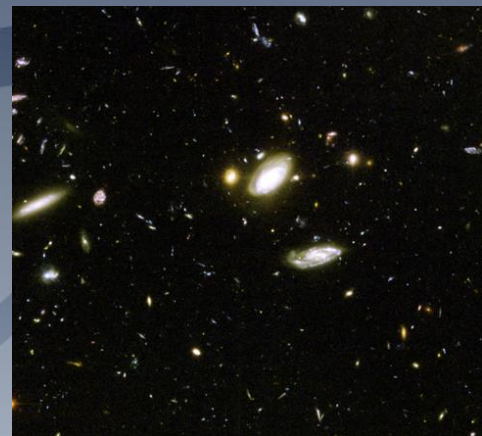


# Astrophysics



## NRC Midterm Review Committee

Third Meeting  
Washington DC  
January 12, 2016

## Paul Hertz

Director, Astrophysics Division  
Science Mission Directorate  
[@PHertzNASA](https://twitter.com/PHertzNASA)

Most of these charts were presented at  
**The 227<sup>th</sup> AAS Meeting in Kissimmee FL**  
<http://science.nasa.gov/documents/>

# Astrophysics - Big Picture



- **The FY16 appropriation provides funding for NASA astrophysics to continue its programs, missions, projects, and supporting research and technology.**
  - The total funding (Astrophysics including JWST) remains at ~\$1.3B.
  - Fully funds JWST to remain on plan for an October 2018 launch.
  - Funds new start for WFIRST, start of formulation planned for February 2016.
  - Will require some adjustments to FY16 plans in response to appropriation levels.
- **The operating missions continue to generate important and compelling science results, and new missions are under development for the future.**
  - Chandra, Fermi, Hubble, Kepler/K2, NuSTAR, Spitzer, Swift, ESA's XMM-Newton all operating well; Senior Review is in Spring 2016 for FY17 and beyond.
  - SOFIA is in 5-year prime operations as of May 2014; 3<sup>rd</sup> generation instrument concept studies selected; Senior Review for SOFIA is in Spring 2018.
  - ESA's LISA Pathfinder successfully launched on December 3, 2015.
  - Missions on track for launch include JAXA's ASTRO-H (2016), NICER (2016), ISS-CREAM (2016), TESS (2017), JWST (2018), ESA's Euclid (2020).
  - WFIRST starting formulation in 2016; 5 SMEX and Mission of Opportunity concept studies selected in 2015 and MIDEX AO in 2016; NASA joining ESA's Athena X-ray observatory and ESA's L3 gravitational wave observatory.
- **Progress being made toward recommendations of the 2010 Decadal Survey.**
  - Update to the Astrophysics Implementation Plan released in December 2014.
  - NRC Mid Decade Review (with NSF, DOE) underway; Jackie Hewitt (MIT) is chair; NASA briefing at October 2015 meeting; NRC committee report expected in May 2016.
  - NASA initiating large mission concept studies as input for 2020 Decadal Survey.

# FY16 Appropriation



This Act includes \$730,600,00 for Astrophysics including ...

- \$90,000,000 for WFIRST, a mission being developed to meet decadal survey goals in observation of dark energy and exoplanets.
  - “The Committee has provided funding for completion of pre-formulation and initiation of formulation of the WFIRST mission using the Astrophysics Focused Telescope Assets, with the goal of completing Key Decision Point-A no later than January 15, 2016. The Committee has accelerated this key mission recommended by the decadal survey and expects it to achieve overlap and scientific synergy with Hubble and the James Webb Space Telescope, including linking science operations and the science archive.”
- \$85,200,000 for the Stratospheric Observatory for Infrared Astronomy (SOFIA)
  - “This agreement acknowledges that NASA has determined that it will not include SOFIA in its 2016 Astrophysics Senior Review since SOFIA has not yet met established requirements for inclusion in a Senior Review. The Committees support this decision and do not provide any funds in this Act for the inclusion of SOFIA in such a review.”

This Act includes \$37,000,000 for EPO

- “As an independent line within the Science Mission Directorate, to be administered by the Astrophysics Division.”

# FY16 Appropriation



Report language included in House Report 114-130 ("the House report") or Senate Report 114-66 ("the Senate report") that is not changed by this explanatory statement or this Act is approved.

- “Within funds provided to advance scientific knowledge of the origins of the universe, the Committee provides \$98,300,000 for the Hubble Space Telescope.”
- “The Committee maintains strong support for the completion of the James Webb Space Telescope [JWST], and provides \$620,000,000, the same as the budget request. ... The bill maintains an overall development cost ceiling for JWST at \$8,000,000,000, and the Committee intends to hold NASA and its contractors to that commitment.”
- “The Committee continues its strong support of Astrophysics and Heliophysics Explorers and expects NASA to provide adequate resources within the amount provided to increase frequency of Explorer Announcements of Opportunity [AO]. Explorer AOs should occur at least every 3 years, and NASA's goal should be to increase the frequency to every 2 years.”

