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

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Webinar for Release of Pre-publication version of Midterm Assessment Report
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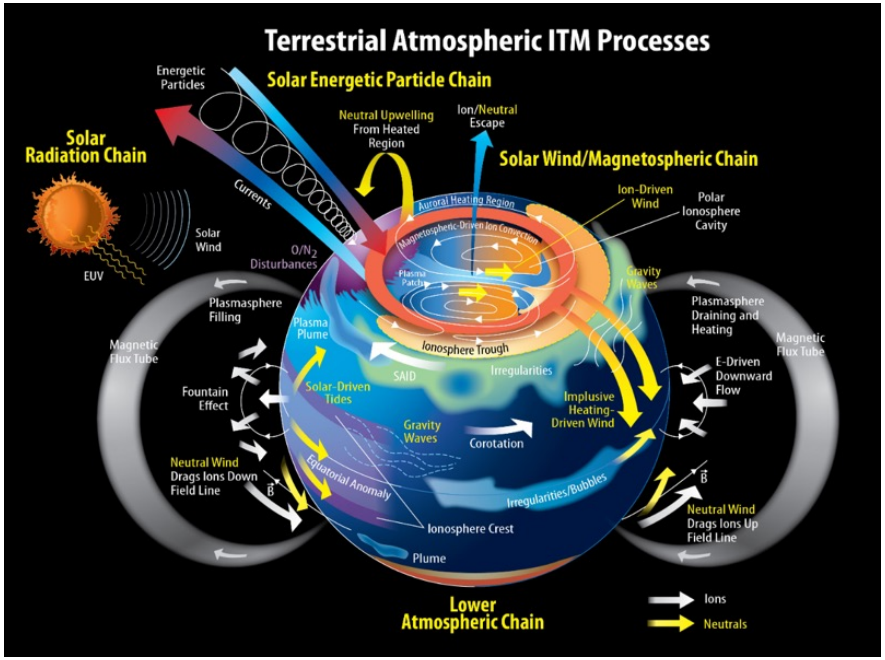
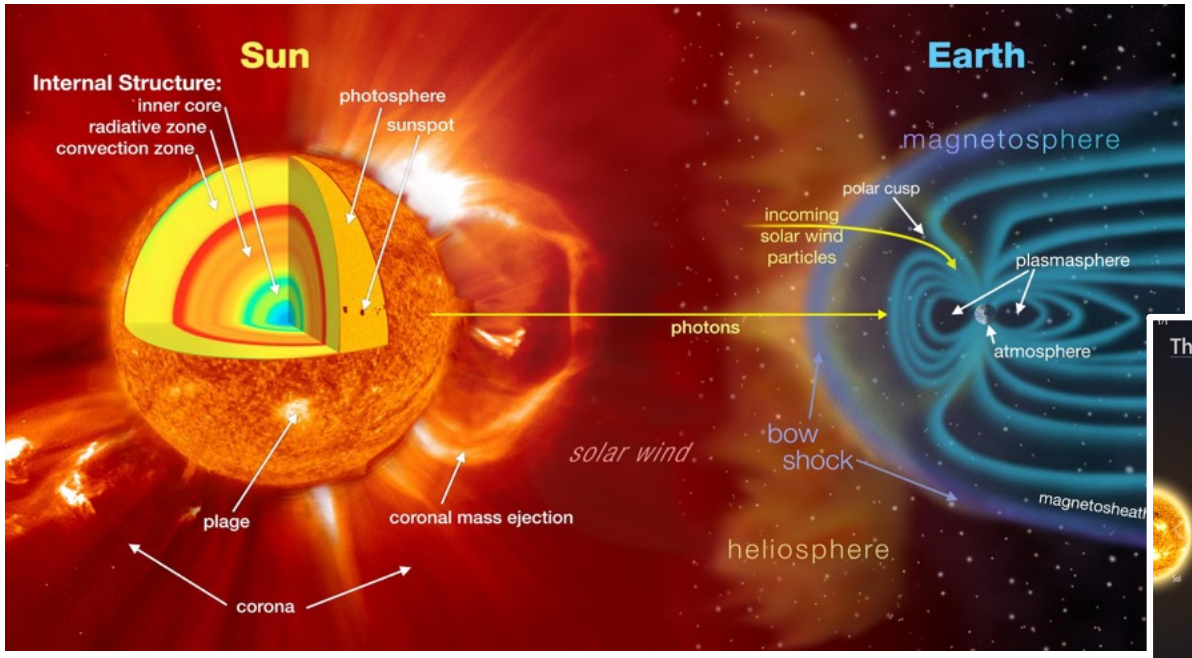
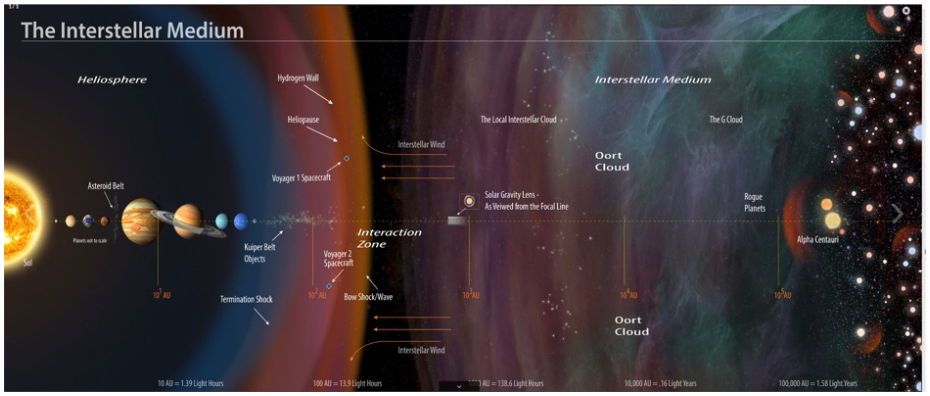
The National Academies of
SCIENCES · ENGINEERING · MEDICINE

Heliophysics: Solar and Space Physics

- There are three primary science disciplines in heliophysics.
  - Atmosphere-Ionosphere- Magnetosphere Interactions (AIMI)
  - Solar Wind- Magnetosphere Interactions (SWMI)
  - Solar and Heliospheric Physics (SHP)

