National Academies of Sciences, Engineering, and Medicine

The Decadal Survey Process

Planetary Science and Astrobiology and Astro2020

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Board Director, Space Studies Board

National Academy of Sciences

On March 3, 1863 at the height of the US Civil War, President Abraham Lincoln signed an Act of Congress to create the National Academy of Sciences.

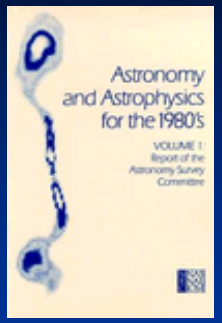
NAS and Astrobiology/Planetary Science

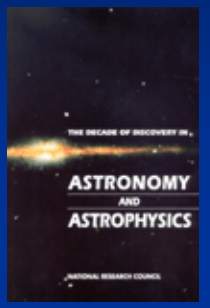
"… the primary scientific goals of this program are immense: a better understanding of the origins of the solar system & the universe, the investigation of the existence of life on other planets, & potentially, an understanding of the origin of life itself."

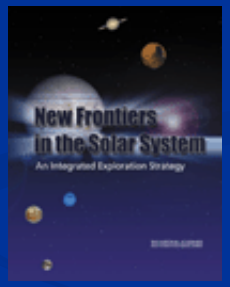
1961 letter from the SSB to NASA Administrator James Webb

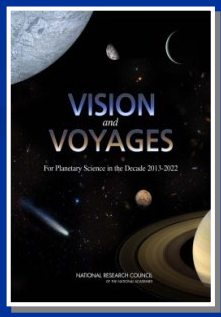
Space Science Decadal Surveys

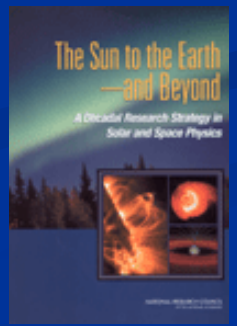
- Astronomy and Astrophysics
  1963, 1973, 1982, 1991, 2001, 2010, (2022)
- Planetary Science
  2003, 2011, (2022)
- Solar and Space Physics
  2003, 2012, (2024)
- Earth Science and Applications from Space
  2007, 2018, (2029)
- Biological and Physical Research in Space
  2011, (2023)









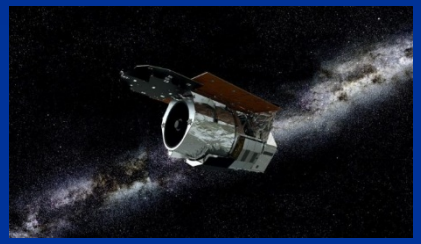


The NASA Great Observatories

A Few Past Decadal Recommended Flagships Launched or Being Built

Astrophysics Decadal

WFIRST



Now the Nancy Grace Roman Space Telescope

NGST (Next Generation Space Telescope)

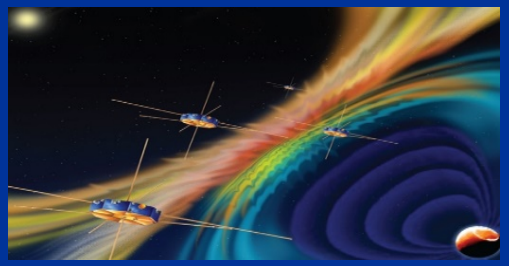
Now the James Webb Space Telescope

Heliophysics Decadal

Solar Probe

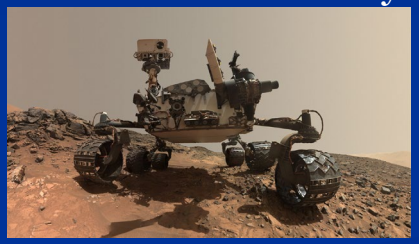
Now the Parker Solar Probe

MMS (Magnetospheric Multiscale Mission)



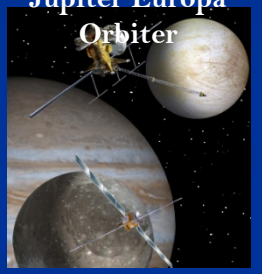
Planetary Science Decadal

Mars Science Laboratory



Now the Curiosity Rover

Jupiter Europa Orbiter



Now Europa Clipper

(Mars Sample Return)

1st Step: Perseverance Rover Caching

The Big Questions in Space Science

Astrophysics: How does the universe work? How did we get here? Are we alone?

Earth Sciences: How do we improve weather and air quality forecasts, understand the coupling of the water and energy cycles and ecosystem change, study sea-level rise, surface dynamics, climate uncertainty, and geological disasters?

Heliophysics: How do we understand the Sun and its interactions with Earth, the interstellar medium, and space weather?

Planetary Sciences: What is the origin and history of the solar system, are we alone, and what hazards and resources lie in space for human exploration?

What is a Decadal Survey?

