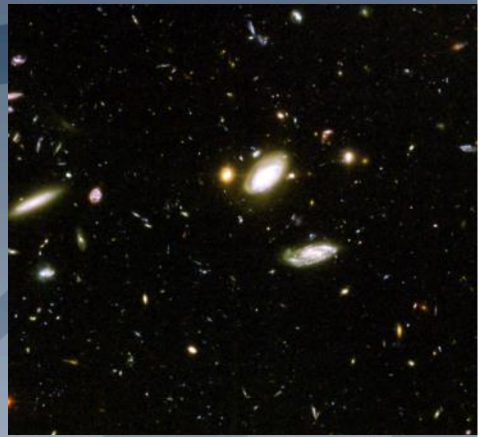
National Aeronautics and Space Administration

# Astrophysics



**Briefing to the Astrophysics Science and Technology Definition Teams**

May/June/July 2016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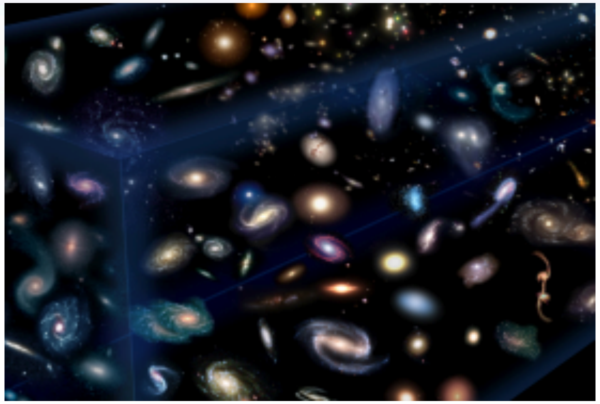
Science Mission Directorate

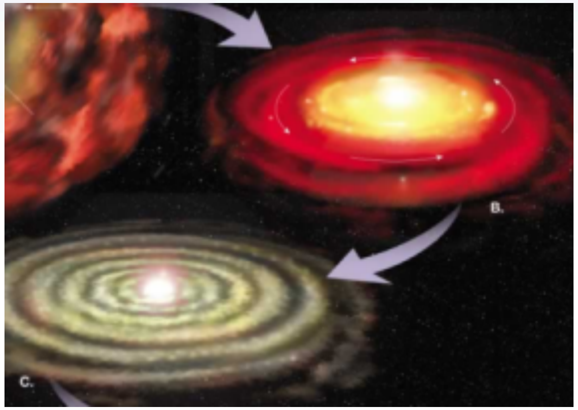
@PHertzNASA

# Why Astrophysics?

**Astrophysics is humankind's scientific endeavor to understand the universe and our place in it.**



1. How did our universe begin and evolve?

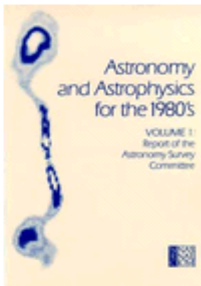



2. How did galaxies, stars, and planets come to be?

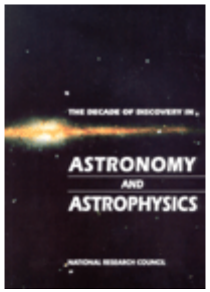
3. Are We Alone?

