

*The National Academies of*  
SCIENCES • ENGINEERING • MEDICINE

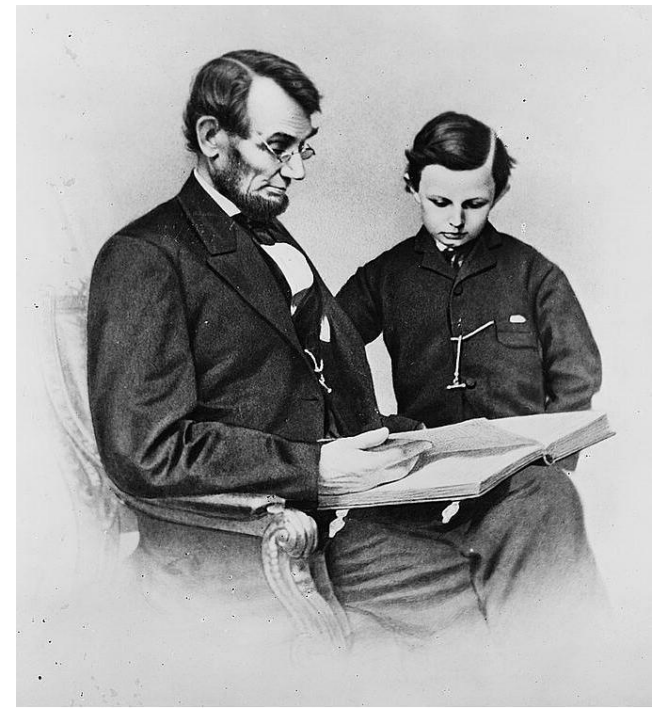
# 58<sup>TH</sup> EUROPEAN SPACE SCIENCES COMMITTEE PLENARY MEETING

2 OCTOBER, 2019

Colleen Hartman  
Director, Space and Aeronautics  
National Academies of Sciences



# 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 NAS.

- The NAS is a **private**, self-perpetuating, society of **distinguished scientists**.
- When asked by the government, its Act mandates it to "**investigate, examine, experiment, and report upon any subject of science or art.**"



# How did they do? First Reports of the NAS, 1863

Tokens were a result of the scarcity of gov't-issued coinage during the Civil War

- **Committee on Weights, Measures, and Coinage**
  - The committee felt that the US should adopt the metric system of weights and measures.
- **Committee to find means to protect the bottoms of iron ships from injury by salt water**
  - No suggestions and no funding were forthcoming until 1908.
- **Committee on Magnetic Deviation in Iron Ships**
  - Iron-clads (wooden hulls with iron plates)
  - Invented by English astronomer Airy: counteracting the local attraction by means of bar magnets placed in suitable locations.

# How do we assure quality in our work?



- Committees deliberates in **closed** meetings to develop draft conclusions and recommendations **free from outside influences**.
- All analyses and drafts of the report remain **confidential**.
- The report is not final and cannot be released until the Academies' **report review process** is completed.

# Selected Recently Released or Upcoming SSB Reports



Studies are an extensive undertaking, conducted by volunteers in the scientific and engineering communities, guided by NAS staff

All reports are available online at [www.nas.edu](http://www.nas.edu)

## Reminder of a study: PP Classification of Sample-Return Missions from Martian Moons

- Although **not considered potential habitats** for life or relevance to prebiotic chemical evolution, studies indicate a significant amount of **material recently ejected from Mars** could be present on the **surface of Phobos and Deimos**.
- Reviews theoretical, experimental, and modeling research on the environments and physical conditions encountered by Mars ejecta during certain processes; recommends whether missions returning samples should be classified as **“restricted” or “unrestricted” Earth return** in the framework of the planetary protection policy maintained by COSPAR; considers ways classification of samples from Deimos differ from Phobos.

Available at: <https://www.nap.edu/catalog/25357/>



# Update on Planetary Protection

- Administrator Bridenstine appointed a new Regulatory and Policy Committee (**RPC**) of the NAC to bring in a private sector perspective.
- In December, 2018, the NAC adopted a RPC recommendation that SMD form a **task force to reassess PP guidelines**, called the Planetary Protection Review Board (PPRB).
  - The PPRB is chaired by Alan Stern.
  - **ASEB/SSB will review the report** for an independent look in the September timeframe.
  - **COSPAR (Len Fisk, President) will be involved in the process.**

