



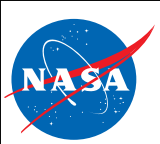
*NASA Headquarters
Overview, ExoPAG 12
Chicago, IL*

June 13, 2015

Astrophysics

Martin Still

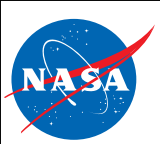
**Deputy Exoplanet Exploration
Program Scientist**



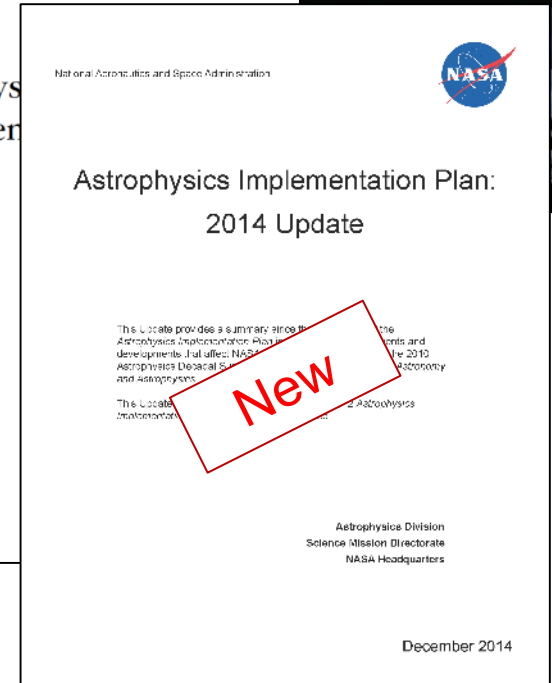
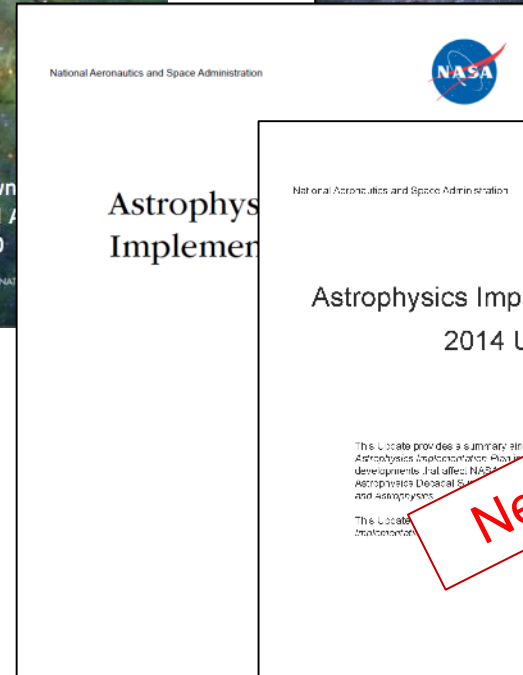
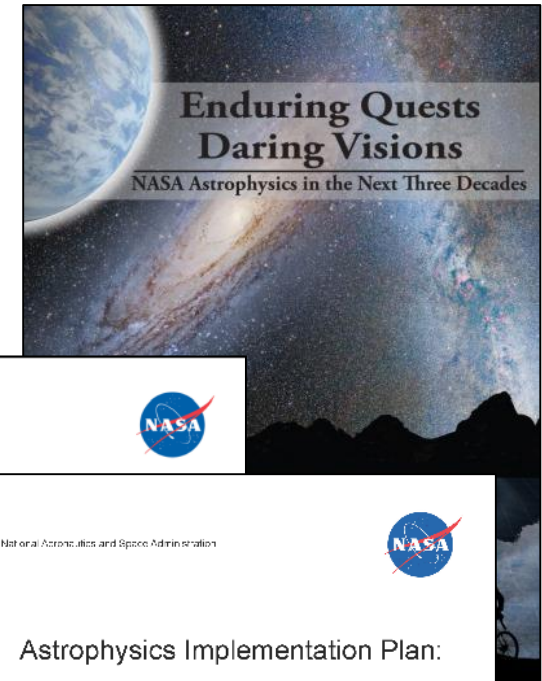
ExoPAG TERMS OF REFERENCE

<https://exep.jpl.nasa.gov/reportsAndDocuments>

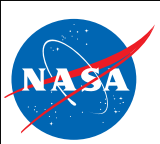
- ExoPAG: solicits and organizes community input into the development and execution of NASA's Exoplanet Explorer Program (ExEP)
- Using the widest possible community outreach:
 - Articulate the key scientific drivers for exoplanet research
 - Evaluate the expected capabilities of potential missions
 - Articulate new technology focus areas
 - Identify related activities that enhance the ExEP, e.g. –
 - Ground-based observing
 - Theory & modeling
 - Community engagement
 - Regularly (re)evaluate ExEP goals and priorities



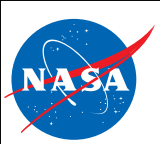
ASTROPHYSICS DRIVING DOCUMENTS



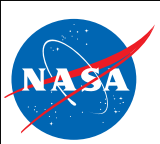
<http://science.nasa.gov/astrophysics/documents>