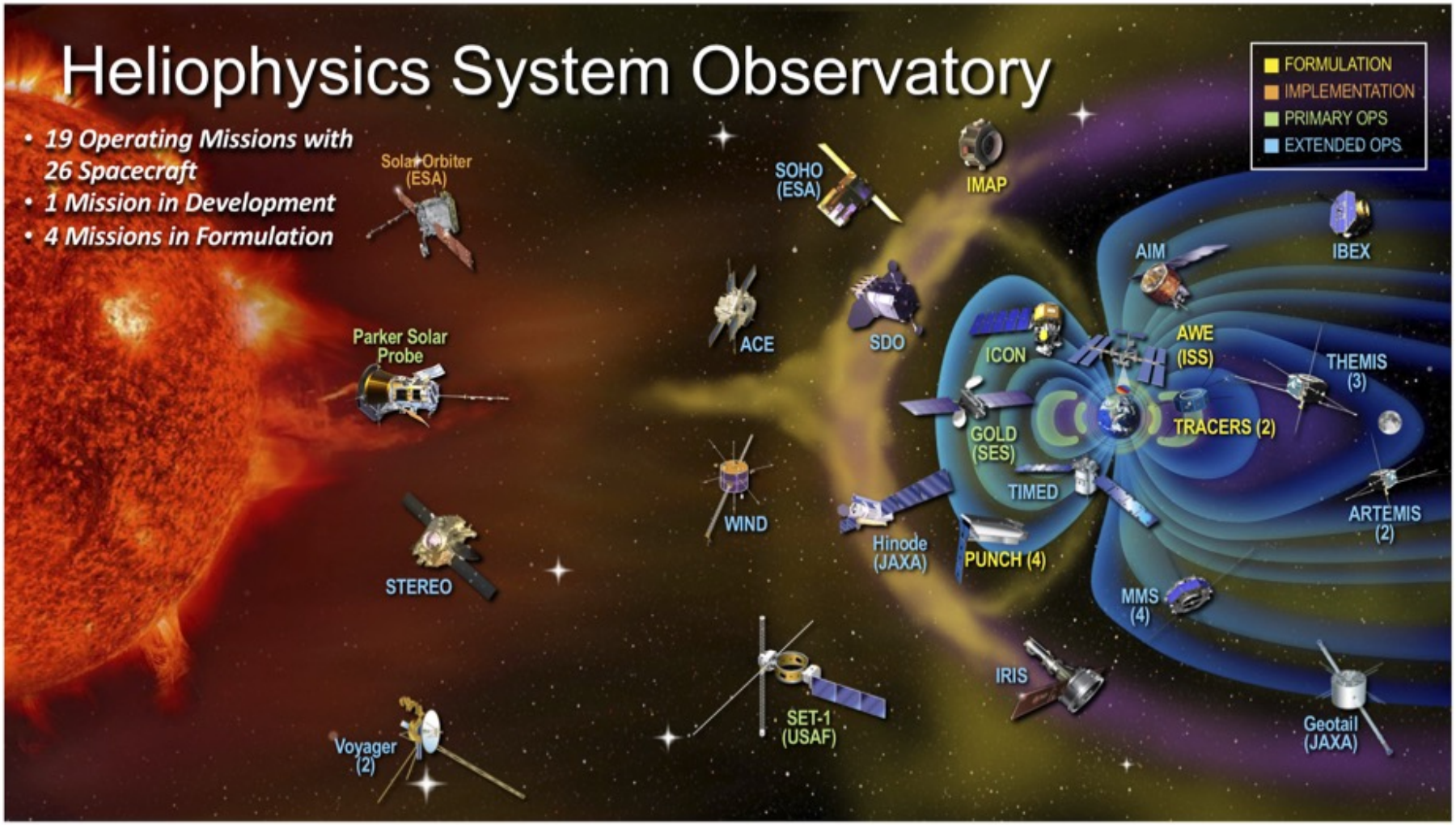






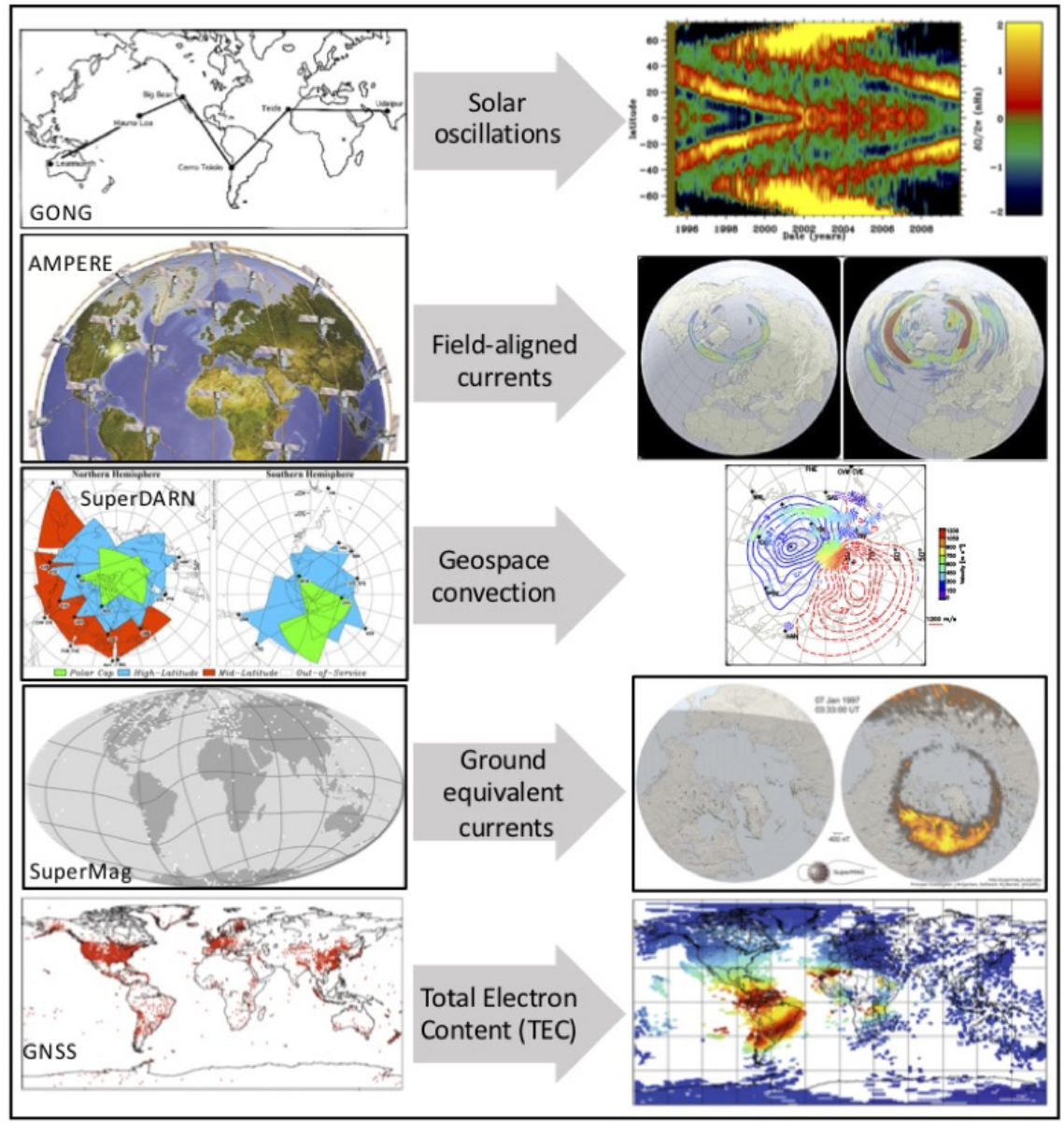
Heliophysics System Observatory (HSO)

- NASA heliophysics missions provide foundation of HSO.



