missions that are competitively selected on annual basis through the research and technology development program.	Ongoing	In 2021, APD launched a strategic mission, James Webb Space Telescope (JWST), a Small Explorer mission Imaging X-ray Polarimetry Explorer (IXPE), and a CubeSat mission Colorado Ultraviolet Transit Experiment (CUTE); advanced the next strategic mission, the Nancy Grace Roman Space Telescope, past its critical design review; selected the Compton Spectrometer and Imager (COSI) as its next Small Explorer mission; and conducted a vibrant science research and technology development program.	The Astrophysics Division has received the 2020 decadal Survey in Astronomy and Astrophysics.
1.2	Astrophysics from the Moon	Astrophysics is included in the Payloads and Research Investigations on the Surface of the Moon (PRISM) solicitation issued by SMD. Operating missions make lunar observations if possible.	Ongoing	No Astrophysics mission selected under PRISM call. [comment: SOFIA is not doing Astrophysics "from the Moon"]	
1.3	Exoplanet Research	APD has partnered with PSD, HPD, and ESD in conducting the Exoplanet Research Program (XRP)	Ongoing	Joint solicitation, review and selection of research proposals has been successfully conducted	Exoplanet research is strengthened by the complementary cross-disciplinary research
1.4	Archiving of Science literature	Foster a culture that encourages innovation and entrepreneurship across all elements of the SMD portfolio	Ongoing	Astrophysics Data System being expanded to include planetary science and heliophysics literature	A central literature repository will be available for the astrophysics, planetary science and heliophysics research community
2.1	APD seeks opportunities across NASA in the pursuit of this strategy	APD participates in EPSCoR and MUREP programs with a view to foster innovation in underrepresented groups.	Ongoing	APD presented the NASA Astrophysics research program to EPSCoR jurisdiction researchers in a Virtual Technical Interchange Meeting	EPSCoR jurisdiction researchers are better informed to respond to research opportunities

2.2	Astrophysics Division retreat	APD has been holding ongoing discussions with all Staff members on their thoughts on how to implement the recommendations of Astro2020 when it is released, and to identify “quick wins”. A retreat will be held to solidify team thoughts, tactical and strategic approaches.	Ongoing	"Quick wins" have been identified	TBD
2.3	Strategic Astrophysics Technology (SAT) and Pioneers Missions	APD has continued to invest in the development of next-generation technologies through the Astrophysics Research and Analysis (APRA) technology program. APRA also supports the development and launch of experimental CubeSat, sounding rocket, and high-altitude balloon payloads. APD has initiated a new program of SmallSat and suborbital-class, PI-led missions. The relatively modest cost ($20M) and rapid development (less than 5 years) is well suited for high risk/high impact mission concepts. . High risk/high impact missions will continue to be encouraged in the annual Pioneers solicitations.	Ongoing	Current APRA investigations include many types of detectors with improvements such as the ability to count individual photons and increasing the number and sensitivity of pixels. Additional supporting technology advancements include next-generation large optics for space telescopes, precision instrumentation for exoplanet characterization, and software tools for future missions and analyses. In the first round of Pioneers selections, at least two of the selected missions are high risk/high impact missions.	The rich portfolio of cutting edge technologies being developed will pay off for future missions
2.4	Astrophysics Pioneers program	A new, annual solicitation including SmallSats doing first class science has been initiated. This program takes advantage of the rapidly expanding SmallSat commercial industry (think StarLink, OneWeb, Planet) to enable astrophysics in a more cost effective way, and also encourages early career PIs to mature and advance their careers.	Ongoing	Solicitation, review and selection of proposals completed	TBD
3.1	Internal Science Funding Model (ISFM)	The ISFM program is targeted for development of strategic science and technology at NASA Centers that align with the core and unique capabilities of each Center. APD has an exciting portfolio of ten ISFM programs, across three NASA Centers, that are funded until the end of FY22	Ongoing	Among the on-going ISFM programs, there are investigations on laboratory astrophysics studying and compiling infrared spectroscopic databases, next generation x-ray optics, characterization of gravitational waves, exoplanet imaging in multi-star systems, time-domain astronomy coordination hub, etc.	All ISFM projects showing good progress
3.2	Partnering with international agencies	The Astrophysics Division seeks partnerships as appropriate including with ESA, CSA, JAXA, ISA, CNES, MPIA		APD partnerships include strategic missions such as Webb, for which the unique contributions include the launch capability provided by ESA, and science instruments provided by all three agencies (including Canada Space Agency - CSA); ESA mission, Euclid, for which NASA is providing the detectors; JAXA mission, XRISM, where NASA provides a science instrument; Israeli Space Agency (ISA) mission, ULTRASAT, where NASA provides the launch and collaborates on the science; and Roman, where ESA, JAXA, CNES, and MPIA are all contributors to key elements of the mission. On-orbit Hookup of MAXI and NICER (OHMAN) is a unique collaboration among international partners on the ISS that combines the JAXA-led MAXI and NASA’s NICER to provide new insight into the transient universe.	TBD

