The Heliophysics 2050 Workshop & Preparation for the Upcoming Decadal Survey

GEM 2021 Virtual Summer Workshop Plenary Session

Monday, July 25, 2021

Moderated by Ian Cohen & Yihua Zheng

Overview

- Purpose – “Debrief” from the Helio2050 workshop, hear expectations from agencies on upcoming Decadal Survey, and prepare for a week of discussions of next-steps and preparations amongst the GEM community
- Agenda:
  - Shasha Zou (Michigan) – Co-Chair, Helio2050 SOC
  - Lijen Chen (GSFC) – Co-Organizer of of Mag Session, Helio2050 SOC
  - Larry Kepko (GSFC) – Co-Organizer of of Mag Session, Helio2050 SOC
  - Maura Hagan (USU) – Co-Chair, NASEM CSSP
  - Elsayed Talaat (NOAA) – Director, Office of Projects, Planning, and Analysis
  - Jared Leisner (NASA) – Program Scientist, NASA HPD
  - Lisa Winter (NSF) - Magnetospheric Director/Acting Geospace Section Head

Workshop Report

Shasha Zou

University of Michigan

Heliophysics 2050 Organizers

NASA Heliophysics Division Organizers

- Jared Leisner
- Patrick Koehn
- Galen Fowler

Institutional Support

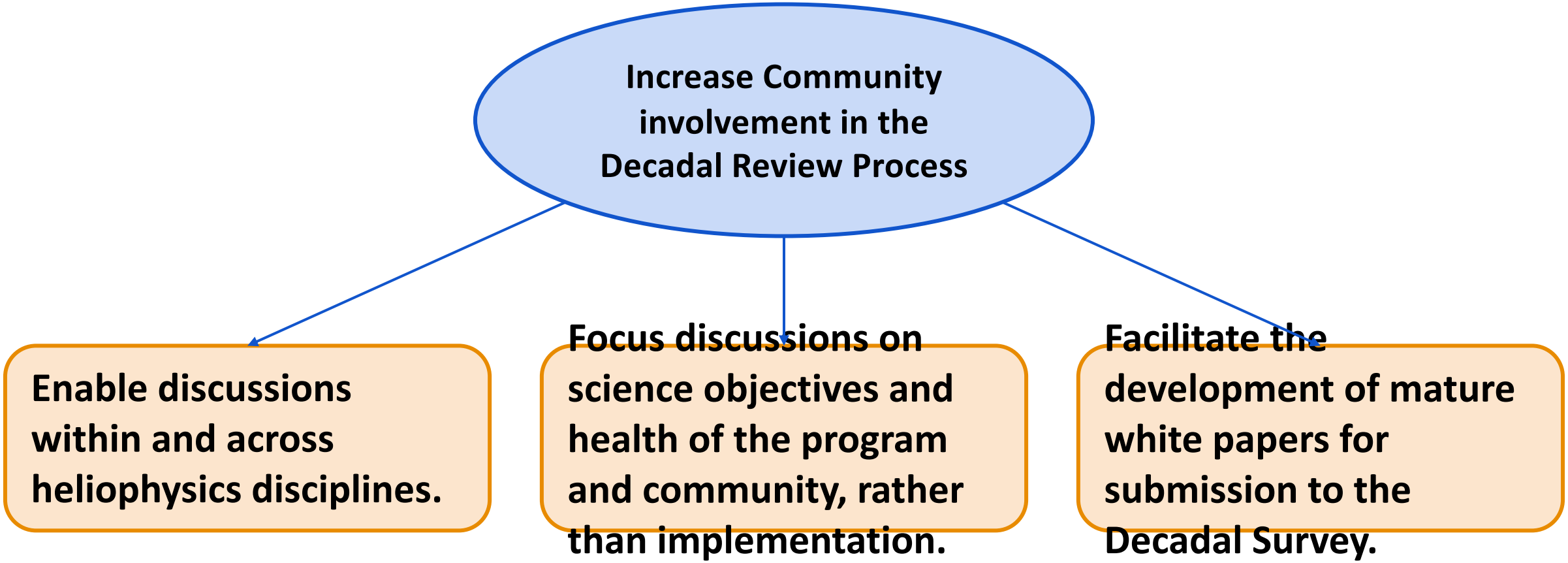
- Lunar and Planetary Institute
- Universities Space Research Association

Science Organizing Committee

• Shasha Zou (co-chair)	University of Michigan
• Sabrina Savage (co-chair)	NASA Marshall
• Amir Caspi	Southwest Research Institute
• Li-jen Chen	NASA Goddard
• Ian Cohen	Johns Hopkins University - APL
• Larry Kepko	NASA Goddard
• Mark Linton	Naval Research Laboratory
• Noe Lugaz	University of New Hampshire

Heliophysics 2050 Purpose and Scope

What does Heliophysics look like in 2050, and what do we do in the next decade to help us get there?



Heliophysics 2050 Workshop Statistics

- **> 1100 registered participants**
- **13 live sessions**
  - **~ 200-300 participants per live session**
  - **Most relevant sessions to GEM:**
  - Magnetosphere
  - Ionosphere, thermosphere, and mesosphere
  - Space Weather
  - Expanding the frontiers
  - Heliophysics as a community in 2050
- **4 poster sessions**
  - **167 posters**

Heliophysics as a Community in 2050

(1) “Whole Heliophysics” collaboration & uniting the field

(2) Cross-disciplinary/Divisional collaborations and efforts

(3) Infrastructure development, & advanced launch and data transmission and processing capabilities

(4) Enabling programmatics: programmatic balance, funding robustness, etc.

(5) Benefits of citizen science, EPO, implementing ML/AI.

(6) Diversity, Equity, Inclusion, Access, and Justice (DEIAJ) topics

Post-workshop Activity

THE WORK IS NOT DONE!

Increase Community involvement in the Decadal Review Process

- **Support post-workshop groups will be provided.**
- **Slack workspaces remain available for continued community discussion.**
- **Agencies and NASEM perspective on Decadal process.**

Post-workshop Activity

The pre- groups got us moving to the workshop, the post-groups are to help the community further develop the ideas with an eye towards decadal white papers. We want to build on the momentum of our very successful Helio2050 workshop and make sure that those discussions and ideas translate directly into content submission to the Decadal.

- A call for **post-Workshop discussion groups is coming out**.
- More info to follow via **community mailing lists** and through: https://www.hou.usra.edu/meetings/helio2050/discussion/
- You are encouraged to start reaching out to colleagues with ideas!

Support post-workshop groups will be provided.

Post-workshop Activity

We encourage the community to continue conversations in the **Slack**, which **will stay up for community use through decadal survey kick-off**: https://heliophysics2-kir7313.slack.com

- **Session summaries and Q&A** have been copied & pinned into the relevant channels.
- One can create new channels there to form small group discussions on specific topics.

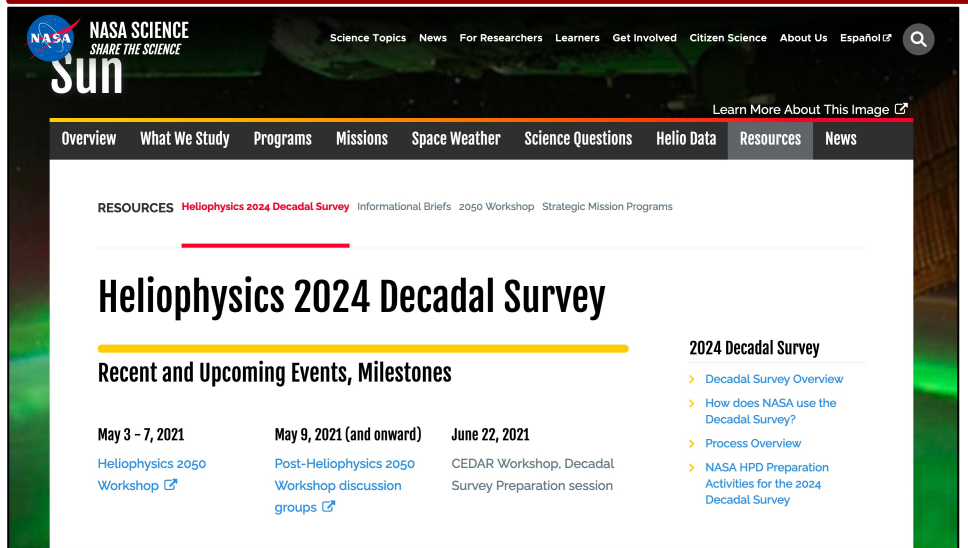
Slack workspaces will remain available for continued community discussion.

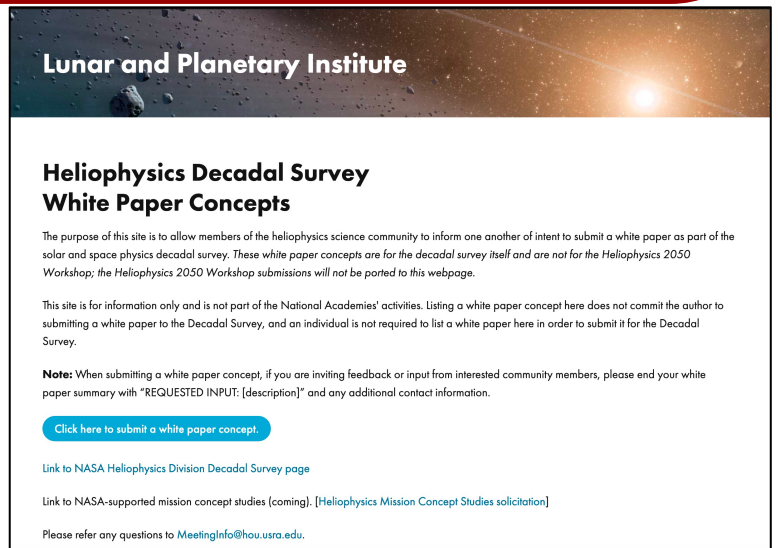
Useful Resources for White Paper Preparation

NASA is hosting **Decadal overview webpage** for the agencies, **check regularly** for more information: https://go.nasa.gov/HelioDecadal.

The time is now to start planning white papers and thinking about panel service.

- You can **publicize your idea and coordinate** with others: https://www.lpi.usra.edu/decadal_whitepaper_proposals/heliophysics/





Useful Resources for White Paper Preparation

NASA Heliophysics Division is supporting **Mission Concept Studies as Decadal Survey input**:

1. **Solar Terrestrial Probes*** (via Heliophysics Mission Concept Studies), proposal due June 23rd.
   - Pre-study report will be published for **community reference** in their decadal survey white papers
   - **These studies are independent of any future mission competitions.**
   - Point of Contact: **Jared Leisner** (jared.s.leisner [at] nasa.gov)
2. **Living With a Star** Architecture Study** is on-going and is a community activity:
   - Statement of Task (via HMCS call): https://bit.ly/2R0Yy4T [NSPIRES]
   - Point of Contact: **Simon Plunkett** (simon.p.plunkett [at] nasa.gov)

* https://science.nasa.gov/heliophysics/programs/solar-terrestrial-probes

** https://science.nasa.gov/heliophysics/programs/living-with-a-star

Useful Resources for White Paper Preparation

Planetary Science and Astro2020 white papers discussing the frontiers of space science and the Community topics:

- https://www.nationalacademies.org/our-work/decadal-survey-on-astronomy-and-astrophysics-2020-astro2020
- https://www.nationalacademies.org/our-work/planetary-science-and-astrobiology-decadal-survey-2023-2032

Mid-Term Assessment Report:

- https://www.nap.edu/catalog/25668/progress-toward-implementation-of-the-2013-decadal-survey-for-solar-and-space-physics

Decadal Survey Lessons Learned and Best Practices (+ processes):

- https://www.nap.edu/catalog/21788/the-space-science-decadal-surveys-lessons-learned-and-best-practices

Capitalize on Your Momentum!

Continue to broaden networks

- **Be inclusive**
- **Reach out to early and mid careers**
- **THINK BIG**

Thank you and please capitalize on your momentum!

Helio2050 Recap

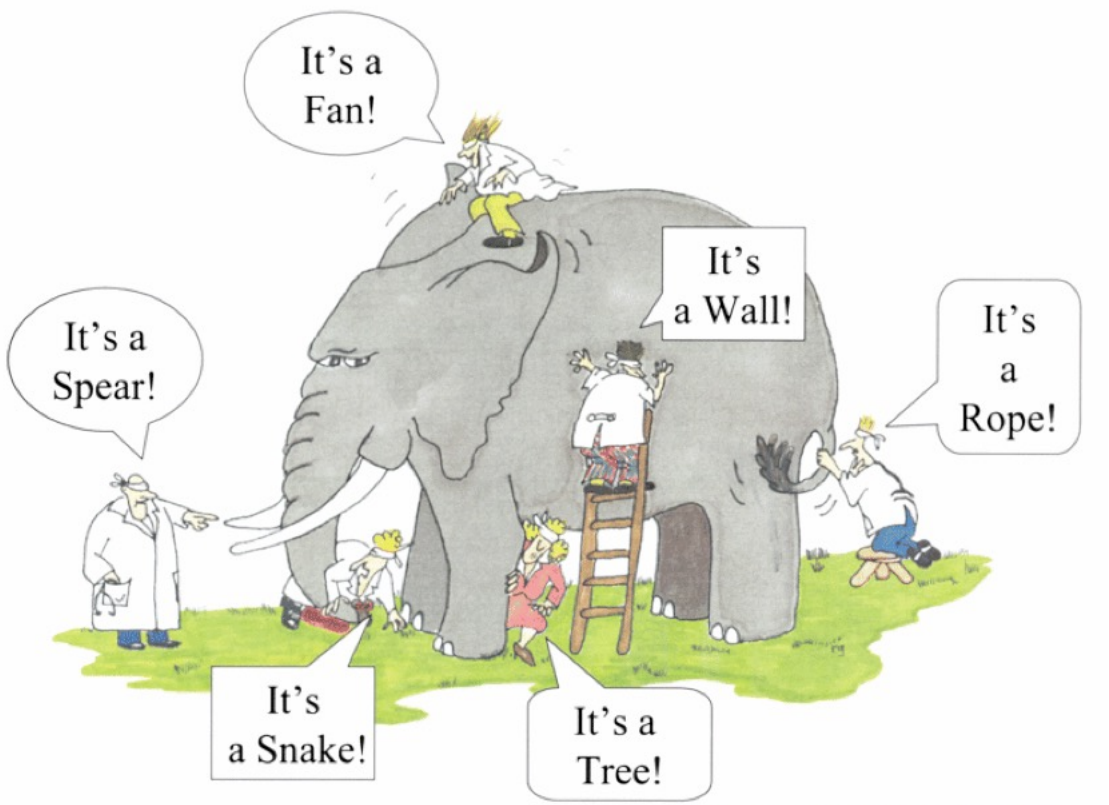
Lijen Chen

Helio2050 – Magnetosphere

Larry Kepko

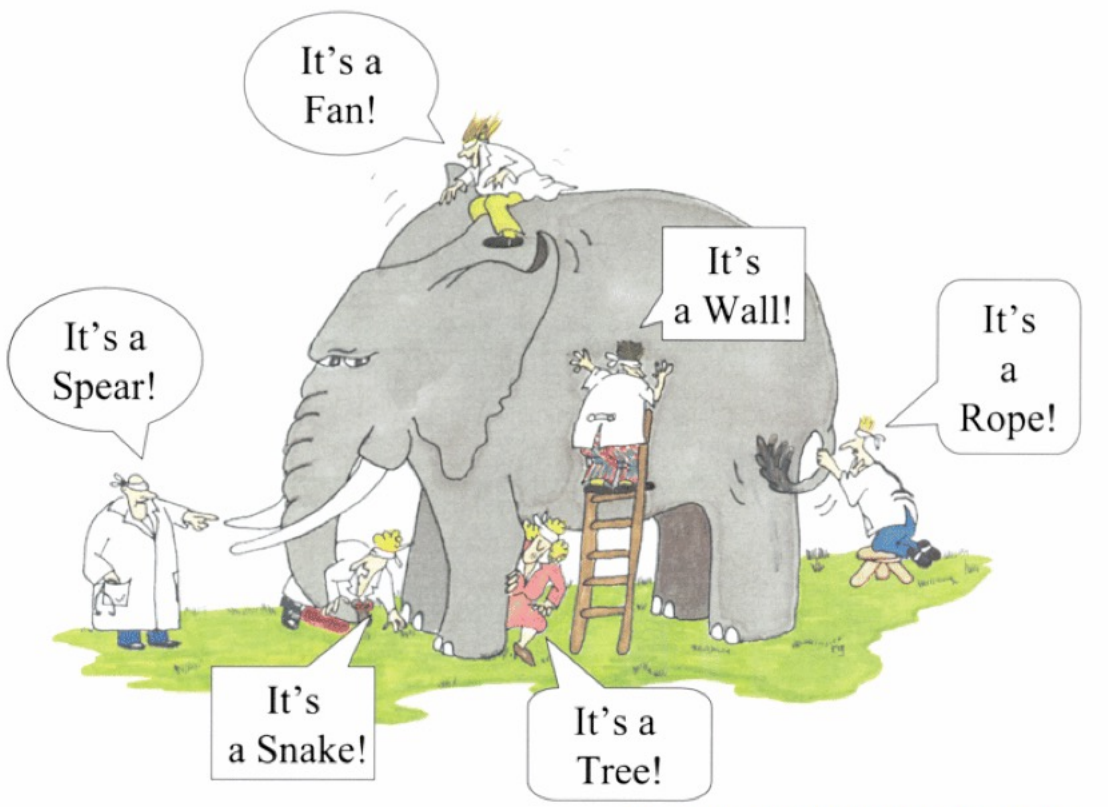
Two themes emerged: “System of Systems” and “Mesoscales”

Parable of 6 blind scientists studying an elephant



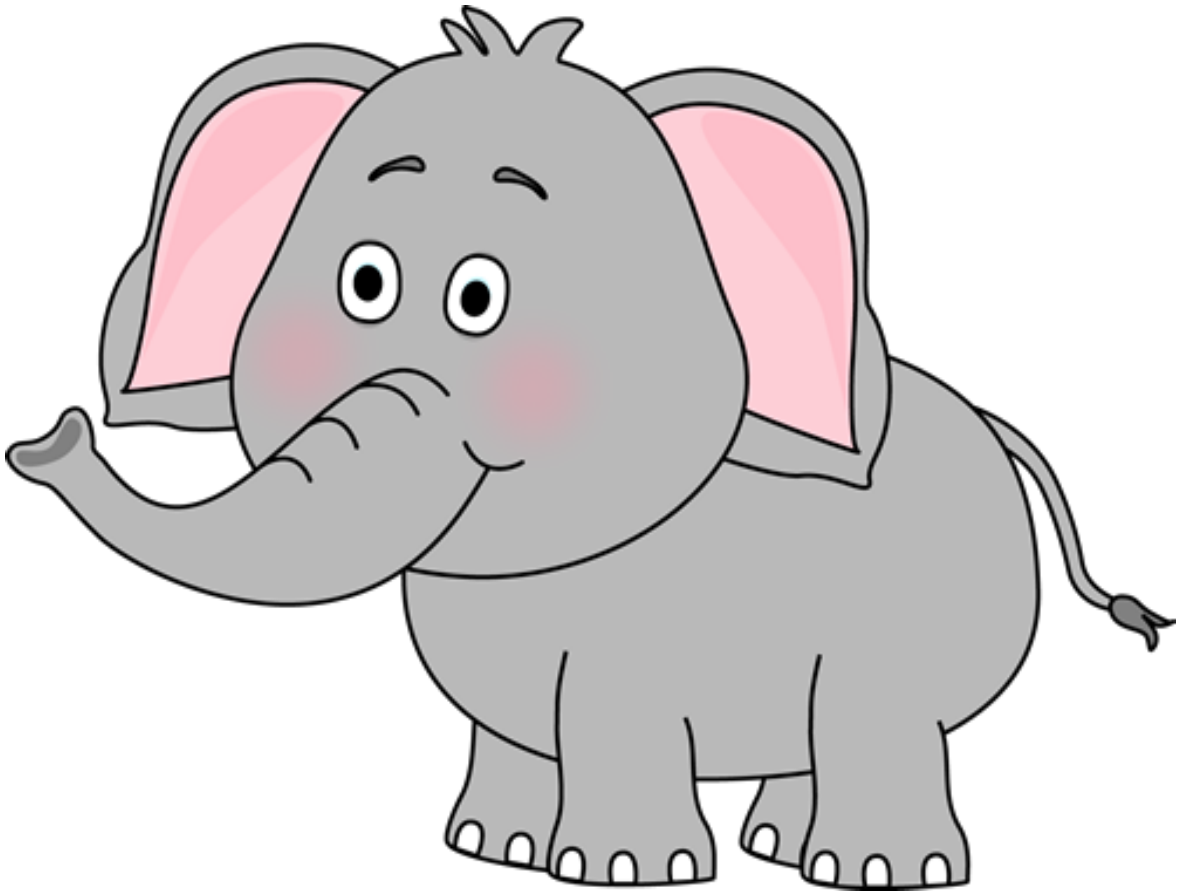
Himmelfarb J et al. Kidney International 2002; 62: 1524

