National Aeronautics and Space Administration

Astrophysics




NASA Update

Astronomy and Astrophysics Advisory Committee
Telecon Meeting
June 6, 2016

Paul Hertz
Director, Astrophysics Division
Science Mission Directorate
@PHertzNASA

SMD Leadership Change

- John Grunsfeld has retired from NASA as of May 31.
- Geoffrey Yoder, previously the Deputy Associate Administrator for SMD, is now the Acting Associate Administrator for SMD.

- Mr. Yoder has spent 16 years in industry and 16 years at NASA, and his prior assignments include Deputy Director for Astrophysics, Acting Director for Astrophysics, JWST Program Director, SMD Deputy AA for Programs, and SMD Deputy AA.
- Mr. Yoder's priorities for SMD are
  - Continuing to advance the SMD missions in formulation, development, and operations.
  - Integrating strategic planning across all Divisions to further advance NASA objectives and Decadal Surveys.
  - Making NASA's technical and capability management more efficient to free up resources for missions and science.
  - Firmly basing NASA's decisions on community input and peer review.

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.
  - Allows all currently operating missions to continue, following 2016 Senior Review.
  - 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 recommended continued operation.
  - SOFIA is in 5-year prime operations as of May 2014; HAWC+ 2nd generation instrument commissioning in Spring 2016; 3rd generation instrument studies underway.
  - ESA's LISA Pathfinder successfully launched on December 3, 2015; performing well.
  - JAXA's Hitomi (née ASTRO-H) launched on February 17, 2016; communication was lost with spacecraft on March 26, 2016, and JAXA has ceased recovery efforts.
  - 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 (2028) and ESA's L3 gravitational wave obs (2034).
- **Progress being made toward recommendations of the 2010 Decadal Survey.**
  - NRC Mid Decade Review (with NSF, DOE) underway; report expected in Jun/Jul 2016.
  - NASA initiating large and medium mission concept studies as input for 2020 Decadal Survey.

Status of AAAC Recommendations

RECOMMENDATION: *Where it can improve overall science productivity and efficiency, cooperation in database design and data sharing is encouraged among US agencies, international agencies, and scientific collaborations.*

- Response: Concur. (i) The DOE/NSF/NASA Three Agency Group (TAG) is discussing this issue specifically for LSST/Euclid/WFIRST data. (ii) The NASA Advisory Council's Big Data Task Force is working this issue more broadly.

  http://science.nasa.gov/science-committee/subcommittees/big-data-task-force/

RECOMMENDATION: *We encourage DOE, NSF, and the university community to continue working toward a plan for a future (Stage 4) ground-based CMB experiment.*

- No NASA response required.

RECOMMENDATION: *Strong efforts by NSF for facility divestment should continue as fast as practical. …*

- No NASA response required.

RECOMMENDATION: *The AAAC encourages NASA to continue working toward a plan to develop a space-based gravitational wave observatory as envisioned by NWNH, through participation in the ESA L3 gravitational wave effort.*

- Response: Concur. NASA has informed ESA of its intent to partner on L3, and discussions on NASA's role are ongoing. (i) NASA has participated fully in ESA's Gravitational Observatory Advisory Team (GOAT). (ii) NASA has established an L3 Study Team to analyze potential NASA contributions to ESA for L3. (iii) NASA is funding L3-relevant technology development through its Strategic Astrophysics Technology (SAT) program.

  http://www.cosmos.esa.int/web/goat/

  http://pcos.gsfc.nasa.gov/studies/L3/

Status of AAAC Recommendations

RECOMMENDATION: *The agencies should continue to pursue international partnerships in order to further accomplish the goals of NWNH. The AAAC's "Principles for Access to Large Federally Funded Astrophysics Projects and Facilities" should guide the process.*

- Response: Concur. All of NASA's current and prospective international partnerships are responsive to the "Principles for Access to Large Federally Funded Astrophysics Projects and Facilities."

RECOMMENDATION: *We urge that the full programmatic funding required by the three agencies to execute their FY 2017 plans, as described in their budget requests, be provided.*

- See discussion of NASA's FY17 budget in later charts,

RECOMMENDATION: *Community based groups, such as the AAS and the APS, should study the recent and projected growth of the leading US astronomy and astrophysics research community for the next decadal survey planning exercise of the end of the decade.*

- No NASA response required.

