



# Heliophysics Division Roadmap Report

Edward DeLuca, Chair

Larry Kepko, Co-Chair

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# 2012-2014 Roadmap Committee

| Name | Institution | Name | Institution |
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| Larry Kepko, Co-Chair | GSFC | Ruth Lieberman | GATS |
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| Russ Howard | NRL | Daniel Winterhalter | JPL |
| Greg Howes | U. Iowa | | |
| Janet Kozyra | U. Michigan | | |

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# Decadal Recommendations

HELIOPHYSICS

## TABLE S.1 Summary of Top-Level Decadal Survey Research Recommendations

| Priority | Recommendation | NASA |
|---|---|---|
| 0.0 | Complete the current program | X |
| 1.0 | Implement the DRIVE initiative | X |
| | Small satellites; midscale NSF projects; vigorous ATST and synoptic program support; science centers and grant programs; instrument development | |
| 2.0 | Accelerate and expand the Heliophysics Explorer program | X |
| | Enable MIDEX line and Missions of Opportunity | |
| 3.0 | Restructure STP as a moderate-scale, PI-led line | X |
| 3.1 | Implement an IMAP-like mission | X |
| 3.2 | Implement a DYNAMIC-like mission | X |
| 3.3 | Implement a MEDICI-like mission | X |
| 4.0 | Implement a large LWS GDC-like mission | X |

## TABLE S.2 Summary of Top-Level Decadal Survey Applications Recommendations

| Priority | Recommendation | NASA |
|---|---|---|
| 1.0 | Recharter the National Space Weather Program | X |
| 2.0 | Work in a multiagency partnership to achieve continuity of solar and solar wind observations | X |
| 2.1 | Continue solar wind observations from L1 (DSCOVR, IMAP) | X |
| 2.2 | Continue space-based coronagraph and solar magnetic field measurements | X |
| 2.3 | Evaluate new observations, platforms, and locations | X |
| 2.4 | Establish a space weather research program at NOAA to effectively transition research to operations | |
| 2.5 | Develop and maintain distinct funding lines for basic space physics research and for space | X |

# Overview

The Heliophysics Division addresses its Agency objectives and the NRC Decadal Survey recommendations in the context of our National Space Policy by working to answer these fundamental science questions:

- **What causes the Sun to vary?**
- **How do the geospace, planetary space environments and the heliosphere respond?**
- **What are the impacts on humanity?**

To answer these questions, NASA's Heliophysics Division is implementing a program to achieve three overarching science goals:

- ***Solve the Fundamental Mysteries of Heliophysics*** (F), Explore the physical processes in the space environment from the Sun to the Earth and throughout the solar system
- ***Understand the Nature of our Home in Space*** (H), Advance our understanding of the connections that link the Sun, the Earth, planetary space environments, and the outer reaches of our solar system
- ***Build the Knowledge to Forecast Space Weather Throughout the Heliosphere*** (W), Develop the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth

# Implementation Issues

The Heliophysics Roadmap Team was charged with implementing the 2013 Heliophysics Decadal Survey (DS). The Decadal Survey establishes strategic objectives and initiatives, and was based on a set of reasonable budget expectations. The budget situation changed dramatically between the beginning of the Decadal Survey and the publication of the Roadmap.

**The difference in projections amounts to an unplanned deficit of $100M per year by 2024, which has significant ramifications for the implementation program.**

# Funding Priorities

The Roadmap team followed the guidelines for funding priorities given in the DS.

The Roadmap provides implementation of the Decadal Survey's highest priorities, including:

- Implementation of NASA's portion of the Diversify, Realize, Integrate, Venture, and Educate (DRIVE) program
- Augmentation of the Heliophysics Explorers
- Rebalancing of the Heliophysics research and flight portfolio.