These national strategic drivers are enduring


1972




1982

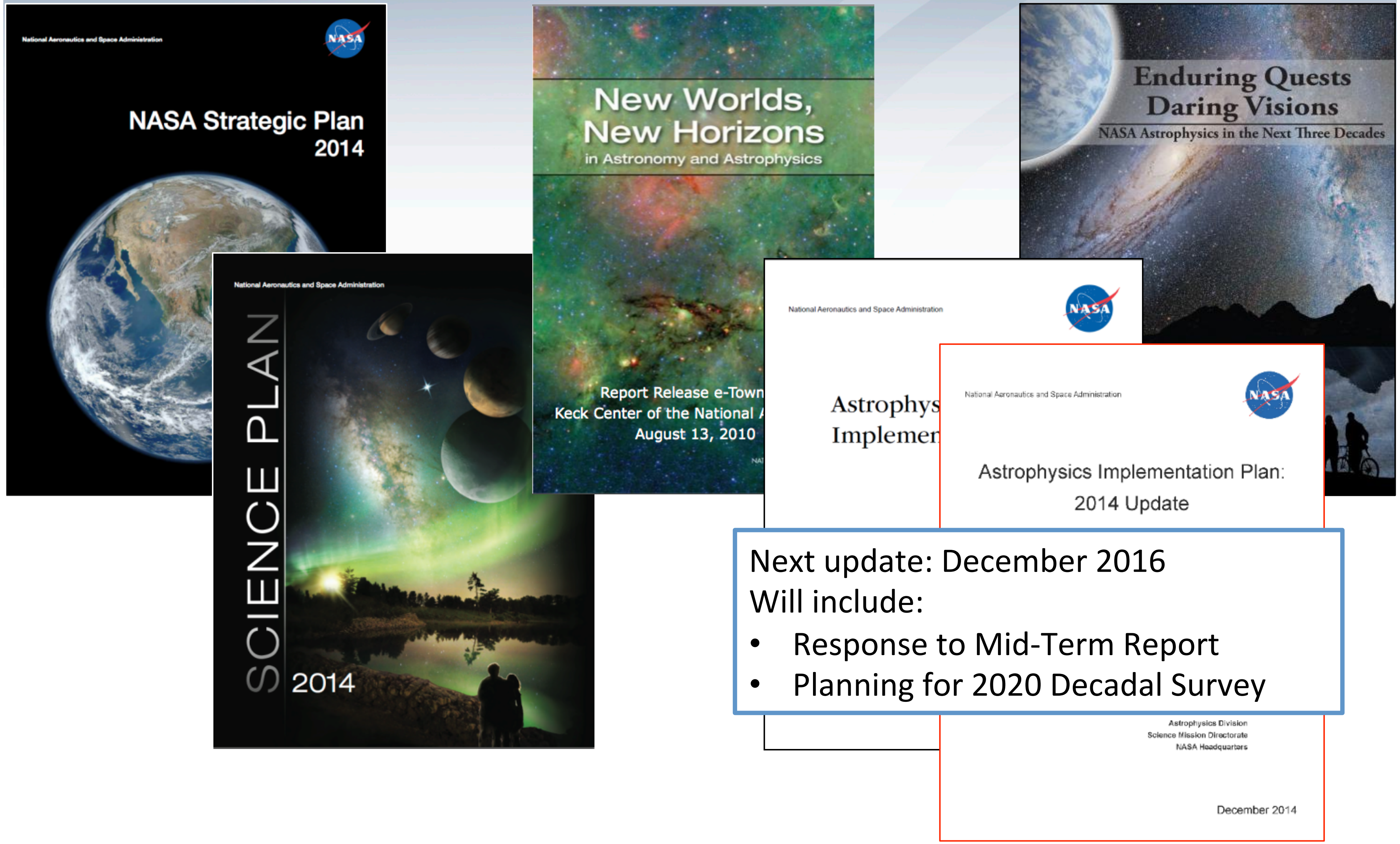



1991


2001


