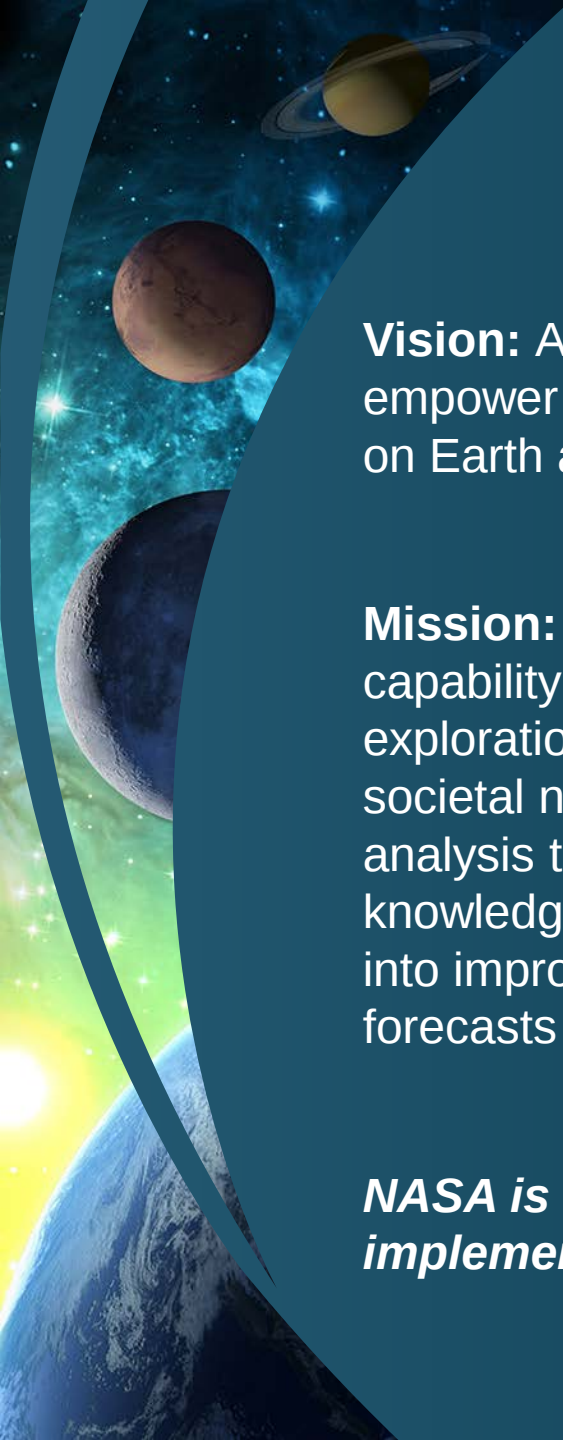




Heliophysics Division

Space Weather Update

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Space Weather Operations and
Research Infrastructure Part II
9 September 2020



NASA Space Weather Strategy

Vision: Advance the science of space weather to empower a technological society safely thriving on Earth and expanding into space.

Mission: 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.

NASA is in the process of developing an implementation plan.

