National Aeronautics and Space Administration

NASA

EXPLORE SCIENCE

NASA Astrophysics FY20 Budget Request

Astronomy and Astrophysics Advisory Committee
Telecon
March 28, 2019

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Science Mission Directorate
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FY 2020 SMD Budget Strategy

Advance National Science and Exploration Goals

Maintain a Balanced and Integrated Science Program

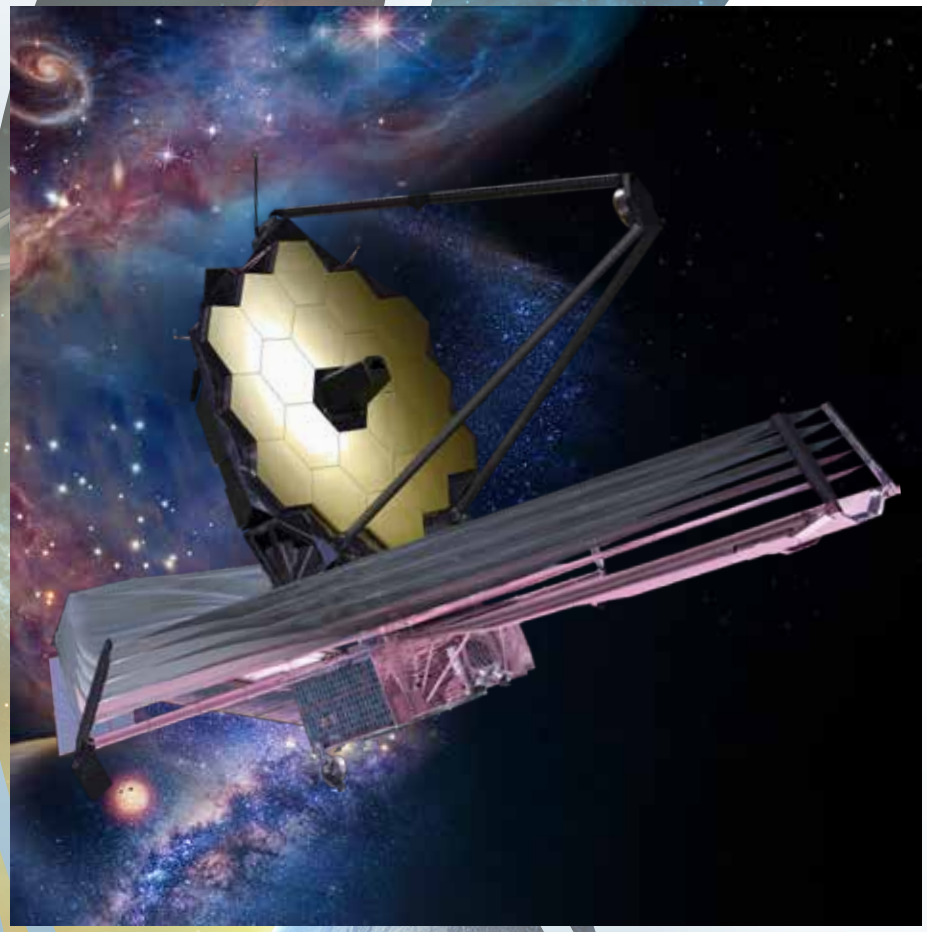
Execute Innovative Partnerships

Inspire Future Leaders

FY 2020 Budget Highlights

Advance National Science and Exploration Goals

- Execute Lunar Discovery and Exploration Program to leverage commercial partnerships and innovative approaches to achieve human and science exploration goals
- Enable Mars Sample Return mission, a decadal survey priority, leveraging international and commercial partnerships
- Prepare for launch of James Webb Space Telescope, world's premiere space telescope



FY 2020 Budget Highlights

Maintain a Balanced and Integrated Science Program

- Execute program informed by National Academies Decadal Surveys
- Continue leveraging innovation and commercial partnerships, including SmallSats/CubeSats, rideshares and hosted payloads; invest in innovative early-stage research and technology to promote economic growth
- Protect Astrophysics portfolio by prioritizing funding for competed astrophysics missions and research; fully fund Webb for launch in 2021; no funding for WFIRST
- Support for Europa Clipper mission; no funding for Europa Lander
- Execute a robust and innovative Earth Science portfolio; no funding PACE and CLARREO-PF

FY 2020 Budget Highlights

Execute Innovative Partnerships

- Pursue science on potential future commercial lunar and Mars missions
- Finalize multiple pilot contracts to purchase Earth observation products from existing private sector SmallSat constellations; for evaluation by NASA researchers
- Leverage data and expertise through interagency partnerships to achieve missions; provide data and products to support operational agencies
- Remain the preferred partner across the globe in all levels of experience, ~400 agreements, comprising nearly 60% of NASA international agreements
- Enable science learners across the U.S. through over 200 community-based organizations