Given the current budgetary situation, the Heliophysics Roadmap recommends that Heliophysics Division (HPD)

1) Remain flexible in its program implementation
2) Utilize the full range of flight opportunities (e.g., sounding rockets, CubeSats, hosted payloads, etc.) to achieve its science objectives,
3) Protect the core Research program
4) Urgently develop ways to increase its flight opportunities that are needed meet the goals of the Decadal Survey subject to the budget shortfall that emerged since its development.

# DS Science Objective & Roadmap Research Focus Areas

The Decadal Survey is identifies four science objectives:

- 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.

# DS Science Objective & Roadmap Research Focus Areas II

**Solve the Fundamental Mysteries of Heliophysics (F)**

- Understand magnetic reconnection (F1)
- Understand the plasma processes that accelerate and transport particles (F2)
- Understand ion-neutral interactions (F3)
- Understand the creation and variability of solar and stellar magnetic dynamos (F4)
- Understand the role of turbulence and waves in the transport of mass, momentum, and energy (F5)

# DS Science Objective & Roadmap Research Focus Areas III

**Understand the Nature of Our Home in Space (H)**

- Understand the origin and dynamic evolution of solar plasmas and magnetic fields throughout the heliosphere (H1)
- Understand the role of the sun and its variability in driving change in the Earth's atmosphere, the space environment, and planetary objects (H2)
- Understand the coupling of the Earth's magnetosphere-ionosphere-atmosphere system, and its response to external and internal forcing (H3)
- Understand the nature of the heliospheric boundary region, and the interactions between the solar wind and the local interstellar medium (H4)

# DS Science Objective & Roadmap Research Focus Areas IV

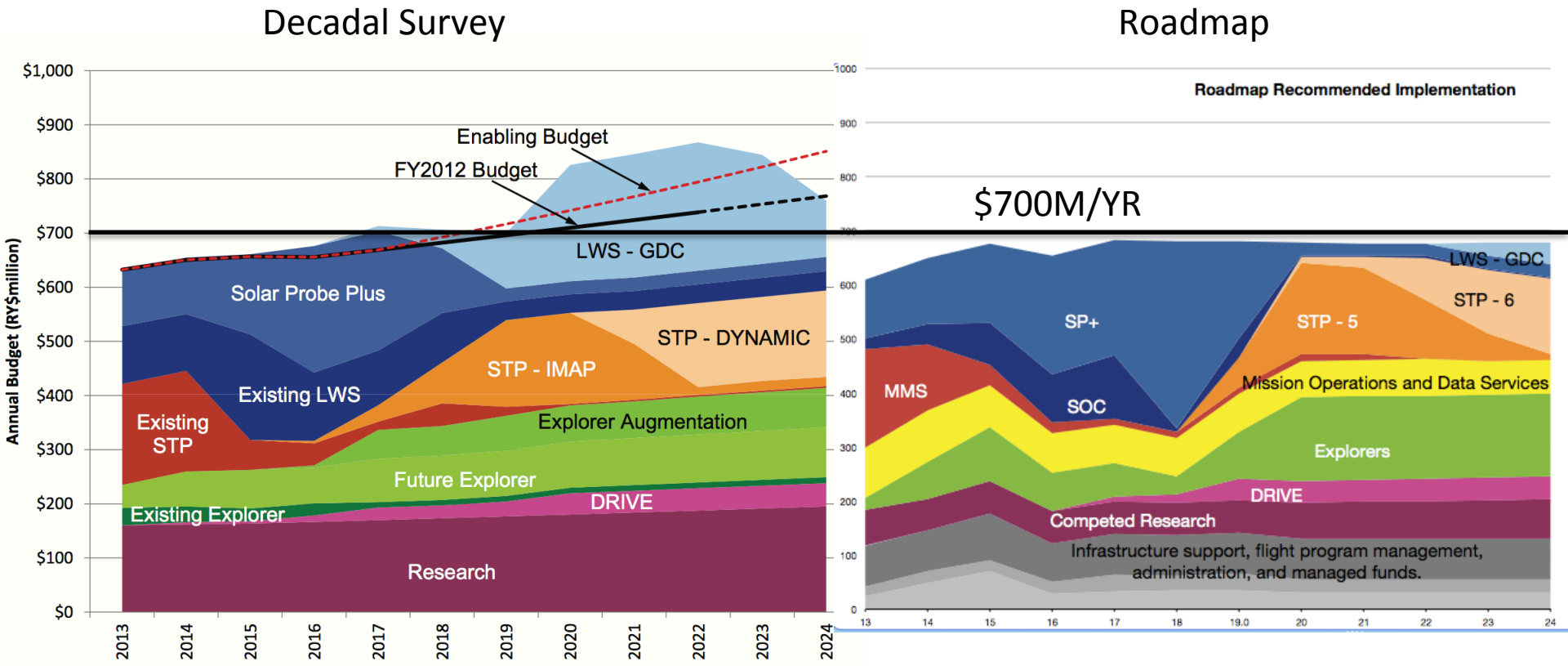
**Build the Knowledge to Forecast Space Weather Throughout the Heliosphere (W)**