1. Observe

- Advance observation techniques, technology, and capability

2. Analyze

- Advance research, analysis and modeling capability

3. Predict

- Improve space weather forecast and nowcast capabilities

4. Transition

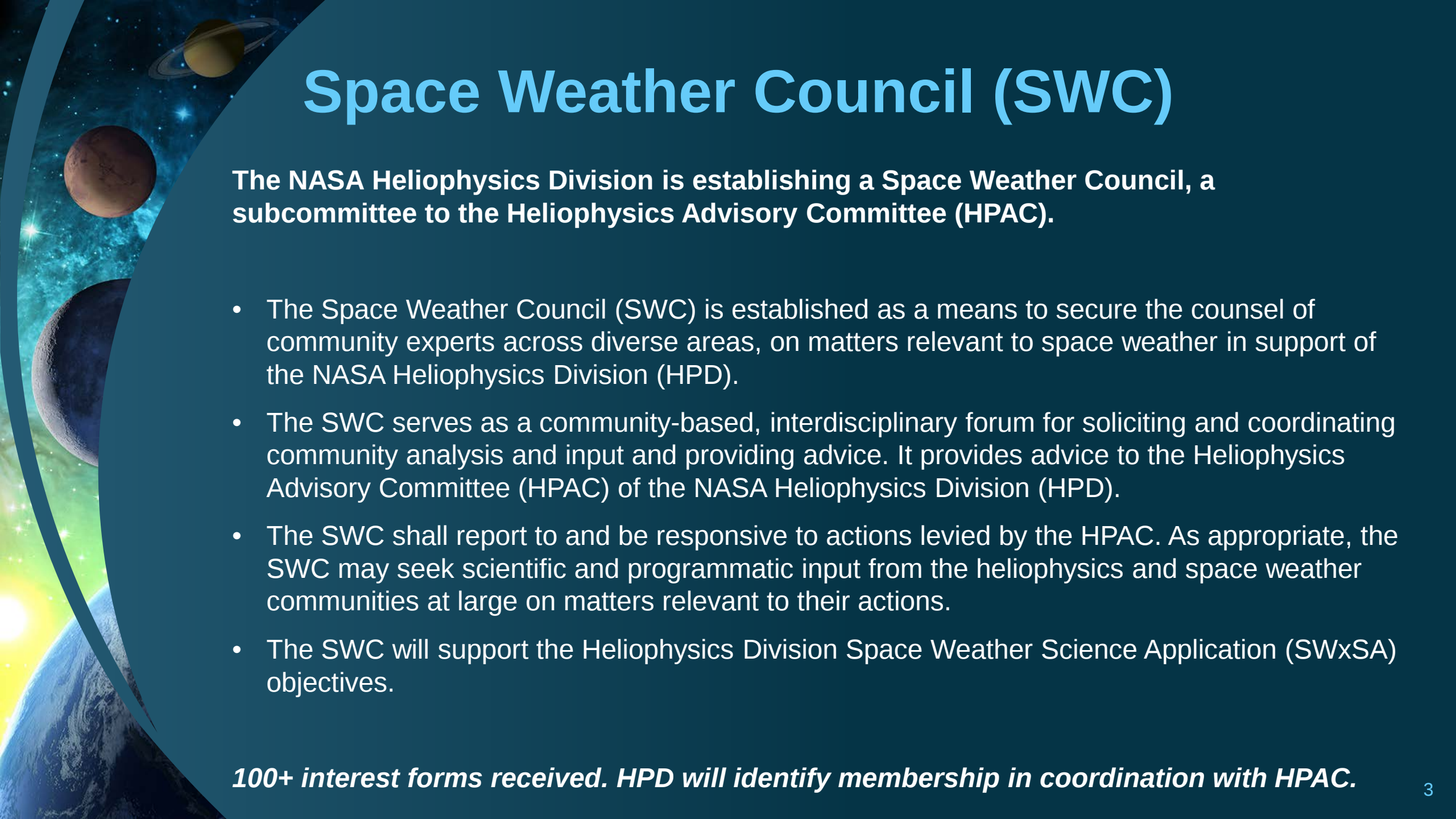
- Transition capabilities to operational environments

5. Support

- Support Robotic and Human Exploration

6. Partner

- Meet National, International, and societal needs consistent with Government directives

A dark blue background with a curved, abstract shape on the left side. Inside this shape, there are images of celestial bodies: a yellow planet with rings (Saturn) at the top, a reddish planet (Mars) below it, and a grey, cratered planet (the Moon) further down. The background is filled with stars and a nebula-like glow.

Space Weather Council (SWC)

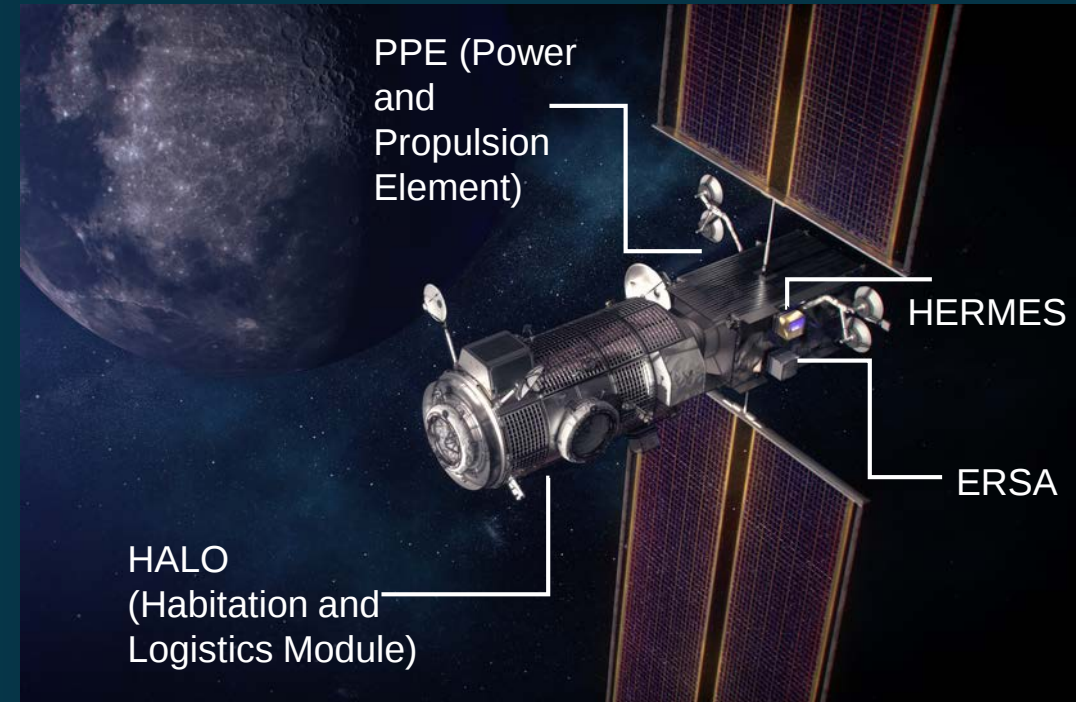
The NASA Heliophysics Division is establishing a Space Weather Council, a subcommittee to the Heliophysics Advisory Committee (HPAC).

