

National Aeronautics and Space Administration



**WFIRST-AFTA  
SDT #4  
Oxon Hill, MD**

January 9, 2014

**Astrophysics**

**Dominic Benford**

**WFIRST Program Scientist  
NASA / HQ**

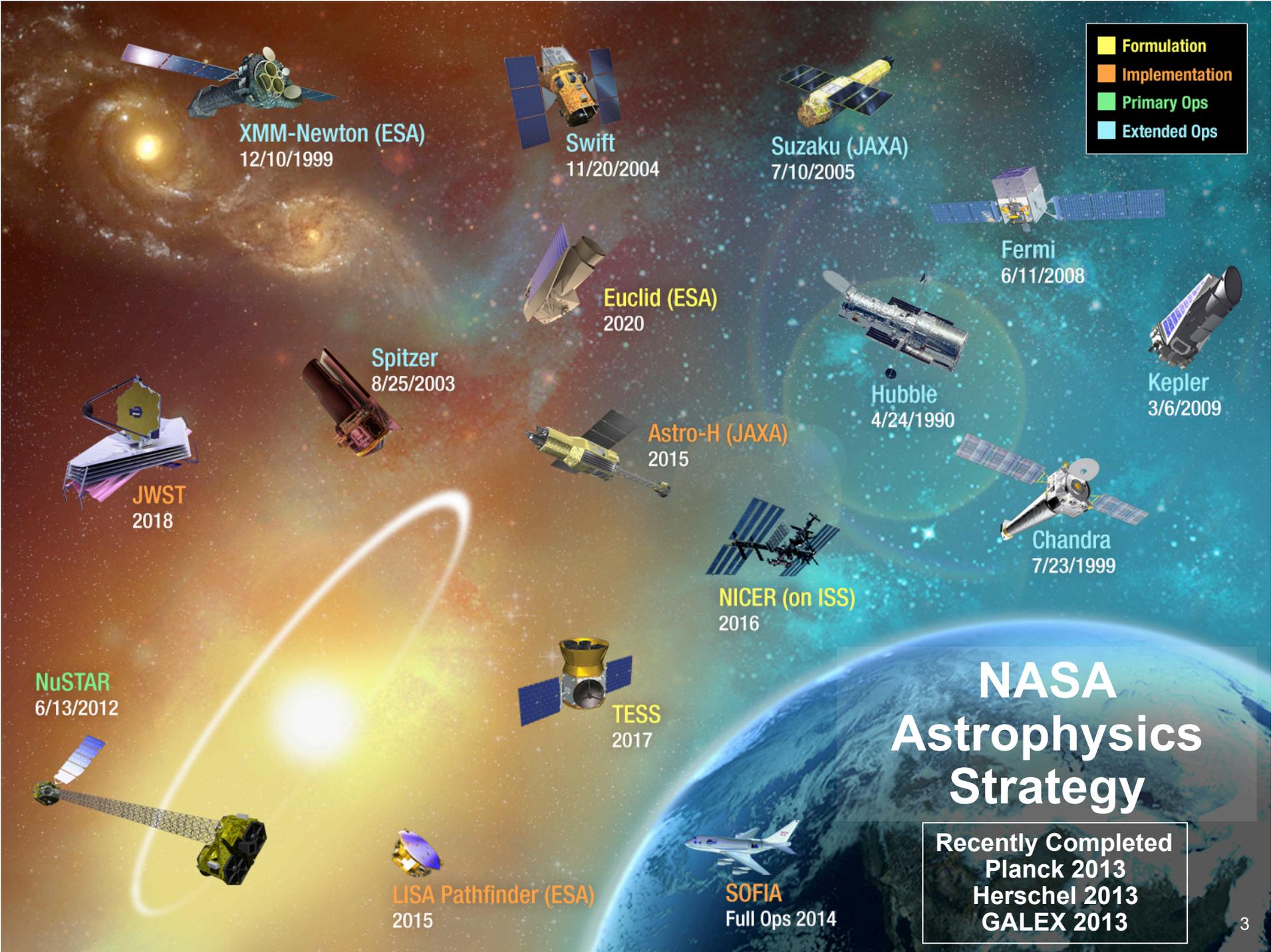
[www.nasa.gov](http://www.nasa.gov)

This presentation is posted at  
<http://science.nasa.gov/astrophysics/documents/>

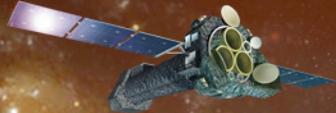


# Outline

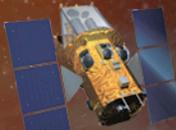
- NASA Astrophysics Strategy
  - The Big Picture
  - Science in 2013
  - Progress Toward the Decadal Survey
- NASA Astrophysics Budget
  - Budget Strategy
  - FY13 Budget
  - FY14 Budget
- NASA Astrophysics Programs
  - Impact of Government Shutdown
  - JWST & WFIRST-AFTA
  - Highlights for 2014
  - Research and Analysis Programs
- NASA Astrophysics Vision



- Formulation
- Implementation
- Primary Ops
- Extended Ops



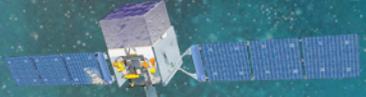
**XMM-Newton (ESA)**  
12/10/1999



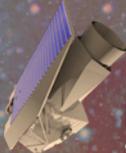
**Swift**  
11/20/2004



**Suzaku (JAXA)**  
7/10/2005



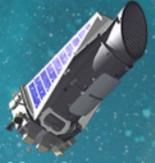
**Fermi**  
6/11/2008



**Euclid (ESA)**  
2020



**Hubble**  
4/24/1990



**Kepler**  
3/6/2009



**Spitzer**  
8/25/2003



**Astro-H (JAXA)**  
2015



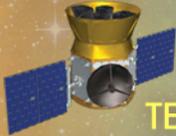
**Chandra**  
7/23/1999



**JWST**  
2018

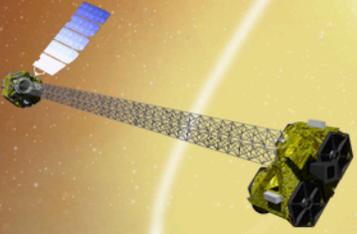


**NICER (on ISS)**  
2016

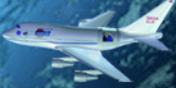


**TESS**  
2017

**NuSTAR**  
6/13/2012



**LISA Pathfinder (ESA)**  
2015



**SOFIA**  
Full Ops 2014

# NASA Astrophysics Strategy

- Recently Completed  
 Planck 2013  
 Herschel 2013  
 GALEX 2013

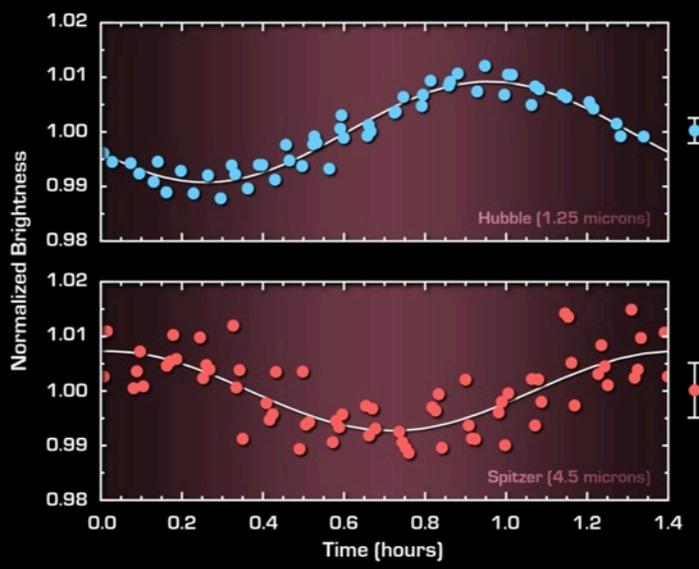
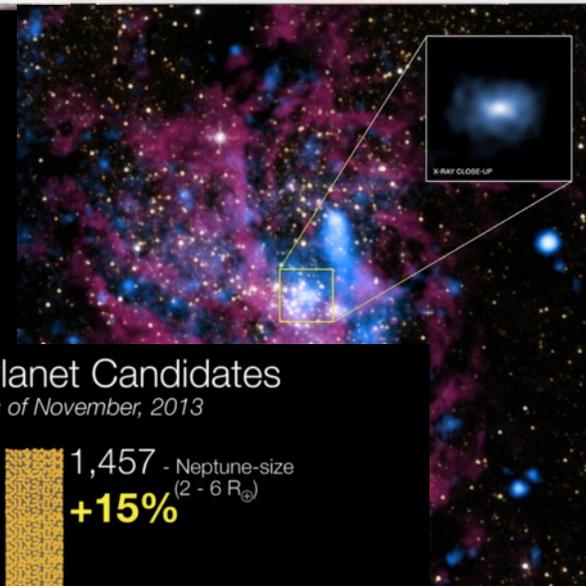
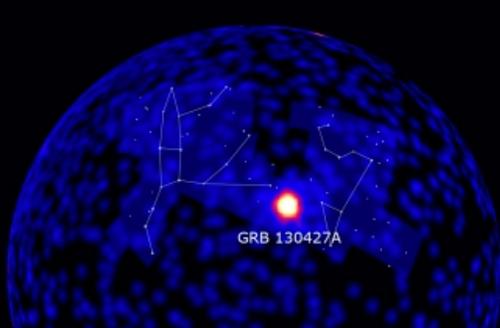


# The Big Picture

- This remains a time of scientific opportunity for NASA Astrophysics.
  - We are poised to answer the most compelling science questions.
  - The budget for NASA astrophysics, which includes JWST, is at ~\$1.25B, a high level.
  - NASA continues to operate large and small space-based observatories spanning the electromagnetic spectrum, including multiple Great Observatories.
  - The James Webb Space Telescope, the highest priority of the community, is on schedule and fully funded for an October 2018 launch.
  - NASA continues to develop contributions to international missions for launch this decade.
  - NASA has downselected two new Explorer projects to begin development for launch this decade, and an Explorer AO is planned for late 2014 to select two more Explorer projects.
  - NASA continues to support individual investigators for data analysis, theory, and technology investigations through open, competitive, peer reviewed processes.
  - NASA is preparing for the strategic mission that will follow JWST.
- The budgetary future remains uncertain.
  - Priorities must be used to guide difficult budget choices.