NSF Heliophysics Ground-based Facilities

- NSF distributed facilities respond to the need for global information to complement the detailed regional measurements.
- DKIST is next major NSF facility to become operational in 2020.



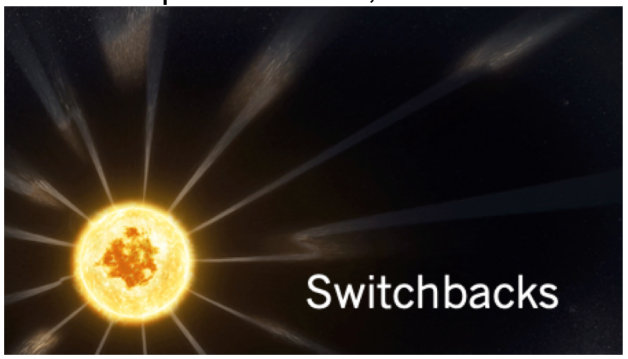
Advances for Heliophysics Research enabled with new missions, facilities, and models

- Parker Solar Probe (PSP): Already making new discoveries; sets record for closest approach to Sun
- Interface Region Imaging Spectrograph (IRIS SMEX) explores the solar chromosphere with unprecedented resolution
- Magnetospheric Multiscale Mission (MMS) probes the fine-scale processes and magnetic reconnection in Earth's magnetosphere
- Global-Scale Observations of the Limb and Disk (GOLD MoO) explores Earth's ionosphere and thermosphere as NASA's first scientific payload hosted on a commercial spacecraft
- Van Allen Probes unlock secrets of particle acceleration in Earth's Van Allen radiation belts
- NSF DKIST new 4-m solar telescope will be operational soon
- NOAA space weather operations advanced with launch of three new observatories: DSCOVR, GOES-16, and GOES-17
- Many advances through more comprehensive physics-based numerical modeling of the complex coupling in the Sun-Earth systems. Several of these models are accessible through the Community Coordinated Modeling Center (CCMC).

NASA Parker Solar Probe

solar wind / magnetic switchback

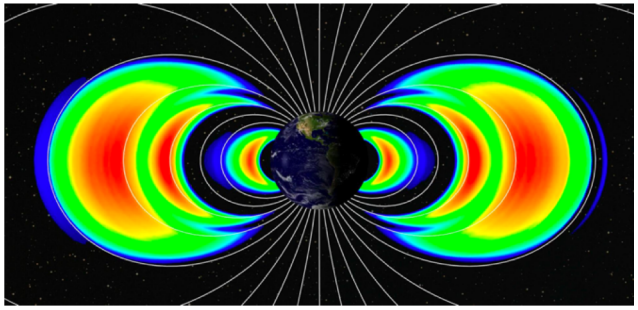
PSP press release, Dec. 2019



NASA Van Allen Probes

3rd radiation belt

Baker *et al.*, *Science*, 2013

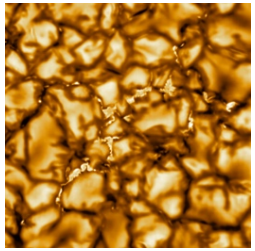


NSF DKIST

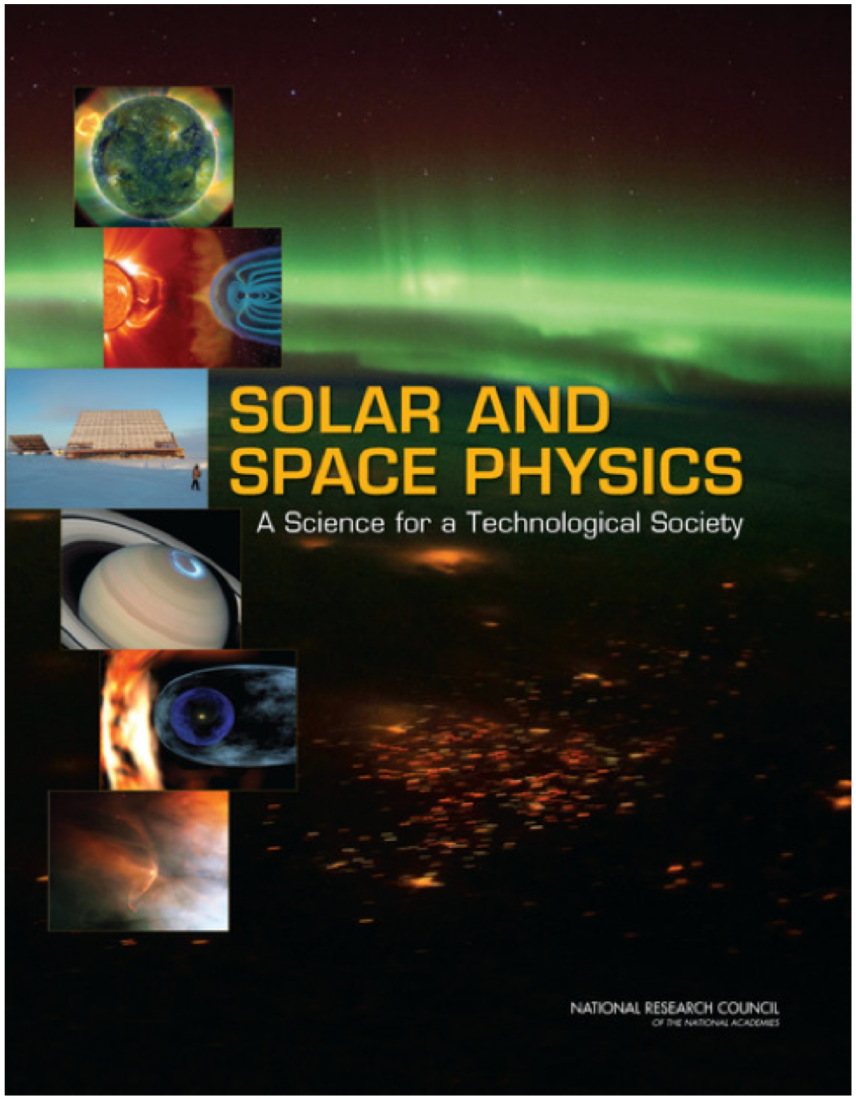
first light image

NSO press release

Jan. 2020



Solar and Space Physics: A Science for a Technological Society



- Congress requires review of NASA science divisions every 5 years.
  - Decadal Survey released in 2013
  - Midterm Assessment started in late 2018
- 2013 Decadal Survey overarching goals
  - Determine the origins of the Sun's activity and predict the variations of the space environment
  - Determine the dynamics and coupling of Earth's magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputs
  - Determine the interaction of the Sun with the solar system and the interstellar medium
  - Discover and characterize fundamental processes that occur both within the heliosphere and throughout the universe

