National Aeronautics and Space Administration

Mary W. Jackson NASA Headquarters
Washington, DC 20546-0001

Reply to Attn of: SMD/Heliophysics Division

Dr. France A. Córdova
Chair, Space Studies Board
National Academies of Science, Engineering, and Medicine
500 5th Street NW
Washington, DC 20001

Dear Dr. Córdova:

I would like to express my sincere appreciation for the Committee's report, *The Next Decade of Discovery in Solar and Space Physics: Exploring and Safeguarding Humanity's Home in Space* (2024). NASA appreciates the Committee's work to bring this comprehensive scientific vision to publication. In particular, I would like to express our gratitude and congratulations to Drs. Robyn Millan and Stephen Fuselier, the Committee's co-chairs; the volunteer members; and the National Academies staff for their diligent support of this effort.

The Heliophysics Division has completed its preliminary assessment of the report's vision and supporting recommendations. Appended to this letter is NASA's initial response to the report's recommendations. The vision is well-aligned with NASA's own desires for the field of heliophysics and we have started examining ways to incorporate elements of the report into our strategic planning.

For updates about this process or any other questions related to our response, please do not hesitate to contact the Director of the Heliophysics Division, Dr. Joseph Westlake, at joe.westlake@nasa.gov.

Sincerely,

Nicola J. Fox Digitally signed by Nicola J. Fox
Date: 2026.07.23 14:07:12 -04'00'

Dr. Nicola J. Fox
Associate Administrator for Science
NASA Headquarters

cc:
SSB/ A. Mohzi
A. Sheffer
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NASA Response to the Decadal Survey for Heliophysics 2024-2033
The Next Decade of Discovery in Solar and Space Physics: Exploring and Safeguarding Humanity's Home in Space

Overview

NASA values the National Academies' Decadal Survey for Solar and Space Physics (Heliophysics) and its strategic vision. We are weaving the spirit of these recommendations into our planning to the greatest extent possible while always upholding our responsibility as trusted stewards of taxpayer dollars.

The evolving space domain in the coming decade presents exciting opportunities to enhance NASA's heliophysics portfolio, delivering impactful science and societal benefits. NASA heliophysics is powerfully positioned to advance strategic priorities.

NASA is excited to strengthen our collaboration with the scientific community, including the National Academies, as we jointly explore new frontiers in space and science. We're confident that we'll continue to deliver groundbreaking discoveries and inspire the world.

NASA's Response to the Recommendations

Recommendation 3-2: The National Oceanic and Atmospheric Administration (NOAA) and the Department of Defense (DoD) should build upon the periodically repeated Space Weather Advisory Group surveys of space weather product users to document the highest-priority customer needs and the best performance metrics and validation methods for available space weather applications. The results should be used to identify high-priority space weather research goals. In addition, processes should be developed to ensure communication of these priorities across NOAA, DoD, the National Aeronautics and Space Administration, and the National Science Foundation to be used when setting research priorities in the agencies' space weather–related programs.

NASA concurs with the spirit of this recommendation. NASA agrees with the importance of effective communication with NOAA, Department of War, and other partner agencies. NASA strongly supports using the Space Weather Advisory Group User Needs Survey to gather user needs.

Recommendation 3-3: National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) space weather research programs (such as NSF's Advancing National Space Weather Expertise and Research toward Societal Resilience [ANSWERS] and NASA's Heliophysics Space Weather Programs) should be targeted to prioritized space weather goals (see Recommendation 3-2).

NASA concurs with the spirit of this recommendation and its alignment of current interagency processes with the PROSWIFT Act.

Building on the insights gathered from the initial Space Weather Advisory Group (SWAG) User Needs Survey in September 2024, the Space Weather Operations, Research, and Mitigation (SWORM) Subcommittee convened interagency discussions in December 2024. This crucial feedback, alongside direct user input, directly informs NASA's space weather applied research and application programs. Consequently, NASA is able to identify and prioritize efforts that directly support key Agency commitments, particularly those vital for human exploration and societal benefit.