- The Space Weather Council (SWC) is established as a means to secure the counsel of community experts across diverse areas, on matters relevant to space weather in support of the NASA Heliophysics Division (HPD).
- The SWC serves as a community-based, interdisciplinary forum for soliciting and coordinating community analysis and input and providing advice. It provides advice to the Heliophysics Advisory Committee (HPAC) of the NASA Heliophysics Division (HPD).
- The SWC shall report to and be responsive to actions levied by the HPAC. As appropriate, the SWC may seek scientific and programmatic input from the heliophysics and space weather communities at large on matters relevant to their actions.
- The SWC will support the Heliophysics Division Space Weather Science Application (SWxSA) objectives.

100+ interest forms received. HPD will identify membership in coordination with HPAC.

HERMES (Heliophysics Environmental and Radiation Measurement Experiment Suite)

- HERMES concentrates on understanding the causes of space-weather variability as driven by the Sun and modulated by the magnetosphere.
- In coordination with the Heliophysics two-spacecraft mission THEMIS/ARTEMIS already in lunar orbit, the Gateway observations will initiate a heliophysics lunar constellation to conduct science investigations into what drives change in our near-Earth space environment that have never before been possible.
- **Milestones**
 - Concept Reviews: Summer 2020
 - KDP-C: December 2020
 - Delivery to Maxar/NG: July 2022



HERMES (cont.)

HERMES Selection

- HPD was invited to develop a lunar space environment capability with Human Exploration & Operations Mission Directorate (HEOMD) to launch with the Power and Propulsion Element of Gateway Phase 1. The instrument package was to be delivered NLT Nov. 2021, an insufficient amount of time to do a traditional solicitation. HPD opted to take advantage of this opportunity and directed the task to Goddard. **However, only instrument procurement was directed – the science team for HERMES will be fully competed.**
- Moving forward, HPD fully intends to compete all future opportunities and to put ourselves in a position to be able to better take advantage of quick turnaround requests, like HERMES, with full community participation.

Request for Information (RFI) for Space Weather Instruments and Missions for Science (SWIMS)

- NASA HPD is seeking information under this RFI to assess community interest, concepts, and rough order of magnitude (ROM) cost for (1) small complete missions, (2) instrument suites, or (3) single instruments, that if flown in space would directly address space weather science and/or observational needs.
- The data collected through this RFI will be used by NASA to help inform future solicitations for instruments, instrument suites, or small complete missions that could be flown on secondary payload adapters or as hosted payloads on a satellite or other platform.

Due via NSPIRES by September 23rd, 2020



NASA Selects 5 MIDEX Proposals for New Space Environment Missions

HelioSwarm: The Nature of Turbulence in Space Plasmas

Determine the fundamental space physics processes that lead energy from large-scale motion to cascade down to finer scales of particle movement within the plasma that fills space, a process that leads to the heating of such plasma. **PI:** Harlan Spence at the University of New Hampshire in Durham.

Solaris: Revealing the Mysteries of the Sun's Poles

Solaris would observe three solar rotations over each solar pole to obtain observations of light, magnetic fields, and movement in the Sun's surface, the photosphere. **PI:** Donald Hassler at the Southwest Research Institute in Boulder, Colorado.

Solar-Terrestrial Observer for the Response of the Magnetosphere (STORM)

First-ever global view of our vast space weather system. **PI:** David Sibeck at GSFC in Greenbelt, Maryland.

Multi-slit Solar Explorer (MUSE)

Provide high-cadence observations of the mechanisms driving an array of processes and events in the corona. **PI:** Bart De Pontieu at Lockheed Martin in Palo Alto, California.

Auroral Reconstruction CubeSwarm (ARCS)

ARCS would explore the processes that contribute to aurora at size scales that have been rarely studied. **PI:** Kristina Lynch at Dartmouth University in Hanover, New Hampshire.

Each proposal will conduct a 9-month mission concept study. Following the study period, NASA will choose up to two proposals for launch.