# Recent Reports

- **Finding Hazardous Asteroids Using Infrared and Visible Wavelength Telescopes**
- **Continuous Improvement of NASA's Innovation Ecosystem: Proceedings of a Workshop (2019)**
- **Report Series: CAPS: Review of the Planetary Science Aspects of NASA SMD's Lunar Science and Exploration Initiative (2019)**
- **Report Series: CAPS: Review of the Commercial Aspects of NASA SMD's Lunar Science and Exploration Initiative (2019)**
- **Planetary Protection Classification of Sample-Return Missions from the Martian Moons (2019)**
- **Strategic Investments in Instrumentation and Facilities for Extraterrestrial Sample Curation and Analysis (2019)**
- **An Astrobiology Strategy for the Search for Life in the Universe (2019)**
- **Open Source Software Policy Options for NASA Earth and Space Sciences (2018)**
- **Exoplanet Science Strategy (2018)**
- **Visions into Voyages for Planetary Sciences in the Decade 2013-2022: A Midterm Review (2018)**
- **Report Series: CAA: Mission Concept Studies (2018)**
- **Review and Assessment of Planetary Protection Policy Development Processes (2018)**

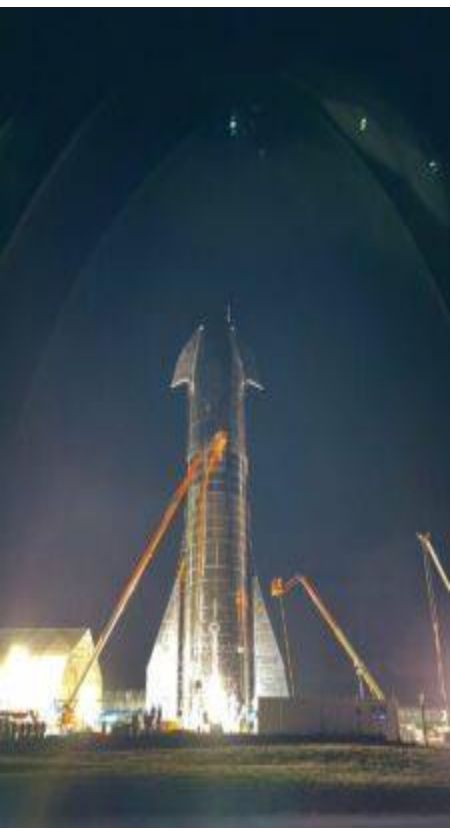


# The Hill and NASA's Budget

- A Continuing Resolution (CR) passed the House and Senate and was signed by the President to keep the government operating until November 21. The CR is needed because none of the regular FY2020 appropriations bills has cleared Congress yet and FY2020 began yesterday.
- NASA will be kept at its current FY2019 spending level until a new appropriations bill is passed (NASA had hoped it would be allowed to spend money above F2019 levels for the Artemis program).

# Senate's CJS and House version

- The Senate's Commerce-Justice-Science bill was approved by the full committee with no substantive changes to the subcommittee's version adopted on Tuesday.
  - They approved \$22.75 billion for NASA.
  - Senate support for Artemis program to return astronauts to the Moon by 2024: some but not all of the extra \$1.6 billion NASA requested in May.
- House version did not include any of the \$1.6 billion (top line for NASA is \$22.32 B).
- Conference between House and Senate yet to come.



# MUSK: FIRST STARSHIP WITH CREW COULD LAUNCH NEXT YEAR

- Starship/Super Heavy system designed to send people to the Moon and Mars.
- A Starship prototype, Mk1, is under construction at SpaceX's test facility in Boca Chica, Texas
- Musk now has added the Moon to his destination list and already signed up a paying customer for the first flight around the Moon (not to land), planned for 2023.
- Two Starhopper tests of the Raptor rocket engine that will be used to power Starship and Super Heavy took place at Boca Chica in July and August.





# Update on Gateway



# Space Policy Directive 1: To The Moon, Then Mars



“Lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities. Beginning with missions beyond low-Earth orbit, the United States will lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars and other destinations...”

# Why go to The Moon?

Proves technologies and capabilities for sending humans to Mars

Establishes American leadership and strategic presence

Inspires a new generation and encourages careers in STEM

Leads civilization changing science and technology

Expands the U.S. global economic impact

Broadens U.S. industry and international partnerships  
in deep space



## **Moon Before Mars**

On the Moon, we can take reasonable risks while astronauts are just three days away from home.

There we will prove technologies and mature systems necessary to live and work on another world before embarking on what could be a 2-3 year mission to Mars.

# The Artemis Program

Artemis is the twin sister of Apollo and goddess of the Moon in Greek mythology. Now, she personifies our path to the Moon as the name of NASA's program to return astronauts to the lunar surface by 2024.

When they land, Artemis astronauts will step foot where no human has ever been before: the Moon's South Pole.

With the horizon goal of sending humans to Mars, Artemis begins the next era of exploration.