NASA Astrophysics

Program Update

Hitomi

(formerly ASTRO-H)

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

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

CURRENT STATUS

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

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

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

UPCOMING EVENTS:

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

Hitomi (formerly ASTRO-H) Anomaly

JAXA Hitomi Experience Report (May 24, 2016)

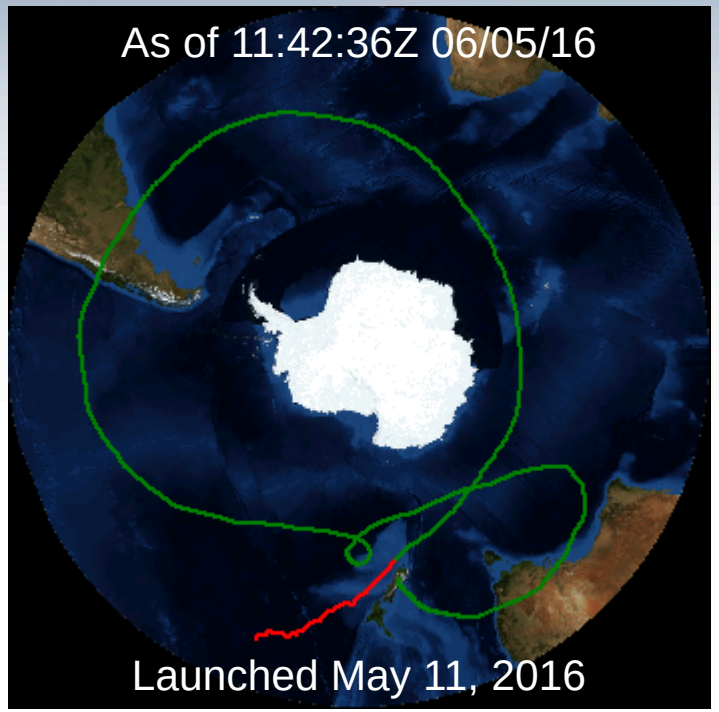
Presumed Mechanism (Summary)

(From “Normal situation” to the “Attitude anomaly Event”, and “Objects separation”)

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

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

2016 New Zealand SPB Campaign



Compton Spectrometer and Imager (COSI)