Geospace Dynamics Constellation

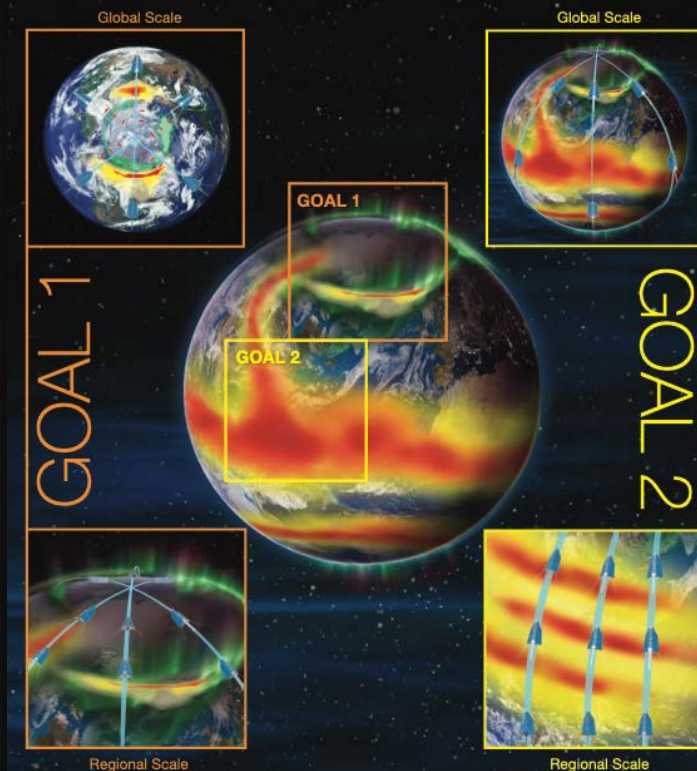
- GDC is a science mission to dramatically improve our understanding of the upper atmosphere and its strong variability in response to energy inputs from the Sun, from near-Earth space, and from the lower atmosphere.
- The Pre-Project Office completed a Mission Concept Review (July 2020).
- KDP-A completed Sep. 8, 2020.
- NASA will competitively solicit the science instrumentation through an AO.