- Characterize the variability, extremes, and boundary conditions of the space environments that will be encountered by human and robotic explorers (W1)
- Develop the capability to predict the origin, onset, and level of solar activity in order to identify potentially hazardous space weather events and all-clear intervals (W2)
- Develop the capability to predict the propagation and evolution of solar disturbances to enable safe travel for human and robotic explorers (W3)
- Understand, characterize, and model the space weather effects on and within terrestrial and planetary environments (W4)

# Status of Document

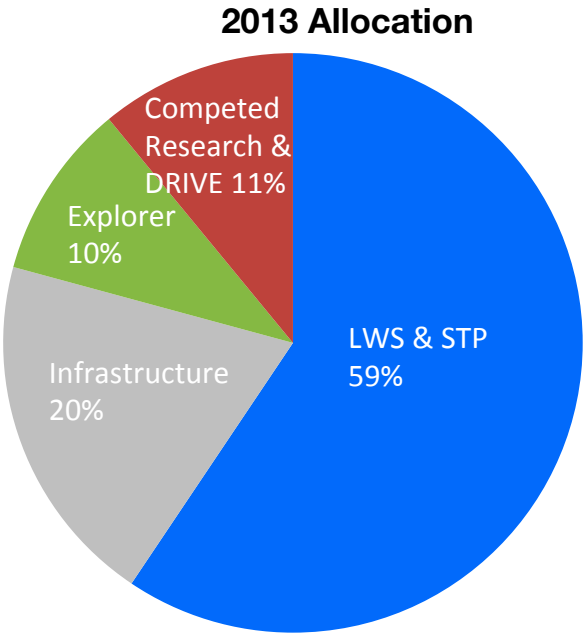
- The final version has been reviewed by DeLuca and Hagan.
- An electronic version of the Roadmap will be released within a few weeks

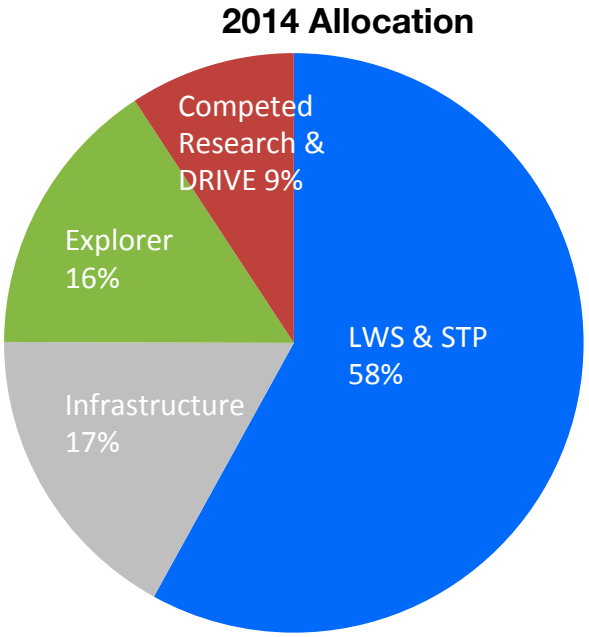
# Decadal Survey Budget & Roadmap Budget