Top-Level Recommendations from the 2013 Heliophysics Decadal Survey

Top Level Recommendations for **Research**				
Research Priority	Recommendation	NASA	NSF	Other (NOAA/AF/ NSWP)
0.0	Complete the current program	X	X	
1.0	Implement the DRIVE initiative	X	X	X
1.1	Diversify observing platforms with microsatellites and mid-scale ground-based assets	X	X	X
1.2	Realize scientific potential by sufficiently funding operations and data analysis	X	X	X
1.3	Integrate observing platforms and strengthen ties between agency disciplines	X	X	X
1.4	Venture forward with science centers and instrument and technology development	X	X	X
1.5	Educate, empower, and inspire the next generation of space researchers	X	X	X
2.0	Accelerate and expand the Heliophysics Explorer program	X		
3.0	Restructure STP as a moderate-scale, PI-led line	X		
3.1	Implement an IMAP-like mission	X		
3.2	Implement a DYNAMIC-like mission	X		
3.3	Implement a MEDICI-like mission	X		
4.0	Implement a large LWS GDC-like mission	X		
Top Level Recommendations for **Applications**				
Applications Priority	Recommendation	NASA	NSF	Other (NOAA/AF/ NSWP)
1.0	Recharter the National Space Weather Program	X	X	X
2.0	Work in a multi-agency partnership for solar and solar wind observations	X	X	X
2.1	Continuous solar wind observations from LQ (DSCOVR, IMAP)	X		X
2.2	Continue space-based coronagraph and solar magnetic field measurements	X		X
2.3	Evaluate new observations, platforms, and locations	X	X	X
2.4	Establish a SWx research program at NOAA to effectively transition from research to operations			X
2.5	Develop and maintain distinct programs for space physics research and space weather application and forecasting	X	X	X

Midterm Assessment Statement of Tasks

The National Academies…shall convene an ad hoc committee to review the responses from NASA's Heliophysics program and the NSF to the 2013 decadal survey, *Solar and Space Physics: A Science for a Technological Society*. The committee's review will include the following tasks:

1. Describe the most significant scientific discoveries, technical advances, and relevant programmatic changes in solar and space physics over the years since the publication of the decadal survey;
2. Assess the degree to which the Agencies' programs address the strategies, goals, and priorities outlined in the 2013 decadal survey and other relevant NRC and Academies reports, considering the national policy framework;
3. Assess the progress toward realizing these strategies, goals, and priorities;
4. Recommend any actions that could be taken to optimize the science value of the Agencies' programs including how to take into account emergent discoveries and potential partnerships since the decadal in the context of current and forecasted resources available to them;
5. Provide guidance about implementation of the recommended portfolio for the remaining years of the current decadal survey given actual funding levels, progress on decadal missions, and science and technology advances, but do not revisit or redefine the scientific priorities or recommended mission science targets;
6. Recommend any actions that should be undertaken to prepare for the next decadal survey--for example: enabling community-based discussions of (a) science goals, (b) potential mission science targets and related implementations, and (c) the state of programmatic balance; as well as identifying the information the survey is likely to need regarding the vitality of the field; and
7. Recommend actions that would enhance all stages of careers for scientists and engineers in the solar and space physics community.

Midterm Committee

17 members, 8 served on 2013 DS

- **Robyn Millan***
  Dartmouth College, co-chair
- **Tom Woods***
  Univ. of Colorado and LASP, co-chair
- **Tim Bastian**,* NRAO
- **Monica Bobra**, Stanford Univ.
- **Anthea Coster**, MIT
- **Ed DeLuca**, Harvard SAO
- **Scott England**, Va. Tech.
- **Stephen Fuselier**, SWRI
- **Ramon Lopez**,* UT Arlington
- **Janet Luhmann**, UC Berkeley
- **Katariina Nykyri**, Embry-Riddle Univ.
- **Jens Oberheide**,* Clemson Univ.
- **Merav Opher**,* Boston Univ.
- **Karel Schrijver**, Lockheed-Martin (ret.)
- **Josh Semeter**,* Boston Univ.
- **Jeff Thayer**,* Univ. of Colorado
- **Alan Title**, Lockheed-Martin ATC

Staff:

- Art Charo, Study Director
- Mia Brown, Research Associate
- Sarah Moran, Lloyd V. Berkner Space Policy Intern
- Gabby Holbert, Program Assistant

*Served on the steering committee or one of the study panels of the 2013 decadal survey in solar and space physics.

Midterm Assessment Process

- The committee was formed in fall 2018
  - met three times in person over the course of the study.
  - Also met on an approximate bi-weekly schedule via teleconference.

- Community input solicited via professional society newsletters, midterm website, and at town hall sessions at:
  - NSF CEDAR (Coupling, Energetics, and Dynamics of Atmospheric Regions) workshop
  - NSF GEM (Geospace Environment Modeling) workshop
  - NSF SHINE (Solar, Heliosphere and Interplanetary Environment) workshop
  - SPD (Solar Physics Division) conference of the American Astronomical Society (AAS)

- Midterm Assessment Poster presentations presented at the GEM and SHINE workshops, SPD conference, and NOAA's Space Weather Week meeting.