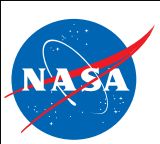
- FY15 appropriation and FY16 budget request provide funding for NASA astrophysics to continue programs, missions, and projects as planned
 - Total funding (Astrophysics+JWST) is flat at ~\$1.3B through FY20
 - Fully fund JWST to remain on Oct 2018 launch plan
 - Fund continued pre-formulation and technology work leading toward WFIRST-AFTA
 - Restore SOFIA to the budget with a reduction in FY15 and full funding beyond
 - Provide funding for SMD's education programs



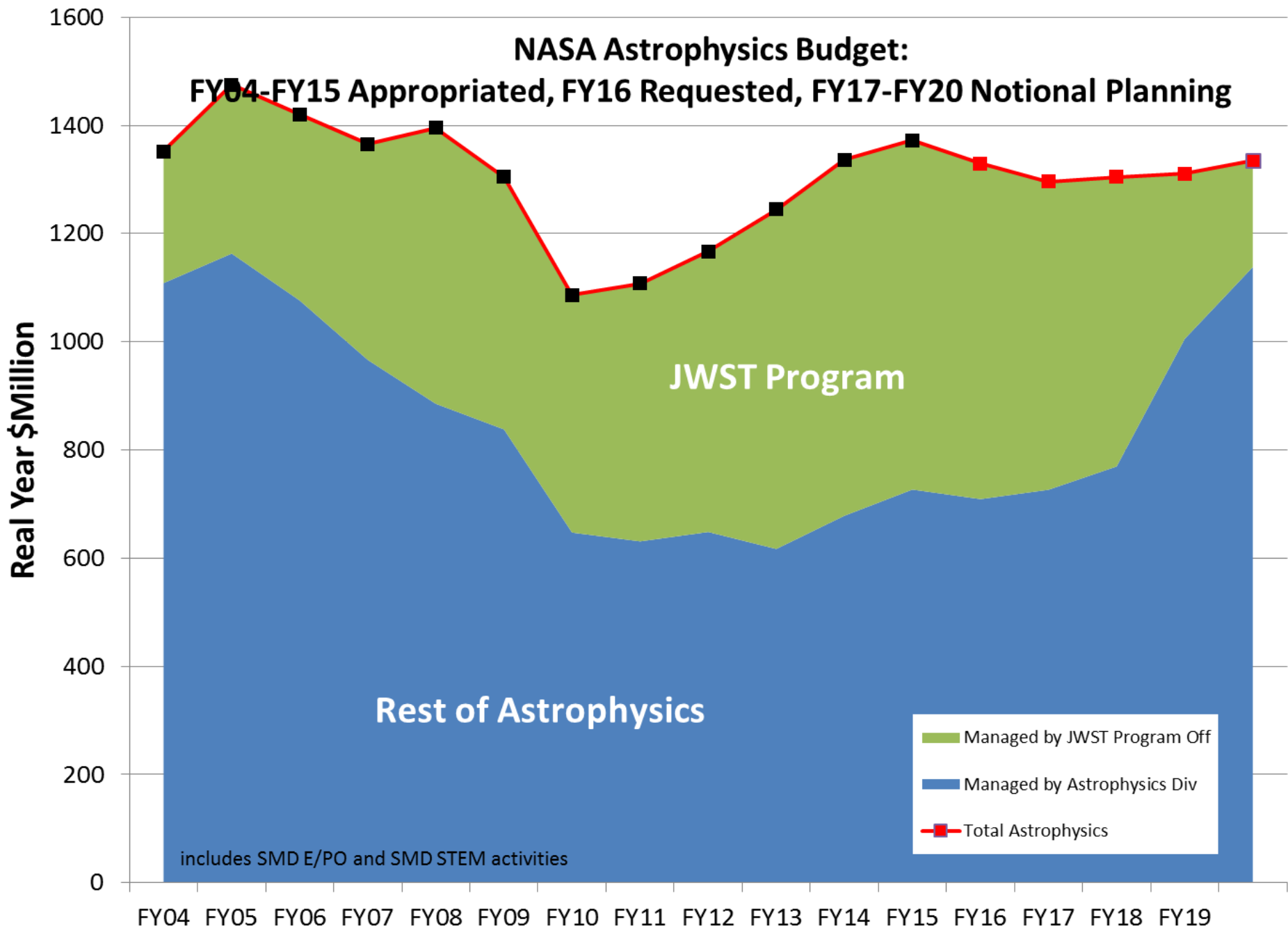
- Operating missions continue to generate important, compelling science results
 - Following the 2014 Senior Review, Chandra, Fermi, HST, Kepler/K2, NuSTAR, Spitzer, Suzaku, Swift, and XMM-Newton continue science operations
 - SOFIA is in prime operations as of May 2014
 - Next Senior Review is 2016, includes SOFIA