2010

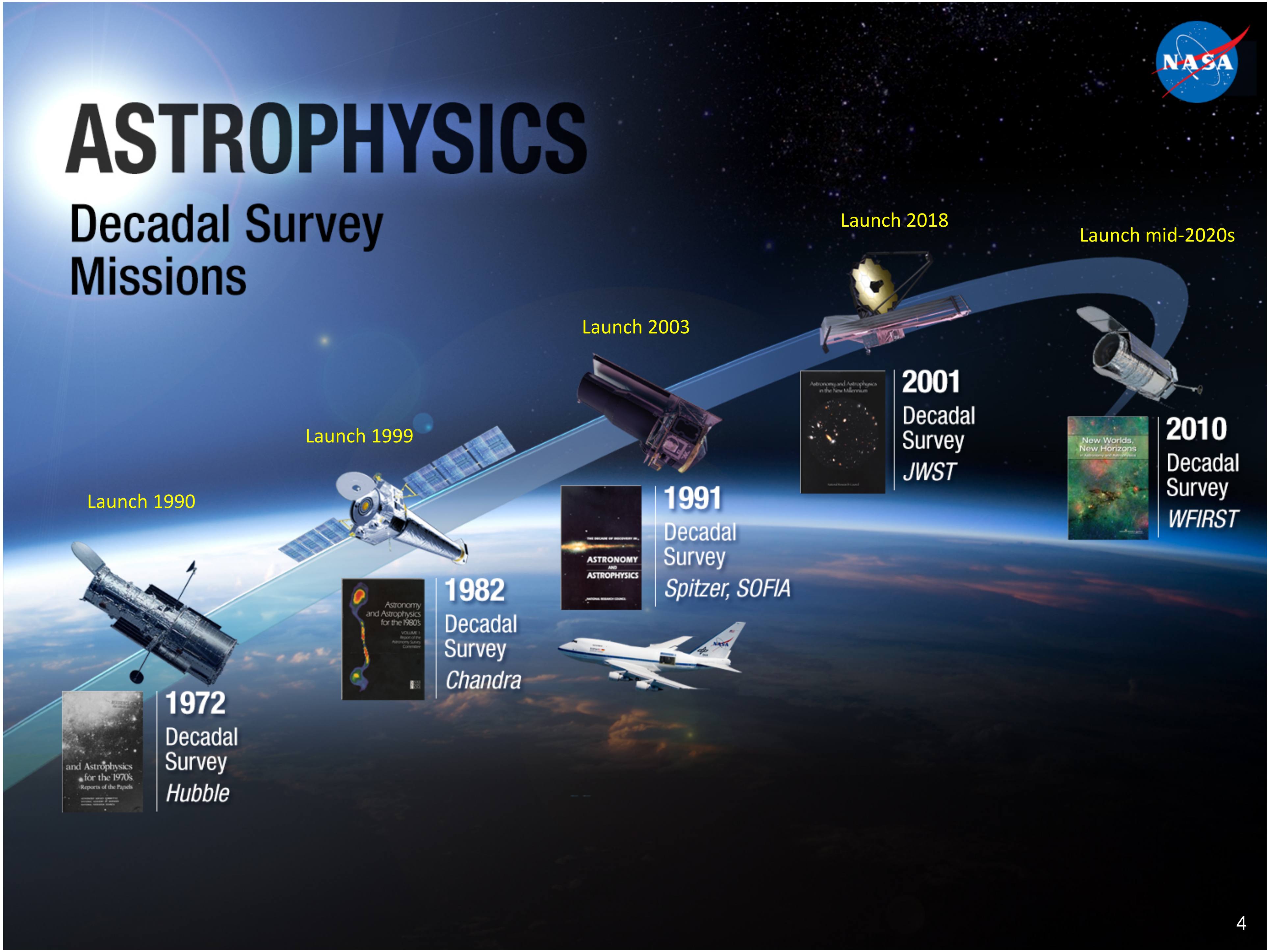
# Astrophysics Driving Documents




Next update: December 2016
Will include:

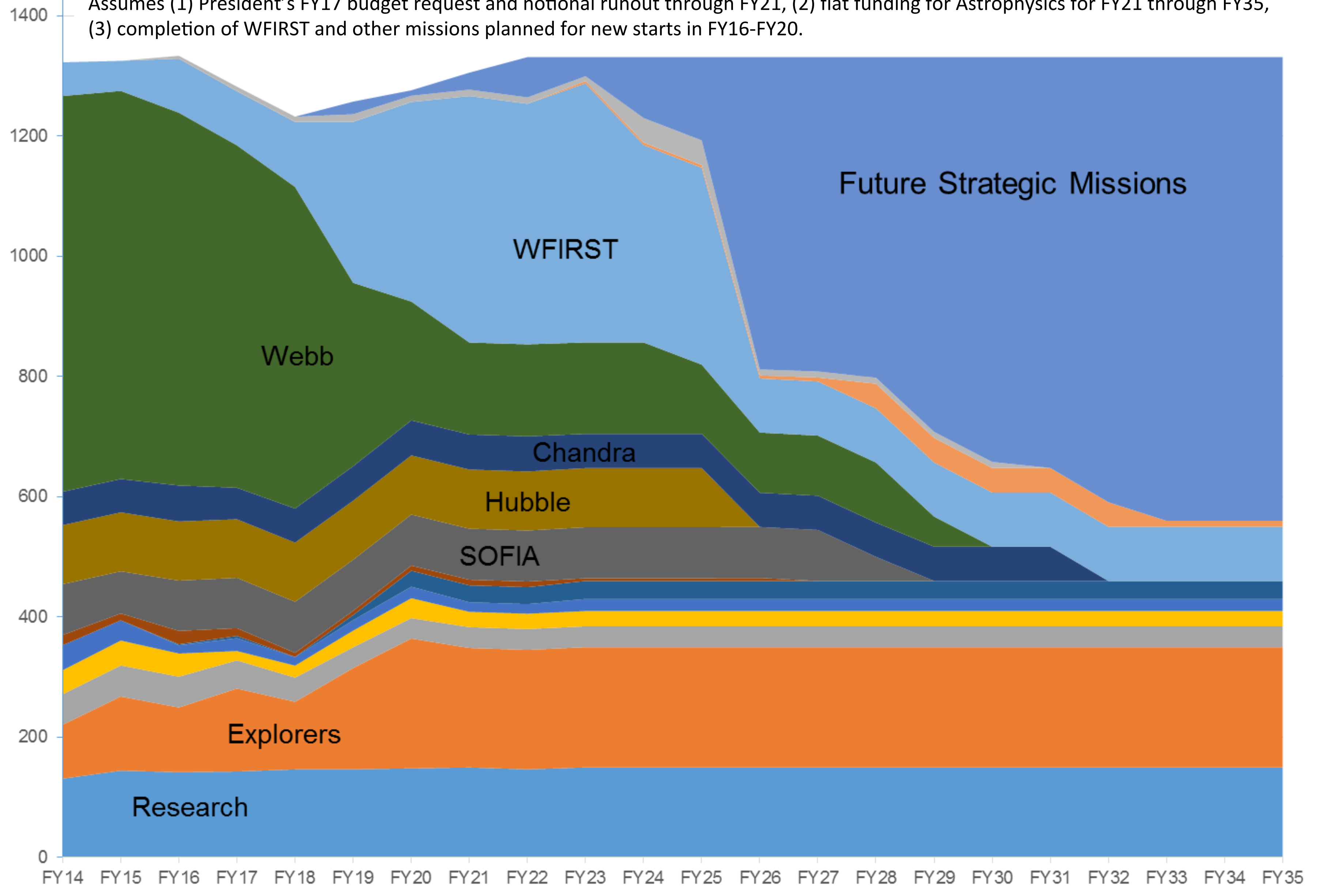
- Response to Mid-Term Report
- Planning for 2020 Decadal Survey