NASA has found that engaging end-users leads to more impactful and beneficial science and operational applications. NASA will continue to work with agency partners to support activities that enable this researcher-user engagement and to refine the Space Weather R2O2R Program Element.

NASA plans to ensure its Living With a Star and Space Weather Programs appropriately focus on maturing scientific capabilities for end-user solutions. NASA approaches space weather through both science-driven research (Living With a Star Program) and user-driven applications (Space Weather Program) and utilize prioritized strategic goals to drive progress in Space Weather.

Conclusion [3.3.2-1]: The PROSWIFT Act tasks the Space Weather Advisory Group (SWAG) to conduct a user survey, to be reevaluated not less than every 3 years, to "assess the adequacy of current federal government goals for lead time, accuracy, coverage, timeliness, data rate, and data quality for space weather observations and forecasting." As these surveys are currently in the planning stage, the results needed for prioritization of activities are not yet available, and the research community lacks a clear set of targets to work toward.

NASA appreciates the Decadal Survey's focus on user engagement.

Since the Decadal Survey began, the first SWAG User Needs Survey was released in September 2024 and led to interagency meetings through SWORM. As a next step, NASA intends to work with other agencies to identify gaps between current capabilities and user needs, which will inform priorities for the Space Weather Program and Living With a Star Program.

Recommendation 3-5: As part of an overall increase in the Heliophysics Division budget, the National Aeronautics and Space Administration should grow the spaceflight element of the Space Weather Program to support larger stand-alone space weather demonstration missions with a cost cap comparable to the Heliophysics Small Explorers (i.e., approximately $150 million in fiscal year 2024).

NASA concurs with the spirit of this recommendation and will explore implementations within the Agency's appropriations. In the FY2026 NASA Budget Technical Supplement, the first Space Weather Future Missions portfolio was introduced.

The Space Weather Program will work with partners within NASA (like the Artemis program) and other agencies (like NOAA), and will discuss with the research and space weather user communities (e.g., commercial satellite operators) to find potential technical implementations.

Recommendation 3-6: NASA should consider space weather enhancements for all National Aeronautics and Space Administration (NASA) missions during preformulation and should look for opportunities to include space weather enhancements on other federal agency missions. Such investments could be realized through the NASA Heliophysics Space Weather Program (see Recommendation 3-5).

NASA concurs with the spirit of this recommendation and will examine opportunities for strategic implementation. Our space weather instrument pipeline has been the entrance into this arena and is making progress towards enabling space weather measurements across the flight portfolio. Effective implementation would mean getting concurrent, interoperable, and validated measurements that fill known gaps, rather than simply adding enhancements to all missions. It is also important that data from these opportunities is high-quality and openly available through NASA archives. Collaborations with industry could also help achieve the goal of this recommendation. Recent talks with commercial companies suggest significant opportunities for developing and hosting instruments, and for data-as-a-service approaches.

Recommendation 4-1: The National Aeronautics and Space Administration, the National Science Foundation, and the National Oceanic and Atmospheric Administration should fund either a professional organization (or group of organizations) or a team of researchers to develop a method to systematically gather demographic information of the current workforce in solar and space physics and obtain past demographic information (where possible) to assess demographic changes. A primary objective of this effort would be to initiate a sustainable structure for continuous, longitudinal data gathering, including at the level of undergraduate majors and conference attendees, to assess the potential future workforce and determine if the pool is sufficient to meet the needs of solar and space physics. Initial results should be provided in advance of the start of the midterm assessment of the present decadal survey.

NASA concurs with the spirit of this recommendation. NASA does collect confidential and voluntary demographic data from all NSPIRES registrants. These data are not made available to Program Scientists and are never used in any part of the proposal selection process.

Conclusion [4.1-1]: A common name for the field that can be broadly called solar and space physics would improve efforts in data gathering, recruitment, education, and public outreach.

NASA concurs with this finding and notes that, since this decadal survey started, significant progress has been made in using 'heliophysics' as the common name.