- Assesses the current status of an entire scientific discipline
- Defines and prioritizes the key scientific questions that could potentially be addressed in the next decade
- Prioritizes the most important initiatives that might be undertaken to address the most important questions
- Conducted by the National Academies, independently of sponsoring agencies and organizations
- Required by NASA Authorization Acts to engage with the National Academies and conduct decadal surveys in all major space science disciplines
- Since 2005, required to include TRACE evaluations.

Sponsoring agencies and Congress view surveys as the formal statement of priority by the US space science community, and have repeatedly stated their intent to give highest priority to the missions identified in the survey

What is the Statement of Task?

- The statement of task for each Decadal can be found on the Space Studies Board website of the National Academies
- It outlines exactly what the sponsors and the National Academies negotiated for the NAS to undertake with the community. Sponsors have no input after the SoT is in place.
- The National Academies requires its committees to do no more or no less than what is specified in the statement of task
- There is additional information (considerations) as suggestions to make the survey most useful; they are not binding on the National Academies' Survey Committee.

Nominations Process

Nominations and self nominations are encouraged. We are looking for individuals with the following characteristics:

- Scientific and technical expertise and objectivity;
- Broad thinking, open-minded, and not an active proponent of a specific project;
- Experience in the management of a project, organization, or equivalent enterprise, is advantageous; and
- Willing to participate in-person or virtual (during Covid) in survey committee activities

White Papers and Early Career

- Current Survey Whitepapers are now published and available on the Bulletin of the American Astronomical Society's website.
- White papers are valued community input: every one is read
- Decadal Surveys impact ALL OF OUR future: early career participation is encouraged
- Fresh ideas and perspectives are respected and ingested; Clarity is paramount
- Flagships, medium class, and small mission concepts, as well as facility class missions, infrastructure ideas are all equally welcome

Technical, Risk, and Cost Estimation (TRACE)

- Independent evaluation of concepts - assuring the analysis is fair, uniform, and tied to historical data to assure accuracy.
- Puts pre-phase A concepts on even footing by evaluating them with whatever information is available and describing the resultant approximation of rough life-cycle cost of a proposed concept.

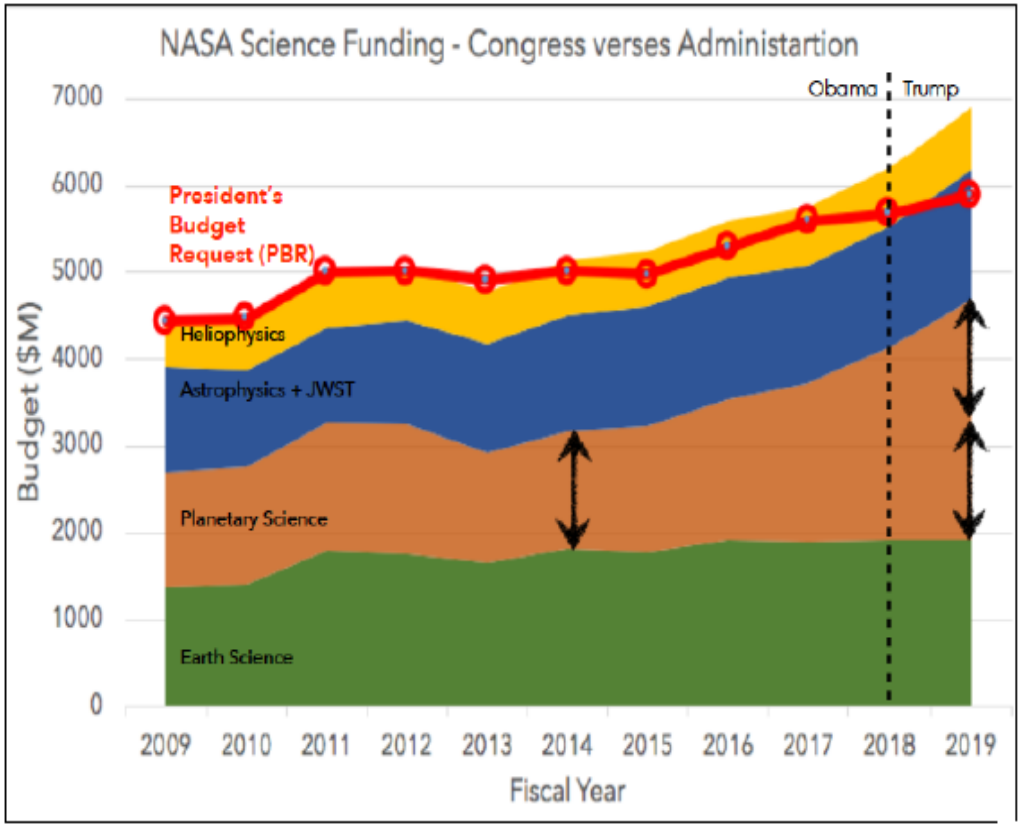
RISK Box - expand & contract the error box commensurate with available info.

