

Astrophysics



Committee on Astronomy and Astrophysics

Space Science Week

National Academy of Science Building

March 30, 2016

Paul Hertz

Director, Astrophysics Division

Science Mission Directorate

[@PHertzNASA](https://twitter.com/PHertzNASA)

Hitomi Anomaly



The Japan Aerospace Exploration Agency (JAXA) found that communication with the X-ray Astronomy Satellite "Hitomi" (ASTRO-H), launched on February 17, 2016 (JST), failed from the start of its operation originally scheduled at 16:40, Saturday March 26 (JST).

Under this circumstance, JAXA set up emergency headquarters, headed by the President, for recovery and investigation. The headquarters held its first meeting today, and has been working for recovery and the investigation of the cause. Updates will be announced as available, at the JAXA website.

JAXA is leading the investigation and is consulting with NASA from a technical and policy perspective. NASA fully supports JAXA and stands prepared to assist as requested going forward.

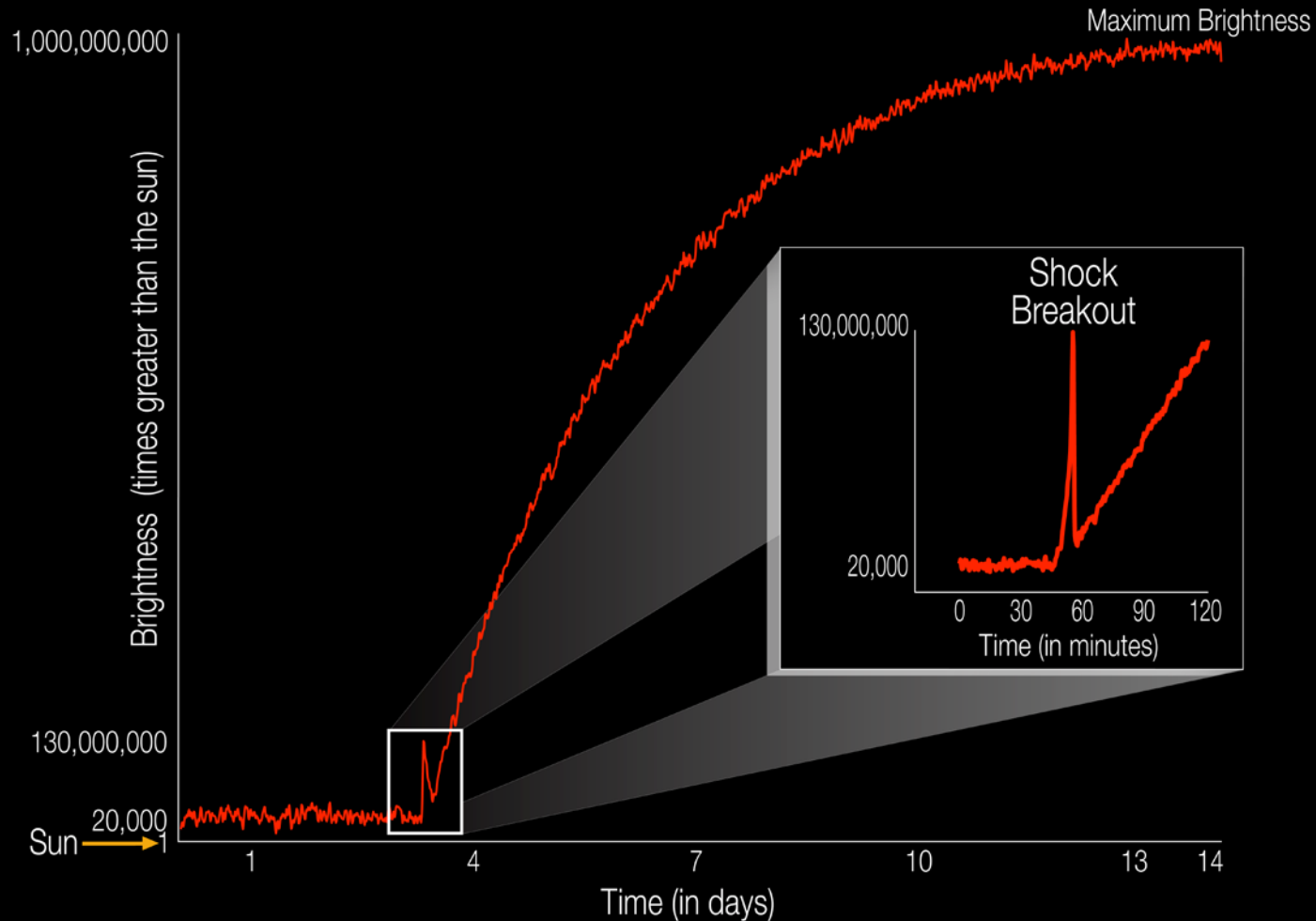
http://global.jaxa.jp/press/2016/03/20160327_hitomi.html

Sunday March 27, 2016

Kepler detects SN Breakout Flash

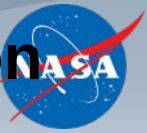


Garnavich et al, Astrophysical Journal (2016; in press)

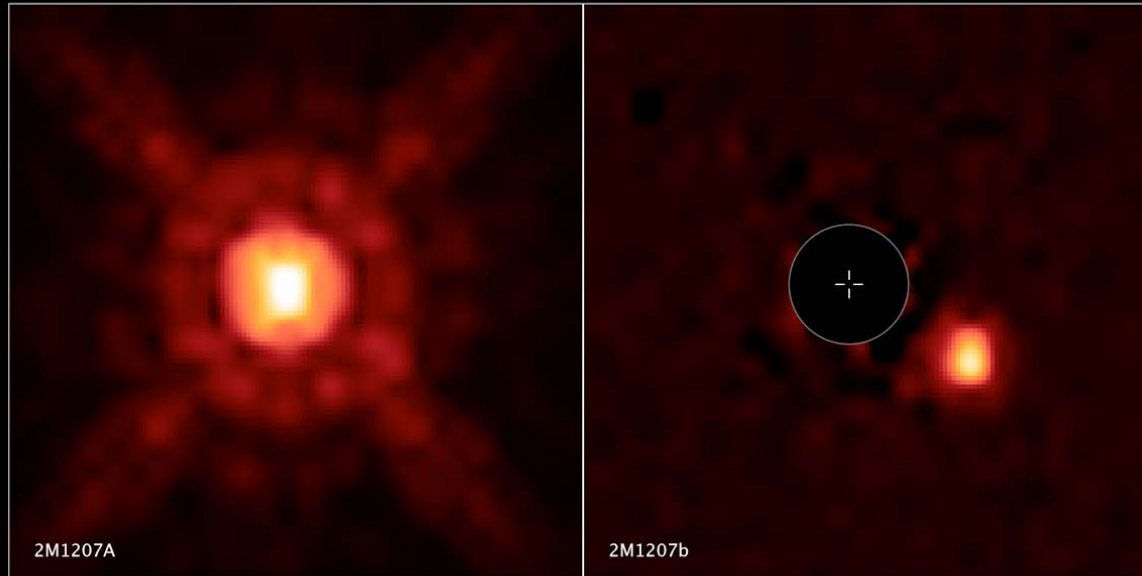


The diagram illustrates the brightness of a supernova event relative to the sun as it unfolds. The explosive death KSN 2011d, as it reaches its maximum brightness, takes 14 days. The shock breakout itself lasts only about 20 minutes. Credits: NASA Ames/W. Stenzel

Hubble resolve Brown Dwarf 2M1207A and Companion

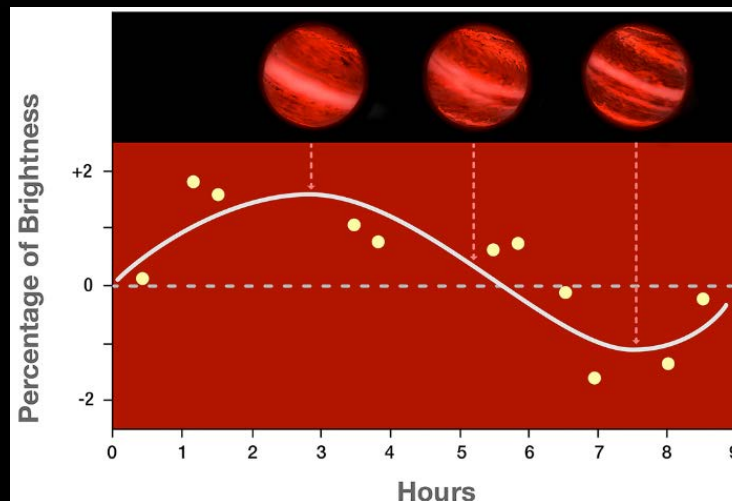


Brown Dwarf 2M1207A and Companion ▪ *Hubble Space Telescope* WFC3/IR



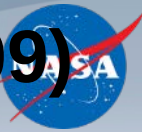
Credit: NASA, ESA,
and Z. Levay (STScI)

NASA, ESA, and Y. Zhou (University of Arizona) ▪ STScI-PRC16-05b

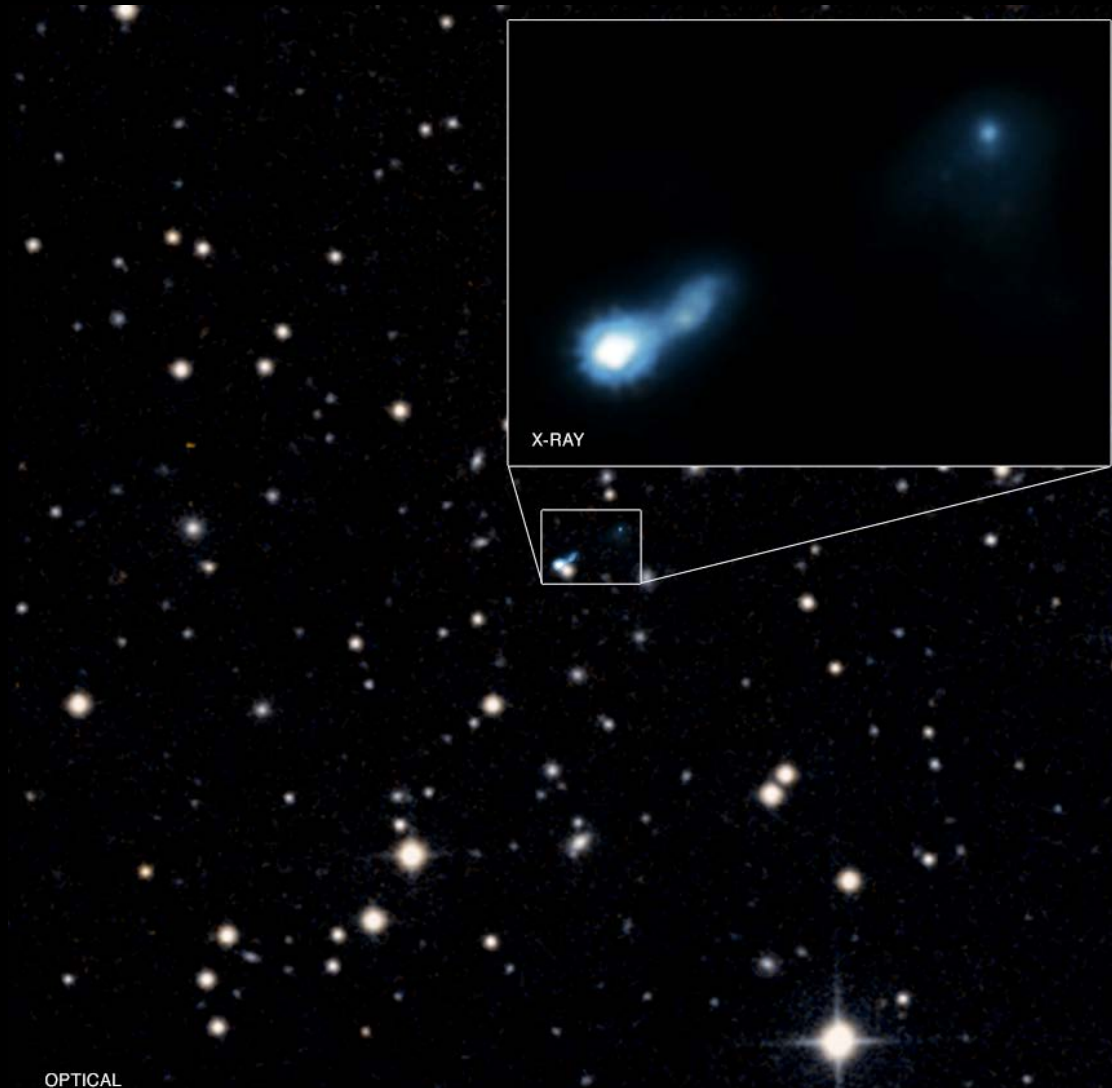


Published in the February 18,
2016 edition of *The
Astrophysical Journal*.

Chandra discovers Black Hole Jet (B3 0727+409)



Published in the January 1, 2016 edition of The Astrophysical Journal Letters.



