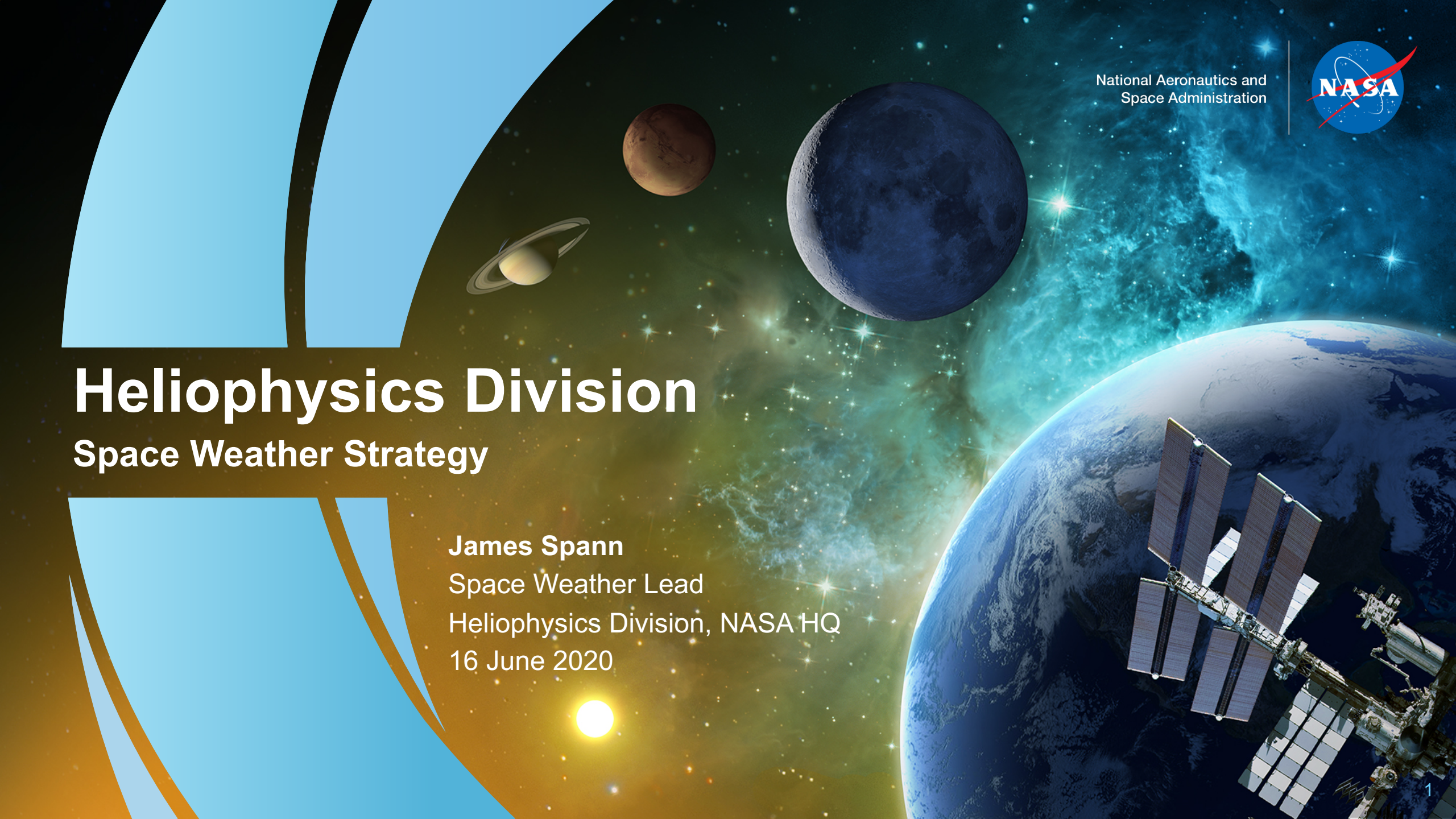
National Aeronautics and Space Administration



Heliophysics Division

Space Weather Strategy

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Heliophysics Space Weather Strategy

This strategy outlines the goals and objectives of NASA Heliophysics Division with respect to space weather. It is consistent with the goals and Agency responsibilities articulated in the 2019 National Space Weather Strategy and Action Plan, as well as the Agency's efforts in human and robotic exploration.

Context

- Understanding space weather is the domain of Heliophysics. Space weather is the applied expression of Heliophysics. In Priority 1 of the 2020 NASA Science Plan, Strategy 1.4 pertains directly to space weather:
  - *Develop a Directorate-wide, target-user focused approach to applied programs, including Earth Science Applications, Space Weather, Planetary Defense, and Space Situational Awareness.*

Heliophysics 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.

