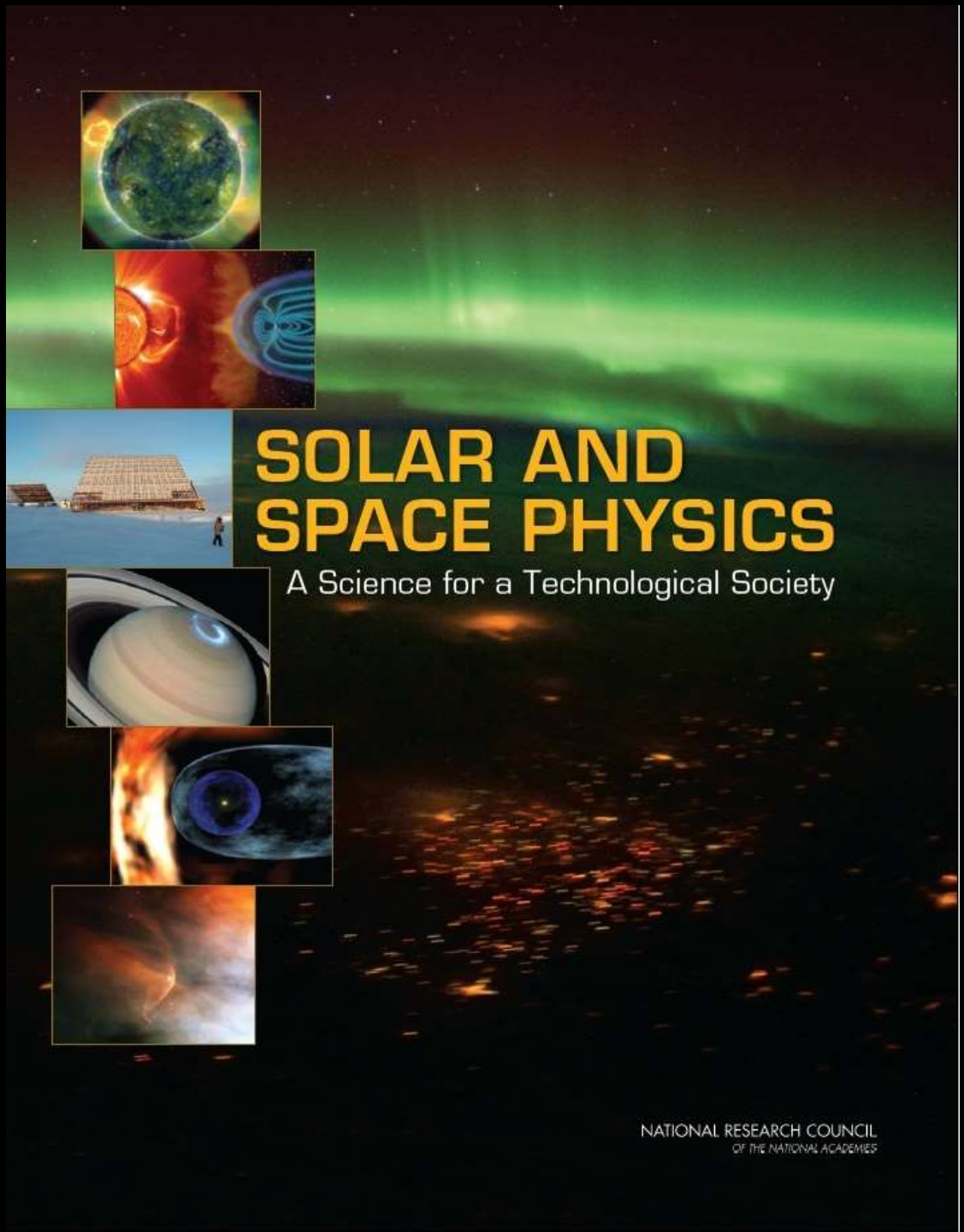


The 2013-2022 Solar and Space Physics Decadal Survey:

The Chair's One-Year (and a Half) Perspective

Daniel N. Baker
NRC Decadal Survey
Steering Committee

(LASP-CU/Boulder)