3.3	Partnerships with the National Science Foundation (NSF), and with the Department of Energy (DOE)	NASA, NSF, DOE are jointly provided advice by the Astronomy and Astrophysics Advisory Committee (AAAC) on the best strategies for cooperation in scientific research. APD initiates joint programs with NSF and DOE in response from advice from the National Academy of Science, and the AAAC.	Ongoing	The instrument NEID: the New NASA-NSF Exoplanet Observational Research (NN-EXPLORE) program's Precision Radial Velocity Spectrograph on the WIYN telescope completed commissioning and is being offered for science. The development of the instrument and the hosting of the data pipeline and archive are funded by NASA, while NSF funds WIYN, the telescope that hosts the instrument. NASA, NSF, and DOE are working together to enable joint analysis of data from their cosmology missions: The Roman Space Telescope and the Rubin Observatory. NASA and DOE are sponsoring a technology and science demonstration on the far side of the Moon to establish the feasibility of studying the dark ages of the universe (before stars and galaxies formed) using sensitive radio instruments.	The NEID instrument will provide astronomers a much needed capability to advance exoplanet research.
3.4	Opportunities include research, advisory groups, mission science teams, public outreach.	SMD research opportunities are open to everyone, including Citizen Scientists, who work with professional scientists to advance SMD science. The High-Altitude Student Platform (HASP) program is being expanded to provide greater opportunities to students to build and fly scientific payloads on balloons. APD reaches out to the entire science community in its effort to populate its review committees and advisory groups. APD flight missions have public outreach programs to take the science of the mission to the public.	Ongoing	APD has made a concerted effort to diversify its advisory committees, peer review committees, and increase research opportunities.	All APD programs have participations from a wide range of institutions
3.5	Partnership with Mass General Hospital	Novel Computed Tomography (CT) medical imaging effort with Mass. General Hospital (MGH) has the potential to reduce radiation dose for CT scans by an order of magnitude thanks to the Modulated X-ray Source (MXS) developed to calibrate NICER.	Ongoing	Mass General Hospital using MXS technology developed for NICER	TBD
4.1	IDEA initiatives within APD	APD participates in the SMD wide IDEA group to develop strategies for increasing diversity of thought and background in its program. Additionally, APD has a focused IDEA group for Research and Analysis programs. APD is widening its reach by presenting its programs at conferences targeted towards underrepresented population.	Ongoing	An inclusion pilot was introduced in the Astrophysics Theory Program, whereby proposers were required to include an inclusion plan in their proposals. The plan was evaluated both by the science panels and a panel of experts. APD participated in the annual meetings of the Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS) and the National Society for Black Physicists (NSBP) where the APD programs have become sponsors and have organized sessions to promulgate NASA science and advertise NASA funding opportunities.	Members of SACNAS and NSBP are better informed about APD research opportunities.

4.2	Astrophysics participation in Science Activation (SciAct)	Competitively selected Astrophysics proposals through the SMD SciAct program generate educational material, conduct targeted engagement activities for learners of all ages and diverse backgrounds through public outlets including libraries, science museums, Community Colleges, and partner with other SciAct to leverage off each other's strengths in sharing NASA's science stories.	Ongoing	The Neurodiversity Network takes NASA science to a new audience of autistic learners, the Cosmic Story Telling with NASA data guides learners in the use of data to answer scientific questions, the Community College Network addresses learners at the College level, while the Universe of Learning is a wide program reaching learners of all ages.	The stories of NASA Astrophysics are influencing learners of all ages, encouraging students to go into STEM careers and creating a more scientifically informed nation.

Biological and Physical Sciences Division

Section	Brief title	Description	Status	Progress	Outcome/ Current Impacts
1.1	Decadal Survey 2023-2032	The Decadal Survey for Biological and Physical Sciences Research in Space 2023-2032 process commenced in 2021. BPS has shared its vision with the National Academies for pursuing transformative science in the areas of Quantum Science, Thriving in Deep Space (particularly Animal Biology and Plant Biology), and Soft Matter (such as colloids, gels, foams). Actively promoted the development of whitepapers with ASGSR through focused virtual meetings and education about the decadal process.	Ongoing	Presented to Decadal Committee - Aug. 16-17, 2021	[comment: It's premature to discuss outcomes prior to seeing the results of the Decadal Survey]
1.2	Lunar Research Initiatives	BPS progressed investigations scheduled to launch aboard Artemis I (BioExpt-1); selected LEIA research to develop payloads/experiments for future lunar research; and worked with Gateway program to secure resource allocations (mass, power, volume, crew time, etc.) for internal radiation measurements, microbial monitoring, and exposure facility.	Ongoing		Transformative science supporting thriving in deep space, enabling exploration
1.3	BPS-Planetary Science Cross-Cutting Research	Within BPS, fluid physics research is contributing to improvements in plant water management. Within SMD, BPS is working with PSD on topics such as growing plants with archived lunar regolith and simulants and optimizing growth conditions are important for lunar habitation; BPS is focusing on transformative science opportunities that will enable In situ Resource Utilization (ISRU) to procure bioavailable nutrients for plants. In concert with the Space Operations Mission Directorate (formerly HEOMD), international Gateway Partners, and other SMD divisions, BPS engaged in developing multi-national Gateway radiation sensor capabilities to monitor and obtain radiation data external (ERSA) and internal (IDA) to the Gateway for crew safety and scientific research, which were one of the first two payloads to be approved as Gateway Payloads. Within SMD, BPS conducted two highly attended lunar surface science workshops that engaged our physical sciences and space biology communities for developing key and priorities for lunar science research and in preparation for developing important scientific white papers for the NAS life and physical sciences Decadal Survey. With the Space Operations Mission Directorate, BPS worked across directorates and international space agency partners to conduct a series of workshops investigating new ISS research capabilities to study and prepare humans for the long duration transit to Mars, which is critical to mitigating the five hazards of human space exploration; the findings are being prepared for publication.	Ongoing		Fundamental insights that will improve plant growth in extreme environments, both in space and on Earth
2.2	BPS-Planetary Science Cross-Cutting Research	See 1.3 accomplishment. Also, extended invitation to PSD to attend ASGSR annual meeting.			

3.2	International Partnerships	BPS has engaged with several international partners such as with DLR on the development of BECCAL, the follow-on to the CAL facility currently on ISS, and for research at the Neumayer III station in Antarctica; with JAXA for research using the Electrostatic Levitation Furnace (ELF) on ISS; with ESA on research using the Electromagnetic Levitator (EML) facility on ISS; with CNES for research using the DEvice for the study of Critical Liquids and Crystallization (DECLIC) facility on ISS; and with Roscosmos for research on future Bio missions.	Ongoing		More efficient and strategic use of resources; open science
3.3	Cross-Cutting Research	BPS regularly collaborates with other government agencies, academia, and commercial entities on cross-cutting investigations that benefit the scientific community, share open science, and optimize resources. One example: A joint solicitation on extending the life of tissue chips, between BPS, NCATS, NIAID, BARDA, NCI, and FDA.	Ongoing		More efficient and strategic use of resources; open science
3.4	BPS Engaging the Scientific Community	In addition to annual solicitations, BPS seeks to expand diversity and engage the scientific community. We do this through a number of ways, including EPSCoR, MUREP outreach, OSTEM, and other initiatives and research opportunities. The Decadal Survey is another critical channel for soliciting whitepapers from the community which will inform the future of BPS research.	Ongoing		Increased engagement from the scientific community, promoting diversity of thought and participation
4.2	Integrated Science	BPS participated in the "Growing Beyond Earth" program run by Fairchild Tropical Botanic Garden, which engaged approximately 350 schools around the country and Puerto Rico. BPS content was selected for NASA SpaceApps Challenge. Other programs include: GeneLab for High Schools, GeneLab for Universities, and SCoPE (connecting NASA SMEs with a cooperative network). Finally, BPS began preparations for the launch of the division's thematic Twitter account, which will help engage audiences of all ages and demographics.	Ongoing		Increased engagement with the general public, generating greater awareness around and excitement about biological and physical sciences research in space