Planetary Science & Astrobiology Decadal Survey

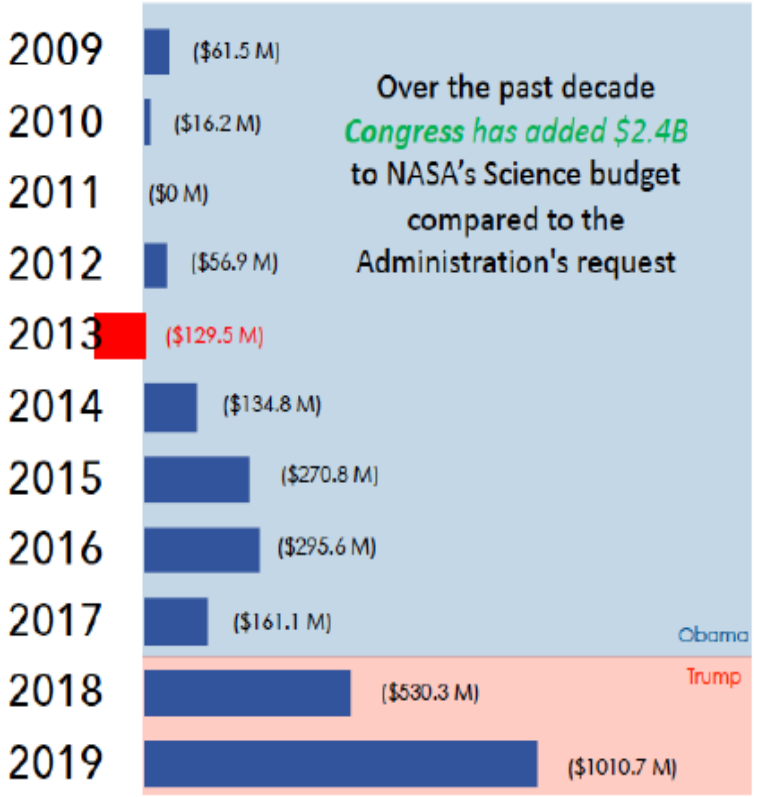
2023 - 2032

PSD's Budget Doubled Since 2014

NASA's *Planetary Science Division budget* has been *doubled* in just 5 years (since FY14)



Annual Congressional funding levels for NASA Science (SMD) by Division



Comparison of annual outcome – enacted versus PBR for NASA's SMD budget

PSADS:Statement of Task

- Overview of planetary science, astrobiology, and planetary defense why they are compelling undertakings, and space- and ground-based research;
- Broad survey of the current state of knowledge of the solar system;
- Most compelling science questions, goals and challenges which should motivate future strategy
- Comprehensive research strategy to advance the frontiers, ranking the highest priority research activities (research activities include any project, facility, experiment, mission, or research program)
  - consideration should be given to the scientific case, international and private landscape, timing, cost category and cost risk, TRL, lifetime, and opportunities for partnerships.
  - balanced, by considering large, medium, and small research activities for both ground and space.

PSADS: SoT (Cont)

- Recommendations for decision rules to accommodate deviations in budget or changes by new discoveries or technological developments;

- Awareness NASA human space exploration programs and potential foreign and U.S. agency partners and identification of opportunities for cooperation, as appropriate;

- Collaborative research between SMD's 4 science divisions (for example, comparative planetology approaches to exoplanet or astrobiology research); between other mission directorates; NASA and the NSF; NASA and other USGA; NASA and private sector; NASA and international partners;

- State of the profession including issues of diversity, inclusion, equity, and accessibility, the creation of safe workspaces, and recommended policies and practices to improve the state of the profession.

PSADS: What is the Same?

- Broad survey of the current state of knowledge
- Inventory of top-level science questions and research activities
- Recommendations on optimum balance between target bodies, large/medium/small missions, ground vs space, etc.
- Decision rules for significant deviations in budget, new discoveries, or technological development
- Assessment of infrastructure and strategic technology development needs
- Ranking large/medium space missions (TRACE), ground-based facilities, supporting research

PSADS: What is New?

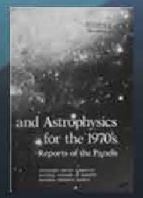
- Higher profile for astrobiology & planetary defense
- Awareness of human exploration activities by NASA & international partners
- More emphasis on collaborations
- Emphasis on consideration of state of the profession

Schedule for Decadal Survey: Planetary Example

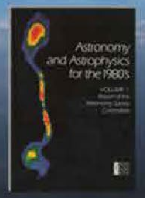
2019	
September	Organizing meeting and town hall at EPSC-DPS
October	Draft statement of task received from NASA
November	LPI launches white paper proposal web site
December	Town hall at AGU meeting
2020	
January	National Academies posts Statement of Task
February	Funding proposal to NASA, NSF agreed to support
March	Early-career event and town hall at LPSC
Survey formally begins once funding is received from the Sponsors!	
Spring	White paper submission begin, chair announced
Summer	White paper deadline and meetings begin
2021	
Autumn	Complete draft of survey report assembled
2022	
Spring	Survey report released, dissemination starts
2023	End of dissemination/NASA contract

Astrophysics

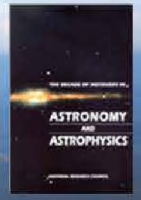
Decadal Survey Missions



1972
Decadal Survey
Hubble



1982
Decadal Survey
Chandra



1991
Decadal Survey
Spitzer

2001
Decadal Survey
Webb

2010
Decadal Survey
Roman

?

