EXPLORESCIENCE

NASA Program of Record, (Pre-)Formulation Activities

Decadal Survey Supplemental Presentation

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Introduction

This input to the Decadal Survey presents high-level information on the current state of the Program of Record, as applicable to NASA. The intent of these slides is to assist the Committee in the beginning of their deliberations, and NASA welcomes the opportunity to speak further to the Committee on this topic.

For the purpose of the Decadal Survey, the Program of Record is those activities which will continue as planned through the next decade in the absence of recommendations from the Decadal Survey to make changes.

Overview

- Heliophysics Division Programs
  - Decadal Survey Supplemental Presentations with relevant information
- Space Flight Projects
  - Extended operations
    - Heliophysics System Observatory Infrastructure
  - In development, prime operations
  - Pre-formulation activities

Programs

- Heliophysics Research
  - Described in the *Research and Analysis Decadal Survey Supplemental Presentation*
- Heliophysics Technology
  - Funded as a separate program in FY21 NASA appropriations
  - Described in the *Technology Decadal Survey Supplemental Presentation*
- Space Weather
  - Identified as a separate program in FY23 President's Budget Request
- Heliophysics Explorers
- Solar Terrestrial Probes
- Living With a Star

Spaceflight Projects (Extended Operations)

Extended Mission Paradigm

- At the end of a mission's prime Phase E, many Heliophysics Division missions begin an extended Phase E ("extended mission")
  - Three-year cycle of reviews for continued operations
    - SMD refers to this process as "Senior Review"
  - Extended mission budgets decrease relative to prime Phase E
    - *Budget Decadal Survey Supplemental Presentation* contains additional details on extended mission budgets

- The 2020 Heliophysics Senior Review made some changes to improve the Senior Review process and operating mission management
  - Focused Senior Review requirements on mission work funded by NASA
    - Replaced Prioritized Science Goals with mission-completed Science Objectives
    - Removed missions' responsibility for community work outside of the mission funding
    - More clearly separated scientific merit of the proposed mission science and the benefit of the mission's measurements to the HSO
  - Levied requirements on mission data documentation and archiving
  - Created "Heliophysics System Observatory (HSO) Infrastructure" [next slide]

HSO Infrastructure

Due to the nature of the heliophysics missions and of heliophysics science, there is a significant benefit to extended mission operations to maintain key measurement capabilities. However, long-lived missions may have difficulty maintaining a sufficiently compelling science investigation to justify continued science operations, and full science operations may not be supportable within the Division budgetary constraints.

To account for these conditions, the Division created a category of extended mission operations called “HSO Infrastructure”. These missions continue their operations as an extended mission, but do not receive NASA funding to execute a scientific research plan. They only receive funding necessary to continue operations and associated activities (e.g., data validation, archiving).

If a mission transitions to HSO Infrastructure, the mission continues operations as part of the HSO but is taken out of the Senior Review cycle. Instead of Senior Review, HSO Infrastructure missions undergo a programmatic review on the same cycle. This review is streamlined relative to Senior Review and focuses on the spacecraft health, continuing value of the measurement capabilities, and other programmatic factors (e.g., budgetary constraints).

Spaceflight Projects (Ext. Mission) [1]

Program	Name [Link]	Mission Phase (Current)	Mission Phase (Jan. 2024, *est.*)	End of Prime Phase E	Lead Agency
Explorers	ACE*	Phase E (Ext.)	Phase E (Ext.)	May 1, 1998	NASA
Explorers	AIM	Phase E (Ext.)	Phase E (Ext.)	Jun. 30, 2009	NASA
Explorers	GOLD	Phase E (Ext.)	Phase E (Ext.)	Oct. 20, 2018	NASA
Explorers	IBEX	Phase E (Ext.)	Phase E (Ext.)	Nov. 19, 2008	NASA
Explorers	ICON	Phase E (Ext.)	Phase E (Ext)	Dec. 15, 2021	NASA
Explorers	IRIS	Phase E (Ext.)	Phase E (Ext.)	Jul. 26, 2013	NASA
Explorers	THEMIS ARTEMIS	Phase E (Ext.)	Phase E (Ext.)	Sep. 30, 2009	NASA

* Heliophysics System Observatory Infrastructure

Spaceflight Projects (Ext. Mission) [2]