Earth Science Division

Section	Brief title	Description	Status	Quantifiable Progress	Outcome/ Current Impacts
1.1	Complete the existing and planned missions/instruments in the Program of Record	In January 2018, the National Academies released a new Earth Science Decadal Survey, entitled "Thriving on Our Changing Planet: A Decadal Strategy for Earth Observation from Space." In addition to recommending creation of the new Earth System Explorers program and new missions to address designated observables, this report recommended that NASA complete the existing and planned missions/instruments in the Program of Record.	Ongoing	Within the POR, 1 project launched; 3 projects passed through a Key Decision Point (KDP); and 7 projects held life cycle reviews (LCRs) **Launches** - Landsat 9 **KDPs** - Libera; KDP-B - SWOT; KDP-D - Landsat 9; KDP-E **LCRs** - SWOT; SIR & PSR - Libera; SRR/MDR - Landsat 9; PSR, ORR, & FRR - TEMPO; Spacecraft CDR & Hosted Payload SIR - PREFIRE; CDR - TSIS-2; PDR - GLIMR; SRR	Implementation of the planned missions/instruments in the Program of Record (POR) is the foundation the 2017 Decadal Survey recommendations were built on. Progress made over 2021 moved NASA's ESD closer to completing this essential goal to deliver on commitments to deploy projects in the Program of Record which will provide many needed Earth system science measures.
1.1	Implement Earth System Observatory	I The Decadal Survey recommended an observing program that prioritized observables to address key science and applications objectives for the coming decade. These include the following high priority "designated observables" (DOs): Aerosols; Clouds, Convection, and Precipitation; Mass Change; Surface Biology and Geology; and Surface Deformation and Change. [comment: deleted text that was duplicative of text in the prior box]	Ongoing	In FY 2021, initiated the pre-formulation phase for four ESO missions addressing: Aerosols; Clouds, Convection, and Precipitation; Mass Change; Surface Biology and Geology. The fifth, targeting Surface Deformation and Change, will remain in the study phase to incorporate lessons learned from the related NASA-ISRO Synthetic Aperture Radar (NISAR) mission.	The four ESO missions in pre-formulation will complete their Mission Concept Reviews in FY 2022. The Mass Change and Surface Biology and Geology missions will target launch in FY 2028. NASA will implement two missions to address Aerosols and Clouds, Convection and Precipitation, with the first scheduled to launch to an inclined orbit in FY 2028 and the second to launch into a polar orbit in FY 2030.
1.3	Execute IDS program in ROSES solicitations	ESD's observing systems advance research and discovery in cross-disciplinary areas, often providing insight into interfaces and new processes of the Earth system. In addition, ESD's R&A solicits Interdisciplinary Research (IDS) in ROSES, designed to address emerging science priorities.	New IDS solicitation in ROSES2022, continued effort on selections from ROSES-19	Several topics across ESD's science focus areas are solicited in each IDS solicitation - for both ROSES-19 and ROSES-22 a total of 7 for each (5 large, 2 small).	ESD's IDS program has made advances in several areas, which are reported in peer reviewed literature. Two of the topics in the IDS solicitation in ROSES-22 have an interdivisional component (Ocean worlds, Earth-moon connections).
1.3	Prototyping of SMD-wide NASA Science Data catalog	The Open-Source Science Initiative (OSSI) managed out of ESD has been building out a catalog of all NASA science data. This effort is beginning with targeted, cross-disciplinary use cases; namely encouraging a better understanding of exoplanet atmospheres, and the impact of space weather on	Prototyping in 2022, expanding in 2023	Leveraging NASA OCIO's enterprise search tools to pull together existing data catalogs relevant to the use cases	SMD-wide data catalog will enable greater cross-disciplinary work across the various divisions

		experiments conducted on-board the ISS.			
1.4	Amplifying cross-benefits of research and applications	Augmentation of currently funded research grants to add an applications-focused component to enable those with historical research focus to get experience working in more applied areas and understanding how to combine research and applications most effectively. Some jointly supported activities take place (e.g., Tropospheric Composition/R&A and HAQAST/Applied Sciences) joint funding of TRACER-AQ airborne campaign (Houston, TX area air quality, summer 2021).	Augmentation opportunity was provided for currently funded R&A investigator teams - one year augmentations in place.	A number of R&A-funded tasks are augmented to include an applications-focused component. Coordination among tasks is enabled by Applied Sciences program through its support to Global Council for Science and the Environment. TRACER-AQ campaign was carried out and reported on at 2022 AMS meeting.	Tasks have been augmented. Next solicitation for augmentations will be done through ROSES-22 under no-due-date approach and is being finalized. GCSE-led coordination meeting is scheduled for near-future.
2.1	Formation and Leadership of Open-Source Science Initiative (OSSI)	OSSI is a coordinated program of activities to help move science and the scientific process towards greater openness for all of NASA SMD	Ongoing, currently funded and led via the Earth Science Data Systems and Office of the Chief Science Data Officer	Release of new Science data policy for all of SMD: SPD-41; Designation of Year of Open Science for 2023 and creation of KPIs for gauging success of the effort; Accelerate major scientific discoveries through supporting the adoption of open science Broaden participation by historically excluded communities	A major OSSI component is Transform to Open Science (TOPS), which will help agencies, organizations, and communities to evolve to an inclusive culture of open science. From 2022 to 2027, TOPS will act as a catalyst to jump-start a suite of coordinated activities to rapidly transform science, including the designation of 2023 as the Year Of Open Science (YOOS).
2.3	Targeted solicitations, emphasis in review panels	ESD solicitations include elements designed to push current boundaries, for example remote sensing theory.	High-risk, high-impact proposal status is noted in review process and discussed at steering committee.	Peer review panel assessment of submitted ROSES proposals were analyzed and revealed ESD systematically selects a higher % of high risk / high impact proposals than the overall selection rate. ESD participated in SMD Blue Ribbon panel and joined in funding two proposals through that; an additional one was recently selected for inclusion as part of SMD Research Catalyst Fund.	Where HR/HI proposals that review well have not been able to be funded through regular process, ESD has actively engaged in SMD processes and provided needed co-funding.
2.4	Targeted solicitations that leverage commercial technologies	Through the Earth Science Technology Program (ESTP), ESD pursues and applies emerging commercial capabilities to the development of Earth-observing technology	Ongoing	Through the In-Space Validation of Earth Science Technologies (InVEST) program element, the ESTP is utilizing commercial advances in spacecraft payload/bus standardization, cloud-based ground stations, and new launch opportunities for secondary payloads to demonstrate new technologies on orbit.	Advanced information systems solicitation targets AI/ML technologies, as well as digital twin concepts, in order to improve the collection, processing, integration, analysis, understanding, and utilization of Earth science data. These technologies can also aid in the implementation of new Earth-observing systems.