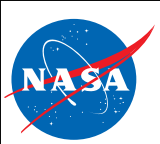


- New missions are under development for the future
 - Missions on track for launch include ISS-CREAM (TBD), LISA Pathfinder (2015), ASTRO-H (2015), NICER (2016), TESS (2017), JWST (2018), Euclid (2020)
 - WFIRST-AFTA is being studied
 - New Explorers are being selected (SMEX in 2015, MIDEX in 2017)
 - NASA joining ESA's Athena and ESA's L3 gravitational wave observatory



- Progress being made against recommendations of the 2010 Decadal Survey
 - Update to the Astrophysics Implementation Plan released in Dec 2014 (<http://science.nasa.gov/astrophysics/documents>)
 - NRC Mid Decade Review (with NSF, DOE) to begin in mid-2015
 - NASA identifying concept studies for 2020 Decadal Survey



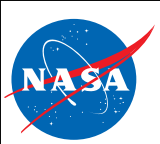


FY15 APPROPRIATION

	2014	2015	2016	2017	2018	2019	2020
Astrophysics	\$678M	\$685M					
JWST	\$658M	\$645M					

Notes

- Provides \$77M more than the President's Budget Request for FY15
- Includes \$50M for continued pre-formulation of WFIRST-AFTA, an increase of \$36M over the Administration request
- Includes \$70M for continued SOFIA operations. Reduction of \$14M from FY14. Directs NASA to
 - a) seek partners to restore SOFIA to its full level, and
 - b) not terminate mission without a Senior Review
- Includes \$38M for scientific ballooning, an increase of \$5M (15%) from FY14
- \$42M for Education SMD-wide as a separate budget line (E/PO is no longer budgeted as 1% of every mission)



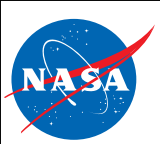
FY16 BUDGET (ADMINISTRATION'S PLAN)

	2014	2015	2016	2017	2018	2019	2020
Astrophysics *	\$678M	\$685M	\$689M	\$707M	\$750M	\$986M	\$1,118M
JWST	\$658M	\$645M	\$620M	\$569M	\$535M	\$305M	\$198M

Notes

- Continues pre-formulation of WFIRST-AFTA
- Supports completion of JWST for 2018 launch
- Supports completion of LPF/ST7, ASTRO-H, NICER, TESS, Euclid
- Plans for continued Hubble operations through FY20, providing overlap with JWST
- Provides full funding for SOFIA operations
- Grows Astrophysics Research and Analysis from ~\$80M/yr to ~\$90M/yr
- Enables selection of SMEX and Explorer Mission of Opportunity from the 2014 AO
- Enables notional release of a MIDEX AO in late-2016
- Plans for mission studies and technology development leading to 2020 Decadal Survey

*Excludes "SMD STEM Activities" in all years

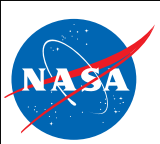


FY16 BUDGET (HOUSE-SIGNED)

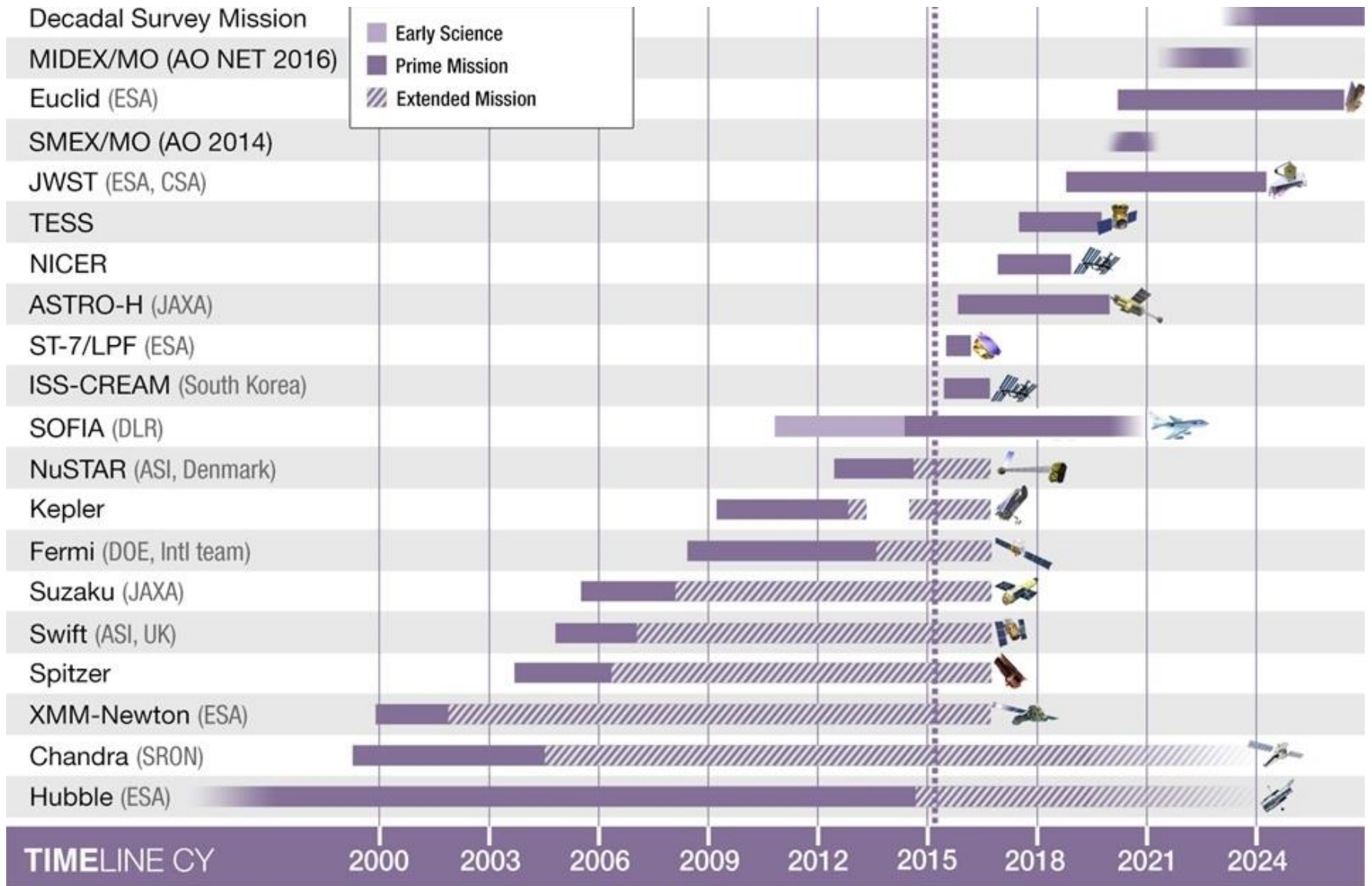
(\$M)	FY15 Appropriation	FY16 Request	FY16 House Mark-up	Δ\$
NASA	18,010.2	18,529.1	18,529.1	0
SMD	5,244.7	5,288.6	5,237.5	-51.1
JWST	645.4	620.0	620.0	0
Astrophysics	726.8	709.1	735.6	+26.5
WFIRST	50.0	14.0	49.8	+35.8
SMD Education	42.0	20.0	32.0	+12.0
Rest of Astroph	634.8	675.1	653.8	-21.3