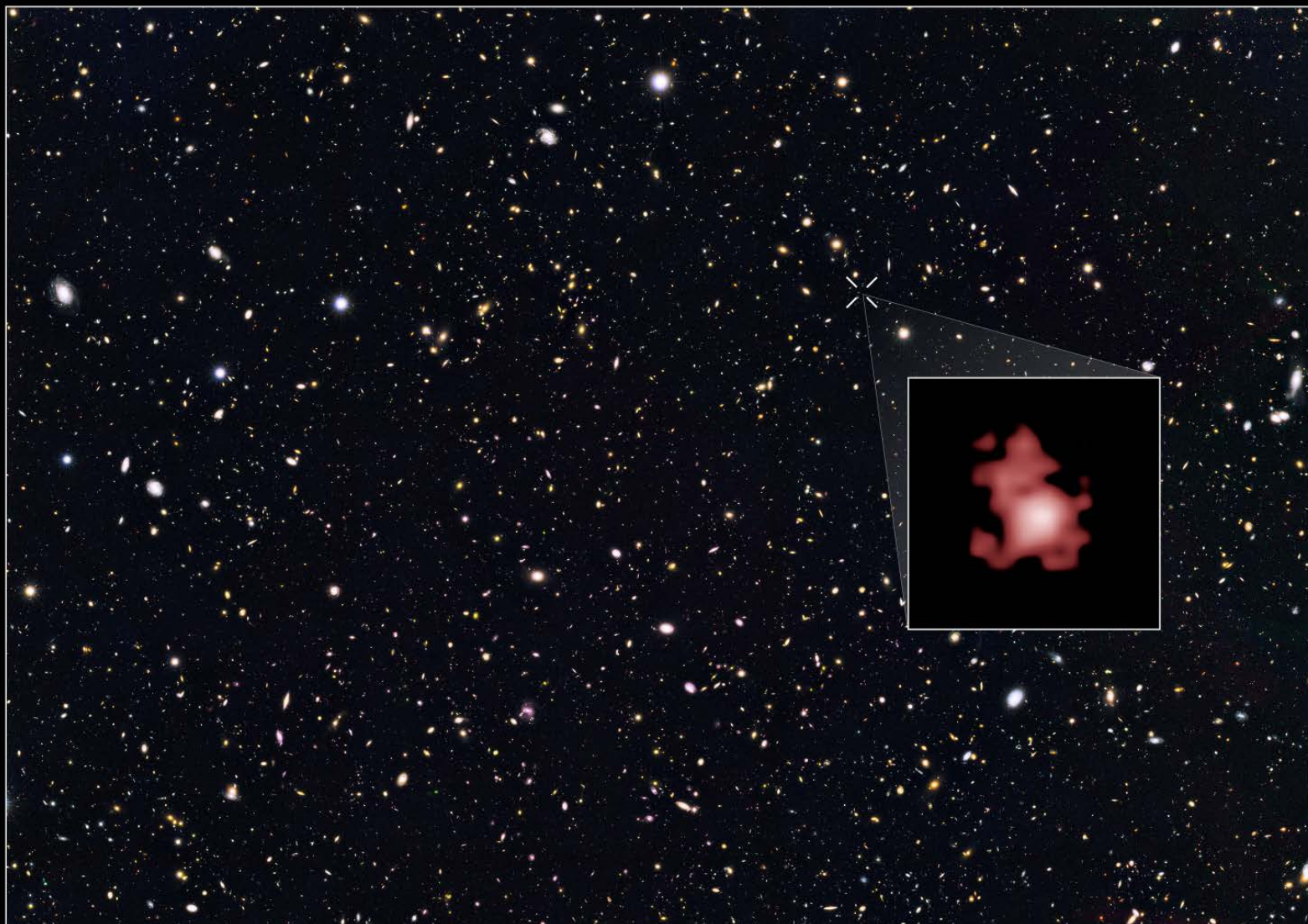
Hubble detects Distant Galaxy



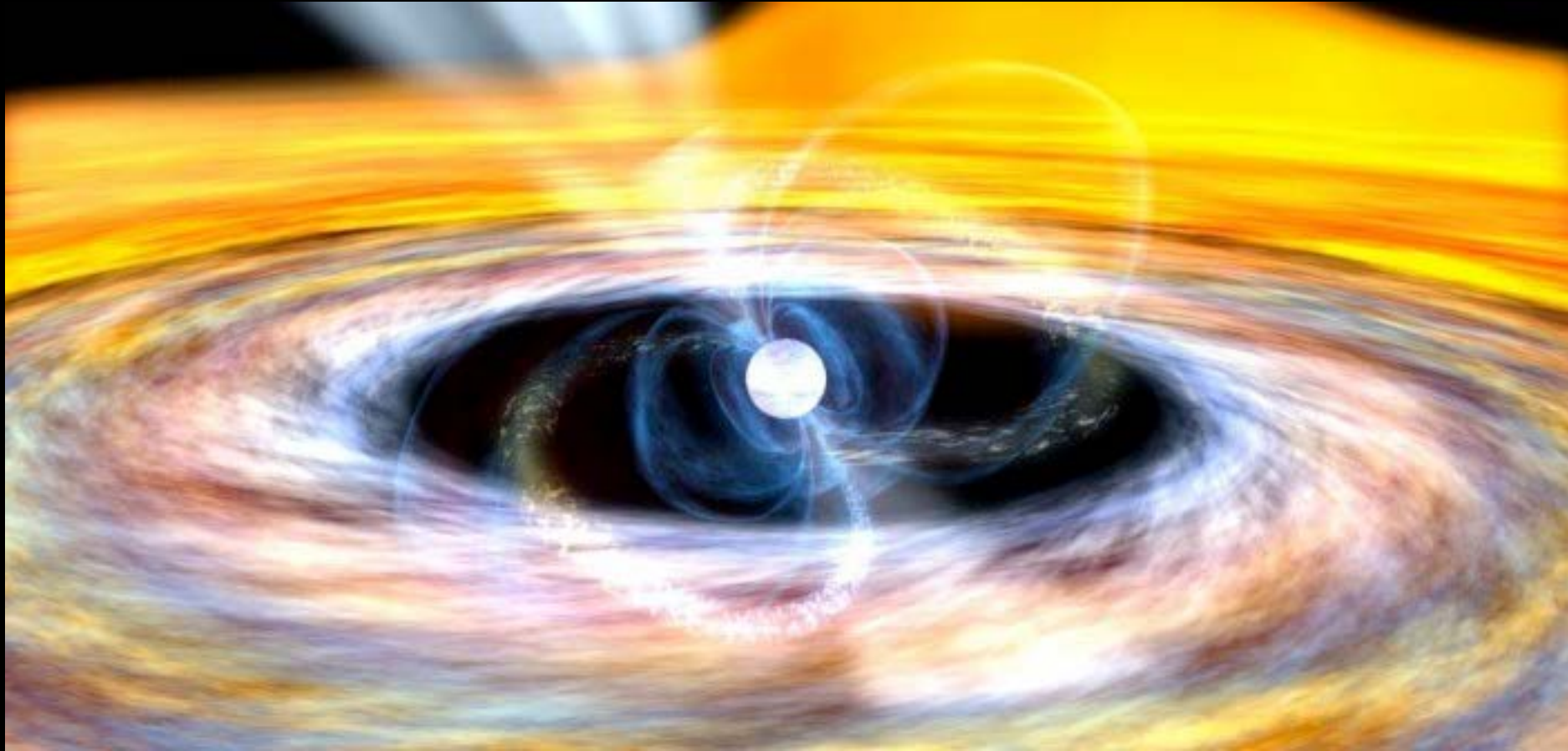
Accepted for Publication in the Astrophysical Journal

Distant Galaxy GN-z11 • Redshift 11.1 • GOODS North Survey

HST • ACS/WFC WFC3/IR



Swift & NuSTAR measure Neutron Star Accretion Disk's Inner Edge



Artist Concept: NASA/Goddard Space Flight Center/Dana Berry

King et al 2016 ApJ 819 L29

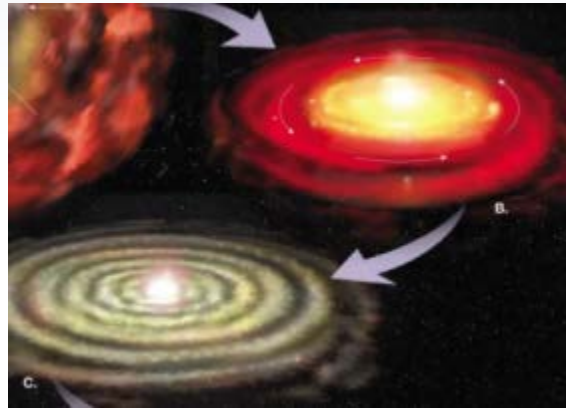
Why Astrophysics?



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



1. How did our universe begin and evolve?

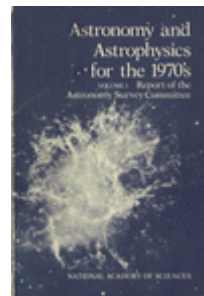


2. How did galaxies, stars, and planets come to be?

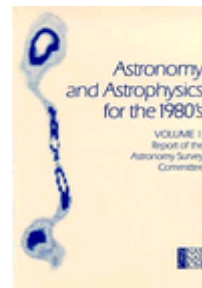


3. Are We Alone?

These national strategic drivers are enduring



1972



1982



1991

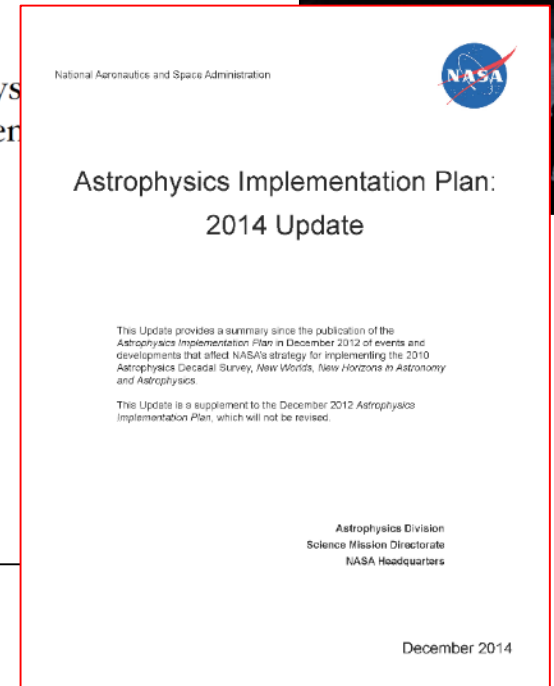
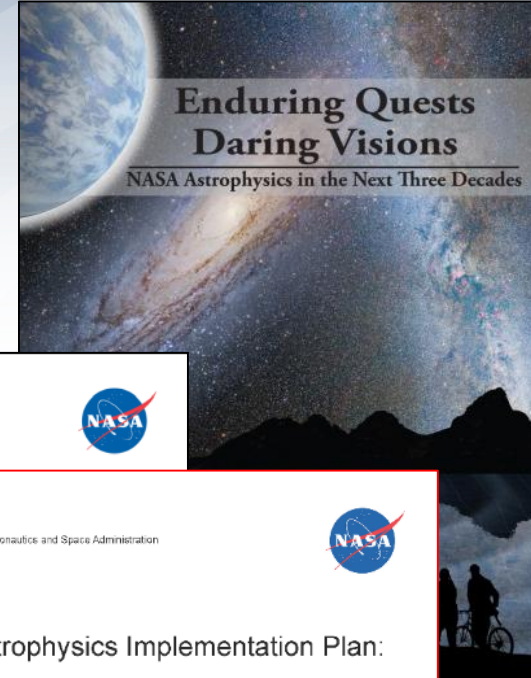
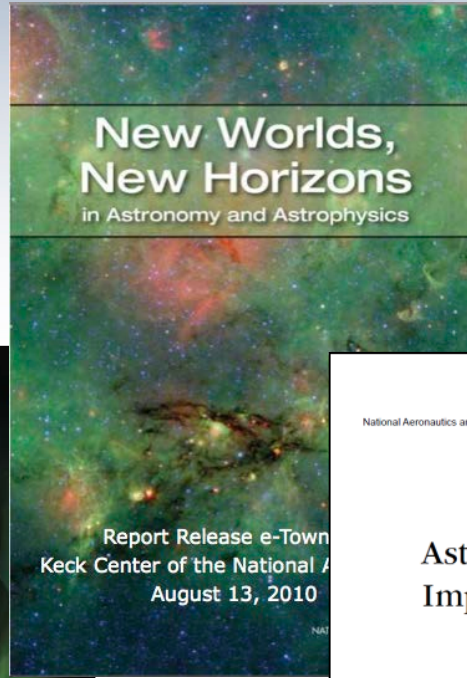
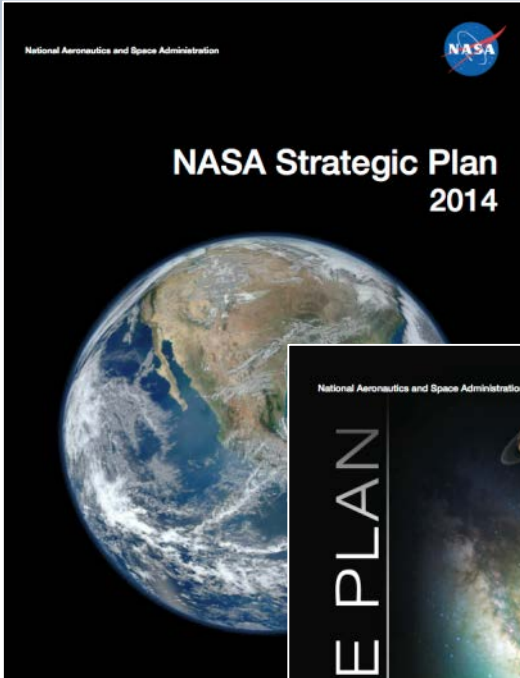


2001



2010

Astrophysics Driving Documents



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

Astrophysics - Big Picture



- **The FY16 appropriation and FY17 President's budget request provide funding for NASA astrophysics to continue its programs, missions, projects, and supporting research and technology.**
 - The total funding (Astrophysics including JWST excluding STEM) remains at ~\$1.35B.
 - Fully funds JWST to remain on plan for an October 2018 launch.
 - Funds WFIRST formulation (new start) starting in February 2016.
 - Will require some adjustments to FY16 plans in response to appropriation levels.
 - Will require some adjustments to FY17 proposal depending on Senior Review outcome.
- **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 in Spring 2016 is for FY17-FY18 and beyond.
 - SOFIA is in 5-year prime operations as of May 2014; HAWC+ 2nd generation instrument to begin commissioning in Spring 2016; 3rd generation instrument concept studies selected; Senior Review for SOFIA is in Spring 2018.
 - ESA's LISA Pathfinder successfully launched on December 3, 2015.
 - JAXA's Hitomi (né ASTRO-H) successfully launched on February 17, 2016.
 - Missions under development for launch include NICER (2017), ISS-CREAM (2017), TESS (2017), JWST (2018), ESA's Euclid (2020), WFIRST (mid-2020s).
 - 5 SMEX and MO concept studies selected in 2015; 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.**
 - NRC Mid Decade Review (with NSF, DOE) underway; Jackie Hewitt (MIT) is chair; NRC Mid Decade Review committee report expected in May 2016.
 - NASA initiating large mission concept studies as input for 2020 Decadal Survey.