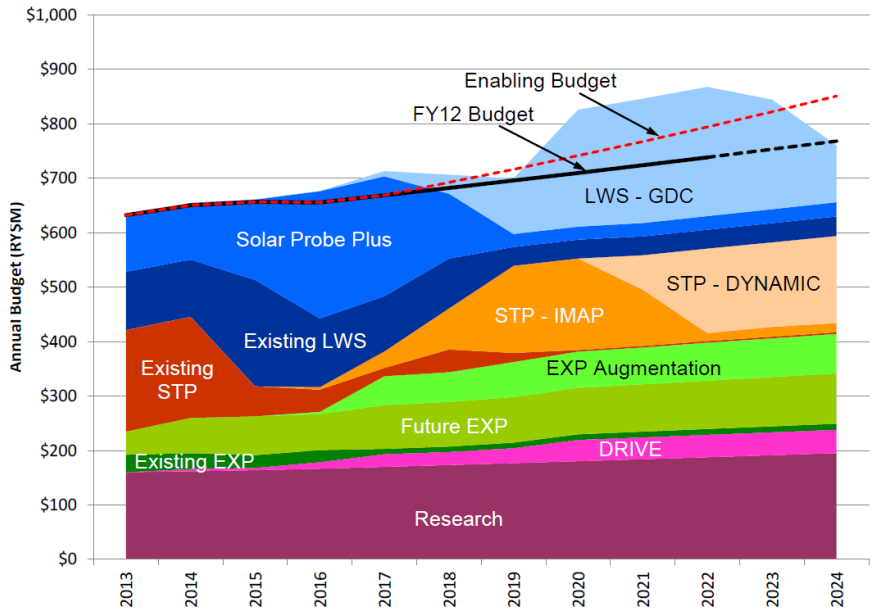
Midterm Report Outline

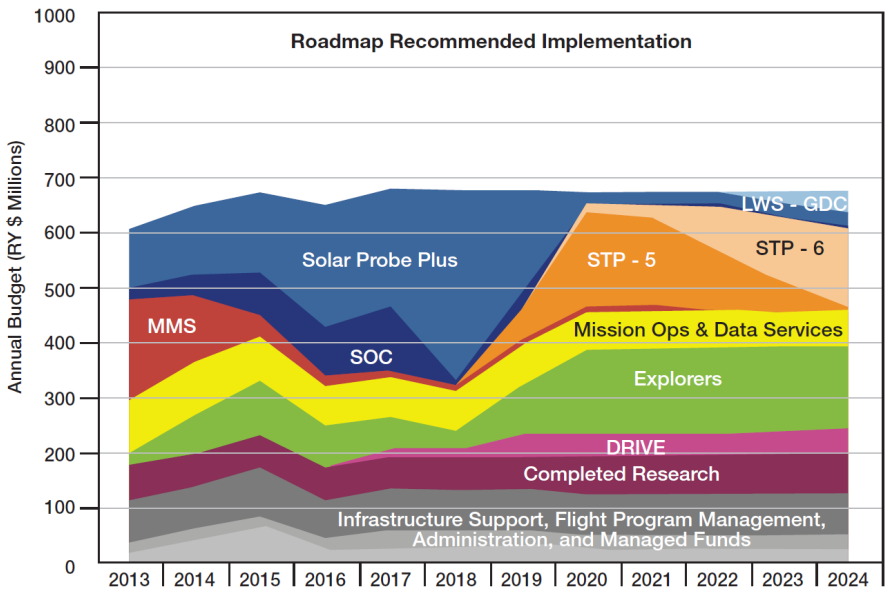
Chapter		# Findings	# Recommendations
S	Summary	-	-
1	Introduction to Heliophysics	-	-
2	Science Discoveries and Technical Adv.	-	-
3	Progress for DS Research Goals	27	5
4	Progress for DS Applications Goals	7	2
5	Heliophysics Career Enhancements	5	1
6	Preparing for Next Decadal Survey	10	3
	Total	49	11

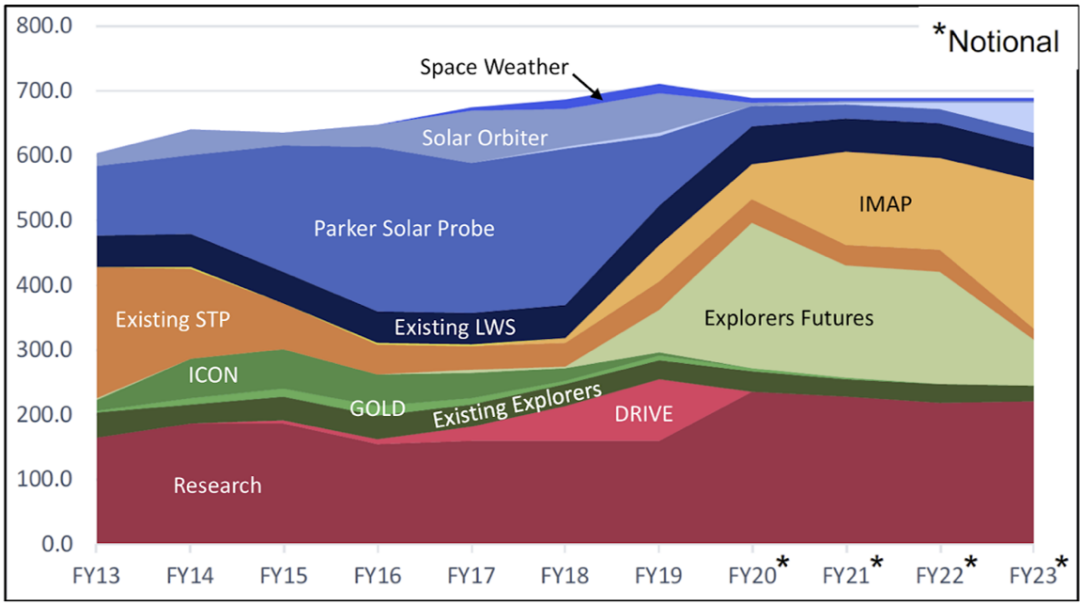
This webinar highlights all eleven recommendations, but just a few key findings are listed.

Changing Landscape - I

- **HPD Budget**: The key constraint in implementation. HPD budget actual was less than assumed by the survey. Over the last 5 years, it rose by 14%, less than inflation.







Changing Landscape - II

- **HPD Leadership**: Six different directors or acting directors from 2011-late 2018.
- **Changes for space weather at the national level:**
  - Release of the National Space Weather Action Plan and Strategy
    - defines responsibilities of 10 government agencies to advance space weather capabilities;
    - provides new opportunities for effective collaboration between agencies.
    - However, these additional responsibilities come with a cost and require additional resources.
  - More recently, NASA's Exploration goals promise to take us back to the Moon and beyond.
- **Opportunities for cross-disciplinary research**
  - For example, the detailed understanding of processes important for magnetospheres, atmospheres, astrospheres, stellar dynamos, and the sophisticated models developed to study our own solar system can be adapted to new stellar and planetary systems.
- **Opportunities enabled by the small-satellite revolution**
- **Increasing role of data science**
- **Citizen science**

Research Progress Graphics

PROGRESS on DS Research Recommendations							
Decadal Survey Recommendations	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
0. Complete the current program	MMS Launch				PSP Launch	SO Expected Launch	
1. Implement the DRIVE initative	*See below for DRIVE Progress*						DKIST Opertaions
2. Accelerate and expand the Explorer program			SMEX SALMON		SALMON	MIDEX	
3. Restructure STP as a moderate-scale PI led line							
3.1 Implement an IMAP-like mission							
3.2 Implement a DYNAMIC-like mission							
3.3 Implement a MEDICI-like mission							
4. Implement a large LWS GDC-like mission						GDC STDT	

Color Key: NASA, NSF, NOAA/other

Majority of the 2013 heliophysics decadal survey recommendations have been implemented or will be implemented over the next few years.

Research: Complete Current Program

2013 DS Recommendation 0.0:
The survey committee's recommended program for NSF and NASA assumes continued support in the near term for the key existing program elements that constitute the Heliophysics Systems Observatory (HSO) and successful implementation of programs in advanced stages of development..

- **Finding 3.1**: Completion of the program of record as recommended in the Decadal Survey, combined with new tools and data analysis approaches, has resulted in significant scientific advances (as highlighted in Chapter 2) and has added important elements to the Heliophysics System Observatory.