PI: Steven Boggs, UC Berkeley

http://www.nsbf.nasa.gov/

http://www.csbf.nasa.gov/newzealand/wanaka.htm

Astrophysics Missions in Development

NICER
2/2017

NASA Mission

Neutron Star Interior Composition Explorer

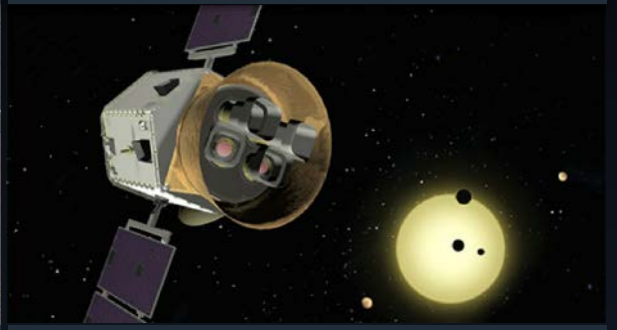
CREAM
6/2017

NASA Mission

Cosmic Ray Energetics And Mass

TESS
12/2017

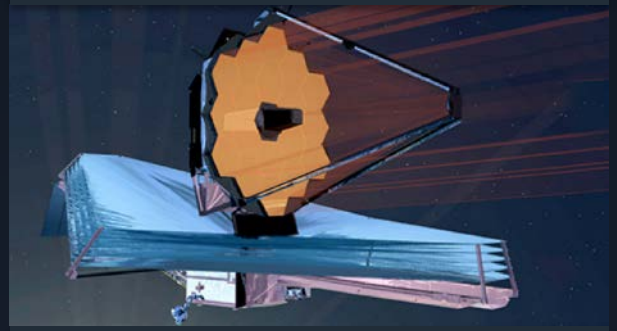
NASA Mission



Transiting Exoplanet Survey Satellite

Webb
10/2018

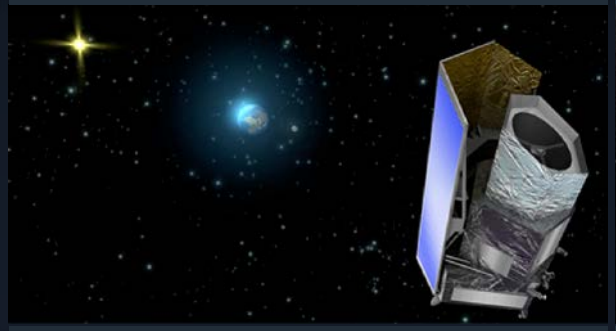
NASA Mission



James Webb Space Telescope

Euclid
2020

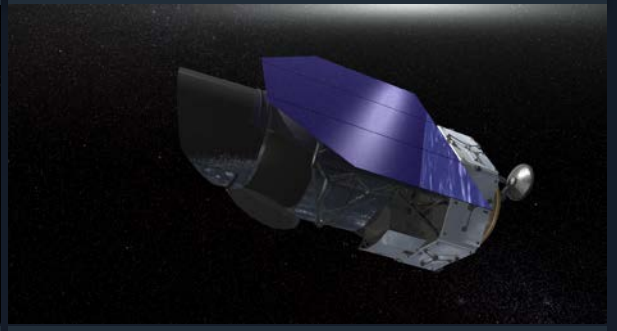
ESA-led Mission



NASA is supplying the NISP Sensor Chip System (SCS)

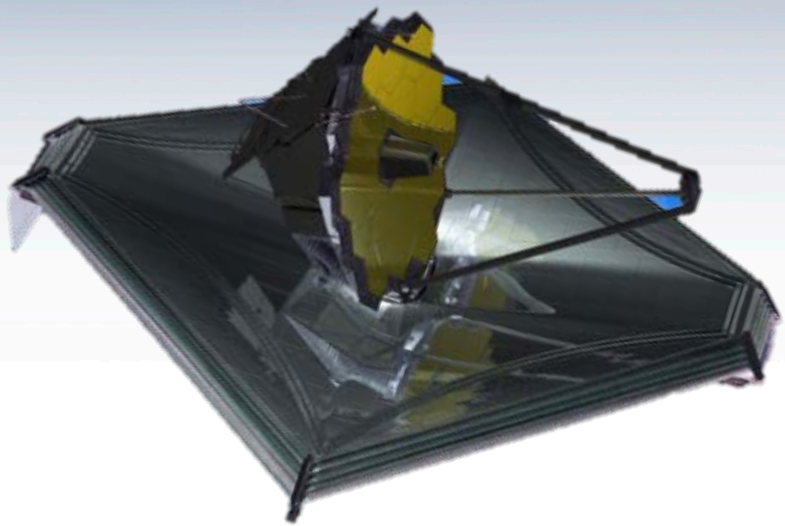
WFIRST
Mid 2020s

NASA Mission



Wide-Field Infrared Survey Telescope

Webb
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

2015-2016 Accomplishments

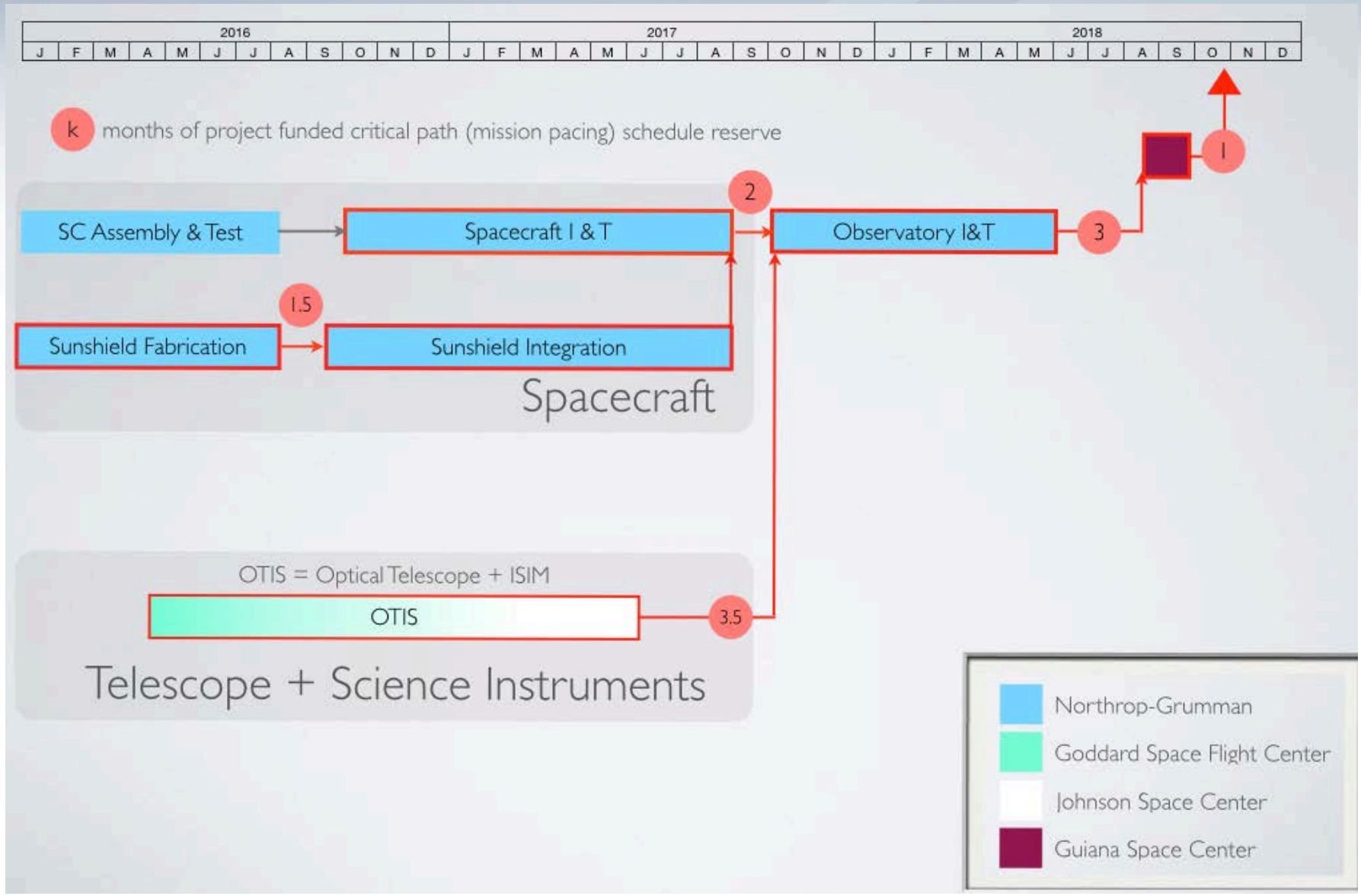
- Telescope mirrors installed ✓
- Science instruments integrated with Telescope ✓
- MIRI cryocooler completed ✓
- Spacecraft bus powered on for first time ✓
- Completed 2nd test of Pathfinder Telescope and ground support equipment at JSC in support of 2017 test of flight hardware ✓