# FY16 Appropriation



Outyears are notional planning from FY16 President's budget request

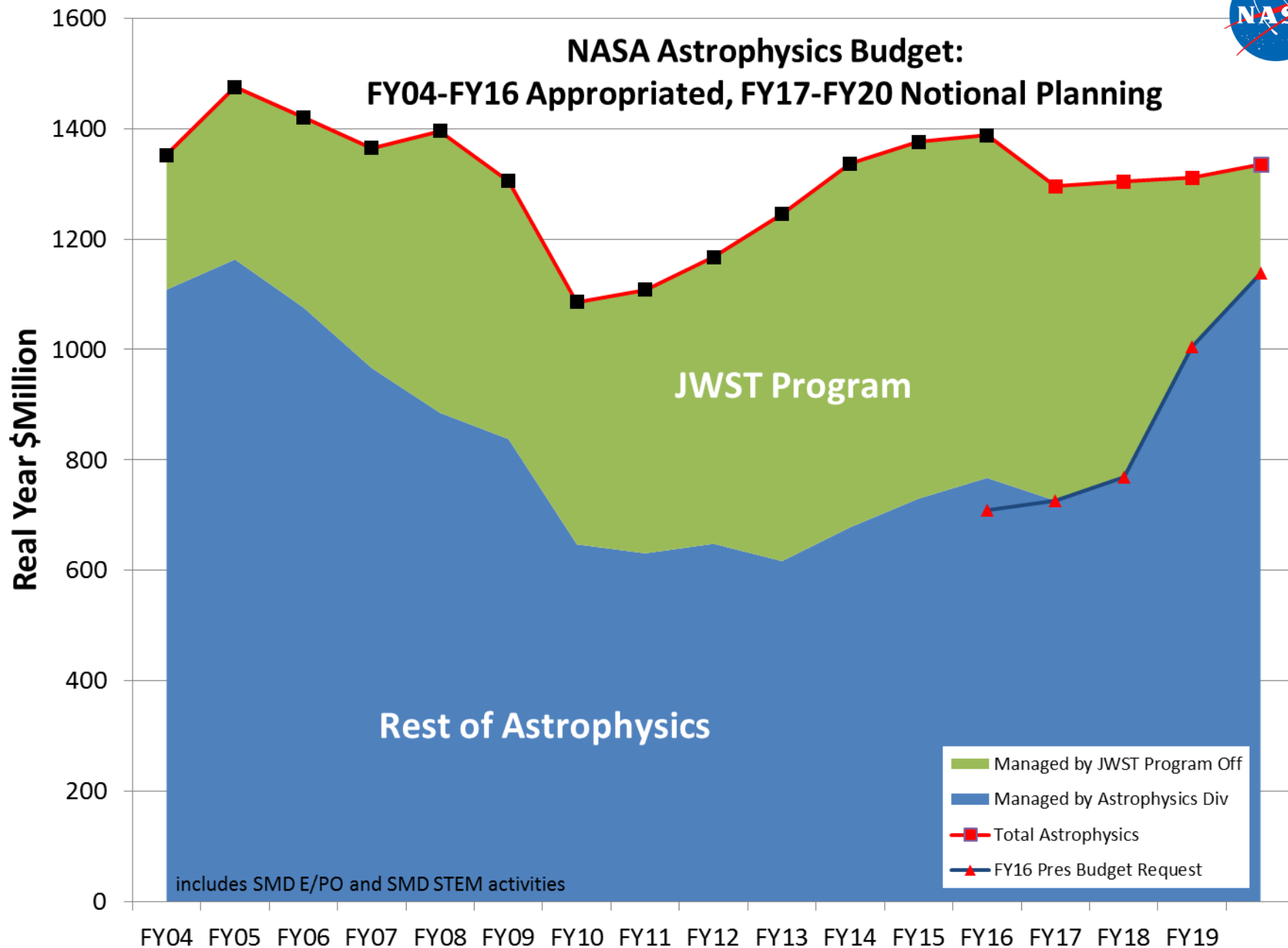
(\$M)	2014	2015	2016	2017	2018	2019	2020
Astrophysics*	\$678	\$685	\$731	\$707	\$750	\$986	\$1118
JWST	\$658	\$645	\$620	\$569	\$535	\$305	\$198
Total	\$1336	\$1330	\$1351	\$1273	\$1285	\$1291	\$1316

\* Excludes "SMD STEM Activities" in all years.