Proposal Selections Since January 2015

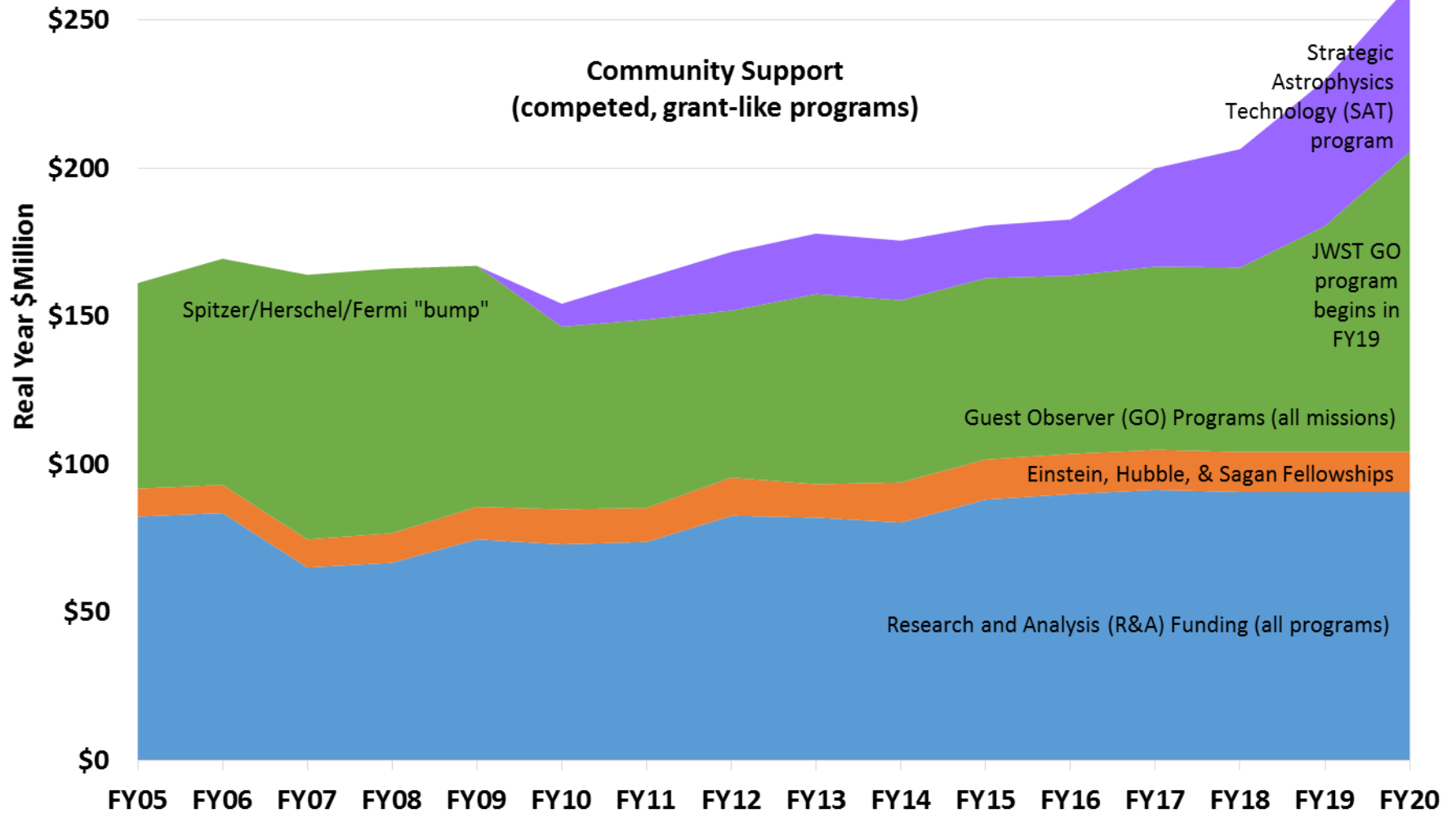
Status: February 25, 2016

	Proposal Due Date	Notify Date	Days past received	Number received	Number selected	% selected
Kepler K2 GO – Cycle 1	Sep 23, 2014	Jan 16, 2015	115	92	36	39%
Swift GI – Cycle 11	Sep 25, 2014	Jan 6, 2015	123	165	39	24%
Roman Tech Fellows	Nov 6, 2014	Feb 3, 2015	89	8	3	38%
NuSTAR GO – Cycle 1	Nov 25, 2014	Apr 17, 2015	143	193	35	18%
Fermi GI – Cycle 8	Jan 22, 2015	June 26, 2015	155	190	36	19%
NESSF-15	Feb 6, 2015	June 2, 2015	116	134	10	7%
Kepler K2 GO – Cycle 2	Feb 27, 2015	June 12, 2015	105	76	35	46%
Chandra GO – Cycle 17	Mar 17, 2015	July 17, 2015	122	582	175	30%
APRA (Basic Research)	Mar 20, 2015	Aug 12, 2015	145	149	40	27%
SAT (Technology)	Mar 20, 2015	Aug 12, 2015	145	27	11	41%
Hubble GO – Cycle 23	Apr 10, 2015	June 24, 2015	75	1114	261	23%
EPDS (Doppler Spectr)	Apr 24, 2015	July 2, 2015	69	6	2	33%
ADAP (Data Analysis)	May 15, 2015	Sep 29, 2015	137	250	51	20%
Exoplanet Research	May 22, 2015	Oct 15, 2015	146	43	7	16%
Kepler K2 GO – Cycle 3	Jul 1, 2015	Oct 14, 2015	105	72	32	44%
SOFIA GI – Cycle 4	Jul 10, 2015	Oct 22, 2015	104	155	82	53%
Spitzer GO – Cycle 12	Sep 11, 2015	Oct 26, 2015	45	104	31	30%
SOFIA 3 rd Gen Instrument	Oct 7, 2015	Dec 10, 2015	64	3	2	67%
WFIRST Sci. Inv. Teams	Oct 15, 2015	Dec 18, 2015	64	38	12	32%
Swift GI – Cycle 12	Sep 25, 2015	Jan 19, 2016	116	185	43	23%
Roman Tech Fellows	Nov 6, 2015	Feb 5, 2016	91	5	3	60%
NuSTAR GO – Cycle 2	Dec 11, 2015		76	185		
Fermi GI – Cycle 9	Jan 22, 2016		34	185		
NESSF-16	Feb 8, 2016		17	136		

100% of 2015 selections announced within 155 days

R&A Selection Rate: 23%; GO Selection Rate: 28%

Planned Community Funding



2015-2016 Antarctic LDB Campaign



Gamma-Ray Imager/ Polarimeter
for Solar flares (GRIPS)

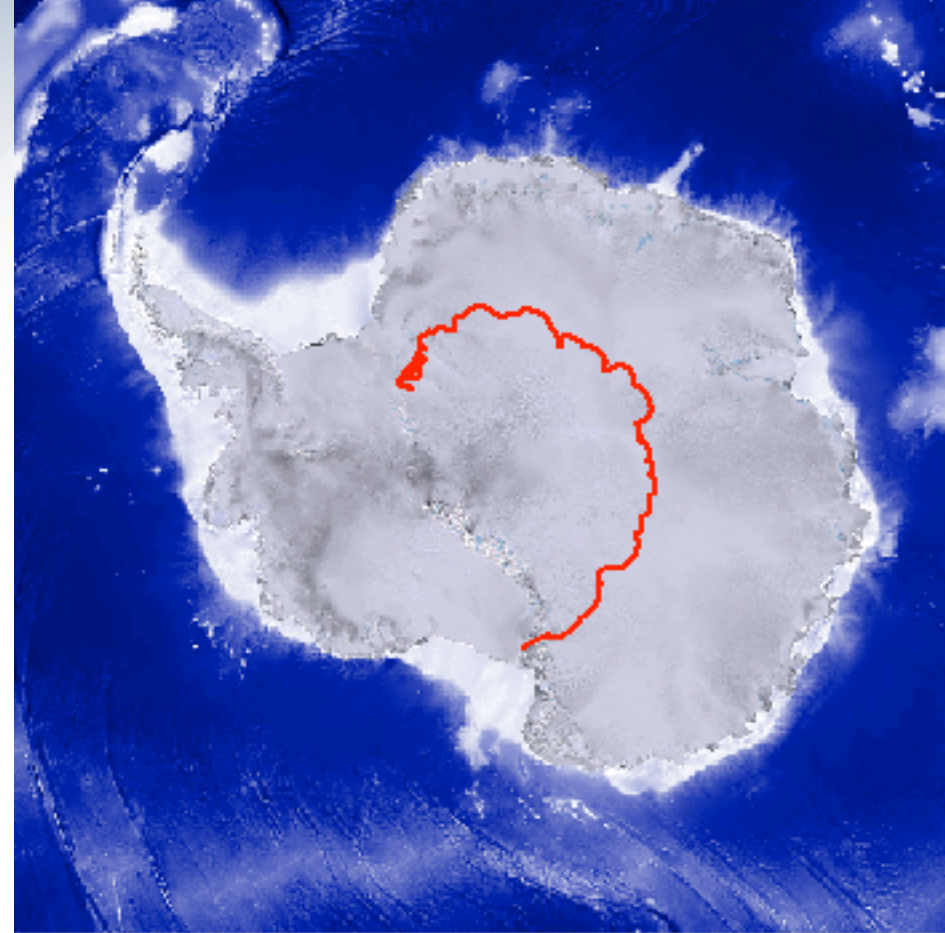
Stratospheric Terahertz
Observatory (STO-II)

<http://www.nsbfnasa.gov/>
<http://www.csbf.nasa.gov/antarctica/ice.htm>

2015-2016 Antarctic LDB Campaign



*Gamma-Ray Imager/ Polarimeter
for Solar flares (GRIPS)*



*Launched January 19, 2016
Flight successfully completed January 30, 2016
Data vault and other critical components recovered*

<http://www.nsbfnasa.gov/>
<http://www.csbf.nasa.gov/antarctica/ice.htm>

Recent & Upcoming Suborbital Launches

- Fall/Winter FY16 Sounding Rocket Launches @ White Sands NM
 - ✓ Colorado High-resolution Echelle Stellar Spectrograph (CHESS 2); K. France, U. Colorado (Feb 21, 2016)
 - Micro-X; E. Figueroa, Northwestern U. (~Nov 2017)
 - CIBER-2; Bock, Caltech (~Dec 2017)
- Winter FY16 Long Duration Balloon Campaign @ McMurdo Antarctica
 - x Stratospheric Terahertz Observatory (STO-II); C. Walker, U. Arizona (Dec 2016)
 - Due to weather, payload will be stored in place to be part of next Antarctica campaign.
- Spring FY16 Ultra Long Duration Balloon Campaign @ Wanaka NZ
 - Compton Spectrometer and Imager (COSI); S. Boggs, U.C. Berkeley (Apr 2016)

CHESS 2



Credit: NASA/WSMR

- CHESS 2 (The Colorado High-resolution Echelle Stellar Spectrograph) sounding rocket experiment facilitates observations of Atomic-to-Molecular transitions phases in translucent clouds for the local Interstellar Medium (ISM) by observing nearby stars that were too bright for Hubble and FUSE.
- Detailed composition and temperature maps at the diffuse/translucent ISM boundary will be possible for the first time with data from CHESS 2.
- The target for CHESS observations is the star Lambda Ori.
- CHESS 2 was launched on a Black Brant 9 from White Sands Missile Range in New Mexico.

2016 Senior Review Panels



Chandra X-ray
Observatory Panel

Hubble Space
Telescope Panel

Budgets already recognized in the notional run-out of the President's FY 2016 budget request. Mature and stable missions with no operational changes.

Main Panel:

Fermi
K2
NuSTAR
Spitzer
Swift
XMM-Newton

Comparative panel.

2016 Senior Review Timeline



Action	Date	Done
Draft Call for Proposals issued	August 20, 2015	✓
Deadline to send comments on draft to NASA	September 10, 2015	✓
Final Call for Proposals issued	September 25, 2015	✓
Senior Review Proposals due	January 22, 2016	✓
Main panel meets in Washington, DC	February 22-25, 2016	✓
HST review and site visit in Baltimore, MD	March 8-10, 2016	✓
CXO review and site visit in Cambridge, MA	March 22-24, 2016	✓
Delivery of panel reports to NASA HQ	April 2016	
NASA Response/direction to projects. Reports released on APD website.	May-June 2016	

For more information:

<http://science.nasa.gov/astrophysics/2016-senior-review-operating-missions/>

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 from this AO.

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

ST-7/LISA Pathfinder

ST-7/Disturbance Reduction System (DRS)



- ESA Mission with NASA Collaborating
- Project Category: 3 Risk Class: C
- DRS flies on the ESA LISA Pathfinder spacecraft
- Sun-Earth L1 halo orbit
- Drag-free satellite to offset solar pressure
- Payload delivery: July 2009
- Launched: December 3, 2015 GMT
- LPF prime mission: 7 months
- Data Analysis: 12 months

CURRENT STATUS:

- LISA Pathfinder successfully launched on December 3, 2015.
- Satellite reached Earth-Sun L1 on Jan 22 and all systems are nominal.
- Test masses released on Feb 15 (“Elwood”) and Feb 16 (“Jake”) are operating nominally.
- Began science operations on March 1, 2016.



- ESA’s LISA Test Package for 90 days
- NASA’s Disturbance Reduction System for 90 days
- ESA planning short (2-3 months) mission extension if all goes well

NASA's L3 Study



- NASA intends to partner with ESA on the ESA-led 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 Pathfinder, NASA has formed 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.
- 15 members (plus 6 member technology analysis group). David Shoemaker (MIT) is Chair. ESA has appointed an observer.
- First meeting held February 17, 2016.
- The L3ST Charter and list of selected members can be found at <http://pcos.gsfc.nasa.gov/studies/L3>.

NASA's Plans for a GW Observatory



Implications of the LIGO detection and announcement: it is about funding and priorities and timing.

- Either we do a US-led LISA, or we participate in ESA's L3 gravitational wave observatory. If we do a US-led LISA, then we do it either before or after WFIRST.
 - We are not doing it before WFIRST, because the Decadal Survey said WFIRST was the higher priority.
 - We would not change this unless the 2020 Decadal Survey tells us to do US-led LISA after WFIRST rather than one of the four large mission concepts that we are beginning to study.
 - ESA plans to launch L3 in 2034.
- Possible outcomes from the 2020 Decadal Survey regarding a space based GW observatory.
 - Continue on the path we are on for a 10% share of L3 in 2034.
 - Increase our share to ensure that the third arm is reinstated and that more US technology is included, subject to ESA approval. This would require the Decadal Survey to allocate a medium-size mission priority to a US share in L3. This gets a better L3 at the expense of not doing something else in the NASA portfolio.
- By the time of the 2020 Decadal Survey, we will have:
 - Outcome of LISA Pathfinder (so far so good but not successful yet).
 - Another 4 years of LIGO results to inform our priorities for GW observatories beyond LIGO.

Hitomi (formerly ASTRO-H)

Soft X-ray Spectrometer and Soft X-ray Telescope Mirrors



CURRENT STATUS

The U.S. provided instrument contributions to the JAXA Hitomi mission.

- 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
- X-ray Electronics Box (X-box)
- High Temperature Superconducting Leads
- Successfully launched from Tanegashima Space Center, Hitomi is continuing on-orbit checkout.