Notes

- Increase WFIRST-AFTA to \$50M, include coronagraph development
- Prohibit SOFIA from 2016 Senior Review (as it is in prime-mission phase)
- Increase E/PO and STEM funding to \$32M

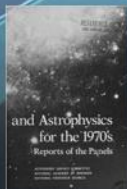


ASTROPHYSICS TIMELINE

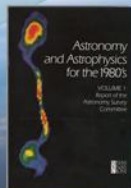
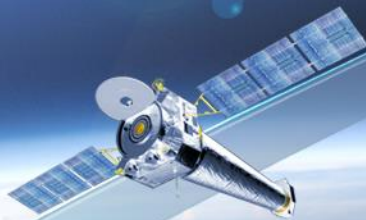


ASTROPHYSICS

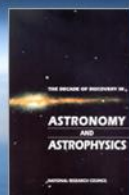
Decadal Survey Missions



1972
Decadal Survey
Hubble



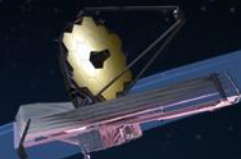
1982
Decadal Survey
Chandra



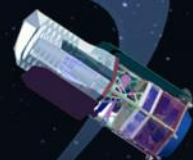
1991
Decadal Survey
Spitzer, SOFIA

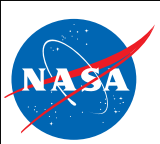


2001
Decadal Survey
JWST



2010
Decadal Survey
WFIRST



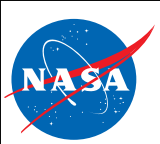


PREPARING FOR THE 2020 DECADAL SURVEY

Large Mission Concepts

- Study 3-4 concepts as prioritized candidate large missions
 - Science case
 - Technology assessment
 - Design reference mission with strawman payload
 - Cost assessment

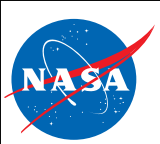
Year	Event
2015	PAGs gather community input on selecting concepts for study
2016	Appoint Science Technology Definition Teams (STDs) and Center study offices, STDs assess technology
2017	Fund technology development through Strategic Astrophysics Technology (SAT)
2018	STDs submit Design Reference Mission (DRM) for cost assessment
2019	STDs issue report → input to Decadal Survey



PREPARING FOR THE 2020 DECADAL SURVEY

Potential Large Mission Concepts

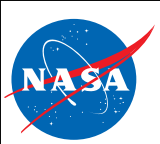
Mission	Description
Habitable-Exoplanet Imaging Mission (HabEx)	The 2010 Decadal Survey recommends that a habitable-exoplanet imaging mission be studied in time for consideration by the 2020 decadal survey
UV/Optical/IR Surveyor	<p>i) The 2010 Decadal Survey recommends that NASA prepare for a UV mission to be considered by the 2020 Decadal Survey</p> <p>ii) The Astrophysics Visionary Roadmap identifies a UV/Optical/IR Surveyor as contributing through improvements in sensitivity, spectroscopy, high contrast imaging, astrometry, angular resolution and/or wavelength coverage.</p>
FAR IR Surveyor	The Astrophysics Visionary Roadmap identifies a Far-IR Surveyor as contributing through improvements in sensitivity, spectroscopy, and angular resolution
X-ray Surveyor	The Astrophysics Visionary Roadmap identifies an X-ray Surveyor as contributing through improvements in sensitivity, spectroscopy, and angular resolution