‘Heliophysics’ was recently entered into the Merriam-Webster dictionary and clearly defines the field. ‘Heliophysics’ is defined as the study of the Sun and its effects throughout the Solar System, and "Space Weather" is defined as applied research on the dynamic conditions of the space environment, including the Sun and its effects on society, human biology, and its extensions in the solar system.

The term ‘heliophysics’ covers many scientific disciplines under one scientific theme and includes the applied research branch, "space weather". A single name for a scientific field becomes stronger when it's widely accepted both within and outside the field.

The use of 'heliophysics' has increased recently, with over 13,000 mentions in traditional media and over 18,000 on social media from May 2023 to May 2024. In December 2024, the American Astronomical Society’s Solar Physics Division renamed its Triennial Earth-Sun Summit to the “Heliophysics Summit”.

Recommendation 4-2: Funding agencies should expand the reach of solar and space sciences in education by expanding the definition of the National Science Foundation’s “broader impacts/societal impacts” and the National Aeronautics and Space Administration’s “broadening impacts” to specifically include developing solar and space science educational materials aimed at K–12 and college students.

NASA concurs with the spirit of this recommendation as it applies to NASA's work. Since the 2014 consolidation of education programs, NASA does not create education curricula but engages learners with scientific content from its spaceflight projects. Within the Science Mission Directorate, the Science Activation Program (SciAct) provides funding for over three dozen teams, including the Heliophysics Education Activation Team (HEAT).

Recommendation 4-4: Funding agencies should expand the reach of solar and space physics by increasing funding opportunities for researchers to lead summer schools, workshops, and other skill-building activities for undergraduate and graduate students. Funding these activities should include time for the researchers who lead them as well as resources, such as paid stipends to address equity, for the students. Such research supplements should require gathering and reporting data on participants, activities, and their impact.

NASA concurs with the spirit of this recommendation as it pertains to NASA’s work. NASA’s Science Mission Directorate and the Heliophysics Division lead opportunities tailored to its spaceflight efforts (e.g., PI Launchpad, Heliophysics Mission Design School, Student Collaborations, RockOn and RockSat sounding rockets). These opportunities are essential for training the next generation of engineers, scientists, and professionals to execute our mission.

Recommendation 4-5: To be proactive about enhancing DEIA+ (diversity, equity, inclusion, and accessibility, as well as anti-racism, accountability, and justice) across the solar and space physics workforce including recruitment, working environments, and retention for all research and mission teams, all the relevant agencies, including the National Aeronautics and Space Administration and the National Science Foundation, should, when possible:

- **Continue and enhance funding of DEIA+ activities by (1) requiring DEIA+ plans for large proposals (more than $1 million) and (2) making supplemental funding available for optional DEIA+ activities as part of proposals;**
- **Enhance the opportunities for the science community to participate in existing host organization–based or agencywide DEIA+ efforts; and**
- **Improve the quality and review process of proposed DEIA+ plans by (1) providing sample activities or successful examples of DEIA+ plans to the community; and (2) reviewing DEIA+ plans associated with large proposals in panels whose members have the appropriate expertise to provide concrete and constructive feedback for improvement.**

NASA does not concur with this recommendation, in accordance with Executive Order 14151, "Ending Radical And Wasteful Government DEI Programs And Preferencing."

Recommendation 4-6: Funding agencies should increase the volume and dissemination of materials that communicate solar and space physics research results and their societal impacts to the general public. The National Science Foundation and the National Aeronautics and Space Administration should increase outreach programs related to active missions, ground-based facilities, and research and expand support of citizen science and participatory science.

NASA concurs with the spirit of this recommendation and will examine ways to increase the volume and dissemination of these materials. NASA currently supports this type of activity in spaceflight projects, its Science Activation (SciAct) program, and citizen science projects. SciAct teams are chosen competitively and work with NASA to increase their impact. NASA primarily supports citizen science through competed research programs. NASA publicizes compelling results across the heliophysics enterprise through its broader public communication efforts. For example, the recent efforts to highlight heliophysics during the total solar eclipse reached viewerships of over 12 million on YouTube, and won several Webbys and two Emmys. This type of targeted communication remains essential to communicating the societal benefit of heliophysics and space weather research.