- Feb 25 – SXS first light ✓
- Feb 28 – Deployment of extendable optical bench ✓
- Mar 6 – Turn on SXI instrument ✓
- April 8 – Open SXS gate valve
- Early May 2016 (TBC) – NASA Cycle 1 GO call coordinated with JAXA GO call

- **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 enables wide range of physical measurements of sources from stellar coronae to clusters of galaxies.
- **Operations:** Prime Mission is 3 years

SOFIA

Stratospheric Observatory for Infrared Astronomy



- **World's Largest Airborne Observatory**
- 2.5-meter telescope
- 80/20 Partnership between NASA and the German Aerospace Center (DLR)
- Science Center and Program Management at NASA-Ames Research Center
- Science Flight Operations at NASA-Armstrong Flight Research Center
- Four US and Two German science instruments commissioned
 - Provide imaging, spectroscopy and photometry ranging from visible to far infrared
 - Advanced science instruments under development for future operation

CURRENT STATUS:

- In the 2nd year of prime mission operation
- Observing status:
 - Cycle 4 started in February 2016
 - Occultation data (Cycle 3) synergetic with New Horizons
 - Calibrated data from Horsehead nebula released to the astronomical community in February 2016 with no proprietary restrictions
 - 7-week, 3 science instrument deployment to Christchurch, New Zealand planned from June 4th – July 25th, 2016
- Second generation instruments:
 - Commissioned upGREAT, multi-pixel heterodyne spectrometer (German instrument)
 - Testing/integrating HAWC+, far infrared imager & polarimeter; 2016 commissioning (U.S. instrument)
- Two Third-generation instruments selected in 2016 for six month study. Down select in August 2016.
- Implemented science community feedback and IG recommendations for improved science productivity
 - Large impact science observation program offerings
 - Increased guest investigator support by a factor of 3
 - Increased capacity to deploy multiple instruments
 - Increased support for future science instrumentation
- Recompeting contract for science mission operations

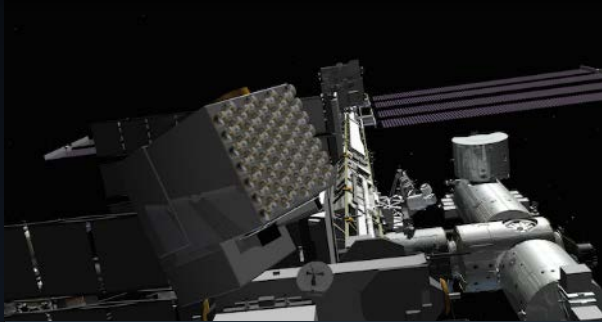
Astrophysics Missions in Development



NICER

NASA Mission

3/2017

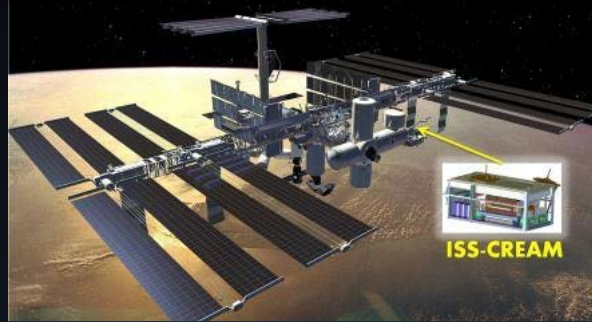


Neutron Star Interior
Composition Explorer

CREAM

NASA Mission

7/2017

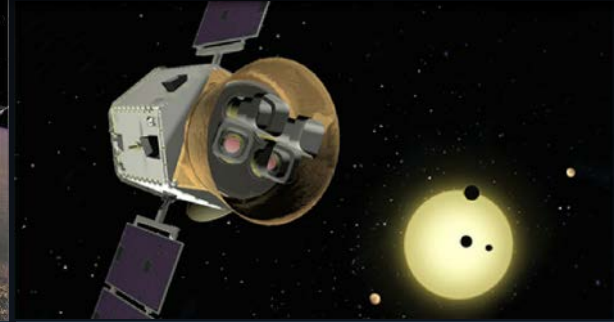


Cosmic Ray Energetics
And Mass

TESS

NASA Mission

8/2017

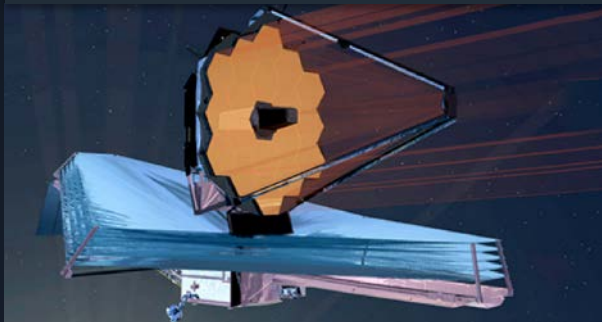


Transiting Exoplanet
Survey Satellite

JWST

NASA Mission

10/2018

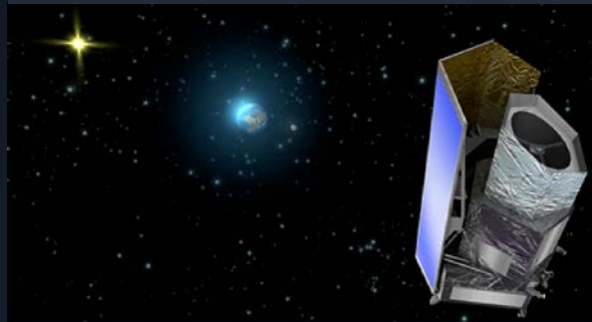


James Webb
Space Telescope

Euclid

ESA-led Mission

2020



NASA is supplying the NISP
Sensor Chip System (SCS)

WFIRST

NASA Mission

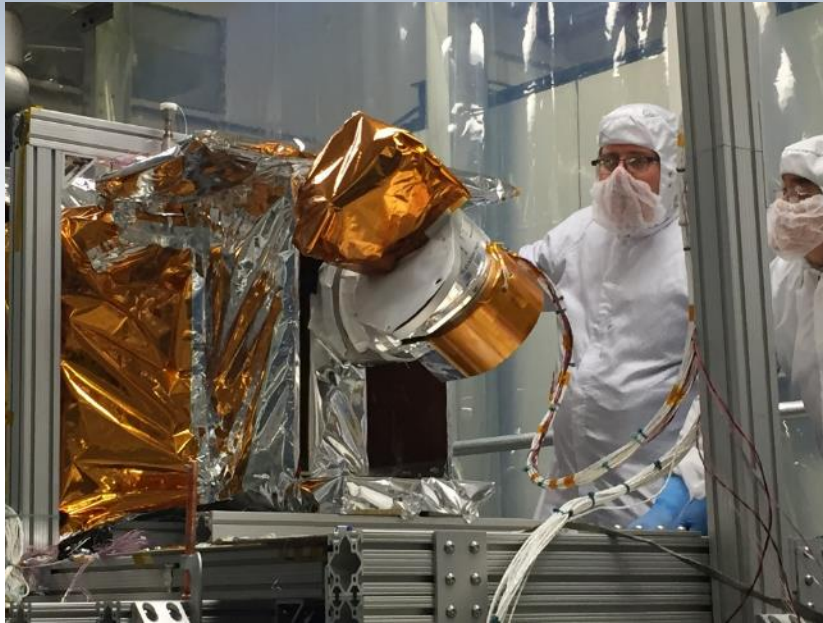
Mid 2020s



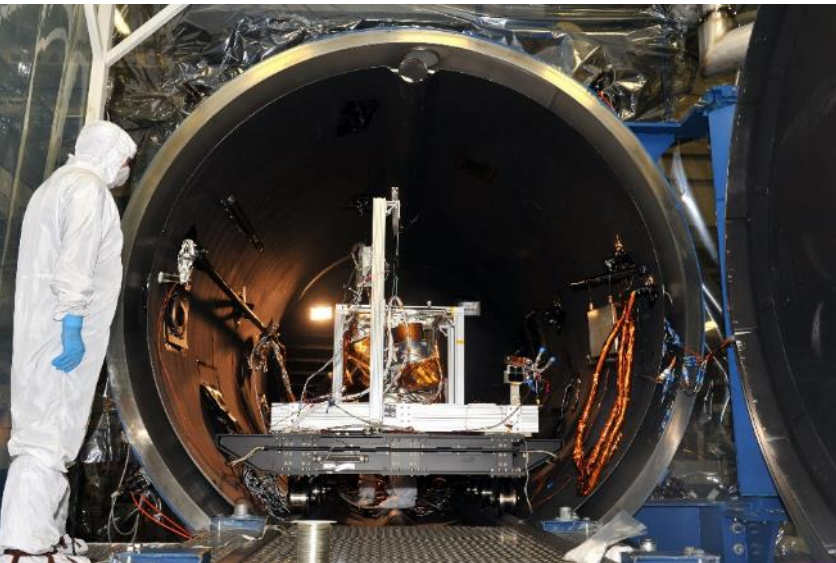
Wide-Field Infrared
Survey Telescope

NICER

Neutron star Interior Composition Explorer



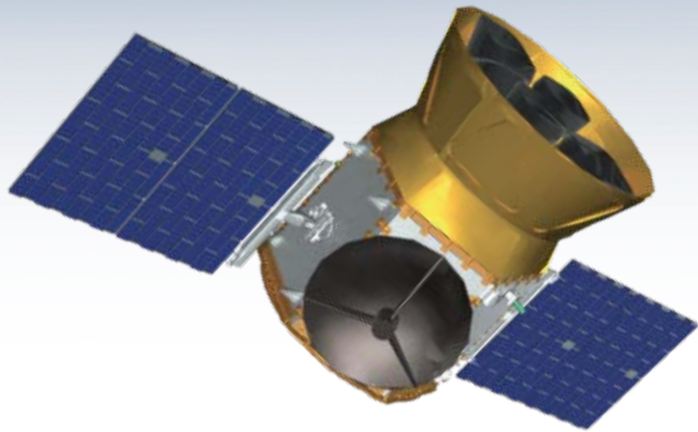
- All subsystems/sub-assemblies have completed fabrication and environmental testing ✓
- The NICER project has now started final payload integration ✓
- December 10-11, 2015: Pre-environmental Review ✓
- January 28, 2016: Start Phase D ✓
- February 2016: Start of payload environmental testing ✓
- Payload will be delivered to KSC in July 2016 and stored at KSC until launch.
- March 2017 (TBC): Launch on SpaceX-11 commercial resupply service (CRS) flight to ISS



<https://heasarc.gsfc.nasa.gov/docs/nicer/>

TESS

Transiting Exoplanet Survey Satellite



CURRENT STATUS:

- CDR held Aug 4-7, 2015
- Delta CDR held Dec 7, 2015
- Spacecraft bus structure delivered Feb 2016.
- Instrument Flight Lens delivery Feb/Mar 2016.
- Completed flight instrument lens hood and spacecraft propulsion tank.



Instrument lens hood

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: NLT June 2018 launch with a 3-year prime mission including 2 years of spacecraft operations and an additional 1 year ground-based observations and analysis. High-Earth elliptical orbit (17 x 58.7 Earth radii).



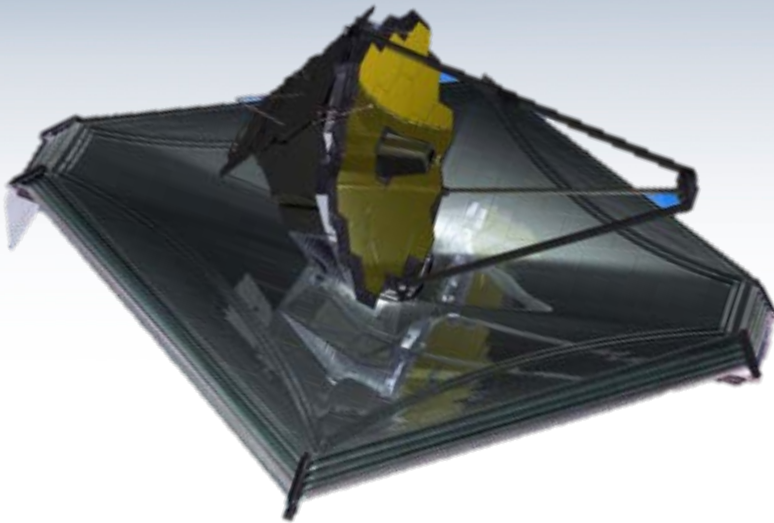
Spacecraft propulsion tank

UPCOMING EVENTS:

- Spring-Summer 2016 - TESS bus integration and instrument integration ongoing.
- Fall 2016-Spring 2017 - TESS Observatory integration and test.
- Fall 2016 - System Integration Review (SIR)
- Fall 2016 - KDP-D
- Summer 2017 - TESS delivery to KSC launch site.

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

- Completed Telescope Structure
- Completed second Telescope Pathfinder test at JSC
- All updates/fixes made to ISIM following 2nd cryovacuum test
- Spacecraft Bus Structure delivered to I&T
- Final ISIM cryovacuum test started
- Mirror installation onto Telescope Structure started

2016 Plans

- Complete ISIM cryovacuum testing ✓
- Complete mirror installation ✓
- Install ISIM into Telescope Structure
- Complete Flight Sunshield Membranes
- Conduct final GSE test at JSC before test of Flight telescope and instruments

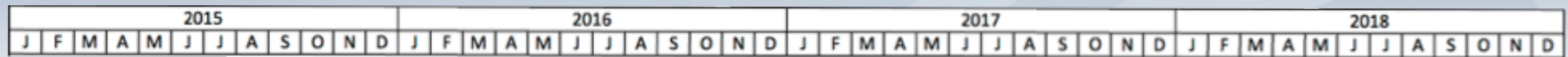
<http://www.jwst.nasa.gov/>

JWST Status Update

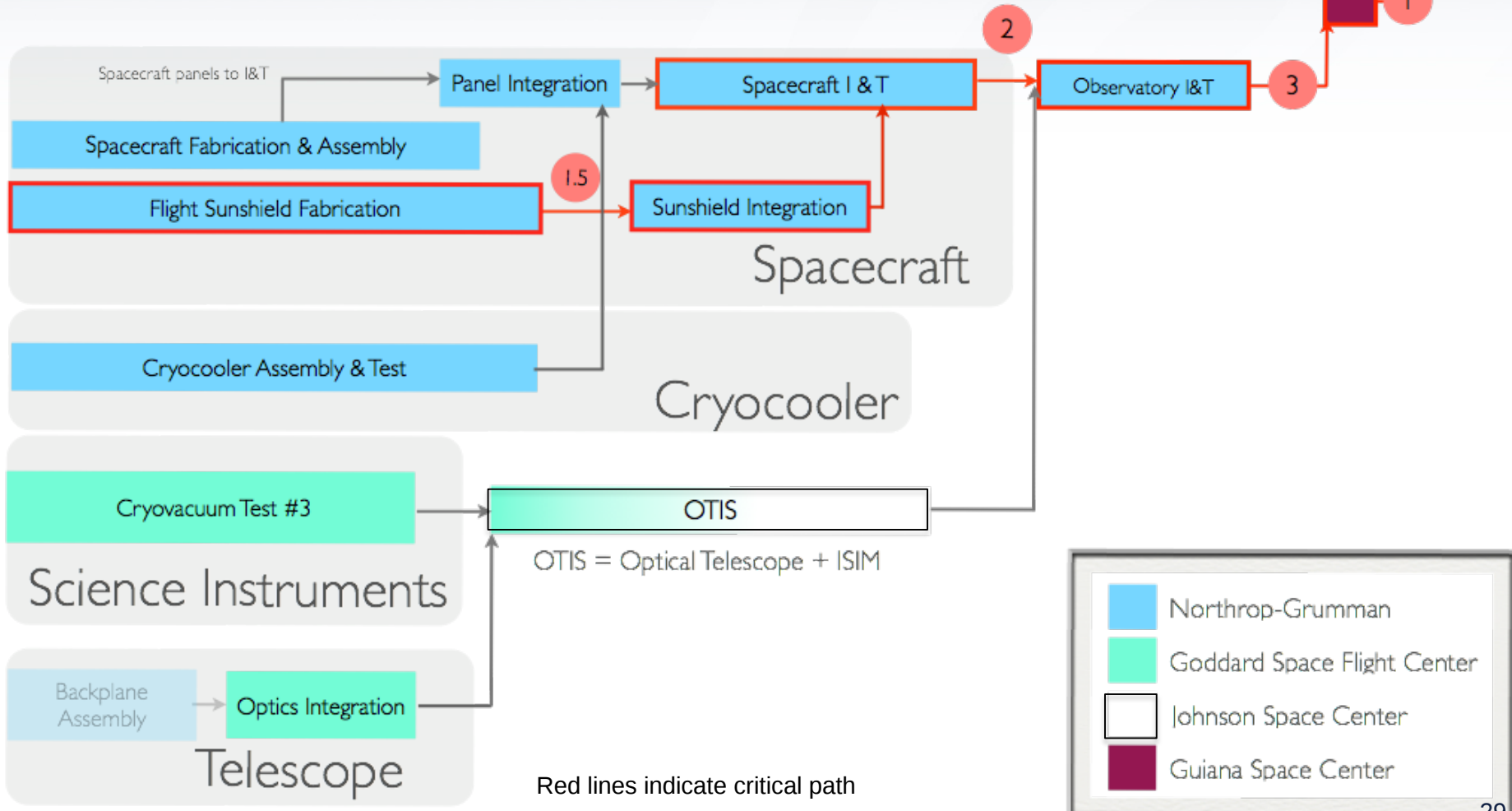


- Working with new GAO examiner team for FY2016 audit.
- ISIM successfully completed its third and final cryovacuum test and is back in the GSFC cleanroom awaiting its next integration steps.
- All primary mirror segments installed onto Telescope Structure, Aft Optics System scheduled to begin this week.
- Optical Ground Support Equipment (OGSE) test #2 analysis completed.
- The "Core2" test hardware is nearly completely assembled at GSFC in preparation for cryo testing this Spring.
- Flight sunshield membrane manufacturing continues. 3 layers still in manufacturing, 2 assembled and shape tested, final membrane seaming completed.
- Significant progress on all other sunshield hardware.
- Redesigned $\frac{3}{4}$ actuator undergoing final analysis.
- Spacecraft bus structure testing almost complete, about to head into propulsion I&T.
- Flight Cryocooler Compressor Assembly (CCA) in final testing stage at JPL and proceeding per plan.
- New horizontal shaker table complete at GSFC, working with vendor resolve vertical shaker table issue .
- Sunshield/Spacecraft are the critical path at 7.5 months of margin with 31 months to go.