2015 ROSES AND GO OPPORTUNITIES

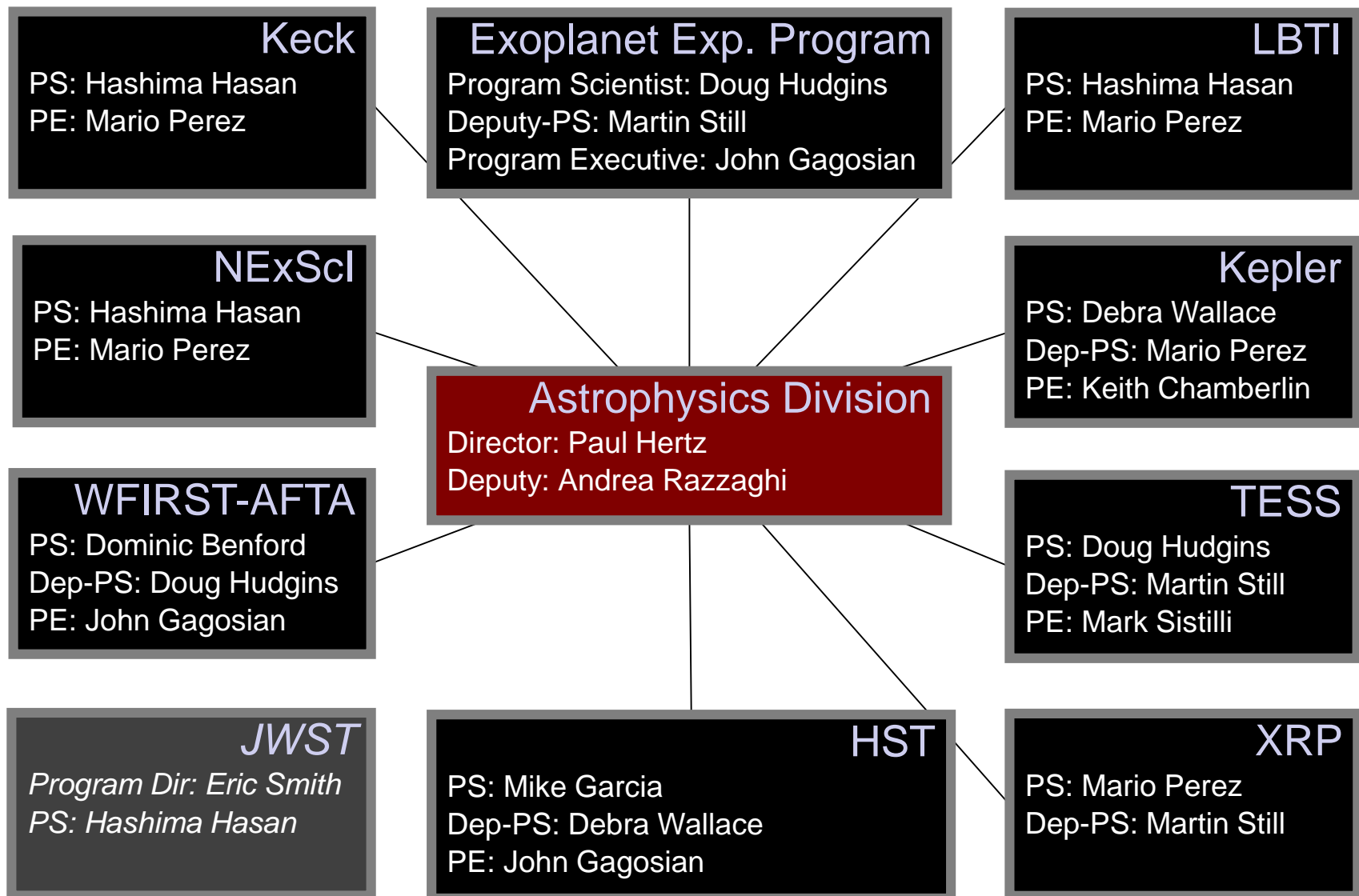
Proposal Opportunity	Due Date	Reference
Kepler K2 Guest Observer – Cycle 2	Feb 27	ROSES-14
Astrophysics R&A (APRA)	Mar 20	ROSES-14
Strategic Astrophysics Technology (SAT)	Mar 20	ROSES-14
Hubble Space Telescope – Cycle 23	Apr 10	www.stsci.edu/hst
Astrophysics Data Program (ADAP)	May 15	ROSES-15
Exoplanet Research Program (XRP)	May 22	ROSES-15
SOFIA – Cycle 4	Jul 10	www.sofia.usra.edu
Spitzer Space Telescope – Cycle 12	Sep 11	ssc.spitzer.caltech.edu
WFIRST Formulation Science	Sep 28	ROSES-15
Kepler K2 Guest Observer – Cycle 3	Sep 23	ROSES-15
N.G. Roman Technology Fellowships (RTF)	Nov 6	ROSES-15
SOFIA 3 rd Generation Instrumentation	Pending	ROSES-15
Astrophysics Theory Program (ATP)	Not this year	