Program	Name [Link]	Mission Phase (Current)	Mission Phase (Jan. 2024, *est.*)	End of Prime Phase E	Lead Agency
Heliophysics Research	Geotail*	Phase F	[Terminated]	Jul. 24, 1992	JAXA
Heliophysics Research	Voyager 1&2	Phase E (Ext.)	Phase E (Ext.)	Aug. 25, 1981	NASA
Heliophysics Research	WIND*	Phase E (Ext.)	Phase E (Ext.)	Jan. 1, 1997	NASA
LWS	SDO	Phase E (Ext.)	Phase E (Ext.)	May 10, 2015	NASA
STP	Hinode	Phase E (Ext.)	Phase E (Ext.)	Nov. 23, 2009	JAXA
STP	MMS	Phase E (Ext.)	Phase E (Ext.)	Sep. 1, 2017	NASA
STP	STEREO	Phase E (Ext.)	Phase E (Ext.)	Jan. 22, 2009	NASA

* Heliophysics System Observatory Infrastructure

Spaceflight Projects (Ext. Mission) [3]

Program	Name [Link]	Mission Phase (Current)	Mission Phase (Jan. 2024, *est.*)	End of Prime Phase E	Lead Agency
STP	SOHO*	Phase E (Ext.)	Phase E (Ext.)	Jun. 1, 1998	ESA
STP	TIMED	Phase E (Ext.)	Phase E (Ext.)	Jan. 20, 2004	NASA

* Heliophysics System Observatory Infrastructure

Spaceflight Projects
(In Development, Prime Operations)

Spaceflight Projects (Prime Phase E/F)

Program	Name [Link]	Mission Phase (Current)	Mission Phase (Jan. 2024, *est.*)	End of Prime Phase E	Lead Agency
LWS	Parker Solar Probe	Phase E	Phase E	Aug. 2025	NASA
LWS	Solar Orbiter	Phase E	Phase E	Q1/2 2028	ESA

Spaceflight Projects (Development) [1]

Program	Name [Link]	Mission Phase (Current)	Mission Phase (Jan. 2024, *est.*)	End of Prime Phase E (*est.*)	Lead Agency
Explorers	AWE	Phase C	Phase E	Aug. 2025	NASA
Explorers	EUVST	Phase B	Phase C/D	Dec. 2028	JAXA
Explorers	ESCAPADE	Phase C	Phase D	Mar. 2027	NASA
Explorers	EZIE	Phase C	Phase D	Jun. 2026	NASA
Explorers	HelioSwarm	Phase B	Phase C/D	Q4 2030	NASA
Explorers	MUSE	Phase B	Phase C/D	Q2 2029	NASA
Explorers	PUNCH	Phase C	Phase D	Oct. 2026	NASA

Spaceflight Projects (Development) [2]

Program	Name [Link]	Mission Phase (Current)	Mission Phase (Jan. 2024, *est.*)	End of Prime Phase E (*est.*)	Lead Agency
Explorers	SunRISE	Phase C	Phase D	Sep. 2026	NASA
Explorers	TRACERS	Phase C	Phase D	Jul. 2027	NASA
LWS	GDC	Phase A	Phase A/B	2032	NASA
LWS	HERMES	Phase C	Phase D	Jul. 2026	NASA
STP	GLIDE	Phase C	Phase D	Feb. 2027	NASA
STP	IMAP	Phase C	Phase D	Feb. 2027	NASA

Spaceflight Projects (Pre-Formulation)

Pre-Formulation Activities

These projects are in pre-formulation. As such, NASA is in a planning phase and has not committed to any project listed below. The scope and supporting details are provided for planning use only. [These slides contain only high-level information, but NASA will provide additional information that is useful to the Decadal Survey Committee.]

In the absence of any recommendations from the 2024 Decadal Survey, NASA expects to proceed with pre-formulation activities and determine whether to move into formulation (i.e. enter Phase A) based upon programmatic discussions and priorities.

Unless recommended otherwise, the Decadal Survey is expected to include the anticipated budget requirements into its recommended budget profile. If an activity does not lead to project formulation, NASA expects any available budget to be assigned according to the Decadal Survey priorities and decision rules.

