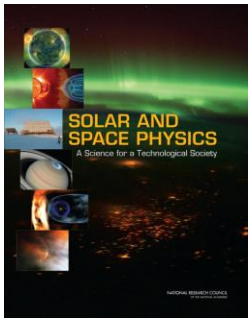
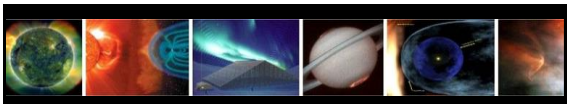
ASTR 4800 - Space Science: Practice & Policy

Today: Guest lecture by Professor Dan Baker, LASP, on *The Decadal Strategy for Solar & Space Physics*

- Next Class: *The Authorization & Appropriations Process in Congress.*
- Chapter 4 in Beyond Sputnik.
- Interview paper due on Oct. 28.



1



The 2013-2022 U.S. National Academies' Decadal Survey in Solar and Space Physics (Heliophysics)

National Academy of Sciences, Engineering, and Medicine (NASEM) Report

2

2

Decadal Surveys

- What-–in essence—is a "Decadal Survey"?
- Who are the targets for a decadal survey?
- What are the possible benefits for a decadal?

3

3

Decadal Survey Purpose and OSTP* Recommended Approach

Decadal Survey benefits:
- Community-based documents offering consensus of science opportunities to retain US scientific leadership
- Provides well-respected source for priorities & scientific motivations to agencies, OMB, OSTP, & Congress

Most useful approach:
- Frame discussion identifying key science questions
  - **Focus on what to do, not what to build**
  - **Discuss science breadth & depth (e.g., impact on understanding fundamentals, related fields & interdisciplinary research)**

*From "The Role of NRC Decadal Surveys in Prioritizing Federal Funding for Science & Technology," Jon Morse, Office of Science & Technology Policy (OSTP), NRC Workshop on Decadal Surveys, November 14-16, 2006

4

4

Objectives of Decadal Survey

- Provide an overview of the science and a broad survey of the current state of knowledge in the field
- Identify the most compelling science challenges
- Identify the highest priority scientific targets for a ten-year interval
- Develop an integrated research strategy

5

5

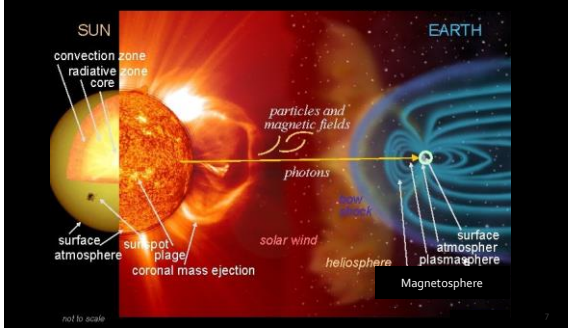
Characteristics of Study

- 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 NASEM-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 Academies.
- Considered challenging financial constraints

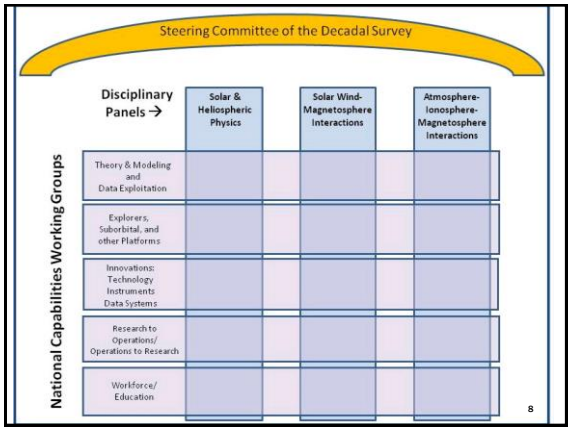
6

6

The Sun-Earth System



7



8

Overarching Goals
for a Decade of Discovery

- Determine the origins of the Sun's activity and predict the variations of the space environment.
- Understand the dynamics and coupling of Earth's magnetosphere, ionosphere, and atmosphere and their responses 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.

9

9

Summary for NASA (in order of priority)

1. Complete implementation of missions that were previously selected
2. Initiate the DRIVE program
3. Execute a robust Explorer program
4. Launch strategic missions in the reinvigorated Solar Terrestrial Probe (STP) line and in the Living With a Star (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).