**http://science.nasa.gov/astrophysics/documents**

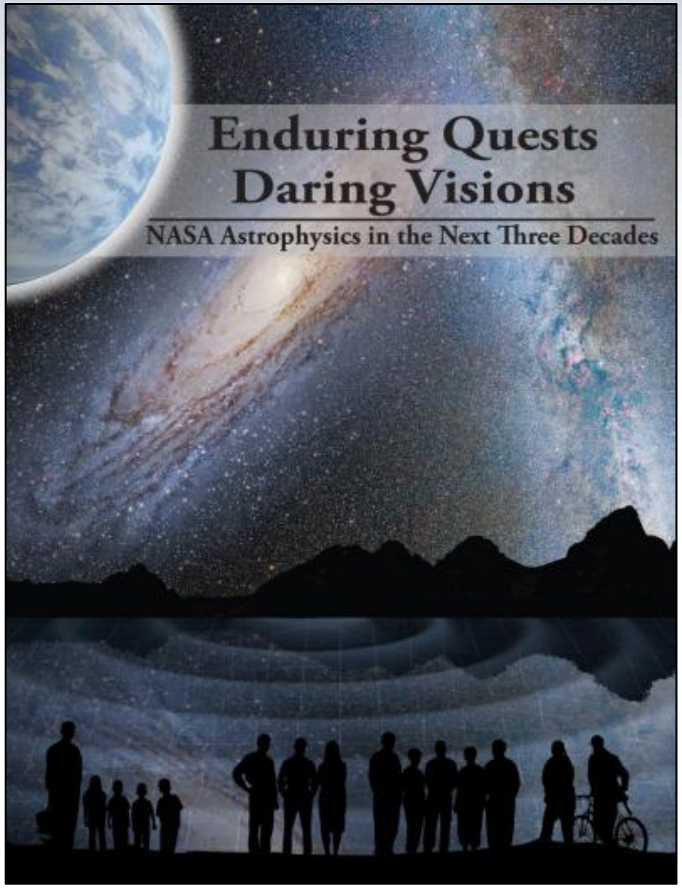

NASA
ASTROPHYSICS
Decadal Survey Missions
Launch 1990
and Astrophysics for the 1970's Reports of the Panels
1972 Decadal Survey Hubble
Launch 1999
Astronomy and Astrophysics for the 1980's
1982 Decadal Survey Chandra
Launch 2003
ASTRONOMY AND ASTROPHYSICS
1991 Decadal Survey Spitzer, SOFIA
Launch 2018
Astronomy and Astrophysics in the New Millennium
2001 Decadal Survey JWST
Launch mid-2020s
New Worlds, New Horizons
2010 Decadal Survey WFIRST

# The Landscape after WFIRST (notional)

Assumes (1) President's FY17 budget request and notional runout through FY21, (2) flat funding for Astrophysics for FY21 through FY35, (3) completion of WFIRST and other missions planned for new starts in FY16-FY20.



# A Community-driven Vision for the 2030s




- Far Infrared Surveyor
- Habitable Exoplanet Imaging Mission
- Large UV/Optical/Infrared Surveyor
- X-ray Surveyor

These four missions were endorsed by the Program Analysis Groups (PAGs) and recommended by the NAC's Astrophysics Subcommittee as the four mission concepts that NASA should study in preparation for the 2020 Decadal Survey.

# Preparing for the 2020 Decadal Survey Large Mission Concepts

NASA has assembled Science and Technology Definition Teams (STDTs) for each of the four large mission candidates to enable Mission Concept Studies as input to the 2020 Decadal Survey.

| | Community STDT Chairs | Center Study Scientist | Study Lead Center | HQ Program Scientist |
|---|---|---|---|---|
| Far IR Surveyor<br>asd.gsfc.nasa.gov/firs | Asantha Cooray<br>Margaret Meixner | David Leisawitz | GSFC | Kartik Sheth |
| Habitable Exoplanet Imaging Mission<br>www.jpl.nasa.gov/habex | Scott Gaudi<br>Sara Seager | Bertrand Mennesson | JPL | Martin Still |
| Large UV/Optical/IR Surveyor<br>asd.gsfc.nasa.gov/luvoir | Debra Fischer<br>Bradley Peterson | Aki Roberge | GSFC | Mario Perez |
| X-ray Surveyor<br>wwwastro.msfc.nasa.gov/xrs | Feryal Ozel<br>Alexey Vikhlinin | Jessica Gaskin | MSFC | Dan Evans |

**http://science.nasa.gov/astrophysics/2020-decadal-survey-planning/**

# Correcting Five Myths about the Large Mission Concept Studies

- This is not a competition and HQ will not select among the studies.
- This is not an AO proposal or a Phase A study.
- NASA will not build the design you come up with even if the Decadal Survey recommends your mission.
- A precise cost estimate is neither expected nor achievable.
- The Center and the Program Office are not in charge of the study; the Community Chairs are responsible for the final product.

# Success Criteria

NASA defines a successful outcome of these studies to be four compelling and executable mission concepts, which will subsequently be prioritized by the 2020 Decadal Survey.

**COMPELLING**: Worthy of a Decadal Survey recommendation (i.e., worth spending billions of $$ for the science return)

- Strong science motivation with well articulated objectives
- Groundbreaking science to be performed in the 2030s
- Synergies with existing/planned major ground- and space-based observatories

**EXECUTABLE**: Technically feasible with a believable path to technology maturation

- Dependence on technology maturation is expected.
- Architecture, mission design, and payload in the STDT report is notional.
- NASA has never launched the mission design that was specified in the Decadal Survey.
- Precise costing is neither expected or achievable.