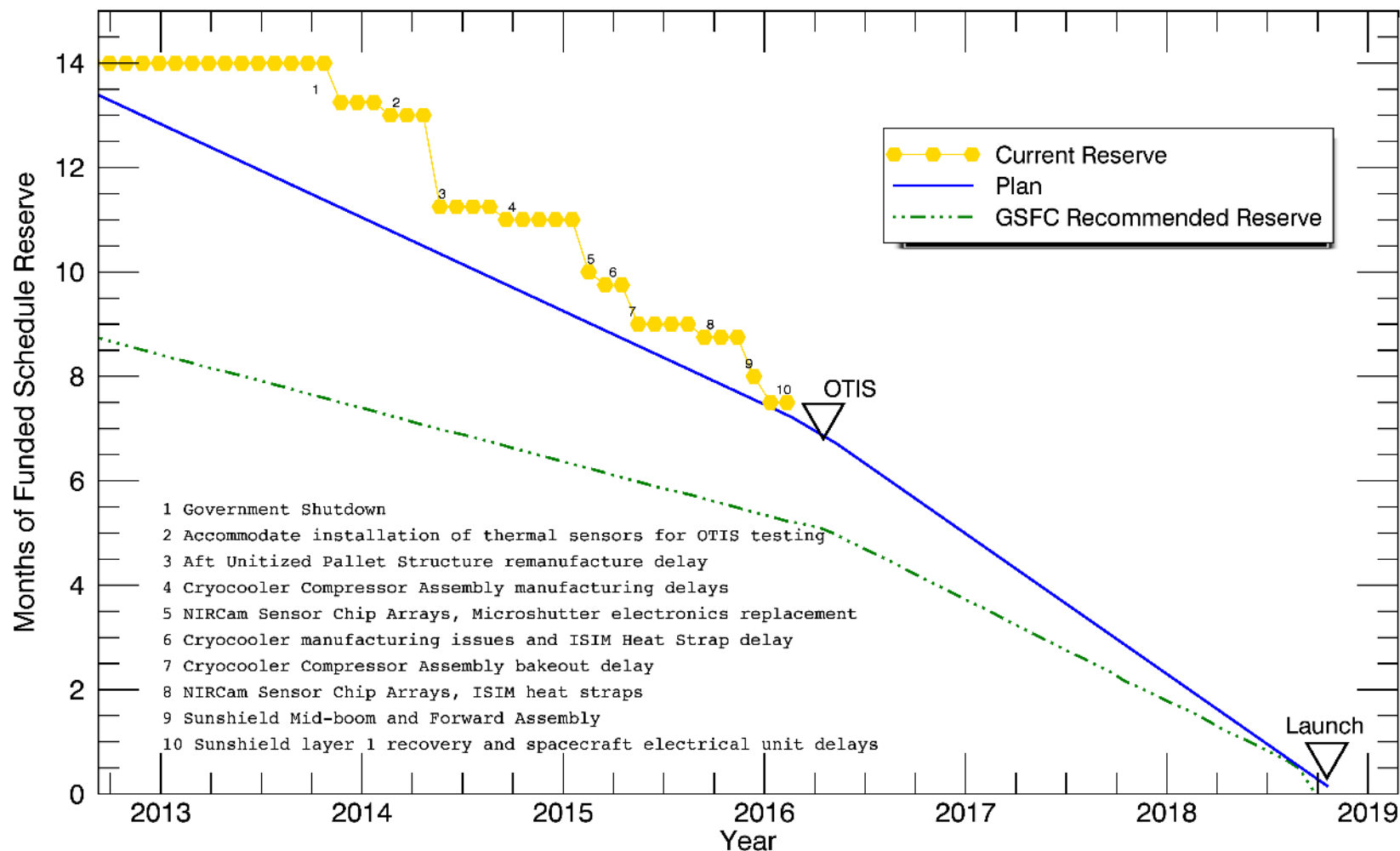
JWST Top Level Schedule



k months of project funded critical path (mission pacing) schedule reserve



JWST Funded Schedule Reserve



JWST Next Major Test Preparations at JSC

Pathfinder with Mirror Simulators
Preparation for Next Test in Chamber A



JWST Mission Operations Control (MOC) at STScI



JWST Hardware Progress



Integrated Science Instrument Module (ISIM) post CV3



Completed Optical Telescope Element (OTE), with secondary mirror and Aft Optics Assembly (AOS) installed, at GSFC SSIDF.

JWST remains on track for an October 2018 launch within its replan budget guidelines

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

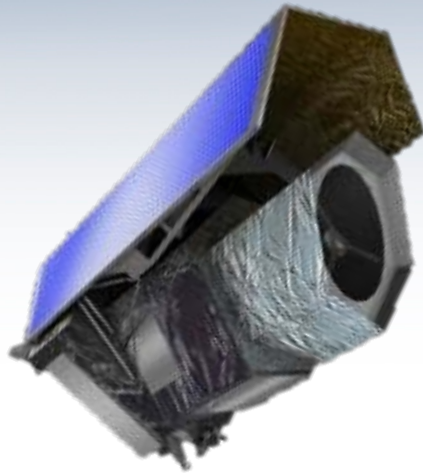
James Webb Space Telescope Summary



- While challenges are arising during final manufacturing and I&T phases:
 - We continue careful monitoring of FY16 UFE and now FY17 UFE,
 - Assembly of the Telescope is complete,
 - The MIRI Flight Cryocooler Compressor Assembly at JPL for testing continues to proceed nominally,
 - Good progress is being made on plan for the spacecraft,
 - OTIS integration and testing has entered an important phase, and
 - Must preserve schedule reserve for future challenges
- JWST team continues to execute to our LRD commitments

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:** December 2020
- **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.

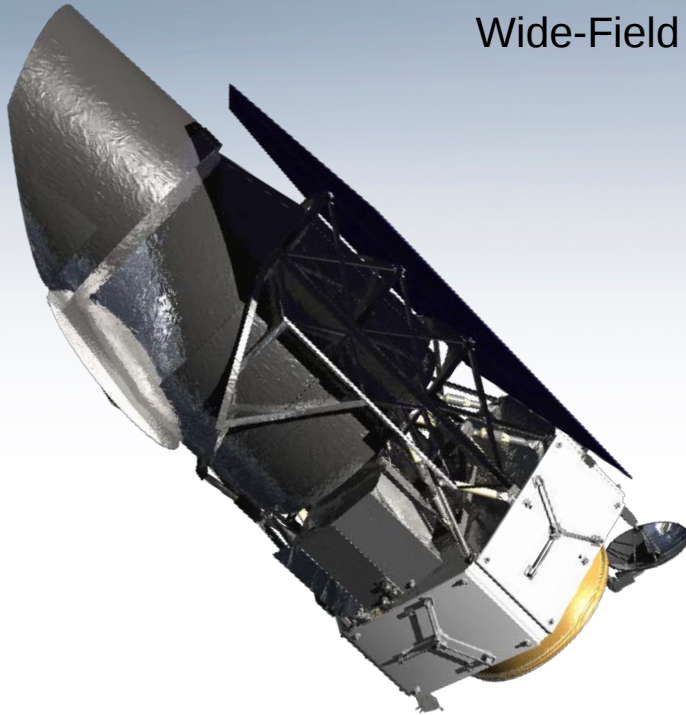
CURRENT STATUS:

- Currently in implementation phase.
- ~60 U.S. scientists are members of the Euclid Science Team that will analyze the data, and make maps of the sky.
- The qualification detectors from the detector vendor are currently being tested at GSFC's Detector Characterization Lab, and JPL has taken delivery of the first flight detectors.
- NASA has all contracts in place for detector fabrication.
- NASA replan was completed on February 26, 2016 which has the first flight detectors being delivered to ESA in March 2017.
 - ENSCI formally made part of the project - provides US science node; reserves augmented to improve risk posture.

<http://sci.esa.int/euclid/>

WFIRST

Wide-Field Infrared Survey Telescope



CURRENT STATUS:

- Completed Mission Concept Review (MCR) held in December 2015
- Formulation Science Investigation Teams selected in December 2015; first meeting held February 2016.
- Passed Key Decision Point A (KDP-A) in Feb 2016
 - Official start of formulation phase
 - Supported by FY16 appropriation and FY17 request
 - Developed and signed Formulation Authorization Document (FAD), Project Formulation Agreement (PFA), and preliminary Program Level Requirements Appendix (PLRA).
 - Successful KDP-A DPMC held January 26, 2016.
 - Successful KDP-A APMC held February 17, 2016.
- Schedule under revision to account for FY16 appropriation of \$90M and FY17 budget request of \$90M. Notional runout of FY17 budget request provides in-guide budget supporting launch in mid-2020s.

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 0.28deg^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 Formulation (Phase A)

WFIRST has begun Formulation

Name	Affiliation	Role
Neil Gehrels, Chair	NASA/GSFC	Project Scientist
David Spergel, Deputy Chair	Princeton University	WFI Adjutant Scientist
Jeremy Kasdin, Deputy Chair	Princeton University	CGI Adjutant Scientist
Dominic Benford, <i>ex officio</i>	NASA/HQ	Program Scientist
Dave Bennett	UMBC & GSFC	Microlensing
Ken Carpenter, <i>ex officio</i>	NASA/GSFC	Project science
Roc Cutri, <i>ex officio</i>	IPAC	Science center
Olivier Doré	NASA/JPL	Cosmology: GRS+WL
Ryan Foley	UIUC	Supernova Cosmology
Scott Gaudi	Ohio State U.	Microlensing
Chris Hirata	Ohio State U.	Cosmology: WL
Jason Kalirai	JHU & STScI	GI/GO – Galactic science
Jeff Kruk, <i>ex officio</i>	NASA/GSFC	Project science
Nikole Lewis	STScI	Coronagraph
Bruce MacIntosh	Stanford	Coronagraph
Roeland van der Marel, <i>ex officio</i>	STScI	Science center
S. Perlmutter	UC Berkeley	Supernova Cosmology
James Rhoads	Arizona State	GI/GO – Cosmic Dawn
Jason Rhodes, <i>ex officio</i>	NASA/JPL	Project science
Aki Roberge	NASA/GSFC	Coronagraph
Brant Robertson	UC Santa Cruz	GI/GO – Galaxy evolution
Alexander Szalay	Johns Hopkins	GI/GO – Archival science
Wes Traub, <i>ex officio</i>	NASA/JPL	Project science
Maggie Turnbull	GSI & SETI	Coronagraph
Yun Wang	Caltech/IPAC	Cosmology: GRS
David Weinberg	Ohio State Univ.	Cosmology: Clusters
Benjamin Williams	U. Washington, Seattle	GI/GO – Nearby Galaxies

207 Members on selected WFIRST Science Investigation Teams!

Albring, Greg	Card, David R	Freedman, Wendy L	Hovel, Andy	Law, David R	Melina, Garrett	Ravindranath, Svara	Seth, Ari	Thomas, Ruth C
Anderson, Albert Jay	Conroy, Andrew	Fleeman, Joshua	Hsiao, Eric Y	Lemson, Gerard	Menard, Bibe	Rejkuba, Marina	Shelden, Stuart B	Trauger, John Terry
Balaj, Charles	Conroy, Chaele	Fischer, Andrew S	Hu, Rensu	Levesque, Emily M	Melan-Gabet, Rafael	Rest, Amin	Shapiro, Charles	Turninon, Jason
Barbary, Kyle	Ornjacic, Denja	Furanello, Steven R	Hudson, Michael J	Lewis, Nicole K	Myrskke, Hiroao	Rhoads, James E	Shapley, Alice E	Turbul, Margaret C
Batista, Natalie	Dalanton, Julianne	Gaudi, Scott	Jain, Bhuvnesh	Line, Michael Robert	Monachesi, Antonella	Riess, Adam	Sheth, Tishu	Van Dyk, Schuyler
Bean, Rachel	Dawson, Rebekah Lere	Geha, Maia	Jang, Corndel Hannah	Lu, Jessica R	Motley, Caroline V	Robarge, Aki	Shvartzvald, Yossi	vonder Linden, Anja
Beckman, Charles A	Debes, John Henry	Giardi, Leo	Jansen, Rolf A	Lupton, Robert	Natali, David	Robertson, Brant	Simon, Amy A	Walker, Matthew
Bel, Eric F	Davies, Susana E	Goddard, Colin	Jarvis, Michael	Lupu, Roxana E	Newman, Jeffrey A	Robinson, Tyler D	Smith, Kendrick M	Wang, Li'an
Benson, Andrew J	Dickinson, Mark E	Gordon, Karl D	Jensen, Harnes	Madintosh, Bruce	Nugent, Peter	Rodney, Steven A	Snyder, Gregory F	Wang, Yun
Bethu, Ralph C	Dolphin, Andy	Gould, Andrew	Jha, Saarth W	Macaul, Piero	Padmanabhan, Nikhil	Rogers, Leslie A	Sommer, Remi	Wechsler, Lisa
Bolatto, Alberto D	Dore, Olivier P	Greene, Jerry E	Johnson, LC	Madhusudan, Niku	Papovich, Casey J	Roman, Duval Julia	Sparks, William B	Weinberg, David H
Boyer, Marita L	Dressler, Alan	Greene, Thomas	Johnson, Kathryn V	Mahata, Sangeeta	Peek, Joshua	Rosenfield, Philip	Spiegel, David N	Wheeler, Coral Rose
Bragaglia, Viridius M	Duchene, Gaspard	Groff, Tyler D	Juic, Maib	Mandel, Kelsey S	Perantolia, Jorge	Rozo, Eduardo	Stark, Christopher C	Wheeler, J. Craig
Bryden, Geoffrey	Dvornik, Cora	Guhathakurta, Puagra	Kalra, Jason	Mandelbaum, Rachel	Perry, Matthew T	Rubin, David	Stark, Daniel	White, Richard L
Budavari, Tamas	Eller, Tim Fredrik	Heap, Sally	Kane, Stephen R	Mandel, Avi M	Perlmutter, Saul	Sako, Masao	Sessun, Keven	Williams, Benjamin F
Bullock, James	Fall, Michael	Haimann, Katrin	Kasch, Jeremy	Matley, Mark S	Perin, Marshal D	Sales, Laura V	Strader, Jay	Willmer, Beth
Burns, Christopher	Fan, Xiaohu	Hebu, George	Kelly, Patrick	Marcis, Christian	Phips, Mark M	Samushia, Lado	Strider, Louis Gregory	Winthorst, Roger A
Burrows, Adam Seth	Ferguson, Henry C	Henderson, Calen B	Kessler, Richard	Martone, Dan	Poleski, Radick	Sand, David	Stubbs, Christopher	Wohl, Isak G
Cahoy, Keri	Flippenko, Abbei	Hinz, Philip	Kessing, Alina	Marin, Nodas	Pontoppidan, Klaus	Sanderson, Robyn E	Suntzeff, Nicholas	Wood-Vasey, Michael
Catti, Nivali, Sebastiano	Finkelstein, Steven L	Hirata, Christopher	Kim, Alex	McComachie, Alan	Postman, Marc	Sandstrom, Karin M	Szalay, Alexander	Woolley, Stan
Capak, Peter	Foley, Ryan J	Ho, Shiley	Kishner, Robert	McElwain, Michael	Pike-Whelan, Adrien	Savransky, Dmitry	Takada, Masahito	Yee, Jennifer C
Carey, Sean Joseph	Foreman-Mackey, Daniel	Hounsell, Rebekah	Krause, Elisabeth	McGlynn, Thomas	Pueyo, Laurent	Schirh, Dan	Teplitz, Hany	Yoshida, Naoki
Chen, Jie	Fotney, Jonathan J	Howard, Andrew	Larg, Dush	Meikner, Margaret	Rabinowitz, David	Sellert, Michael	Thacker, Anuradha R	Zackrisson, Erik

