National Aeronautics and Space Administration

EXPLORE SCIENCE

NASA Astrophysics Update

Astrophysics Advisory Committee
March 5, 2020

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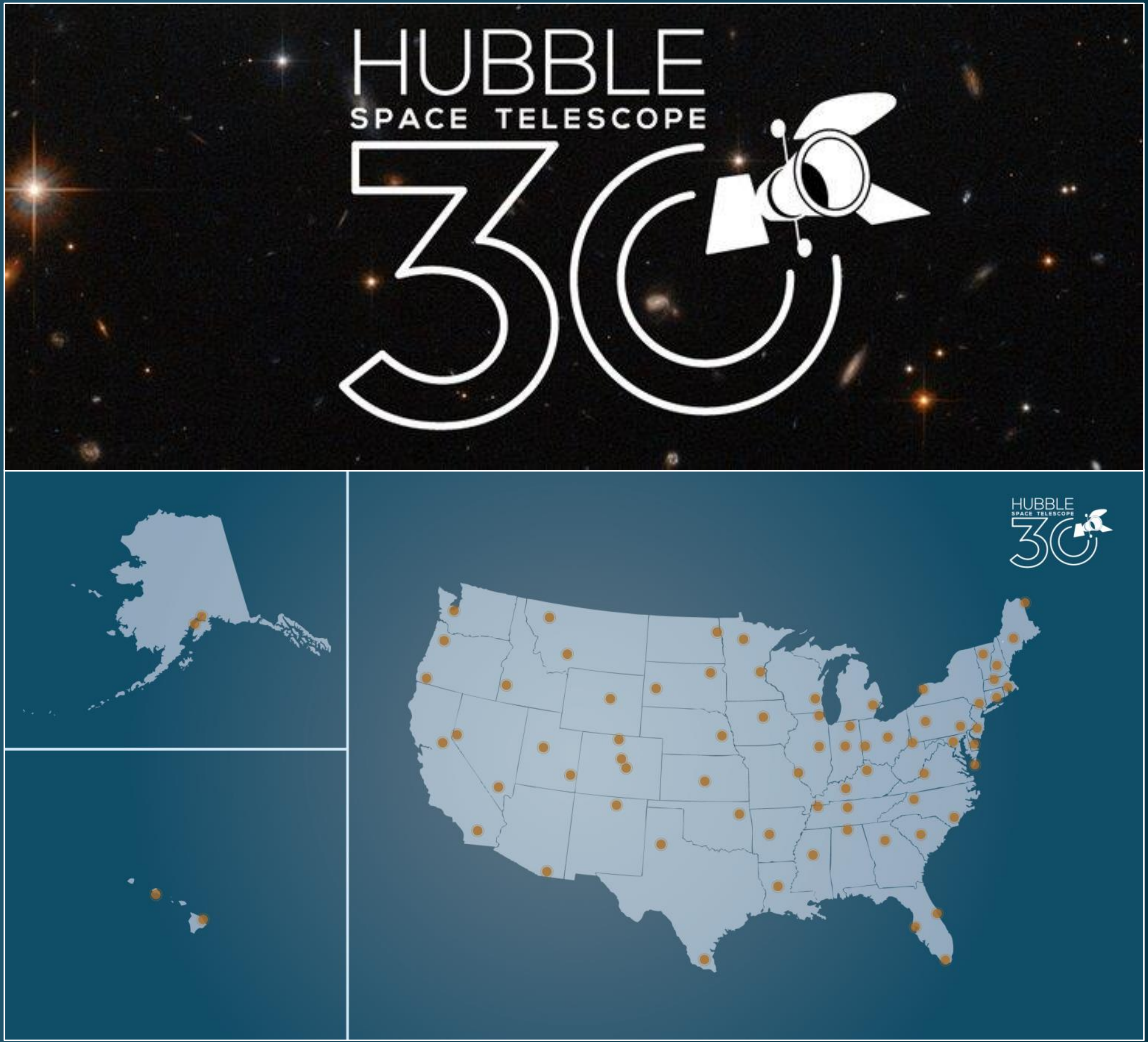
NASA Astrophysics
Celebrate Accomplishments

https://www.nasa.gov/content/hubbles-30th-anniversary


HUBBLE
SPACE TELESCOPE
30

After 16.5 yrs of science exploration on the infrared cosmic frontier as one of NASA's Great Observatories, Spitzer ended its mission on Jan 30, 2020, 2:30 PST.