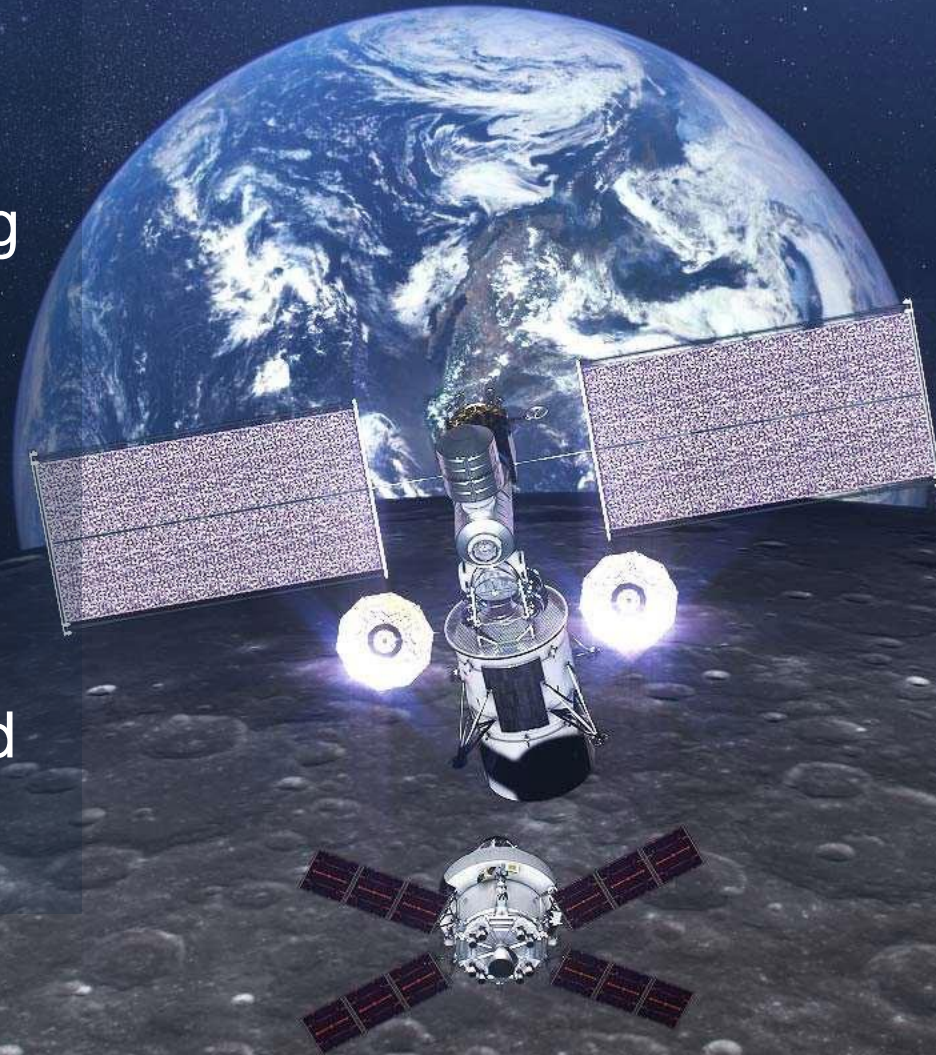
# Phase 1 & Phase 2 Definitions

## Phase 1: Today – 2024 Human surface landing

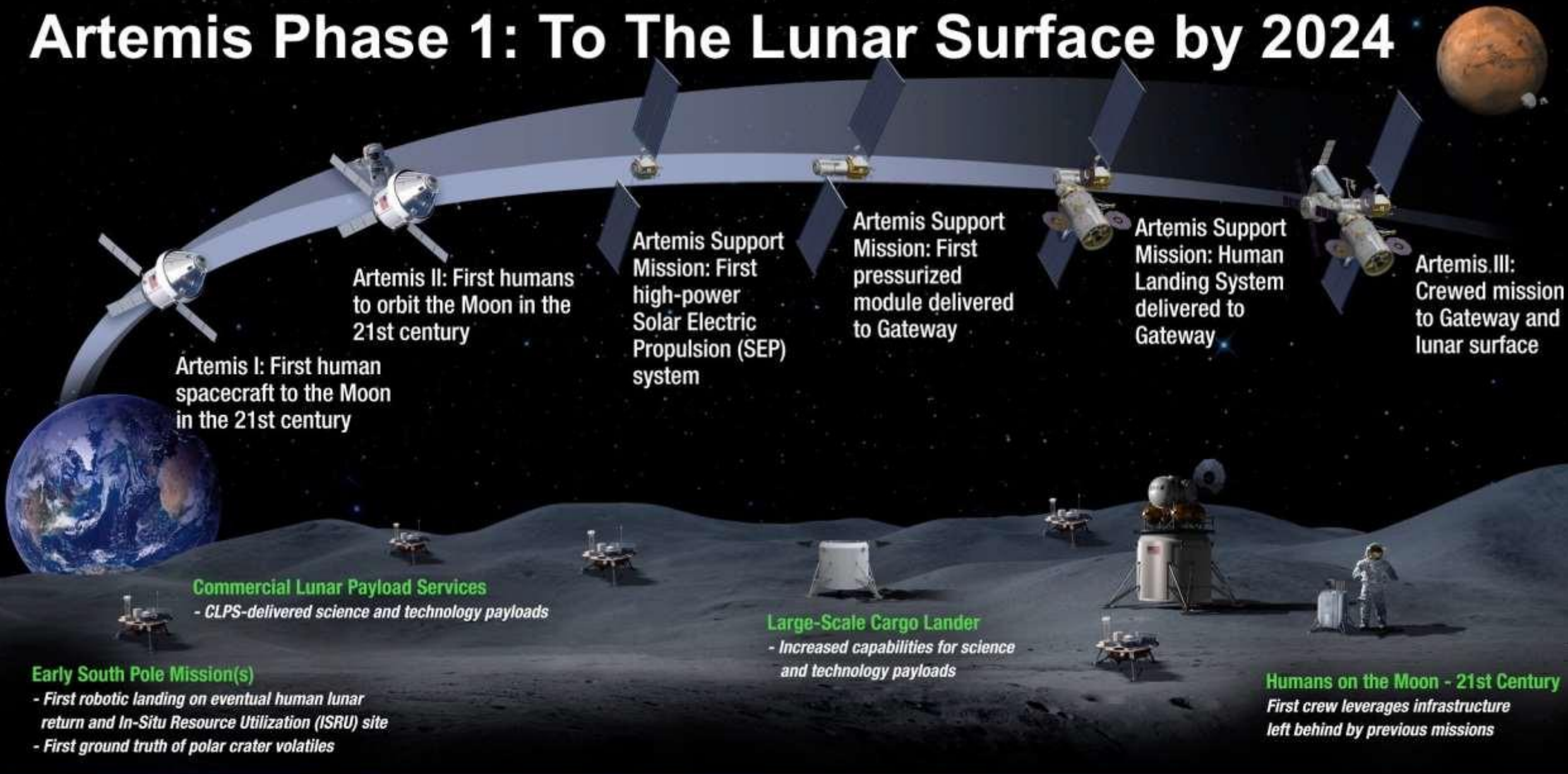
Missions and systems required to achieve landing humans on the surface of the Moon in 2024

## Phase 2: by 2028

Establish a sustainable long-term presence on and around the Moon



# Artemis Phase 1: To The Lunar Surface by 2024



**Artemis I:** First human spacecraft to the Moon in the 21st century

**Artemis II:** First humans to orbit the Moon in the 21st century

**Artemis Support Mission:** First high-power Solar Electric Propulsion (SEP) system

**Artemis Support Mission:** First pressurized module delivered to Gateway

**Artemis Support Mission:** Human Landing System delivered to Gateway

**Artemis III:** Crewed mission to Gateway and lunar surface

### Commercial Lunar Payload Services

- CLPS-delivered science and technology payloads

### Early South Pole Mission(s)

- First robotic landing on eventual human lunar return and In-Situ Resource Utilization (ISRU) site
- First ground truth of polar crater volatiles

### Large-Scale Cargo Lander

- Increased capabilities for science and technology payloads