2016 Plans

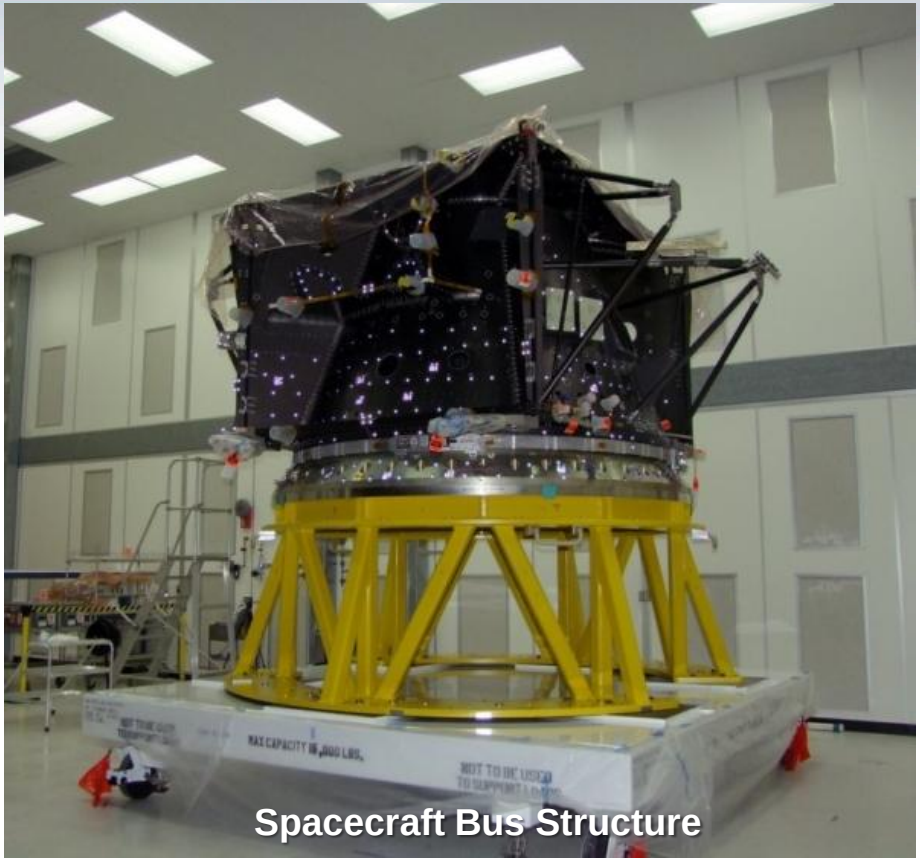
- Complete ambient testing of combined Telescope and instruments
- Complete spacecraft bus
- Complete sunshield membrane fabrication
- Cryovacuum testing of combined Telescope and instruments at JSC
- Integrate Sunshield and Spacecraft