# Science comes first

- First objective: A compelling science case for addressing critical science questions in the following decades
- Only then: The technical parameters necessary to achieve these goals, which will include:
  - Design Reference Mission, including notional payload.
  - Technology assessment.
  - Notional time to mature technology and develop mission.
- And at the very end: Cost assessment, major technical issues, and risk reduction plans as a function of science capability.

# A Community Driven Process


The Drivers
**The Community Chairs**

**The STDT Members**
Design the compelling science / technology case

The Liaison
**Center Study Scientist**

The Engine
**Center Study Team**
Center Study Manager manages resources

# Interactions with NASA

- The Community Chairs are ultimately responsible for the delivery of a compelling and feasible mission concept. The Community Chairs and the Center Study Scientist interact directly with the HQ Program Scientists.
- The Program Scientists for your study are the Division Director's eyes and ears for this activity.
- The Center Study Manager leads the technical work in support of your study.
- The Program Offices facilitate the implementation of your study.
- The Management Plan is a work in progress. Changes have been made based on feedback from Study Teams and experience of the last few months. Rev B is posted here:

  http://science.nasa.gov/astrophysics/2020-decadal-survey-planning/


Spitzer
8/25/2003
Kepler
3/7/2009
Formulation
Implementation
Primary Ops
Extended Ops
LISA Pathfinder (ESA)
12/3/2015
Webb
2018
WFIRST
Mid 2020s
Euclid (ESA)
2020
Chandra
7/23/1999
XMM-Newton (ESA)
12/10/1999
TESS
2017
Swift
11/20/2004
NuSTAR
6/13/2012
Your Mission Here
Fermi
6/11/2008
Hubble
4/24/1990
CREAM (on ISS)
2017
NICER (on ISS)
2017
SOFIA
Full Ops 5/2014

# NASA Astrophysics

# Considering ASTRO-H2

# Hitomi
(formerly ASTRO-H)
## Soft X-ray Spectrometer and Soft X-ray Telescope Mirrors

- **Explorer Mission of Opportunity**
- **PI**: R. Kelley, Goddard Space Flight Center
- **Launch Date**: Feb 17, 2016 on JAXA H-IIA
- **Science Objectives**: Study the physics of cosmic sources via high-resolution X-ray spectroscopy. The SXS will enable a wide range of physical measurements of sources ranging from stellar coronae to clusters of galaxies.

**CURRENT STATUS**

The U.S. provided key instrument contributions to the JAXA Hitomi mission, including:

- – Soft X-ray telescope mirrors (SXT-S and SXT-I)
- – X-ray Calorimeter Spectrometer Insert (CSI), including Adiabatic Demagnetization Refrigerator (ADR) and ADR Controller
- – Aperture Assembly

- Following successful activation of the observatory and instruments, Hitomi suffered a mission-ending spacecraft anomaly on March 26, 2016
- Prior to mission failure, the SXS demonstrated a spectral resolution of ~4.7 eV, significantly exceeding the pre-launch requirement
- The SXS completed several science observations, including a scientifically significant observation of the Perseus Cluster

**UPCOMING EVENTS:**

- Finalization of JAXA mishap investigation
- PI-led team complete analysis and archiving of available data

# Hitomi (formerly ASTRO-H) Anomaly
## JAXA Hitomi Experience Report (May 24, 2016)

## Presumed Mechanism (Summary)
(From “Normal situation” to the “Attitude anomaly Event” and “Objects separation”)

- On March 26th, attitude maneuver to orient toward an active galactic nucleus was completed as planned.
- After the maneuver, unexpected behavior of the attitude control system caused incorrect determination of its attitude as rotating, although the satellite was not rotating actually. In the result, the reaction wheel to stop the rotation was activated and lead to the rotation of satellite.
- In addition, unloading of angular velocity by Magnetic Torquer operated by attitude control system did not work properly because of the attitude anomaly. The angular momentum kept accumulating in reaction wheel.
- Judging the satellite is in the critical situation, ACS switched to Safe Hold mode, and the thrusters were used. At this time ACS provided atypical command to the thrusters by the inappropriate thruster control parameters. As a result, it thrusted in an unexpected manner, and it is estimated that the satellite rotation was accelerated.
- Since the rotation speed of the satellite exceeded the designed speed, parts of the satellite that are vulnerable to the rotation such as solar array paddles, Extensible Optical Bench and others separated off from the satellite. <u>There is high possibility that the both Solar Array Paddles had broken off at their bases and were separated.</u>