Inspire Future Leaders

- Achieve excellence by relying on diverse teams, both within and external to NASA, to most effectively perform SMD's work
- Attract and retaining talent by promoting a culture that actively encourages diversity and inclusion and removes barriers to participation
- Encourage development of future leaders, including the next generation of mission principal investigators, through targeted outreach and hands-on opportunities
- Support early career scientists to build careers working with NASA
- Engage the general public in NASA Science, including providing opportunities for citizen scientists

FY 2020 Budget

Program Highlights

Planetary Science

- Lunar Discovery and Exploration program continues to grow commercial partnerships and innovative approaches to achieving science, technology demonstration and human exploration objectives
- Enables Mars Sample Return launch as early as 2026
- Accelerates launch readiness date for Europa Clipper to 2023

Astrophysics

- Webb re-planned for 2021 launch
- Maintains regular cadence of Astrophysics Explorers and Missions of Opportunity
- Given its significant cost and competing priorities within NASA, provides no funding for WFIRST space telescope

Heliophysics

- Space Weather increase will strengthen cross-agency collaboration on Research-to-Operations/Operations-to-Research
- Provides for a balanced Heliophysics portfolio, including enhanced emphasis on small missions, technology development and expanded opportunities for R&A

Earth Science

- Continues focused, balanced Earth science portfolio
- Maintains regular cadence of Venture Class missions and instruments solicitations
- Healthy research and applied science programs, and SmallSat/CubeSat investments

Science Mission Directorate

Astrophysics

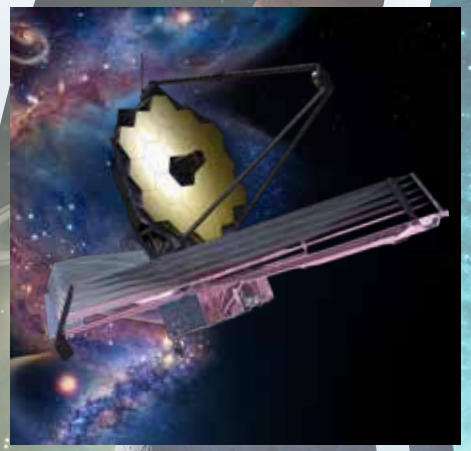
FY20 President's Budget Request for Astrophysics including Webb Telescope

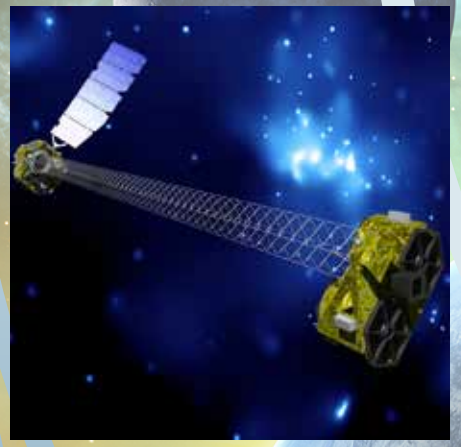
The FY20 President's Budget Request was released on March 11 with details released on March 18

The Budget requests a decreased level of funding for NASA Astrophysics

Total funding requested for FY20 (Astrophysics including Webb) is ~1.197B, a decrease of $187M (14%) from the FY18 appropriation and a decrease of $299M (20%) from the FY19 appropriation