2.5	Launch OpenET platform	Open and freely accessible data optimized to the specific needs of data users is a core strategy of all Applied Sciences work. In 2021 Applied Sciences released a data resource for agriculture and water managers to view water use across 17 U.S. western states. Called OpenET, it is the first-ever free and openly available data resource for water use in the western U.S., measuring water use through the commonly used data point of 'evapotranspiration.' It does this by incorporating Landsat and other Earth science data on land temperature, a commonly used way of measuring agricultural water use.	Released for public use Oct. 2021	Used by many U.S. agricultural groups, including E.J. Gallo, the nation's largest wine producer.	Called a "transformative tool" for measuring water use by agricultural experts due its scope and use of 'freely available data."
2.5	Connections of Water Quality and Public Health: WHO Adoption of CyAN Harmful Algal Bloom Tracking	The Health and Air Quality program area works to bring Earth science data on hydrology to public health experts, veterinarians and others who study the connections between environment and human health as part of efforts in OneHealth. In 2021, for the first time the World Health Organization included satellite tracking information into guidance on monitoring harmful algal blooms on a global level.	Ongoing and expanding	In 2021, for the first time the World Health Organization included satellite tracking information into guidance on monitoring harmful algal blooms on a global level. The update draws directly from the NASA/EPA Cyanobacteria Assessment Network (CyAN) which allows for monitoring the health of lakes and coastlines by satellite. They can detect outbreaks long before human eye might call for in situ testing.	Economic analyses indicated significant savings over local on-site water testing, considering the avoidance of health care costs and avoided lost wages by closing lakes and shorelines in timely manner. Published studies of economic impact range from $100K for individual lakes and $M nationwide.
3.1	Early phase coordination for Earth System Observatory	Multi-center study teams were set up for the 5 designated observables identified by the National Academies in their 2017 Decadal Survey (grouped into 4 studies) with participation from numerous centers looking at both science and engineering aspects. The multi-center approach was central to this and led to significant cooperation. Upon completion of these and the initiation of Earth System Observatory, the studies produced by the multi-center study teams served as the basis for the pre-phase A activities underway.	Ongoing	Multi-center study team reports are complete and now pre-phase A studies are being carried out for all of the ESO missions. The study teams are working closely with the NASA Centers to ensure roles and responsibilities are aligned with each Center's unique strengths, talent and technical capabilities.	There is considerable information now about how these missions could potentially be carried out in terms of implementation approach, cost, potential partners, and scientific goals. This information will help ESD to develop an acquisition strategy that balances the capabilities of the NASA Centers with those of our partners for delivery of the ESO.
3.2	NASA-ESA coordination	NASA is strengthening its ties with the European Space Agency (ESA) to be a more formal, higher-level agreement that builds on the highly successful Joint Program Planning Group (JPPG) effort that has been going on for a decade, with foci in mission planning, calibration/validation, and data. A meeting of the JPPG is planned for Mach 1-2 in Washington, DC (COVID permitting).	A new agreement has been signed. JPPG engagement continues.	The Sentinel-6 Michael Freilich satellite was launched in late 2020. This is the first formal mission cooperation between NASA ESD and ESA. Engineering studies completed for two more joint missions, CRISTAL and CIMR. A joint NASA/ESA/JAXA dashboard was created to document the role of Earth Observation satellites in providing	Global surface altimetry observations continue with Sentinel 6 MF and will continue later with Sentinel 6B. Numerous airborne campaigns have been jointly carried out, and data sharing efforts facilitate availability of ESA and NASSA data to both communities.

				information to help the world respond to the Covid pandemic.	
3.3	Continuing the Landsat legacy in partnership with USGS	The NASA-USGS Landsat program (now Sustainable Land Imaging or SLI) continues to extend the 40+ year legacy of providing land surface data critical for land managers and policy makers. Through 2021, NASA ESD continued to actively engage with the USGS to ensure the Landsat legacy continues to further national interests by successfully launching Landsat 9 and initiating development activities for the follow-on mission, Landsat NeXt.	Ongoing	Achieved ESD Flight Program GPRAMA measure to complete the Landsat 9 Pre-Ship Review (PSR). Successfully launched Landsat 9 on September 27, 2021 and continued engagement with USGS to initiate Pre-Phase A acquisition strategy activities for Landsat NeXt.	With Landsat 8 still in orbit, the successful launch of Landsat 9 with improved technology to detect more subtle changes, and initiation of Landsat NeXt expands and ensures our continued ability to see how the Earth changes over time.
3.3	NASA Earth Satellite Data integrated into tools to track dust storms and Valley Fever	In 2021, NOAA's National Weather Service and the World Health Organization integrated data from a monitoring system comprised of satellite data and innovative ground sensors that track dust storms and Valley Fever. Dust storms are becoming more common in the U.S. due to drier conditions which is leading to a rise of people catching the soil fungus-based disease Valley Fever.	Tracking and risk assessment system established	Applied Sciences supported the development of the monitoring system, as well as oversaw its integration in 2021 into efforts by the U.S. National Weather Service and the World Meteorological Organization to track and issues risk-based alerts on the rising incidence of dust storms as well as the concurrent rise in people contracting Valley Fever, a disease caused by a soil-based fungus spread via dust.	Outcome and impacts will be better warnings before dust storms, which have impacts on human health and transportation and commerce; also expecting better preparedness for Valley Fever warnings and outbreaks.
3.5	Commercial small-sate data purchase and analysis	NASA is increasing its involvement with private sector satellite providers through the Commercial SmallSat program. Private sector entities can request to participate in our program and ongoing data purchase agreements have been established with some, evaluation-oriented short-term purchase agreements have been established with others, and the process of enabling additional such agreements with additional respondents is under way. Data from new providers continues to be evaluated, and investigators have been funded to work with commercially-provided data.	2 continuing purchase agreements exist (with uplifted licenses). 2 companies have contracts for purchase of data for evaluation for which evaluation processes are underway.	Data from two companies have been purchased (Spire, Planet) with uplifted licenses to make available to all US-funded investigators. Data from Airbus and Blacksky are currently being studies after initial data purchase through augmentation of research and applications tasks.	Commercial data are now routinely available to NASA and other US-funded investigators and becoming actively used in research and applications.