Recent Accomplishments

- Key Decision Point A (KDP-A) completed – February 17, 2016.
- Mission Concept Review (MCR) successfully completed in December.
- WFIRST technology (Coronagraph and IR detectors) continue to make excellent progress. All HQ milestones successfully completed.
 - A HQ chartered Technology Assessment Committee (TAC) provides for external review of technology milestones for coronagraph and IR detectors.
- President's Budget Request for FY17 has 90M from SMD and 10M from STMD. Recent augmented funding (FY14-16, 203M) has enabled significant mission progress.
 - Technology maturation.
 - Increased fidelity in the design reference.
- An industry Request For Information (RFI) was issued in July 2015 for potential participation in WFIRST. Inputs received and management briefed on results.
- Wide Field concept study RFP released January 4th. Recently awarded concept studies for the Wide Field Optical Mechanical Assembly (WOMA) to Ball and Lockheed.
- WFIRST Formulation Science Working Group and Science Investigation Teams selection made December 17, 2015. WFIRST Formulation Science Working Group (FSWG) kick-off with Project held February 2-4, 2016.

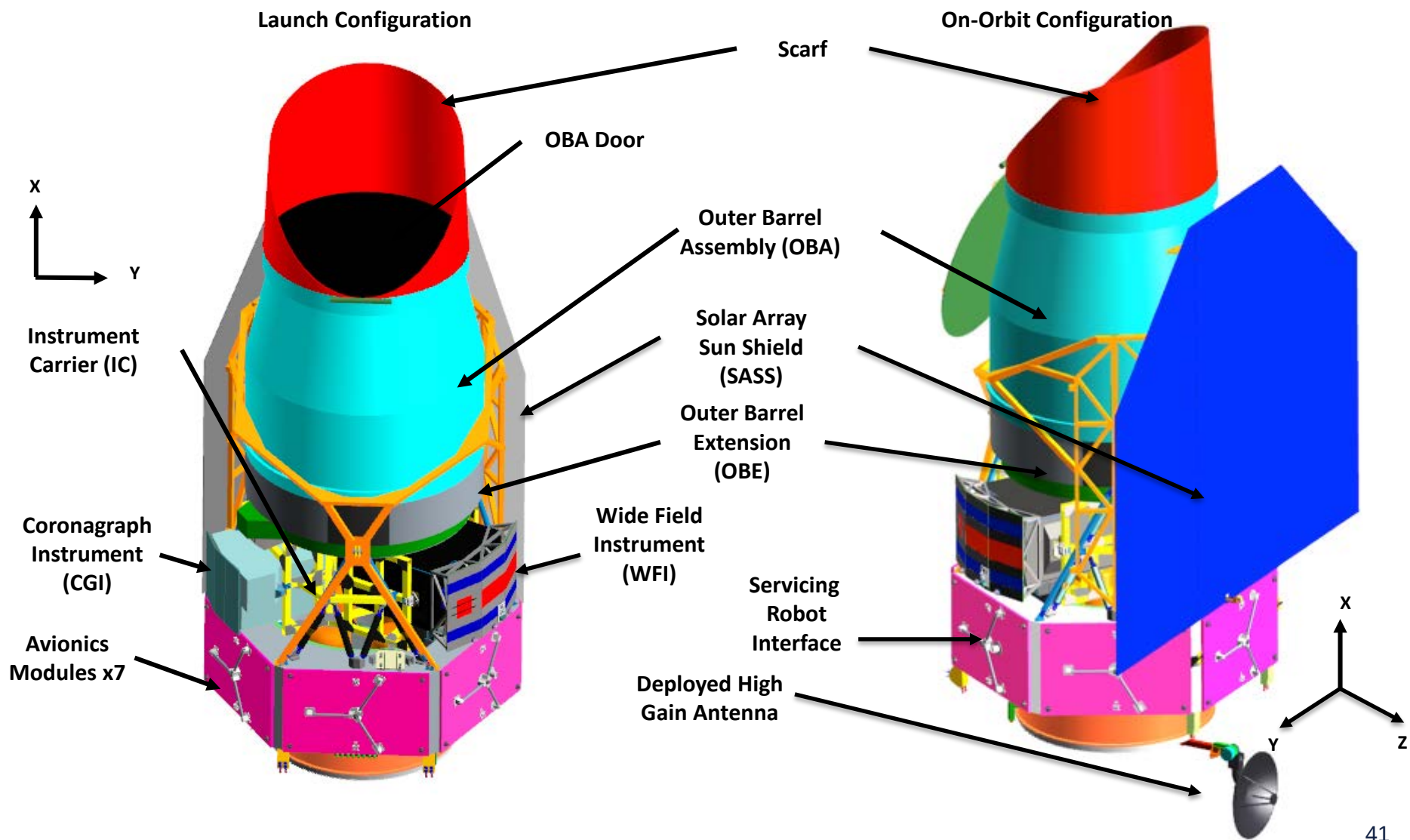
- New Worlds New Horizons (NWNH) Science Objectives
 - Produce multi-band NIR sky survey: expansion history, growth of structure, planetary systems statistical census and robust Guest Observer program
- Mature exoplanet direct imaging technologies – demonstrate new internal starlight suppression techniques
 - Image and characterize giant planets and debris disks
- WFIRST is Category 1 project – Agency Program Management Council (APMC)
- Utilization of existing 2.4m aperture telescope.
- Two instruments: Wide Field and Coronagraph instruments.
- WFIRST designated Class B mission (NPR 8705.4); Coronagraph technology demonstration is designated as Class C.
- L2 orbit (current baseline) launched from Eastern Test Range (ETR).
- 6 ¼ year mission life.
- Modular spacecraft and instrument design to facilitate robotic servicing.
- Potential international partner contributions are under discussion.
- WFIRST part of Exoplanet Exploration Program (ExEP).



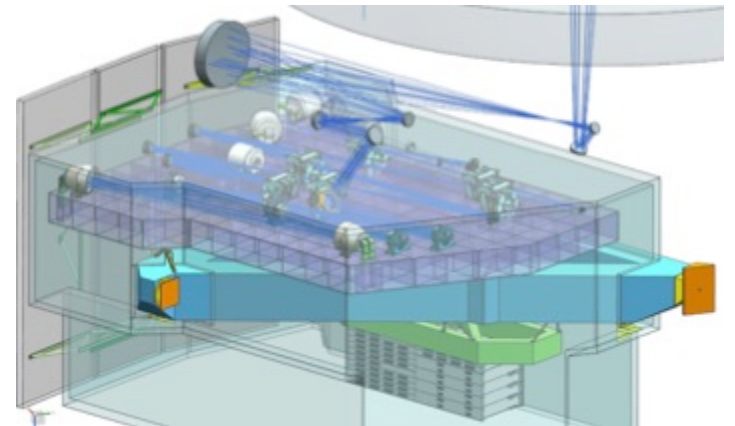
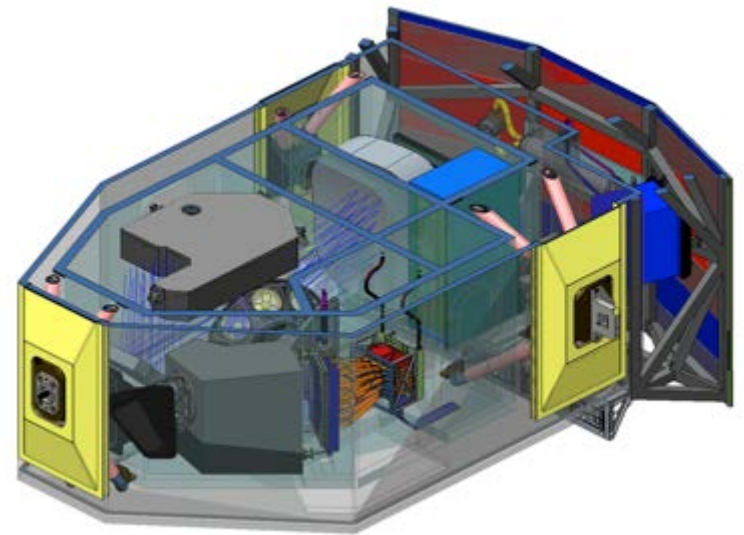
WFIRST

WIDE-FIELD INFRARED SURVEY TELESCOPE
DARK ENERGY • EXOPLANETS • ASTROPHYSICS

Observatory Configuration

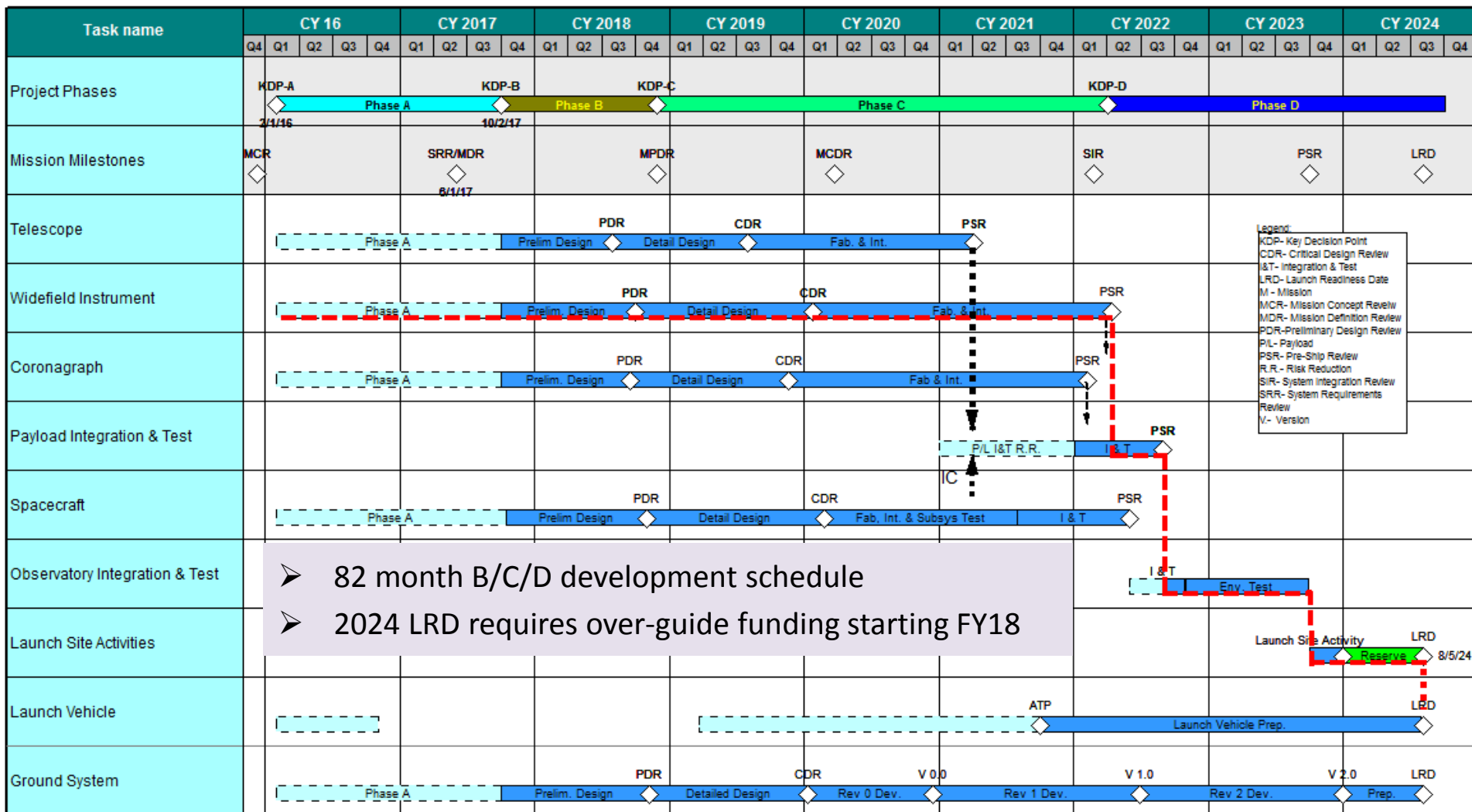


- Wide Field Instrument (WFI) - GSFC
 - Provides wide field imaging and spectroscopy in support of the dark energy surveys and the microlensing survey.
 - Provides integral field spectroscopy in support of the supernova survey and weak lensing photometric redshift calibrations.
 - Provides guide star data for observatory fine pointing.
- Coronagraph Instrument (CGI) - JPL
 - Provides high contrast imaging and integral field spectroscopy in support of exoplanet and debris disk science.