- *Launch of Solar Orbiter and transition of operations for DKIST are two primary program elements to complete in 2020.*

DRIVE Initiative

Diversify

Realize

Integrate

Venture

Educate

2013 DS Recommendation 1.0:
The survey committee recommends implementation of a new, integrated, multiagency initiative (DRIVE—Diversify, Realize, Integrate, Venture, Educate) that will develop more fully and employ more effectively the many experimental and theoretical assets at NASA, NSF, and other agencies.

DRIVE Progress Graphic

Diversify	2014	2015	2016	2017	2018	2019	2020
New NSF midscale project line.					Midscale RI-2 proposals due		
Augment NSF CubeSat program				2 CubeSats selected		CubeSat Ideas Lab	
New NASA tiny-satellite grants program	ROSES 2013 H-TIDeS		MinXSS, first NASA SMD CubeSat launch				
Suborbital and tiny-satellites: at least six per year.	NASA has met or exceeded goal of six (6) new starts per year between 2013- 2017						
Realize							
Enhance NSF funding for NSO solar synoptic observations	FY16 $2.5M for GONG		NOAA/NSF MOA for GONG				
Enhance NSF funding for DKIST operations				FY19 $8M Ops funding + $3.5M for L2 data		DKIST first light	
Augment NASA MO&DA support and ehance NASA guest investigator (GI) program	ROSES 2014: Van Allen/BARREL and IRIS subelements		ROSES 2016 -2017: MMS subelement		ROSES 2019: Outer Heliosphere subelement		
Integrate							
NASA: join NSF and DOE in multiagency program on laboratory plasma astrophysics and spectroscopy.	ROSES 2013-2019: H-TIDeS includes LNAPP element						
Ensure NSF funding for subjects that fall between sections, divisions, and directorates (e.g. outer heliosphere)							
Coordinate NASA-NSF-NOAA ground- and space- based solar-terrestrial observations and technology	Joint Support of GONG Network by NSF and NOAA						
Venture							
New NASA-NSF Heliophsysics Science Centers					NASA HSC Step-2 proposals due		
Consolidate NASA technology funding in SR&T, LWS, and LCAS programs into a single program; address technology needs for constellation missions	ROSES 2013 H-TIDeS includes ITD elemnet			H-TIDeS element split into H-TIDeS and H-FORT			
Educate							
Enhance and Diversify NSF Faculty Development in Space Sciences (FDSS) program	2015: 2 FDSS awards				2019 6 FDSS awards		
Continue NSF CISM summer school	CISM summer school renamed Boulder Space Weather Summer School, administered and organized by NCAR, funded by NSF						
Have NSF community workshops for professional development of graduate	Continuation of Annual CEDAR, GEM Summer Student Workshops						
Recognize Solar and Space Physics as subdiscipline for NSF's annual Survey of Earned Doctorates							

Color Key: NASA, NSF, NOAA/other

DRIVE Success

DRIVE has been successful as an organizational framework, and most of the DRIVE recommendations have been implemented.

- There are 20 Findings about the DRIVE activities.
- **Finding 3.19:** DRIVE is an organizational framework that encourages innovation and balance across NASA and NSF R&A programs, thus maximizing the science return of Agency investments. In the future, DRIVE may include new elements or augmentations that go beyond the limited number of recommendations made in the DS. It is essential to continue tracking and making visible the elements of DRIVE.
- **Recommendation 3.1: NASA and NSF should continue to use the DRIVE framework within their R&A programs. As the program elements that are part of DRIVE continue to evolve, they should remain visible and continue to be tracked in a transparent manner.**

DRIVE Future

- **Recommendation 3.2: In consideration of developments and emerging opportunities since the DS was published, the following recommendations are made to optimize the science value of the Agencies' programs for the remaining years of the current decadal survey interval:**
  1. **NSF should extend support for the routine delivery of DKIST higher level data products past 2020 with the goal to routinely process data to Level 2 (physical quantities based on calibrated measurements) at the DKIST Data Center.**
  2. **NSF and NOAA should extend the operations for NSO's synoptic observations past 2021, and NSF should begin investigating potential agency partners and design concepts for the next generation of GONG instruments.**
  3. **NSF should critically evaluate its facilities operations model to ensure that the science return is maximized over the lifecycle of each instrument.**
  4. **NASA and NSF should maximize the scientific return from large and complex data sets by supporting (1) training opportunities on modern statistical and computational techniques, (2) science platforms to store, retrieve, and process data using common standards, (3) funding opportunities for interdisciplinary collaboration, and (4) supporting the development of open source software. These four components should be considered alongside experimental hardware in the planning and budgeting of instrumentation.**

(R3.2 #5-#7 are on next page)

DRIVE Future

- *Continuation of* **Recommendation 3.2: In consideration of developments and emerging opportunities since the DS was published, the following recommendations are made to optimize the science value of the Agencies' programs for the remaining years of the current decadal survey interval:**

  (R3.2 #1-#4 are on previous page)

  5. **NASA should find ways to increase solar and space physics community participation in strategic missions and enhance the diversity of mission teams.**
  6. **NASA and NSF should strengthen their mutual coordination of ground-based and space-based observations, to include NASA investment in ground-based measurements that support their missions, and coordination of NSF ground-based facilities in support of NASA missions, including suborbital campaigns.**
  7. **Both NASA and NSF should create inter-divisional funding opportunities that support science areas that bridge established divisional boundaries at the Agencies.**

Research: Explorers

2013 DS Recommendation 2.0:
The survey committee recommends that NASA accelerate and expand the Heliophysics Explorer program. Augmenting the current program by $70 million per year, in fiscal year 2012 dollars, will restore the option of Mid-size Explorer (MIDEX) missions and allow them to be offered alternately with Small Explorer (SMEX) missions every 2 to 3 years. As part of the augmented Explorer program, NASA should support regular selections of Missions of Opportunity.

- **Recommendation 3.3: The committee encourages NASA to continue to work towards the goals set out by the DS for Explorer missions. 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 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 disruptive small-sat technology,**
  - **(2) continue to strive towards reduced launch costs, for example through ride sharing.**

Research: Solar-Terrestrial Probes (STP)

2013 DS Recommendation 3.0:
The survey committee recommends that NASA's Solar-Terrestrial Probes program be restructured as a moderate-scale, competed, principal-investigator-led (PI-led) mission line that is cost-capped at $520 million per mission in fiscal year 2012 dollars including full life-cycle costs.

STP Prioritized Reference Missions: 3.1 IMAP, 3.2 DYNAMIC, 3.3 MEDICI

- **Finding 3.26:** 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. As anticipated in the decadal survey, the MEDICI mission is not expected to start until the next decade.
- **Finding 3.27:** The DYNAMIC science goals remain compelling and of high priority for the heliophysics community. The targeted science goals and measurement capabilities of GOLD, AWE, and ICON do not address several key objectives in the top-level DS science challenge posed by DYNAMIC.
- **Recommendation 3.4: NASA should take the steps necessary to release an Announcement of Opportunity for a DYNAMIC-like mission.**
  - Per the decadal survey, such a mission would begin as the next STP mission after IMAP.
  - Steps in preparation for the AO could include a new study of its mission goals.