Initial Recognition

- Plans are useless—Planning is indispensible

  General Dwight D. Eisenhower

Characteristics of Study

- Study initiated in Fall 2010.
- National in scope, including NASA, NSF, NOAA and DOD investments in solar and space physics
- Review was community based
  - 300 white papers with ideas and new concepts
  - Numerous town-hall meetings and workshops
  - 85 NRC-appointed participants
  - 18 Steering Committee members
- Recommended program fit to available resources.
  - Cost and technical evaluation (CATE) of selected NASA reference mission concepts performed by the Aerospace Corp., which worked under contract with the NRC.
- Considered challenging financial constraints

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.

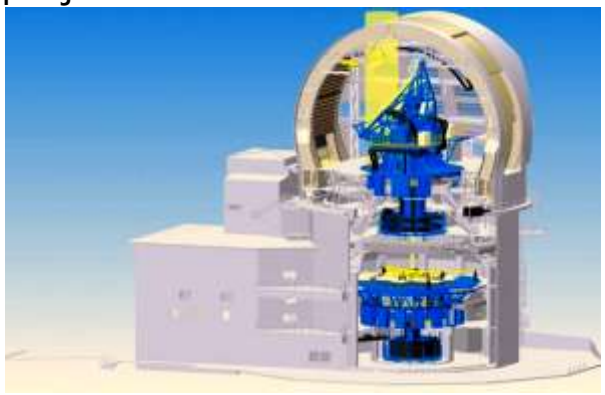
Complete the Ongoing Program

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

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.**
  - **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.**

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.**

2. Accelerate and Expand the Heliophysics Explorer Program

- The recommended augmentation of the Explorer line ($70 million/year) 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***

Living with a Star

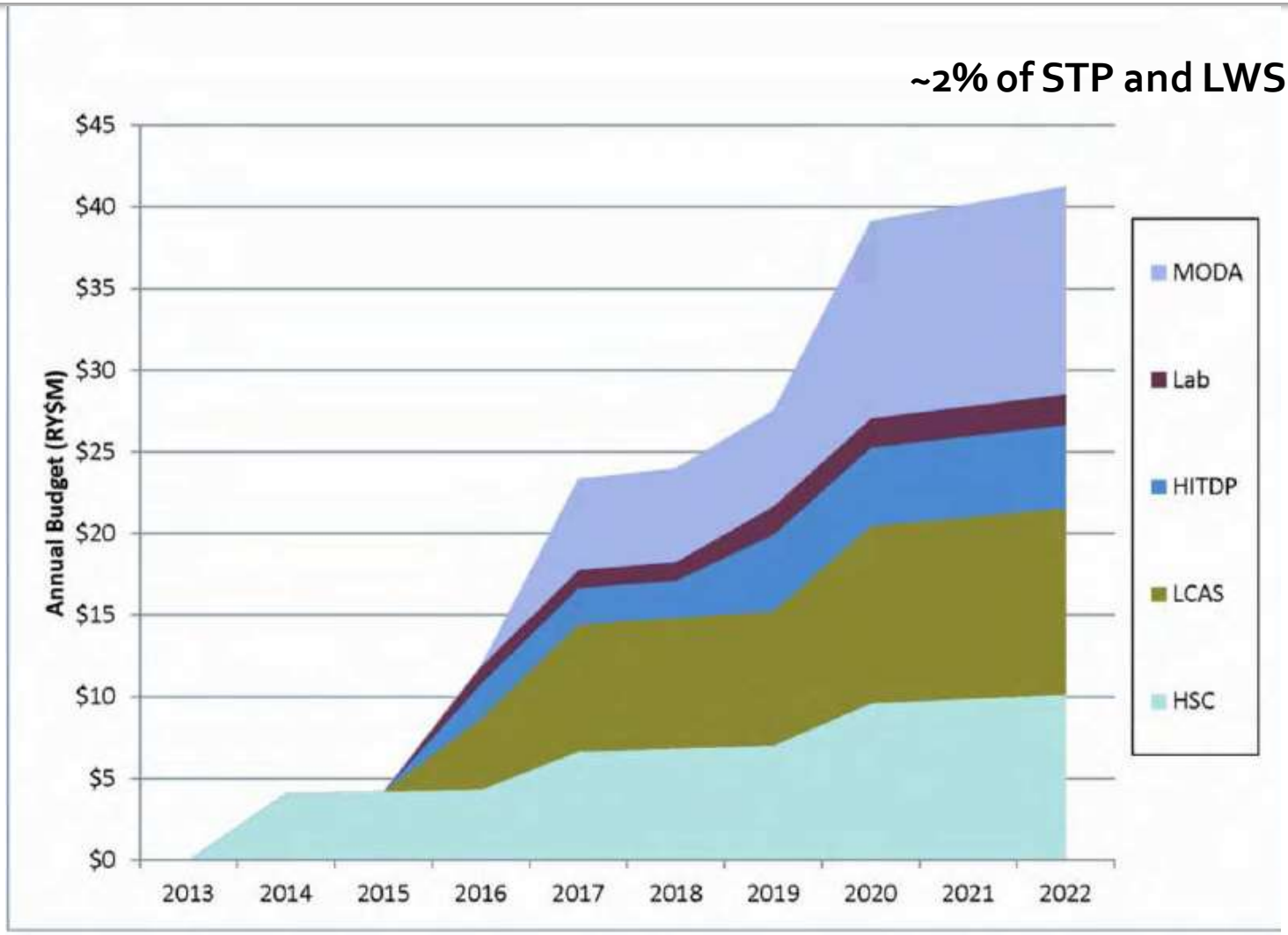
- LWS: Missions, Targeted Research and Technology Programs
- Survey committee does not recommend changes to the organization of LWS missions, which have been highly successful.
  - Large-class mission line.
  - Center-led.