2021
Decadal Survey

Astro2020 (2020 – 2030) Decadal Survey Goal

- Ambitious missions prioritized by previous Decadal Surveys have always led to paradigm shifting discoveries about the universe

- If you plan to a diminishing budget, you get a diminishing program

Now is the time to be ambitious!

Astro2020 Statement of Task Highlights

- Review current state of astronomy and astrophysics
- Identify compelling science challenges
- Develop research strategy to advance scientific frontiers, 2022-2032
  - Recommend and rank high priority activities
  - Consider international and private landscape
  - Consider TRACE and timing
- Develop decision rules for robust program
- Assess the state of the profession
  - Provide specific, actionable and practical recommendations

Astro2020 Survey Scope

- Ground- and space-based observational, theoretical, computational, laboratory astrophysics (*NASA, NSF*), and archival activities;
- Solar astronomy, but any prioritization in this area will be limited to ground-based activities directed to NSF, and relate to National Academies report, Solar and Space Physics: A Science for a Technological Society (2012).
- Gravitational-wave observations used to inform or as they relate to the full breadth of astronomy and astrophysics. If the committee feels it is appropriate, the report may comment on areas of technology investment in ground-based gravitational-wave observations that would give the best scientific returns. *However, activity recommendations shall be limited to those that fall within the areas of implementation by the NSF and NASA Astrophysics.*

Astro2020 Survey Scope

- Multi-messenger astronomy and astrophysics investigations using the wide variety of messengers including the full breadth of electromagnetic observations, gravitational-waves, and particles from astronomical sources.
- Many projects with science topics aligned with the DOE Office of High Energy Physics may also contribute to multi-messenger astrophysics. *However, specific multi-messenger activity recommendations shall be limited to those that fall within the areas of implementation by the NSF and NASA Astrophysics.*

Astro2020 Survey Scope

- The science of exoplanets, including the search for life in the universe. Consider 2 NASEM reports: “Exoplanet Science Strategy”)and “Astrobiology Science Strategy for the Search for Life in the Universe”, as well as areas of potential collaboration between and within agencies and non-federal entities.

Astro2020 Survey Scope

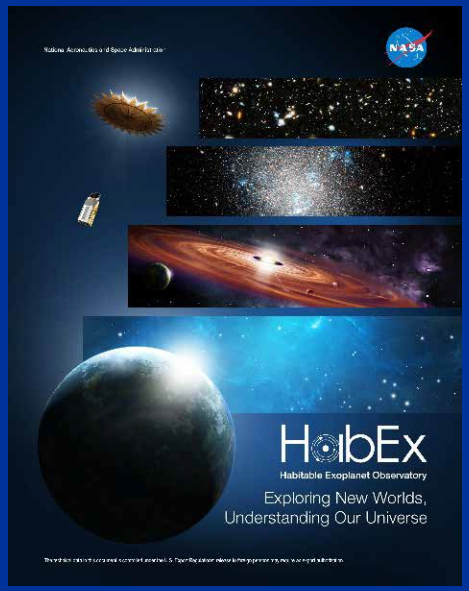
- The scope of the study will exclude:
  - Fundamental physics, such as studying the physics of particles and fields, other than through naturally occurring observables.
  - Direct detection or accelerator-based dark matter particle searches that are traditionally considered and carried out by the NSF and DOE particle physics communities.
  - Microgravity research (see BPS Decadal Survey)
  - Construction of projects whose agency-supported implementation is already in progress, specifically JWST, DKIST, LSST, and DESI.

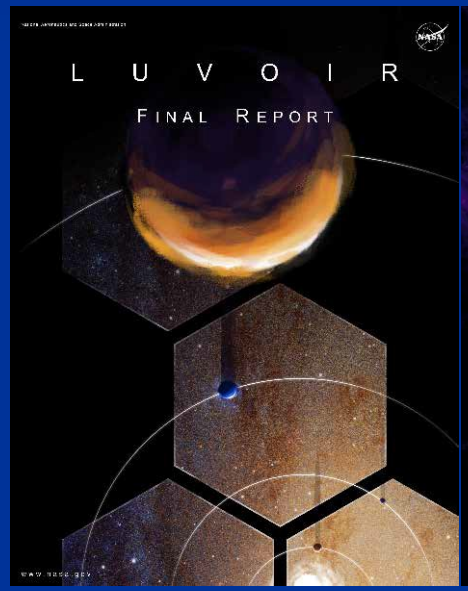
Additional NASA Guidance LISA, WFIRST, ATHENA