Engineering feats extended mission life post-cryo in 2009 and overcame challenges due to Spitzer's increasing distance from Earth.

Spitzer Space Telescope

Spitzer enabled discovery near and far, to the edge of the universe, yielding 8,800+ refereed papers.

- First detection of light from an exoplanet
- First detection of molecules in exoplanet atmospheres
- Measurement of star formation history of the Universe to z>2, looking back >10 Gyr
- Measurement of the stellar mass of the Universe to z>8, looking back ~13 Gyr

www.spitzer.caltech.edu/final-voyage

The Legacy of the Spitzer Space Telescope Celebrated

- Hosted by the California Institute of Technology and sponsored by Ball Aerospace
- 11-13 February 2020

https://conference.ipac.caltech.edu/legacyofspitzer/

TESS

Transiting Exoplanet Survey Satellite

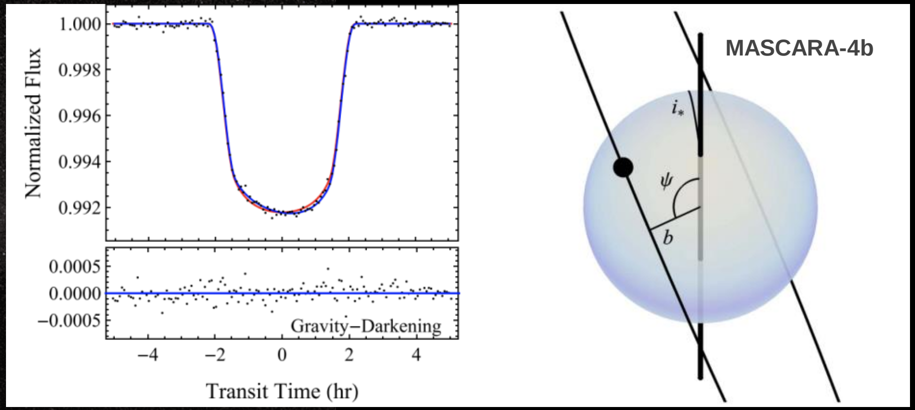
Observation Sector 22 (Orbit 51) in progress

41 confirmed planets
1700 planet candidates

223 publications submitted, 169 peer-reviewed (52% exoplanets, 48% astrophysics)

Last update: Feb 23, 2020

TESS detects planets in misaligned orbits around rapidly rotating A-type stars



Oblate stars (due to rapid rotation) exhibit surface temperature gradients, with darkness near the stellar equator ('gravity-darkening')

Asymmetric transit shapes can reveal a planet in an orbit misaligned with the spin of a gravity-darkened star

- TESS observations of MASCARA-4b shows that it is a hot Jupiter in a highly misaligned orbit (Ahlers et al. 2020)
- TESS observations show Kepler-13Ab also exhibits spin-orbit misalignment (Szabo et al. 2020)
- TESS is expected to observe >400k rapid rotators and should find ~2k planets around A and F stars (Barclay et al. 2019), many of which will have spin-orbit misaligned orbits

An artist's illustration shows that the stars in the TOI 1338 system make an eclipsing binary — they circle each other in our plane of view. If you could hover near the planet TOI 1338 b, you would see an eclipse every 15 days. Credit: NASA's Goddard Space Flight Center/Chris Smith (USRA)

JANUARY 20, 2020

High School Student Discovers New Planet Three Days Into His NASA Internship

BY HANNAH SHARIFF

CCSS NAS-4 Interest Level 3-10 Favorite

17-year-old Wolf Cukier discovered a new planet, 1,300 light-years away in the constellation Pictor, on the third day of his NASA internship (Credit: Wolf Cukier)

NASA Astrophysics
Committed to Improving

Excellence through Diversity

Research shows that excellence of teams and diversity go hand-in-hand, especially in innovative activities

- Excellent teams require diverse opinions and perspectives, and foster a sense of community by encouraging healthy behavior through actions

Team size should match the work required and the skills needed

- Teams should be built with diversity in mind from the beginning, not as an afterthought

Change is hard. It happens incrementally, but it is important that we do what we can right now to tackle these issues