1.Implement the DRIVE Initiative

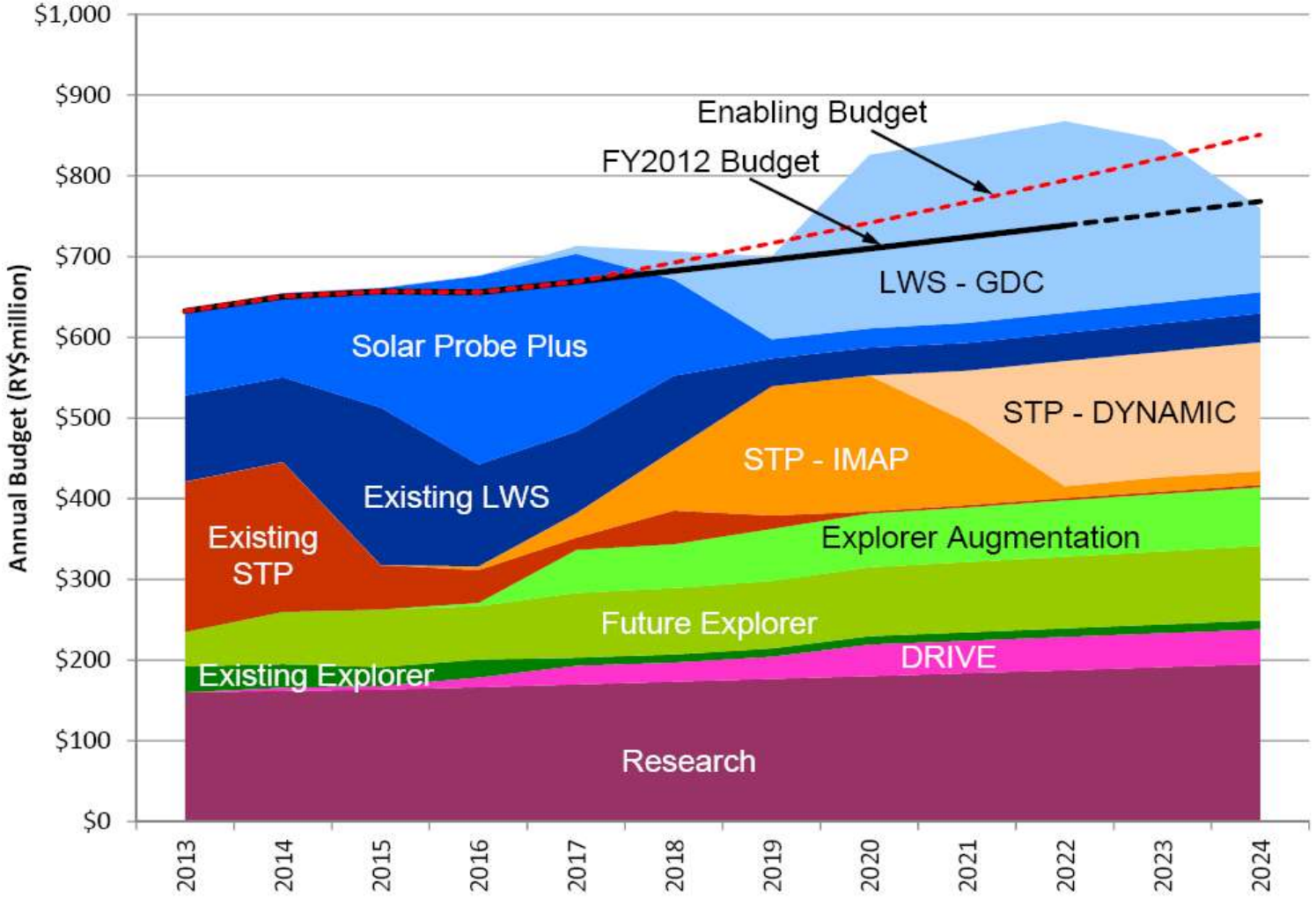
- **Will enable NASA, NSF and other agencies to more effectively exploit their scientific assets:**