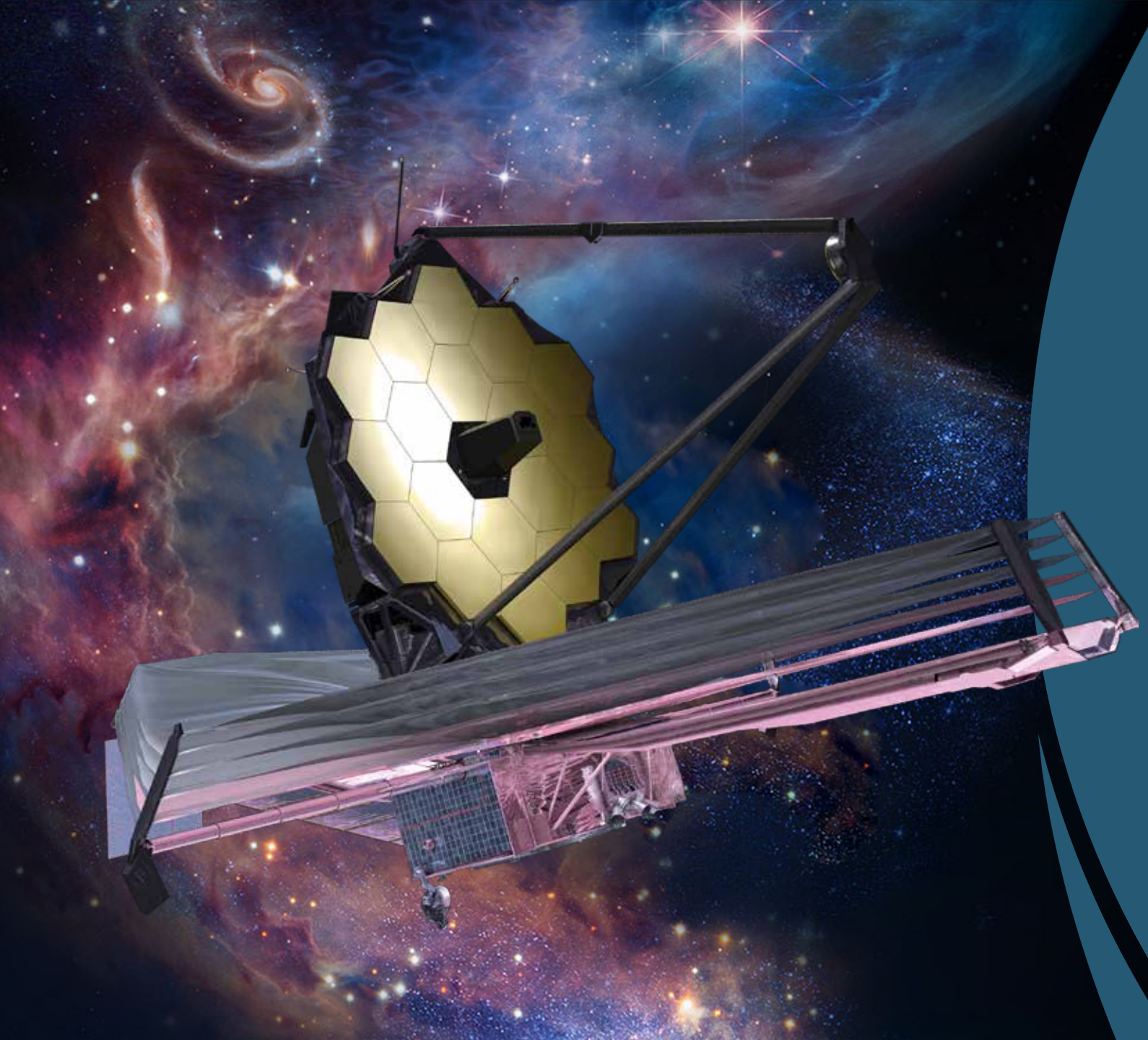
https://nasa.gov/budget





Astrophysics in FY20 PBR

- Accommodates Webb replan to March 2021 LRD
- Supports formulation of a probe mission as early as 2022, conditional on Decadal Survey recommendations
- Maintains decadal cadence of four AOs per decade for Astrophysics Explorers and Missions of Opportunity
- Funds SOFIA for three years beyond end of prime mission in FY19 at reduced budget; two alternate reviews are planned in 2019 in lieu of inclusion in 2019 Senior Review
- Extends operating missions (other than Hubble and Chandra) at reduced budget beyond FY20 following 2019 Senior Review
- Supports mission concept studies and technology investments to implement Astrophysics Decadal Survey priorities starting in 2022
- Given its significant cost and competing priorities within NASA, provides no funding for WFIRST space telescope



Webb

The James Webb Space Telescope

- Science payload completed three months cryogenic testing at end of 2017
- Spacecraft and sunshield integration complete January 2018
- Spacecraft element including sunshield will complete environmental testing in Summer 2019
- Science payload and spacecraft integration planned for Fall 2019
- Launch scheduled for 2021
- Webb overrun covered using offsets from Astrophysics Probes