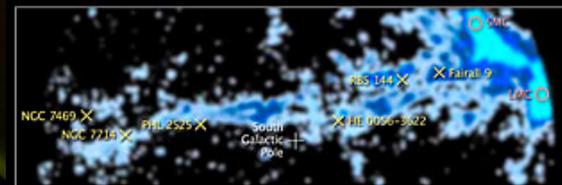
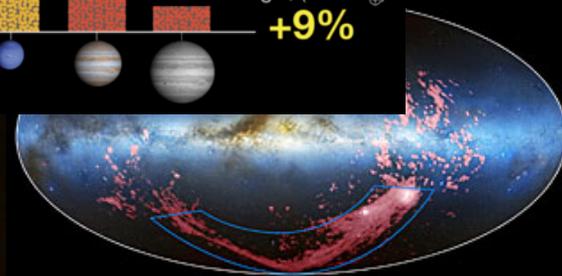
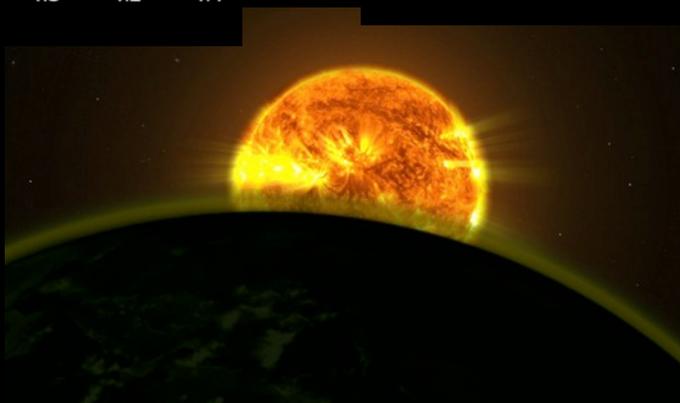
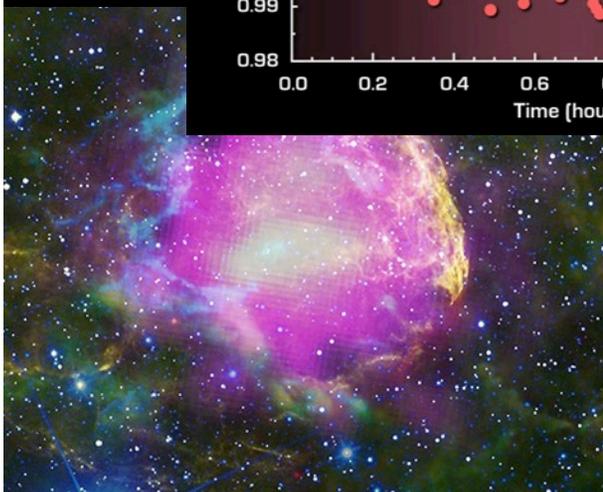
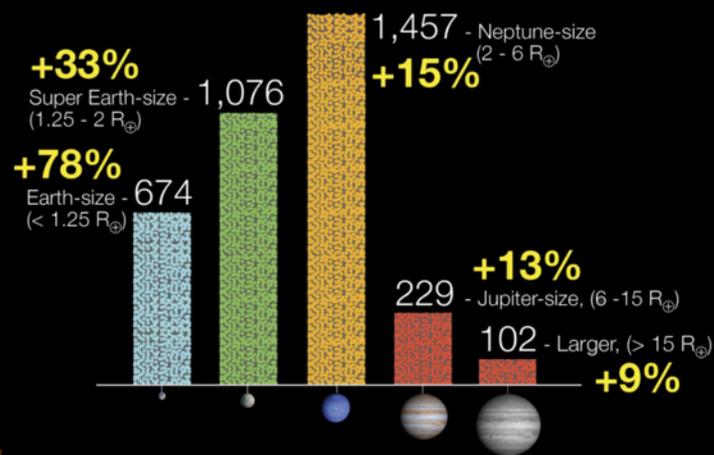


# Science in 2013



## Sizes of Planet Candidates

Totals as of November, 2013



# ASTROPHYSICS

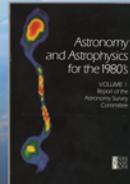
## Decadal Survey Missions

1990



1972  
Decadal Survey  
*Hubble*

1999



1982  
Decadal Survey  
*Chandra*

2003



1991  
Decadal Survey  
*Spitzer*

LRD: 2018



2001  
Decadal Survey  
*JWST*

LRD: 2020s



2010  
Decadal Survey  
*WFIRST*



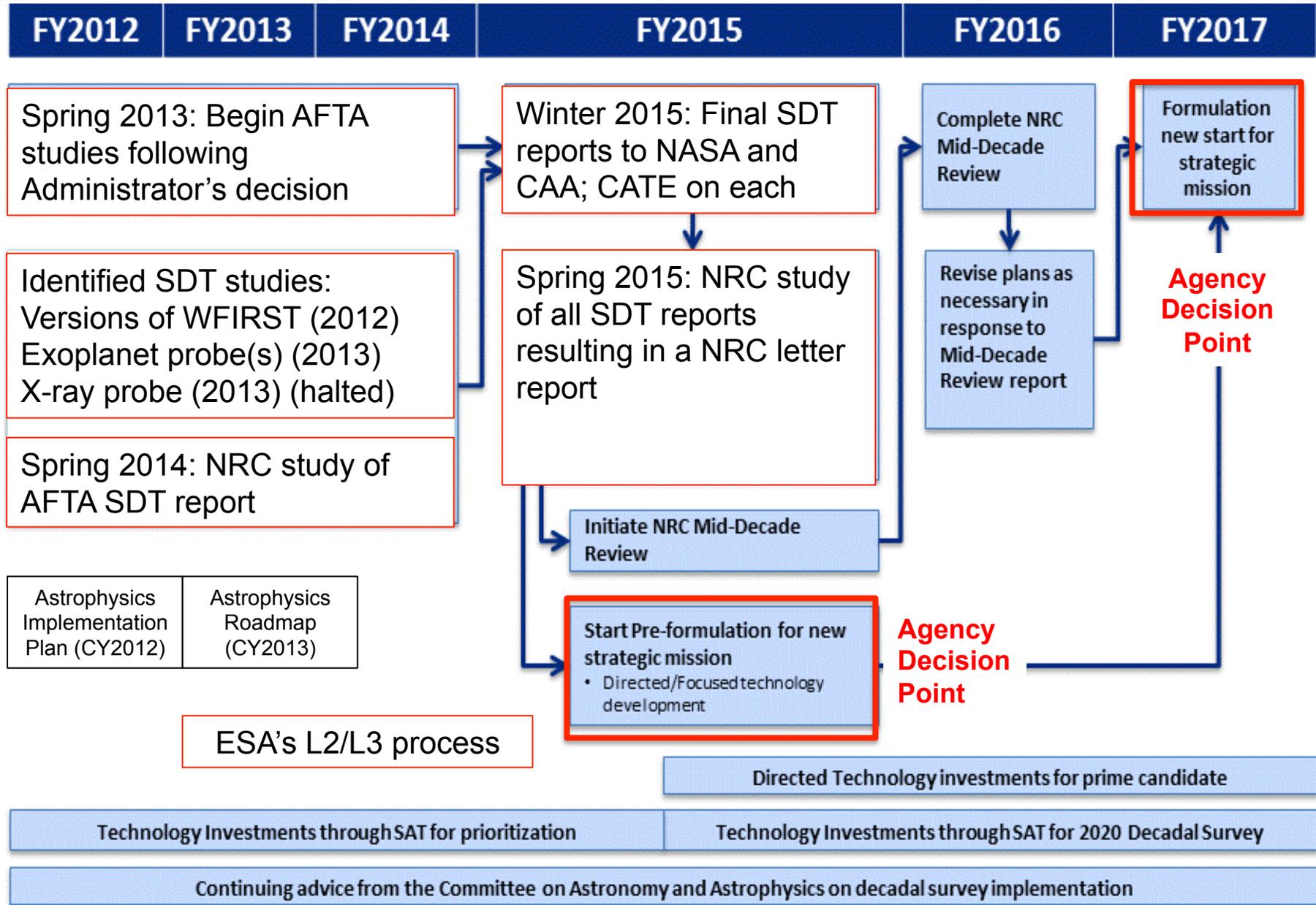
# Progress Toward Decadal Survey Priorities