Recommendation 5-1: The National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), and the National Oceanic and Atmospheric Administration (NOAA) should address the science and space weather goals of the decadal survey by managing space-based missions and ground-based instruments within the context of an integrated HelioSystems Laboratory (HSL). The HSL would include the

NASA missions that comprise the Heliophysics System Observatory (HSO), NSF-funded ground-based instruments, NOAA space-based assets, and flagship-level theory and modeling, which all work together in concert to provide data for scientific and space weather research.

Specific recommendations for elements of the HSL are as follows:

- **A. NASA, NSF, and NOAA should create an HSL working group to develop tools and standards for the scientific community to coordinate joint observations of NASA, NSF, NOAA, and international assets. The goal is to encourage joint observing campaigns by making collaboration easier.**
- **B. NASA should manage the HSO as a strategic network of all current and planned missions, with regular assessments of contributions from international missions and NASA missions in their prime phase, and potential contributions from planned missions. For missions in the extended phase, NASA should determine how the senior review and infrastructure mission evaluations fit into a strategic framework that emphasizes system-level coherence.**
- **C. NASA should organize a tactical HSO working group, with membership from HSO mission teams, to coordinate observations and maximize the scientific return of the HSO.**
- **D. Early in the pre-formulation phase of each new space mission, NSF, NASA, and NOAA, possibly in collaboration with international partners, should hold strategic discussions about potential contributed ground-based components that could enhance the science return.**
- **E. [Not addressed to NASA]**
- **F. [Not addressed to NASA]**

NASA concurs with the spirit of this recommendation, specifically strengthening the strategic focus of its portfolio by better integrating its theory, modeling, and spaceflight projects. Coordinating with partner agencies offers strong benefits. For clarity, the specific recommendations are addressed separately:

- A. NASA concurs with the benefits of cross-agency coordination and will examine with partner agencies the potential development of tools and standards.
- B. NASA concurs with this recommendation. In 2020, NASA updated Senior Review criteria to better improve and incentivize system-level investigations using the entire Heliophysics System Observatory (HSO). Senior Review 2026 emphasizes system-level coherence and coordination among projects in the HSO and promotes open participation in HSO science investigations.
- C. NASA concurs with the spirit of this recommendation and supports the idea of coordinating observations cost-effectively without adding extra management layers. While inter-project coordination has often happened organically, NASA has successfully supported focused collaborations (e.g., HSO Connect) and continues to look for similar opportunities.
- D. NASA concurs with this recommendation for NASA-led (directed) projects, which are the only [pre]formulation efforts it leads. During the early planning stages, NASA sets the scientific scope and requirements for its projects. After these are set, NASA

will continue its standard practice of engaging partner agencies in strategic discussions for their contributions to enhance science returns.

E. [Not addressed to NASA]
F. [Not addressed to NASA]

Recommendation 5-4: In addition to maintaining the current range of grant opportunities for theory and modeling, the National Aeronautics and Space Administration (NASA) should establish a flagship-level heliophysics community science modeling program capable of addressing heliophysics problems that have broad community interest and that require complex community models. This program should be funded at a level that enables training, hiring, and retaining interdisciplinary teams of highly specialized professionals. NASA should establish a sustained infrastructure for these core teams to engage community participation in developing, using, and maintaining the models. To define and implement the program, NASA Heliophysics Division should gather community input and consider examples (e.g., the various Earth system models) from other NASA divisions, other federal agencies, and international organizations.

NASA concurs with the spirit of this recommendation, specifically strategically organizing its support for theory and modeling and will examine potential ways to do so. However, flagship-level funding for a community modeling program cannot currently be accommodated with the President's Budget or enacted funding levels without displacing investments in other science activities. NASA agrees that its modeling efforts should complement and be strategically integrated with heliophysics spaceflight activities [pp. 175-177, 215-217].