10

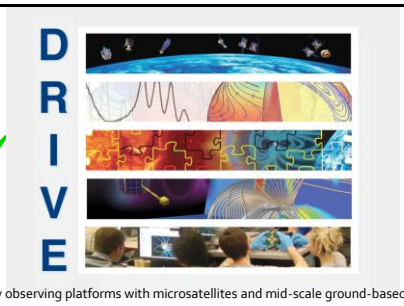
10

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
  - For NASA: complete Radiation Belt Storm Probes, Magnetospheric Multiscale, Solar Probe Plus, Solar Orbiter; also IRIS and other Explorer selections. ✓
  - For NSF: complete Advanced Technology Solar Telescope. ✓

11

11



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

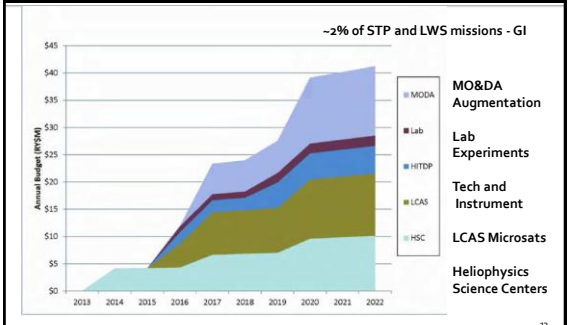
Venture forward with science centers and instrument and technology development

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

12

12

Implementation of DRIVE at NASA

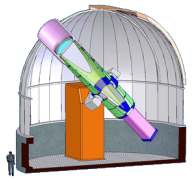


13

13

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.



14

14

Accelerate and Expand the NASA 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 Missions of Opportunity (MOOs).

15

15

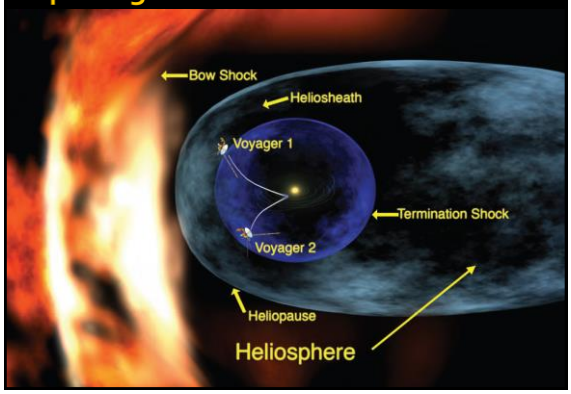
Restructure Solar-Terrestrial Probes as a Moderate-scale PI-led Line

- 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 ~$500 million per mission in fiscal year 2012 dollars including full lifecycle costs.

16

16

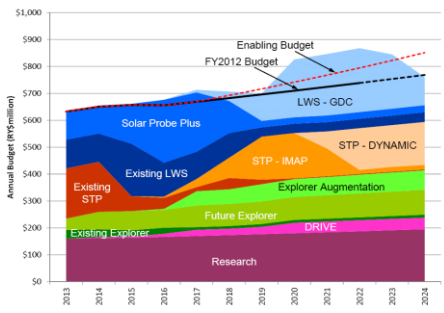
Exploring the Local Interstellar Medium



17

17

Decadal Plan for NASA's Heliophysics Division



18

18

Decision Rules (in recommended order)

1. Missions in the STP and LWS lines should be reduced in scope or delayed to accomplish higher priorities.
2. If further reductions were 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 were 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.