FY20 President's Budget Request for Astrophysics including Webb Telescope

What's Changed

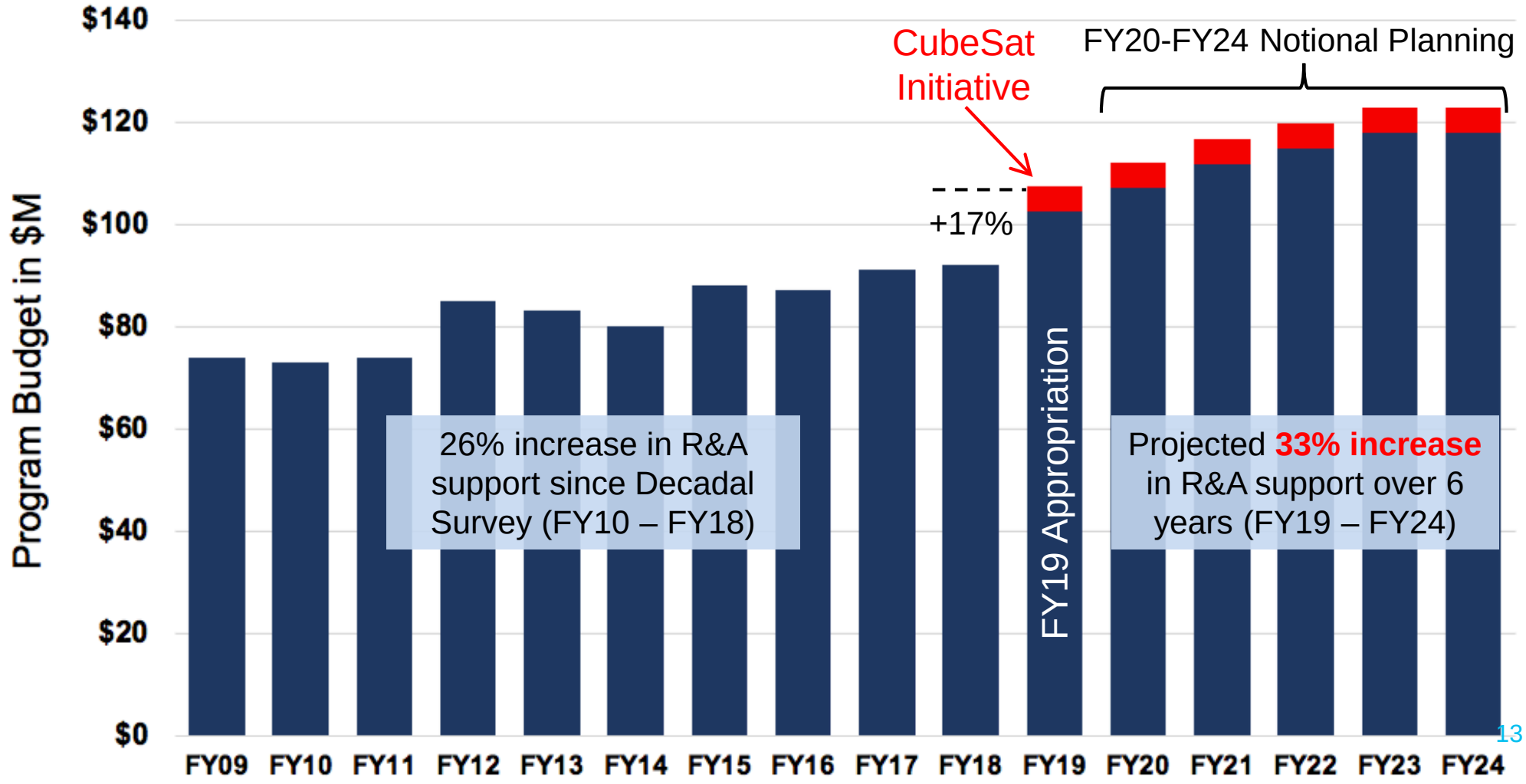
- Webb budget increased consistent with 2018 re-plan, Webb proceeding toward launch in 2021
- Probe program deferred to fund Webb replan
- SPHEREx begun within Explorers program as next Astrophysics MIDEX
- SOFIA mission funded beyond 5-year prime mission, extended mission starts in FY 2020 with details pending 2019 independent reviews
- Provides no funding for WFIRST space telescope

What's the Same

- Cadence of four Explorer and Mission of Opportunity AOs per decade
- Spitzer ends operations January 2020 per 2016 Senior Review
- Phase A studies of Small Explorers (SMEX) and Missions of Opportunity from 2019 AO
- IXPE, GUSTO, XRISM, and Euclid development remains on track and within budget
- Hubble, Chandra, and 6 smaller operating missions continue pending 2019 Senior Review
- CubeSat initiative and four balloon campaigns within healthy research program
- Mission concept studies and technology investments to support Astro2020