### Humans on the Moon - 21st Century

First crew leverages infrastructure left behind by previous missions

## LUNAR SOUTH POLE TARGET SITE

# 2024

Develop essential hardware and systems required for a 2024 landing

## CREW

  
At least 2 on the South Pole

## SUITS

  
Initial capability suit

## EXPEDITION DURATION

Hours-Days  
(open trade)

## ROCKETS



## PARTNERS

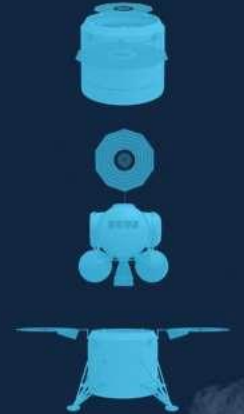
  
Significant collaboration with U.S. industry  
  
Potential opportunities for international partners

## ACCESS



## REUSABILITY

Desired, but not required



# 2028

Establish a sustainable human lunar presence with robust, reusable systems

## CREW

  
Up to 4 on the Moon

## SUITS

  
Sustained capability suit

## EXPEDITION DURATION

Days-Weeks  
(open trade)

## ROCKETS



## PARTNERS

  
U.S. industry and international collaboration

## ACCESS



Increased mobility from the pole; global access through robotic landings and possible human expeditions

## REUSABILITY

Enables sustainability



# Astro2020 Decadal Survey: An Update

- \* What is the process
- \* Where are we today?