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

Implementation of DRIVE at NASA



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.

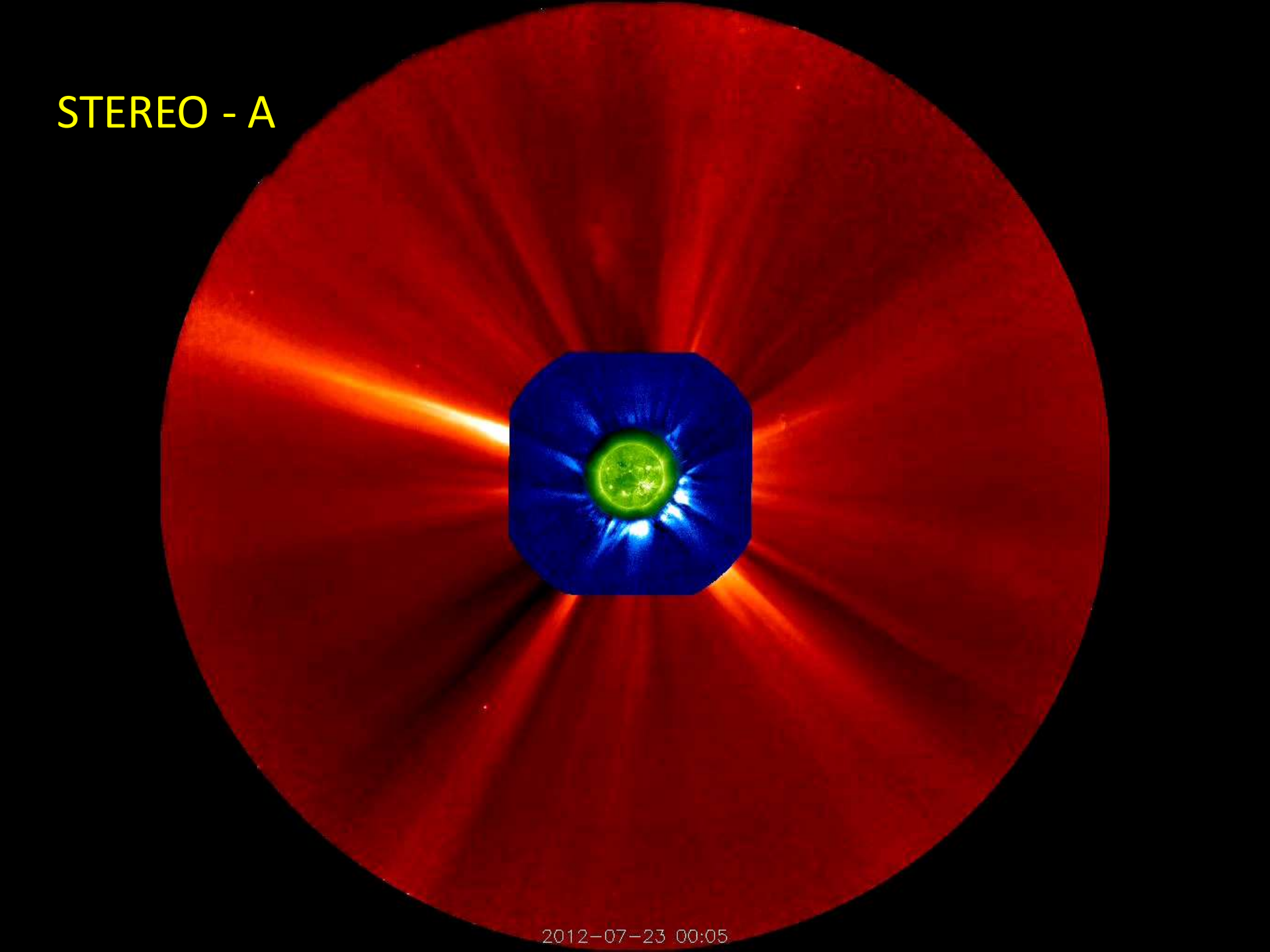
Assessment

The 2013-2022 Decadal Survey:

- Joins (the rubble heap?)--Earth Science, Astro, and Planetary studies;
- Has been eviscerated by budget actions of NASA, OMB, Congress;
- Requires immediate intervention by NASA leadership to salvage any hope of even minimal accomplishments;
- Has little hope of getting started on larger goals in this designated decadal interval; and
- Calls into question the value, utility, and credibility of the National Academy processes in the present budgetary and political climate.