Research: Living With a Star (LWS)

2013 DS Recommendation 4.0:
The survey committee recommends that, following the launch of RBSP and SPP, the next LWS science target focus on how Earth's atmosphere absorbs solar wind energy. The recommended reference mission is Geospace Dynamics Constellation (GDC).

- **Finding 3.28:** The GDC STDT, per their charge, was not permitted by Federal Advisory Committte Act (FACA) regulations to select a particular mission architecture to meet GDC science objectives.

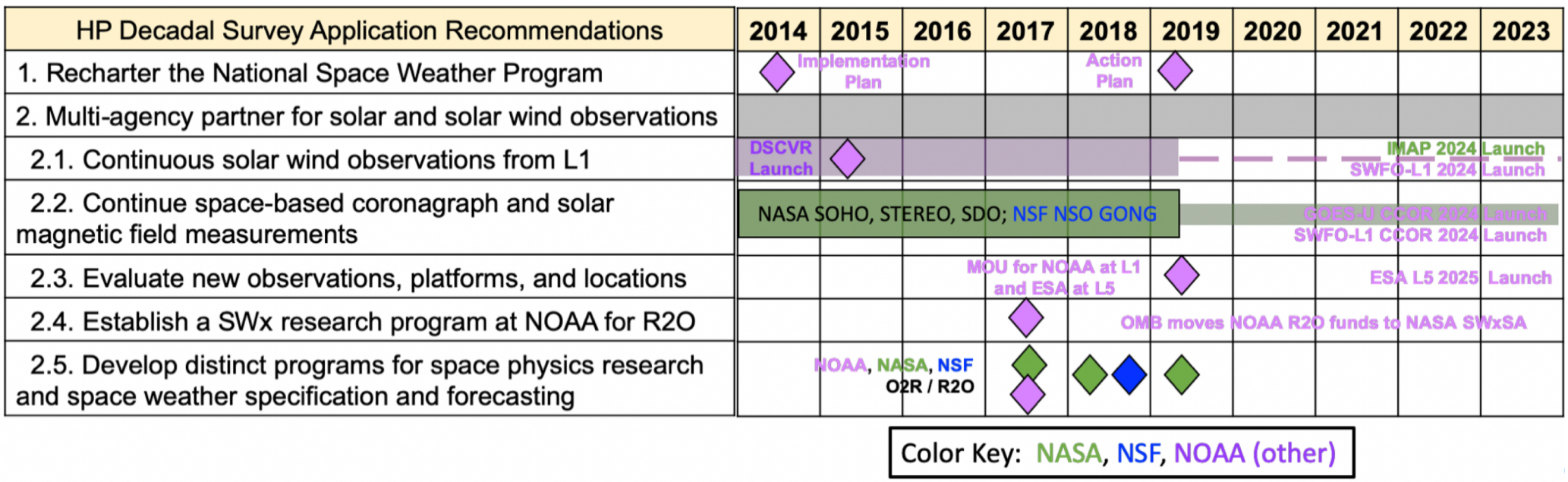
- **Recommendation 3.5: In order to proceed towards meeting the top-level decadal survey LWS mission recommendation, NASA should take the steps necessary to define a specific mission architecture formulation and implementation scheme for GDC within the next 3 years.**

Applications (Space Weather) Progress

2013 DS Recommendations for Applications:

A1.0. As part of a plan to develop and coordinate a comprehensive program in space weather and climatology the survey committee recommends that the National Space Weather Program be rechartered under the auspices of the National Science and Technology Council.

A2.0. The survey committee recommends that NASA, NOAA, and the Department of Defense work in partnership to plan for continuity of solar and solar wind observations beyond the lifetimes of ACE, SOHO, STEREO, and SDO.



Space Weather - I

- **Recommendation 4.1: In order to make efficient progress on the high-level goals in NSWSAP, NASA should develop, in collaboration with NOAA and NSF GEO & MPS and their research communities, an implementation roadmap for space-weather science and for capability transfer between research and operations (R2O and O2R).**

  This document should identify and prioritize the science focus areas and the associated essential observables and data-driven space-environmental models that are critical to "significantly advance understanding and enable improved characterization and prediction of space weather" as part of the overall national space weather enterprise as well as for NASA's internal needs related to the exploration of space.

NOAA, NASA, and NSF collaborations on space weather have significantly improved over the past few years.

NASA's Space Weather Science and Applications (SWxSA) program has newly developed in 2019. The SWxSA program appears poised to implement this midterm assessment recommendation.

Space Weather - II

- **Recommendation 4.2: 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 NSWAP. This should be available as input to the next Decadal Survey.**

Career Enhancements

Midterm Assessment Committee Task 7:
Recommend actions that would enhance all stages of careers for scientists and engineers in the solar and space physics community.

- **RECOMMENDATION 5.1: 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.**

  The next decadal survey should include a State of the Profession Panel, similar to the Astro2020 decadal survey. The State of the Profession Panel should have in advance the demographics / diversity survey data recommended in this report's Recommendation 6.2.

  Some potential solutions for increasing diversity include:

  - Adjusting the evaluation and selection methods for awarding proposals and observing time, such as dual anonymous reviews;
  - Incentivizing or requiring activities that increase diversity and inclusion, such as mentoring and apprenticeships to create a broader pool of possible mission and project PIs and reaching out to minority-serving universities to establish partnerships and recruit students;
  - Encouraging review panels, workshops, conferences, and other meetings to adopt explicit codes of conduct which remind all involved to respect civil, inclusive conduct in these activities.

Diversity and Next Decadal Survey

- **Recommendation 6.2: NASA 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 (see also this report's Recommendation 5.1).**

  Thereafter, to benefit all of the space science disciplines within NASA's Science Mission Directorate (SMD) and to inform decadal survey planning across SMD, NASA at the SMD-level should conduct this demographics / diversity survey on a 5-year cadence with clear identification of science areas relevant for each science division.

  - It is important that career survey specialists are involved in a new survey. For example, the American Institute of Physics (AIP) led the survey in 2012.

Next Decadal Survey - I

Midterm Assessment Committee Task 6:
Recommend any actions that should be undertaken to prepare for the next decadal survey--for example: enabling community-based discussions of (a) science goals, (b) potential mission science targets and related implementations, and (c) the state of programmatic balance; as well as identifying the information the survey is likely to need regarding the vitality of the field.

- **Recommendation 6.1: NASA and NSF should implement and fund advanced planning for the next decadal survey that involves the community strategically in the formulation of decadal goals and stretch goals (ambitious objectives that might extend past the next decade).**

  NASA and NSF could request the Space Studies Board's Committee on Solar and Space Physics (SSB-CSSP) to evaluate options for implementing this planning for the next decadal survey.