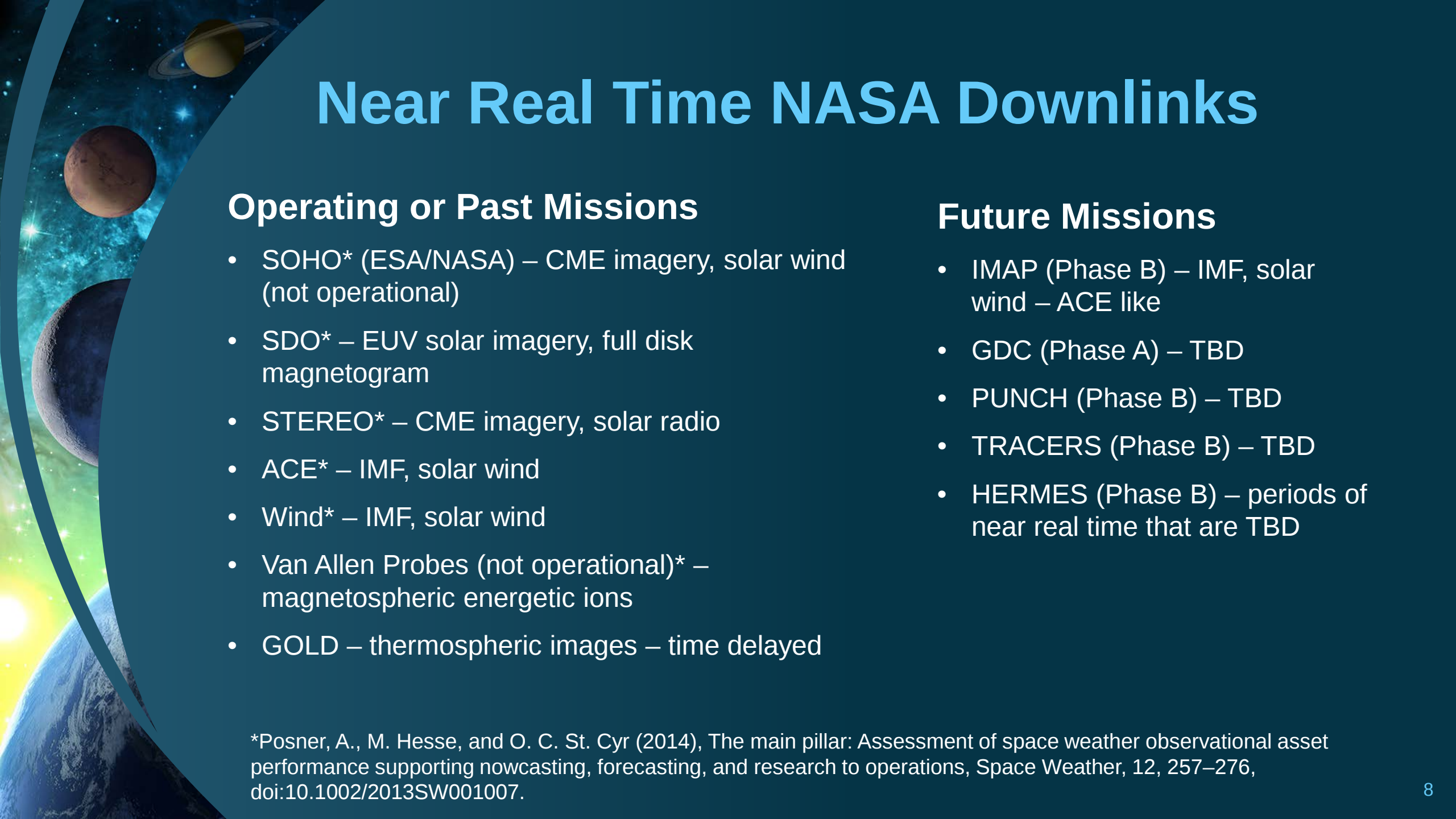
GDC Goal 1

Understand how the high latitude ionosphere-thermosphere system responds to variable solar wind/magnetosphere forcing.

GDC Goal 2

Understand how internal processes in the global ionosphere-thermosphere system redistribute mass, momentum, and energy.





Near Real Time NASA Downlinks

Operating or Past Missions

- SOHO* (ESA/NASA) – CME imagery, solar wind (not operational)
- SDO* – EUV solar imagery, full disk magnetogram
- STEREO* – CME imagery, solar radio
- ACE* – IMF, solar wind
- Wind* – IMF, solar wind
- Van Allen Probes (not operational)* – magnetospheric energetic ions
- GOLD – thermospheric images – time delayed

Future Missions

- IMAP (Phase B) – IMF, solar wind – ACE like
- GDC (Phase A) – TBD
- PUNCH (Phase B) – TBD
- TRACERS (Phase B) – TBD
- HERMES (Phase B) – periods of near real time that are TBD

*Posner, A., M. Hesse, and O. C. St. Cyr (2014), The main pillar: Assessment of space weather observational asset performance supporting nowcasting, forecasting, and research to operations, Space Weather, 12, 257–276, doi:10.1002/2013SW001007.

A space-themed background featuring a curved view of Earth's horizon at the bottom left, a bright yellow sun in the bottom left corner, and several celestial bodies in the dark blue space. These include a ringed planet (Saturn) at the top left, a reddish planet (Mars) in the upper middle, and a grey, cratered planet (the Moon) in the middle left. The background is filled with stars and nebulae.

International Collaborations

ESA L5 Mission

- ESA/NASA in discussions about providing a science instrument that complements the current payload and provides operational data as well as science data, as well as possible support for a sub-system.

CSA Arctic Observing Mission (AOM)

- The mission is proposed by Canada as an international collaboration to collect data on weather, greenhouse gases, air quality and space weather over the Arctic.
- The mission concept study for the AOM mission is led by Environment & Climate Change Canada (ECCC) and the Canadian Space Agency.
- CSA has expressed an interest in NASA ultimately supplying a dedicated space weather payload to the mission.
- HPD finds value participating in AOM because of the potential heliophysics investigations that are made possible with remote and in situ instruments from the AOM platform at high latitude and altitude

The background of the slide is a cosmic scene. The top half features a dark blue nebula with wispy, ethereal structures and several bright, multi-pointed stars. The bottom half is dominated by a vibrant orange and yellow nebula, also filled with numerous stars of varying brightness. A solid dark blue horizontal band runs across the middle of the image, serving as a backdrop for the central text.

BACKUP

1. Observe: Advance observation techniques, technology, and capability

- 1.1 Identify technologies and techniques for which enhanced or future investments would produce results that significantly and positively impact space weather understanding and prediction
- 1.2 Create opportunities to develop observation techniques and instrumentation
- 1.3 Establish and sustain recurrent flight cadence and supporting infrastructure opportunities for space weather instrumentation and missions
 - a. Develop and launch a NASA-led pathfinder mission that contributes significantly to the National space weather enterprise
- 1.4 Identify and implement the capability to ensure that real-time and latent data streams for space weather-relevant space observations are available

2. Analyze: Advance research, analysis and modeling capability

- 2.1 Identify analysis capabilities that would advance space weather understanding and prediction
- 2.2 Establish opportunities to support the develop improved data analysis and modeling capabilities
- 2.3 Work with NSF and other Federal agencies, and with international space agencies to advance research and analysis capabilities relevant to space weather

3. Predict: Improve space weather forecast and nowcast capabilities

- 3.1 Develop a structure and process that funnels basic research information to an applied focus
 - a. Create opportunities to use existing and past observations to develop improved forecast and nowcast capability
 - b. Create opportunities for the scientific community and the GSFC Community Coordinated Modeling Center to test and validate forecast and nowcast models that show promise for operational environments
 - c. Periodically assess the opportunity to capture new discoveries into forecasting and nowcasting models