DYNAMIC

Full name: Dynamical Neutral Atmosphere-Ionosphere Coupling

Summary

- DYNAMIC was recommended as a stand-alone mission in the 2013 Solar and Space Physics Decadal Survey, as the decade's second Solar Terrestrial Probes mission.
- NASA released draft plans for the DYNAMIC acquisition strategy via the SOMA Homepage (October 2021). NASA began pre-formulation for DYNAMIC as a small-spacecraft mission that would leverage concurrent Geospace Dynamics Constellation (GDC) measurements.
- On June 13, 2022, NASA delayed the release of a DYNAMIC draft AO.

Current state: Pre-formulation (pre-Phase A)

Schedule:

- AO release currently scheduled for FY23
- Prime science operations planned to overlap with Geospace Dynamics Constellation

Cost: $250M (FY23), pending budget availability

Webpage(s)

- NASA Acquisition Homepage

ENLoTIS

Full name: ESA-NASA Lower Thermosphere-Ionosphere Science

Summary

- ENLoTIS is an agency cooperation on potential future lower thermosphere-ionosphere satellite mission concepts, targeting studies of neutral-ion interactions and related science topics with *in situ* sampling of geophysical parameters (neutrals, plasma, fields, energetic particles). The specific altitude region of interest sits at the interface between Earth and Space, in the 100-200 km altitude range and capturing the ionospheric E-region.

Current state

- Working group developing science objectives and high-level observation requirements
- Further pre-formulation efforts to follow the initial working group report

NASA contribution

- Current support for the ENLoTIS Working Group (initial report on science objectives and high-level observational requirements).
- Potential future contribution to joint mission

Schedule: LRD NET 2028

Cost: Not yet specified, not expected to exceed $250M (FY23)

Webpage(s)

- ENLoTIS Working Group

Orbital Debris Mission (SSA/OD)

Full name: Not yet named

Summary

- Planned by HPD to address science objectives in low Earth Orbit related to the presence of neutral dust, small debris, and other space objectives in this “Space Working Environment”
- Mission is expected to address SSA/OD-generated signatures in the near-Earth plasma and potential tracers for space weather effects

Current State

- HPD has conducted small internal studies on the scope of potential SSA/OD science investigations, and has completed a mission concept study to identify driving mission requirements and constraints, and an enabling budget profile.
- Early pre-formulation underway, planned under the Space Weather Program

Schedule: LRD NET 2028

Cost: Not yet specified, not expected to exceed MIDEX-class

Webpage(s)

- Not yet established

Vigil

Full name: Vigil

Summary

- A Space Weather observatory mission lead by the European Space Agency. It will be the first satellite in orbit around the Sun-Earth L5. A primary endpoint of observations will be increasing the fidelity of current CME accelerations and energy measurements. The spacecraft will stream a constant feed of near real-time data on potentially hazardous solar activity, before it rolls into view from Earth.

Current state

- NASA community planning information released as public announcement.

NASA contribution: EUV imager (expected), downlink support (potential)

Schedule: LRD NET 2028

Cost: Not yet specified, expected <$40M (FY22)

Webpage(s)

- ESA public announcements: Overview, Space Safety

AOM

Full name: Arctic Observing Mission

Summary

- As currently conceived, the AOM is an international operational mission composed of dual satellite mission in HEO orbits. The mission would focus on greenhouse gases and air quality, but would include a space weather instrument suite for space weather activities. Observations and analysis would focus on the high-latitude/polar region over North America.
- NASA intends to support research activities as part of its participation.

Current state:

- AOM is under consideration by the Government of Canada for implementation with international partners.

NASA contribution: TBD

Schedule: TBD

Cost: TBD

Webpage(s)

- CSA public announcements: Overview, Tender Notice

2013 Decadal Survey Recommended Missions

Explorers

2013 Decadal Recommendation:

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.

NASA Implementation: NASA accelerated the rate of solicitations and expanded the Explorers program to include contributions to international missions (EUVST) and to broaden the scope of heliophysics research (ESCAPADE). Further, NASA extended the Missions of Opportunity call to the Solar Terrestrial Probes program (GLIDE).