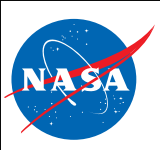
ROSES: <https://nspires.nasaprs.com>



ASTROPHYSICS DIVISION STAFF

visiting positions often available





Backup

Astrophysics Division - Science Mission Directorate

Jan 06, 2015

Resource Management

Omana Cawthon+
Clemencia Gallegos-Kelly+

Director

Paul Hertz

Deputy Director

Andrea Razzaghi

Lead Secretary: Kelly Johnson

Secretary: Leslie Allen

Program Support Specialist: Jackie Mackall

Cross Cutting

Technology Lead: Billy Lightsey*

Division E/PO POC: Hashima Hasan (Lead Comm Team)

Division Public Affairs POC: Lisa Wainio*

Information Manager: Lisa Wainio*

Hubble 25 Coordinator: Amber Straughn*

Astrophysics Research

Program Manager: Wilt Sanders*

Program Support: Janet Larson*

Astrophys Data Analysis: Doug Hudgins*

Astrophysics Theory: Keith MacGregor*

Exoplanet Research: Mario Perez*

APRA lead: Michael Garcia*

Cosmic Ray, Fund Phys: Vernon Jones, Keith MacGregor*

Gamma Ray/X-ray: Michael Garcia*, Stefan Immler*

Lou Kaluzienski, Rita Sambruna,
Wilt Sanders*

Optical/Ultraviolet: Michael Garcia*, Hashima
Hasan, Mario Perez*, Martin Still*

IR/Submillimeter/Radio: Dominic Benford*, Doug Hudgins,
Eric Tollestrup*

Lab Astro: Vacant

Roman Tech Fellows: Billy Lightsey*

Data Archives: Hashima Hasan

Astrophys Sounding Rockets: Wilt Sanders*

Balloons Program: Vernon Jones(PS), Mark Sistilli (PE)

Programs / Missions

Program Scientist

Program Executive

Exoplanet Exploration (EXEP)

Program

Doug Hudgins

John Gagosian

Keck

Hashima Hasan

Mario Perez*

Kepler

Debra Wallace*

John Gagosian

LBTI

Hashima Hasan

Mario Perez*

NExScl

Hashima Hasan

Mario Perez*

Cosmic Origins (COR)

Program

Mario Perez*

Lia LaPiana

Herschel

Dominic Benford*

Jeff Hayes

Hubble

Michael Garcia*

John Gagosian

JWST

Hashima Hasan

N/A

SOFIA

Eric Tollestrup*

John Gagosian

Spitzer

Keith Macgregor*

Jeff Hayes

Physics of the Cosmos (PCOS)

Program

Rita Sambruna

Lia LaPiana

Athena

Michael Garcia*

Lia LaPiana

Chandra

Stefan Immler*

Jeff Hayes

Euclid

Eric Tollestrup*

Keith Chamberlin*

Fermi

Keith MacGregor*

Jeff Hayes

Planck

Rita Sambruna

Jeff Hayes

ST-7/LPF

Wilt Sanders*

Keith Chamberlin*

XMM-Newton

Stefan Immler*

Jeff Hayes

Astrophysics Explorers (APEX)

Program

Wilt Sanders*

Mark Sistilli

ASTRO-H

Lou Kaluzienski

Jeanne Davis

NICER

Rita Sambruna

Jeanne Davis

NuSTAR

Lou Kaluzienski

Jeff Hayes

Suzaku

Stefan Immler*

Jeff Hayes

Swift

Martin Still*

Jeff Hayes

TESS

Doug Hudgins

Mark Sistilli

WFIRST/AFTA

Dominic Benford*

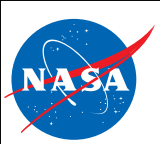
Lia LaPiana

+ Member of the Resources Mgmt Division

* Detailee, IPA, or contractor

JWST now part of the JWST Program Office.