4. Transition: Transition capabilities to operational environments

- 4.1 Create a pipeline that conveys the results and outputs of the NASA Heliophysics research and technology programs to a space weather proving ground environment where models and techniques are assessed
- 4.2 In coordination with NOAA, establish a testbed capability to transition forecasting and nowcasting models (SWPC) and transition observations and data streams (NESDIS)
- 4.3 Establish formal relationships between NASA and DoD, and with international space agencies, to exchange data and observation capabilities, and effectively transition data, improved forecasting and nowcasting capabilities, and improved observation techniques

5. Support: Support Robotic and Human Exploration

- 5.1 Advance the partnership between the Heliophysics Division and 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
 - a. Develop Earth-independent observational and model assessment capabilities needed for on-board space environment forecasting on long-duration crewed missions
 - b. Identify opportunities to manifest space observation capability to improve forecasting of space environment in support of space exploration
 - i. Deliver Gateway HERMES payload and establish a Science Operation Center
 - ii. Establish a competed HERMES science team to conduct science investigations
- 5.2 Provide key real-time data streams to the Agency for forecasting, nowcasting, and anomaly resolution for robotic and crewed missions

6. Partner: Meet National and International needs consistent with U.S. Government directives

- 6.1 Secure the counsel of space weather expertise within the government, academia, commercial and private sector
 - a. Seek advice of the NASA Heliophysics Advisory Committee (HPAC) on matters relevant to space weather
 - b. Secure the results of a NASA focused gap analysis of space weather knowledge, observational and data capability, and forecasting and nowcasting capability
 - c. Engage NASEM on matters relevant to space weather
- 6.2 Provide key real-time data streams to sister agencies for forecasting, nowcasting, and anomaly resolution
- 6.3 Continue active participation at the Executive level with OSTP
 - a. Partner with other Federal Agencies to achieve the objectives of the National Space Weather Strategy and Action plan
- 6.4 Represent the U.S. in international space weather research fora to advance the global capability and enhance U.S. ability to meet its space weather needs
 - a. Provide leadership to the UN COPUOS space weather activities
 - b. Partner with international agencies to further the capability of space weather forecasting/nowcasting
 - i. Coordinate with ESA for NASA participation in the Lagrange Mission
 - ii. Coordinate with CSA for NASA participation in the Arctic Observation Mission
 - iii. Coordinate with other space agencies as the opportunity arises and is appropriate, to include the establishment of an International Agency Space Weather Coordination Group

SWxSA Strategy by Goal			
Theme	Goal	Objective	
1. Observe	Advance observation techniques, technology, and capability	1.1	Identify technologies and techniques for which enhanced or future investments would produce results that significantly and positively impact space weather understanding and prediction
		1.2	Create opportunities to develop observation techniques and instrumentation
		1.3	Establish and sustain recurrent flight cadence and supporting infrastructure opportunities for space weather instrumentation and missions
		1.4	Identify and implement the capability to ensure that real-time and latent data streams for space weather-relevant space observations are available
2. Analyze	Advance research, analysis and modeling capability	2.1	Identify analysis capabilities that advance space weather understanding and prediction
		2.2	Establish opportunities to support the develop improved data analysis and modeling capabilities
		2.3	Work with NSF and other Federal agencies to advance research and analysis capabilities relevant to space weather
3. Predict	Improve space weather forecast and nowcast capabilities	3.1	Develop a structure and process that funnels basic research information to an applied focus
4. Transition	Transition capabilities to operational environments	4.1	Create a pipeline that conveys the results and outputs of the NASA Heliophysics research and technology programs to a space weather proving ground environment where models and techniques are assessed
		4.2	In coordination with NOAA, establish a testbed capability to transition forecasting and nowcasting models (SWPC) and transition observations and data streams (NESDIS).
		4.3	Establish formal relationships between NASA and DoD to exchange data and observation capabilities, and effectively transition data, improved forecasting and nowcasting capabilities, and improved observation techniques.
5. Support	Support Robotic and Human Exploration	5.1	Advance the partnership between the Heliophysics Division and 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
		5.2	Provide key real-time data streams to the Agency for forecasting, nowcasting, and anomaly resolution for robotic and crewed missions
6. Partner	Meet National, International, and societal needs consistent with Government directives	6.1	Secure the counsel of space weather expertise within the government, academia, commercial and private sector
		6.2	Provide key real-time data streams to sister agencies for forecasting, nowcasting, and anomaly resolution
		6.3	Continue active participation at the Executive level with OSTP
		6.4	Represent the U.S. in international space weather research fora to advance the global capability and enhance U.S. ability to meet its space weather needs

The background of the slide is a composite of two cosmic images. The top half features a dark blue and black space scene with a prominent, glowing blue nebula on the right side and several bright stars. The bottom half shows a vibrant orange and yellow nebula on the left, transitioning into a greenish-blue nebula on the right, with numerous stars scattered throughout.