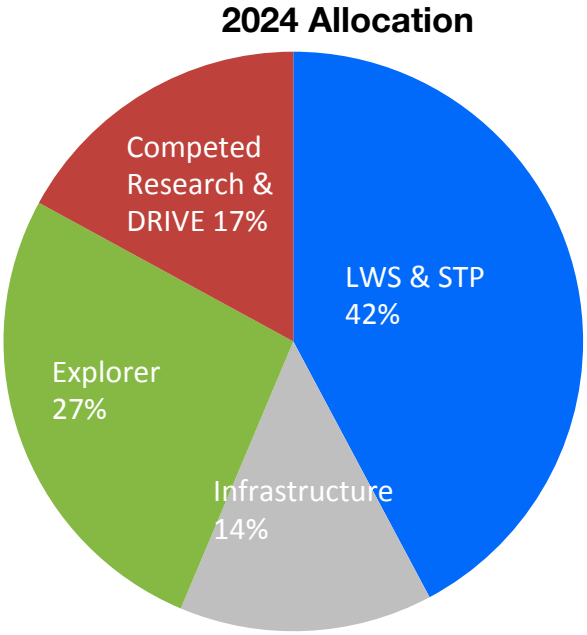


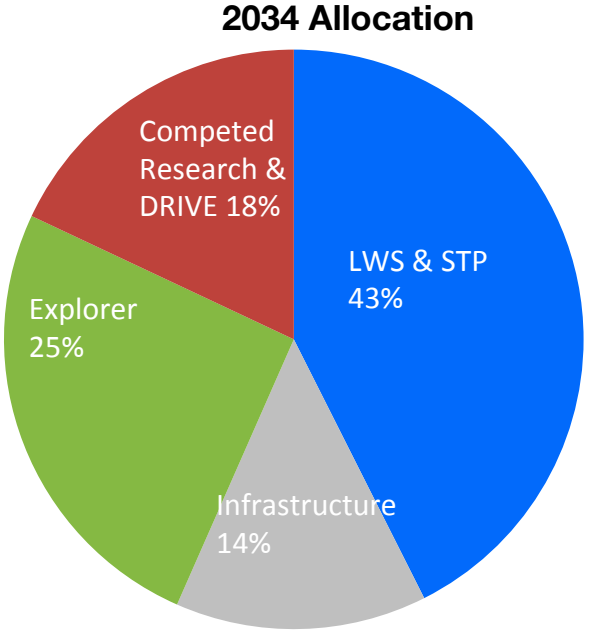

Left: 10-year Budget from Decadal Survey. Right: Roadmap Budget from NASA/OMB. NOTE: $100M/year difference in 2024. NOTE: Decadal "Research" line includes fixed costs (aka sounding rocket operations).