4.1	Outreach to Minority Serving Institutions and Engagement across NASA.	The ESD R&A program has carried out four "virtual site visits" to Minority Serving Institutions (MSIs0, providing opportunities for NASA program managers to learn about research interests and capabilities at those institutions while sharing information about programs and opportunities at NASA. A targeted solicitation on increasing the participation of MSIs in NASA's surface-based measurement network was released following release of a Request for Information on potential MSI interest in such a program. ESD has partnered with the Office of STEM Engagement in its Minority University Research and Education Program (MUREP) in an ocean-focused program and provided financial support to enable full selection of qualified proposers.	The ROSES element on MSI participation in surface-based measurement networks is currently open (proposals due 3/16). The OCEAN activity with OSTEM is underway.	Four virtual site visits were held - 2 of which supported multiple institutions. One was specifically focused on those MSIs involved in the SaSa program funded by the Science Engagement and Partnerships division (to which ESD R&A provided supplemental funding as well as science inputs)	Greater engagement and coordination with OSTEM - recently asked by OSTEM to join a meeting with NOAA on educational activities related to MSIs. Additional virtual site visits being considered.
4.2	Provide information on diversity of potential peer reviewers	ESD has asked that program managers carrying out research proposal review actively address diversity in developing peer review panels and report on it in their steering committee packages that are shared with management and peers. By bringing visibility to this effort, additional thought is going into how to diversity the peer review community.	Information on potential peer reviewers is shared at steering committee.	Each steering committee package has information about those approached for panel roles.	Greater recognition on part of program officers. This effort will become part of larger SMD-wide effort through new SPD being finalized.
4.3	Food and Drink Campaign	The Food and Drink campaign highlighted the extensive ways NASA data and science impact the country and the world's food supply, a supply that is under increasing pressure due to climate change.	The communications campaign was completed in 2021; acts as a platform for continued focus and emphasis in 2022.	The series of stories and videos comprising the campaign were highlighted across all NASA communications platforms, resulting in both public and internal-to-NASA understanding of the work done on agriculture support by the Applied Sciences program and others.	In 2021, the content was used extensively to promote the launch of Landsat 9, America's longest-running satellite program. It is also forming the base of continued effort to reach new and different audiences to NASA Earth science communications.

Heliophysics Division

Section	Brief title	Description	Status	Quantifiable Progress	Current Impacts
1.1	As of late-2021, NASA Heliophysics is poised to complete recommendations outlined in the 2013 Decadal and midterm assessment.	The Division has enhanced and expanded the Heliophysics System Observatory with new, innovative missions, a robust suborbital program, and leveraged creative rideshare strategies. The Division has invested in research and technology to enable enhanced return on science. As a result of these actions, NASA has the largest and most vibrant Heliophysics System Observatory in its history.	Ongoing	IMAP, PUNCH, and SunRISE confirmed in 2021 Geospace Dynamics Constellation (GDC) passed KDP-A in Sep 2020 and instrument solicitations received Sep. 2021 5 Medium Class Explorers (MIDEX-19) step-1 selections announced in Aug 2020: STORM, HelioSwarm, MUSE, ARCS, and Solaris Initiated planning for DYNAMIC mission as a PI-led mission 12 missions in formulation or development and another 6 under study TRACERS (w/MAGIC, a tech demo) proceeded into formulation and is preparing for KDP-C Missions of Opportunity selected in Dec 2020: EUVST (JAXA partner mission) and EZIE ESCAPADE confirmed in Aug. 2021 GLIDE and HERMES were both confirmed in Jan. 2022. 14 CubeSats in development, 4 on orbit Solar Cruiser (MSFC tech demo) and GLIDE Missions of Opportunity selected in Dec 2020 (IMAP rideshares via ESPA ring) Space Situational Awareness/Orbital Debris coordination and technology maturation	
1.2	NASA Heliophysics Space Weather strategy supports robotic and human exploration.	Heliophysics is actively working with the Human Exploration and Operations Mission Directorate (HEOMD) to provide expertise on space environment conditions that enable the health and safety of astronauts beyond low-earth orbit. HERMES will be the first scientific payload on Gateway in support of the Artemis program. To effectively engage space weather community in supporting forecasting research at Mars, the transition of the Radiation Assessment Detector (RAD) instrument on Curiosity rover on Mars from Planetary Science Division to the Heliophysics Division is underway.	Ongoing	HERMES was confirmed by passing its KDP C milestone in Jan. 2022, with a NET launch date of late 2024.	