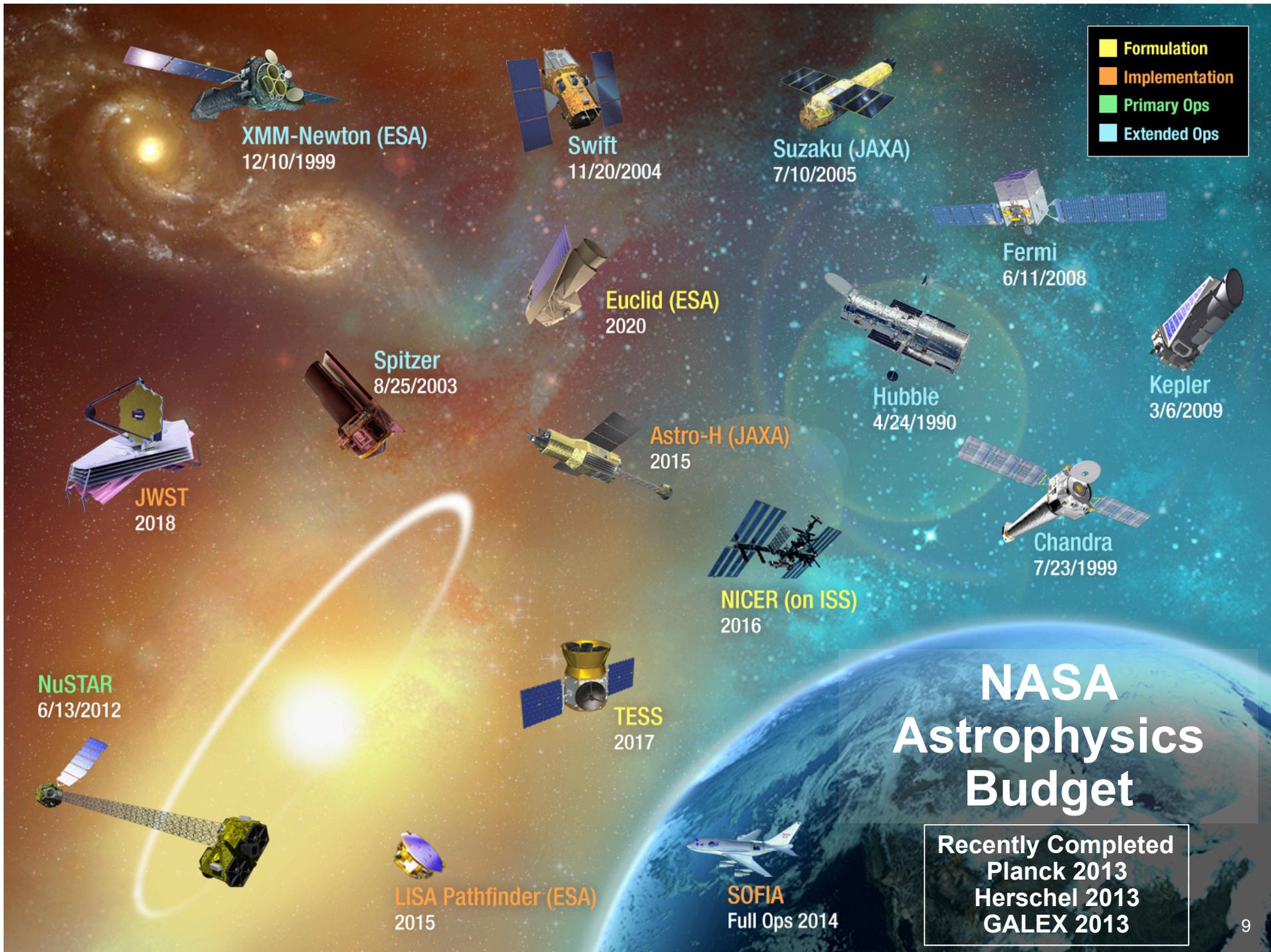
## The President's Budget Request for FY14 supports

L1. WFIRST	Preformulation and focused technology development for AFTA (a 2.4m version of WFIRST) are underway to enable a new start NET FY17
L2. Augmentation to Explorer Program	Increased from ~\$90M in FY07 and ~\$115M/yr in FY10 to ~\$140M/yr in FY16 and beyond; supports AOs in 2014, 2017, ...
L3. LISA	Strategic technology investments plus discussing partnership in ESA's L3 gravitational wave observatory
L4. IXO	Strategic technology investments plus discussing partnership in ESA's L2 X-ray observatory
M1. New Worlds Technology Development Program	Focused technology development for a coronagraph on WFIRST; mission concept studies and strategic technology investments
M2. Inflation Probe Technology Development Program	Three balloon-borne investigations plus strategic technology investments



# Implementing the Decadal Survey

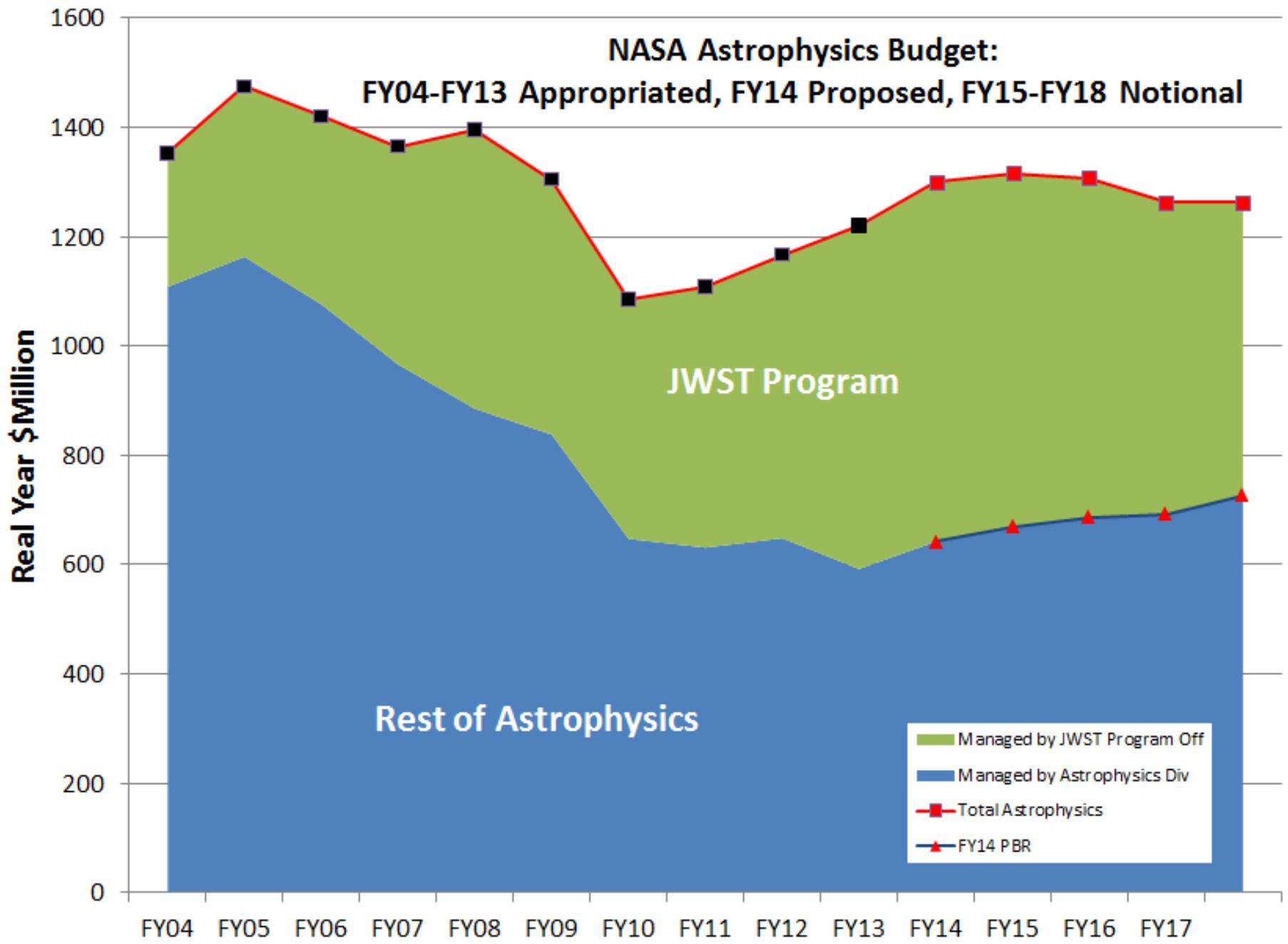






# Astrophysics Budget Strategy

- Use the scientific priorities of the 2010 Decadal Survey to guide strategy and inform choices.
- There is inadequate available budget to implement the 2010 Decadal Survey recommendations as written.
- A goal is to be prepared to start a new strategic NASA Astrophysics mission to follow JWST as soon as funding becomes available, while continuing to advance Decadal Survey science during the interim.
  - WFIRST-AFTA (WFIRST using existing 2.4 m telescopes)
  - Moderate missions (“probes”) derived from the science objectives of the prioritized missions and recommendations in the 2010 Decadal Survey are being studied, in addition to a large mission (WFIRST), to be prepared for a mid-decade decision.
- As appropriate, collaborate with international partners to realize Decadal Survey priorities and recommendations.
  - Partner on ESA’s Euclid mission (complements WFIRST commitment)
  - Partner on ESA’s L2 x-ray observatory (responds to IXO recommendation)
  - Partner on ESA’s L3 gravitational wave observatory (responds to LISA recommendation)





## FY13 Budget Appropriation

- Congress appropriated \$659M for Astrophysics & \$628M for JWST.
  - Matched President's budget request before sequestration.
  - Rescission (~1.8%), Sequestration (~5%), and other budget adjustments resulted in an FY13 Astrophysics budget significantly lower.
  - Astrophysics ended at \$617M (\$42M reduction) & JWST ended at \$628M for FY13.
- Astrophysics made reductions totaling \$42M (6.4%) in the following areas.
  - Reduced carry-over for operating missions, includes rephasing of GO funds.
  - Rephased unneeded FY13 reserves for developing missions.
  - Rephased R&A funding until FY14 for some PIs, reduced selections.
  - Slowed down development of current and future Explorers.
  - Postponed needed upgrades in infrastructure programs.
  - Downstream impacts include.
    - Lowered R&A selection rates in 2013 (for FY14 funding).
    - Delays in future Explorer AOs.
    - Other reductions in FY14 where funding requirements were deferred.