Linda Sparke on detail to MSFC



Kepler

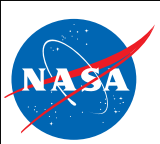
Kepler Space Telescope



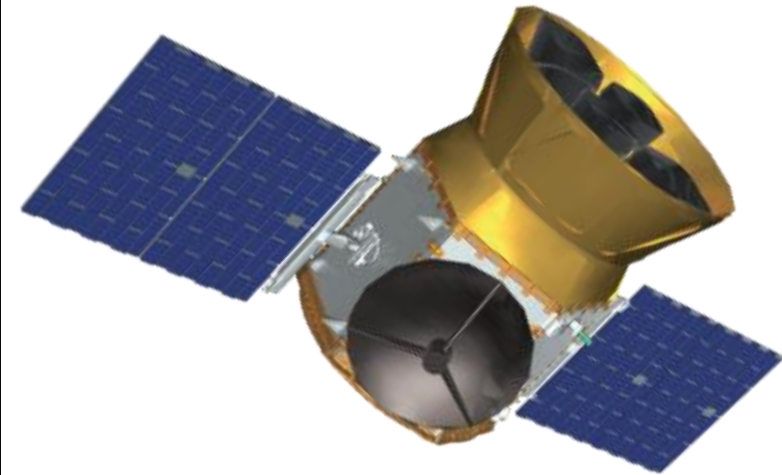
- **NASA's first space mission dedicated to the search for extrasolar planets, or exoplanets**
- **PI:** W. Borucki, NASA Ames Research Center
- **Launch Date:** March 6, 2009
- **Payload:** 0.95-meter diameter telescope designed to measure the tiny dimming that occurs when an orbiting planet passes 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:

- Kepler "K2" observation method was approved for operations through FY2016 after completion of the 2014 Senior Review.
 - Kepler is conducting observations along the ecliptic, changing its orientation four times per year.
 - The fifth 75-day Campaign started in April 2015 and runs until July 2015.
 - Targets are selected via proposals from the community. Step 1 cycle 3 proposals (covering Campaigns 8-10) are due June 2, 2015 and Step 2 proposals are due on July 1, 2015.
- **K2 Campaign 9 will target the Galactic bulge in a focused Microlensing.**
 - Campaign will measure parallaxes and obtain distances and masses for a significant number of microlensing events including those caused by bound and free-floating planets.
 - Efforts are underway to maximize scientific value by partnering with a ground-based, southern telescope to obtain multi-color photometry of the K2 field.
- December 18, 2014: First confirmed planet discovery using K2 observation method
- From 2009-13, Kepler continuously monitored 100 sq. deg. field in constellations of Cygnus and Lyra for 4+ years.
 - These observations ended after failure of 2nd reaction wheel.
- Analysis of first 4 years of Kepler data has revealed:
 - Approximately 4600 exoplanet candidates
 - Over 1000 candidates confirmed as planets to date
 - More than 100 planets discovered in their star's "habitable zone".
- Analysis of the full (4+ year) Kepler data set ongoing.



TESS Transiting Exoplanet Survey Satellite



Standard Explorer (EX) Mission

PI: G. Ricker (MIT)

Mission: All-Sky photometric exoplanet mapping mission.

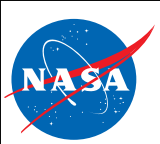
Science goal: Search for transiting exoplanets around the nearby, bright stars.

Instruments: Four wide field of view (24x24 degrees) 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

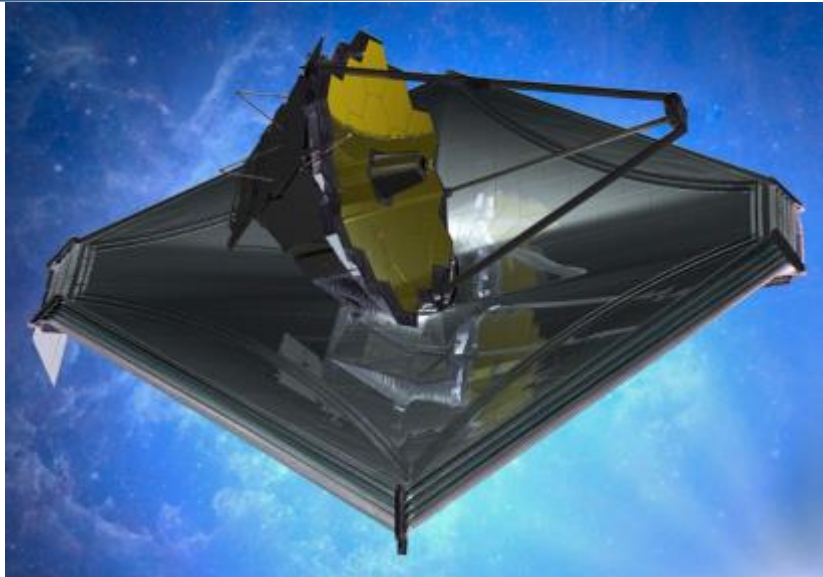
CURRENT STATUS:

- Downselected April 2013.
- Major partners:
 - PI and science lead: MIT
 - Project management: NASA GSFC
 - Instrument: Lincoln Laboratory
 - 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 \(SRR\) successfully completed on February 12-13, 2014.](#)
 - [Preliminary Design Review \(PDR\) successfully completed Sept 9-12, 2014.](#)
 - [Confirmation Review, for approval to enter implementation phase, successfully completed October 31, 2014.](#)
 - [Critical Design Review \(CDR\) planned April 2015.](#)