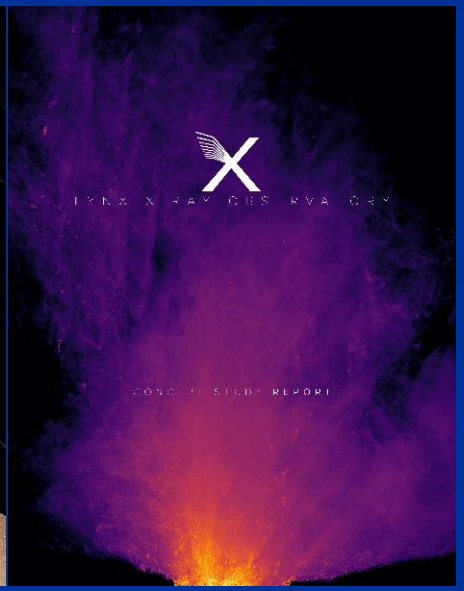
The following additional scope guidance provided by NASA:

- The study will assess whether NASA's plans for WFIRST, Athena, and LISA play an appropriate role in the research strategy for the next decade.
- The study may include findings and recommendations regarding those plans, as appropriate, including substantive changes in NASA's plans.
- Recommendations may include, but not limited to, actions ranging from increased investments (upscopes) to reduced investments (descopes) and termination. It is not necessary to rank WFIRST, Athena, and LISA among other recommended activities for space.