1.3	Helio 2050 Workshop	In advance of the 2024 Solar and Space Physics Decadal Survey, the Heliophysics Division sponsored a "Helio2050 Workshop" in coordination with NOAA and NSF to discuss the future needs and focus areas for the solar and space physics field. This workshop was built to enable cross- and interdisciplinary connections. The Expanding the Frontiers session brought together the different heliophysics disciplines, planetary science, and astrophysics to discuss how and where the scope of heliophysics can grow. Conversations and efforts are ongoing in advance of the 2024 Decadal Survey.	Completed	The Heliophysics 2050 Workshop was held May 3-7, 2020. The Workshop had over 1,150 registered attendees, with 425 to 650 engaged in each session. The Workshop directly led to follow-on discussion groups and workshops to continue the heliophysics community's preparation for the Decadal Survey.	
1.4	NASA Space Weather Strategy	In 2020-21, NASA HPD formally developed and rolled out a comprehensive Space Weather strategy and action plan. The vision is to advance the science of space weather to empower a technological society safely thriving on Earth and expanding into space. The mission of the strategy and implementation plan is to establish a preeminent space weather capability that supports robotic and human space exploration and meets national, international, and societal needs by advancing measurement and analysis techniques, and by expanding knowledge and understanding for transitioning into improved operational space weather forecasts and nowcasts.	Ongoing	Various elements of the implementation plan are actively underway. A communications plan has been developed to effectively communicate the goals and status of the Space Weather Strategy.	
1.4	Orbital Debris and Space Situational Awareness	In Jan. 2021, HPD initiated a cross-cutting strategic activity for basic Research & Development in Orbital Debris (OD) and Space Situational Awareness (SSA) – in support of the current NASA Enterprise Risk on the Orbital Debris Environment and the recommendations of Jan. 27, 2021, Office of Inspector General (OIG) report on “NASA’S Efforts to Mitigate the Risks Posed by Orbital Debris”. Strategic objectives: Develop and deploy the space-based instruments and other investigations to dramatically improve our understanding of the micro-debris environment in the 500-1000 km altitude range; Develop and deploy space-based instruments and other investigations to allow for better prediction of the natural processes that lead to the losses of orbital debris in the Earth atmosphere; Integrate these measurements into the Orbital Debris science and modeling activities conducted by the NASA Orbital Debris program office, as well as to improve Space Situational Awareness forecasting.	Ongoing	The SSA/OD initiative includes three ongoing projects: Competed Research & Support Activities (New ROSES element), Directed Orbital Debris measurement instruments Tech Maturation to raise the technological readiness level (TRL) for three concepts, including one flight opportunity with the STP program, and OD Flight Mission planning and Technology Development. Preliminary work is underway to conceptualize a satellite mission to address the outstanding Agency Risk on the Orbital Debris Environment. Four Tiger Team efforts, have been conducted to evaluate both scientific and operational needs for such a mission, and detailed mission planning for a platform for this range of interconnected activities and research needs related to SSA, OD, and resulting spacecraft effects is underway.	

2.2	DRIVE Science Centers	Diversify, Realize, Integrate, Venture, Educate (DRIVE) Science Centers are part of an integrated multi-agency initiative, put forward as a high priority recommendation of the 2013 Solar and Space Physics Decadal Survey. DSCs, which fall under the "Venture" aspect of the DRIVE initiative, address grand challenge goals that are both ambitious and focused enough to be achievable within the lifetime of the center - in other words, problems poised and ready for major advances. This program is intended to support science that cannot be effectively done by individual investigators or small teams, but requires the synergistic, coordinated efforts of a research center. In order to maximize the potential for these science centers to deliver on innovative and breakthrough science, they are expected to include aspects in their design that support collaboration and deep knowledge integration across the full range of expertise (scientific, computational, educational) within them, as recommended in a recent report B.13-2 by the National Academy of Sciences, Enhancing the Effectiveness of Team Science. NASA HPD has funded 9 SCs in Phase 1 is preparing for Phase 2 selections (up to 2 SCs) in early 2022.	Ongoing	Phase II proposals were submitted in October 2021. The evaluation and selection process is underway as of February 2022. Each Phase I DSC developed strategic plans for Phase II, aimed at innovation, diversity, and integrative science and engaged the science community through online seminar series and workshops. In addition to impacts in breakthrough science, Phase I Science Centers engaged in initiatives to increase diversity and inclusion and developing plans for future pilots, all of which will help to develop the future STEM workforce.	Investments in DSCs are seeding the heliophysics community with team science expertise critical to a range of other HPD science research programs.
2.4	HPD Technology Program	The future success of Heliophysics depends on the ability to produce novel and transformative technologies, capabilities, and mission concepts. The Heliophysics Technology Program will strategically invest in the development of instrument and technologies and methodically mature and demonstrate them to enable infusion into future missions. NASA's goal is to enable previously infeasible science investigations; improve existing measurement capabilities; reduce the cost, risk, and/or development times for Heliophysics science instruments and advanced space missions of the future; and yield applications to the broader economy (e.g., space weather).	Ongoing	The Heliophysics Technology Program was successfully proposed as a new program in the FY 2022 budget and the budget was secured. The program includes elements transferred from other programs which were funded out of the R&A, including Heliophysics Technology and Instrument Development for Science (HTIDeS) and Heliophysics Flight Opportunities Studies (HFOS; currently funded out of Heliophysics Research), as well as the Solar Cruiser technology demonstration Mission of Opportunity (previously funded under the Solar Terrestrial Probe program) and the Magnetometers for Innovation and Capability (MAGIC) technology demonstration mission, a technology demonstration rideshare (previously funded under the Explorers program). In FY 2022 NASA centers were solicited to submit ideas for putting in place a Heliophysics Strategic Technology Office (HESTO), to support the Heliophysics Division in strategic management of its technology portfolio. It is expected that HESTO will be put in place in FY 2022 and grow with the proposed budget profile.	