Recommendation 5-5: To ensure continued success, the National Aeronautics and Space Administration and the National Science Foundation should conduct comprehensive, community-based reviews of their CubeSat programs.

NASA concurs with spirit of this recommendation, specifically periodically reviewing its programs and will investigate implementing a future review following established Agency procedures. Some aspects of the program identified by the Decadal Survey benefit from or require knowledge only available within the agency. NASA uses external input in reviews when appropriate, such as the SmallSat LEARN forum which facilitates networking and learning within the NASA SmallSat Community.

Recommendation 5-6: The National Aeronautics and Space Administration should create opportunities for principal investigator–led projects in the size range $10 million to $35 million (not including launch costs) that could accept higher risk than the Missions of Opportunity and be realized with minimal requirements for mission assurance and agency oversight.

NASA concurs with the spirit of this recommendation and supports developing appropriately sized opportunities that support its strategic science portfolio. NASA must deliver scientific

results across a broad range of projects with its available resources. NASA will examine trade-offs and potential interactions between these projects and Announcements of Opportunity [p. 192; Recommendation 5-7(E)], the appropriate risk posture and necessary oversight, and the impact of launch costs.

Recommendation 5-7: The National Aeronautics and Space Administration should maintain a robust and vibrant Explorers program by

- **A. Adding a Heliophysics Large Explorer (HeLEX)-class mission to the Explorer line. The HeLEX-class mission should have a principal investigator–managed mission cost roughly twice that of the Medium-Class Explorer (MIDEX) and could be supported at least once per decade;**
- **B. Maintaining a balance in Explorer mission sizes by alternating opportunities; in the period of this decadal, the next Explorer opportunity should be MIDEX, followed by a Small Explorer (SMEX), then HeLEX and then SMEX.**
- **C. Striving to maintain a 2–3 year cadence for Explorers and a 2–3 year cadence for Missions of Opportunity (MOs);**
- **D. Carefully considering the balance of all mission sizes across the Heliophysics Division before selecting more than one Explorer mission after Phase A and ensure that the 2–3 year cadence can be maintained;**
- **E. Separating the announcement of opportunity and proposal cycles for MOs from those of the full missions (SMEX, MIDEX).**

NASA concurs with the spirit of this recommendation, specifically maintaining a healthy scientific portfolio of spaceflight projects. However, NASA requires a strategic and focused spaceflight portfolio, which requires deviating from the recommendation's specific points. NASA will address the specifics in the following ways:

- A. NASA recognizes the value of a Principal Investigator (PI)-led moderate-scale project class and implemented this in the previous decade within the Solar Terrestrial Probes Program. NASA will continue to use this approach when it is most effective and can be accommodated within budgets.
- B, C, D. NASA may need to modify the recommended Explorers Program cadence and project sizes to support strategic projects that enable NASA to "realistically meet the challenges of the 2024 Decadal Survey's broad guiding questions" [p. 248].
- E. NASA will implement the most effective solicitation cadence for the portfolio. NASA will also engage with proposing institutions to better understand their priorities when facing multiple solicitations.

Recommendation 5-8: The highest priority for a new Solar Terrestrial Probes mission is one to investigate the system-level global coupling between the solar wind, magnetosphere, and ionosphere, while resolving mesoscale dynamics. This requires a heterogenous constellation mission that includes in situ measurements and remote sensing. If a science and technology definition team study is appropriate for the implementation, then it should

be done early in the decadal survey interval in time to support development starting in fiscal year 2027.

NASA concurs with the spirit of this recommendation. The FY 2027 President's Budget assumes Solar Terrestrial Probes are consolidated within the strategic Living with a Star Program to increase efficiency. NASA will consider the most cost-effective ways to implement a mission. Development timelines will depend on available funding. NASA will examine potential implementations, including using commercial providers alongside or instead of the standard Announcement of Opportunity process.

Recommendation 5-9: The highest priority for a new National Aeronautics and Space Administration Living With a Star mission is one to explore the solar polar regions to understand how polar magnetic fields and flows reveal the Sun's global dynamics and the mechanisms that underlie the solar dynamo and shape the solar activity cycle. A science and technology definition team study should be completed by approximately the middle of the decadal interval (i.e., before fiscal year [FY] 2029) in time to support mission development starting in FY2029.