Parable of 6 blind scientists studying an elephant

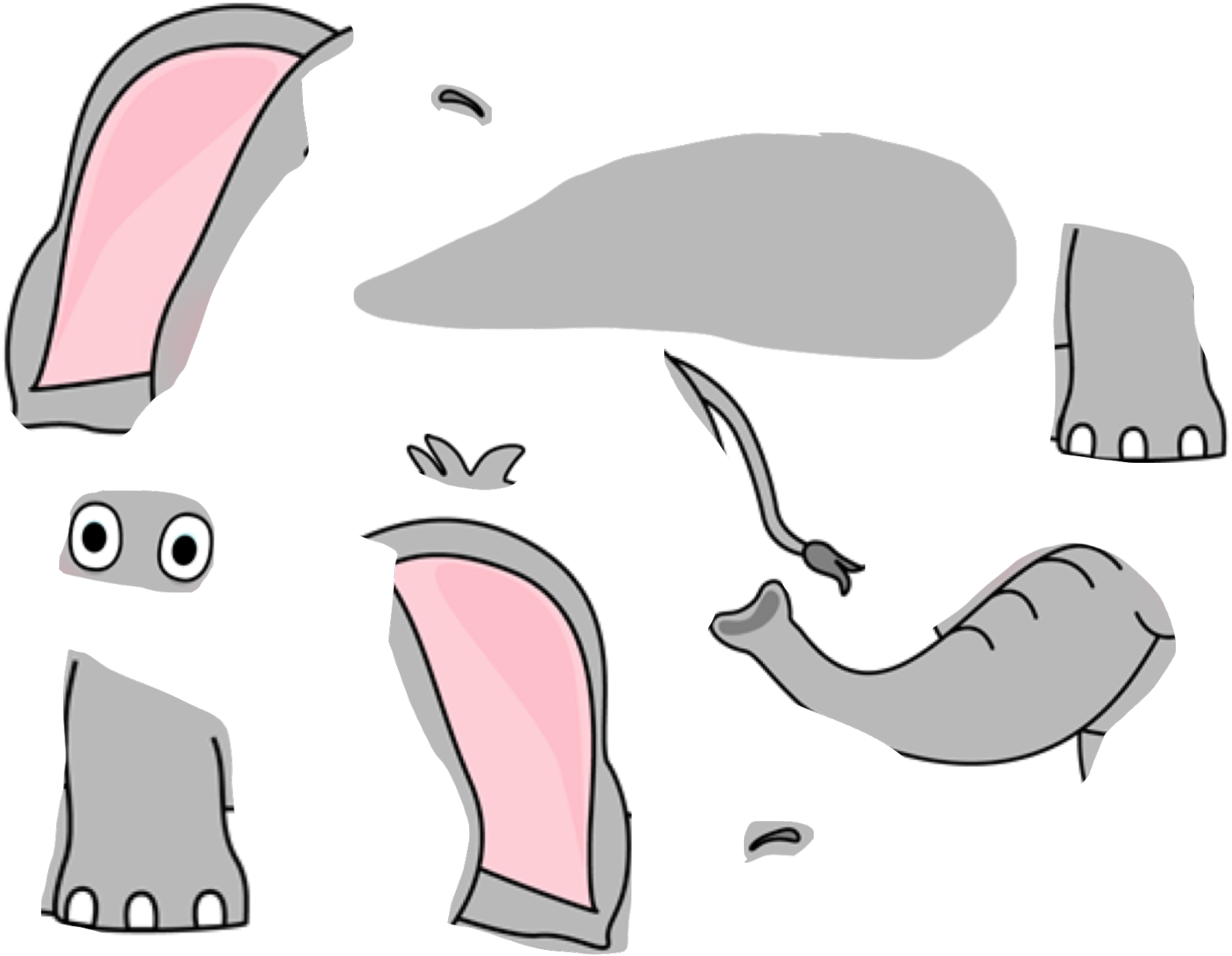


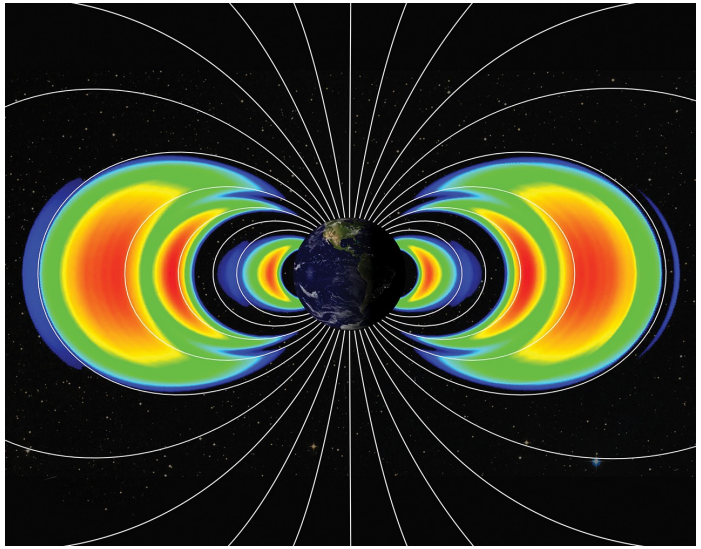
Himmelfarb J et al. Kidney International 2002; 62: 1524

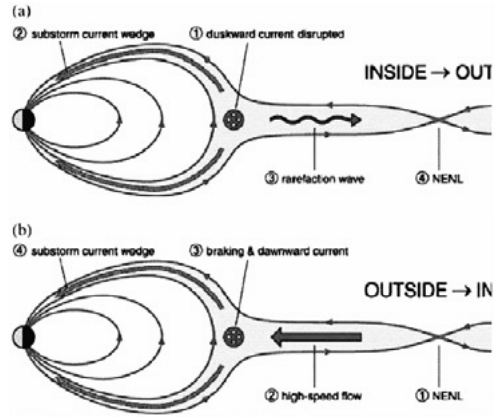
But we all know we're studying an elephant, and we're not blind.



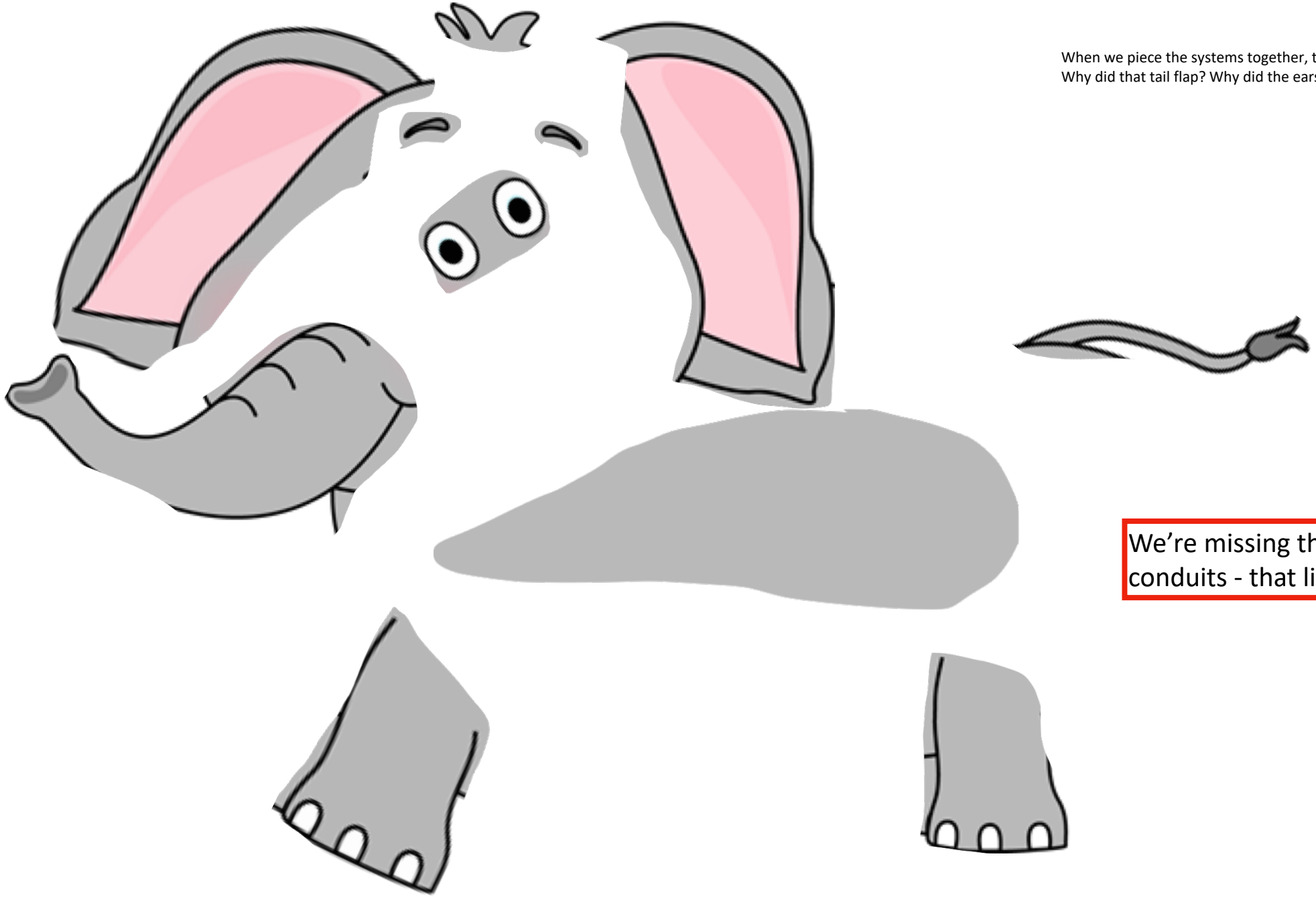
The elephant, like the magnetosphere, is a “system of systems”. And all too often we study the systems in isolation, with microscopes.



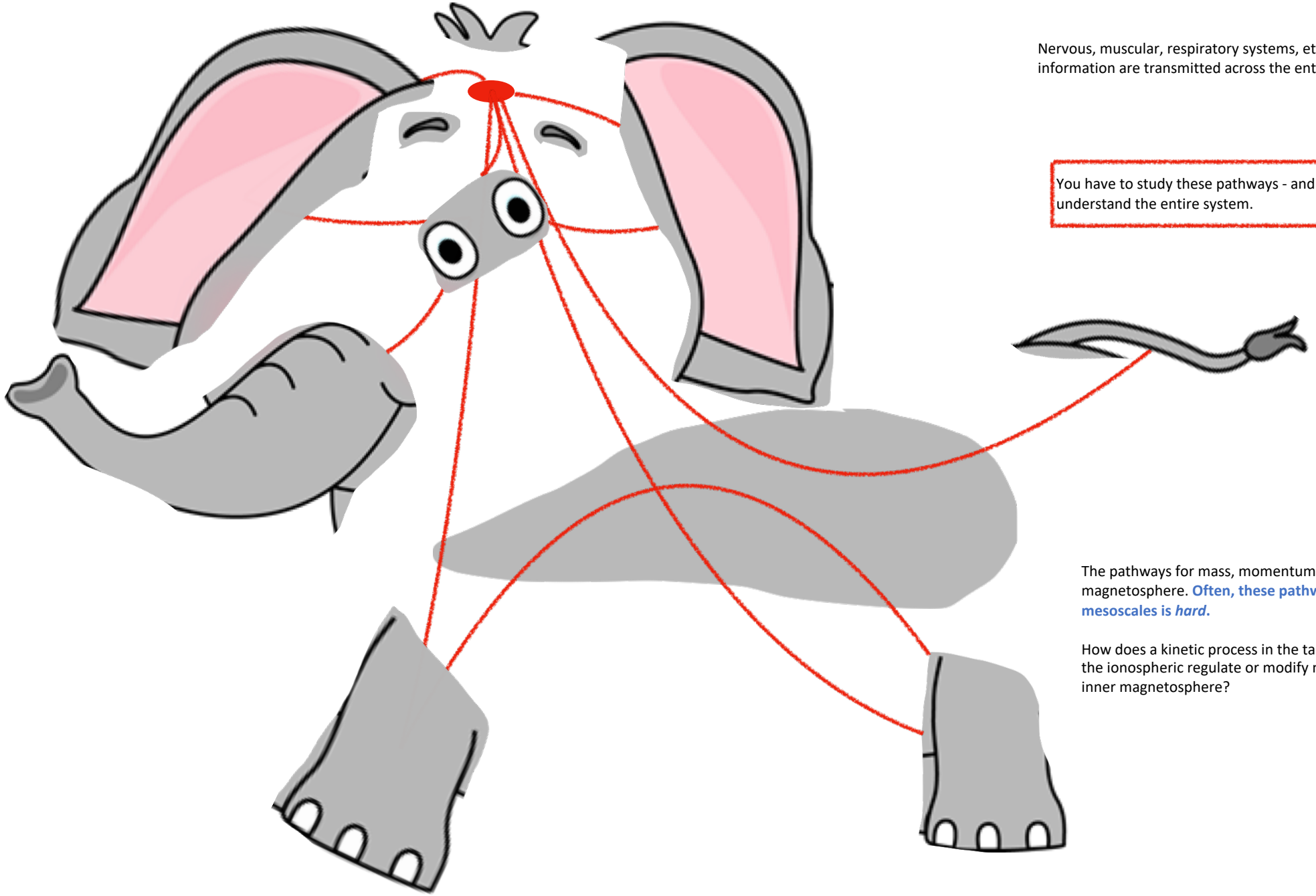




When we piece the systems together, there are gaps. Rare to see the system as a whole. Why did that tail flap? Why did the ears wiggle?



We’re missing the pieces - the pathways and conduits - that link the systems together.



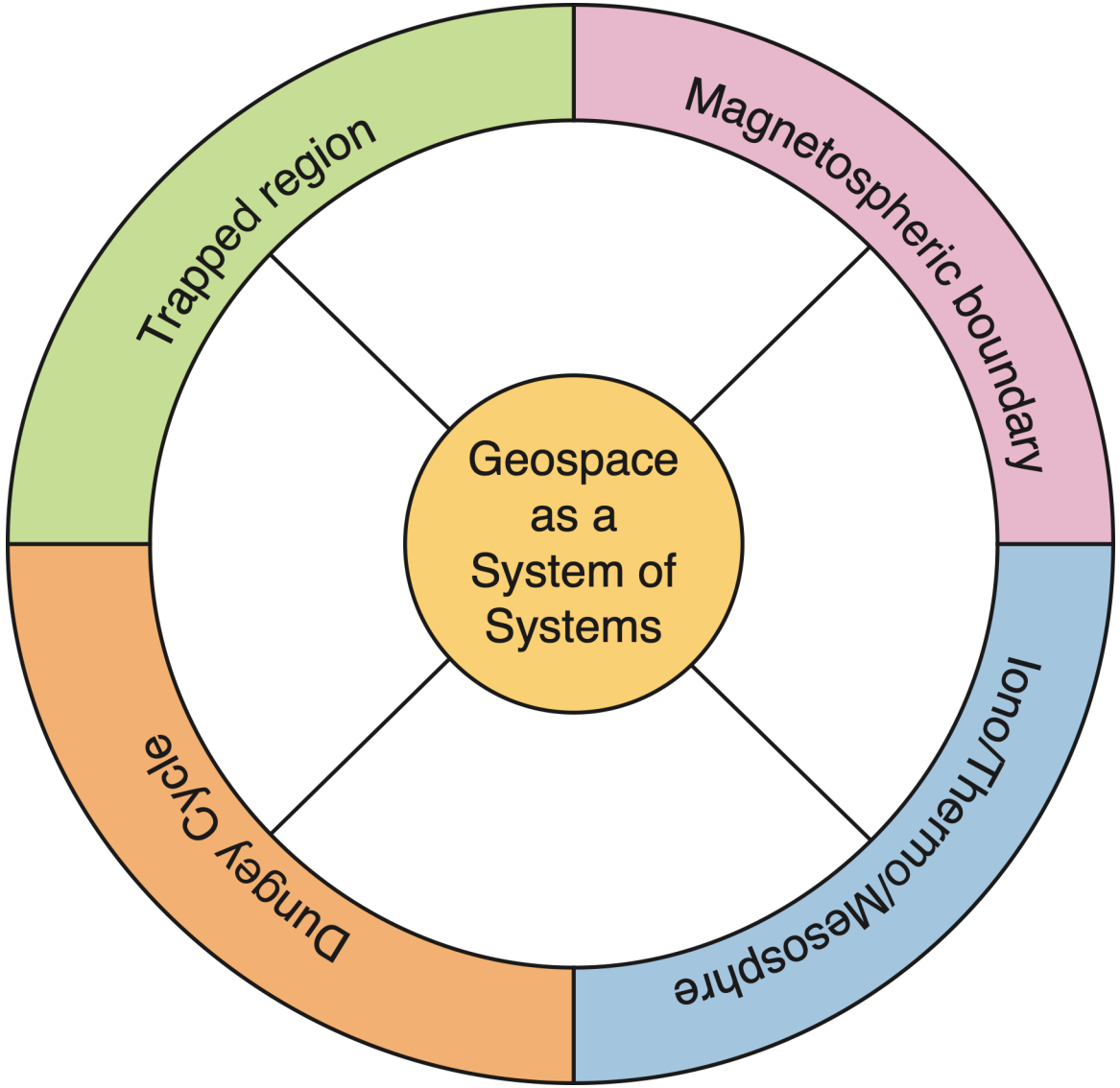
Nervous, muscular, respiratory systems, etc. The pathways by which energy and information are transmitted across the entire system, so that they work together.

You have to study these pathways - and how each system responds to them - to understand the entire system.

The pathways for mass, momentum and energy transport are understudied in Earth's magnetosphere. **Often, these pathways are through the mesoscales (1-3 RE), and studying mesoscales is *hard*.**

How does a kinetic process in the tail lead to a global reconfiguration in minutes? How does the ionospheric regulate or modify magnetospheric convection? How do BBFs energize the inner magnetosphere?

Making progress on understanding Geospace as a “Systems of Systems”



“Hub and Spoke” System of Systems white paper structure provides a science framework for the Decadal Survey

——— 4 actions ———

1. Resolve the mesoscales
   - Mesoscales are difficult to measure. Need both good temporal and spatial resolution - in many cases, constellations with simultaneous imaging
2. Measure the state parameters
   - L1, open flux, FAC intensities & location - the magnetosphere’s vital signs
3. Continue to develop advanced numerical modeling
   - Realistic ITM coupling, inner magnetosphere & cold plasma, and data assimilation
4. Validate models and benchmark scientific advancements (links 1-3)
   - Move from the qualitative to the quantitative.

Tightly integrate ground-based and space-based assets with numerical modeling under a **“whole of system”** approach.

Effort should be broad-based and diverse, taking advantage of expertise in other disciplines, and ***international in scope***.

Don’t break down silos of expertise - gather them under a large research effort with a shared vision (DRIVE centers and ISFMs are good examples to follow)

GEM (+CEDAR and SHINE) is a natural group to advance this concept for the Decadal - if this is the direction the community wants to go.