Goals

- NASA plays a vital role in space weather research by providing unique, significant, and exploratory observations and data streams for theory, modeling, and data analysis research, and for operations.
- NASA's contributions to observing and understanding space weather are critical for the success of the National and International space weather enterprise.
- NASA has a preeminent space weather capability through the pursuit of the following goals:

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

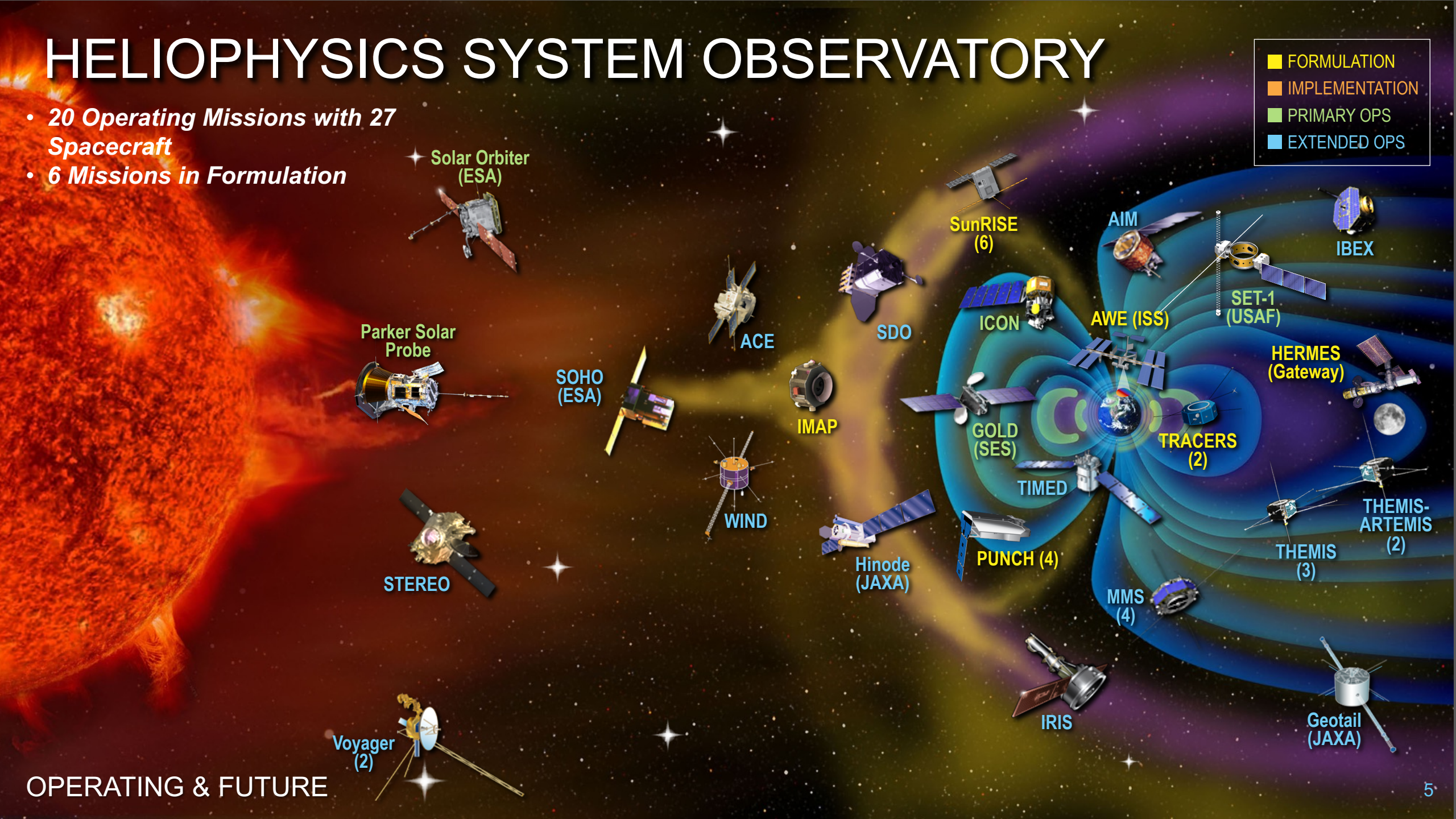
- Support Robotic and Human Exploration

6. Partner

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

HELIOPHYSICS SYSTEM OBSERVATORY

- *20 Operating Missions with 27 Spacecraft*
- *6 Missions in Formulation*



OPERATING & FUTURE

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 development of 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 capabilities 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

Next Steps

- Establish a Space Weather Council as a subcommittee to HPAC
- Release the Request for Information (RFI) for Space Weather Instruments and Missions for Science (SWIMS)
- Develop a space weather implementation plan
- Establish a NASA SWxSA team to serve as a sounding board and implementation team
- Conduct a space weather science and measurement gap analysis

BACKUP

SPACE WEATHER COUNCIL

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.

SPACE WEATHER RFI

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

- NASA HPD is seeking information under this Request for Information (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.
- These could be flown as secondary payloads integrated onto Evolved Expendable Launch Vehicle Secondary Payload Adapter (ESPA) rings or as an instrument or an instrument suite as a hosted payload on a satellite or other platform.
- Any of these options may be exercised as future Science Mission Directorate (SMD) Heliophysics missions or payloads.
- **Release Date:**
- **Responses Due:**
- **Next Steps:**

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 Assessent
	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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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 Assessent
	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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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 Assessent
	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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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, 6 bullets in 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