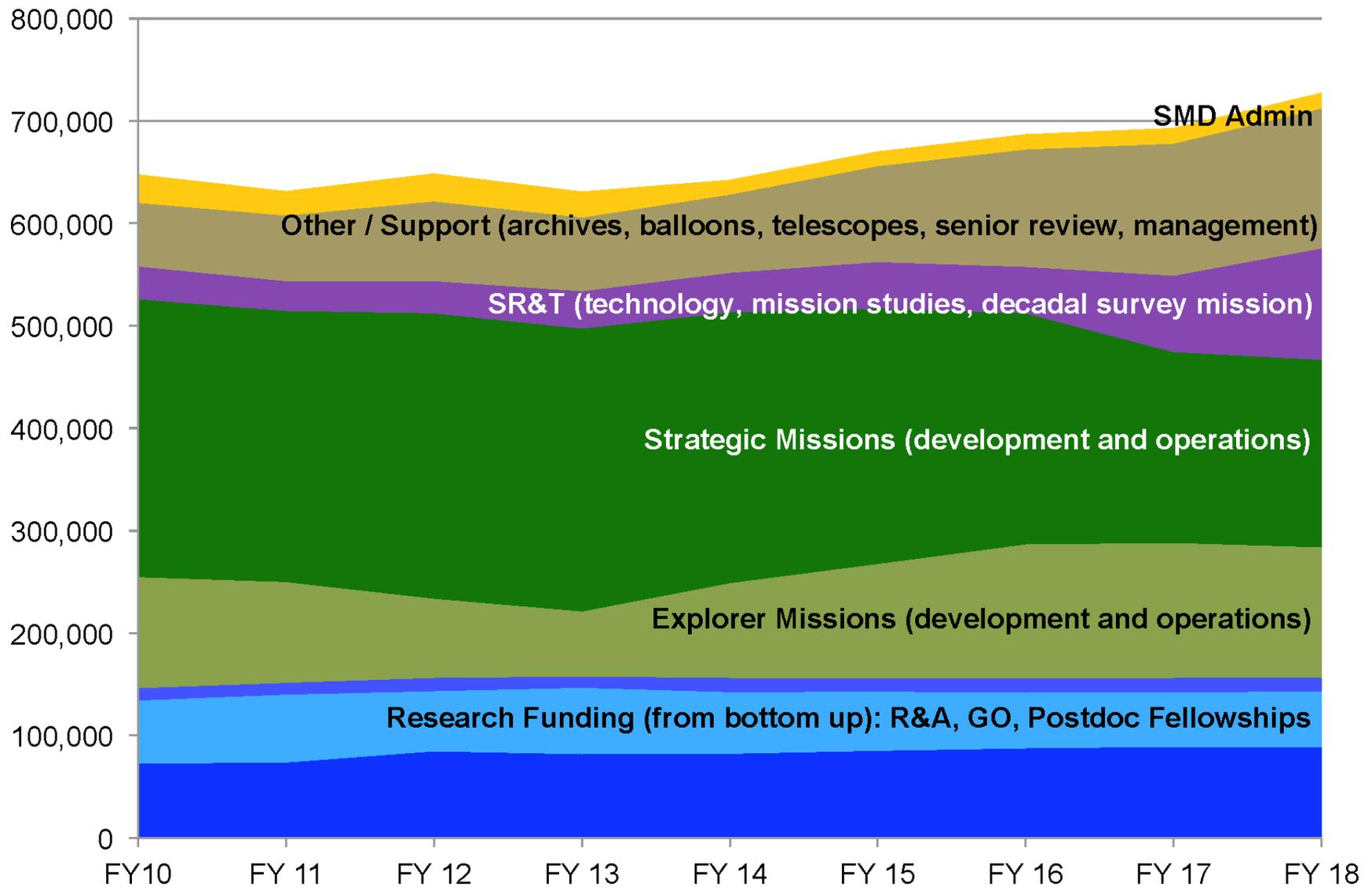
## FY14 Budget Appropriation

- President requested \$642M for Astrophysics and \$658M for JWST.
  - Request includes full funding required for JWST; new projects for TESS, NICER, Euclid; mission extensions per 2012 Senior Review; core funding for research and suborbital projects; planning budget wedge for strategic mission starting in FY17.
  - Request includes no funding for E/PO.
- Continuing resolution through January 15, 2014, is at FY13 post-sequestration level.
  - JWST is prioritized by NASA and will receive the funding required to maintain progress toward a 2018 LRD per the new baseline plan.
- Budget agreement sets FY14 and FY15 budget levels.
  - Astrophysics budget for FY14 is still TBD, but likely to be between President's Request (\$642M) and FY13 post-sequestration (\$617M).
  - Our current plans for missions and R&A follow the President's Request, so reductions and deferrals in some programs are expected.



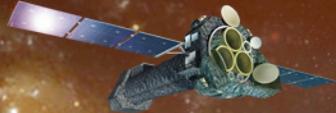
# Astrophysics Balance (w/out JWST)

Astrophysics Budget (w/out JWST) in \$K  
FY10-FY12 Actuals; FY13 Estimate; FY14 Request; FY15-FY18 Notional





- Formulation
- Implementation
- Primary Ops
- Extended Ops



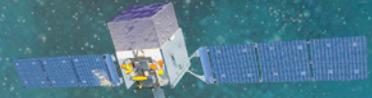
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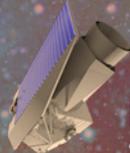
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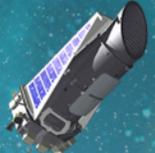
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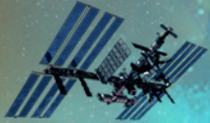
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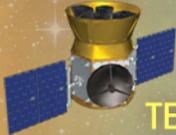
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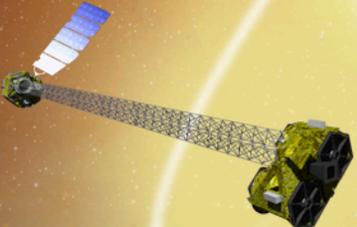


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**SOFIA**  
Full Ops 2014

# NASA Astrophysics Programs

- Recently Completed  
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 Herschel 2013  
 GALEX 2013



## Major Impacts of Government Shutdown

- The 2013-2014 Antarctic long duration balloon campaign is cancelled.
  - The shutdown came at a critical time, there were insufficient resources and time to prepare the McMurdo station and the payloads for launch.
  - Three astrophysics LDB flights have been cancelled for 2013-2014:
    - SPIDER (PI: W. Jones, Princeton) – CMB polarization
    - BACCUS (PI: A. Malinin, U. Maryland) – Cosmic-ray astrophysics
    - Super Pressure Balloon 100 day test flight (Balloon Program Office)
  - They will compete with other payloads planned for next year.
- SOFIA cancelled 9 science flights with U.S. instruments.
  - Rescheduling FLITECAM commissioning delays FOC milestone.
- Stand down in ASTRO-H soft x-ray spectrometer (SXS) integration and test will result in a ~5 week delivery delay to JAXA.
  - SXS is near ASTRO-H critical path, so will have TBD impact on ASTRO-H integration and test schedule.
  - Delay increases U.S. cost to complete SXS.
- Other development projects took schedule hits including 1 month on ISS-CREAM payload.
- Operating missions continued most activities, some delay in science data processing.
- There will be delays in sending out research funding.