NASA concurs with the spirit of this recommendation, specifically the science priority for this investigation and will investigate its feasibility. Development timelines always depend on available funding. This strategic mission would complete new science needed to understand the origins of space weather that impacts life and society on Earth and in its surrounding space environment. The complexity of the recommended mission concept requires an initial assessment of the science objectives, technical maturity, and programmatics (cost and schedule) and may consider approaches to this mission beyond the traditional Living With a Star flagship approach.

Recommendation 5-10: The National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF) should expand and coordinate opportunities for carrying out scientific research that combines ground- and space-based observations. Grant funding opportunities should continue to enable and enhance joint analysis of ground-space data as appropriate. NSF and NASA should offer additional funding opportunities that support joint aggregation, assimilation, and analysis of ground- and space-based data and production and archiving of combined ground-space data products.

NASA concurs with the spirit of this recommendation, specifically the benefit of combining ground- and space-based observations, and respects NSF's leadership in supporting research with and the archiving of ground-based observations. NASA has historically supported ground-based observations in its funding opportunities when appropriate for specific NASA program goals. NASA has worked with NSF to coordinate ground- and space-based observations when mutually beneficial (e.g., Solar Orbiter and Daniel K. Inouye Solar Telescope) and plans to continue doing so.

NASA intends to continue supporting the development of standards and tools for heliophysics data, regardless of source, through the International Heliophysics Data Environment Alliance.

Furthermore, NASA supports NSF in their leadership of an interagency working group on policies and practices for archiving ground-based observations.

Recommendation 5-11: The National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), and the National Oceanic and Atmospheric Administration (NOAA) should continue to support the development of modern cyberinfrastructure to enable effective sharing and utilization of heterogeneous data produced across the integrated HelioSystems Laboratory. Future investments should consider the following agency roles and approaches:

- **NSF is well positioned to take a leadership role in this activity because the agency has an established history of funding community cyberinfrastructure programs of this scope.**
- **The NSF Cyberinfrastructure for Sustained Scientific Innovation program could serve as a funding vehicle; early-stage proof-of-concept efforts can be funded through this and other programs that offer smaller grants.**
- **NASA Heliophysics Division should integrate data-storage and data-sharing facilities, such as the space physics data facility, virtual observatories, and mission science gateways, into the new cyberinfrastructure.**
- **Integration of data systems should include coordination with NOAA, which should invest in the capability to provide data in formats compatible with the research data.**

NASA concurs with the spirit of the recommendation and will consider potential implementations in coordination with partner agencies. NASA is developing the Heliophysics Digital Resources Library (HDRL) to be the single source of data for NASA Heliophysics missions. The HDRL portal will continue to improve, becoming more accessible to the broader community and incorporating discovery and search of related datasets, including those from NSF and NOAA programs. NASA will engage with partner agencies through an existing interagency working group to ensure HDRL interfaces effectively with other data sources.

Recommendation 5-12: The National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF) should actively contribute to a cultural change that would better foster cross-divisional research. Specifically, they should increase support for cross-divisional research by

- **Gearing research and data analysis programs toward better supporting cross-disciplinary projects. Mechanisms could include stating interdisciplinary goals in proposal calls, explicitly identifying calls that may span multiple divisions or directorates and improving the review process—for example, by broadening the panelist expertise.**
- **Initiating and funding interdisciplinary workshops to advance and develop cross-disciplinary collaborations.**
- **Initiating and funding NASA Science Mission Directorate (SMD)-wide opportunities for cross-disciplinary "Centers of Excellence" that would combine multidisciplinary**

teams to address cross-disciplinary research questions spanning across SMD divisional boundaries.

NASA concurs with the spirit of this recommendation when it serves a high-priority strategic goal. NASA has actively contributed to cross-divisional programs and incorporated cross-/interdisciplinary scope into its programs over the last decade, using methods like those recommended.