SPACE WEATHER COUNCIL

The background of the slide is a composite of two cosmic images. The top half features a dark blue and black space scene with a bright, glowing blue nebula on the right side and several distant stars. The bottom half shows a vibrant orange and yellow nebula on the left, transitioning into a greenish-blue nebula on the right, with numerous stars scattered throughout.

SPACE WEATHER RFI

The background of the slide is a composite of two cosmic images. The top half features a dark blue and black space scene with a bright, wispy blue nebula on the right and several sharp, bright stars. The bottom half shows a vibrant orange and yellow nebula on the left, transitioning into a greenish-blue area on the right, also filled with numerous stars.

CROSS-REFERENCE WITH 2019 NSW-SAP & 2013 DECADAL

Heliophysics Space Weather Strategy				2019 National Space Weather Strategy and Action Plan (NSW-SAP)	2013 Decadal Survey for Solar and Space Physics / 2020 Midterm Assessment	
	Theme	Goal	Objective	Objective	Reference	
1	Observe	Advance observation techniques, technology, and capability	1.1	Identify technologies and techniques for which enhanced or future investments would produce results that significantly and positively impact space weather understanding and prediction	1.1, 2.1, 2.4, 2.8, 2.10	Table 4.2, recommendation 2.3; Chapter 7, p. 140, New Elements, Midterm R4.1
			1.2	Create opportunities to develop observation techniques and instrumentation	2.3, 2.4, 2.5, 2.6, 2.7, 2.8	Table 4.2, recommendation 2.3; Chapter 7, p. 140, New Elements
			1.3	Establish and sustain recurrent flight cadence and supporting infrastructure opportunities for space weather instrumentation and missions	2.2, 2.8	Table 4.2, recommendation 2.3; Chapter 7, p. 140, New Elements, Midterm R3.4
			a.	Develop and launch a NASA-led pathfinder mission that contributes significantly to the National space weather enterprise	2.2, 2.8	Table 4.2, recommendation 2.3; Chapter 7, p. 140, New Elements
			1.4	Identify and implement the capability to ensure that real-time and latent data streams for space weather-relevant space observations are available	2.2, 2.8	Table 4.2, recommendation 2.3; Chapter 7, p. 140, New Elements
2	Analyze	Advance research, analysis and modeling capability	2.1	Identify analysis capabilities that advance space weather understanding and prediction	1.1, 2.1, 2.4, 2.8, 2.10	Table 4.2, recommendation 2.5; Chapter 7, p. 140, New Elements, Midterm R4.1
			2.2	Establish opportunities to support the develop improved data analysis and modeling capabilities	2.3, 2.4, 2.5, 2.6, 2.7, 2.8	Table 4.2, recommendation 2.5; Chapter 7, p. 140, New Elements
			2.3	Work with NSF and other Federal agencies to advance research and analysis capabilities relevant to space weather	2.3, 2.3, 2.5, 2.7, 2.8	Table 4.2, recommendation 2.0, 2.5; Chapter 7, p. 140, New Elements, Midterm 4.1
3	Predict	Improve space weather forecast and nowcast capabilities	3.1	Develop a structure and process that funnels basic research information to an applied focus	2.3, 2.3, 2.5, 2.7, 2.8	Table 4.2, recommendation 2.3, 2.5; Chapter 7, p. 140, New Elements, Midterm R4.1
			a.	Create opportunities to use existing and past observations to develop improved forecast and nowcast capability	2.5, 2.6, 2.7	Table 4.2, recommendation 2.3, 2.5; Chapter 7, p. 140, New Elements
			b.	Create opportunities for the scientific community and the GSFC Community Coordinated Modeling Center to test and validate forecast and nowcast models that show promise for operational environments	1.3, 1.6, 2.2, 2.7, 2.8, 2.9, 2.10, 3.2, 3.3	Table 4.2, recommendation 2.3, 2.4, 2.5; Chapter 7, p. 140, New Elements, Midterm R4.1
			c.	Periodically assess the opportunity to capture new discoveries into forecasting and nowcasting models	1.1, 1.6, 1.8, 2.1, 2.4, 2.6, 2.8, 2.10	Table 4.2, recommendation 1.0, 2.3