# Decadal Surveys - Overview

- Community-driven, **bottom-up studies** to formulate a community consensus on the **most compelling science** questions for the decade ahead in each science disciplines.
- Identifies a **prioritized lists of missions and/or research objectives** and, in some cases, ground-based research activities to address the highest-priority science.
- Appointment of a **Steering Committee** and a set of topical panels (no two surveys are the same) with a total of up to **80-120 volunteers**.
- Provides for **extensive community input** via hundreds of white papers, community forums, and other outreach activities; includes independent **Technical, Risk, and Cost Evaluation** of proposed initiatives and recommendations.
- International input is solicited by the **Steering Committee** and often a **non-US scientist** is a member of the **Steering Committee**; **Astro2020** has **Tim de Zeeuw, Leiden University**.

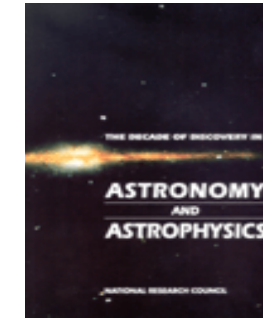
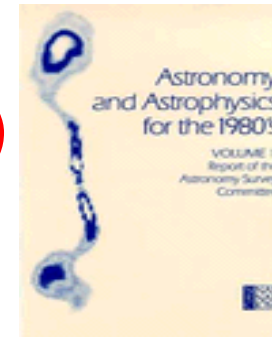
## *Decadal Surveys & The Law*

The **NASA Authorization Acts of 2005 and 2008** provided a formal legislative mandate for **Decadal Surveys** in each **NASA science area**.

- The **2005 act** also mandated **National Research Council reviews of NASA's performance in each discipline at 5-year intervals** (Public Law 109-155).
- The **2008 act** called for **“independent estimates of the life cycle costs and technical readiness of missions assessed in the decadal surveys whenever possible”** (Public Law 110-422) and for identifying conditions or events that might trigger a reexamination of the survey's priorities.

## Astronomy and Astrophysics

1963, 1973, 1982, 1991, 2001, 2010, (2020)

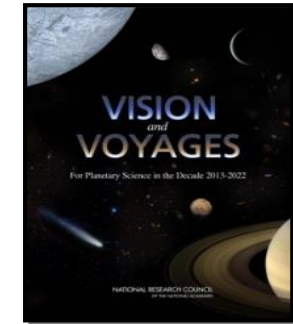
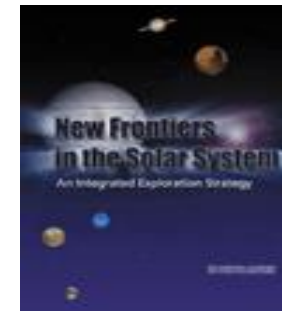


## Biological and Physical Research in Space

2011, (2022)

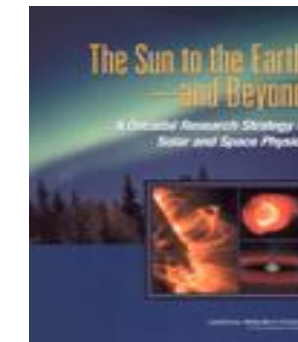
## Earth Science and Applications from Space

2007, 2018, (2029)



## Solar and Space Physics

2003, 2012, (2024)



## Planetary Science

2003, 2011, (2022)

# Future Decadal Survey Schedule (CY)

## Astronomy and Astrophysics

2016 August: 2010 Midterm Delivered to Sponsors  
2018 November: Decadal 2020 Task Starts  
**2020 2nd half:** Decadal 2020 Delivered to Sponsors

## Biological and Physical Sciences

2017 December: Midterm Delivered to Sponsor  
**2019 2nd half:** Decadal Task Starts  
2022 1st half: Decadal Delivered to Sponsors

## Planetary Sciences

2018 July: Midterm Delivered to Sponsors  
**2020 1st half:** Decadal 2022 Task Starts  
2022 1st half: Decadal 2022 Delivered to Sponsors

## Solar and Space Physics

2018 July: Midterm Task Starts  
**2019 2nd half:** Midterm Delivered to Sponsors  
2022 1st half: Decadal 2024 Task Starts  
2024 1st half: Decadal 2024 Delivered to Sponsors

## Earth Science and Applications from Space

2017 December: Decadal 2017 Delivered  
**2022 2nd half:** 2017 Midterm Task Starts  
2023 2nd half: 2017 Midterm Delivered to Sponsors  
2025 1st half: Decadal 2027 Task Starts



# Typical Elements of a Survey Report

- **Overview** of relevant discipline.
- Broad survey of the current **state of knowledge**.
- Inventory of the top-level **science questions**.
- Recommendations on **optimum balance** between fields, large/medium/small projects, ground versus space, etc.
- Assessment of **infrastructure**.
- Discussion of strategic **technology** development needs.
- **Prioritized list** of recommended strategic space missions/research, ground-based facilities and supporting research.