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

Webb Top Level Schedule



JWST Spacecraft


Spacecraft Bus Structure

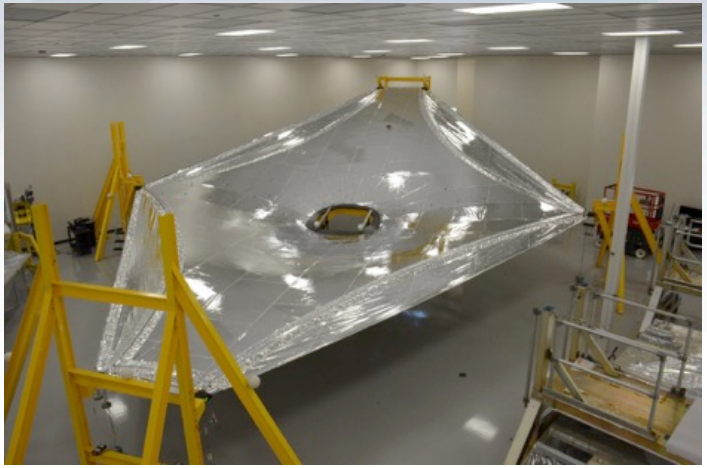
Powered-On Configuration on the –J2 Panel

Spacecraft Bus making good progress at Northrop-Grumman.
Currently in propulsion system integration stage

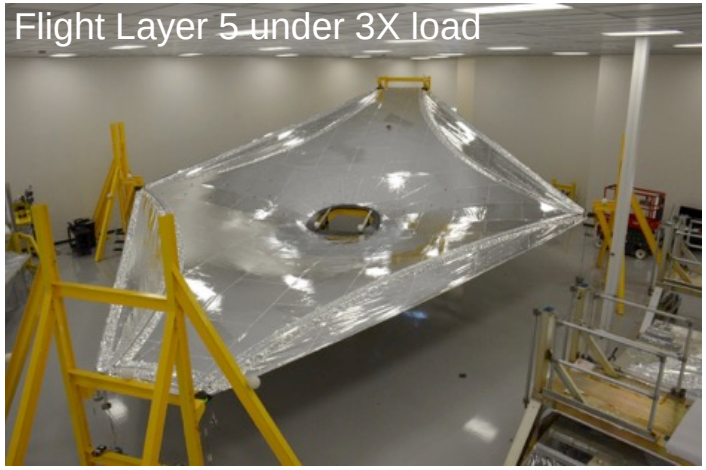
Webb Sunshield

Manufacturing Activity	L3	L4	L5	L2	L1
Cut Gores & Coating removal	✓	✓	✓	✓	✓
Rip stops	✓	✓	✓	✓	✓
Sub-assembly TSB seaming	✓	✓	✓	✓	✓
Assembly TSB seaming	✓	✓	✓	✓	✓
ACS off-nominal Bonding	✓	✓	✓	N/A	N/A
Bonding & Assembly	✓	✓	✓	✓	In-process
Initial Shape Test (IST)	✓	✓	✓	✓	N/A
Hole Tool (-J2 side)	✓	✓	✓	✓	
Hole Tool (+J2 side)	✓	✓	✓	✓	
Vent Holes	✓	✓	✓		
Grounding	✓	✓	In-process		
MDMS	✓	✓	In-process		
Acceptance Shape Test (AST)	✓	✓			
Epaulets & Closeout	✓	✓			
Verification	✓	✓			
Package & Ship	✓	✓			