Projects [LRD, Agency Baseline Commitment]

EZIE [Jun. 2024]
TRACERS [Nov. 2025]
HelioSwarm [Q4 2028]
EUVST [Dec. 2026]
SunRISE [Sept. 2025]
GLIDE (STP) [Dec. 2025]
MUSE [Q2 2027]
PUNCH [April 2025]
AWE [Dec. 2023]
ESCAPADE [Oct. 2024]

IMAP

Full name: Interstellar Mapping and Acceleration Probe

Summary

- IMAP was recommended by the 2013 Decadal Survey as the decade's first Solar Terrestrial Probes mission
- NASA solicited a stand-alone investigation to address a preponderance of the science objectives identified in the 2013 Decadal Survey.
- AO released in 2017, selection announced in 2018

Current state:

- Phase C (confirmed in July 2021)

Schedule

- Launch planned for early 2025

Webpage(s)

- IMAP homepage at Princeton University
- IMAP blog at NASA

DYNAMIC

Full name: Dynamical Neutral Atmosphere-Ionosphere Coupling

Summary

- DYNAMIC was recommended by the 2013 Decadal Survey as the decade's second Solar Terrestrial Probes mission. The recommendation was for a stand-alone mission.
- NASA released draft plans for the DYNAMIC acquisition strategy via the SOMA Homepage (October 2021). NASA began pre-formulation for DYNAMIC as a small-spacecraft mission that would leverage concurrent Geospace Dynamics Constellation (GDC) measurements.
- On June 13, 2022, NASA delayed the release of a DYNAMIC draft AO.

Current state: Pre-formulation (pre-Phase A)

Schedule:

- AO release currently scheduled for FY23
- Prime science operations planned to overlap with Geospace Dynamics Constellation

Webpage(s)

- NASA Acquisition Homepage

This slide repeats information from the previous section.

GDC

Full name: Geospace Dynamics Constellation

Summary

- GDC was recommended by the 2013 Decadal Survey as the next Living With a Star (LWS) mission.
- NASA convened a Science and Technology Definition Team (STDT) to refine and update the decadal recommendations. The report was delivered in October 2019.
- NASA directed project management to NASA Goddard Space Flight Center, under the direct management of the LWS Program Office.
- GDC science team selections began in November 2021
  - Interdisciplinary Scientists: November 2021
  - Three investigations (w/ instruments): April 2022
  - Two investigations (w/ instruments): April 2022 (Competitive Phase A), down-selection planned in December 2022

Current state: Phase A (passed KDP A in September 2020)

Schedule: Launch planned no earlier than 2029

Webpage(s)

- GDC blog at NASA

End

Acronyms

Acronym	Full Name
ACE	Advanced Composition Explorer
AIM	Aeronomy of Ice in the Mesosphere
AOM	Artic Observing Mission
AWE	Atmospheric Waves Experiment
CUPID	Cusp Plasma Imaging Detector
DYNAMIC	Dynamical Neutral Atmosphere-Ionosphere Coupling
ENLoTIS	ESA-NASA Lower Thermosphere-Ionosphere Science
ESCAPADE	Escape, Plasma, Acceleration and Dynamics Explorers
EUVST	Extreme Ultraviolet High-Throughput Spectroscopic Telescope Epsilon Mission
EZIE	Electrojet Zeeman Imaging Explorer
GDC	Geospace Dynamics Constellation
GLIDE	Global Lyman-alpha Imager of the Dynamic Exosphere
GOLD	Global-scale Observations of the Limb and Disk
HERMES	Heliophysics Environmental and Radiation Measurement Suite

Acronyms

Acronym	Full Name
HSO	Heliophysics System Observatory
IBEX	The Interstellar Boundary Explorer
ICON	Ionospheric Connection Explorer
IMAP	Interstellar Mapping and Acceleration Probe
IRIS	Interface Region Imaging Spectrograph
LWS	Living With a Star
MMS	The Magnetospheric Multiscale Mission
MUSE	Multi-Slit Solar Explorer
PUNCH	Polarimeter to Unify the Corona and Heliosphere
SDO	The Solar Dynamics Observatory
SET	The Space Environment Testbeds
SOHO	Solar & Heliospheric Observatory
SSA/OD	Space Situational Awareness/Orbital Debris
STEREO	Solar Terrestrial Relations Observatory

Acronyms

Acronym	Full Name
STP	Solar Terrestrial Probes
SunRISE	Sun Radio Interferometer Space Experiment
THEMIS	Time History of Events and Macroscale Interactions during Substorms
TIMED	Thermosphere Ionosphere Mesosphere Energetics and Dynamics
TRACERS	Tandem Reconnection and Cusp Electrodynamics Reconnaissance Satellites