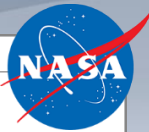
- Provides \$90M for WFIRST and directs NASA to start Formulation.
- Provides full funding (\$85M) for SOFIA operations and places SOFIA into the 2018 Astrophysics Senior Review.
- Provides full funding (\$98M) for continued Hubble operations.
- Provides \$37M for SMD STEM education activities.
- Requires reduction of \$36M in rest of Astrophysics portfolio.

(\$M)	FY16 Request	FY16 Approps	Delta
JWST	\$620	\$620	--
WFIRST	\$14	\$90	+\$76
SOFIA	\$85	\$85	--
Hubble	\$97	\$98	+\$1
Rest of Astrophys*	\$493	\$457	-\$36 (-7%)
Total	\$1309	\$1351	+\$42

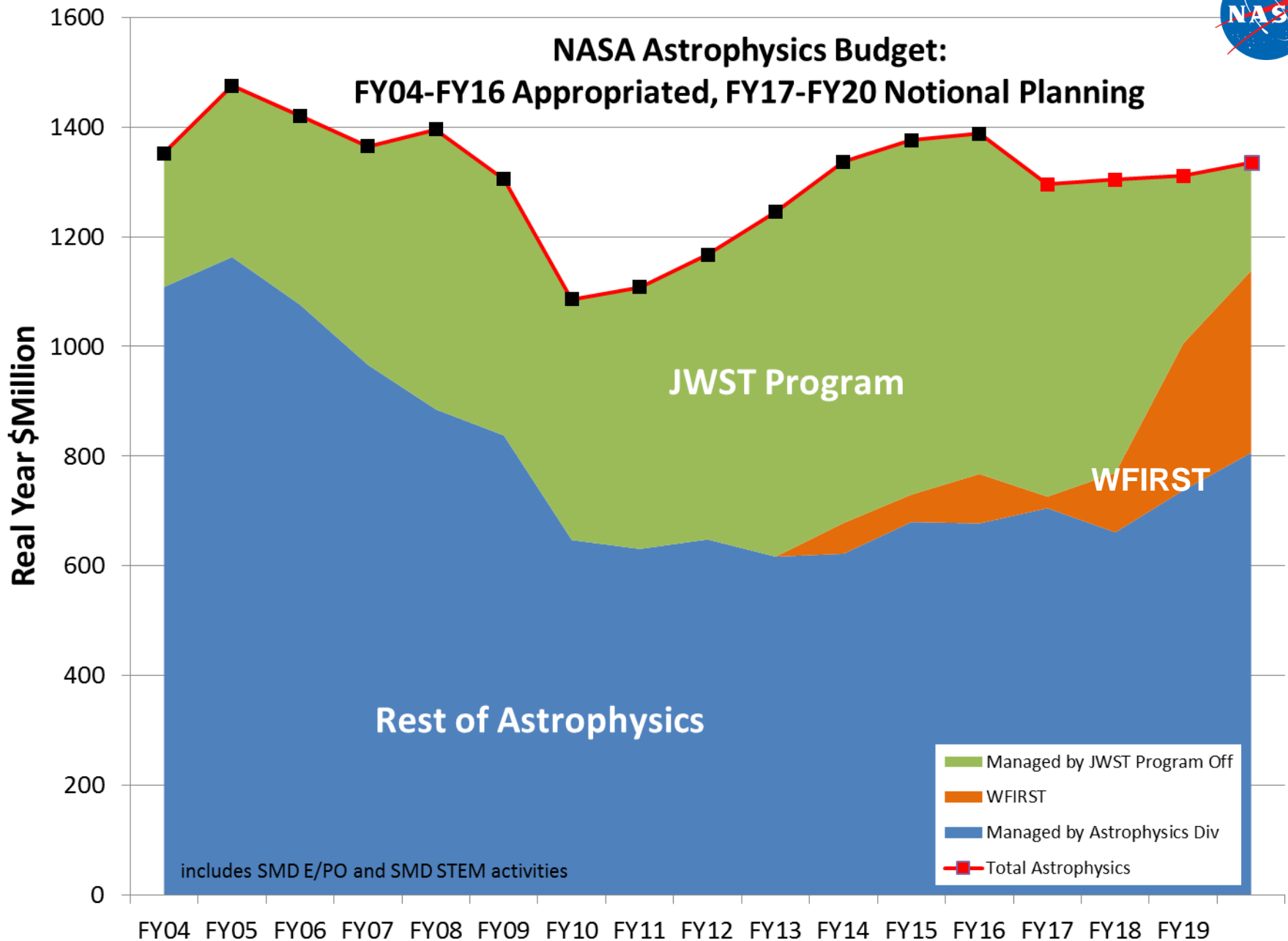
\* Excludes "SMD STEM Activities."