# Programmatic Balance



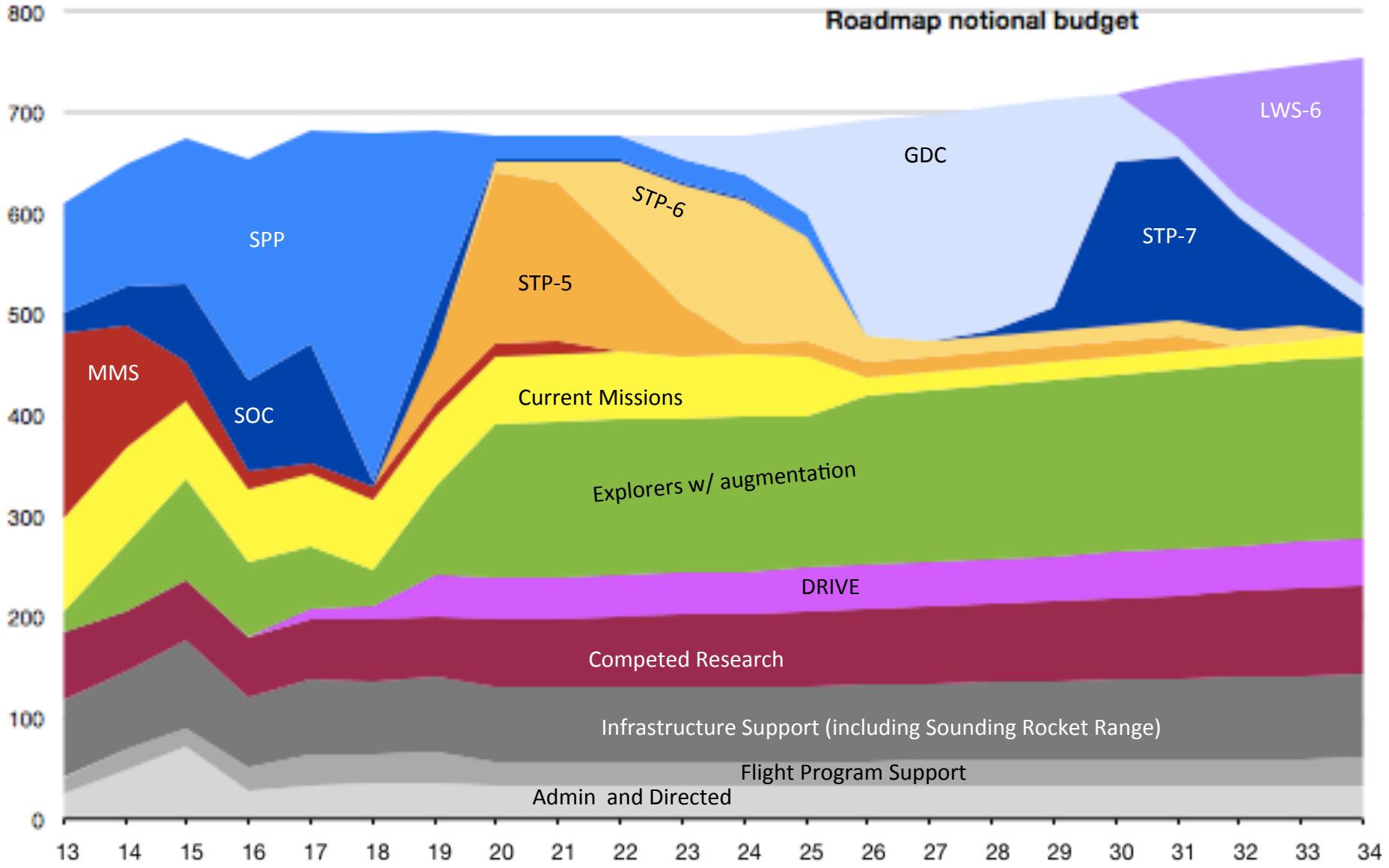




We can change the distribution of funds even with flat budgets. Achieving this pushes STP and LWS missions out.

# Full Roadmap Budget



# Conclusions

- We are implementing DRIVE and will increase Explorer/MoO budgets within the current budget predictions,

However

- The strategic missions are significantly delayed as a result of the budget constraints and our decisions to emphasize the competed research program and the Explorer program.

- Mitigating Action:
  - The development of Small-sat/Cube-sat technology will be important for achieving new scientific measurements with tightly constrained budgets.
  - The HP Division and the community (through future roadmaps or STDTs) will have to address the trade between mission cost and flight opportunities for the strategic missions. We are carrying the strategic mission costs as estimated by the Decadal Survey, ~$520M STP, ~$1B LWS.