Flight Layer 2 Membrane



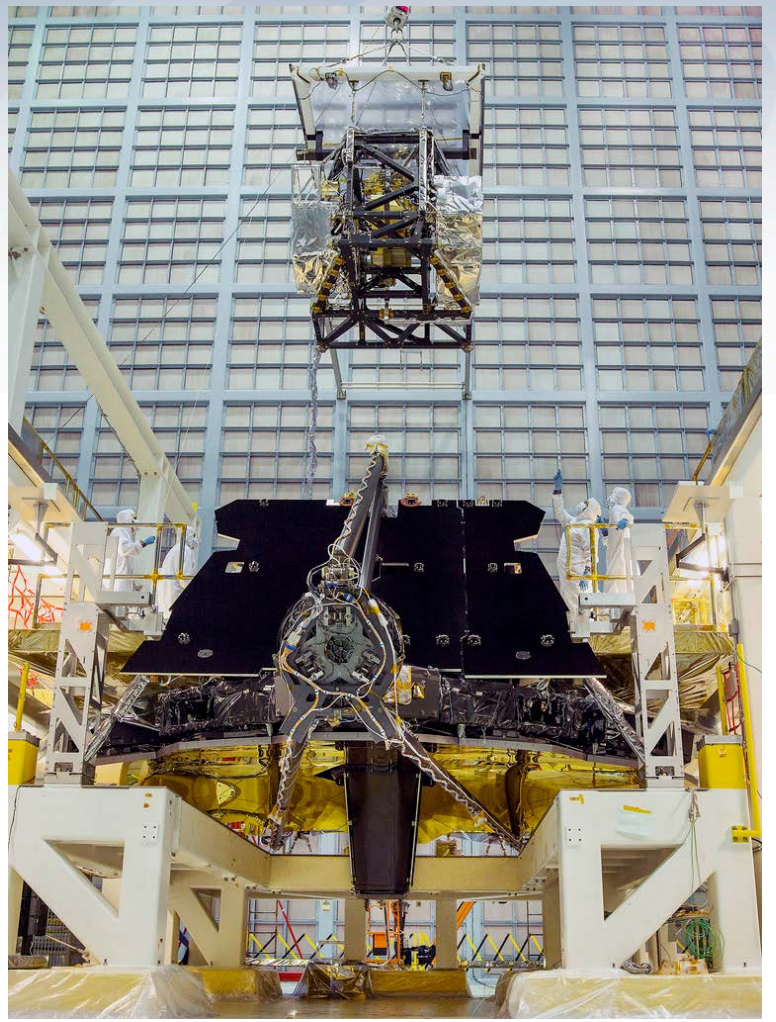
Flight Layer 5 under 3X load



Flight Layer 1 Membrane

Webb Telescope & Instruments

Primary Mirror on a turnover fixture at GSFC

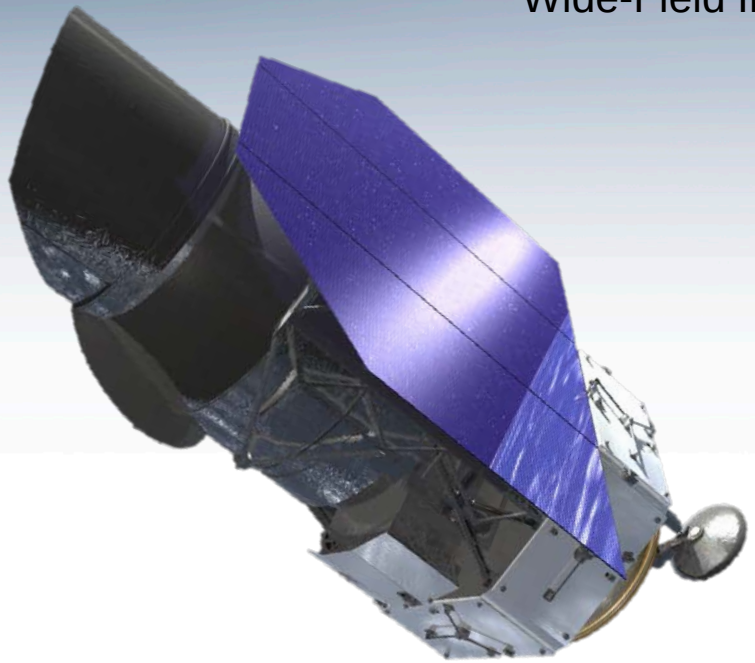


Science Instruments being installed into Telescope Backplane Support Fixture

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

WFIRST

Wide-Field Infrared Survey Telescope



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 0.8-2μm

Instruments (design reference mission): Wide Field Instrument (camera plus IFU), Coronagraph Instrument (imaging/IFS)

Phase: Currently in Formulation (Phase A)

CURRENT STATUS:

- Completed Mission Concept Review (MCR) held in December 2015
- Formulation Science Investigation Teams selected in December 2015; first meeting held February 2016.
- Ball and Lockheed Martin selected in February 2016 to support Wide-field Instrument Concept Studies
- Passed Key Decision Point A (KDP-A) in Feb 2016
  - Official start of formulation phase
  - Successful KDP-A held February 17, 2016
  - Established management agreement for total mission cost to govern formulation trades
  - Next major milestone is acquisition strategy meeting (ASM) in July 2016
- On track for TRL-6 of new technologies in 2017
- Working toward System Requirements Review (SRR) in June 2017 and KDP-B in October 2017
- FY17 budget request matches FY16 appropriation of $90M. In-guide budget supports launch in mid-2020s.