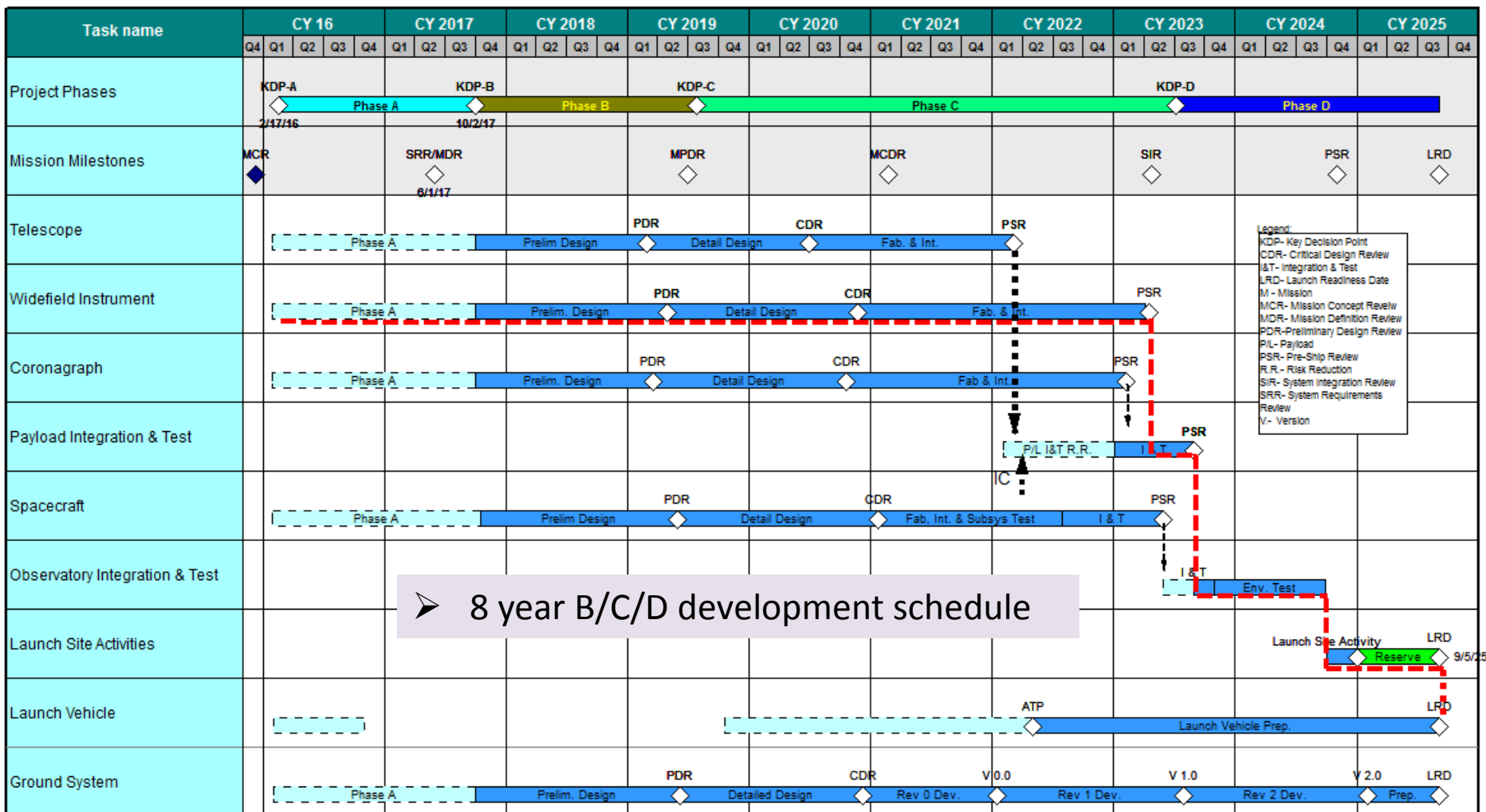
Mission Schedule – 2024 LRD

Overguide Schedule



Mission Schedule – 2025 LRD

In-Guide Schedule



WFIRST KDP-A Budget Estimates

- WFIRST mission life-cycle cost was updated for MCR design configuration and the Key Decision Point A (KDP-A) milestone.
- The current WFIRST budget guidelines are constrained in FY18-20. As a result, the Project is working two development schedule profiles – an overguide 2024 launch date and an in-guide 2025 launch date.
- Mission cost was updated for the following:
 - increased launch vehicle costs,
 - increased science team funding (including number of teams selected),
 - design maturation (L2 changes & maturing design),
 - extended Phase A (KDP-A accelerated),
 - telescope outer barrel assembly configuration changes and
 - funding for Wide Field industry studies.
- The Project's life-cycle estimate over the range of launch vehicles and launch dates is 2.3–2.7B in FY15\$. That equates to 2.7B to 3.2B in RY\$.
- Budget includes STMD funding in FY16/17 for the coronagraph technology. STMD is considering funding portion of coronagraph flight development.
- International contributions – discussions in process for potential contributions from Europe/ESA, Canada and Japan. Contributions include elements of Wide Field instrument, Coronagraph and ground system.

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."

FY17 Budget Request



	Astrophysics	JWST	STEM	Astrophysics including JWST excluding STEM	Astrophysics including JWST including STEM
FY16 appropriation	\$731M excluding STEM	\$620M	\$37M	\$1351M	\$1388M
FY17 notional runout of FY16 request	\$727M including STEM	\$569M	\$20M	\$1276M	\$1296M
FY17 request	\$782M including STEM	\$569M	\$25M	\$1326M	\$1351M

FY17 Budget Request

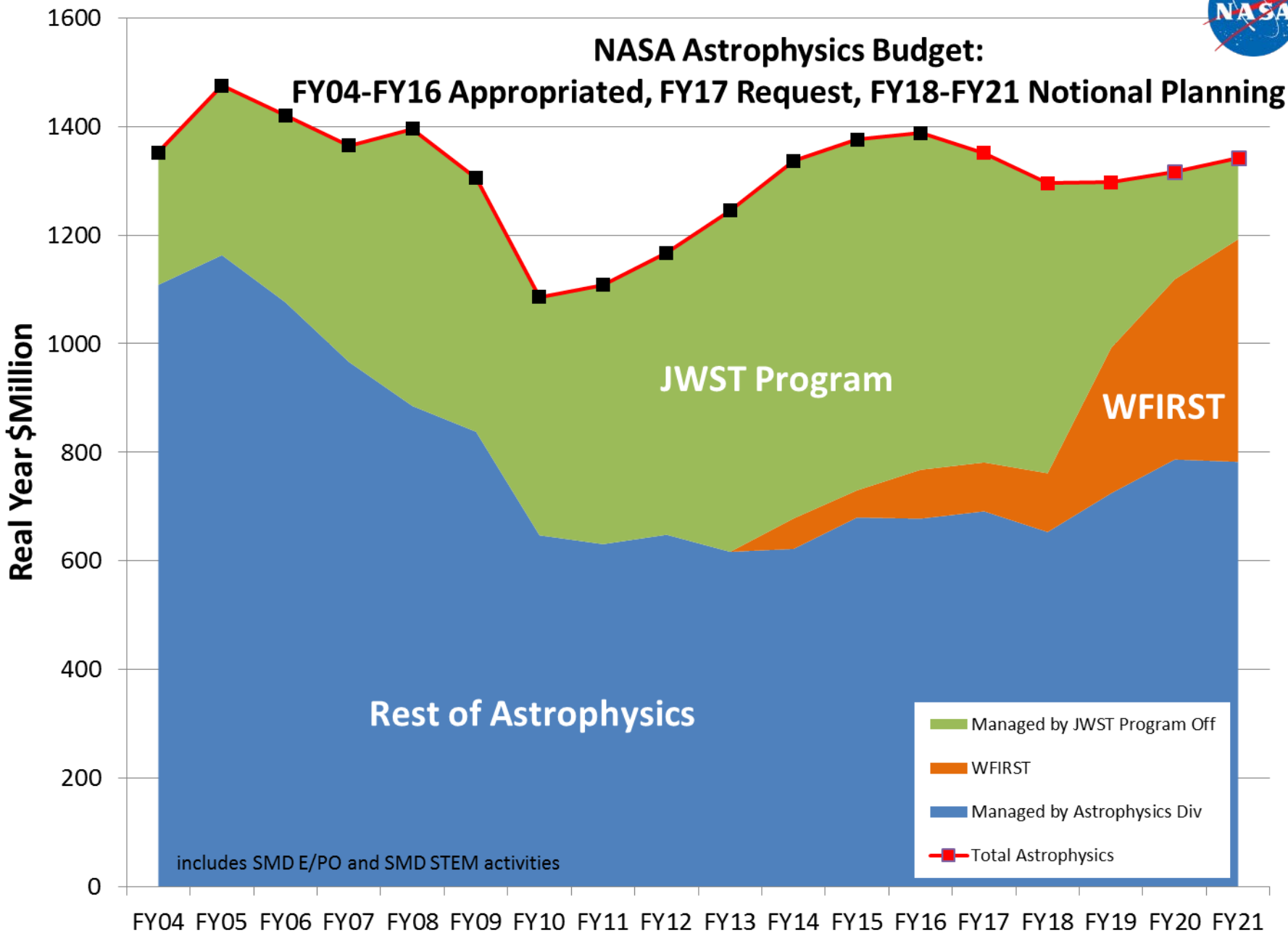


Outyears are notional planning from FY17 budget request

(\$M)	2015	2016	2017	2018	2019	2020	2021
Astrophysics*	\$685	\$731	\$757	\$737	\$967	\$1094	\$1168
JWST	\$645	\$620	\$569	\$534	\$305	\$197	\$150
Total*	\$1330	\$1351	\$1326	\$1271	\$1272	\$1291	\$1318

* Excludes "SMD STEM Activities" in all years.

- This budget request is an excellent budget request for NASA Astrophysics (\$1,326M excluding STEM).
- It compares well with the FY16 Appropriation (\$1,351M excluding STEM) and significantly exceeds the FY17 notional runout in the President's FY16 request for NASA Astrophysics including JWST (\$1,276M excluding STEM).
- This budget request and the notional runout allows WFIRST to be executed without additional funding.
- This budget request and the notional runout support other Decadal Survey priorities.
 - Continued Explorer AOs at the cadence of 4 per decade.
 - Partnerships on ESA's Athena X-ray observatory and L3 gravitational wave observatory.
 - Precursor exoplanet science and technology including Large Binocular Telescope Interferometer, Extreme Precision Doppler Spectrometer, and WFIRST Coronagraph.
 - Retains prior growth in R&A and suborbital programs.
- Senior Review funding may be inadequate to continue all currently operating missions.
 - FY16 budget for Six Senior Review missions is \$62M. FY17 Senior Review budget is \$37M.





CY16 and FY17 Planned Accomplishments

- JAXA's **Hitomi** (nee ASTRO-H) mission launched (KDP-E) on February 17, 2016.
- **WFIRST** entered formulation (KDP-A) on February 17, 2016.
- The main panel of the **Astrophysics Senior Review** was held February 2016. The **Fermi Gamma-ray Space Telescope, Kepler/K2, Nuclear Spectroscopic Telescope Array (NuSTAR), Spitzer Space Telescope, Swift Explorer, and XMM-Newton** were reviewed.
- The **Astrophysics Senior Review** for the **Hubble Space Telescope** and **Chandra X-ray Observatory** was held in March 2016.
- NASA's **ST7/DRS** experiment on ESA's LPF will begin science operation in June 2016.
- **NICER** will be delivered to Kennedy Space Center by July 2016 and launched to the International Space Station (KDP-E) on CRS SpaceX-11 in FY17.
- Commissioning flights for the second-generation High-resolution Airborne Wideband Camera (HAWC+) instrument will be completed aboard **SOFIA** by August 2016.
- An Announcement of Opportunity (AO) for the next **Astrophysics Medium-Class Explorer (MIDEX)** and **Mission of Opportunity** will be released in FY16 [NET September 2016].
- The payload for **TESS** will be integrated and tested (KDP-D) by September 2016.
- The Step 2 downselect will be made for the next **Astrophysics Small Explorer (SMEX)** and **Explorer Mission of Opportunity** in FY17 [NET December 2016].
- The **ISS-CREAM** experiment will be launched to the International Space Station (KDP-E) on CRS SpaceX-12 in FY17.
- A critical design review for **SOFIA's** third-generation instrument will be conducted in FY17.
- Spacecraft integration and testing will be completed for **TESS** in FY17.
- **WFIRST** will have its System Requirements Review (KDP-B) in FY17.
- Four **Balloon** campaigns are planned in FY16, and four campaigns are planned in FY17.
- Four Astrophysics **Sounding Rocket** payloads have been successfully launched in FY16, and at least two are planned in FY17.