# Technical, Risk, and Cost Evaluation (TRACE)

- Independent assessment of likely **technical risk** associated with **priority mission concepts**
- Most Decadal Surveys have used the **Aerospace Corp** to conduct independent assessments using proprietary methodology.
- **Adjustments** to some mission concepts can occur after a TRACE analysis.
  - Selective rescoping & to validate adjusted concepts.

**CHALLENGE: State of mission formulation for large missions**

# Astro2020 Survey Scope (NASA, NSF, DOE)

- Ground and space-based observations, theory, computation, lab astrophysics
- Ground-based solar astronomy
- Gravitational-wave observations related to astronomy and astrophysics
- Multi-messenger astronomy and astrophysics
- Exoplanets & Astrobiology
  - Informed by 2 recent NAS studies: *Exoplanet Science Strategy* and *Astrobiology Strategy for the Search for Life*
- Consider implementation & scope of **WFIRST, Athena, LISA**
  - Need not be ranked
- **Excluded:** direct dark matter detection, microgravity research, fundamental physics, projects under construction (JWST, DKIST, LSST, DESI)

# Astro2020 Statement of Task Highlights

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

# Astro2020 Steering Committee Membership

**Fiona A. Harrison, Co-Chair**

*California Institute of Technology*

**Robert C. Kennicutt, Jr., Co-Chair**

*University of Arizona and Texas A&M*

**Julianne Dalcanton**

*University of Washington*

**Pieter van Dokkum**

*Yale University*

**Andrew S. Driesman**

*Johns Hopkins University Applied Physics Laboratory*

**Jonathan J. Fortney**

*University of California, Santa Cruz*

**Gabriela Gonzalez**

*Louisiana State University*

**Jordan A. Goodman**

*University of Maryland*

**Marc P. Kamionkowski**

*Johns Hopkins University*

**Bruce A. Macintosh**

*Stanford University*

**Jacobus M. Oschmann**

*International Society for Optics and Photonics (SPIE)*

**Rachel A. Osten**

*Space Telescope Science Institute*

**Lyman A. Page, Jr.**

*Princeton University*

**Eliot Quataert**

*University of California, Berkeley*

**Wanda A. Sigur**

*Lockheed Martin, Retired*

**Rachel Somerville**

*Flatiron Institute/Rutgers University*

**Keivan G. Stassun**

*Vanderbilt University*

**Jean L. Turner**

*University of California, Los Angeles*

**Tim de Zeeuw**

*Leiden University*

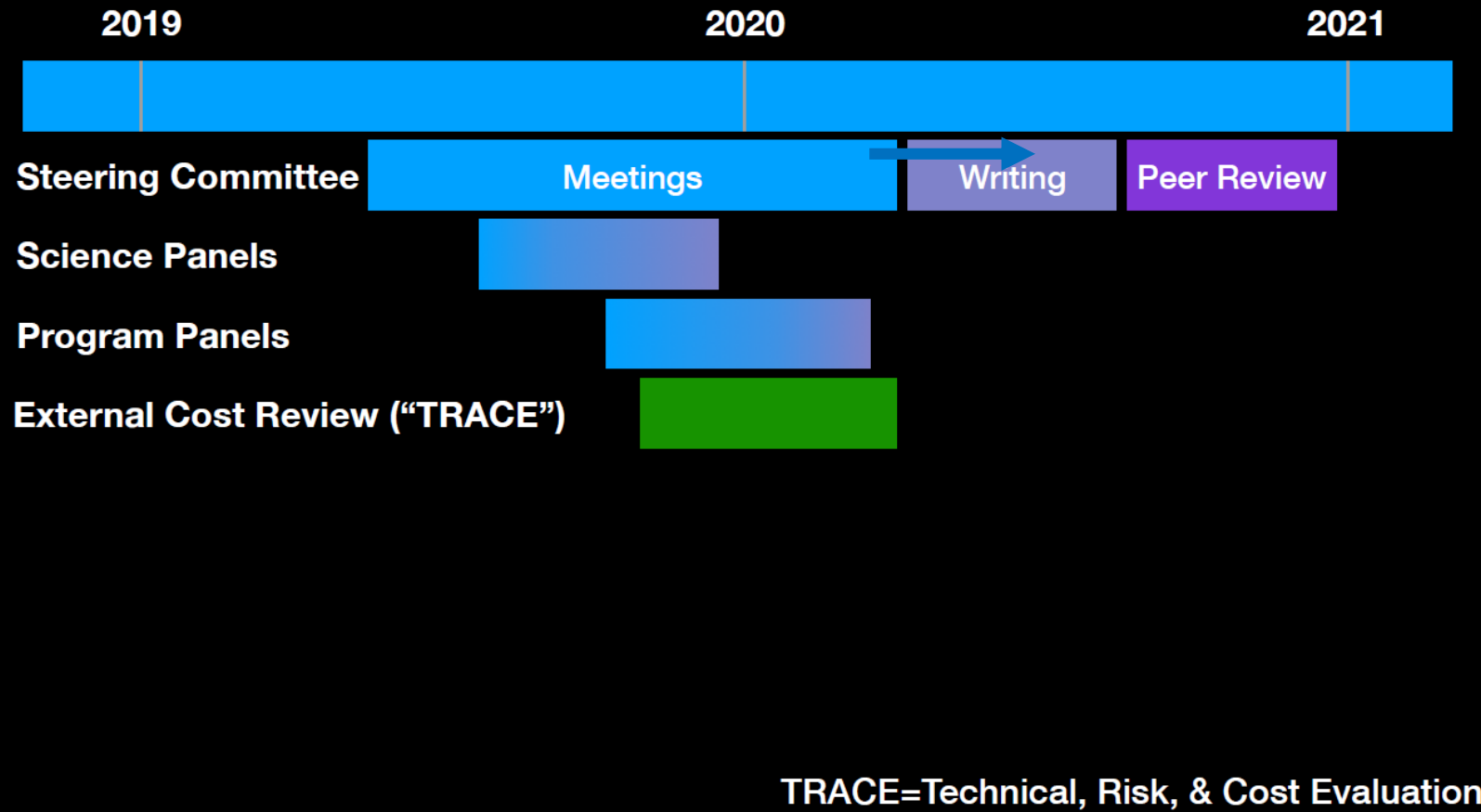
**Ellen G. Zweibel**

*University of Wisconsin, Madison*