WFIRST has begun Formulation

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

NASA Astrophysics

Budget Update

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 Astrophysics*	$493	$457	-$36 (-7%)
Total	$1309	$1351	+$42

* Excludes "SMD STEM Activities."

FY16 Appropriation & NASA Operations Plan

- Addressing the $36M reduction across the rest of Astrophysics

Project	$ FY16	Impact
Explorers Futures	$11M	Two month delay in development of future Explorer missions
TESS	$11M	Use of reserves not needed by the TESS project in FY16, with payback to the TESS project in FY17 and FY18 (rephasing of reserves)
ASTRO-H	$7M	Use of reserves held by the ASTRO-H project in case of problems in I&T or a launch delay; not needed by ASTRO-H project because ASTRO-H launched on time
R&A	$3M	One year reduction; fewer selections spread over FY16-FY17
Spitzer	$3M	Additional support from SMD makes up for reduction

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

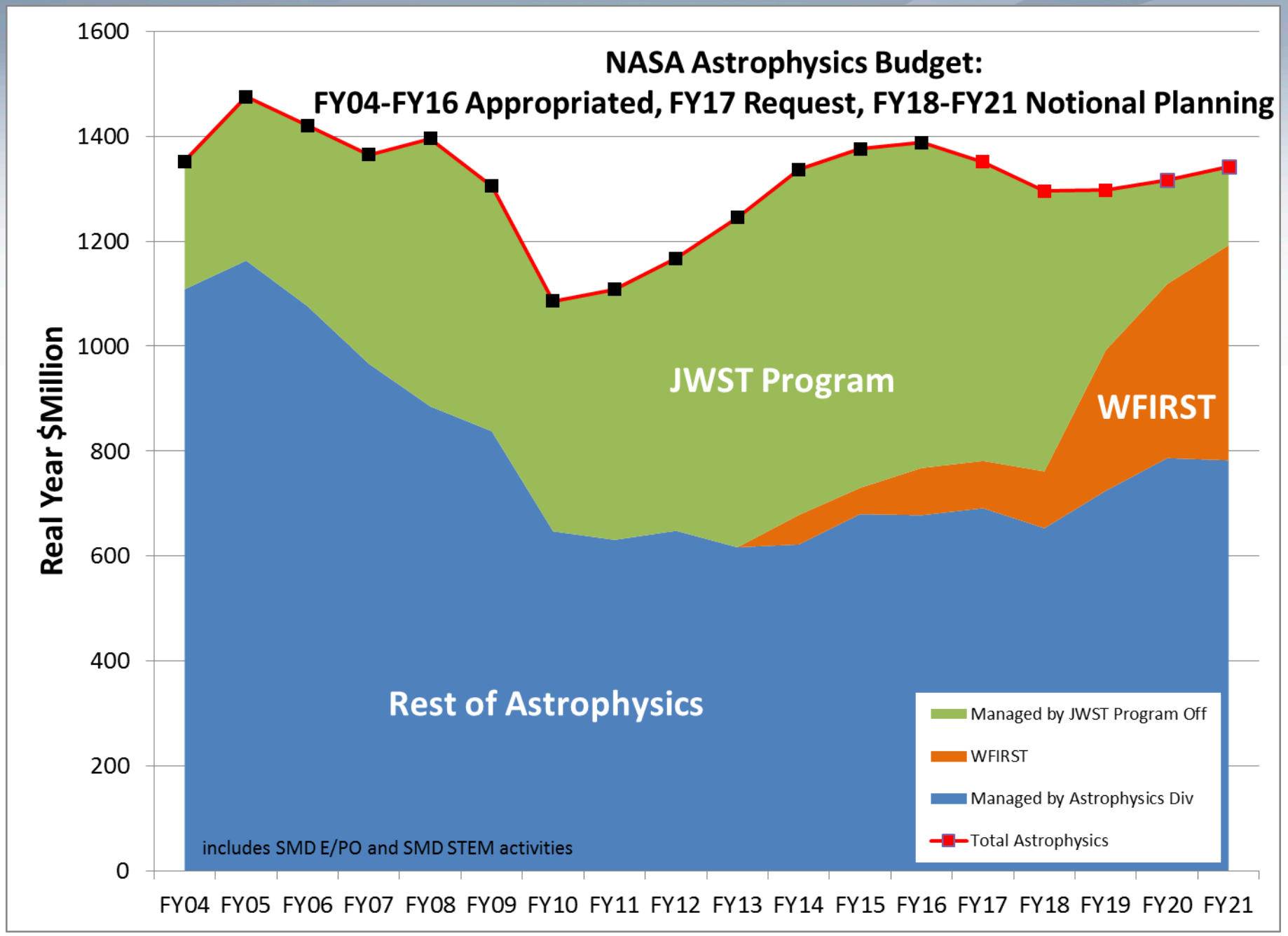
FY17 Budget Request

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.