Cross-divisional collaboration examples include the Juno Participating Scientist Program, the Exoplanet Research Program, and Habitable Worlds. In 2019, the Living With a Star Program added "Stellar Impacts on Habitability" as a Strategic Science Area and later solicited a Focused Science Team on “Atmospheric Loss and Habitability in the Presence of a Star”. In the 2024 Heliophysics Internal Scientist Funding Model (ISFM) program, the Heliophysics Division selected the Sellers Exoplanet Environment Collaboration (SSEC) to address cross-divisional research topics.

Recommendation 5-14: For missions that are moved to the infrastructure category, the National Aeronautics and Space Administration should ensure that sufficient funding is provided for mission teams to calibrate and process data to Level 2 (calibrated data products that are in physical units, appropriate for use by the rest of the science community), deliver to the Space Physics Data Facility, and carry out scientific validation.

NASA concurs with the spirit of this recommendation for all projects in the heliophysics fleet, regardless of category, depending on available resources. If resources are insufficient, NASA must either reduce one or more mission to simple operations and data archiving or decommission them. NASA uses the Senior Review process to assess its operating mission fleet. In recent Announcements of Opportunity and the 2020 and 2023 Senior Reviews, NASA has improved requirements for data calibration, validation, and archiving. NASA is currently clarifying and updating its policy for extended operations, focusing on these topics.

Recommendation 5-15: To maximize the scientific return on previous investments, the National Aeronautics and Space Administration (NASA) should provide expanded opportunities for scientific research that uses archival data alone, without also requiring data from NASA infrastructure missions, currently operating missions, or a theory or modeling component. This could be achieved by expanding existing programs or creating a new heliophysics data analysis program element that would support data analysis projects.

NASA concurs with the spirit of this recommendation. The heliophysics research program has supported the use of archival data alone in recent years and prioritizes the most compelling science.

Recommendation 5-16: The National Aeronautics and Space Administration (NASA) Heliophysics Division’s research program should be augmented to maintain a typical

proposal success rate of at least 25 percent and to increase grant sizes to account for cost increases owing to inflation and open science requirements. In the longer term, NASA should conduct an analysis to determine the appropriate size for research grants, taking into consideration typical salaries in the field, how people are funded, how many grants is a reasonable expectation for each person to have, grant duration, and the particular challenges of open source requirements for theory and modeling.

NASA concurs with the spirit of this recommendation, specifically supporting the capabilities and research needed to accomplish strategic science objectives. The research program is key to preparing for future spaceflight projects and maximizing science returns from mission data. Community capabilities are crucial for these outcomes and are a major part of NASA's considerations. However, determining the correct research program size requires a metrics-based assessment and review within a strategic and focused Heliophysics portfolio. Metrics based on a proposer's perspective, like a 25% success rate, do not necessarily reflect program-level success or NASA's strategic priorities. NASA's success metrics must focus on completing strategic science objectives, including enabling future spaceflight activities. NASA will examine the research program to see if it can better align with Heliophysics strategy [pp. 173-174, 215-217].

Recommendation 5-17: The National Aeronautics and Space Administration (NASA) should ensure that theory and modeling needs are identified early in the pre-formulation phase for strategic (Living With a Star and Solar Terrestrial Probes) missions for example, as part of a science and technology definition team. NASA should then determine the appropriate mechanisms for filling these needs. Selecting interdisciplinary scientists through open competition to join the mission team is one possible way to accomplish this.

NASA concurs with the spirit of this recommendation and will examine appropriate mechanisms. As this decadal survey stated, it is necessary to execute theory and modeling studies to enable the pre-formulation of future spaceflight investigations [pp. 175-177]. NASA will continue to optimize this process, including modifying the research program to better focus on theory and modeling needs for future strategic projects [pp. 175-177, 215-217] and will determine the most efficient and effective method to fill these needs.