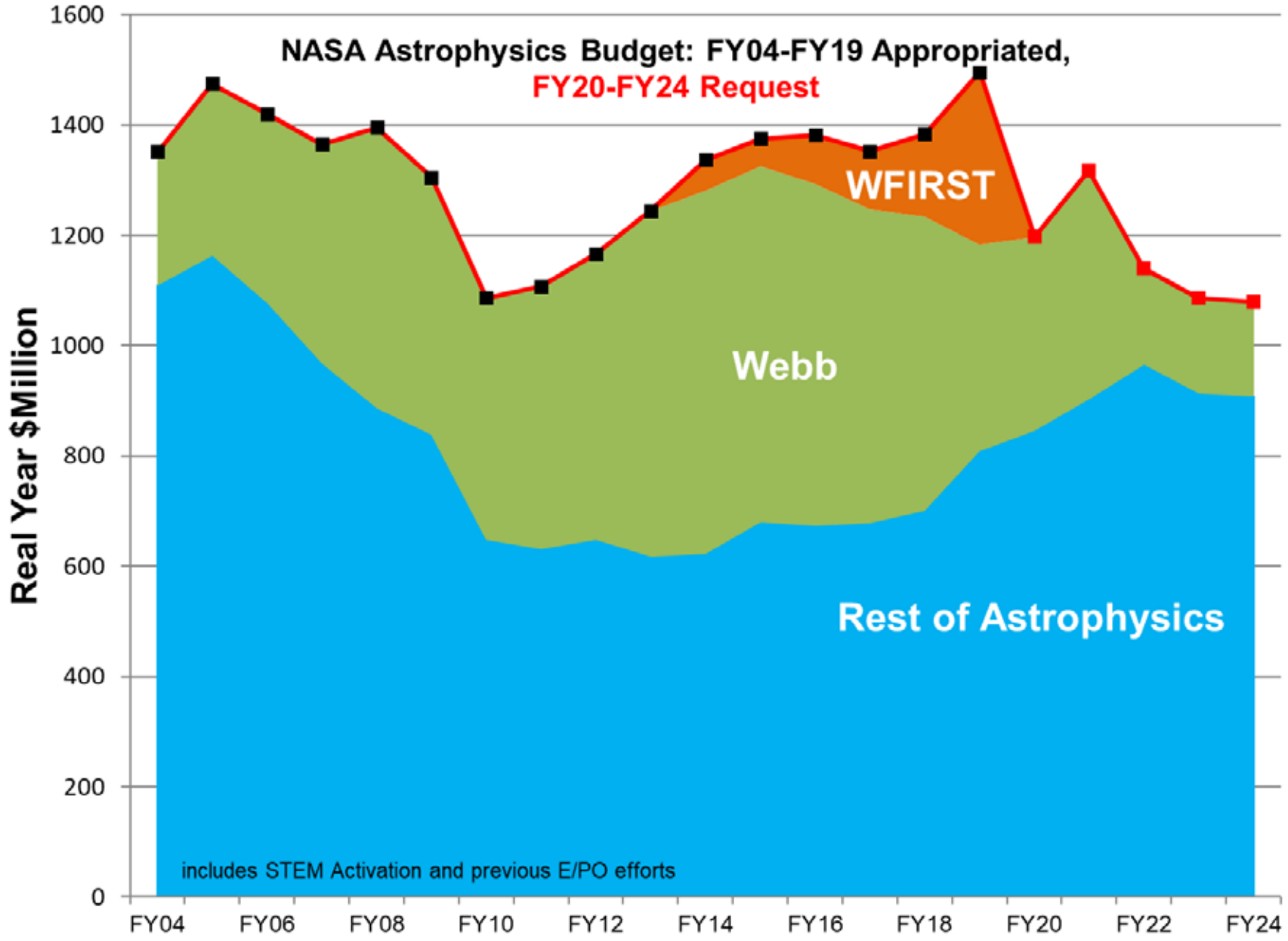
Growth in R&A Funding ($M)

Program	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24
R&A	$74	$73	$74	$85	$83	$80	$88	$87	$91	$92	$103	$107	$112	$115	$118	$118
CubeSat											$5	$5	$5	$5	$5	$5
Total	$74	$73	$74	$85	$83	$80	$88	$87	$91	$92	$108	$112	$117	$120	$123	$123



Planned Accomplishments FY19-20

- Webb will complete environmental testing of spacecraft/sunshield element in September 2019
- Webb will begin observatory integration September 2019 followed by observatory testing to be completed by August 2020; will be shipped to Kourou Space Center launch site, arriving September 2020
- WFIRST will complete element preliminary design reviews by September 2019
- NASA will release next SMEX and Mission of Opportunity AO April 2019; will select SMEX and Mission of Opportunity proposals for Phase A studies May 2020
- The Astrophysics Senior Review will be completed June 2019; Independent reviews of SOFIA operations and science prospects will be completed May 2019
- IXPE will conduct critical design review May 2019; GUSTO will conduct critical design review July 2019
- XRISM will deliver Resolve instrument hardware to JAXA October 2019; Euclid will deliver final NASA flight hardware to ESA October 2019
- Spitzer will complete mission and be decommissioned January 2020


NASA Astrophysics Budget: FY04-FY19 Appropriated,
FY20-FY24 Request
Real Year $Million
1600
1400
1200
1000
800
600
400
200
0
WFIRST
Webb
Rest of Astrophysics
includes STEM Activation and previous E/PO efforts
FY04
FY06
FY08
FY10
FY12
FY14
FY16
FY18
FY20
FY22
FY24

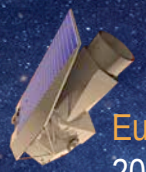
BACKUP

FY19 Astrophysics Budget Missions

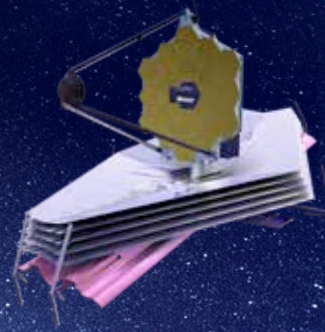
+ SMEX/MO (2025), MIDEX/MO (2028), etc.