Inspiring Future Leaders

- Achieve excellence by relying on diverse teams, both within and external to NASA, to most effectively perform SMD's work
- Attract and retain 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 opportunities for citizen scientists

[1] https://science.nasa.gov/researchers/new-pi-resources [2] https://science.nasa.gov/researchers/pi-launchpad

Mission Principal Investigator Development

- Seek to increase the diversity of mission principal investigators and develop the next generation of mission leaders to ensure that new ideas and mission concepts are brought forward
- NASA Science has:
  - Developed a consolidated PI resources webpage at https://science.nasa.gov/researchers/new-pi-resources, which also includes SMD presentation on lessons learned from past selections
  - Introduced a pre-reviews of mission peer review panels to ensure diversity and reduce conflicts of interest
  - Included career development positions and associated evaluation criteria as part Discovery and New Frontiers AOs
  - Held first “PI Launchpad” in November 2019 at the University of Arizona; concept conceived by Erika Hamden, Assistant Professor, Astronomy and Assistant Astronomer, Steward Observatory
  - Hosted “So You Think You Want To Be A NASA Mission PI” town halls at AGU in December 2019 and AAS in January 2020
- Upcoming activities include:
  - Looking to host two Launchpad Workshops per year starting in Spring 2020

First PI Launchpad

- Aimed at researchers and engineers who would like to submit a NASA space mission proposal in the next few years but don't know where to start
- Two-and-a-half day, interactive workshop held in Tucson, AZ on Nov. 18-20, 2019
- Very competitive application process. Selected ~40 participants. All costs paid for thanks to a grant from the Heising-Simons Foundation to our partner, the University of Arizona
- Goals:
  - Lead participants from science question to draft requirements, STM, *etc.*
  - Provide first exposure to how to choose partners, assemble teams, *etc.*
  - Provide networking opportunities with mission managing organizations, spacecraft providers and each other
- Targeting Spring CY2020 at University of Michigan for the next PI Launchpad

Roman Technology Fellowship Program

- 19 current and recent fellows
- Typically in academia and National Laboratories
- Budget stable at about $1.3 M per year
- $300 K in startup funds for each fellow, over 3 years

Dr. Nancy Grace Roman
1925-2018

RTF fellows at the RTF Special Session held at the AAS meeting in June 2018: From the left: Erika Hamden (Caltech/U. Arizona), Cullen Blake (U. Pennsylvania), Brian Fleming (U. Colorado), and Abigail Vieregg (U. Chicago)

2019 Roman Technology Fellows selected in November 2019 (ROSES-2018):

Regina M. Caputo (Ph.D. 2011), NASA-GSFC, Gamma-ray and Cosmic-ray astrophysics

Sarah N. Heine (Ph.D. 2014), MIT, Bragg Reflector Optics and Gratings for Polarimetry

Gregory N. Mace (Ph.D. 2014), UT Austin, Advanced Optics and Spectroscopy Applications

https://science.nasa.gov/researchers/sara/fellowship-programs/nancy-grace-roman-technology-fellowships-astrophysics-early-career-researchers/

NASA Hubble Fellowship Program

Fellows are asking for the assurance of parental leave and the option of saving for their eventual retirement with the assistance of their employer.

- Fellows who are employees of their host institutions typically have these benefits.
- Stipendiary fellows to do not receive employee benefits even though the NHFP is willing to pay the full cost of the employee benefits package.

The Space Telescope Science Institute (STScI) is proposing a change to the requirements for NHFP host institutions.

> *Starting with academic year 2022-2023, in order to host new NASA Hubble Fellowship Program (NHFP) Fellows, host institutions must offer their NHFP Fellows the opportunity to be employees. Employee status is being required to afford NHFP Fellows the same leave, vacation, retirement and health benefits (as applicable) given by these institutions to their postdoctoral fellows hired on grants or contracts as employees. Host institutions are also encouraged, but not required, to offer Fellows the option of choosing to be a stipendiary fellow rather than an employee if that is a better match to the Fellow's needs.*

STScI is soliciting comments from host institutions, see the letter from STScI Director Ken Sembach at http://www.stsci.edu/stsci-research/fellowships/nasa-hubble-fellowship-program/nhfp-host-institution-employment-policy.