Heliophysics Space Weather Strategy				2019 National Space Weather Strategy and Action Plan (NSW-SAP)	2013 Decadal Survey for Solar and Space Physics / 2020 Midterm Assessment
	Theme	Goal	Objective	Objective	Reference
4	Transition	Transition capabilities to operational environments	4.1 Create a pipeline that conveys the results and outputs of the NASA Heliophysics research and technology programs to a space weather proving ground environment where models and techniques are assessed	1.3, 1.6, 2.2, 2.3, 2.5, 2.7, 2.8, 2.9, 2.10, 3.2, 3.3,	Table 4.2, recommendation 2.4, 2.5; Chapter 7, p. 140, New Elements, Midterm R4.1
			4.2 In coordination with NOAA, establish a testbed capability to transition forecasting and nowcasting models (SWPC) and transition observations and data streams (NESDIS).	2.2, 2.3, 2.5, 2.7, 2.8	Table 4.2, recommendation 2.0, 2.4, 2.5; Chapter 7, p. 140, New Elements, Midterm R4.1
			4.3 Establish formal relationships between NASA and DoD to exchange data and observation capabilities, and effectively transition data, improved forecasting and nowcasting capabilities, and improved observation techniques.	2.8, 2.9	Table 4.2, recommendation 2.0, 2.4, 2.5; Chapter 7, p. 140, New Elements, Midterm R4.1
5	Support	Support Robotic and Human Exploration	5.1 Advance the partnership between the Heliophysics Division and 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	2.5, 2.9,	Table 4.2, recommendation 2.0, 2.5
			a. Develop Earth-independent observational and model assessment capabilities needed for on-board space environment forecasting on long-duration crewed missions	1.3, 1.6, 2.2, 1.3, 2.7, 2.8, 2.9, 2.10, 3.2, 3.3	Table 4.2, recommendation 2.5; Chapter 7, p. 140, New Elements
			b. Identify opportunities to manifest space observation capability to improve forecasting of space environment in support of space exploration	2.2, 2.11	Table 4.2, recommendation 2.3; Chapter 7, p. 140, New Elements
			i. Deliver Gateway HERMES payload and establish a Science Operation Center	2.2, 2.8, 2.9, 2.10	Table 4.2, recommendation 2.3; Chapter 7, p. 140, New Elements
			ii. Establish a competed HERMES science team to conduct science investigations	2.2, 2.8, 2.9, 2.10	Table 4.2, recommendation 2.5; Chapter 7, p. 140, New Elements
			5.2 Provide key real-time data streams to the Agency for forecasting, nowcasting, and anomaly resolution for robotic and crewed missions	2.2, 2.8, 2.9, 2.10	Table 4.2, recommendation 2.3, 2.5; Chapter 7, p. 140, New Elements

Heliophysics Space Weather Strategy				2019 National Space Weather Strategy and Action Plan (NSW-SAP)	2013 Decadal Survey for Solar and Space Physics / 2020 Midterm Assessment
	Theme	Goal	Objective	Objective	Reference
6	Partner	Meet National, International, and societal needs consistent with Government directives	6.1 Secure the counsel of space weather expertise within the government, academia, commercial and private sector	NSW-SAP	Table 4.2, recommendation 1.0
			a. Seek advice of the NASA Heliophysics Advisory Committee (HPAC) on matters relevant to space weather	1.1, 1.6, 1.8, 2.1, 2.4, 2.6, 2.8, 2.10	Table 4.2, recommendation 1.0
			b. Secure the results of a NASA focused gap analysis of space weather knowledge, observational and data capability, and forecasting and nowcasting capability	1.1, 2.1, 2.4, 2.8, 2.10	Table 4.2, recommendation 1.0, 2.5, Midterm R4.1
			c. Engage NASEM on matters relevant to space weather	1.1, 1.2	Midterm R4.1
			6.2 Provide key real-time data streams to sister agencies for forecasting, nowcasting, and anomaly resolution	2.2, 2.8	Table 4.2, recommendation 2.3; Chapter 7, p. 140, New Elements
			6.3 Continue active participation at the Executive level with OSTP	NSW-SAP	Table 4.2, recommendation 2.0; Chapter 7, p. 140, New Elements
			a. Partner with other Federal Agencies to achieve the objectives of the National Space Weather Strategy and Action plan	NSW-SAP	Table 4.2, recommendation 1.0, 2.0; Chapter 7, p. 140, New Elements, Midterm R4.1
			6.4 Represent the U.S. in international space weather research fora to advance the global capability and enhance U.S. ability to meet its space weather needs	2.10	Table 4.2, recommendation 2.0
			a. Provide leadership to the UN COPUOS space weather activities	2.10	Table 4.2, recommendation 2.0
			b. Partner with international agencies to further the capability of space weather forecasting/nowcasting	2.10	Table 4.2, recommendation 2.5; Chapter 7, p. 140, New Elements
			i. Coordinate with ESA for NASA participation in the Lagrange mission	2.10	Table 4.2, recommendation 2.3; Chapter 7, p. 140, New Elements
			ii. Coordinate with CSA for NASA participation in the Arctic Observation Mission	2.10	Table 4.2, recommendation 2.3; Chapter 7, p. 140, New Elements
			iii. Coordinate with other space agencies as the opportunity arises and is appropriate, to include the establishment of an International Agency Space Weather Coordination Group	2.10	Table 4.2, recommendation 2.0