# JWST

## James Webb Space Telescope



### Large Infrared Space Observatory

Top priority of 2000 Decadal Survey

**Science themes:** First Light; Assembly of Galaxies; Birth of Stars and Planetary Systems; Planetary Systems and the Origins of Life

**Mission:** 6.5m deployable, segmented telescope at L2, passively cooled to <50K behind a large, deployable sunshield

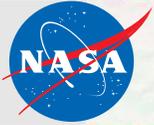
**Instruments:** Near IR Camera, Near IR Spectrograph, Mid IR Instrument, Near IR Imager and Slitless Spectrograph

**Operations:** 2018 launch for a 5-year prime mission

**Partners:** ESA, CSA

### CURRENT STATUS:

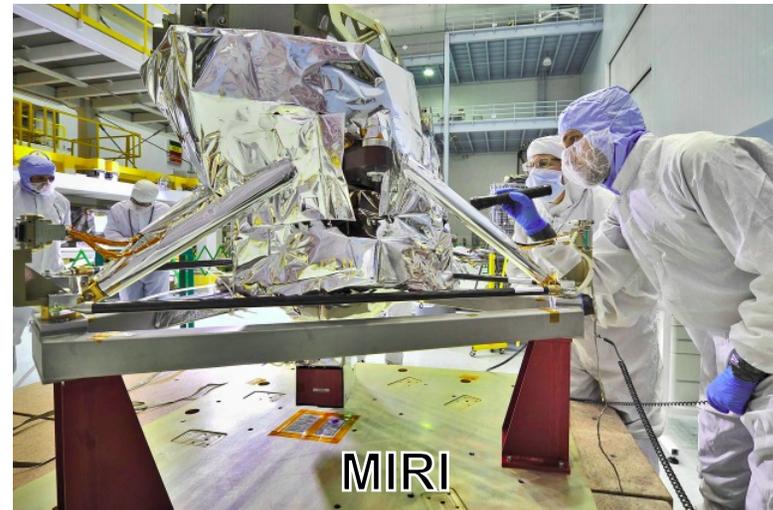
- Project has entered its long and challenging Integration and Test activities.
- Technical progress continues to be significant.
  - Instruments are delivered and in integration & test phase.
  - All optics are complete (primary segments, secondary, tertiary and fine steering mirrors) and delivered to GSFC.
  - Telescope wings are complete; backplane support fixture and center section are complete.
  - Spacecraft completing reviews leading to spacecraft Critical Design Review (Jan 2014).
- Project is performing within the budget, to schedule.
  - Government shutdown did not impact October 2018 launch date.
- FY14 is the peak funding year with many critical activities.



# JWST

## James Webb Space Telescope

- JWST remains on schedule for its October 2018 launch





# Kepler

## Kepler Space Telescope



- **NASA's first space mission dedicated to the search for extrasolar planets, or exoplanets**
- **PI:** W. Borucki, NASA Ames Research Center
- **Launch Date:** March 6, 2009
- **Payload:** 0.95-meter diameter telescope designed to measure the tiny dimming that occurs when an orbiting planet passes in front of ('transits') a star
- **Scientific objectives:**
  - conduct census of exoplanet systems
  - explore the structure and diversity of extrasolar planetary systems
  - determine the frequency of habitable, Earth-sized planets in our galaxy

### CURRENT STATUS:

- Continuously monitored 100 sq. deg. field in constellations of Cygnus and Lyra for 4+ years
- Analysis of first 3 years of Kepler data has revealed:
  - 3538 exoplanet candidates orbiting 2658 unique stars
  - 167 candidates confirmed as planets to date
  - More than 100 planets discovered in their star's "habitable zone"—the region in the planetary system where liquid water might exist on the surface of a planet
  - two dozen of the habitable zone planet candidates are less than twice the size of the Earth
- Analysis of the full (4+ year) Kepler data set ongoing
- Spacecraft suffered failure of 2 reaction wheels in July 2012 and May 2013:
  - Only 2 functional reaction wheels remain
  - Not sufficient to maintain precise pointing on the Kepler field
- Project has developed strategy for a new science mission that requires only 2 reaction wheels (see <http://www.nasa.gov/kepler/a-sunny-outlook-for-nasa-keplers-second-light>)
- New mission concept will be proposed to the 2014 Astrophysics Senior Review



# SOFIA

## Stratospheric Observatory for Infrared Astronomy



- **World's Largest Airborne Observatory**
- 2.5-meter telescope
- Capable of observing from the visible to the far infrared
- 80/20 Partnership between NASA and the German Aerospace Center (DLR)
- Mission Ops based at NASA-Dryden
- Science Ops based at NASA-Ames
- Six First-Generation instruments
  - Four U.S., two German
  - Imaging, Spectroscopy, and Photometry
- Limited Science Ops began 2010
- Full Operational Capability in 2014

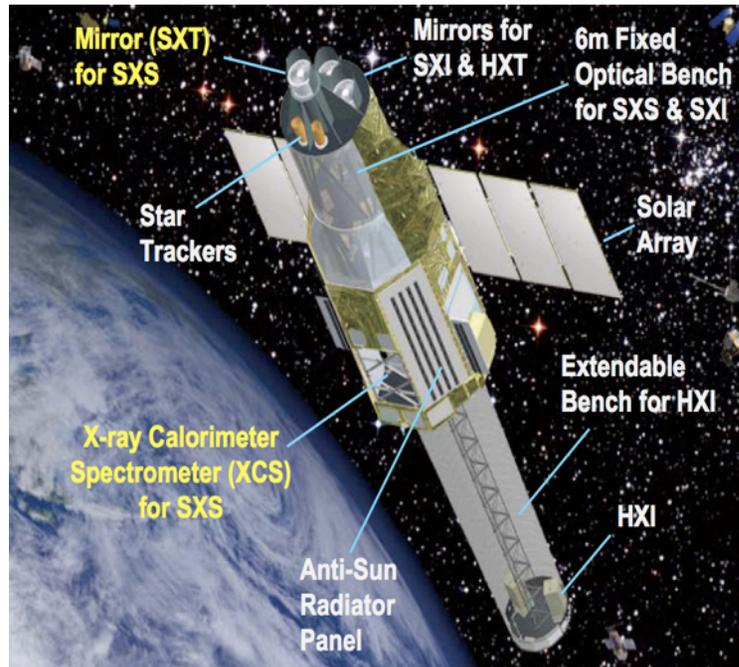
### CURRENT STATUS:

- Completed 46 successful flights during Calendar Year 2013
  - 25 science (153 research hours)
  - 10 instrument commissioning
  - 5 engineering/test
  - 6 ferry flights (to/from deployment)
- Completed Inaugural Southern Hemisphere Deployment, July 2013
  - Christchurch, New Zealand
  - 9 science flights in 14 nights
  - 100% of objectives achieved
- One remaining step to achievement of Full Operational Capability (FOC)
  - Completion of commissioning flights for 4<sup>th</sup> instrument
- Cycle 2 science investigations chosen
  - To be executed in 2014
- Second generation instruments under development (1 U.S., 1 German)
  - HAWC+: upgraded far infrared imager and polarimeter
  - upGREAT: multi-pixel heterodyne spectrometer



# 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:** Nov 2015 on JAXA H-IIA
- **Science Objectives:** Provides the high-resolution spectroscopy to detect abundant elements (heavier than He) that emit characteristic x-rays. Enables wide variety of physical measurements from black holes to clusters of galaxies
- **Operations:** Prime Mission is 3 years

### CURRENT STATUS

The U.S. is providing instrument contributions to the JAXA ASTRO-H mission.

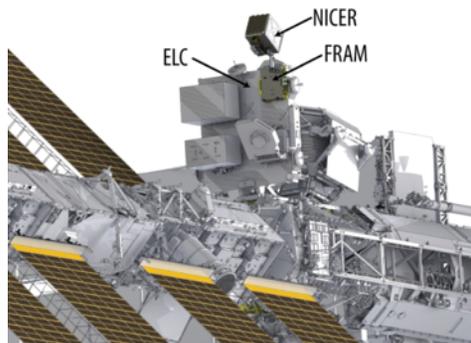
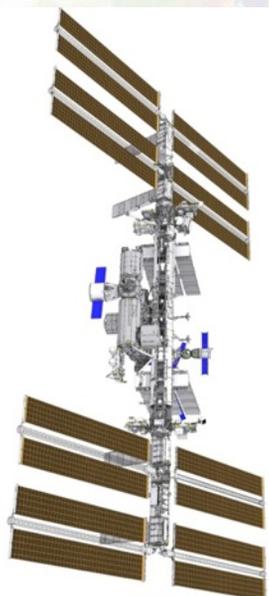
- X-ray calorimeter spectrometer insert (CSI), including the 3 stage adiabatic demagnetization refrigerator and detectors, and Aperture Assembly - Delivery April 2014.
- ADR controller (ADRC) – Delivery Feb 2015
- X-ray Electronics Box – Delivery May 2014
- Soft X-ray telescope mirrors (SXT Mirror 1 and 2) – Both delivered.
- ASTRO-H project rebaselined in November 2013 to account for JAXA schedule changes and impact of U.S. government shutdown in Oct. of 2013.