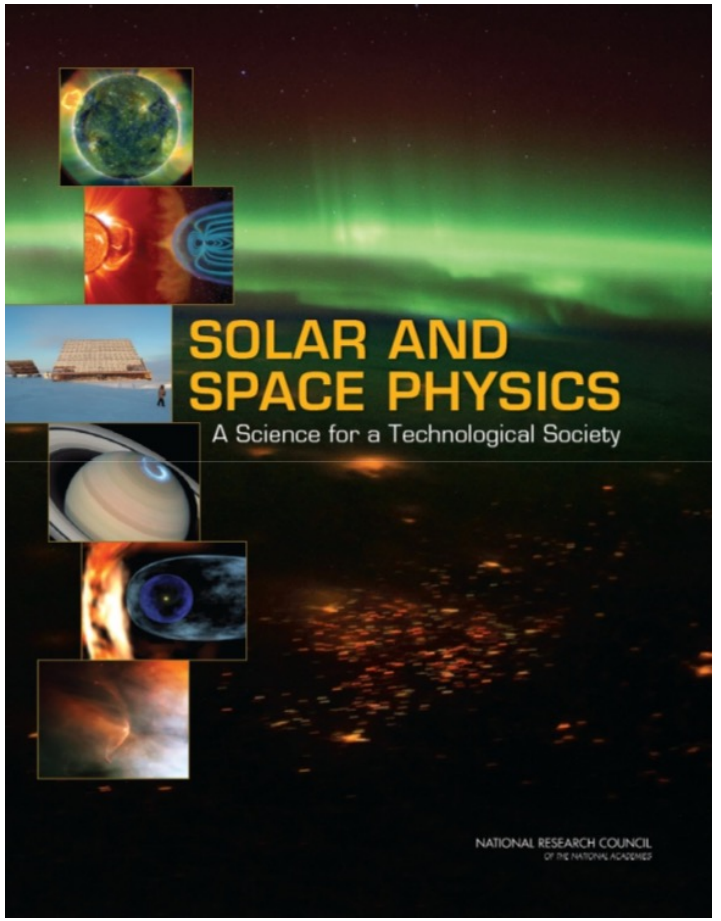
bit.ly/HelioDS_WPList = spreadsheet to help coordinate white papers

Planning for the 2024-2033 Decadal Survey in Solar and Space Physics/Heliophysics

Maura Hagan, Committee on Solar & Space Physics
on behalf of
Art Charo and Abigail Sheffer
Space Studies Board, The National Academies
Overview for VGEM Workshop--July 26, 2021

Why Undertake a Decadal Survey?

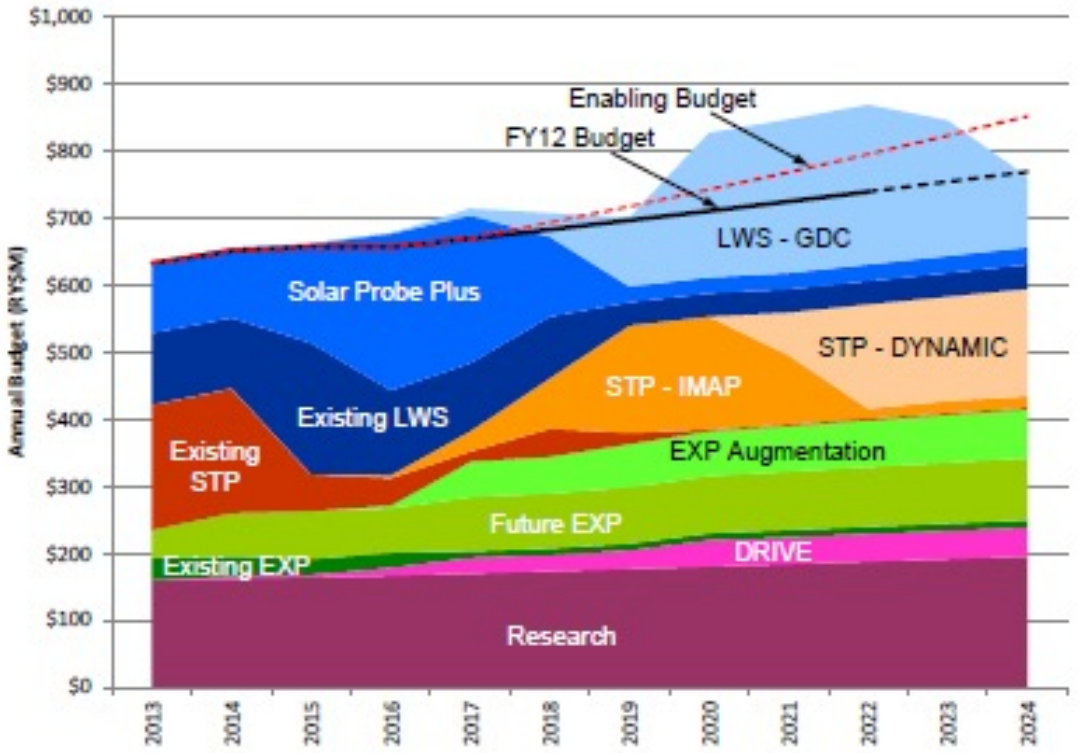
- Community-based assessment of the state of knowledge in the field;
- Identify and prioritize questions for the next decade;
- Provide recommendations for programmatic directions and explicit priorities for government investment in research and facilities, including space flight missions. Takes into account research and technology infrastructure, interagency coordination, international cooperation;
- Recommendations for state of the profession and health of the enterprise; and
- Mandated by the 2005 & 2008 NASA Authorization Acts.



Facilitates Planning, Coordination, Advocacy, and Outreach

Solar and Space Physics: A Science for a Technological Society (2013)

- Sponsors: NASA (HPD) and NSF (GEO/AGS-Geospace). NOAA participation, but not $.
- Presented a prioritized program of basic and applied research for 2013-2022 to advance scientific understanding of the Sun, Sun-Earth connections and the origins of "space weather," and the Sun's interactions with other bodies in the solar system.
- Recommendations directed to the study sponsors and other federal agencies, esp. NOAA, which is responsible for the operational forecast of space weather. For NASA, includes the cost and phasing of the recommended program.



FAQs-I

- *Who are the expected sponsors?* NASA (HPD), NOAA (NESDIS), and NSF (GEO/AGS-Geospace Section).
- *Why wasn't NOAA a sponsor last time*? Impact of a Continuing Resolution.
- *What's new*? Better coordination among the sponsoring agencies, esp. in developing "Statement of Task" (SOT) with regards to Space Weather. NSF Mid-scale Program likely to receive greater attention. More upfront activities by the sponsors. Expect State of the Profession topics in the SOT.
- *When will the survey get started*? Probably no earlier than December 2021. As of July 2021: SOT--draft only; Study approval by Academies--cannot occur until SOT is finished and contracts are signed with the sponsors.
- *Are you planning on having community town halls prior to the survey*: Yes, details are TBD.
- *Will there be special forums for early career scientists*? Yes, to help introduce the survey to a wider audience and to aid in the solicitation of white papers from a broader audience.

FAQs-II

- *How will the survey be organized*? Likely similar to previous decadals—an overall steering committee that is responsible for all recommendations, supported by a number of study panels and working groups.
- *Will the panel structure be the same as the 2013 survey*? TBD, but 2013 was similar to 2003.
- *Will the survey recommend "missions"?* TBD, but probably not. The 2013 survey prioritized science targets and mapped these to reference designs that could be evaluated for their technical feasibility and approximate cost.
- *How will survey participants be identified*? Primarily via community calls for nominations, including self-nominations. We also hear from community leaders, relevant parts of the Academy, and the agencies. Last time, we had about 100 scientists on the various committees and working groups of the survey. Steering committee tends to have more experienced members of the community; essential that they all wear "big hats."

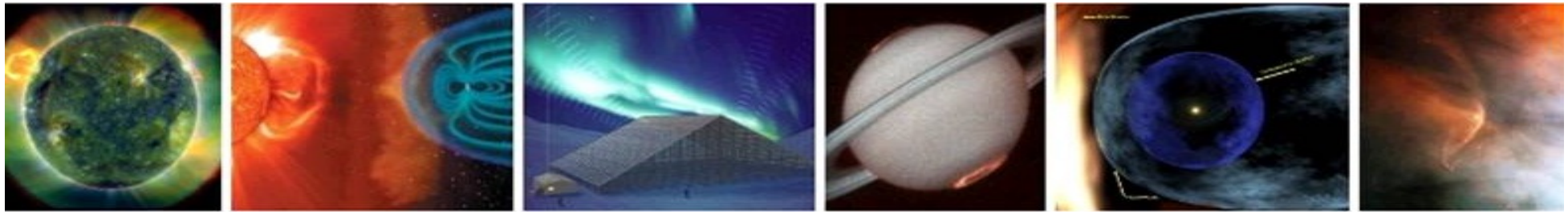
FAQs-III

- *Can employees of the sponsor serve*? Yes, if they are in research positions vs. management with control over budgets.
- *What about PIs, authors of white papers, known advocates—can they serve*? See next slide, FAQs-IV.
- *What is the best way to get involved with the survey*? Write a white paper. Details will be broadcast ahead of the survey. Note that NASA has front-ended the survey with various activities including the Heliophysics 2050 Workshop and their white paper activity and mission concept studies.
- *Does the number of authors on a white paper increase its visibility to the survey committee*? No.
- *Who reads the white papers*? Typically initial screens by the survey panels, but all are made available to everyone.

FAQs-IV: Nominations Caveat

- Prospective members of Academies committees have their financial relationships reviewed to prevent actual or perceived conflicts of interest.
- We have special considerations for the authors of white papers and mission studies:
  - All authors of science-focused white papers are eligible to be considered;
  - First authors of space mission- or ground-based project-focused white papers cannot serve on the steering group or on any panel likely to be considering their mission; and
  - PIs of the NASA-funded, pre-decadal mission-concept studies cannot serve on the steering committee or on any panel likely to be considering their mission.

Backup Slides: Overview of Previous Decadal Survey in Solar and Space Physics (Heliophysics)



The 2013-2022 NRC Decadal Survey in Solar and Space Physics (Heliophysics)

Daniel N. Baker, University of Colorado, Chair

Thomas H. Zurbuchen, University of Michigan, Vice-Chair

National Research Council Staff

Art Charo, Space Studies Board, Study Director

Abigail Sheffer, Space Studies Board

Report from the Decadal Survey Steering Committee: *Solar and Space Physics: A Science for a Technological Society*

2013-2022: A decade of discovery enabled by new and innovative approaches and tools and by treating heliophysics as a system; focus on societal impact.

Topics to be Covered

- The Decadal Survey Process
- Accomplishments of the Past Decade
- The Recommended Scientific Program
- A Revitalized National Space Weather Program

Background

Objectives of Review

1. Provide an overview of the science and a broad survey of the current state of knowledge in the field
2. Identify the most compelling science challenges
3. Identify the highest priority scientific targets for the interval 2013-2022
4. Develop an integrated research strategy

Characteristics of Study

- Study initiated in Fall 2010; **sponsors: NASA and NSF**
- **National in scope**, including NASA, NSF, NOAA and DOD investments in solar and space physics
- Review has been **community based**
  - 300 white papers with ideas and new concepts
  - Numerous town-hall meetings and workshops
  - 85 NRC-appointed participants serving on 3 study panels, 5 working groups and an 18 member steering committee
- Recommended **program fit to resources** anticipated in a challenging fiscal environment
  - Cost and technical evaluation (CATE) of selected NASA reference mission concepts performed by the Aerospace Corp., which worked under contract with the NRC
- **No grandfathering** of previous decadal recommendations

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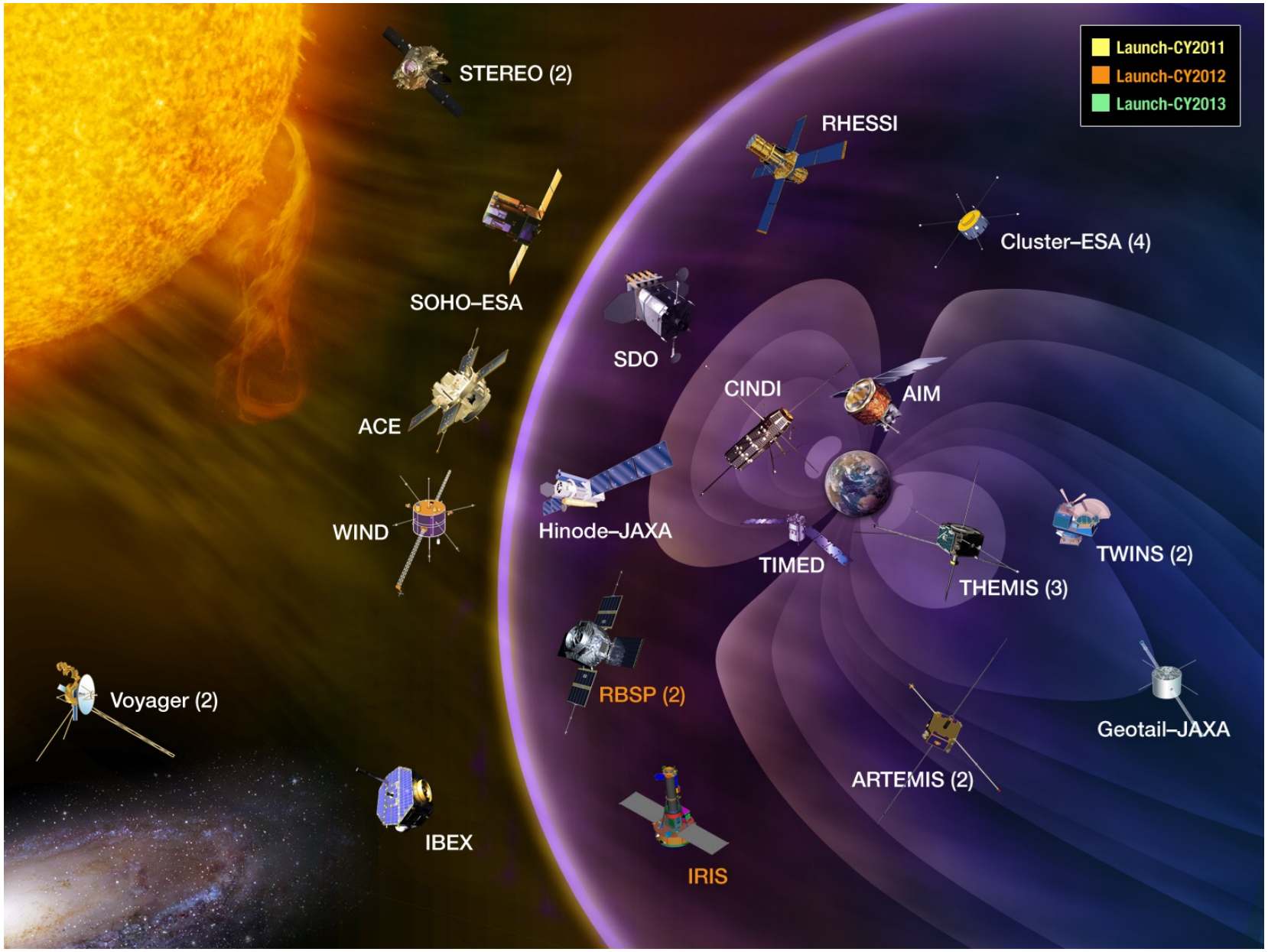
Accomplishments of the Past Decade

The Heliophysics System Observatory




AMISR RISR
AMISR PFISR
Sondrestrom
WSO
Millstone Hill
NSO SP/KP
SuperDARN
Super DUAL AURORAL RADAR NETWORK
SFO
NRAO
BBSO
Jicamarca
NSO ATST
Arecibo
MSO

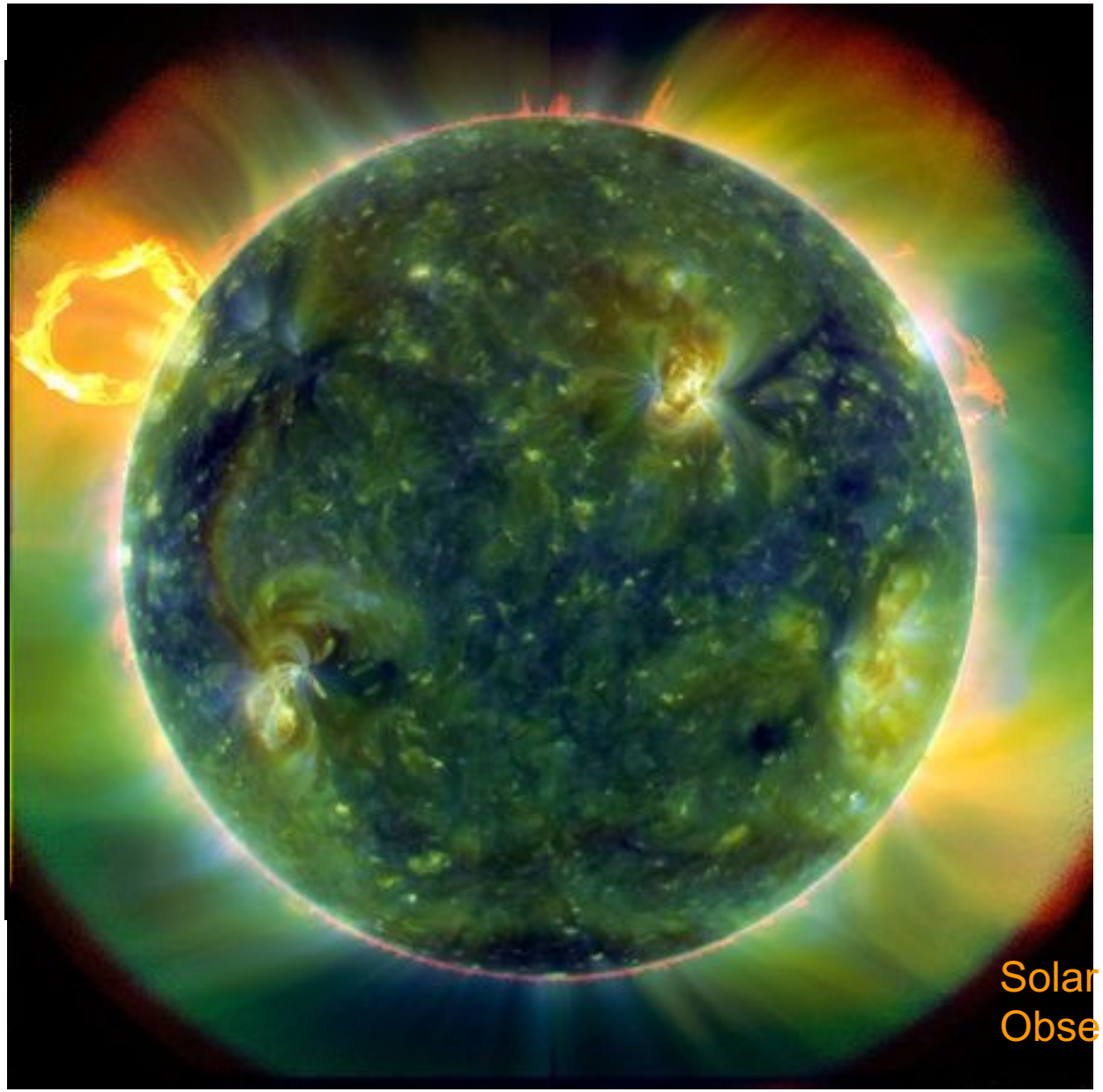
Space Weather Experiment

The LASP/CSSWE launched onboard the Atlas 5 rocket on September 13, 2012, from the Vandenberg Air Force Base in California. (Courtesy United Launch Alliance)

The LASP/CSSWE team poses near a LASP Mission Operations room in 2011. CSSWE houses the Relativistic Electron and Proton Telescope integrated little experiment (REPTile). (Courtesy LASP)