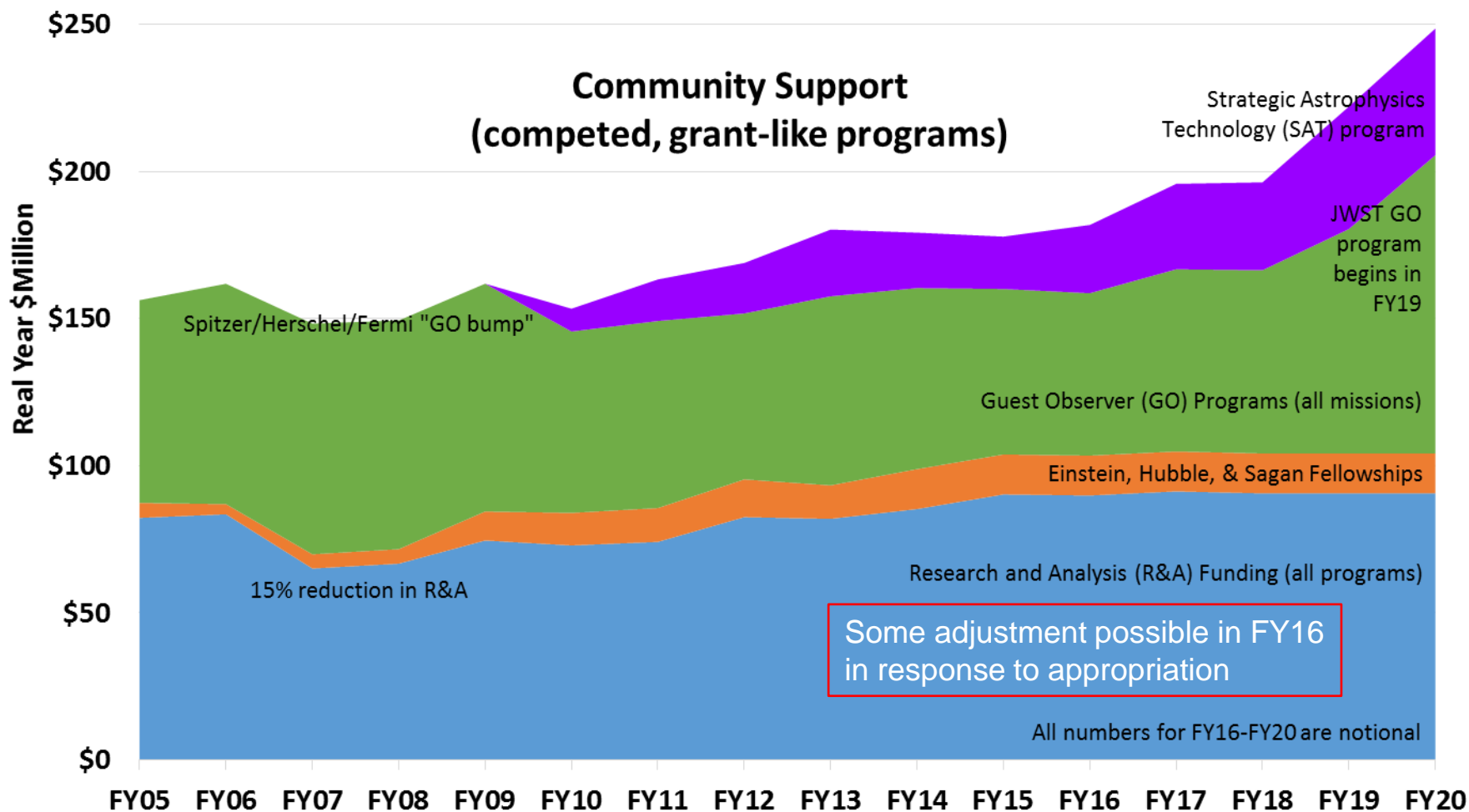




# NASA Astrophysics Budget: FY04-FY16 Appropriated, FY17-FY20 Notional Planning



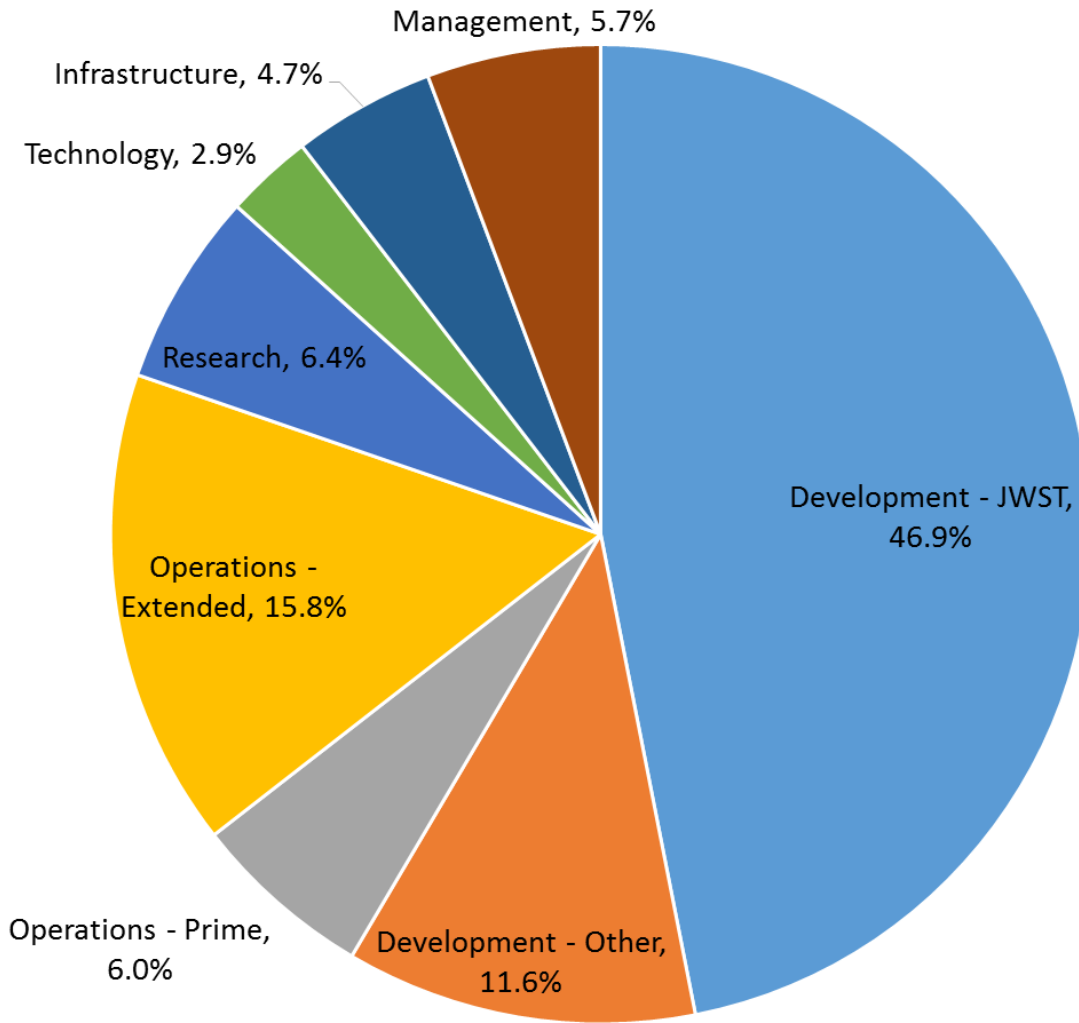
# Core Research



Corrected from October



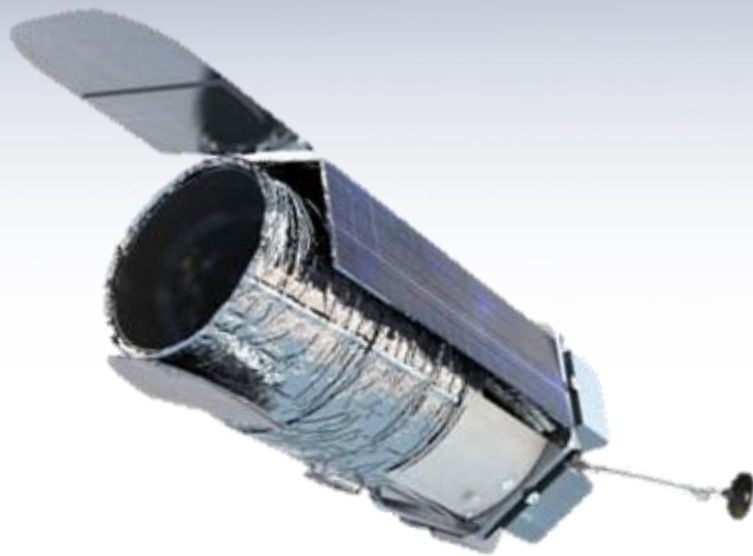
# FY15 Astrophysics Budget Fractions



FY15 Budget	100.0%	\$1,376M
Dev - JWST	46.9%	645M
Dev - Other	11.6%	159M
Ops - Prime	6.0%	82M
Ops - Ext	15.8%	217M
Research	6.4%	88M
Technology	2.9%	40M
Infrastructure	4.7%	65M
Management	5.7%	79M
GO - Prime		1.6M
GO - Ext		59.7M