**http://http://global.jaxa.jp/projects/sat/astro_h/**

# Considering ASTRO-H2

**Background**

- The capability of spatially resolved, high spectral resolution x-ray images has been a key science objective of NASA since the 1985 selection of a GSFC microcalorimeter for the original AXAF payload.
- This capability has not yet been realized on an orbital mission, and the potential science return remains unrealized.
  - Placed on AXAF-S when AXAF descoped, then cancelled.
  - JAXA included a microcalorimeter built by GSFC on the ASTRO-E, ASTRO-E2 (Suzaku), and ASTRO-H (Hitomi) missions. None of these missions reached normal operations.
- The successful demonstration of the Soft X-ray Spectrometer (SXS), along with its cooling chain, on ASTRO-H (Hitomi) demonstrated TRL-9 for this technology and retired the technology maturation risk.
- On June 1 & June 14, JAXA President Okumura announced JAXA's intent to study a rebuild of Hitomi ("ASTRO-H2") and JAXA has asked NASA to consider participating in the mission.
  - NASA has agreed to consider a build-to-print of the instrument demonstrated on ASTRO-H (Hitomi).
  - JAXA has indicated a desire to begin development of ASTRO-H2, if approved, in FY2017.

# Considering ASTRO-H2

**Benefit**

- Cited in the 2010 Decadal Survey as a "truly revolutionary technology," an X-ray microcalorimeter will provide a major leap forward in our understanding of the universe.
- The science community has communicated the importance of this science and the impact of the loss of ASTRO-H (Hitomi) directly to NASA.
- Achieving the science possible with a relatively modest observatory (e.g., ASTRO-H2 with SXS) in advance of a large observatory with a next generation microcalorimeter instrument (Athena with the X-ray Integral Field Unit (XIFU) microcalorimeter) would significantly enhance the science return and mitigate the technical risk of the Athena mission.
- The report from the X-ray Science Interest Group (XRSIG) of the Physics of the Cosmos Program Analysis Group (PhysPAG), dated July 5, 2016, offers more details.

# Considering ASTRO-H2

**Cost**

- Assuming a build-to-print SXS instrument (detector system including cooling chain and associated electronics plus two mirror systems), and taking into account lessons learned and available flight spare parts, the estimated cost for the U.S. (4.5 year Phase A-D, not including operations and GO program) would be $70-90M (FY2017-FY2021).
- At this time, it is not known whether any additional funding would be made available to supplement the planned NASA astrophysics budget to undertake a NASA contribution to ASTRO-H2.
- The approximately $20M per year required for a NASA contribution to ASTRO-H2 is smaller than the challenges to the planned astrophysics program in recent appropriations that have been accommodated with modest acceptable impact.
- The funding required for a NASA contribution to ASTRO-H2 would need to start in FY2017, so delaying future Astrophysics Explorers AOs (like the 2016 MIDEX AO) would not free up funding in the appropriate year; NASA therefore does not intend to delay the 2016 MIDEX AO even if a decision is made to proceed with ASTRO-H2.

# Considering ASTRO-H2

**Plan**

- NASA is studying the possibility of contributing for ASTRO-H2 a build-to-print copy of the flight hardware provided for Hitomi.
- NASA will work with JAXA to address the root causes that JAXA has identified as being responsible for the Hitomi mishap and loss of mission. NASA and JAXA will address these issues to assure that any future JAXA/NASA partnership missions will be successful.
- Should NASA agree to participate in ASTRO-H2, the development of the ASTRO-H2 hardware and guest observer facility would be directed to GSFC rather than competed through a competitive proposal opportunity, such as an Explorers MO AO. Only the GSFC team can execute a build-to-print project, on a rapid schedule and at the lowest cost.
- Should NASA agree to participate in ASTRO-H2, NASA will work with JAXA to make the ASTRO-H2 observatory available to the general observer (GO) community at a level equal to or greater than was planned for Hitomi.
- NASA will continue discussions with JAXA in August 2016 regarding a possible ASTRO-H2 mission.