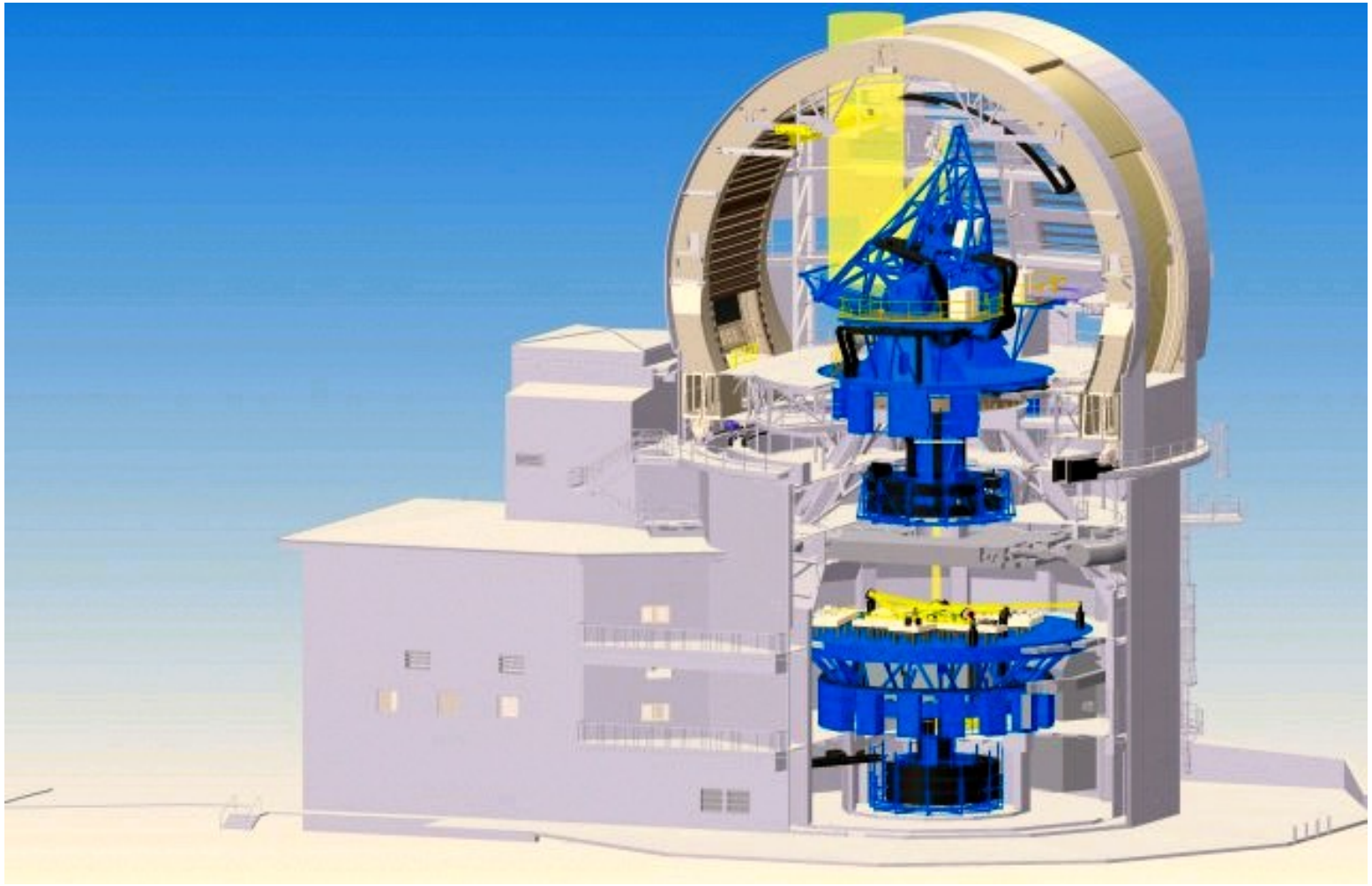
Solar Physics

Understanding Solar Variability



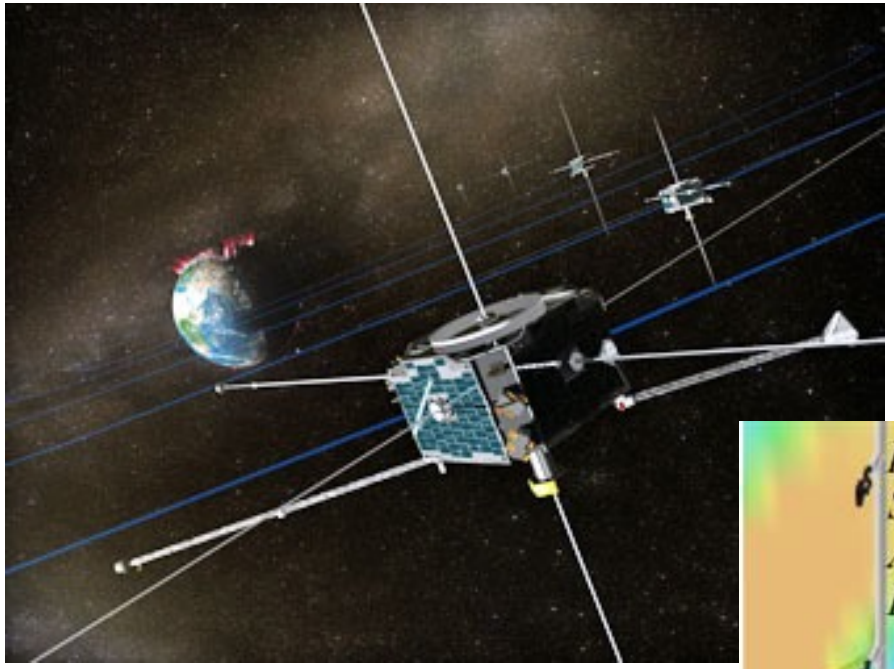
Solar Dynamics Observatory

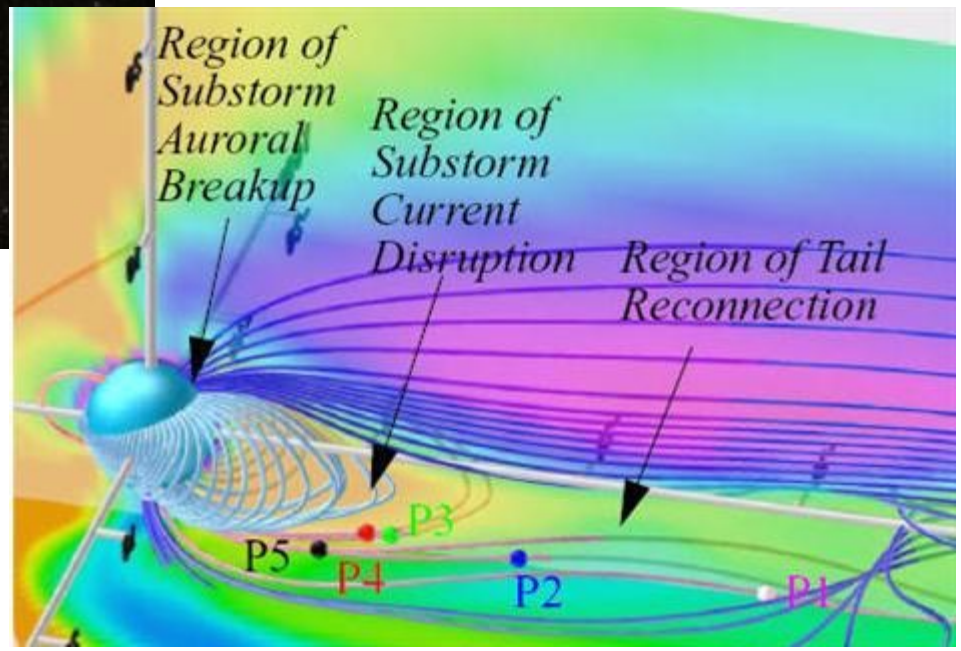
NSF’s Advanced Technology Solar Telescope



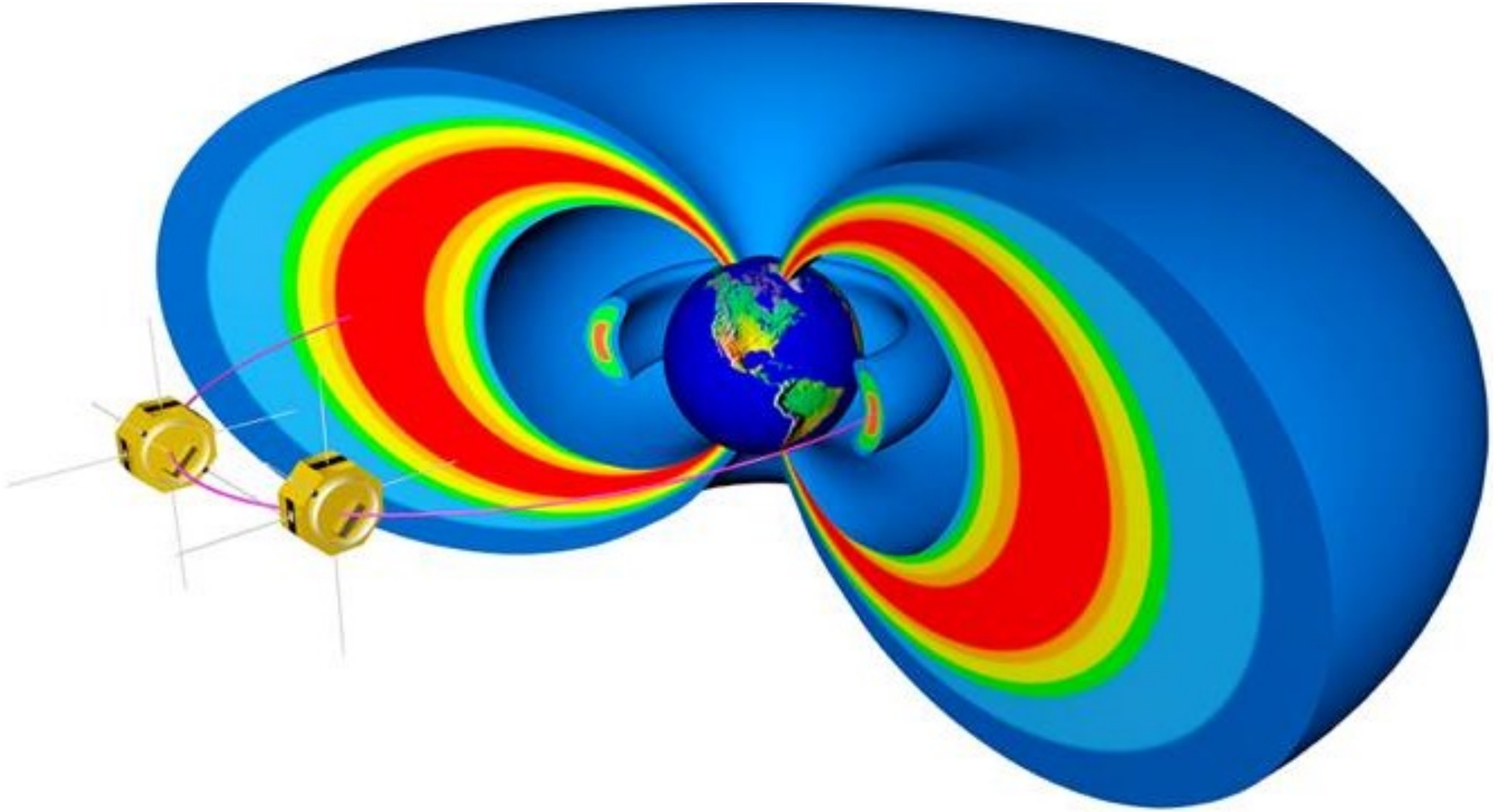
Planetary Magnetospheres

THEMIS: 5-Spacecraft Mission



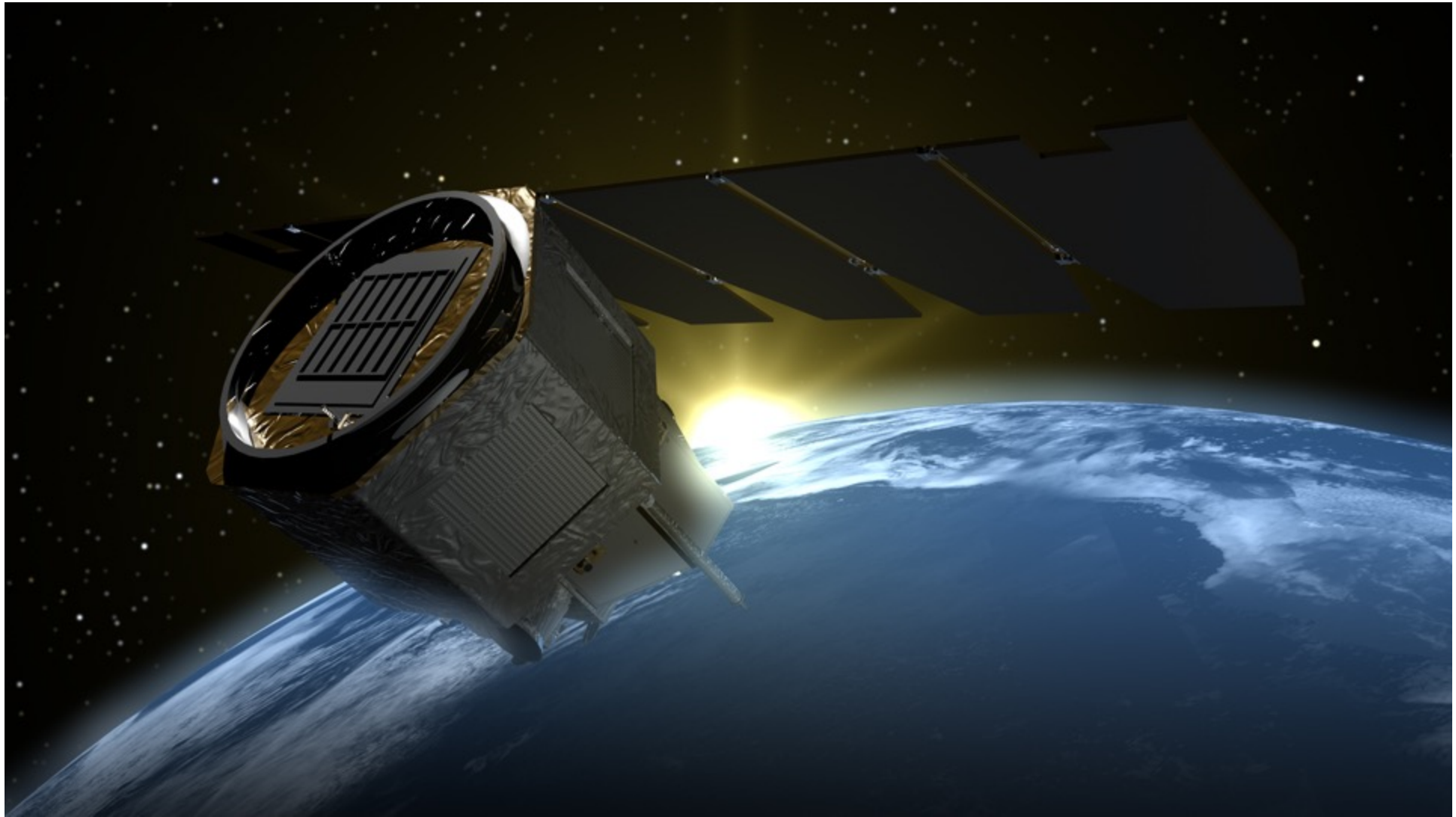


The Radiation Belt Storm Probes Mission

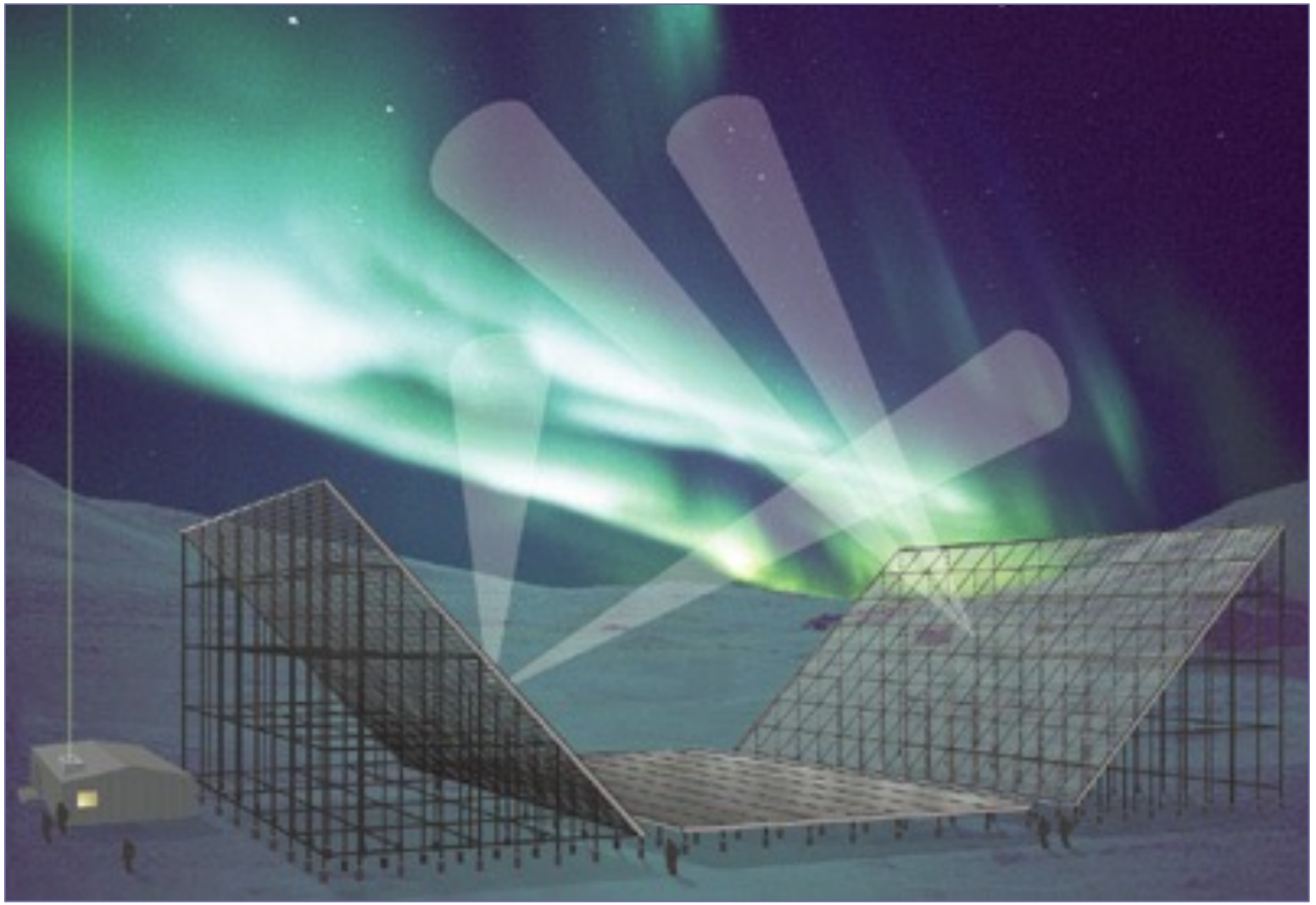


Ionosphere and Atmosphere

Aeronomy of Ice in the Mesosphere (AIM)



NSF’s AMISR



Elements of the Recommended Scientific Program

Overarching Goals for a Decade of Discovery

- 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.

Complete the Current Program

- The survey committee's recommended program for NSF and NASA assume continued support in the near-term for the key existing program
  - For NASA: complete RBSP, MMS, Solar Probe Plus, Solar Orbiter; also IRIS and Explorer selections.
  - For NSF: complete ATST.

1.Implement the DRIVE Initiative

- **DRIVE** (Diversify, Realize, Integrate, Venture, Educate) will enable NASA, NSF and other agencies to more effectively exploit their scientific assets.

