Consensus Study Report

February 2020

HIGHLIGHTS

Progress Toward Implementation of the 2013 Decadal Survey for Solar and Space Physics: A Midterm Assessment

The National Academies' 2013 Decadal Survey for Solar and Space Physics identified key priorities and presented, for the period 2013-2022, a comprehensive heliophysics research and applications program for NASA, NSF, and NOAA. In late 2018, a new National Academies study committee was formed[1] to undertake a planned midterm assessment of progress made towards decadal survey goals. This report highlights important recent advances in the field, evaluates progress made towards decadal survey goals, makes recommendations on how sponsoring agencies can best implement remaining decadal survey priorities given current available resources, and outlines steps that might be taken in advance of the initiation of the next decadal survey.

IMPORTANT ADVANCES IN HELIOPHYSICS

Over the past six years, U.S. investments in the field of solar and space physics have enabled major scientific advances, which have been reported in thousands of research papers. Launched in August 2018, NASA's Parker Solar Probe (PSP) has set the record for the closest approach to the Sun of a human-made object, and the initial data has already led to important scientific discoveries about the solar wind. The Van Allen Probes mission, recently ended, has changed our understanding of the very structure of Earth's radiation belts. The Interface Region Imaging Spectrograph Small Explorer (IRIS SMEX) studied the solar atmosphere with unprecedented resolution. The Magnetospheric Multiscale Mission (MMS) investigated magnetic reconnection in Earth's magnetosphere, and the Global-Scale Observations of the Limb and Disk Mission of Opportunity (GOLD MoO) became NASA's first scientific payload hosted on a commercial spacecraft. In addition, NOAA has expanded its space weather operations by launching the Deep Space Climate Observatory (DSCOVR) and the Geostationary Operational Environmental Satellite (GOES-16 and GOES-17) missions.

New ground-based observatories and operational assets have also been deployed. NSF has completed the Jansky Very Large Array (JVLA) and is projected to complete the Daniel K. Inouye Solar Telescope (DKIST) observatory in 2020. All of these resources contribute to a robust observational network, the Heliospheric System Observatory (HSO). The HSO is an evolving fleet of spacecraft and ground-based observatories from different agencies and international partners that works, along with theory and modeling, to advance our understanding of the local space environment.

Despite budgetary challenges, the majority of the 2013 decadal survey recommendations have been implemented or will be implemented over the next few years. Completion of the program of record as recommended in the 2013 decadal survey, combined with new tools and data analysis approaches, has resulted in significant scientific advances and has added important elements to the HSO.

[1] *As per language in the 2005 NASA Authorization Act*

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THE CHANGING LANDSCAPE FOR HELIOPHYSICS

Budget - The NASA Heliophysics Division (HPD) budget did not increase as anticipated in the 2013 decadal survey. Instead, the budget decreased in purchasing power when corrected for inflation. This budget reality impacted NASA's ability to fully implement the recommendations of the decadal survey, causing some recommended projects to be delayed.

Opportunities for Crossdisciplinary Research - The continual discovery of new exoplanets provides new opportunities, as solar and space physics research originally applied to our own solar system can be adapted to new stellar and planetary systems.

Small Satellites and CubeSats - Rapid technology development has accelerated the number of small-satellite science missions, especially CubeSats. Growth in the small satellite commercial sector is also providing new ways of designing and building satellites, as well as new opportunities for rideshares, hosted payloads, and data buys. *Because CubeSat missions are intended to be low-cost, higher-risk exploratory missions, NASA will need to ensure that reporting requirements are not imposed at the level required for larger missions.*

Increasing Role of Data Science - Maximizing the scientific return from increasingly large and complex datasets requires better infrastructure, enhanced professional training, and support for open source software. Advanced tools have become increasingly available since the decadal survey was published.

DRIVE INITIATIVE

The DRIVE initiative, first recommended in the 2013 decadal survey, provided a new way to structure Research and Analysis (R&A) programs in order to maximize the science return of NASA missions and NSF facilities. NASA and NSF have made progress on most of their DRIVE goals, including an expanded small satellite program, improved interagency coordination, and the creation of new NASA-NSF Heliophysics Science Centers.

RECOMMENDATION: NASA and NSF should continue to use the DRIVE framework within their R&A programs.

The full report includes number of detailed recommendations to NASA and NSF on how to best optimize the science value of their programs for the remaining years of the current decadal survey interval.

EXPLORERS PROGRAM

NASA has made progress in strengthening the Explorers program—competitively selected small-to-mid-size missions—as recommended in the 2013 decadal survey. However, the committee sees the growth of mission cost in a relatively flat budget setting as a significant hazard to the ability to sustain the program's 3-year cadence in the future.

RECOMMENDATION: In order to maintain a 3-year (or ideally faster) launch frequency of Explorers, we recommend that NASA develop a more efficient management environment and an improved contract/grant structure, both to reduce mission cost and to shorten the interval from Announcement of Opportunity (AO) to launch. In this context, we recommend that NASA (1) adopt new procedures to facilitate a more cost-efficient implementation of smaller satellites and instruments using game-changing small-sat technology, and (2) continue to strive toward reduced launch costs, for example through ride sharing.