3.1	Internal Scientist Funding Model (ISFM)	The Internal Scientist Funding Model (ISFM) is for civil servant scientists to perform long-term, strategic directed research that is necessary for NASA to achieve its major Heliophysics science goals. ISFM fosters collaboration rather than competition between NASA and community scientists on Heliophysics theory, modeling, and data analysis. The full range of activities performed by internal scientists is eligible for being selected as part of an ISFM work package, including hypothesis-driven research. In addition, all ISFM directed work packages must be Strategic; that is: Utilizing unique NASA facilities, capabilities and/or skills or be of such duration or scope that the government benefits by NASA doing it in house and requiring or benefiting from long-term stability, especially for the long-term availability of some capability whose utilization may not be required at all times, but whose availability is required. ISFM packages must include at least one element that is Science Enabling: Providing a service or supporting research being done by the scientific community, i.e., other researchers depend/rely on the results of this work or providing a capability to the nation (e.g., data, model or technology development). ISFM awards were made in early 2021 and will run for three years.	Ongoing		
3.2	NASA HPD International Collaborations	HPD's Space Weather Activities Program has engaged with several international partners for forthcoming missions that provide space weather observation and research opportunities, including ESA's L5 mission, Brazil's SPORT, and Canada's Arctic Observing Mission. NASA HPD is also actively engaged with JAXA on the EUVST mission (Phase B).	Ongoing		
3.3	Collaboration with NOAA on Space Weather Activities	Collaborating with NOAA to continue assessing the goals and objectives laid out in the PROSWIFT Act that will lead to future support for interagency efforts, space weather observations, research, modeling, operational forecasting, and applications	Ongoing	Alongside NOAA and NSF, established the National Academy of Science Space Weather Roundtable. Working with NOAA to build NOAA-NASA NWFO L-1 space weather monitoring mission.	
3.3	Coordination with NSF	In October 2021, the Heliophysics Division and the Geospace Section of the National Science Foundation held a Program Scientist and Program Manager summit to share best practices and identify areas of common interest and potential areas for future collaboration.	Ongoing	Sub-working groups are currently meeting to continue follow-on conversations and activities.	
3.3	Coordination with the Department of Energy (DOE)	In 2021, NASA HPD held exploratory meetings with the U.S. Department of Energy Office of Science, specifically the Fusion Energy Sciences sector, to discuss current areas of research focus and to identify potential areas for future collaboration. Areas of interest include test beds, sensor development, and plasma science research.	Ongoing		

3.3	Coordination with NOAA and NSF on the 2024 Solar and Space Physics Decadal Survey	NASA HPD is actively engaged with NOAA and NSF to develop the 2024 Solar and Space Physics Decadal Survey in coordination with NASEM.	Ongoing	2024 Heliophysics Decadal Statement of Task has been finalized with NASEM and the Decadal Survey kick off is expected in Summer of 2022.	

Joint Agency Satellite Division

Section	Brief title	Description	Status	Quantifiable Progress	Outcome/ Current Impacts
3.3	Coordination with NOAA on Continuity of Weather Observations from Geostationary Orbit	JASD is partnering with NESDIS to build the capability for future geostationary weather observations beyond the GOES-R Program. The GeoXO Program is expected to provide operational weather data starting in the early 2030's.	Ongoing	Approved GeoXO to enter Phase A at Joint NOAA/NASA Agency Program Management Council in July 2021	Critical program is being formulated in response to user needs
3.3	Coordination with NOAA on Innovative Approaches to Low Earth Orbit Weather Observations	JASD is partnering with NESDIS on Innovative approaches to Low Earth Orbit weather observations, taking advantage of Commercial, DoD, and NASA advancements in SmallSat constellation architectures and lower-cost access to space	Ongoing	Approved QuickSounder Project to enter formulation in October 2021, demonstrating streamlined approaches to mission development; Conducted a series of interagency Constellation Reliability Workshops to establish standards for evaluating future mission concepts.	Incorporating innovation to reduce cost of future missions and ensure a resilient weather observation system
3.3	Coordination with NOAA on Future Space Weather Monitoring Capability	Consistent with Heliophysics Division collaboration with NOAA on response to PROSWIFT Act, JASD is partnering with NESDIS to establish capability for long term operational space weather monitoring beyond the current SWFO program	Ongoing	Supported June 2021 Department of Commerce Milestone 0 Review for NOAA Space Weather Next Program; Interagency Agreement and Formulation Authorization Document currently in development.	Critical program is being formulated in response to user needs

Planetary Science Division

Section	Brief title	Description	Status	Quantifiable Progress	Outcome/ Current Impacts
1.1	Strategic PSD program	PSD strategy is to manage an executable, compelling and exciting portfolio strategically balanced between (1) large directed, and medium- and small-sized competed missions, (2) missions in formulation, development, and operations, and (3) missions, R&A and investments in technology and supporting infrastructure. PSD also leverages international and commercial partnerships to complement NASA-led planetary missions and address additional Decadal Survey priorities. Finally, PSD strives to advance the highest quality planetary science research and technology programs.	Ongoing	In 2021: Perseverance landing and Ingenuity "first" flight; Lucy launch, DART launch; VIPER confirmed; NEOSurveyor initiated Phase B; Discovery selections of VERITAS and DAVINCI; international partnership with ESA on EnVision selected to move forward; R&A implemented dual anonymous peer review (DAPR) for many elements and introduced no due date (NoDD) to improve proposal quality	
1.2	VIPER	The VIPER mission will make key observations of the lunar surface, providing important ground truth data for interpreting remote sensing observations of volatiles. These data are needed to address the question of whether it is possible to reduce the need for multiple missions to ferry oxygen, water, fuel and other supplies needed to sustain long-term human exploration.	Ongoing	VIPER was confirmed in 2021	
1.3	RCNs for Astrobiology	Research Coordination Networks (RCN) are a virtual structure to support groups of NASA funded investigators to communicate and coordinate their research, training, and educational activities across disciplinary, organizational, divisional, and geographic boundaries. RCN is a meta-activity that indoctrinates new PIs, nourish the already indoctrinated and identify additional areas of research that could benefit from an interdisciplinary, interdivisional approach.	Ongoing	4 RCN's covering, Exoplanet system science, Ocean worlds, Life Detection, prebiotic chemistry in Earth environments and are adding a fifth covering the progression from the earliest cells to multicellularity.	
1.3	Exoplanet Research	PSD has partnered with APD in conducting the Exoplanet Research Program (XRP), and is investigating partnership with HPD and ESD	Ongoing	Joint solicitation, review and selection of research proposals has been successfully conducted	
1.4	New Database for NEOs	The Planetary Science Division is working with the Astrophysics Division to develop a collaboration for archiving with public access for the Near-Earth Object Surveyor mission data set in the Infrared Processing and Analysis Center (IPAC) at Caltech.	Just started		TBD 2022
2.1	FIRE Training	PSD designed and implemented a training program called Foster Innovation In Risky Environments (FIRE) to encourage PSD PSs and PEs to take risks. The course emphasized the DiSC [(D)ominance, (i)nfluence, (S)teadiness and (C)onscientiousness] personality profiles assessment to understand differences in	Ongoing	PSD sponsored 16 staff to complete the training.	Planning second round for all PSD staff