  Some specific ideas for this advanced planning include:

  - NASA-supported opportunities for the heliophysics community to host Assessment Group workshops in order to develop strategic science challenges and goals and to define high-priority measurements for the STP and LWS programs in advance of starting the next heliophysics Decadal Survey, and
  - NSF-supported workshops to strategically plan the next decade science challenges and goals and to identify high-priority measurements for the Mid-Scale Research Infrastructure and other research infrastructure concepts with the heliophysics community.

Next Decadal Survey - II

- **Recommendation 6.3: NASA, NSF, and NOAA, the anticipated principal sponsors of the next solar and space physics decadal survey, should work together to develop an integrated statement of task that reflects the research and application needs for each agency and across the federal government. To address the evolving needs for science-driven strategic plans, the agency sponsors should ensure the following items are included as tasks for the next decadal survey committee:**
  - **Definition of distinct science goals and implementation strategies for NASA's STP and LWS programs,**
  - **Evaluation of strategic plans with nominal (baseline) budget and optimal (best-case) budget,**
  - **Inclusion of decision rules for guiding implementation of recommendations, and**
  - **Identification of enabling technology needed in the coming decade to support longer term stretch goals.**

Next Decadal Survey - III

Some emerging topics for the next decadal survey are summarized in Finding 6.10. They are not in priority order nor an exhaustive list of topics for the next decadal survey.

- **Finding 6.10:** The next heliophysics decadal survey committee could consider the following important topics:
  - Trade study on SMEX/MIDEX AO cadence versus number of missions selected per AO,
  - Expansion of the HSO concept to include NSF's ground-based facilities and many upcoming small-sat science missions,
  - Identifying critical measurements in the current NASA and NSF facilities for future system-science plans and how to continue such observational capabilities,
  - Better integrated approach for including the science of space weather within NASA and NSF to improve space weather predictability,
  - Engaging NOAA in developing space weather research and applications for the next decadal survey
  - Improving the multi-agency and international coordination of heliophysics research and space weather applications,

(List continues on next slide)

Next Decadal Survey – III (cont'd)

- **Finding 6.10: continued**
  - NASA cross-divisional opportunities for exoplanetary-planetary, astrospheric-heliospheric, solar-stellar, and atmosphere-Earth science research and development of a prioritized strategy for implementing such cross-disciplinary research,
  - Consolidation of ground-based solar, heliospheric, and space weather science could be better supported within a new division under a single directorate at NSF.
  - NSF improving and broadening its structure for heliophysics research (e.g., outer heliosphere and planetary science elements are currently missing),
  - NSF improving the cost effectiveness of the operations of their many ground-based observatories, such as by sharing data analysis tools and data centers,
  - Evaluating the mission class requirements for NASA's Explorer program,
  - Identifying viable structural solutions to better support the heliophysics research grant programs, with particular emphasis on early-career scientists and soft-money scientists (those who are not professors or government employees), and
  - Better inclusion of emerging computer, data, and cloud technology and practices.

Questions?

Please enter questions in the Q&A box on Zoom.

Useful Links

Midterm Assessment Report (pre-pub):
http://nap.edu/25668

2013 Decadal Survey Report:
https://nap.edu/13060

Backup Slides

Key Findings: DRIVE Developments

- **Finding 3.2:** CubeSat missions are intended to be low-cost, higher-risk exploratory missions. The number of CubeSat science missions has increased significantly in this decade. While recognizing the challenge of managing a rapidly increasing number of CubeSat projects, NASA needs to ensure that managerial oversight does not translate into the imposition of additional reviews and reporting requirements to the level of larger missions.

- **Finding 3.5:** A plan exists to support NSO's synoptic observations in the short term. The long-term plan past 2021 for supporting these synoptic observations is unclear. To address this would require immediate attention.

Key Findings: DRIVE Developments

- **Finding 3.14:** Many elements of the HSO are aging, and there is a risk of losing key capabilities. In order to realize the vision of the HSO, some longer-term strategic planning is required to prioritize the critical support needed at both the mission level and the program level. Moreover, the HSO can be viewed as a National resource that goes beyond NASA missions. Data from small missions, ground-based facilities, and international assets have become increasingly important. An opportunity exists to elevate the HSO concept to better manage and exploit this critical resource for scientific progress.

Key Findings: DRIVE Developments

- **Finding 3.15:** Heliophysics has much to contribute to areas of broad SMD interest including stellar system and exoplanet research as well as future major exploratory efforts such as, for example, the Lunar Gateway missions. The expertise and knowledge that exists within the heliophysics community is not as widely exploited as it could be to obtain the maximum value of its investments because there are insufficient opportunities to engage across division lines.

- **Finding 3.16:** A regular cadence for HSCs is needed. In order for HSCs to be impactful, the next call for Step-1 proposals should be released within a year of the down selection for Step-2 proposals. Moreover, NSF participation in the HSCs has not been realized.

Key Findings: DRIVE Progress

- **Finding 3.11:** Laboratory research, from plasma physics to spectroscopy, is a critical, foundational component for heliophysics research. The NASA LNAPP program is a positive step towards increasing opportunities for laboratory experiments, but it does not fully address the DS recommendation, specifically the need for increased NASA-DOE collaboration.
- **Finding 3.20:** NASA and NSF have made progress on most of their DRIVE elements, although some of the DRIVE elements were implemented only recently. Funding constraints imposed by the decadal survey requirement to complete the current program are a contributing factor.
- **Finding 3.21:** Some elements of DRIVE for NSF have not been fully implemented. These include ensuring funding for science areas that fall between divisions such as outer heliosphere research, full participation in Heliophysics Science Centers, and recognition of solar and space physics as a subdiscipline in the annual survey of earned doctorates.

Key Findings: Career Enhancements

- **Finding 5.1.** The effectiveness of grants issued by NSF and NASA for research in solar and space physics could be improved by:
  - Shortening the cycle from proposal to funding availability. In some programs, and especially for younger scientists and postdocs, the cycle is too long.
  - Adjusting the size of grants. Typical grants, while they have grown in size, are often too small or short-term to tackle the larger challenges. Larger grants may be more effective for some programs. On the other hand, smaller grants or "seed grants", with smaller proposals, quicker reviews, and shorter funding cycles could invigorate new research directions and could be more supportive of early-career scientists.
- **Finding 5.5**: Increasing the participation and inclusion of individuals of different genders, races, cultures, and ages in positions of leadership roles in heliophysics (e.g., mission PIs) and for recognition (e.g., honors, awards) would better reflect today's societal makeup. It has been shown that women and underrepresented minorities in STEM fields face consistent bias in proposal selections, hiring, salaries, observing time awards, paper citations, and prizes / awards. It is critical to better track the demographics of the heliophysics community in order to assess the effectiveness of programs that seek to increase the diversity of its membership.