# NICER

## Neutron Star Interior Composition Explorer

Intl  
Space  
Station  
(ISS)



- **Explorer Mission of Opportunity**
- **PI:** Keith Gendreau, GSFC
- **Launch:** August 2016 on Space-X Falcon 9
- **Science Objectives:** Perform high-time-resolution and spectroscopic observations of neutron stars in the .2-12 keV energy range to study the physics of ultra-dense matter in the core of neutron stars.
- **Instrument:** X-ray Timing Instrument uses X-ray concentrators and detectors to detect X-ray photons and return energy and time of arrival.
- **Platform:** Located externally on the ISS, ExPRESS Logistics Carrier 2, Starboard 3 site
- **Operations:** Operated on a non-interference basis for 18 months
- **SEXTANT** for Pulsar navigation demo funded by NASA's Space Technology Mission Directorate

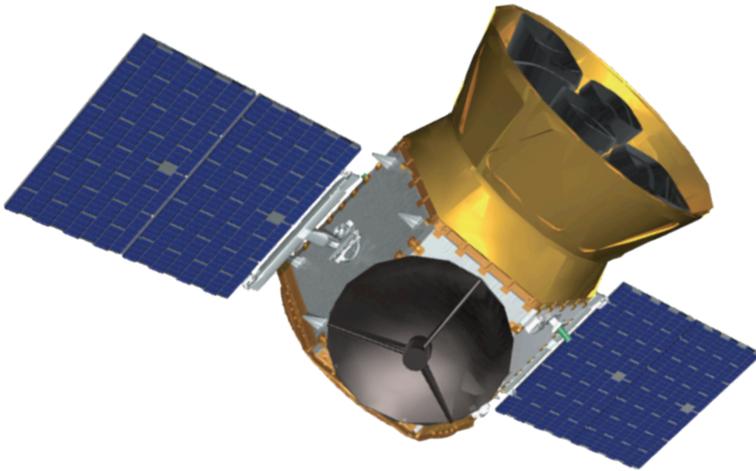
### CURRENT STATUS:

- Downselected April 2013.
- Science team and project management both led by NASA GSFC.
- Development progressing on plan.
  - Contracts for subsystems being put in place.
- The Preliminary Design Review successfully completed in December 2013.
- The Confirmation review, for approval to enter implementation phase, is scheduled for late January 2014.



# TESS

## Transiting Exoplanet Survey Satellite



### Standard Explorer (EX) Mission

**PI:** G. Ricker (MIT)

**Mission:** All-Sky photometric exoplanet mapping mission.

**Science goal:** Search for transiting exoplanets around the closest and brightest stars in the sky.

**Instruments:** Four wide field of view CCD cameras with overlapping field of view operating in the Visible-IR spectrum (0.6-1 micron).

**Operations:** 2017 launch with a 2-year prime mission

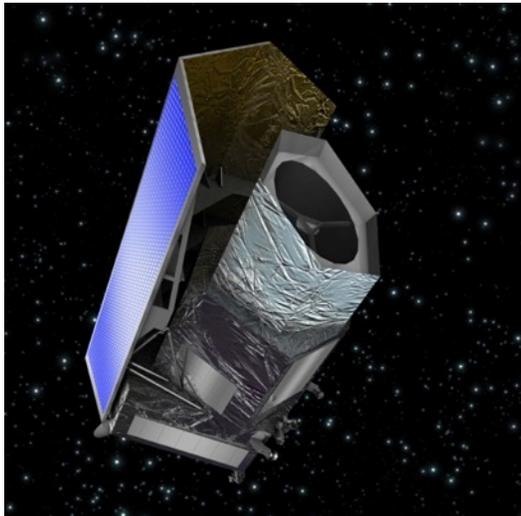
### CURRENT STATUS:

- Downselected April 2013.
- Major partners:
  - PI and science lead: MIT
  - Project management: NASA GSFC
  - Instrument: Lincoln Labs
  - Spacecraft: Orbital Science Corp
- Tentative launch readiness date August 2017.
- High-Earth elliptical orbit (17 x 58.7 Earth radii).
- Development progressing on plan.
  - Systems Requirement Review planned for February 2014.
  - Confirmation Review, for approval to enter implementation phase, is planned for Fall 2014.



# Euclid

## A visible and near-infrared telescope to explore cosmic evolution



- **ESA Cosmic Vision 2015-2025 Mission,** M-Class with NASA participation.
- 1.2-m mirror, visible & near-IR images, spectra
- **Launch Date:** Mar 2020, 5 year prime mission
- **Science Objectives:**
  - Euclid will look back 10 billion years into cosmic history.
  - Probe the history of cosmic expansion (influenced by dark energy and dark matter) and how gravity pulls galaxies together to form the largest structures.
  - The shapes of distant galaxies appear distorted because the gravity of dark matter bends their light (gravitational lensing). Measuring this distortion tells us how the largest structures were built up over cosmic time.
  - Measuring how strongly galaxies are clumped together tells us how gravity influences their motions, and how dark energy has affected the cosmic expansion.

### CURRENT STATUS:

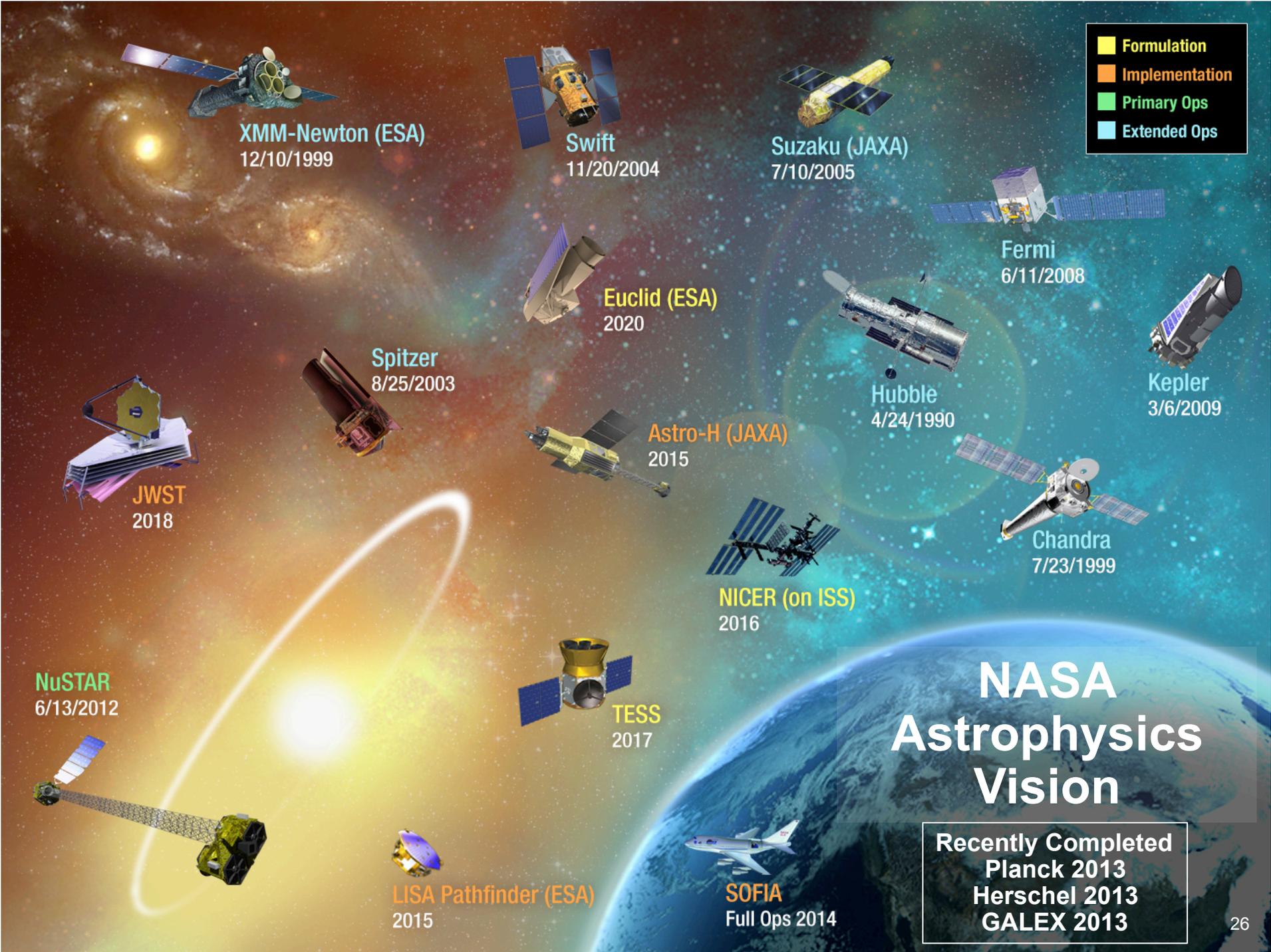
- Currently in implementation phase.
- ~50 U.S. scientists are members of the Euclid Science Team that will analyze the data, and make maps of the sky.
- First experimental manufacturing run for the Euclid near-infrared detectors to complete in FY 2014 (ESA).
- NASA will initiate the buy for the flight infrared detectors in FY 2014.
- NASA will test and characterize the near-IR flight detectors.



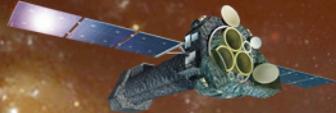
# ESA's New Vision to Study the Invisible Universe

Based on Nov 28, 2013 ESA Press Release

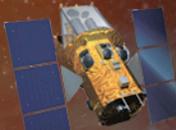
- The hot energetic Universe and the search for elusive gravity waves will be the focus of ESA's next two large science missions.
- The science theme "the hot and energetic Universe" was selected for L2, and expected to be pursued with an advanced X-ray observatory.
  - Launch date ~2028
- The L3 mission will study the gravitational Universe, searching for ripples in the very fabric of space-time created by celestial objects with very strong gravity, such as pairs of merging black holes.
  - Launch date ~2034
  - Will require development of a spaceborne gravitational wave observatory or extreme precision 'gravitometer'.
- NASA has expressed a strong interest to ESA in contributing to ESA's next large astrophysics missions if they are responsive to the U.S. Decadal Survey
  - The U.S. Decadal Survey recommended an international partnership for a gravitational wave observatory and an X-ray observatory.
- NASA and ESA will have a bilateral meeting, on January 8-10, 2014 in D.C., to discuss a potential NASA contribution.