# WFIRST – AFTA

Wide-Field Infrared Survey Telescope with Astrophysics Focused Telescope Assets



## Wide-Field Infrared Survey Telescope

Top priority of 2010 Decadal Survey

**Science themes:** Dark Energy, Exoplanets, Large Area Near Infrared Surveys

**Mission:** 2.4m widefield telescope at L2; using existing hardware, images  $0.28\text{deg}^2$  at  $0.8\text{-}2\mu\text{m}$

### Instruments (design reference mission):

Wide Field Instrument (camera plus IFU),  
Coronagraph Instrument (imaging/IFS)

**Phase:** Currently in pre-formulation

## CURRENT STATUS:

- Completed Mission Concept Review (MCR) held in December 2015
- Formulation Science Investigation Teams selected in December 2015
- Planning for Key Decision Point A (KDP-A) in Feb 2016
  - Official start of formulation phase
  - Supported by FY16 appropriations
- Industry RFI released July 2015; RFP for industry studies released in January 2016
- Other activities include:
  - Technology development for detectors and coronagraph (with STMD); prototyping key parts
  - Assessment of telescopes + risk mitigation
  - Mission design trades; performance simulations
- Maturing key technologies by FY19
  - H4RG infrared detectors for widefield imager
  - Internal coronagraph for exoplanet characterization
  - Milestones on road to achieve TRL-5 by end of CY16, TRL-6 by end of CY18; reports made public

**WFIRST starts Formulation in February 2016**

# WFIRST – AFTA

Wide-Field Infrared Survey Telescope with Astrophysics Focused Telescope Assets



## WFIRST Science Investigation Teams

PI	PI Institution	Title	Topic
<b>Olivier Dore</b>	JPL	Cosmology with the WFIRST High Latitude Survey	Galaxy Redshift Survey, Weak Lensing Survey
<b>Ryan Foley</b>	Illinois	Optimizing the WFIRST Type Ia Supernova Survey	Supernovae Survey
<b>Scott Gaudi</b>	Ohio State	Preparing for the WFIRST Microlensing Survey	Microlensing Survey
<b>Jeremy Kasdin</b>	Princeton	WFIRST Coronagraph Instrument Adjutant Scientist	Coronagraph Instrument Adjutant Scientist
<b>Jason Kalirai</b>	STScI	Resolving the Milky Way with WFIRST	GI/GO
<b>Bruce Macintosh</b>	Stanford	Optimizing WFIRST Coronagraph Science	Coronagraphy
<b>Saul Perlmutter</b>	LBNL	Investigating the Nature of Dark Energy using Type Ia Supernovae	Supernovae Survey
<b>James Rhoads</b>	Arizona State	Cosmic Dawn with WFIRST	GI/GO
<b>Brant Robertson</b>	UC Santa Cruz	WFIRST Extragalactic Potential Observations	GI/GO
<b>David Spergel</b>	Princeton	WFIRST Wide Field Instrument Adjutant Scientist	Widefield Instrument Adjutant Scientist
<b>Alexander Szalay</b>	Johns Hopkins	Archival Research Capabilities of the WFIRST Data Set	GI/GO
<b>Margaret Turnbull</b>	SETI Institute	Harnessing the Power of the WFIRST Coronagraph	Coronagraphy
<b>Benjamin Williams</b>	Washington	WFIRST Infrared Nearby Galaxy Survey	GI/GO

# Explorers MDEX and MO AO in 2016



- The target schedule for the solicitation:
  - Release of draft AO: Spring 2016 (target)
  - Release of final AO: Late summer 2016 (target)
  - Proposals due: 90 days after AO release
  - Selection for 9-month competitive Phase A studies: Summer 2017 (target)
  - Down-selection: Late 2018 (target)
- MDEX Parameters
  - PI-managed mission cost cap is \$250M (FY17\$), not including the cost of the Expendable Launch Vehicle (ELV) or any contributions.
  - Standard launch services on an ELV will be provided for MDEX missions at no charge against the mission cost cap; no MDEX ISS-attached payloads.
  - MDEX launch readiness date no later than December 2023.
- Mission of Opportunity Parameters
  - PI-managed mission cost cap is \$70M (FY17\$) for Partner MOs and Small Complete Mission MOs, including ISS-attached payloads.
  - PI-managed mission cost cap is \$35M (FY17\$) for suborbital-class MO.
  - Small Complete Mission launch readiness date no later than December 2022.
  - Partner Mission of Opportunity endorsement need date before January 2022.
- Astrophysics Explorer Program planning budget is sufficient to select and execute one MDEX mission and one MO.