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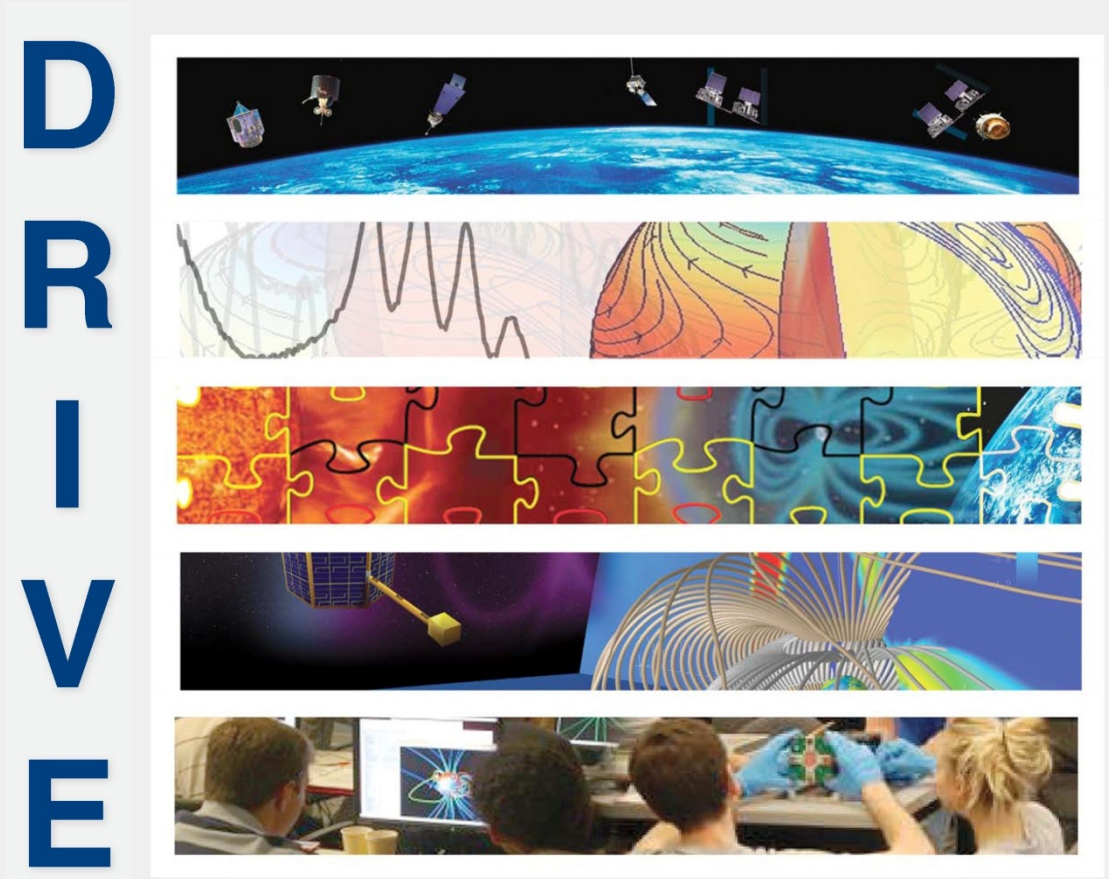

Diversify observing platforms with microsatellites and mid-scale ground-based assets

Realize scientific potential by sufficiently funding operations and data analysis

Integrate observing platforms and strengthen ties between agency disciplines

Venture forward with science centers and instrument and technology development

Educate, empower, and inspire the next generation of space researchers

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DRIVE for NSF

- **Diversity**:
  - **Recommendation: NSF's CubeSat program should be augmented to enable at least two new starts per year.** Detailed metrics should be maintained, documenting the accomplishments of the programs in terms of training, research, technology development, and contributions to space weather forecasting.
  - Create a mid-scale ($4-90M) line for ground-based projects.

- **Realize**: Provide sufficient funding for efficient and scientifically productive operation of Advanced Technology Solar Telescope.

- **Integrate**:
  - **Recommendation: NASA should join with NSF and DOE in a multi-agency program on laboratory plasma astrophysics and spectroscopy, with an expected NASA contribution ramping from $2 million per year (plus increases for inflation), in order to obtain unique insights into fundamental physical processes.**
  - **Recommendation: NSF should ensure that funding is available for basic research in subjects that fall between sections, divisions, and directorates, such as planetary magnetospheres and ionospheres, the Sun as a star, and the outer heliosphere. In particular, outer-heliospheric research should be included explicitly in the scope of research supported by the AGS section at the NSF.**

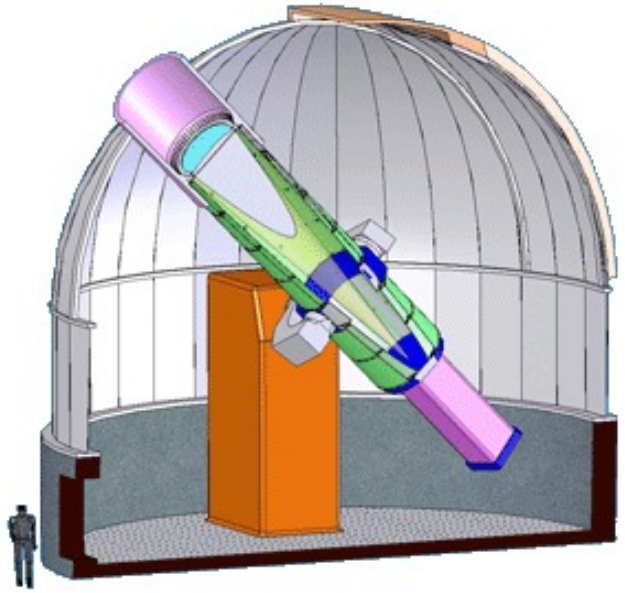
DRIVE for NSF, Cont'd

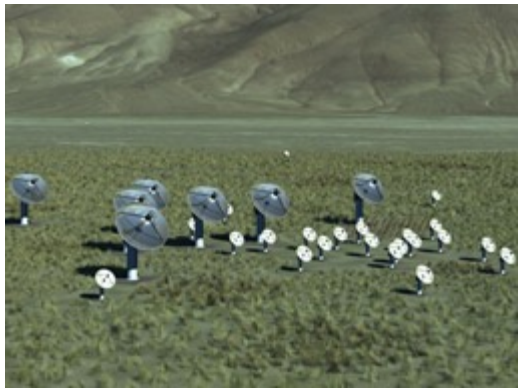
- **Venture**: Multi-agency development of critical mass science centers.
  - **Recommendation: NASA and NSF together should create heliophysics science centers (HSCs) to tackle the key science problems of solar and space physics that require multidisciplinary teams of theorists, observers, modelers, and computer scientists, with annual funding in the range of $1 million to $3 million for each center for 6 years, requiring NASA funds ramping to $8 million per year (plus increases for inflation).**

- **Educate**: Promote faculty and curriculum development and visibility of solar and space physics.
  - **Recommendation: NSF Faculty Development in Space Sciences (FDSS) program should be continued and be considered open to applications from 4-year as well as PhD-granting institutions as a means to broaden and diversify the field. NSF should also support a curriculum development program to complement the FDSS program and support its faculty.**

Mid-Scale Line for NSF

- A new funding line for mid-scale projects at the National Science Foundation will facilitate long-recommended ground-based projects, such as COSMO (COronal Solar Magnetism Observatory) and FASR (Frequency-Agile Solar Radio-telescope), by closing the funding gap between large and small programs.





2. Accelerate and Expand the Heliophysics Explorer Program

- The recommended augmentation of the Explorer line allows for missions in a restored MIDEX line to be deployed in alternation with SMEX missions at a 2-3 year cadence; also allows regular selection of MOOs.

3. Restructure Solar-Terrestrial Probes as a Moderate-scale PI-led Line

- NASA's Solar Terrestrial Probes program to be restructured as a moderate-sized, competed, principal investigator-led (PI-led) mission line that is cost-capped at $520 million per mission in fiscal year 2012 dollars including full lifecycle costs.

STP Prioritized Science Targets

1. Understand the outer heliosphere and its interaction with the interstellar medium; measure solar wind inputs to the terrestrial system.
   - *Reference mission:* ***IMAP (****to be launched* in time to overlap with Voyager)
2. Provide a comprehensive understanding of the variability in space weather driven by lower atmosphere weather on Earth.
   - *Reference mission:* ***DYNAMIC***
3. Determine how the magnetosphere-ionosphere-thermosphere system is coupled and how it responds to solar and magnetospheric forcing.
   - *Reference mission:* ***MEDICI***

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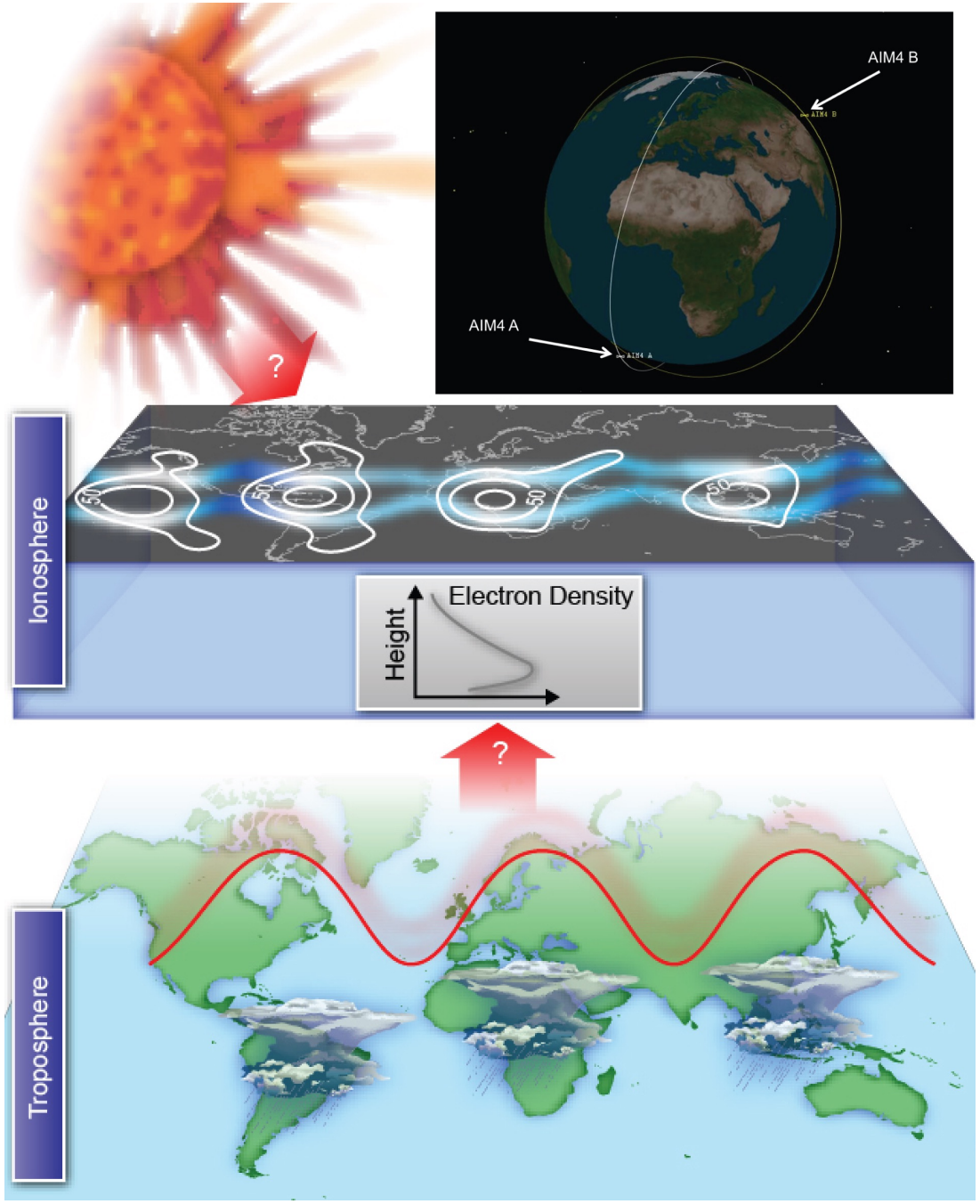
DYNAMIC

Dynamical Atmosphere Ionosphere Coupling



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Living with a Star

- LWS: Missions, Targeted Research and Technology Programs
- Survey committee does not recommend changes to the organization of LWS missions, which have been highly successful.
  - Large-class mission line.
  - Center-led.

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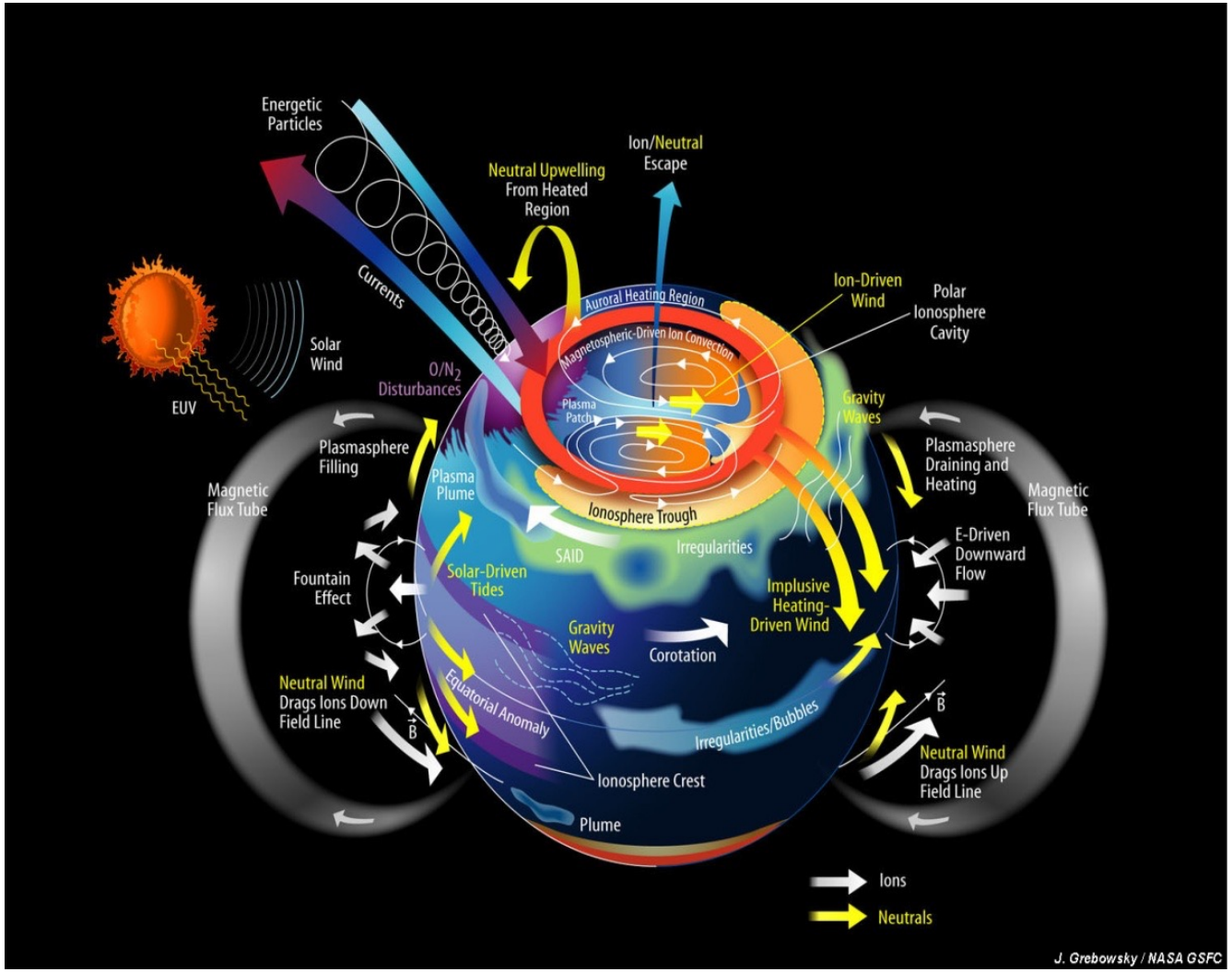
Global Dynamics Constellation



- The upper atmosphere is intimately connected to the entire space environment, including the solar wind/magnetosphere and the troposphere.
- Lack of simultaneous, global measurements; i.e., high inclination orbits at more than one local time, prevents progress in understanding how the ionosphere/thermosphere operates and responds as a "system."
- New evidence suggests a strong influence from the lower atmosphere.

Recommendations Regarding Space Weather Applications

Background

- NASA research satellites, such as ACE, SOHO (with ESA), STEREO, and SDO, designed for scientific studies have provided over the past decade or more critical measurements essential for specifying and forecasting the space environment system, including the outward propagation of eruptive solar events and solar wind conditions upstream from Earth.
- While these observational capabilities have become essential for space environment operations, climatological monitoring, and research, NASA currently has neither the mandate nor the budget to sustain these measurements into the future.
- A growing literature has documented the need to provide a long-term strategy for monitoring in space, and elucidated the large number of space weather effects, the forecasting of which depend critically on the availability of suitable data streams.

Overview of Recommendations (prioritized)

- **The National Space Weather Program should be re-chartered under the auspices of the National Science and Technology Council and should include the active participation of the Office of Science and Technology Policy and the Office of Management and Budget. The [re-chartering] plan should build on current agency efforts, leverage the new capabilities and knowledge that will arise from implementation of the programs recommended in this report, and develop additional capabilities, on the ground and in space, that are specifically tailored to space weather monitoring and prediction.**
  - Re-chartering provides an opportunity to review the program and to consider issues pertaining to program oversight and agency roles and responsibilities.
  - A comprehensive plan for space weather and climatology is also needed to fulfill the requirements as presented in the June 2010 U.S. National Space Policy and as envisioned in the 2010 National Space Weather Program Strategic Plan.

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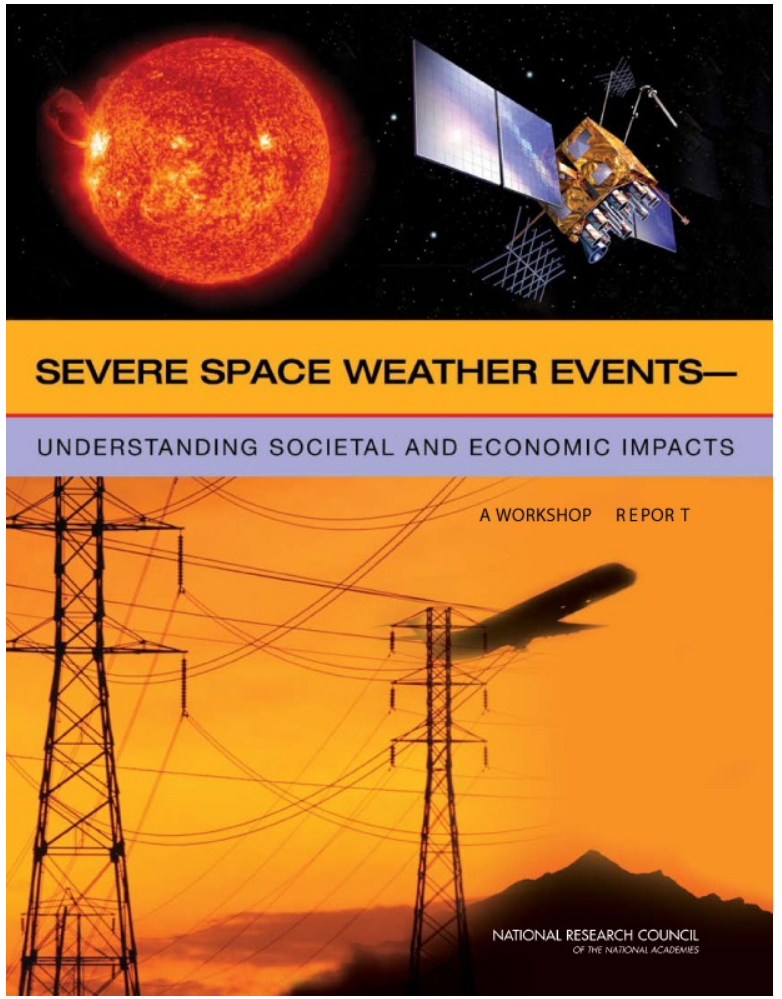
Overview of Recommendations, Cont'd.