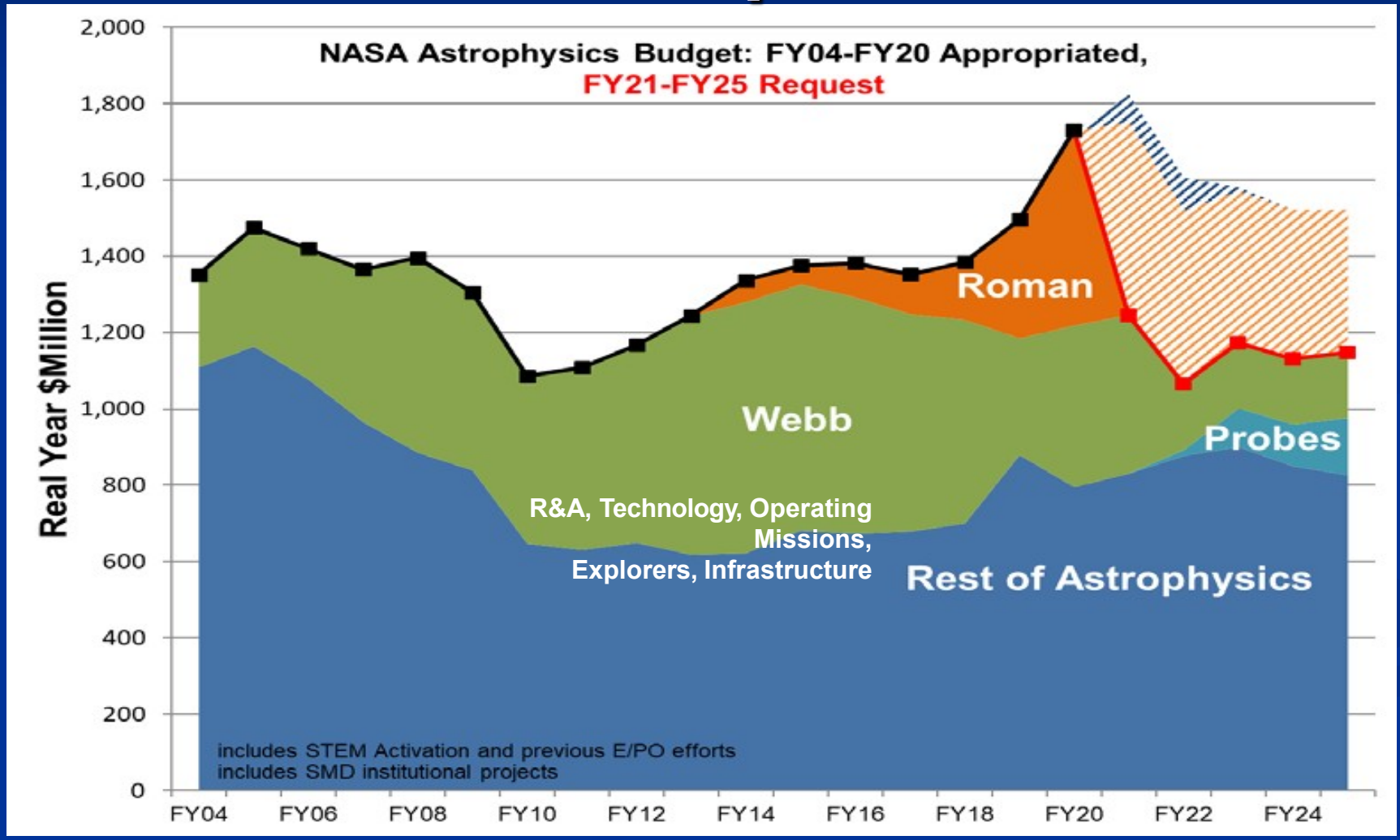
Astro2020 Large Mission Study Concepts







Astrophysics Budget – FY21 Request

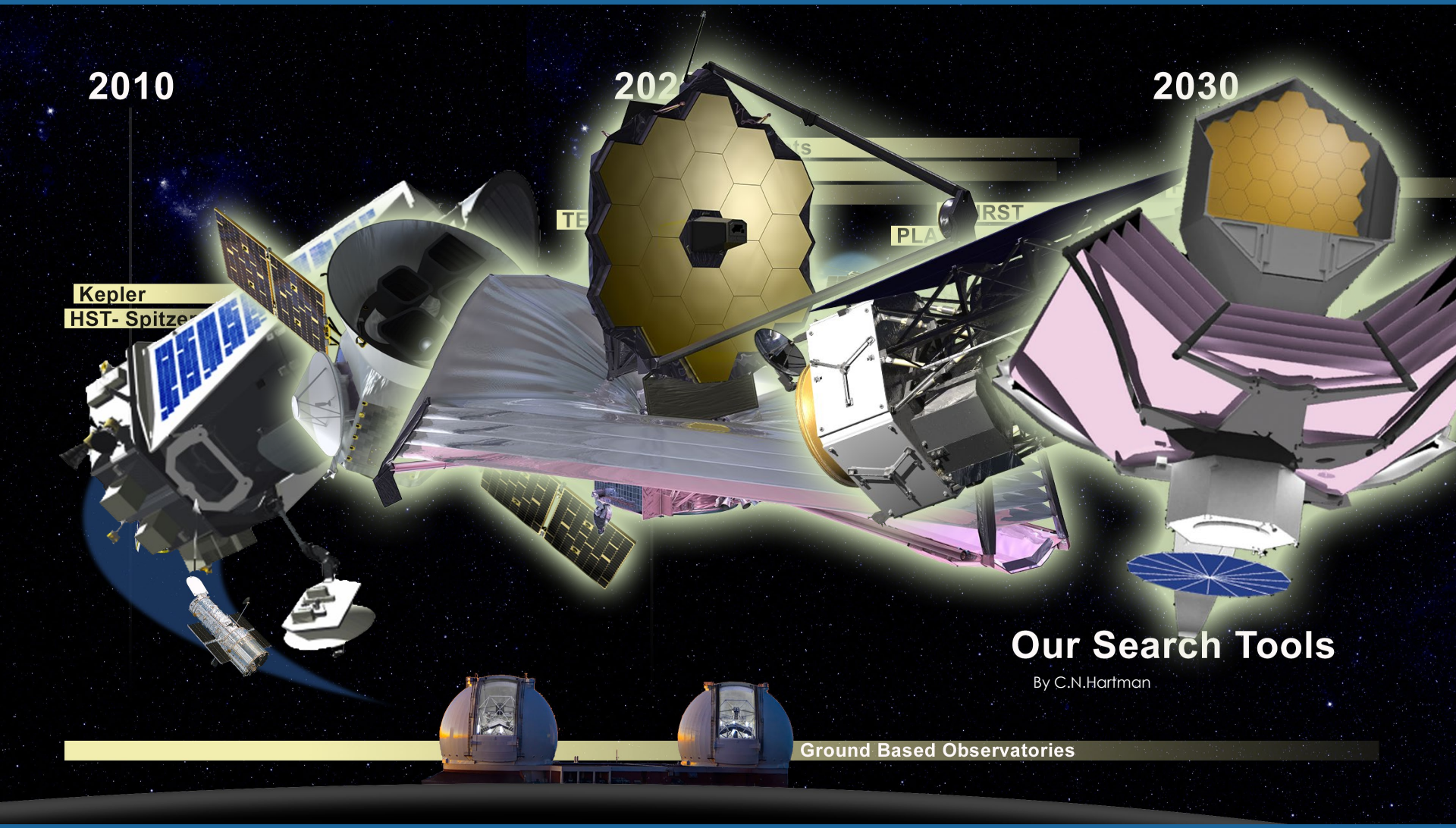


Astro2020: Perspectives from Sponsoring Agencies

- All 3 sponsors & the National Academies want to see ambitious programs backed by strong science cases
  - ultimately these will be constrained by our budgetary guidance
- Need for clear decision rules
- 4 flagship & 10 probe concepts delivered for further evaluation
- The decadal also received major ground-based submissions (TMT/GMT, ngVLA, CMB S4, IceCube2)

Changes from Previous Decadal Surveys

- Increased institutional and demographic diversity on survey committee and panels
- As always, strict consideration of potential conflicts of interest
- Fully supported State of Profession panel
  - members to include social science, demographics experts
  - emphasis on developing actionable recommendations


2010
202
2030
Kepler
HST- Spitze
Our Search Tools
By C.N.Hartman
Ground Based Observatories

The National Academies of
SCIENCES • ENGINEERING • MEDICINE

Update on a few other Space Studies Board

CoPP discipline committee of the SSB Nuclear Propulsion to Mars Study

The National Academies of SCIENCES ENGINEERING MEDICINE

THE COPP COMMITTEE STATEMENT OF TASK

Study of those aspects of planetary environments, the life sciences, spacecraft engineering and technology, and science policy relevant to the *control of biological cross-contamination* arising from the robotic spacecraft missions and the human exploration and utilization of solar system bodies.