<http://explorers.larc.nasa.gov/APMDEX2016/>

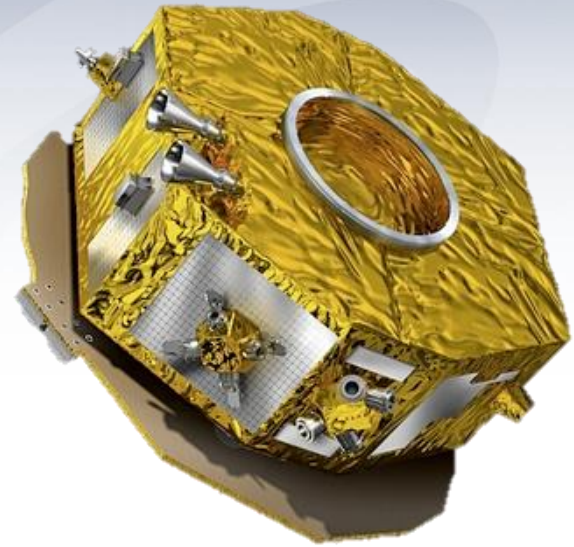


# LISA Pathfinder

## ST-7/Disturbance Reduction System (DRS)



Launched December 3, 2015



Dec 3	Launch
Dec 11	On way to L1
Feb 3	Uncage test masses
Mar 4	Commissioning
June/July	DRS ops

<https://lisapathfinder.org/>

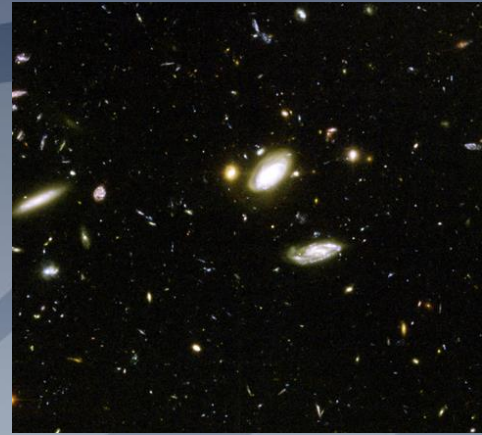
# NASA's L3 Study



- NASA intends to partner with ESA on the ESA-led Large 3 (L3) gravitational wave mission with launch in 2034. This responds to the recommendations of the 2010 Astrophysics Decadal for a space-based gravitational wave observatory.
- Following the successful launch of the LISA Path Finder, NASA is forming an L3 Study Team (L3ST) drawing membership from members of the US astrophysics community.
- The goals of the L3ST are:
  1. Analyze the options for NASA participation in the L3 mission and work with the European L3 consortium on proposals to ESA; and
  2. Prepare a report to the 2020 Decadal Survey on NASA's participation, including possible options, in the L3 mission as a minority partner.
- Dear Colleague Letter on December 7, 2015; applications due December 21, 2015; members to be announced NLT January 31, 2016.
- The L3ST Charter, a list of FAQs, and list of selected members (after January 15) can be found at <http://pcos.gsfc.nasa.gov/studies>.