2. Multi-agency Partnership for Solar/Solar Wind Observations
   - L1 Solar Wind (DSCOVR, IMAP)
   - Coronagraph and Magnetograph
   - Evaluate New Observations and Platforms
   - Establish a SWx Research Program for Effective Research to Operations Transition at NOAA
   - Establish Distinct Programs for Space Physics Research and Space Weather Forecasting and Specification

The Societal and Economic Impacts of Severe Space Weather Events

- May 22-23,2008 in Washington DC
- Approximately 80 attendees from academia, industry, government, and industry associations
  - Association reps aggregated data and helped avoid concerns about proprietary or competition-sensitive data
- Analyses in specific areas; e.g., GPS, power industry, aviation, military systems, human and robotic exploration beyond low-Earth orbit
- Econometric analysis of value of improved SpaceWx forecasts



Plan for continuity of solar and solar wind observations beyond ACE, STEREO and SDO

- Continue ACE solar wind observations with DSCOVR, followed by IMAP. Develop a plan for continuing these observations.
- Continue space-based coronagraph and solar magnetic field.
- Evaluate utility of new observations made from new locations, possibly via different platforms.
- NOAA to establish a program to effectively transition space weather research to operations.
- Distinct funding lines for basic space physics and space

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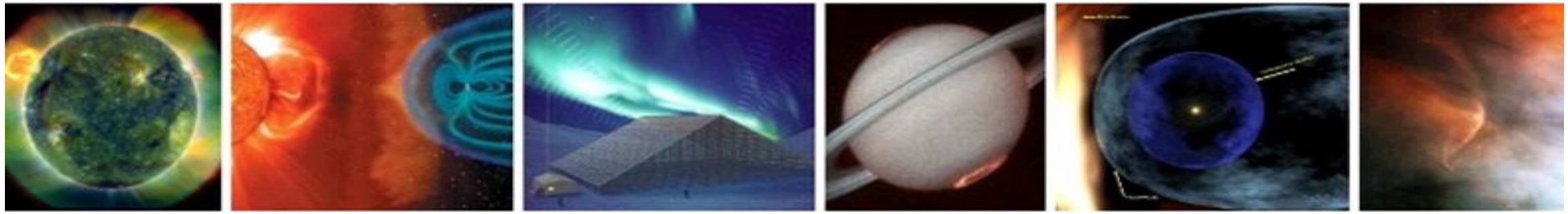
Summary

The 2013-2022 Decadal Survey:

- Fits the current fiscal boundary;
- Focuses on research and its societal impact;
- Empowers the community to innovate, take advantage of the unique constellation of missions and data available today, and study the coupled domains of heliophysics *as a system;*
- Builds the community's strength and facilitates development of cost-effective PI-class missions; and
- Recommends exciting missions of historical significance that hold tremendous promise for new discoveries.



Solar and Space Physics: A Science for a Technological Society

2013-2022: A decade of discovery enabled by new and innovative approaches and tools and by treating heliophysics as a system; focus on societal impact.

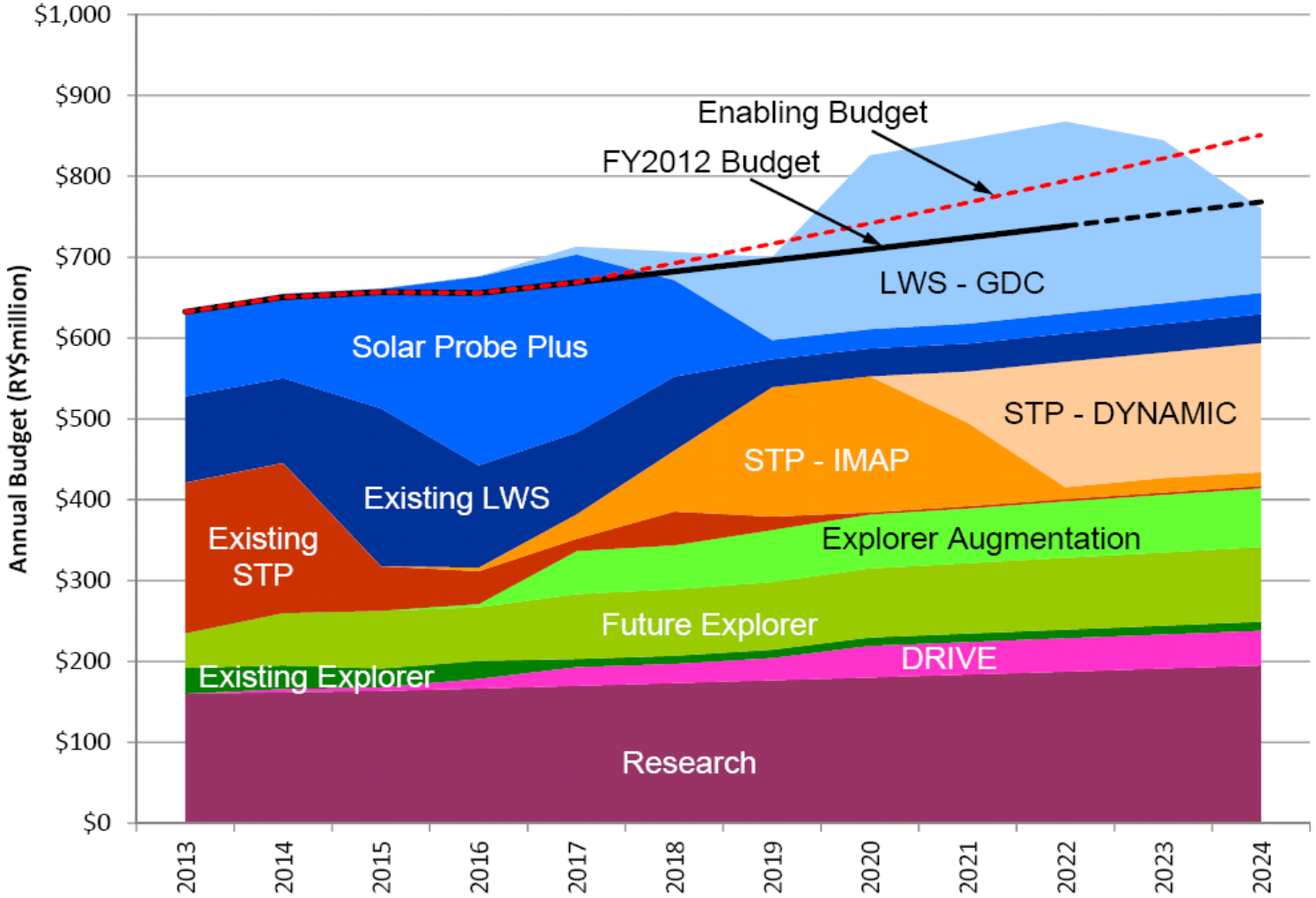
http://www.nap.edu/catalog.php?record_id=13060

Additional Slides

Summary for NASA (in order of priority)

1. Complete implementation of missions that are currently selected
2. Initiation of the DRIVE program
3. Execution of a robust Explorer program
4. Launch of strategic missions in the reinvigorated STP line and in the LWS line to accomplish the committee's highest-priority science objectives. This includes first the notional IMAP investigation and then DYNAMIC and MEDICI in the STP program and GDC as the next larger-class LWS mission.

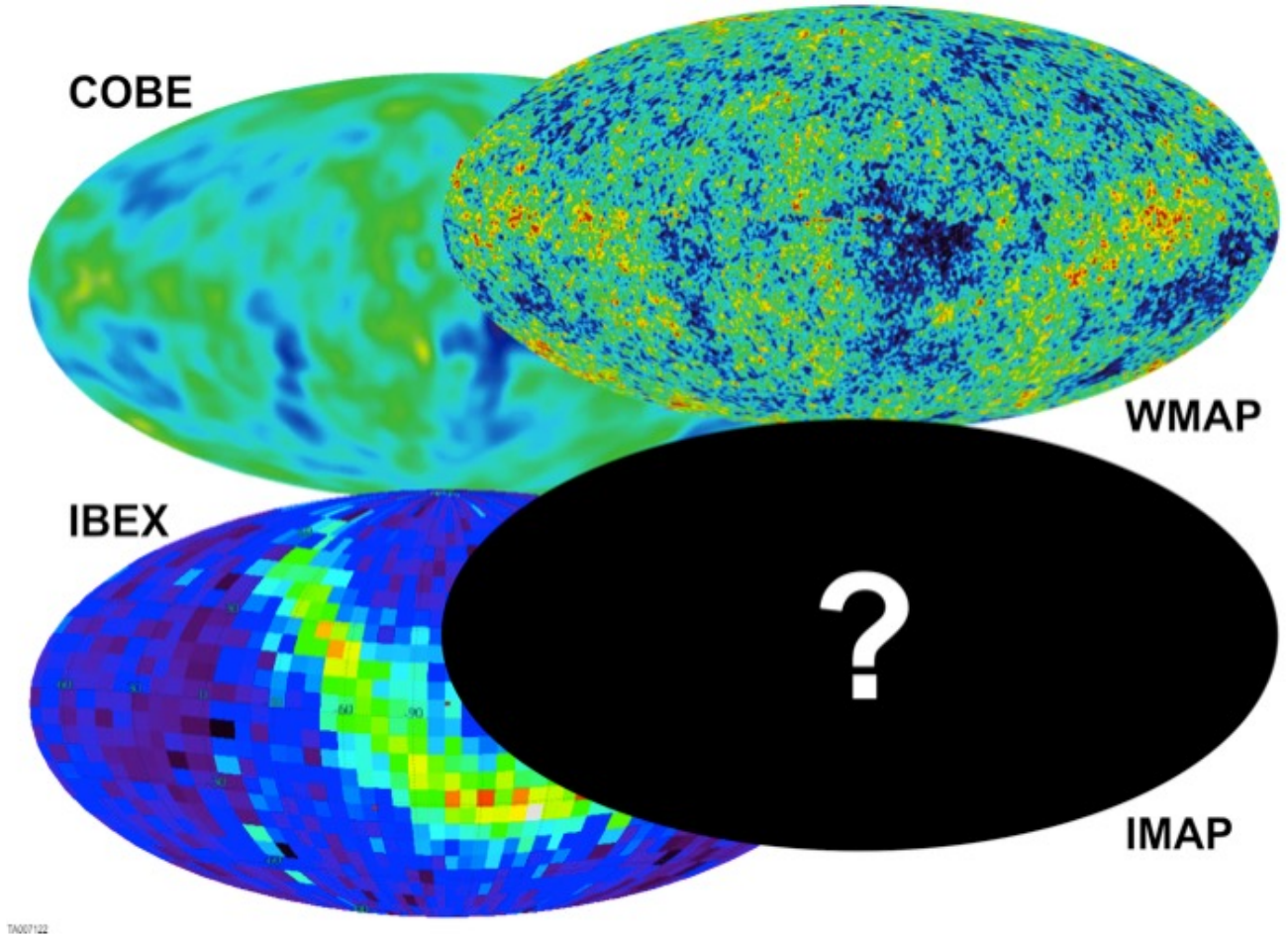
Decadal Plan for NASA's Heliophysics Division



Decision Rules (in recommended order)

1. Missions in the STP and LWS lines should be reduced in scope or delayed to accomplish higher priorities.
   - Report provides explicit triggers for a NASA review of Solar Probe Plus to contain cost and/or program balance.
2. If further reductions are needed, the recommended increase in the cadence of Explorer missions should be scaled back, with the current cadence maintained as the minimum.
3. If still further reductions are needed, the DRIVE augmentation profile should be delayed, with the current level of support for elements in the NASA research line maintained as the minimum.

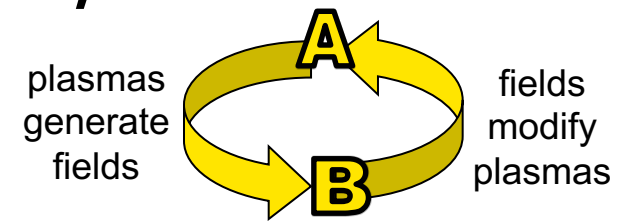
IMAP – Interstellar Mapping & Acceleration Probe

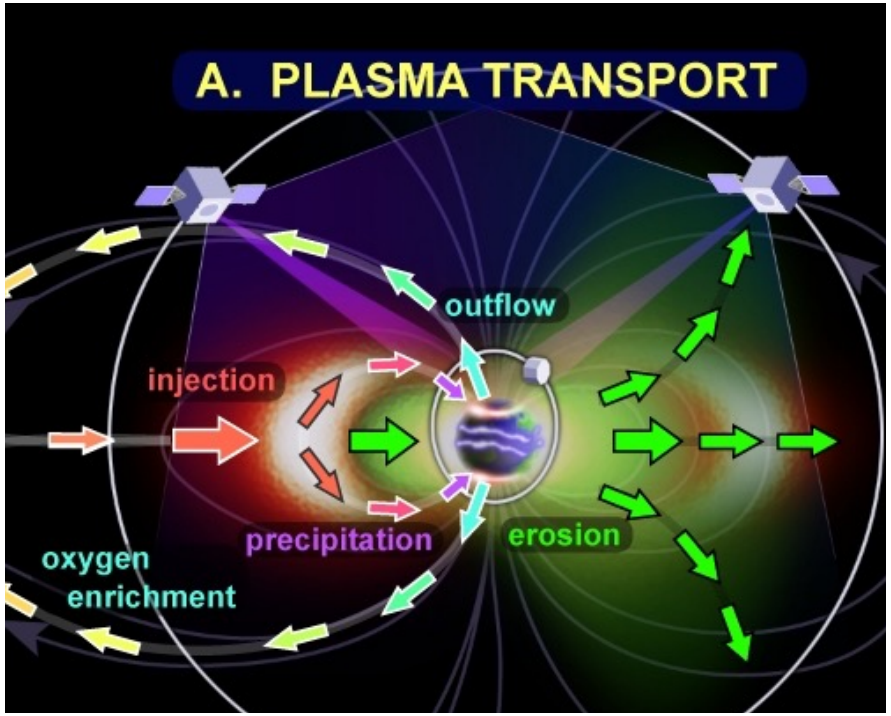


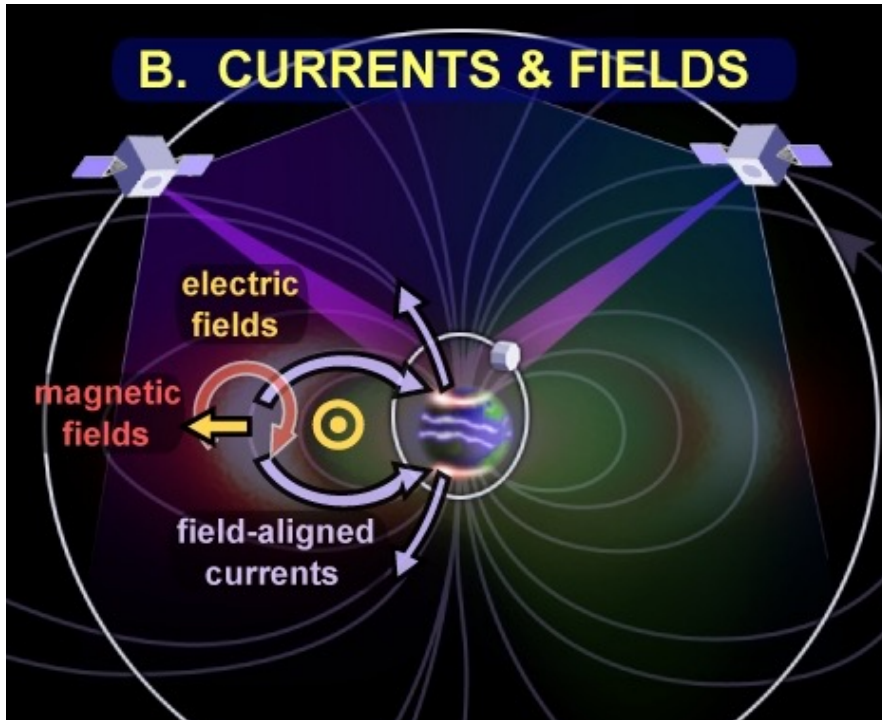
Properties and composition of interstellar medium

- Nature of heliospheric boundaries
- Nature of particle acceleration in this boundary region
- Nature of heliosphere near L1

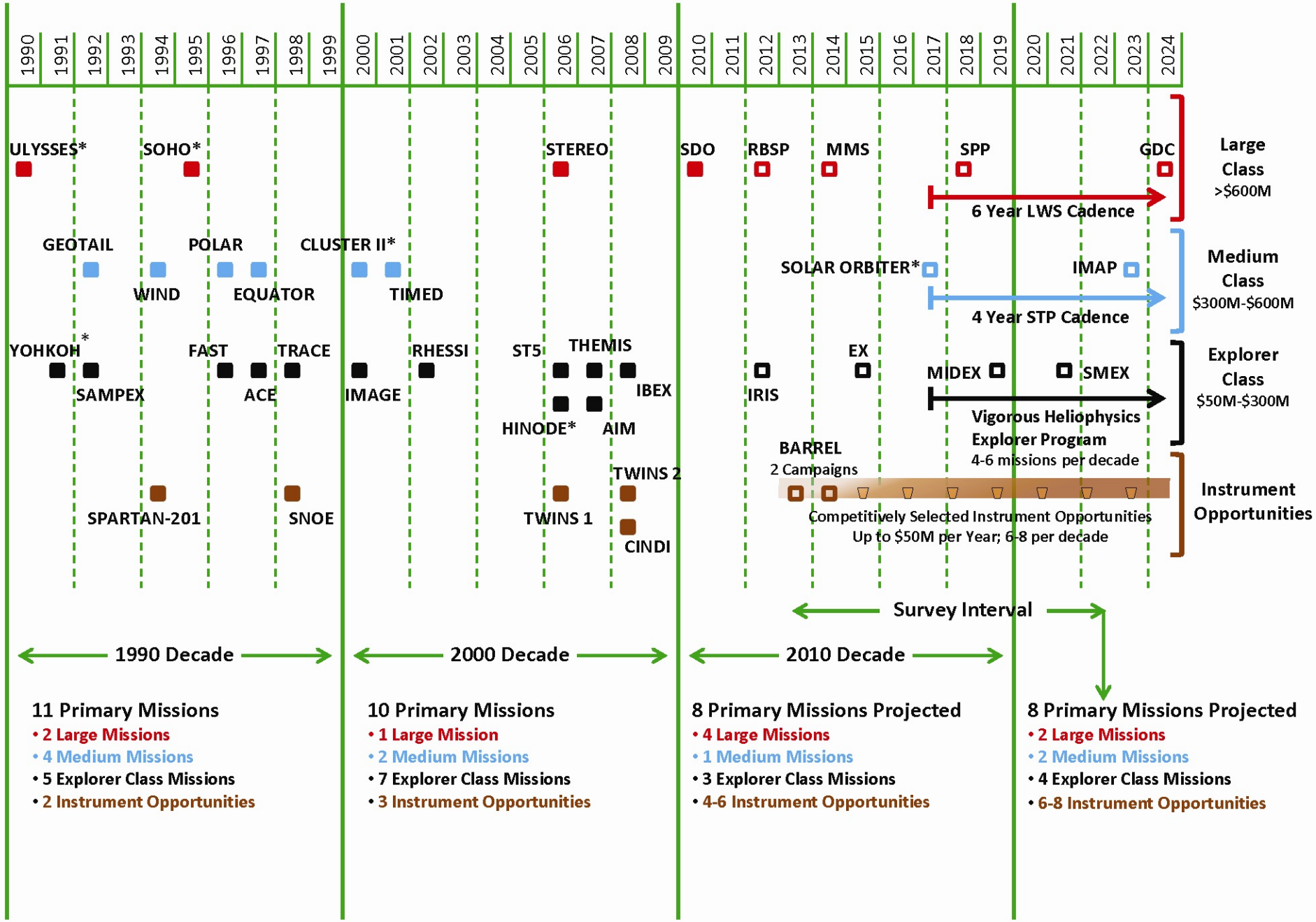
MEDICI (Magnetosphere Energetics, Dynamics, and Ionospheric Coupling)