Background: Space Weather

- 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.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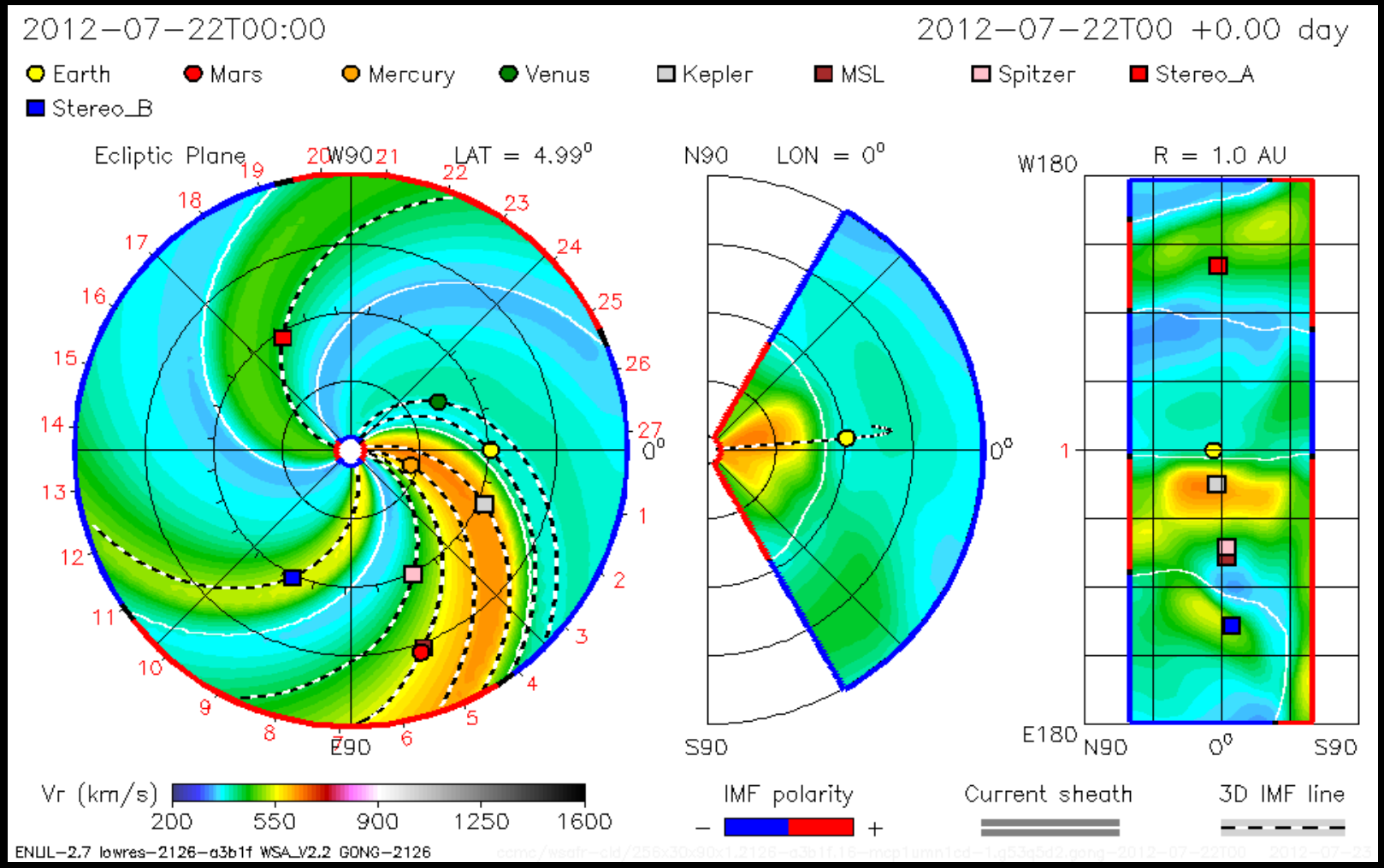
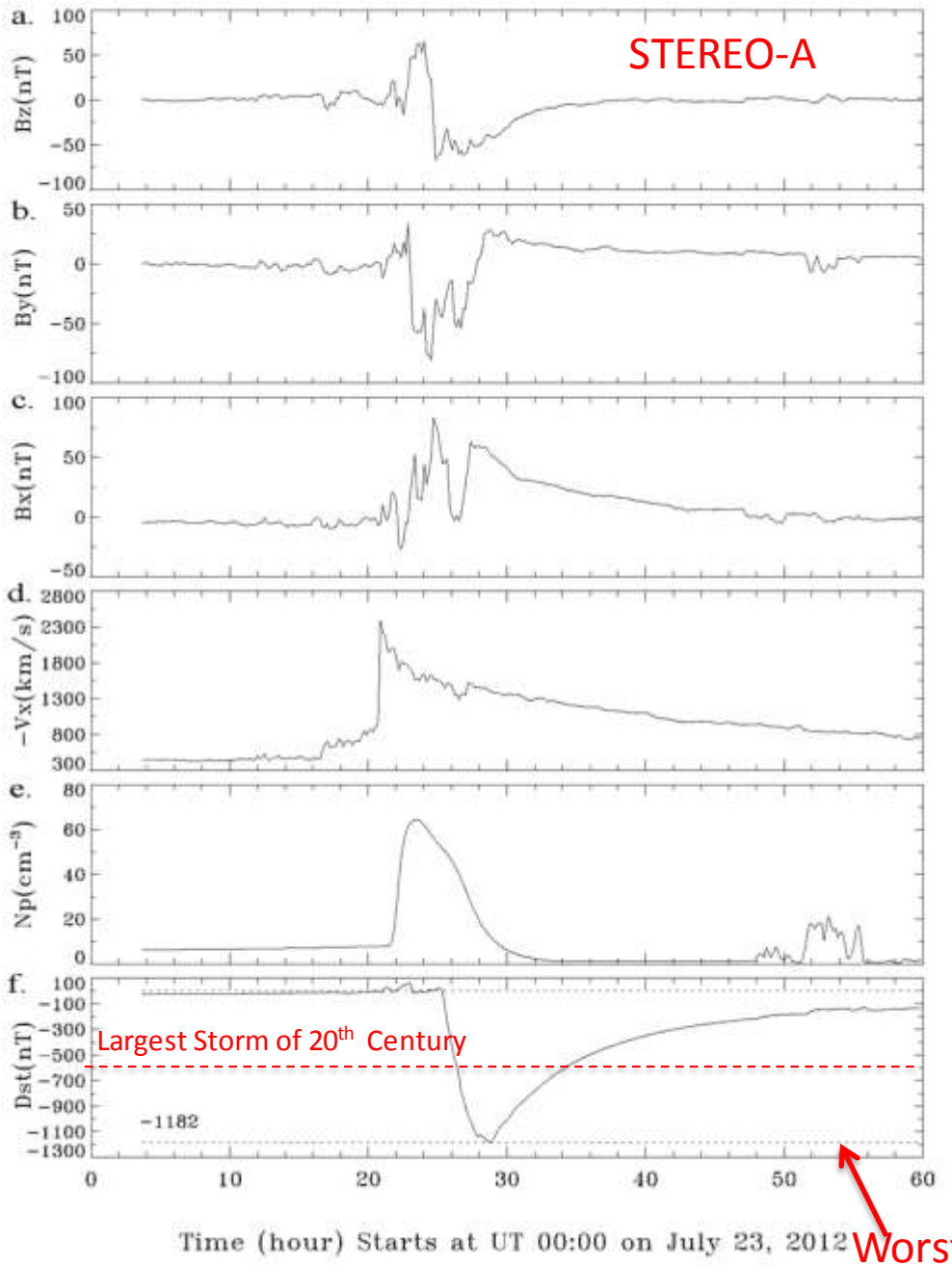
WSA-ENLIL Model: Solar Wind Speed