NASA Astrophysics Budget:
FY04-FY16 Appropriated, FY17 Request, FY18-FY21 Notional Planning
Real Year $Million
1600
1400
1200
1000
800
600
400
200
0
JWST Program
WFIRST
Rest of Astrophysics
includes SMD E/PO and SMD STEM activities
Managed by JWST Program Off
WFIRST
Managed by Astrophysics Div
Total Astrophysics
FY04 FY05 FY06 FY07 FY08 FY09 FY10 FY11 FY12 FY13 FY14 FY15 FY16 FY17 FY18 FY19 FY20 FY21

FY17 Appropriations

- Both the House and the Senate appropriation subcommittees for NASA have marked up the President's budget request for NASA.
- Neither chamber has had a full vote on the NASA appropriation.
- Both chambers made changes to the President's budget request for NASA. The differences must be resolved before the FY17 NASA appropriation can be signed into law.

($M)	FY17 Request	Senate Mark	Senate Delta	House Mark	House Delta
Total Astrophysics	1350.9	1376.4	+25.5	1362.3	+11.4
JWST	569.4	569.4		569.4	
Hubble	97.3	98.3	+1.0		
SOFIA	83.8	83.8		85.2	+1.4
WFIRST	90.0	120.0	+30.0		
Mirror Tech		5.0	+5.0		
Starshade Tech				10.0	+10.0
STEM	25.0	42.0	+17.0	37.0	+12.0
Rest of Astrophysics		457.9	-27.5	685.7	-12.0

NASA Astrophysics

Planning for the 2020 Decadal Survey

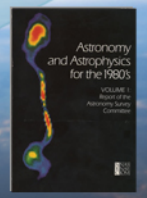
Responding to the 2010 Decadal Survey

Prioritized Recommendation	NASA plans
LARGE ACTIVITIES	
WFIRST	In Phase A, launch in mid-2020s
Explorers	Planning 4 AOs per decade
LISA	Partnering on ESA's space-based gravitational wave observatory
IXO	Partnering on ESA's Athena x-ray observatory
MEDIUM ACTIVITIES	
Exoplanet technology	WFIRST coronagraph, Starshade and coronagraph technology development
Inflation Probe technology	3 balloon-borne technology experiments
SMALL ACTIVITIES	
R&A augmentations	R&A up 20% since FY10
Mid-TRL technology	Initiated Strategic Astrophysics Technology program
Suborbital missions	Initiated ultra long duration balloon capability

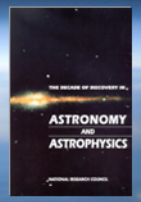
ASTROPHYSICS

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 Astrophysics Decadal Survey

- NASA has begun to study large mission concepts as input to the 2020 Decadal Survey
  - A well informed Decadal Survey makes better recommendations
- NASA has appointed Science and Technology Development Teams and initiated four large mission concept studies
  - Far Infrared Surveyor
  - Habitable Exoplanet Imaging Mission
  - Large Ultraviolet/Optical/Infrared Surveyor
  - X-ray Surveyor
- Science and Technology Definition Teams have a significant role and responsibility
  - Develop science case
  - Flow science case into mission parameters
  - Vet technology gap list
  - Direct trades of science vs cost/capability
- NASA is also planning to issue a call for medium-size mission concept studies (Astrophysics Probes)

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

Preparing for the 2020 Decadal Survey
Large Mission Concepts

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

	Community STDT Chairs	Center Study Scientist	Study Lead Center	HQ Program Scientist
Far IR Surveyor	Asantha Cooray Margaret Meixner	David Leisawitz	GSFC	Kartik Sheth
Habitable Exoplanet Imaging Mission	Scott Gaudi Sara Seager	Bertrand Mennesson	JPL	Martin Still
Large UV/Optical/IR Surveyor	Debra Fischer Bradley Peterson	Aki Roberge	GSFC	Mario Perez
X-ray Surveyor	Feryal Ozel Alexey Vikhlinin	Jessica Gaskin	MSFC	Dan Evans

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


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