Historical and Recommended Mission Cadence

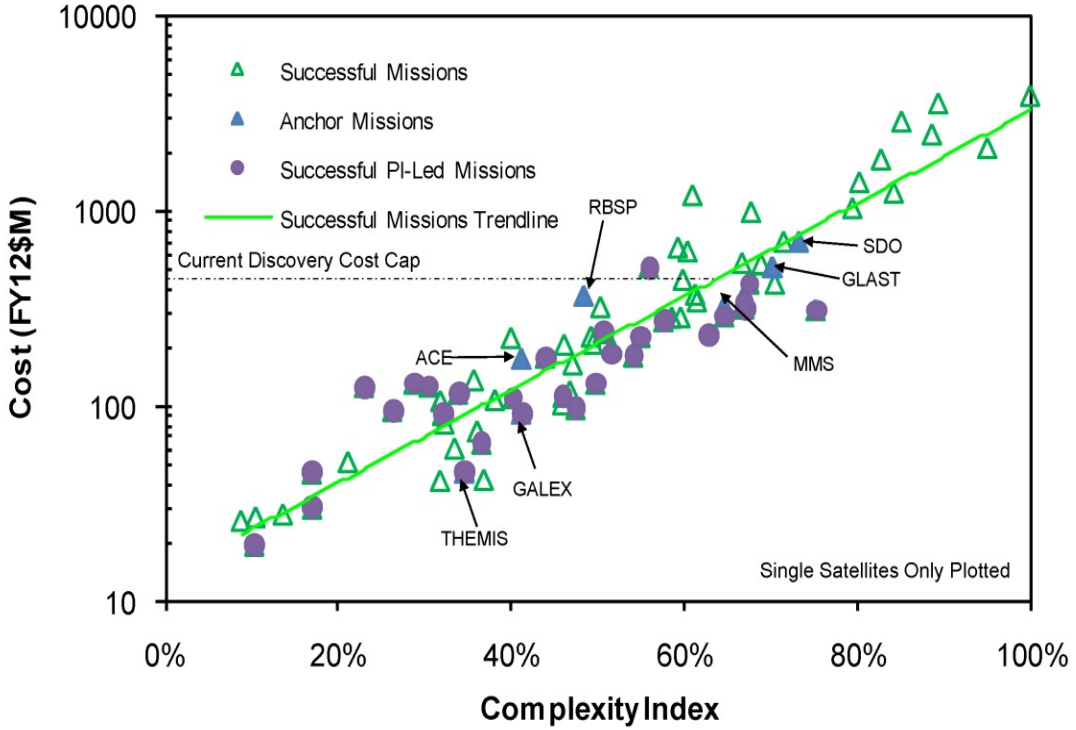


PI-Mode Mission Strategy

- Strategic balancing the portfolio for the coming decade is driven by the need for faster mission cadence and reduced mission cost.
- The PI-Mode development approach is a proven method for managing mission content to achieve maximum science value within a controlled cost structure.
- Historical data demonstrates that the PI-Mode when executed for small and medium Space Physics missions is a statically proven method for achieving cost-effective science.

PI-Mode Complexity-Cost Analysis

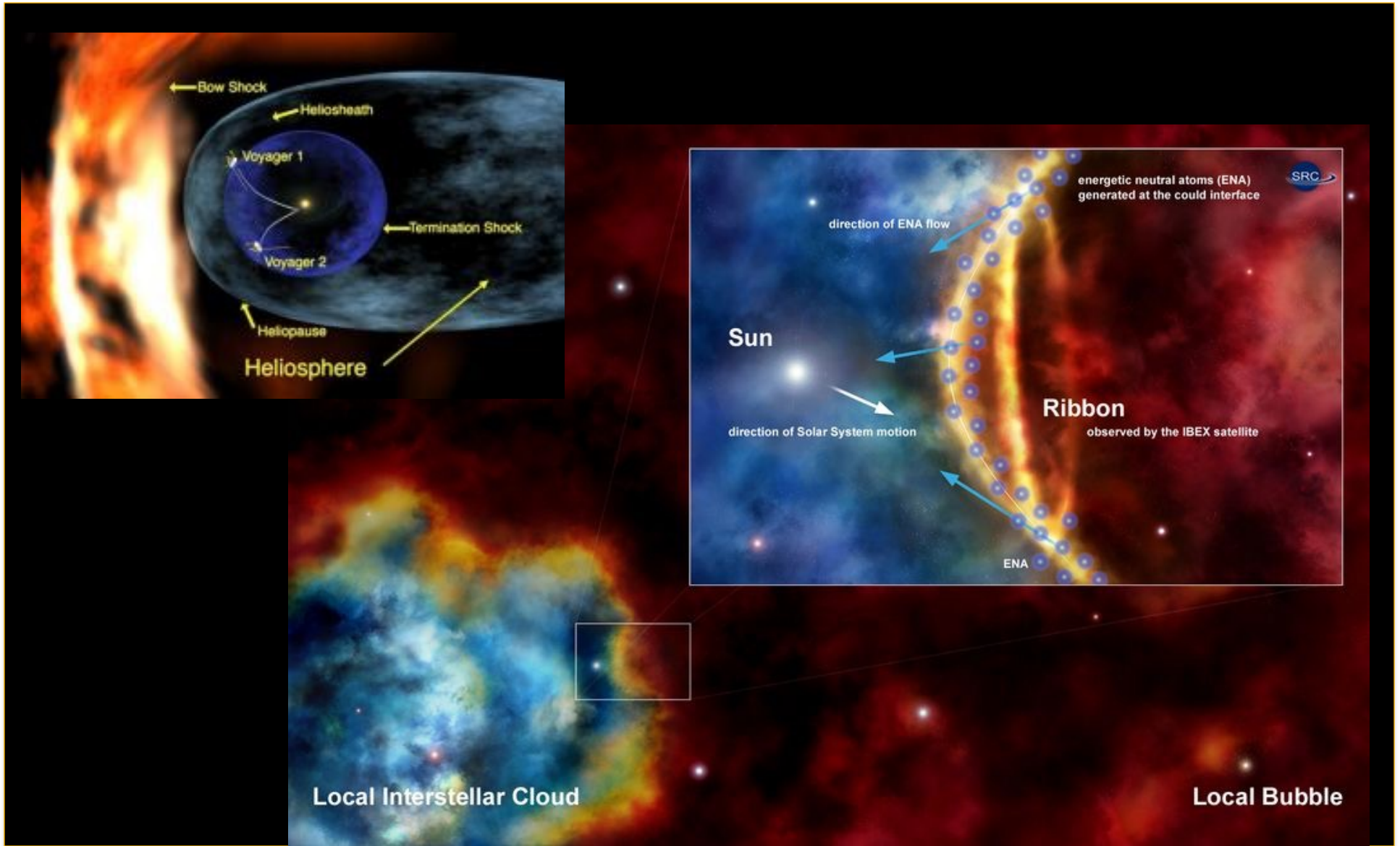
- Analysis by Aerospace Corporation as part of CATE validation process concluded that *"The actual costs of PI-led missions tend to be less than the actual costs of other missions of a comparable complexity ."*
- The figure to the right illustrates this conclusion for missions in the low to mid cost range of 40% to 80% complexity.
- It is important to recognize that the percentage of post-PDR cost growth is not necessarily tied to complexity.
- PI-led missions are by nature cost constrained such that they "managed down" to a lower initial complexity in order to achieve acceptable cost and schedule margin at the time of confirmation.
- Requirements driven missions by their nature tend to grow in complexity and cost prior to confirmation.



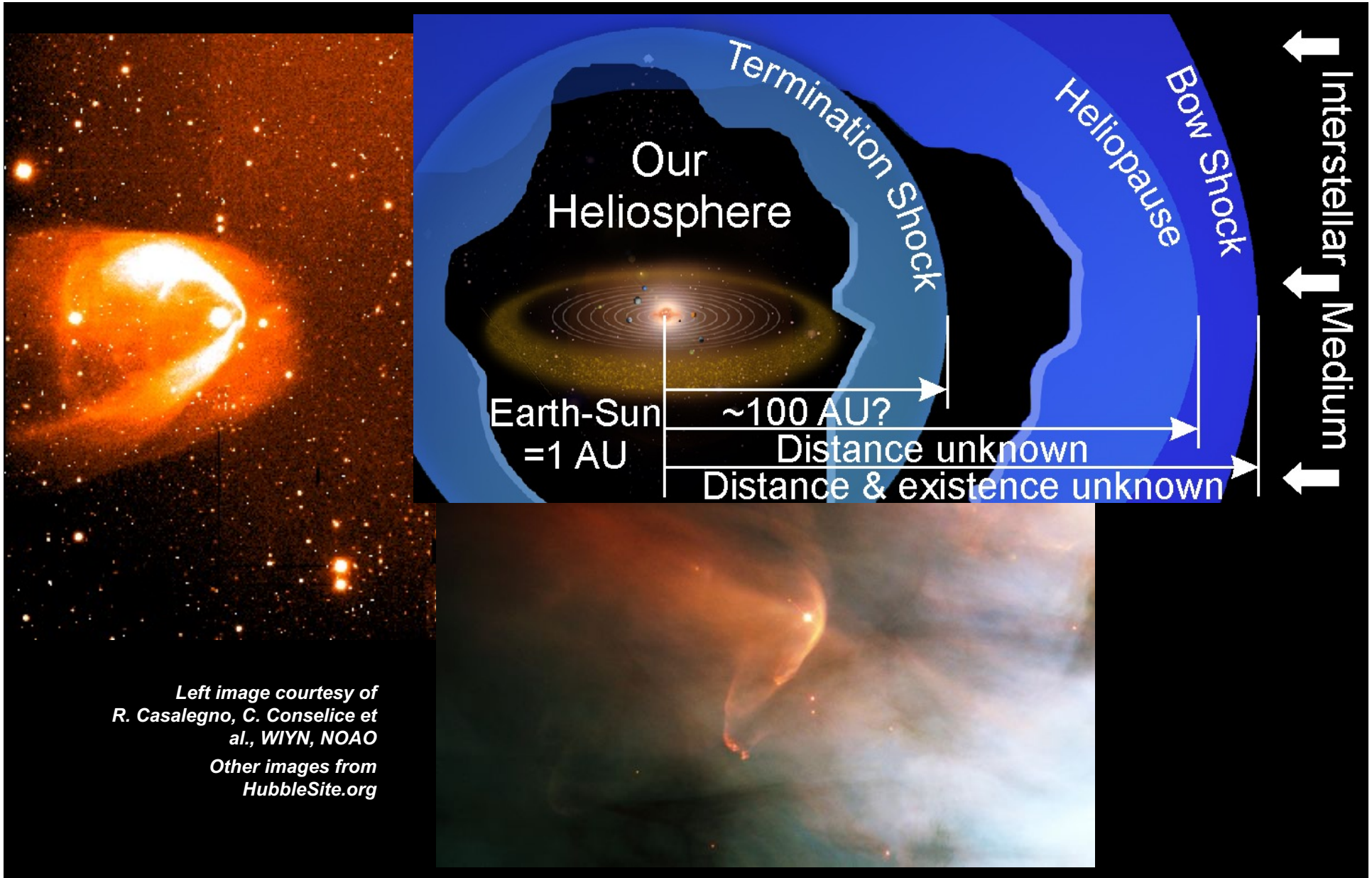
-- 85% of the PI-led missions are below the 50th percentile median trendline.

-- The median cost for these missions is only 70% of the cost of missions of similar complexity.

Voyager and IBEX



Astrospheres and Our Heliosphere

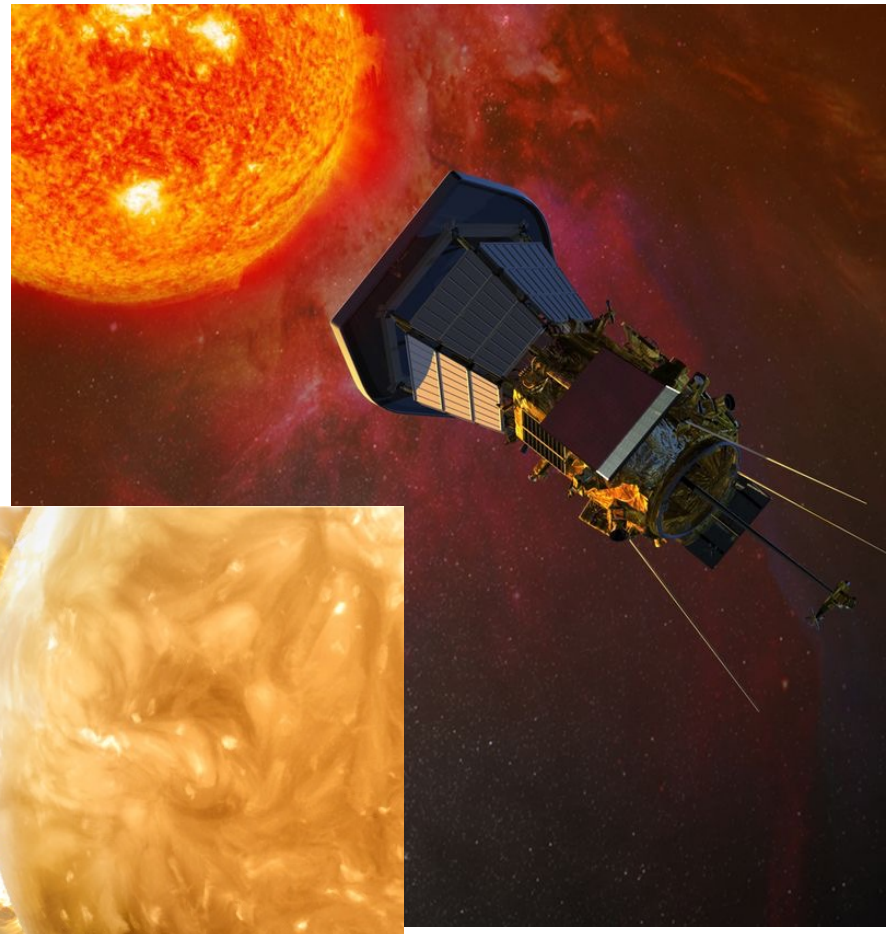


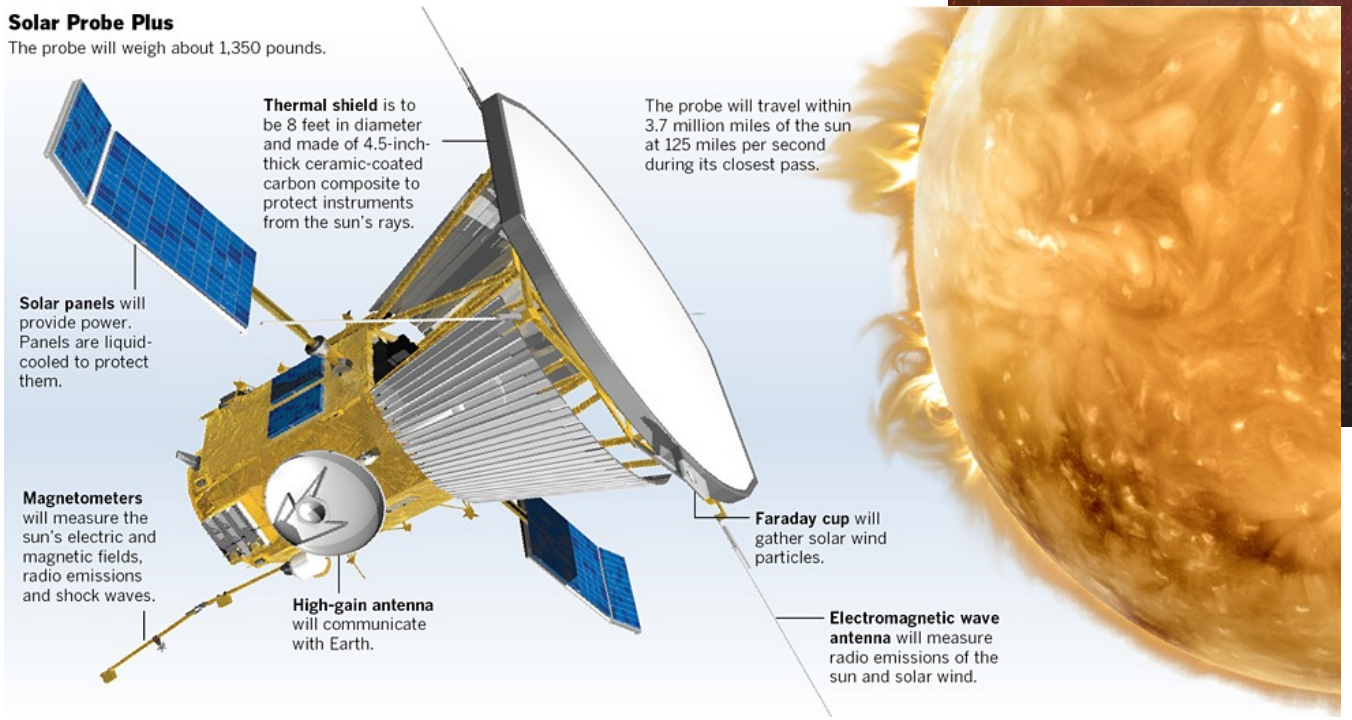
Left image courtesy of R. Casalegno, C. Conselice et al., WIYN, NOAO

Other images from HubbleSite.org

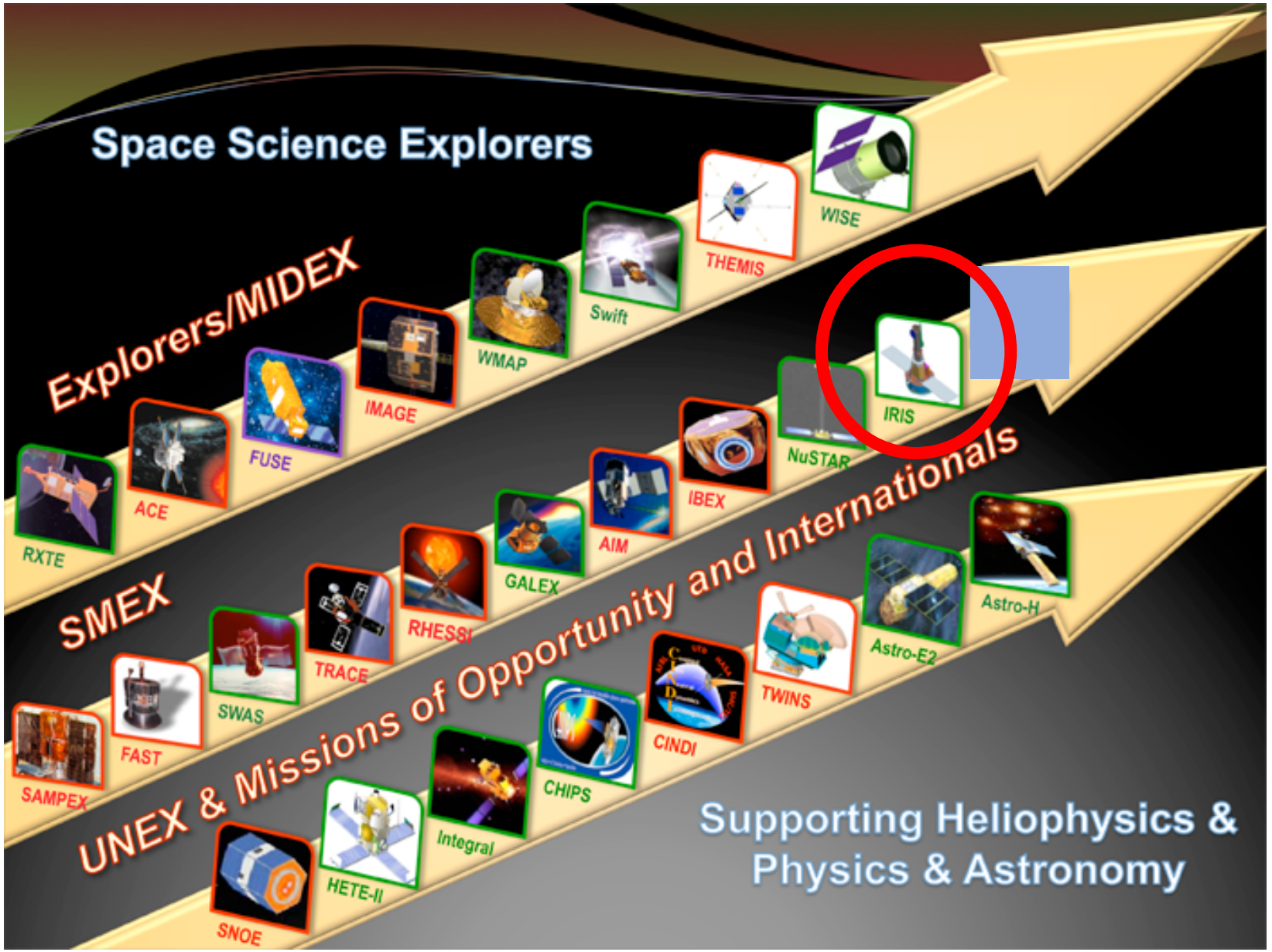
Solar Probe Plus - 2018

Multiple deep passes into solar corona





Explorers: Remarkable Smaller Missions



Dr. Elsayed Talaat
Director, Office of Projects, Planning, and Analysis

NOAA's Next-Gen Earth Observation Strategy

Integrated, Adaptable, and Affordable: Orbits, Instruments & Systems

LEO

Miniaturized instruments on small, lower cost, and proliferated satellites and partner data improving forecasts through better and additional data. Better precipitation forecasts, wave height predictions, ocean currents, and more.