IMF Bz

IMF By

IMF Bx

Solar Wind Speed

Solar Wind Density

Storm Time (Ring Current) Index, Dst

Worst case: 24 July 2012

[Baker et al., **Space Weather**, 2013]

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.

Key Steps From EIS Summit (London, May 2012)

- **Establish severe space weather working group** to identify and define the most reasonable extreme space weather event(s) that might be the basis for operators of the bulk power grid and for system engineers to base threat analysis upon;
- **Identification of the critical infrastructures and facilities** that MUST continue to have power across the nation during extreme space weather events or during EMP attack scenarios (spearheaded by FERC);
- **Detailed modeling of the effects and interconnections of the national power grid** under the influence of severe space weather (Point 1. above) or other threat such as EMP attack (undertaken by companies, system engineers, and operators with the protection of key assets in Point 2. above);
- **Specific and detailed work to identify techniques and engineering solutions that would keep GIC (or EMP) isolated** from key infrastructure (blocking solutions). This would require work by power engineers and transformer experts.

D. N. Baker, Space Weather Journal, July 2012)

Summary

The 2013-2022 Decadal Survey:

- Fit the 2012 fiscal boundary;
- Focused both on research and its **societal impact**;
- Endeavored to empower the community to innovate, take advantage of the unique constellation of missions and data available right now and to **study the coupled domains of heliophysics *as a system*;**
- Strove to build on the community's strength and to facilitate development of cost-effective PI-class missions; and
- Recommended exciting missions of historical significance that held tremendous promise for new discoveries that could also **serve powerfully the needs of Space Weather**.

Epilogue

It is hard to put into words the disappointment I feel:

- National Academy leadership has been found wanting;
- NASA has failed to commit to any planning fidelity;
- The EOP has effectively abandoned NASA (and space science leadership);
- Congress pays lip-service to space and Earth science, but has no real commitment to the program;

Can we build new partnerships and leverage new possibilities?

- Dave Chenette – HPD
- Kathy Sullivan – NOAA
- France Cordova – NSF

If NASA, Academies, and partner agencies don't act now, I despair of any sensible space research program surviving.