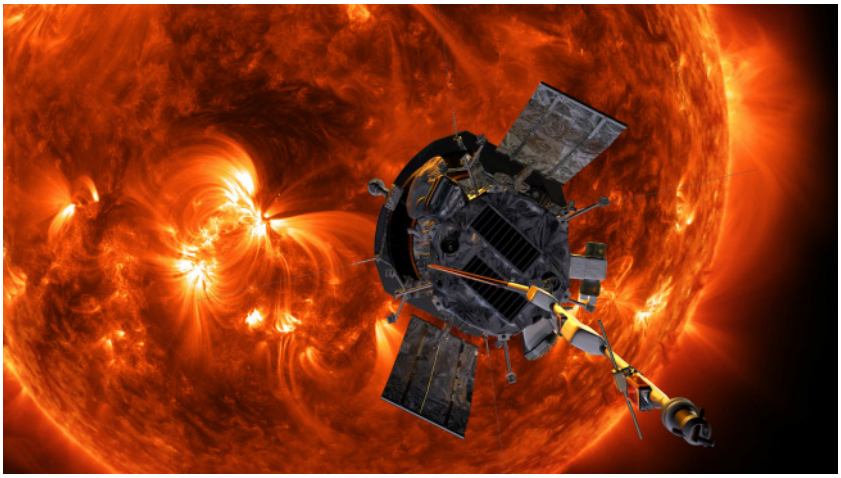
SOLAR-TERRESTRIAL PROBES

The Solar-Terrestrial Probes (STP) program is an important component of heliophysics research, focusing on studying fundamental processes occurring throughout the heliosphere, including the Sun-Earth system. Formulation of the first of three recommended STP missions has begun, but IMAP comes 3 years later than anticipated in the decadal survey, and the next STP mission (DYNAMIC) has not started.

RECOMMENDATION: NASA should take the steps necessary to release an AO for a DYNAMIC-like mission as the next STP mission.

A NEW PLAN FOR SPACE WEATHER

The release of the National Space Weather Strategy and Action Plan (NSWSAP) defines the responsibilities of 10 government agencies to advance space weather capabilities, and provides new opportunities for effective collaboration between agencies. However, these additional responsibilities come with a cost and require additional resources. These developments show the ever more important need for involvement of NOAA in the decadal



Launched in August 2018, NASA's Parker Solar Probe (PSP) has set the record for the closest approach to the Sun of a human-made object, and the initial data has already led to important scientific discoveries about the solar wind. Image Credit: NASA

survey process. Another critical missing piece in the current strategic planning is a roadmap that coordinates scientific activities and provides metrics for measuring progress. Such a roadmap is needed to outline how all of the agencies' programs work in concert to improve our predictive capabilities for space weather events.

RECOMMENDATION: In order to make efficient progress on the high-level goals in the NSWSAP, NASA should develop, in collaboration with NOAA and the NSF's Directorate for Geosciences and Directorate for Mathematical and Physical Sciences and their research communities, an implementation roadmap for space-weather science and for capability transfer between research and operations.

RECOMMENDATION: NOAA, along with other operational agencies, should develop notional budgets for space weather operations that would include identifying the need for new space weather funding lines required to fulfill the responsibilities added to their existing tasks by the NSWSAP. This should be available as input to the next decadal survey.

INCREASING DIVERSITY IN HELIOPHYSICS

A diverse research community sparks innovation, inspires variety in problem solving approaches, and achieves a broader range of creative outcomes. Creating a diverse, equitable, inclusive, and safe work environment should be a priority for NASA Heliophysics, NSF, and NOAA. Although the present NASA leadership has taken some action to increase diversity, the proposed solutions so far are somewhat ad hoc, and it is not clear if there is a long-term strategy or metrics that can be used to measure progress.

RECOMMENDATION: NASA, NSF, and NOAA should develop strategic plans for the heliophysics community with goals and metrics to improve the diversity of race, gender, age, and country of origin.

Initiatives for increasing diversity could include (1) changing the selection methods for mission PIs, proposals, and observing time, (2) increasing efforts in mentoring, and (3) incentivizing activities that increase diversity and inclusion. The next decadal survey should address these issues.

RECOMMENDATION: NASA's Heliophysics Division should conduct a demographics/diversity survey before the next heliophysics decadal survey to understand how the community's demographics have evolved and to assess whether progress has occurred in enhancing diversity in the community. The next decadal survey should include a State of the Profession Panel, similar to the Astro2020 decadal survey.

PREPARING FOR THE NEXT DECADAL SURVEY

The process of preparing for decadal surveys has evolved since the last heliophysics decadal survey, and lessons learned from the other science divisions could benefit heliophysics strategic planning. In particular, community workshops for defining critical science goals and funded mission concept development as employed by NASA's Planetary Science Division and Astrophysics Division have been highly productive in preparing for decadal surveys in those fields. *In addition, it is critically important for future planning of space weather applications to have NOAA better integrated into strategic plans for the next decade.*

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