GEO

Continuous real-time observations supporting warnings and watches of severe weather and hour-by-hour changes. High-inclination orbits to observe northern latitude & polar regions.

Space Weather Obs.

Reliably monitoring space weather from all applicable orbits (e.g., L1, GEO, LEO, HEO, L5) to protect the nation's valuable, critical infrastructure. New capabilities at L5 and high earth orbit provide additional insight and improve forecasts.

Common Ground Services

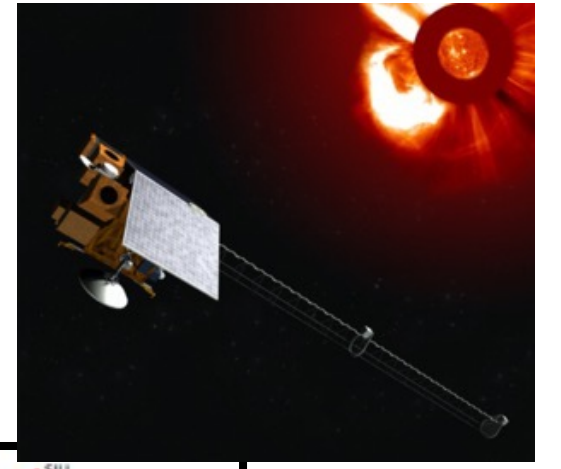
Secure ingest of data in different formats from different partners requires a flexible, scalable platform. Common Services approach integrates cloud, AI, and machine-learning capabilities to verify, calibrate, and fuse data into new and better products and services.

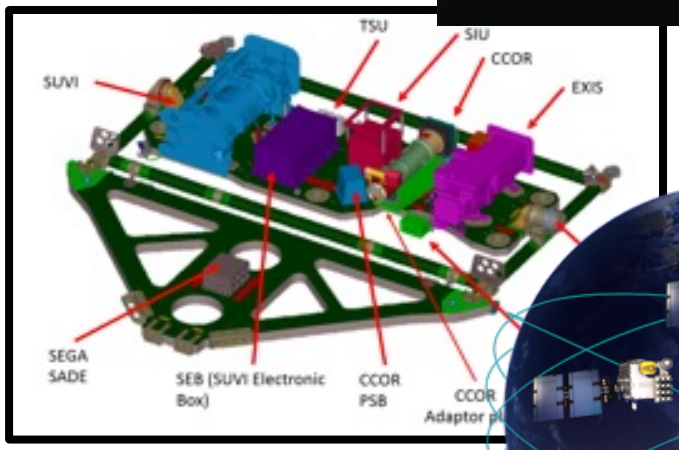
Starting Point – 2025 Program of Record

2025 NOAA Space Weather
Observing Program of Record
Starting point for NASEM Infrastructure Workshop

- SWFO – L1
- GOES–East, GOES–West (CCOR1 on 1)
- COSMIC-2
- GOLD
- Metop – C, SG A1, SG B1
- *ESA – L5 (2027)*

What's next for 2030 and beyond?





NOAA/NESDIS Formulating a Space Weather Observations Program

- Diverse observing requirements must be made from diverse vantage points (LEO, GEO, Sun-Earth line, L1 and off the Sun-Earth line)
- Continuity and anticipated product improvement need dates are varied:
  - Long Lead Instrumentation
  - Next Generation L1 & off-Sun-Earth-axis
  - Space Weather Ground Operations
  - Geostationary Observations
  - Tundra/High Elliptical Orbit Observations
  - Low Earth Orbit Observations
- Program formulation will initialize a loosely coupled program with an initial set of projects.
- NOAA co-sponsoring next NASEM Solar and Space Physics Decadal Survey


National Aeronautics and
Space Administration
NASA
EXPLORESCIENCE
Decadal Survey Preparation
Jared Leisner
Heliophysics Division
NASA
July 26, 2021
https://go.nasa.gov/HelioDecadal

Decadal Survey: What?

- One principal way that NASA solicits and leverages technical expertise from the science community
  - Conducted by the National Academies of Sciences, Engineering, and Medicine (NASEM) Space Studies Board (SSB)

- NASA often partners with other Government Agencies with overlapping/complementary scientific and technical responsibilities
  - Joining NSF and NOAA, robust tri-agency discussions/recommendations
    - Coherent space weather pipeline, basic research to applications to operations

- Important to recognize the impact of a single coherent, concise document that provides the scientific foundation for an Agency strategy
  - Scientific priorities
  - Projects that can complete focused objectives to address the priorities
  - Capabilities that enable or enhance the projects' science return
  - Community that develops the capabilities, executes the projects

Decadal Survey: Why?

- Congressionally mandated in 51 USC §20305
  - Scientific prioritization
  - Technical and cost feasibility of assessed projects “whenever possible”
    - Note: feasibility assessment does not mean recommend a specific project, project implementation
  - Decision rules

- Important to recognize the impact of a single coherent, concise document that provides the scientific foundation for an Agency strategy
  - Prioritize science focuses, both for missions and non-mission activities
  - Inform internal programmatic discussions and to clearly communicate with the Agency’s stakeholders
  - Inform creation or evolution of research programs, planning for new mission concepts, collaborations with NASA and non-NASA partners, and other activities

Decadal Survey: Vision

- Strategy to advance and expand the field
  - Significant successes in our field in the past decade
  - Space science is growing, our science is necessary for success
  - Strategic progression
    - Where are we this decade?
    - Where will we be next decade?
    - Where do we want to be the decade after that?

- Solar Terrestrial Probes, Living With a Star programs
  - NASA has reframed to better distinguish (Mid-term Rec. 6.5)
  - Recommendations focus on science objectives, strategy
  - Flexibility for NASA to implement, maintain healthy programs
  - Expect range of mission sizes, mix of PI-led and directed

Decadal Survey: Vision

- Multi-decadal strategy, each decade should complete its science and prepare for the next decade's
  - Decadal mid-term assessment: Recommendation 6.1.
- Expanding the frontiers of solar and space physics: stellar systems, exoplanets, habitability, supporting human exploration
  - Decadal mid-term assessment: Finding 3.15. Recommendation 3.2.
  - NASEM: *Astrobiology Strategy for the Search for Life in the Universe*, *Exoplanet Science Strategy*
- Data, code, computing infrastructure/computing
  - Decadal mid-term assessment: Finding 3.10, 3.18, 5.3, etc. Recommendation 3.2.
  - NASEM: *Open Science by Design*, *Open Source Software Policy Options for NASA Earth and Space Sciences*
- State of the Profession
  - Decadal mid-term assessment: Finding 5.5. Recommendation 5.1.
  - NASEM: *Increasing Diversity and Inclusion in the Leadership of Competed Space Missions*, *Foundation for Assessing the health and Vitality of the NASA Science Mission Directorate's Research Communities*

Decadal Survey: Community Engagement

- Heliophysics 2050
  - Community initiation, leading of the pre-decadal conversation
  - Pre-Workshop, Post-Workshop discussion groups
  - Topics
    - Disciplinary science, interdisciplinary science, expansionary science
    - Space weather activities
    - Solar and space physics community

- Heliophysics Mission Concept Studies
  - Mission concepts for Solar Terrestrial Probes

- Living With a Star Architecture Study

https://go.nasa.gov/HelioDecadal

Questions?

https://go.nasa.gov/HelioDecadal

GEM Update on the Solar and Space Physics Decadal from the National Science Foundation

Dr. Lisa Winter

Division of Atmospheric and Geospace Sciences

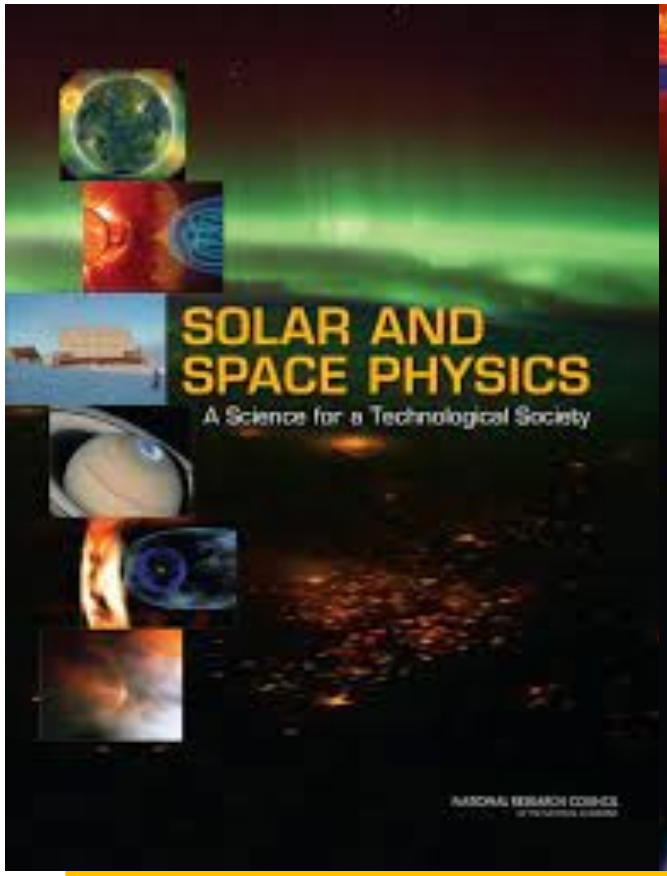
Solar and Space Physics Decadal

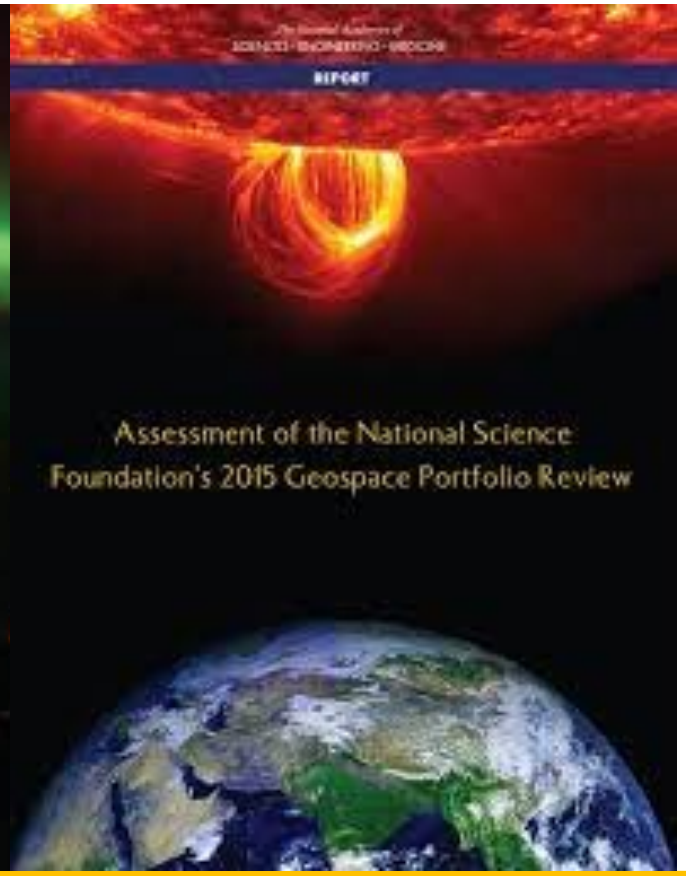
Participating NSF Programs

- Division of Atmospheric and Geospace Sciences
- Division of Astronomical Sciences
- Division of Physics
- Office of Polar Programs

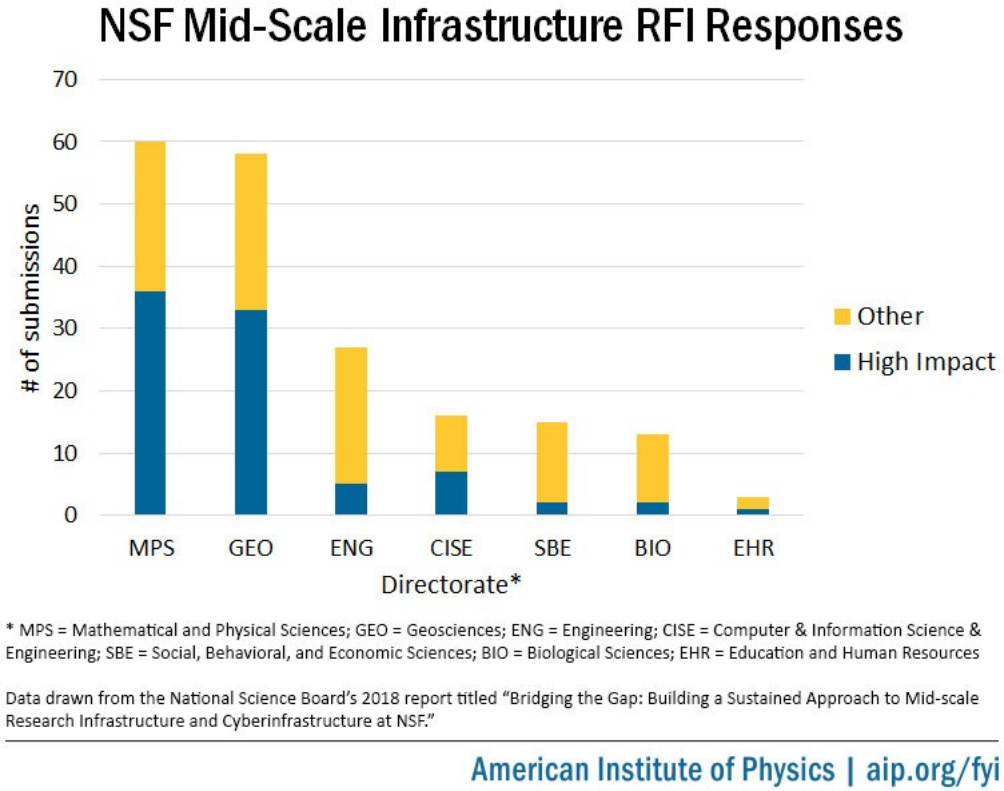
To Define:

- The **SCIENCE** Priorities
- The **INFRASTRUCTURE** needed to achieve the science
- Support for the diverse range of the **PEOPLE** we want to be engaged in science

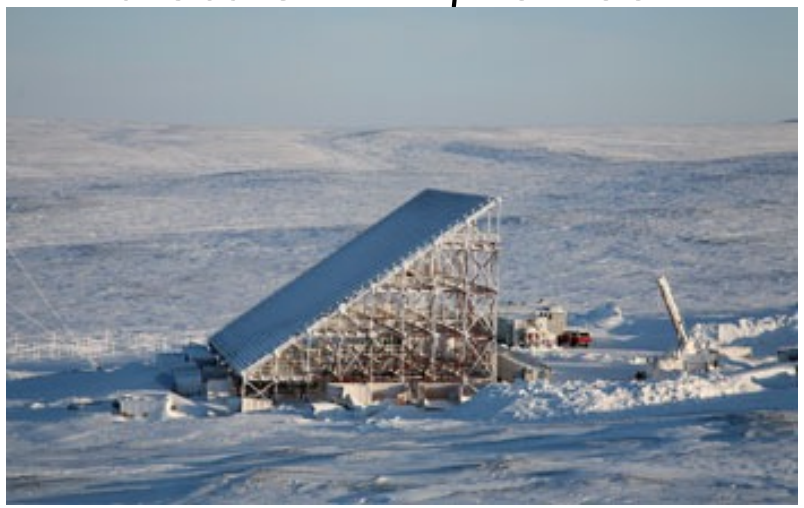

SOLAR AND
SPACE PHYSICS
A Science for a Technological Society


REPORT
Assessment of the National Science
Foundation's 2015 Geospace Portfolio Review

Research Infrastructure

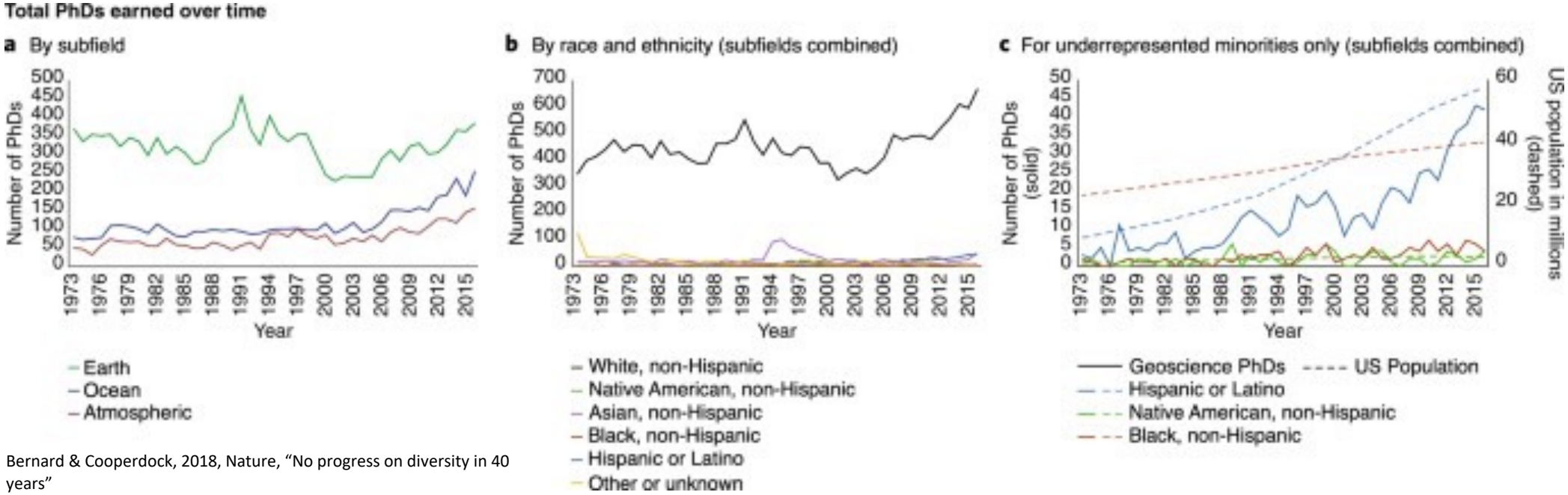


- Defining the Next Generation Ground-based Facilities
- NSF Mid-Scale Research Infrastructure
  - Mid-Scale RI 1: $6-20M
  - Mid-Scale RI 2: $20-100M



Support for the Community of Researchers

- Early-career scientists
- Diversity, Equity, and Inclusion
- **Broader Impacts**
- Where are we and how can we



Bernard & Cooperdock, 2018, Nature, "No progress on diversity in 40 years"