		terms of communications and needs for intellectual safety.			
2.2	Critical Teamwork Training	PSD Sponsored the Critical Teamwork in a Virtual World training to foster communications and improved work productivity during virtual meetings.	Completed	PSD sponsored 16 staff to complete the training.	
3.1	ISFM	PSD is working with the Centers to chart paths for ISFMs that provide both core support for Center activities and which provide tangible benefits to the broader scientific community.	Ongoing	External review of PSD's ISM	
3.2	EnVision	PSD is actively supporting the collaboration with ESA to supply the VenSAR radar instrument to the EnVision mission.	Ongoing	Solicited for VenSAR Science Team. Developing governance framework with ESA. Beginning formulation for VenSAR instrument.	LRD is 2031
3.3	Planetary Defense activities with other agencies	This is a coordination activity.	Ongoing	The Planetary Science Division collaborated with the Federal Emergency Management Agency for detailing FEMA Joint Operations Advisor Leviticus A. Lewis to NASA to help lead ongoing Planetary Defense Coordination Office activities with other agencies that fall under the National Near-Earth Object Preparedness Strategy and Action Plan.	Improved coordination for the CY2022 tabletop exercise for government agencies involved in the Action Plan (e.g., NASA, FEMA, USSF, NSF, etc.) for a hypothetical scenario with a short-warning asteroid impact of Earth.
3.4	Interdisciplinary Consortia for Astrobiology Research	Astrobiology is an interdisciplinary field that includes all sciences from astronomy to biology and has been promoting cross disciplinary collaboration since 1998. Most recently, the program has instituted a new research program ICAR, Interdisciplinary Consortia for Astrobiology Research. Astrobiology is inherently cross-divisional, and ICAR emphasizes this to pursue innovative and ground-breaking discoveries.	Implemented	Eight teams were selected through the ICAR solicitation to carry out cross-disciplinary research into astrobiology of interest to NASA.	
3.5	Joint awards for Astrobiology	Astrobiology works with several foundations to fund research and fellowship opportunities mostly for early career scientists.	Ongoing		This year the Research Corporation for Science Advancement, the Heising-Simons Foundation, NASA, and the Kavli Foundation made awards totaling

					$1,100,000 to eight multidisciplinary teams of researchers in the inaugural year of Scialog: Signatures of Life in the Universe.
4.1	No due date for proposals to R&A programs	In 2021, PSD introduced the No Due Date (NoDD) approach for a number of its R&A programs. NoDD provides two key benefits: it allows for broader participation in PSD R&A programs by reducing barriers to entry for small institutions; and it reduces the proposal-review-selection cycle time for new and innovative ideas.	Ongoing	Two cohorts	TBD 2022
4.1	Implement the H2O program	Observing the intersection of science and exploration with a NASA mission can be a transformative experience with long-standing benefits. NASA's Planetary Science Division (PSD) is considering ways to significantly increase the number of undergraduates exposed to our mission science teams, with an emphasis on reaching underrepresented students in STEM, through an immersive, accessible program called Here to Observe (H2O). Starting in October 2021, a cohort of undergraduate students from participating partner institutions will be paired with mentors from NASA planetary science mission teams in engaging, observation opportunities as exploration activities unfold. Some missions might be preparing for launch while others might be making active scientific measurements & discoveries, but the goal for H2O will remain the same: through sustained mentoring, we aim to spark an interest and reduce barriers for underrepresented students considering STEM careers	Ongoing	• Undergraduate student observers have been selected through institutionally-defined criteria o University of Puerto Rico (UPR) - 15 students selected (2 leaders, 11 participants, 3 backups) - UPR campuses: UPR Mayaguez, UPR Rio Piedras, UPR Bayamon, UPR Arecibo, Inter American University, UPR Ponce - Majors: Mechanical Engineering, Physics, Electrical Engineering, Computer Engineering, Aeronautics, Biology o Virginia State University (VSU) - 13 students selected (leaders TBD) - Majors: Manufacturing Engineering, Computer Science, Computer Engineering o Howard University (HU) - 2 student leaders selected (participant selection still underway) - Majors: Mechanical Engineering, Physics and Astronomy • Student observer cohorts have been paired with PSD missions o Clipper with UPR o Dragonfly with VSU o Lucy with HU • The first H2O event was a Lucy launch watch party, with all student observers from UPR, HU, and VSU invited to participate on Oct 16th. Lucy provided a few student ambassadors to host the event. • Mission mentor matching is underway. One mission mentor per student observer. Mentor matching will be completed around the same time we finalize the calendar of events for each mission (approx. one 1-hr observing or enrichment activity per month), working alongside the PSD mission liaisons (Shannon MacKenzie from Dragonfly, Katherine Kretke from Lucy, and Rachel Klima from	TBD 2022

				Clipper). The student leaders are in the driver's seat defining the events	
4.1	DEIA added to mission communications plans	We have required that all communications plans for new missions will have to have a specific section on DEIA outreach.	Just started	-	TBD 2022
4.1	Planetary Science Early Career Award	The Planetary Science Early Career Award (ECA) program supports the professional development of outstanding early-career scientists in areas relevant to the Planetary Science Division (PSD). Support from the program is intended to help promising individuals play an increasing and meaningful role in the planetary science community. We place special emphasis on those projects that demonstrate the intention to foster a culture that encourages collaboration in pursuit of common goals (STRATEGY 2.2) and increase the diversity of thought and backgrounds represented across the entire SMD portfolio through a more inclusive environment (STRATEGY 4.1).	Implemented	In the first two years of the ECA program, 11 promising early career award recipients were funded for projects ranging from the study of the climate and impact history of planetary systems, to developing large regional laboratory facilities and flight systems for future planetary missions. All 11 recipients intend to build research groups to foster other early career researchers, often from underrepresented groups.	TBD 2023


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