Spitzer
8/25/2003

WFIRST
Mid 2020s



Euclid (ESA)
2022

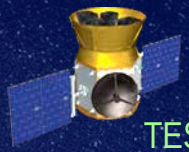


Webb
2021

Formulation
Implementation
Primary Ops
Extended Ops

Chandra
7/23/1999

XMM-Newton (ESA)
12/10/1999

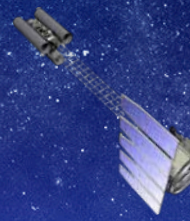


TESS
4/18/2018

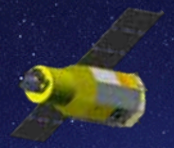
NuSTAR
6/13/2012

Swift
11/20/2004

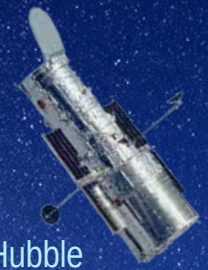
Fermi
6/11/2008



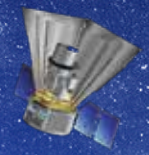
IXPE
2021



XRISM (JAXA)
2022



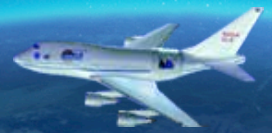
Hubble
4/24/1990



SPHEREx
2023

ISS-NICER
6/3/2017

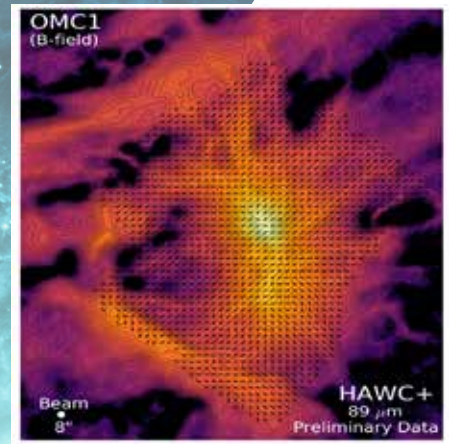
GUSTO
2021



SOFIA
Full Ops 5/2014

+ Athena (ESA) (early 2030s), LISA (ESA) (early 2030s)

Revised
March 7, 2019



Astrophysics Overview

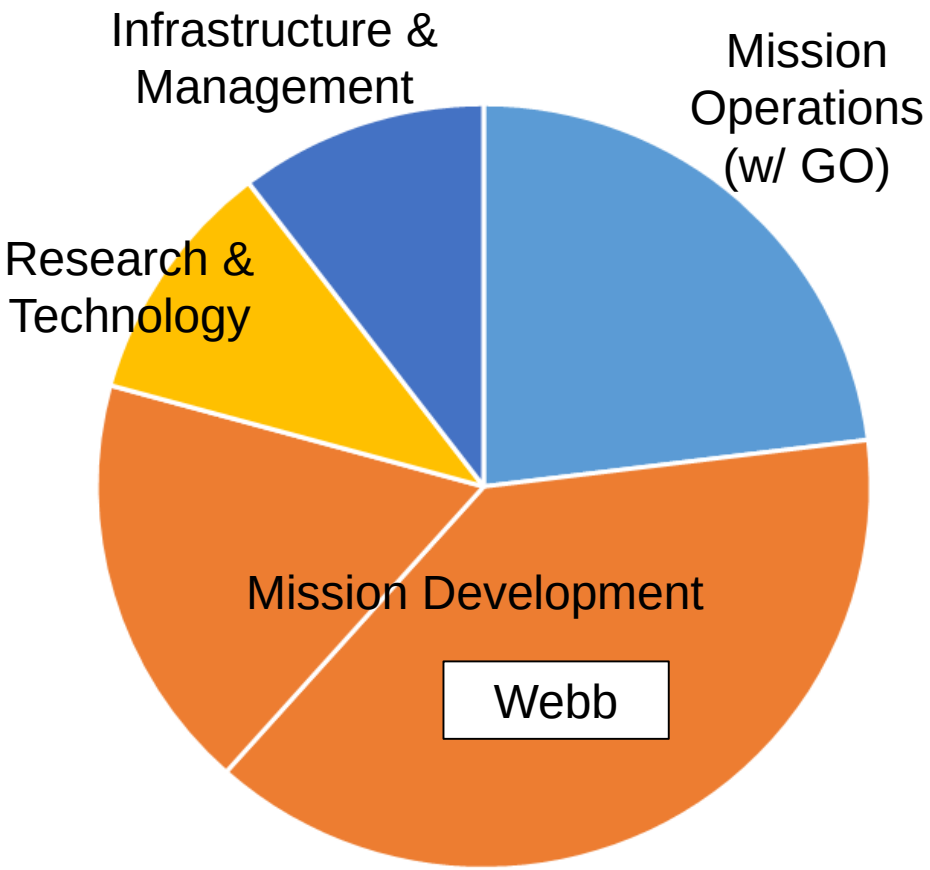
Strategic Objective

- Discover how the Universe works, explore how it began and evolved, and search for life on planets around other stars

Major Activities

- Building, launching, and operating strategic and competed space observatories, many with international partners
- Developing technologies to enable future observatories, both large and small
  - Basic R&D as well as focused technology development
- Conducting and sponsoring cutting-edge research, mission enabling studies, technology demonstrations, and workforce development
  - Suborbital-class projects using scientific balloons, sounding rockets, SmallSats/CubeSats, International Space Station, and other platforms
  - Analysis of data from NASA and partner space observatories
  - Theoretical and computational investigations
  - Laboratory experiments in support of astrophysical understanding