Recommendation 5-18: To ensure their continued success, the National Aeronautics and Space Administration should review the structure of DRIVE Science Centers program and Space Weather Centers of Excellence program around the time of the midterm assessment. This could be either in conjunction with the midterm assessment or as a separate study feeding into the midterm assessment.

NASA concurs with the spirit of this recommendation, specifically periodically reviewing these programs and will examine how to implement a future review using established Agency procedures. However, program review timelines may not align with this decadal survey's midterm assessment. NASA's Space Weather Program annually evaluates its performance and is developing plans for an overall assessment process with Technology and Transition Readiness

advisors. NASA has also implemented regular reviews of individual DRIVE Science Centers as part of program-level management activities.

Recommendation 5-19: The National Aeronautics and Space Administration (NASA) Heliophysics Division should expand opportunities for instrument development that align with decadal survey goals and provide opportunities for in-flight demonstrations to raise technology readiness levels. NASA should consider expanding the role of the Heliophysics Strategic Technology Office to manage some of these activities and increase collaboration with the Space Technology Mission Directorate as appropriate.

NASA concurs with the spirit of this recommendation and will incorporate decadal survey goals into its Technology Program priorities. In-flight demonstrations are important for raising technology readiness levels, and NASA is working to increase these opportunities using suborbital, rideshare, and Research and Technology Mission Directorate (RTMD's) flight opportunities programs.

Recommendation 5-20: The National Aeronautics and Space Administration Science Mission Directorate (SMD) should develop a cross-divisional approach for planning, operation, and management of future projects and programs for interdisciplinary science. Specifically,

- **Include science representatives from all SMD divisions in the planning stages for Habitable Worlds Observatory;**
- **Support development of a mission to interstellar space and other future, large, long-term cross-divisional missions;**
- **Coordinate inclusion of interdisciplinary instruments on flagship missions to diversify science opportunities (e.g., include particles and fields instruments on Uranus Orbiter Probe, support for Europa Clipper cruise phase);**
- **Facilitate the cross-divisional aspects of space weather (e.g., radiation prevention and prediction) in particular, in the planning of Moon-to-Mars missions;**
- **Proactively engage with the Space Operations Mission Directorate (SOMD) and the Exploration Systems Development Mission Directorate (ESDMD) to ensure that communications needs for SMD missions will continue to be met in the future;**
- **Assess science-enabling instrument and flight system technology needs for the next generation, including next-generation radioisotope thermoelectric generators and solar sails.**

NASA concurs with the spirit of this recommendation and will pursue opportunities where feasible, beneficial, and affordable. Successful collaborations within SMD typically have one lead Division with a compelling, stand-alone project, to which other Divisions can offer minor investments to augment scope without significantly driving technical requirements. Collaborations with non-SMD organizations (e.g., Human Spaceflight Mission Directorate) focus on complementary capabilities/responsibilities and are part of regular agency planning.

Recommendation 6-1: If there is insufficient funding to accomplish the entire research strategy, then NASA should implement decision rules in the following order:

- **First, delay the start of the Living With a Star (LWS) Solar Polar Orbiter reference mission, and then**
- **Delay the start of the Solar Terrestrial Probes (STP) Links reference mission;**
- **Delay the Space Weather budget augmentation for space weather demonstration missions;**
- **Delay the announcement of opportunity for the next Explorer/Mission of Opportunity (but revert to the 3-year cadence after budget conditions become favorable again);**
- **Delay implementation of the community science modeling program;**
- **Delay the augmentation of the Heliophysics Research Program;**
- **Delay the development, implementation, or launch of the Dynamical Neutral Atmosphere–Ionosphere Coupling (DYNAMIC) STP mission; then**
- **Delay the development, implementation, or launch of the Geospace Dynamics Constellation (GDC) LWS mission.**

NASA acknowledges this recommended prioritization for activities in the next decade. NASA will make thoughtful, impactful decisions about mission timing and scope to ensure that every endeavor propels Heliophysics and Space Weather forward. NASA is powerfully positioned to advance on these strategic priorities and as trusted stewards of American taxpayer dollars is committed to returning groundbreaking discoveries and inspiring the world.