## Decadal Survey Timeline

- Co-Chairs **Fiona Harris and Rob Kennicutt** announced -Nov 2018
- **Survey committee** identified & appointed - Spring 2019
- **Panels** formed - Late Spring, 2019 *In progress*
- Panel **deliberations** - Late CY2019
- Survey deliberations and report **writing** - Spring to Summer 2020
- Public **report released** - Early 2021
- Presentations to stakeholders - after public report released

# Notional Decadal Survey Timeline



# White Papers

- White papers are the primary method for community input and drive what the survey considers
- Science whitepapers ~590 submissions
  - submitted in March 2019, all read and discussed by science panels
- Activity and Project, and State of the Profession Consideration (APC) whitepapers
  - 300+ papers submitted July 10
  - ~250 APC white papers are relevant for program panels
  - ~70 papers address State of Profession
- Some topics inevitably straddle panel boundaries. We have attempted to assign general subtopics to a single panel
- All papers can be viewed at:
  - [https://sites.nationalacademies.org/DEPS/Astro2020/DEPS\\_192906](https://sites.nationalacademies.org/DEPS/Astro2020/DEPS_192906)



# Astro2020 Decadal Survey Panel Structure

## Science Panels

- Cosmology
- Galaxies
- Interstellar Medium, Star and Planet Formation
- Stars, the Sun, and Stellar Populations
- Compact Objects and Energetic Phenomena
- Exoplanets, Astrobiology, and the Solar System

## Program Panels

- Electromagnetic Observations from Space 1
- Electromagnetic Observations from Space 2
- Optical and Infrared Observations from the Ground
- Radio, Millimeter, and Submillimeter Observations from the Ground
- Particle Astrophysics and Gravitation
- Enabling Foundation for Research
- State of the Profession and Societal Impacts

# New for Astro2020

- Panel on An Enabling Foundation for Research

laboratory astrophysics; theory, computation, simulation; data collection, archiving, and analysis; facilities, funding, and programs; general technology development; international and private partnerships, and relevant areas of public policy.

- Panel on the State of the Profession and Its Societal Impacts

gather information on the health and demographics of the astronomy and astrophysics community and make actionable recommendations to the Astro 2020 committee on the topics of demographics, diversity and inclusion, workplace climate, workforce development, education, public outreach, benefits to the nation, and relevant areas of astronomy and public policy.