NASA's Astrophysics Program



FY 2018 Budget: $1.38B

Strategic Missions

- Flagships and probes led by NASA
- Contributions to partner-led missions

PI-led (competed) Missions

- Explorers missions (small and medium)
- Contributions to partner-led missions

Supporting Research and Technology

- Research and Analysis
- Technology development
- Suborbital payloads (balloons, sounding rockets)
- CubeSats and ISS-attached investigations

Infrastructure and Management

- Data archives
- Balloon Program
- Mission studies

Major Recent Accomplishments FY18-19

- Webb payload completed cryotesting November 2017 and shipped to California January 2018
- XRISM passed Preliminary Design Review / Confirmation Review and entered Phase C January 2018
- TESS launched April 2018, began science operations July 2018 following commissioning
- Hubble detected the most distant, at 9 billion light years, ordinary star ever detected April 2018
- Webb Independent Review Board completed review and NASA announced March 2021 launch date June 2018
- Fermi detected an outburst from a distant supermassive black hole at the same time NSF's IceCube detects a neutrino, marking the first extragalactic neutrino detection July 2018
- Kepler exhausted its fuel and ceased operations October 2018
- Kepler and Hubble detected the first Exomoon candidate orbiting an exoplanet 8,000 light years away October 2018
- Astrophysics Decadal Survey began November 2018
- IXPE and GUSTO passed their Confirmation Reviews and entered the implementation phase
- Voyager 1 detected no Hawking radiation from primordial black holes, limiting their contribution to the mysterious dark matter January 2019
- ISS-NICER completed its prime mission in January 2019
- First flight hardware electronics packages delivered to ESA for Euclid mission February 2019
- SPHEREx selected as next Astrophysics MIDEX mission February 2019

Science Budget Request Summary ($M)

	Actual FY 18	Enacted FY 19	Request FY 20	Out-years FY 21	FY 22	FY 23	FY 24
Science	6,211.5	6,905.7	6,303.7	6,319.0	6,319.0	5,919.5	5,919.0
Earth Science	1,921.0	1,931.0	1,779.8	1,785.6	1,779.7	1,666.5	1,674.6
Earth Science Research	461.6		447.9	466.9	484.1	508.1	532.4
Earth Systematic Missions	899.4		719.2	701.5	664.1	501.5	481.3
Earth System Science Pathfinder	242.0		275.4	255.1	253.0	265.2	248.3
Earth Science Data Systems	204.4		214.4	229.0	239.3	250.1	267.7
Earth Science Technology	60.4		69.6	79.2	82.8	84.6	86.4
Applied Sciences	53.2		53.3	53.9	56.3	57.0	58.5
Planetary Science	2,217.9	2,758.5	2,622.1	2,577.3	2,629.4	2,475.4	2,454.9
Planetary Science Research	279.5		266.2	272.6	268.6	270.2	301.9
Planetary Defense	76.0	160.0	150.0	150.0	150.0	119.5	150.0
Lunar Discovery and Exploration	22.0	218.0	210.0	327.0	417.0	494.0	512.0
Discovery	258.3	381.2	502.7	393.4	364.4	371.6	371.6
New Frontiers	88.1	130.2	190.4	261.2	341.9	387.3	291.7
Mars Exploration	678.0	650.0	546.5	472.2	481.7	506.1	590.1
Outer Planets and Ocean Worlds	676.2	760.9	608.4	549.6	463.7	224.2	68.8
Technology	139.8	210.2	147.9	151.3	142.1	102.5	168.8
Astrophysics	850.4	1,191.6	844.8	902.4	965.2	913.5	907.7
Astrophysics Research	203.1		250.7	309.3	302.5	299.1	298.8
Cosmic Origins	211.2		185.3	173.9	181.7	121.7	121.7
Physics of the Cosmos	118.0		148.4	128.5	123.3	117.8	117.4
Exoplanet Exploration	200.8		46.4	44.3	45.6	46.1	48.5
Astrophysics Explorer	117.4		214.1	246.4	312.0	328.8	321.4
James Webb Space Telescope	533.7	304.6	352.6	415.1	175.4	172.0	172.0
Heliophysics	688.5	720.0	704.5	638.6	769.3	692.0	709.8
Heliophysics Research	206.3		237.0	223.6	214.7	219.3	222.0
Living with a Star	376.1		107.6	83.6	108.7	121.9	118.3
Solar Terrestrial Probes	45.2		177.9	220.4	210.9	192.7	152.0
Heliophysics Explorer Program	60.9		182.0	111.1	235.0	158.1	217.5