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

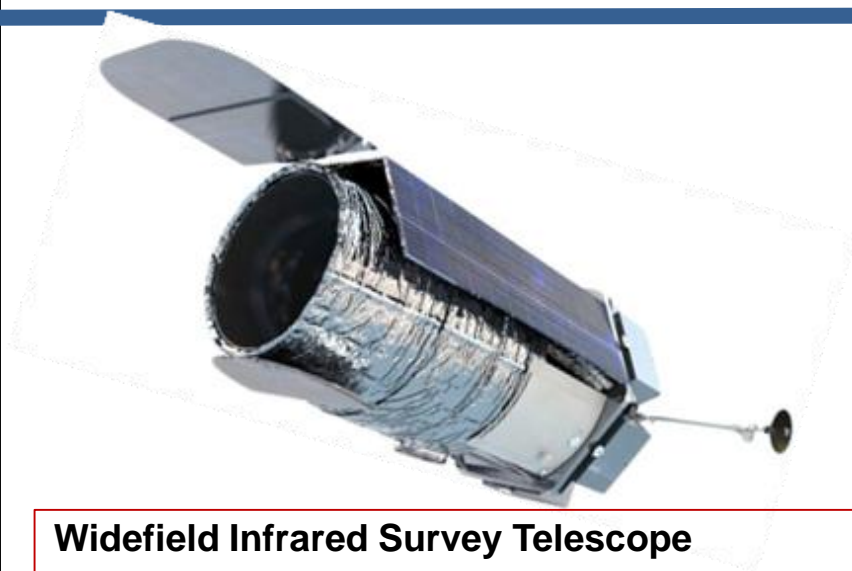
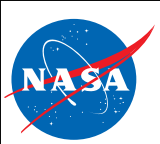
2015 Accomplishments

- All instruments re-integrated into ISIM after planned cryovacuum 2 rework (near-IR detector replacement, microshutter unit replacement)
- First pathfinder telescope cryo testing at JSC underway
- Flight Telescope Backplane assembly completed
- 1st Flight sunshield layer delivered, 3 more in manufacturing

Remaining 2015 Plans

- Complete MIRI cryocooler
- Start Assembly of the Primary mirror segments onto the Flight Backplane
- Start 3rd and final cryovacuum test of science instrument suite (ISIM)
- Deliver spacecraft bus to testing

<http://jwst.nasa.gov/>



Widefield 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 GEO, uses existing AFTA hardware to image 0.28 deg^2 at $0.8\text{-}2.0 \mu\text{m}$

Instruments (design reference mission): Wide Field Instrument, Coronagraph Instrument

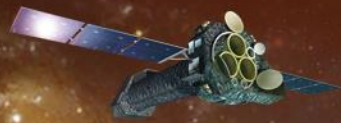
- FY15 Budget Request and FY15 Appropriation support pre-formulation of WFIRST/AFTA
- Plans support Agency/Administration decision for formulation to begin NET FY 2017, should funding be available.

<http://wfirst.gsfc.nasa.gov/>

CURRENT STATUS:

- May 2013, NASA Administrator Bolden directed study of WFIRST/AFTA and preserve option for FY17 new start if budget is available.
 - No decision expected before early CY 2016.
- Currently in pre-formulation phase.
 - Activities include technology development for detectors and coronagraph (with STMD), assessment of the 2.4m telescopes including risk mitigation, mission design trades, payload accommodation studies, and observatory performance simulations.
- Maturing key technologies by FY19.
 - H4RG infrared detectors for widefield imager.
 - Internal coronagraph for exoplanet characterization.
- March 2014 NRC study on WFIRST/AFTA offers positive view of AFTA, with concerns about technology and cost risks.
- WFIRST Preparatory Science (WPS) funds ROSES proposals that are relevant to WFIRST's goals and WFIRST-specific simulations and models.
- SDT final report submitted January 31, 2015, and available online at wfirst.gsfc.nasa.gov.
- Solicitation for members of Formulation Science Working Group (F-SWG) to be released soon

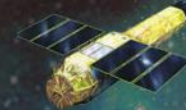
- Formulation
- Implementation
- Primary Ops
- Extended Ops



XMM-Newton (ESA)
12/10/1999



Swift
11/20/2004



Suzaku (JAXA)
7/10/2005



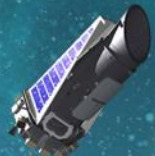
Fermi
6/11/2008



Euclid (ESA)
2020



Hubble
4/24/1990



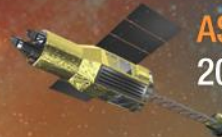
Kepler
3/6/2009



JWST
2018



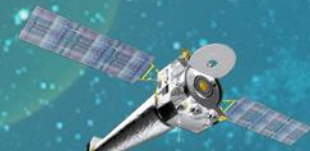
Spitzer
8/25/2003



ASTRO-H (JAXA)
2015

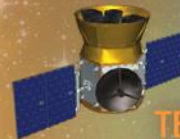
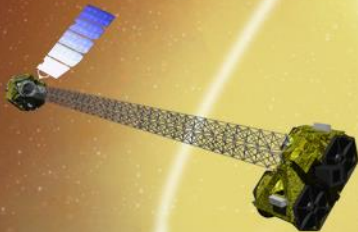


NICER (on ISS)
2016



Chandra
7/23/1999

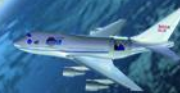
NuSTAR
6/13/2012



TESS
2017



LISA Pathfinder (ESA)
2015



SOFIA
Full Ops 2014

NASA Astrophysics Strategy