19

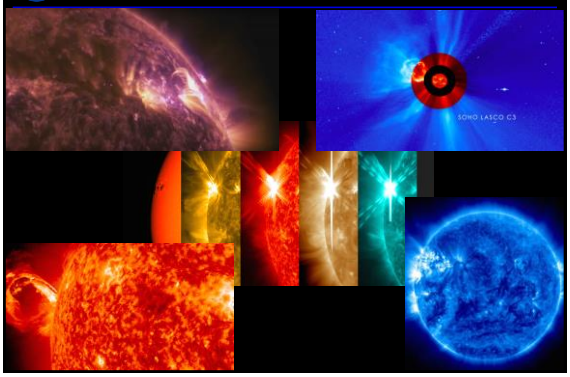
19

Progress Since Survey Rollout

20

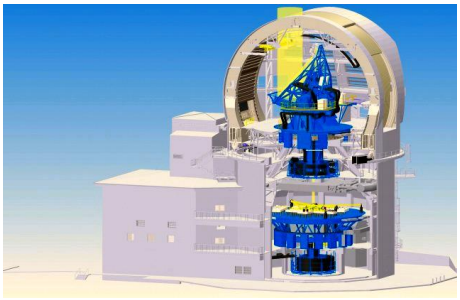
20

Comprehensive Solar Observations



21

NSF's Daniel K. Inouye Solar Telescope



22

22

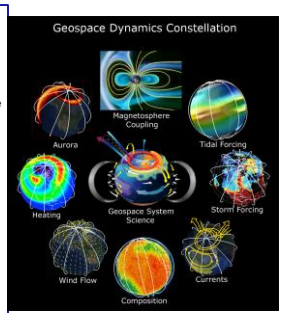
Expected Outcome → Major impact to our knowledge of I/T/Mag System and its coupling to the Sun, Space Weather effects

Geospace Dynamics Constellation will provide:

Breakthroughs in our understanding, providing simultaneous, self-consistent global patterns at 320-450 km of key parameters and interconnections that produce the dynamical global interaction between the atmosphere-ionosphere and the magnetosphere/solar wind.

Unprecedented knowledge, for example of how global upper atmospheric winds, neutral density and E-fields (ion drifts) and currents respond to variations in solar EUV irradiance, tropospheric forcing, and solar wind/magnetospheric driving.

Global, simultaneous measurements as input for data-starved models that will of great benefit for both ionospheric/thermospheric and magnetospheric research as well as large variety of space weather applications.



23

Addressing Space Weather

24

Space Weather Recommendations (prioritized)

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

25

National Space Weather Action Plan

A National Space Weather Action Plan (NSWAP) establishes a process to implement the National Space Weather Strategy

The NSWAP establishes specific activities with:

- implementation timelines
- detailed actions
- specific agency assignments

26

Congressional Response and Actions

For Immediate Release
April 20th, 2016
Contact: Gardner Press Office, 202-224-5941

Gardner, Peters, Booker Introduce Bipartisan Legislation to Improve Efforts to Predict, Respond To Space Weather Events

WASHINGTON, DC - U.S. Senators Cory Gardner (R-CO), Gary Peters (D-MI), and Cory Booker (D-NJ) introduced the Space Weather Research and Forecasting Act, bipartisan legislation to improve efforts to predict and mitigate the effects of space weather events, which can have significant economic and security implications, on Earth and in space. The legislation will strengthen space weather research and response by delineating clear roles and responsibilities to the agencies that study and predict space weather events, including the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), the National Science Foundation (NSF), and the Department of Defense (DOD).

Space weather events are caused by constantly changing conditions in the Sun's magnetic fields and have the potential to disrupt the electric power grid, communications networks, GPS, satellites and aircraft operations leading to serious economic and safety consequences. These events can impact infrastructure and businesses, including causing outages at electric utilities, disrupting GPS and communication networks, and forcing airlines to reroute air traffic, resulting in multi-million dollar economic damages. Estimates for damages from a worst-case scenario space weather event could be up to $2 trillion and impact as many as 40 million people.

"Because space weather may have severe implications for our economic and national security as well as the potential to interrupt the delivery of essential services, it's important that we prioritize the research and development necessary to reduce the risk and allow our nation to react and recover from these events," said Gardner.

27

27

Space Weather Bill Signed

28

28

Summary of Survey

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 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**.

29

29

Assessment

The 2013-2022 Decadal Survey:

- Joined Astro and Planetary decadal surveys in facing challenges to implementation;
- Was restrained by budget inaction of NASA, OMB, Congress;
- Required intervention by NASA leadership to improve prospects of key forward motion;
- Still needs continued community pressure to assure action on larger goals in the designated decadal interval; and
- Also demands reinvigoration of the National Academy processes in the present budgetary and political climate.

30

30

Key Strategy Point

Plans are useless—Planning is indispensable

General Dwight D. Eisenhower

31

31

Questions?

32

32

Current Forefront Space Policy Issues

- Low Earth Orbit (LEO) Safety/SSA
- Planetary Protection
- China Policy
- Space Commercialization
- Science in the "New Space" Era
- International Partnerships

LASP

33

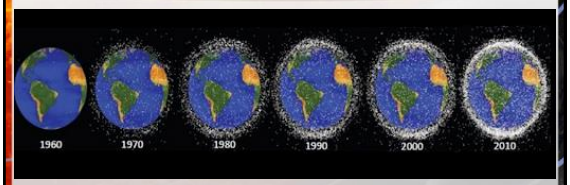
The Continuing UAE Partnership

Next stop: The Asteroid Belt!