- Formulation
- Implementation
- Primary Ops
- Extended Ops



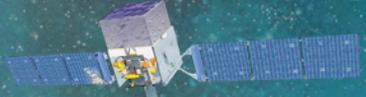
**XMM-Newton (ESA)**  
12/10/1999



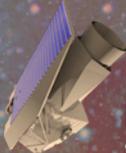
**Swift**  
11/20/2004



**Suzaku (JAXA)**  
7/10/2005



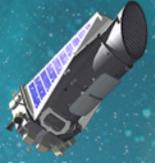
**Fermi**  
6/11/2008



**Euclid (ESA)**  
2020



**Hubble**  
4/24/1990



**Kepler**  
3/6/2009



**Spitzer**  
8/25/2003



**Astro-H (JAXA)**  
2015



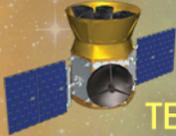
**Chandra**  
7/23/1999



**JWST**  
2018

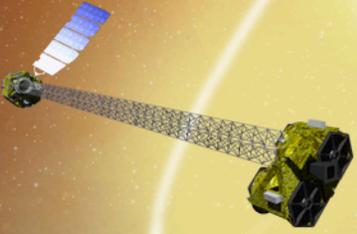


**NICER (on ISS)**  
2016

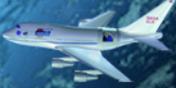


**TESS**  
2017

**NuSTAR**  
6/13/2012



**LISA Pathfinder (ESA)**  
2015



**SOFIA**  
Full Ops 2014

# NASA Astrophysics Vision

- Recently Completed**  
 Planck 2013  
 Herschel 2013  
 GALEX 2013



# WFIRST – AFTA

## Widefield Infrared Survey Telescope with Astrophysics Focused Telescope Assets



- **Top priority in 2010 Decadal Survey**
- **Study Baseline Payload:**
  - 2.4m existing telescope assets
  - Widefield imager
  - Coronagraph
- **Science objectives:**
  - Hubble-quality imaging over 200x the field
  - Comprehensive study of dark energy
  - Systematic census of outer planets
  - Coronagraphic imaging of exoplanets
  - 25% time for community competitive selected GO program
  - Enhancing JWST science

### CURRENT STATUS:

- May 2013, NASA Administrator Bolden directed Astrophysics Division to study WFIRST-AFTA and preserve option for FY17 new start if budget is available
  - No decision expected before early 2016
- Currently in pre-formulation phase
  - NRC study in early 2014
  - SDT final report due Jan 2015
- Maturing key technologies to TRL 5 by FY 17 and TRL 6 by FY19
  - Infrared detectors
  - Internal coronagraph for exoplanet characterization

### Mission description:

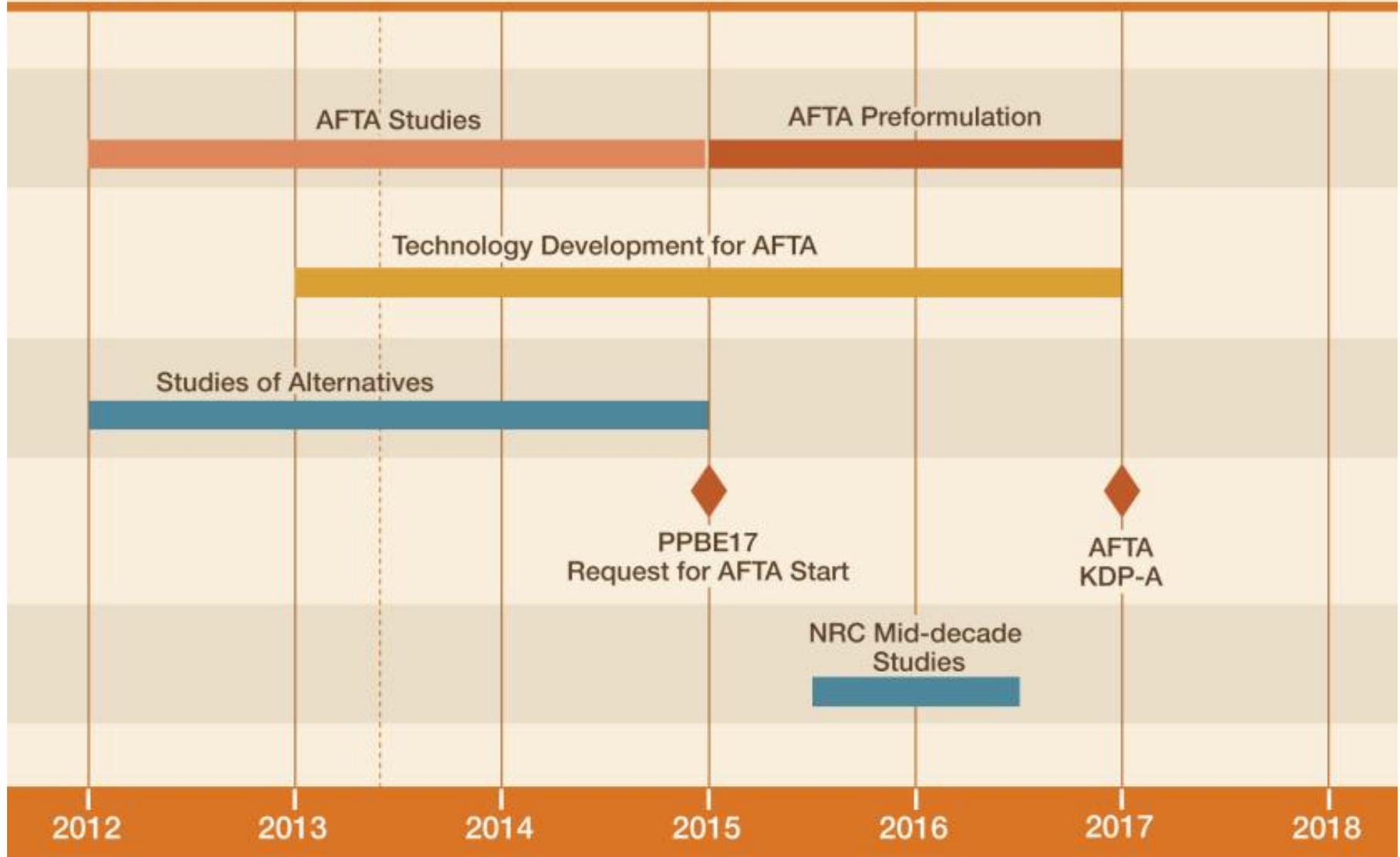
- #1 Large-Scale Priority: Widefield infrared survey telescope for Dark Energy, Exoplanets, IR Surveys
- #1 Medium-Scale Priority: Development and demonstration of technology for direct imaging and characterization of exoplanets



# Plan for WFIRST-AFTA Preformulation

## Widefield Infrared Survey Telescope using Astrophysics Focused Telescope Assets

### AFTA timeline





## Major Activities for CY 2014

- Senior Review for Operating Missions (March 2014)
- AO for Small Explorer (SMEX) and Mission of Opportunity (Fall 2014)
- Commission three more SOFIA instruments: FLITECAM, FIFI-LS, EXES (throughout 2014)
- Deliver ISS-CREAM for launch to Space Station (launch in 2014) (Fall 2014)
- Deliver ASTRO-H soft X-ray spectrometer to JAXA (launch in 2015) (April 2014)
- Confirm NICER Explorer Mission of Opportunity (launch in 2016) (January 2014)
- Confirm TESS Explorer Mission (launch in 2017) (Fall 2014)
- Complete and test JWST instrument suite (launch in 2018) (Summer 2014)
- Begin Euclid detector flight build (launch in 2020) (Winter 2014)
- Participate in ESA's L2 (X-ray observatory) Mission Study (launch in 2028)



# Astrophysics Senior Review in 2014

- Astrophysics will conduct a Senior Review for Operating Missions (in conformity with PL 109-155, §304(a)).
  - Coordinated reviews for Hubble, Chandra, and the remainder of the MO&DA portfolio to be held in the March 2014 timeframe.
  - Missions are required to submit self-identified mission objectives as well as budgets, FTE/WYE levels, and assessment against prior SR proposal.
  - All missions will be comparatively assessed by a single Senior Review Panel with the exception of the Hubble Space Telescope and the Chandra X-ray Observatory. The Hubble Space Telescope and the Chandra X-ray Observatory will be reviewed during this timeframe in self-contained separate, but similar reviews, by individualized Senior Review Panels.
- Senior Review Timeline.
  - Final Call for Proposals issued: November 15, 2013
  - Senior Review Proposals due: January 31, 2014
  - Senior Review panel meets: late March/ early April 2014
  - Panel's report & APD response: June 2014
- Missions invited.
  - Hubble, Chandra
  - Fermi, NuSTAR, Spitzer, Suzaku, Swift, XMM-Newton, Kepler (K2), Planck, WISE (MaxWISE)



## 2014 Astrophysics Explorer AO

- Community Announcement released on November 12, 2013, indicating NASA will solicit proposals for SMEX missions and Missions of Opportunity.
- Draft AO targeted for spring 2014, with Explorer Workshop ~ 2 weeks later.
- Final AO targeted for late summer/early fall 2014, with Pre-Proposal Conference ~ 3 weeks after final AO release. Proposals due 90 days after AO release.
- PI-managed cost cap \$125M (FY2015\$) for SMEX, not including cost of ELV or transportation to the ISS.
- Missions of Opportunity allowed in all three categories: Partner Mission of Opportunity, New Missions using Existing Spacecraft, or Small Complete Mission, including those requiring flight on the ISS.
- PI-managed cost cap \$35M for sub-orbital class MOs, which include ultra-long duration balloons, suborbital reusable launch vehicles, and CubeSats. Other MOs (not suborbital-class) have a \$65M PI-managed cost cap.
- Two-step process. Step 1 selects 2-3 SMEX missions and 1-2 MOs for 1-year Phase A concept studies, Step 2 down-selects 1 SMEX and 1 MO for Phase B and subsequent phases.