- Formulation
- Implementation
- Primary Ops
- Extended Ops

Spitzer
8/25/2003

Kepler
3/7/2009

WFIRST
Mid 2020s

LISA Pathfinder (ESA)
12/3/2015

JWST
2018

Euclid (ESA)
2020

Chandra
7/23/1999

XMM-Newton (ESA)
12/10/1999

TESS
2017

NuSTAR
6/13/2012

Swift
11/20/2004

Hitomi (JAXA)
2/17/2016

Fermi
6/11/2008

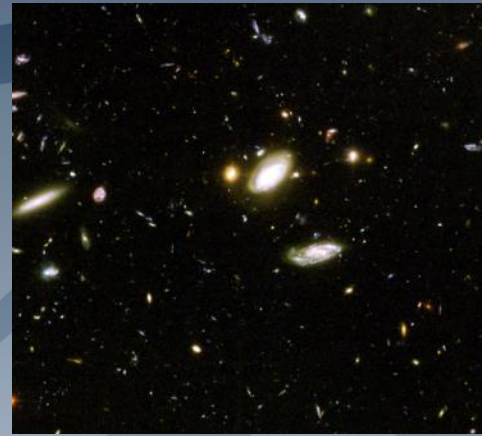
Hubble
4/24/1990

CREAM (on ISS)
2017

NICER (on ISS)
2017

SOFIA
Full Ops 5/2014

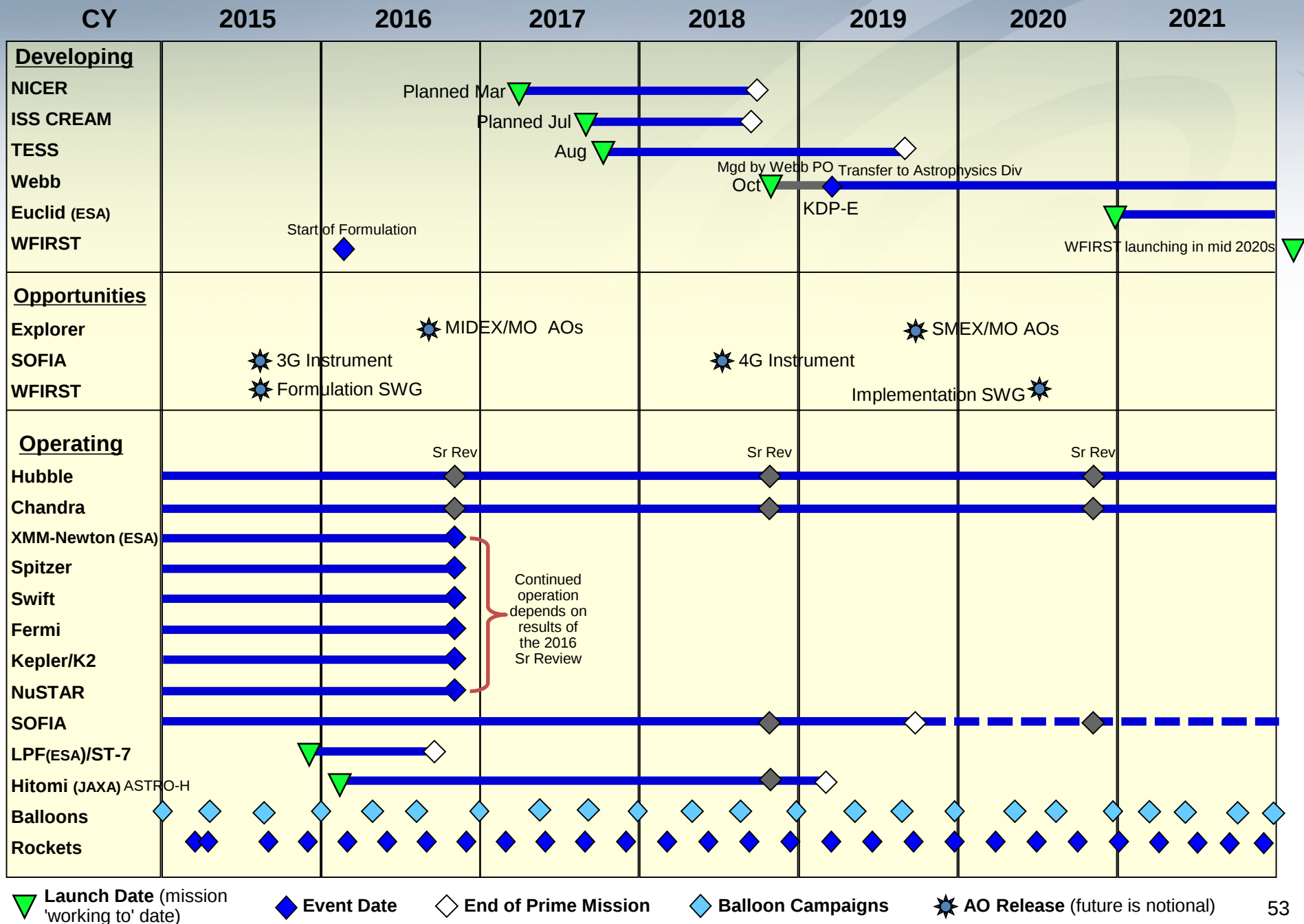
Astrophysics



BACKUP

Astrophysics Science Mission Events

Last updated: February 22, 2016





Astrophysics Program Content

	Actual <u>FY 2015</u>	Enacted <u>FY 2016</u>	Request <u>FY 2017</u>	Notional			
				<u>FY 2018</u>	<u>FY 2019</u>	<u>FY 2020</u>	<u>FY 2021</u>
Astrophysics	730.7		781.5	761.6	992.4	1,118.6	1,192.5
<u>Astrophysics Research</u>	<u>201.7</u>		<u>226.1</u>	<u>236.3</u>	<u>235.7</u>	<u>248.5</u>	<u>252.0</u>
Science Education	42.0		25.0	25.0	25.0	25.0	25.0
Astrophysics Research and Analysis	71.1		72.7	73.0	73.0	73.0	73.0
Balloon Project	38.0		37.0	37.3	37.4	38.9	40.4
<u>Other Missions and Data Analysis</u>	<u>50.6</u>		<u>91.4</u>	<u>101.0</u>	<u>100.3</u>	<u>111.6</u>	<u>113.6</u>
Astrophysics Data Curation and Archival	18.6		17.8	18.8	18.9	18.9	18.9
Astrophysics Data Program	17.0		17.6	17.6	17.6	17.6	17.6
Astrophysics Senior Review	-		37.4	49.3	40.5	33.6	34.0
Contract Administration, Audit & QA Svcs	15.0		14.9	15.0	15.0	15.1	15.1
Astrophysics Directed R&T	-		3.7	0.2	8.4	26.4	28.1
<u>Cosmic Origins</u>	<u>201.0</u>		<u>198.5</u>	<u>198.4</u>	<u>197.3</u>	<u>195.5</u>	<u>209.5</u>
Hubble Space Telescope (HST)	98.6		97.3	98.3	98.3	98.3	98.3
Stratospheric Observatory for Infrared Astronon	70.0		83.8	84.8	84.8	84.8	84.8
<u>Other Missions and Data Analysis</u>	<u>32.4</u>		<u>17.4</u>	<u>15.3</u>	<u>14.2</u>	<u>12.4</u>	<u>26.4</u>
Cosmic Origins Future Missions	1.2		1.1	1.5	1.5	1.5	1.5
Spitzer	14.6		3.5	-	-	-	-
Herschel	5.1		1.0	-	-	-	-
Cosmic Origins SR&T	8.8		9.3	10.9	9.8	8.0	22.0
Cosmic Origins Program Management	2.6		2.5	2.9	2.9	2.9	2.9

Astrophysics Program Content (cont'd)



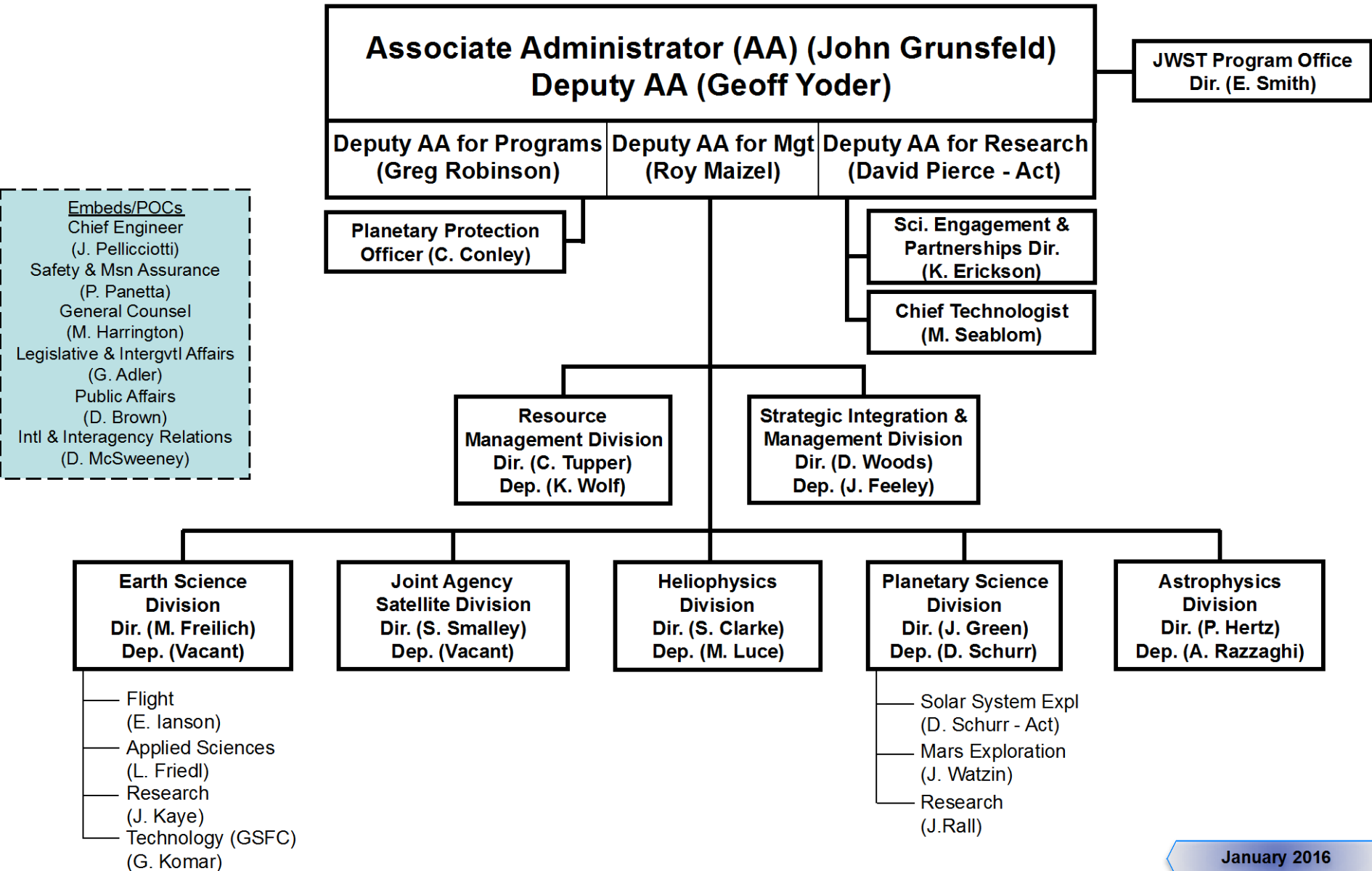
	<u>Actual</u> <u>FY 2015</u>	<u>Enacted</u> <u>FY 2016</u>	<u>Request</u> <u>FY 2017</u>	<u>Notional</u>			
				<u>FY 2018</u>	<u>FY 2019</u>	<u>FY 2020</u>	<u>FY 2021</u>
<u>Physics of the Cosmos</u>	<u>104.1</u>		<u>94.1</u>	<u>88.0</u>	<u>94.1</u>	<u>97.7</u>	<u>94.0</u>
Physics of the Cosmos Future Missions	0.1		0.5	2.1	2.1	2.5	2.5
Euclid	7.5		12.9	7.5	7.7	9.9	6.1
Chandra X-Ray Observatory	55.6		52.4	56.7	57.4	58.4	58.4
Fermi Gamma-ray Space Telescope	16.9		-	-	-	-	-
XMM	2.9		-	-	-	-	-
Planck	6.0		-	-	-	-	-
Physics of the Cosmos SR&T	12.0		25.4	18.5	23.7	23.8	23.9
Physics of the Cosmos Program Management	3.0		2.9	3.2	3.2	3.2	3.2
<u>Exoplanet Exploration</u>	<u>100.6</u>		<u>133.8</u>	<u>148.0</u>	<u>309.3</u>	<u>373.3</u>	<u>450.8</u>
Decadal Strategic Mission (WFIRST)	50.0		90.0	108.2	267.7	331.8	409.9
Exoplanet Exploration Future Missions	0.9		0.5	1.1	8.2	8.3	8.3
Kepler	17.2		2.8	-	-	-	-
Keck Operations	6.0		6.1	6.2	-	-	-
Large Binocular Telescope Interferometer	2.0		1.3	-	-	-	-
Exoplanet Exploration SR&T	19.4		28.0	26.5	27.6	26.9	26.2
Exoplanet Exploration Program Management	5.1		5.1	6.0	5.9	6.3	6.4

Astrophysics Program Content (cont'd)



	Actual	Enacted	Request	Notional			
	<u>FY 2015</u>	<u>FY 2016</u>	<u>FY 2017</u>	<u>FY 2018</u>	<u>FY 2019</u>	<u>FY 2020</u>	<u>FY 2021</u>
<u>Astrophysics Explorer</u>	<u>123.3</u>		<u>129.0</u>	<u>91.0</u>	<u>156.0</u>	<u>203.5</u>	<u>186.2</u>
Transiting Exoplanet Survey Satellite (TESS)	80.1	73.5	87.0	27.9	9.1	2.5	0.0
<u>Other Missions and Data Analysis</u>	<u>43.2</u>		<u>42.0</u>	<u>63.1</u>	<u>146.9</u>	<u>201.1</u>	<u>186.2</u>
Astrophysics Explorer Future Missions	1.1		16.8	42.7	132.2	192.6	178.5
ASTRO-H (SXS)	11.3		12.0	11.4	9.5	-	-
NICER	11.7		3.5	1.3	-	-	-
Nuclear Spectroscopic Telescope Array	7.4		-	-	-	-	-
Swift	4.9		-	-	-	-	-
Suzaku (ASTRO-E II)	0.6		-	-	-	-	-
Astrophysics Explorer Program Management	6.2		9.8	7.7	5.1	8.5	7.7
James Webb Space Telescope	645.4	620.0	569.4	533.7	304.6	197.2	149.8
Astrophysics + Webb Total	1,376.1		1,350.9	1,295.3	1,297.0	1,315.8	1,342.3

SMD Organization Chart



Astrophysics Division, NASA Science Mission Directorate

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*

Education POC: Hashima Hasan (Lead Comm Team)

Public Affairs POC: Kartik Sheth

Information Manager: Lisa Wainio*

Astrophysics Research

Program Manager: Linda Sparke

Program Support: Pam Terrell*

Astrophysics Data Analysis: Doug Hudgins

Astrophysics Theory: Keith MacGregor*

Exoplanet Research: Martin Still*

APRA lead: Michael Garcia*

Cosmic Ray, Fund Physics: Thomas Hams*, Vernon Jones,
Keith MacGregor*, Rita Sambruna

Gamma Ray/X-ray: Dan Evans, 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,
Kartik Sheth, Erin Smith*

Lab Astro: Doug Hudgins

Theory & Comp Astro Net: Keith MacGregor*

Roman Tech Fellows: Billy Lightsey*

Data Archives: Hashima Hasan

Astrophys Sounding Rockets: Wilt Sanders

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

Programs / Missions & Projects

Program Scientist

Program Executive

Exoplanet Exploration (EXEP)

Program

Keck

Kepler/K2

LBTI

NExSci

NN-EXPLORE

WFIRST

Doug Hudgins

Hashima Hasan

Mario Perez*

Hashima Hasan

Hashima Hasan

Doug Hudgins

Dominic Benford*

John Gagosian

Mario Perez*

K. Chamberlin*/Jeff Hayes

Mario Perez*

Mario Perez*

John Gagosian

John Gagosian

Cosmic Origins (COR)

Program

Herschel

Hubble

JWST

SOFIA

Spitzer

Mario Perez*

Dominic Benford*

Michael Garcia*

Hashima Hasan

Hashima Hasan

Erin Smith*

Shahid Habib*

Jeff Hayes

Jeff Hayes

Ray Taylor^

Shahid Habib*

Jeff Hayes

Physics of the Cosmos (PCOS)

Program

Athena

Chandra

Euclid

Fermi

Planck

ST-7/LPF

XMM-Newton

Rita Sambruna

Michael Garcia*

Stefan Immler*

Linda Sparke

Keith MacGregor*

Rita Sambruna

Rita Sambruna

Stefan Immler*

Shahid Habib*

Jeanne Davis

Jeff Hayes

Keith Chamberlin*

Jeff Hayes

Jeff Hayes

Keith Chamberlin*

Jeff Hayes

Astrophysics Explorers (APEX)

Program

ASTRO-H

NICER

NuSTAR

Suzaku

Swift

TESS

Wilt Sanders

Lou Kaluzienski

Rita Sambruna

Lou Kaluzienski

Stefan Immler*

Martin Still*

Doug Hudgins

Jeanne Davis

Jeanne Davis

Jeanne Davis

Jeff Hayes

Jeff Hayes

Jeff Hayes

Mark Sistilli

+ Member of the Resources Mgmt Division

* Detailee, IPA, or contractor

^ JWST is part of the JWST Program Office.

March 14, 2016