1. To monitor progress in **implementing the planetary protection guidelines** for activities identified in the planetary science decadal survey—Vision and Voyages for Planetary Science in the Decade 2013-2022 and relevant reports.

2. To serve as a **source of information and advice** on those measures undertaken by **robotic spacecraft and human exploration missions to protect the biological and environmental integrity of extraterrestrial bodies.**

COPP STATEMENT OF TASK

Through its regular meetings, the CoPP will also serve the secondary functions of:

1. Providing an independent**, authoritative forum** for the scientific community, the federal government, international space agencies, relevant private-sector entities and organizations, and the interested public to **identify and discuss emerging issues in the scientific, technical, and engineering aspects of planetary protection policies and guidelines;**

2. Identifying and prioritizing necessary research and development activities required to advance the development of planetary protection guidelines designed to ensure that the exploration and utilization of extraterrestrial environments is conducted responsibly; and,

3. Providing a forum for interactions with the **International Science Council's Committee on Space Research and other national and international organizations** through the addition of international participants when appropriate and in coordination with the SSB.

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COMMITTEE ON PLANETARY PROTECTION

Planetary Protection for the Study of Lunar Volatiles

Committee on Planetary Protection
Space Studies Board

National Academies of Sciences, Engineering, and Medicine

Permanently Shadowed Regions of the Moon

- The Moon's polar axis is nearly perpendicular to the ecliptic plane (axial tilt = 1.5°), and as a result, some cratered polar regions are continually in shadow.
- Some of these regions have been in shadow for as much as two billion years or more and are referred to as permanently shadowed regions (PSRs).
- The areal extent of PSRs in the polar regions is substantial—in excess of 10^4 km^2.
- Because the temperatures in the PSRs can be so low (<50 K) with seasonal temperatures between 40 and 110 K, various volatiles—for example, H2O, NH3, CO2, SO2, CO, and H2S—are stable against sublimation and can exist for billions of years if undisturbed.

Transfer of Volatiles to Lunar Polar Cold Traps by Spacecraft Exhaust

- **Simulations of water produced by the Chinese Chang'e-3 lunar lander thruster (Prem et al. 2020) show that the water is globally distributed, and up to 20 percent of the exhaust water may travel to PSRs in a few days.**
- **Efficient combustion in rocket engines inherently produces mostly water, carbon dioxide, and also nitrogen for hypergols, with a few percent of carbon monoxide and hydrogen. More complex molecules are at mass fractions of order 10^{-9} or lower. Thus, most contamination from landers will be molecules that are already at high concentrations in the PSRs and will result in a very small contribution to their measured signal, likely within the measurement uncertainty.**
- **If a uniform distribution over PSRs is assumed, robotic exploration missions will result in water contribution of 10^{-10} or less mass fraction in the collected samples. For more complex molecules, the expected mass fraction of 10^{-18} or less in collected samples is likely to be below the detection limit of instruments.**

Likelihood of Transfer of Volatiles to Polar Cold Traps from Spacecraft Reaching the Lunar Surface

<u>Finding 5</u> : There is a lack of, and need for, studies to characterize the chemical composition, transport, and level of contamination of volatiles that would be harmful to future investigations of prebiotic chemical evolution to be pursued at the PSRs. This information is necessary to determine whether to establish a planetary protection requirement for missions to these areas of the Moon, such as a requirement for reporting the inventory of propellants, combustion products, and potential off-gassing volatiles from a spacecraft.

Space Nuclear Propulsion for Human Mars Exploration

- **Focus:** Nuclear thermal propulsion (NTP) and nuclear electric propulsion (NEP) systems for the human exploration of Mars.
- **Baseline Mission:** 2039 launch, mission time < 750 days, separate cargo and crewed vehicles, in-orbit assembly.