# Community Participation

## PhysPAG

- Executive Cmte: 13 members
- SAGs: 5 Active
- Chair: John Nousek
- Website: <http://pcos.gsfc.nasa.gov/physpag>

## COPAG

- Executive Cmte: 10 members
- SAGs: 6 Active
- Chair: Ken Sembach
- Website: <http://cor.gsfc.nasa.gov/copag>

## ExoPAG

- Executive Cmte: 11 members
- SAGs: 3 Active
- Chair: Scott Gaudi
- Website: <http://exep.jpl.nasa.gov/exopag>

## Science and Technology Definition Teams (STDTs) in Progress:

- AFTA use of telescope assets: 20 members
- Exoplanet Probe with Internal Coronagraph: 10 members
- Exoplanet Probe with External Occulter: 10 members
- X-ray Astrophysics Probe: 14 members [disbanded 12/12/13]

Preliminary reports from the studies are due Spring 2014.

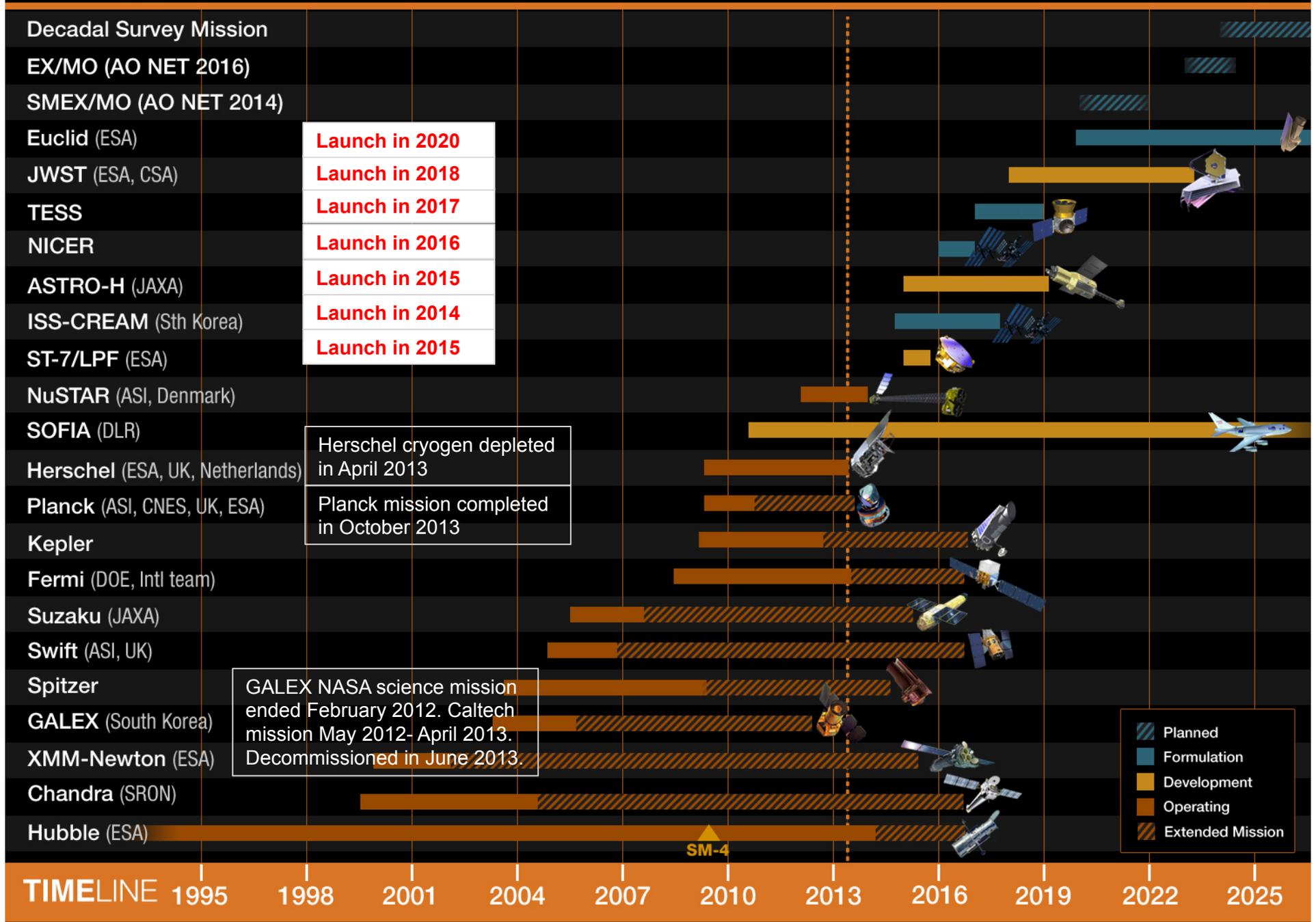
Final reports from the studies are due in January 2015.

## Advisory Committees:

- NRC Committee on Astronomy and Astrophysics (CAA)
- Astronomy and Astrophysics Advisory Committee (AAAC)
- NASA Advisory Council's Astrophysics Subcommittee (APS)

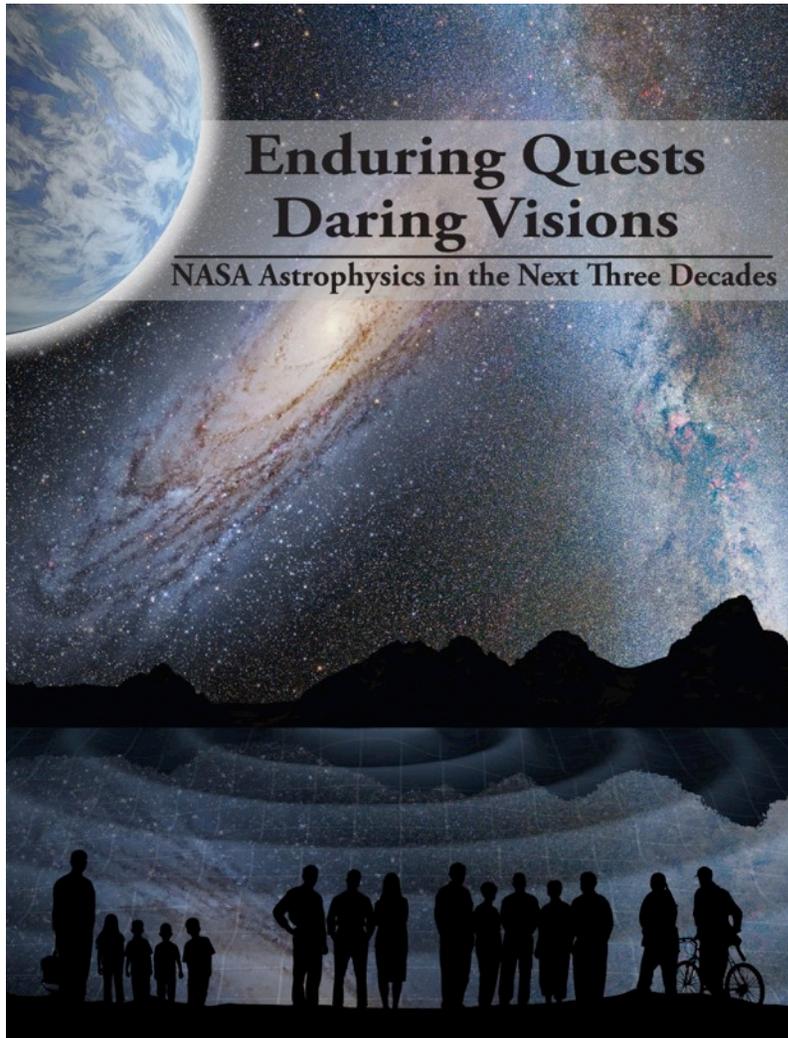
# Astrophysics Missions timeline

Last updated: April 15, 2013





# Enduring Quests, Daring Visions



- A 30 year vision to address the enduring questions:
  - Are we alone?
  - How did we get here?
  - How does the universe work?

	Near-Term	Formative	Visionary
Gravitational Waves		Gravitational Wave Surveyor	Gravitational Wave Mapper
Cosmic rays	JEM-EUSO		
Radio			Cosmic Dawn Mapper
Microwaves		CMB Polarization Surveyor	
Infrared	JWST	Far IR Surveyor	
Optical	WFIRST-AFTA	Euclid	LUVOIR Surveyor
Ultraviolet	TESS	Gaia	ExoEarth Mapper
X-rays	NICER	Astro-H	Xray Surveyor
Gamma rays			Black Hole Mapper

<http://science.nasa.gov/science-committee/subcommittees/nac-astrophysics-subcommittee/astrophysics-roadmap/>