Astrophysics Program Content

	Actual FY 18	Enacted FY 19	Request FY 20	Out-years FY 21	FY 22	FY 23	FY 24
Astrophysics	**850.4**	**1,191.6**	**844.8**	**902.4**	**965.2**	**913.5**	**907.7**
Astrophysics Research	203.1		250.7	309.3	302.5	299.1	298.8
Astrophysics Research and Analysis	74.1	83.4	86.6	90.2	92.2	94.2	94.2
Balloon Project	36.6		44.8	44.8	44.8	44.8	44.8
Science Activation	44.0	45.0	45.6	45.6	45.6	45.6	45.6
Other Missions and Data Analysis	48.5		73.7	128.7	119.9	114.5	114.2
Astrophysics Data Curation and Archival	18.2		21.2	21.2	21.5	22.0	22.0
Astrophysics Data Program	17.6		20.4	21.6	22.6	23.6	23.6
Astrophysics Senior Review				33.5	20.5	27.3	31.6
Contract Administration, Audit & QA Svcs	12.7		12.7	12.7	12.7	12.7	12.7
Astrophysics Directed R&T			19.4	39.7	42.7	28.9	24.3
Cosmic Origins	211.2		185.3	173.9	181.7	121.7	121.7
Hubble Space Telescope (HST)	98.3	98.3	83.3	93.3	98.3	98.3	98.3
Stratospheric Observatory for Infrared Astronom	85.2	85.2	73.0	60.0	60.0		
Other Missions and Data Analysis	27.7		29.0	20.6	23.4	23.4	23.4
Cosmic Origins SR&T	15.5		17.1	18.4	18.4	18.4	18.4
SIRTF/Spitzer	11.2		8.5	1.0			
Cosmic Origins Future Missions	1.0		2.2	0.0	3.8	3.8	3.8
Astrophysics Strategic Mission Prog Mgmt			1.2	1.2	1.2	1.2	1.2

Astrophysics Program Content

	Actual FY 18	Enacted FY 19	Request FY 20	Out-years FY 21	FY 22	FY 23	FY 24
Physics of the Cosmos	118.0		148.4	128.5	123.3	117.8	117.4
Euclid	19.8		13.7	11.0	8.9	9.9	10.3
Physics of the Cosmos Future Missions	0.2		2.0	1.1	3.8	3.5	3.7
Chandra X-Ray Observatory	56.9		58.4	58.4	58.4	58.4	58.4
Fermi Gamma-ray Space Telescope	13.0		14.0				
XMM	2.5		3.5				
Physics of the Cosmos SR&T	20.9		50.9	52.1	46.3	40.1	39.0
PCOS/COR Technology Office Management	4.6		5.9	5.9	6.0	6.0	6.0
Exoplanet Exploration	200.8		46.4	44.3	45.6	46.1	48.5
WFIRST	150.0	312.2					
Kepler	10.0		1.3				
Keck Operations	6.2		6.7	6.9	7.0	7.2	7.4
Large Binocular Telescope Interferometer	1.8						
Exoplanet Exploration SR&T	26.4		29.1	30.0	28.9	28.9	28.6
Exoplanet Exploration Tech Office Mgmt	5.3		6.5	6.8	7.3	7.7	7.7
Exoplanet Exploration Future Missions	1.0		2.8	0.6	2.4	2.2	4.7

Astrophysics Program Content

	Actual FY 18	Enacted FY 19	Request FY 20	Out-years FY 21	FY 22	FY 23	FY 24
Astrophysics Explorer	117.4		214.1	246.4	312.0	328.8	321.4
Imaging X-Ray Polarimetry Explorer	23.5		70.2	45.3	7.4	4.5	0.5
X-Ray Imaging and Spectroscopy Mission	22.0		29.7	25.7	22.5	17.6	15.8
GUSTO	4.7		11.1	7.8	6.3	1.0	
Nuclear Spectroscopic Telescope Array	4.8		7.8				
Neil Gehrels Swift Observatory	3.9		5.5				
Transiting Exoplanet Survey Satellite	33.5		5.0	0.2			
Neutron Star Interior Composition Explor	2.1						
Astrophysics Explorer Future Missions	11.8		84.8	154.2	267.0	295.1	299.2
Astrophysics Explorer Program Managemen	11.1			13.3	8.8	10.7	5.9
James Webb Space Telescope	**533.7**	**304.6**	**352.6**	**415.1**	**175.4**	**172.0**	**172.0**

Cost Performance of Recently Launched Missions

NASA Science is providing reliable cost estimates for its missions, contributing to program stability

	KDP-C Baseline	Actual/ Estimated	Actual vs. Original
NuSTAR	109.9	116.0	6%
Landsat 8	583.4	502.8	-14%
IRIS	140.7	143.0	2%
LADEE	168.2	188.2	12%
MAVEN	567.2	472.0	-17%
GPM	555.2	484.3	-13%
OCO-2	249.0	320.3	29%
SMAP	485.7	454.3	-6%
MMS	857.3	875.3	2%
Astro-H	44.9	71.2	59%
OSIRIS-REx	778.6	620.8	-20%
CYGNSS	151.1	127.1	-16%
SAGE-III	64.6	88.2	37%
TSIS-1	49.8	21.8	-56%
TESS	323.2	273.4	-15%
InSight	541.8	635.8	17%
GRACE-FO	264.0	248.7	-6%
Parker	1055.7	974.3	-8%
ICESat 2	558.8	736.6	32%
GEDI	91.2	88.5	-3%
Total	7640.2	7442.7	-3%

Science missions launched since the requirement for a 70% JCL have *underrun* Phase C/D budget commitments by a net 3%