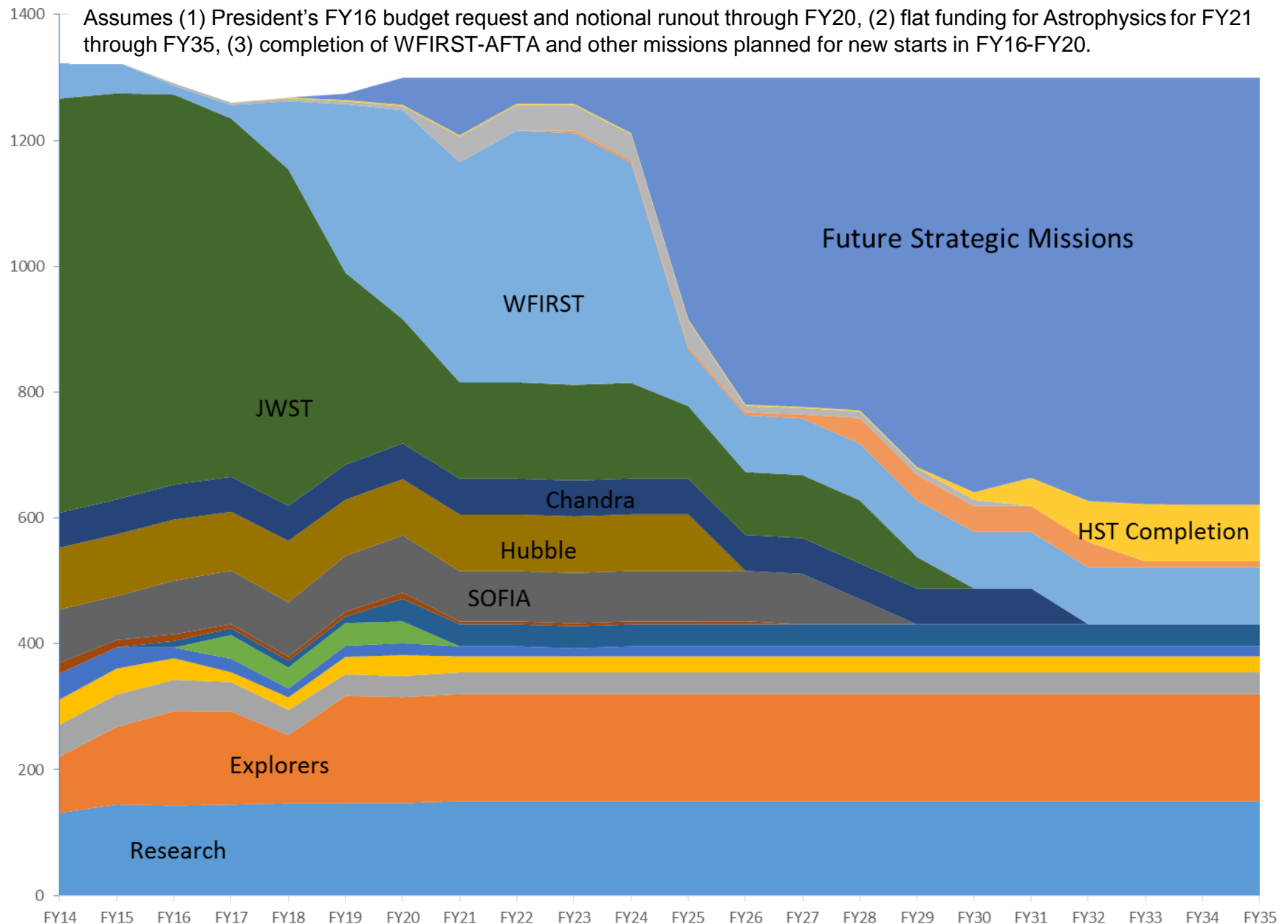
# Astrophysics

## Preparing for the 2020 Decadal Survey in Astronomy and Astrophysics





# Notional 20 Year Sandchart



# Preparing for the 2020 Decadal Survey

## Large Mission Concepts



NASA is initiating community-led studies of the following four large mission concepts.

	Community STDT Chair	Center Study Scientist	Study Lead Center	HQ Program Scientist
Far IR Surveyor	TBD	David Leisawitz	GSFC	Kartik Sheth
Habitable Exoplanet Imaging Mission	TBD	Bertrand Mennesson	JPL	Martin Still
Large UV/Optical/IR Surveyor	TBD	Aki Roberge	GSFC	Mario Perez
X-ray Surveyor	TBD	Jessica Gaskin	MSFC	Dan Evans

# Preparing for the 2020 Decadal Survey Large Mission Concepts



NASA is asking for applications for membership on the four large mission concept Science and Technology Definition Teams (STDTs)

- STDTs have significant role and responsibility
  - Develop science case
  - Flow science case into mission requirements
  - Vet technology gap list
  - Direct trades of science vs cost/capability
- STDT members will be appointed by NASA HQ
  - Community call for applications will be released via NSPIRES and Astrophysics Programs mailing lists on the day after the AAS Town Hall
  - Responses requested by February 1, 2016
- STDTs will be chartered and managed by HQ
  - Charter and management plan available at

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

# Preparing for the 2020 Decadal Survey

## Thinking about Probes



- Suggestion for the Decadal Survey: Recommend a Probe AO.
  - Similar to Planetary Science Division's New Frontiers AO
  - Decadal Survey prioritizes a short list of mission concepts that should be accomplished on a Probe budget for the Probe AO
  - NASA issues a Probe AO and selects a Probe proposal that is responsive in a compelling manner to Decadal Survey identified science objectives for one of the mission concepts (determined by peer review) and can be accomplished as a Probe (determined by TMC review)
  - Funding allotted to Probes "slows down" the large mission(s) that follow WFIRST
- Suggestion for the Decadal Survey: Identify probe concepts for further study
  - NASA is considering funding "probe studies," selected through ROSES, that do not include NASA-led mission design exercises or costing analysis
  - Decadal Survey could identify a few high priority probe concepts for further definitization and costing
- Probes continue to be discussed by Astrophysics PAGs.
- Plans for Probe Studies will be discussed at the March 2016 meeting of the Astrophysics Subcommittee.

# Astrophysics Mission Portfolio 2015