# Community Input

APCs and Science White Papers: hundreds received

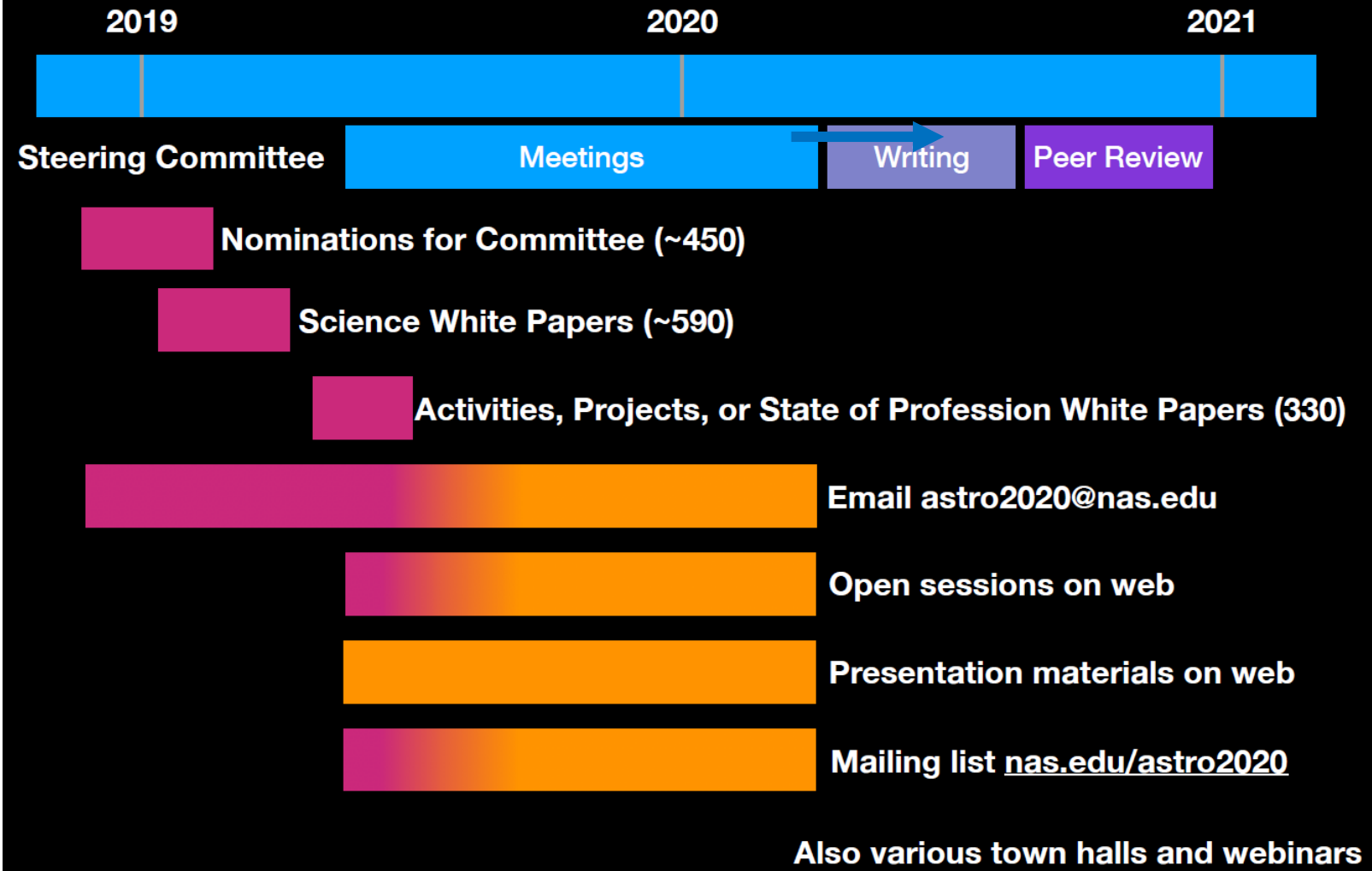
Call for Activity, Project, and State of the Profession Consideration (APC) and Science White Papers

Key science goals, technical overview, drivers, partnerships, schedule & cost

**Received ~590 Science papers and ~300 APC White papers!**

- Space
  - Small <\$500M
  - Medium \$500M - \$1.5B
  - Large >\$1.5B
- Ground
  - Small <\$20M
  - Medium \$20M - \$70M
  - Large >\$70M

# Public Participation





## *Why care about Decadal Surveys?*

They are both **swords and shields**



They are **swords** because a high decadal ranking provides a program manager with an argument supporting a new activity.

They are **shields** because they protect highly ranked programs from attack. The first Decadal Survey in any discipline is always difficult.

The changing environment over a decade is always an inherently difficult process to map, but **Decision Rules** can allow for more relevant advice with changing budgets, mission costs.

# Upcoming NAS SSB Events: You are Invited!

- October 22-24 Committee on Solar and Space Physics (CSSP), DC
- October 28-29 Forum for New Leaders in Space Science, DC
- October 29-31 Committee on Biological and Physical Science in Space (CBPSS) Irvine, CA
- November 6-8, 2019 **Space Studies Board**, Irvine, CA
- March 31-April 2, 2020 **Space Science Week**, DC (Emphasis on **International Panel & participation**)
- April 28-30, 2020 **Space Studies Board & Joint SSB/ASEB**, DC

SpaceX two-stage Falcon 9 launch 2019



The Times They are  
A-Changing

Blue Origin New Shepard Test Flight May 2019



Thank You!  
Questions?