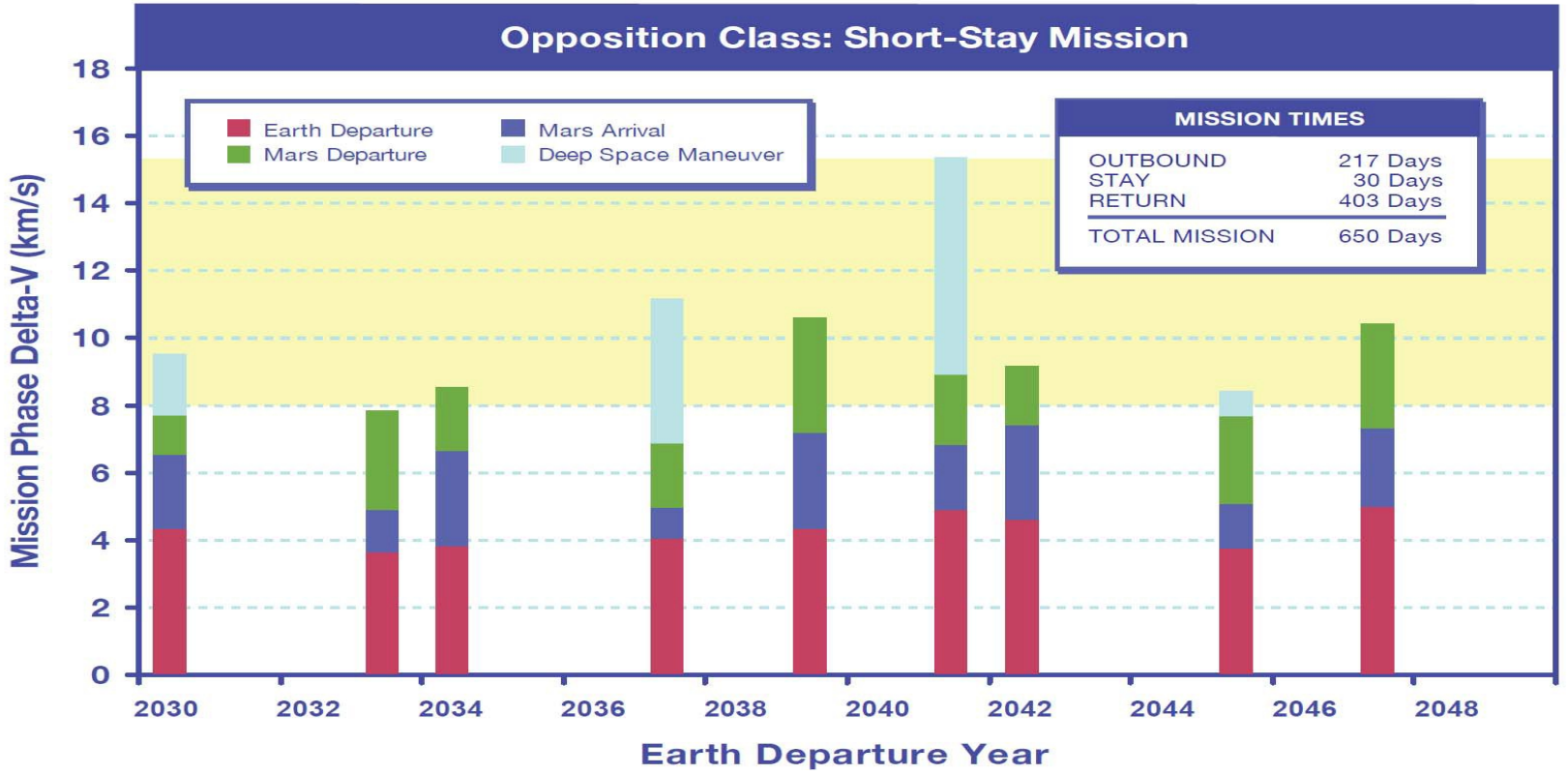
The National Academies of SCIENCES ENGINEERING MEDICINE

Statement of Task

- **Focus: Nuclear thermal propulsion (NTP) and nuclear electric propulsion (NEP) systems for the human exploration of Mars**
  - **NTP**
    - **Specific impulse (Isp) of at least 900 s**
    - **Hydrogen propellant heated to at least 2500 K***
  - **NEP**
    - **Power level of at least 1 MWe**
    - **Mass-to-power ratio (kg/kWe) substantially lower than the current state of the art**
- **Identify:**
  - **Primary technical and programmatic challenges, merits, and risks**
  - **Key milestones and a top-level development and demonstration roadmap**
  - **Missions that could be enabled by each technology**

***Committee determined that 2700 K required for Isp of 900 s**

Propulsive Requirements: Baseline Mission



Next Steps

- **NEP and NTP systems show great potential to facilitate the human exploration of Mars.**
- **Using either system to execute the baseline mission by 2039 will require an aggressive research and development program.**
- **Such a program would need to begin with NASA completing an extensive and objective architecture assessment in the coming year and making a significant set of technology investments in the present decade.**
- **Such a program should include subsystem development, prototype systems, ground testing and cargo missions as a means of flight qualification prior to first crewed use.**

Roger Meyers will testify at a House Hearing next Wednesday!

Thank You!

Additional information about:
the Space Studies Board's Decadal Surveys
http://sites.nationalacademies.org/SSB/SSB_052297

The Space Studies Board
http://sites.nationalacademies.org/SSB/index.htm