LASP

34

Earth Orbit (LEO) Safety: Situational Awareness



The launching of hundreds (and thousands) of new small spacecraft into Low-Earth orbit (LEO) is making space dangerous and unusable in many ways**. This and all orbital debris must be brought under control.**

LASP

35

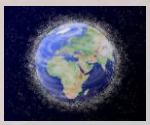
Physics — OPINION

Stand Up for Satellite Regulation

Scientists should push for the establishment of global rules on launching commercial satellites that could pose hazards in space and that could hinder astrophysical observations.

By Daniel Baker

Like many space researchers, I am excited by the "New Space" wave currently sweeping through robotic space exploration. This wave involves the launch into space of a rapidly increasing number of small, but highly capable, spacecraft, or "smallsats." Many smallsats are being used for scientific purposes—solar, magnetospheric, and ionospheric studies, Earth remote sensing, and astrophysical observations—and they hold immense promise for rapidly collecting useful information about the cosmos and about Earth's environment.



Artist's impression of space debris around Earth (the size of debris compared to Earth is exaggerated).
Credit: AFP/Carin Cain

But there is another side to New Space. Along with the dozens of scientific smallsats that are launched each year, thousands—possibly tens of thousands—of commercial satellites are being prepped for launch, most of which are also small (weighing in at less than ~ 150 kg). The proliferation of these satellites entails significant risks for space systems and for science, as it could generate hazardous space debris and hinder astronomy observations. In my view, satellite launches on such a large scale should be curtailed until the space community fully understands the problems these satellites pose and puts in place regulations that prevent or mitigate those problems.

Most of the proposed commercial smallsats will circle our planet in low Earth orbit (LEO)—altitudes lower than 2000 km—and provide communication capabilities. Improving point-to-point communication for people all over our planet is an important goal. But if Earth becomes encased in a cocoon of small spacecraft, there are tremendous risks.

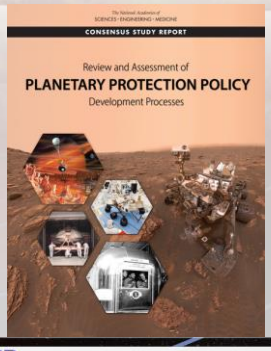
First, tens of thousands of new objects in LEO mean that there would be more pieces of "stuff" that need to be avoided by other "stuff." One spacecraft crashing into another orbiting object could start a cascade of collisions that could create a volume of debris a million times larger than that of the two initially colliding objects. It is already challenging to keep track of both the currently operating spacecraft in LEO and the thousands upon thousands of pieces of space junk from derelict spacecraft and rocket bodies. Adding to this problem makes no sense.

Second, putting so many spacecraft in LEO is a threat to safely launching other satellites to higher altitude orbits. Most space

LASP

36

Planetary Protection



While it is quite exciting that the U.S. and other nations are planning to explore brave new worlds, there must be care to avoid contaminating planets and moons. **Key Issue**

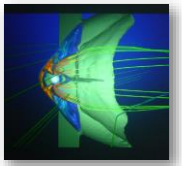
LASP

37

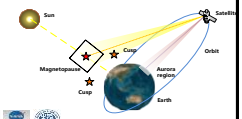
China: How can we work in an effective way with one of the great world space powers?

Part 1 Space Weather Missions

Project Overview



- Elliptical Orbit：5000km@perigee 19 Re@apogee
- Launch: 2023~24
- Lifetime：3 years



[from Prof. Chi Wang]

National Space Science Center, CAS

38

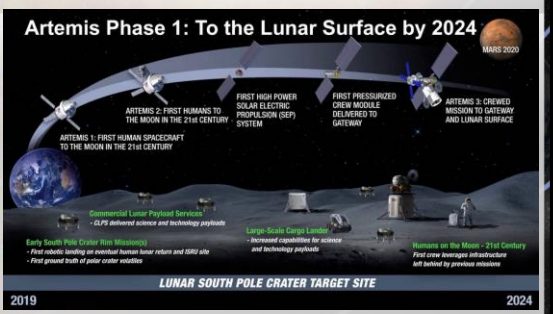
Space Commercialization

It is remarkable that space commerce is taking a firmer foothold. But how will space science work with new space companies and how will research thrive?

LASP

39

Return to the Moon



How well will the human exploration work with the robotic (research) community?

LASP

40