Direct any questions or comments on this policy to nhfp@stsci.edu by March 18, 2020.

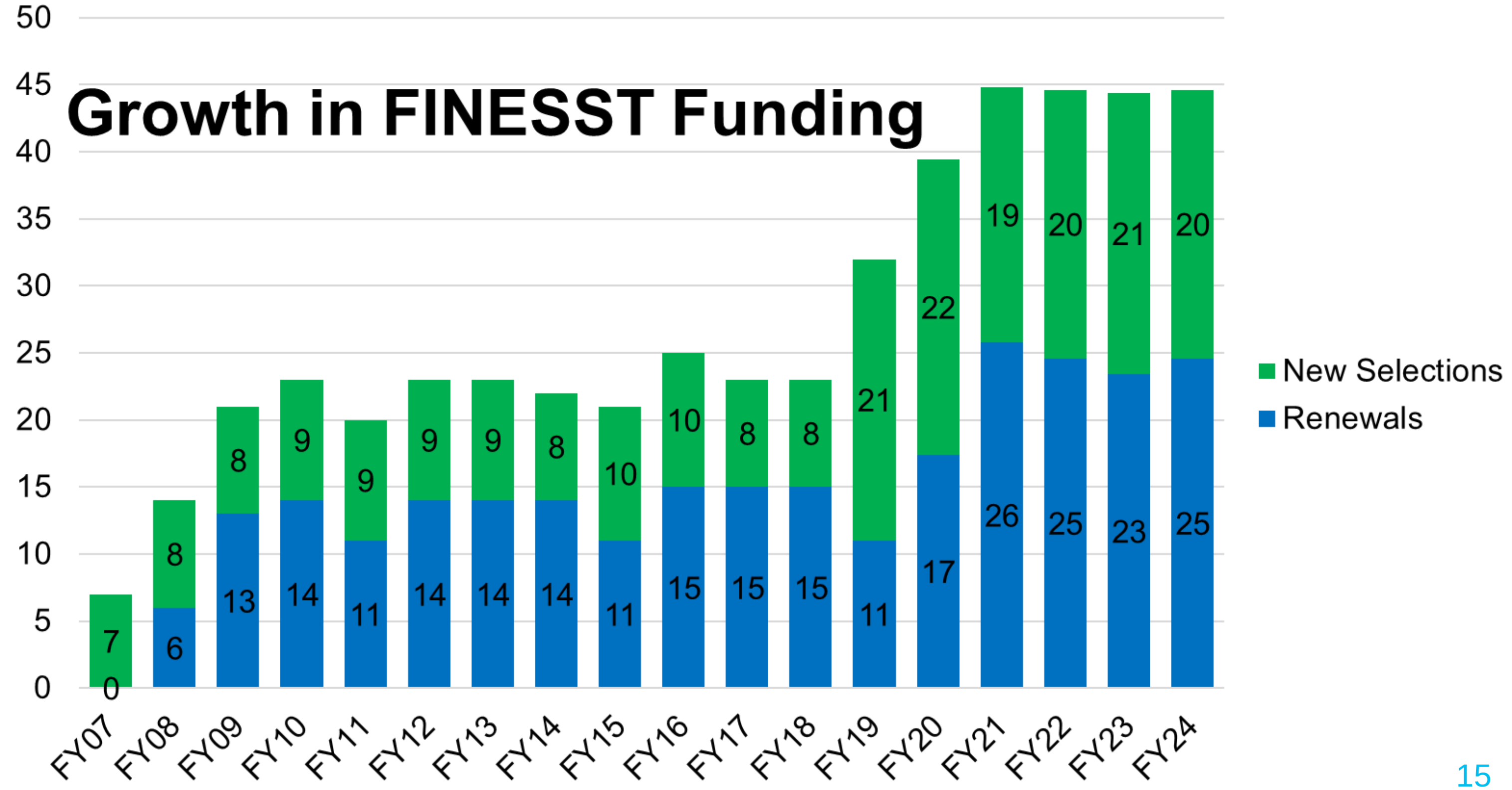
Graduate Student Research Awards

NASA Earth and Space Science Fellowship (NESSF) program name is changing to Future Investigators in NASA Earth and Space Science and Technology (FINESST) in 2019 to more accurately capture the nature of awards.

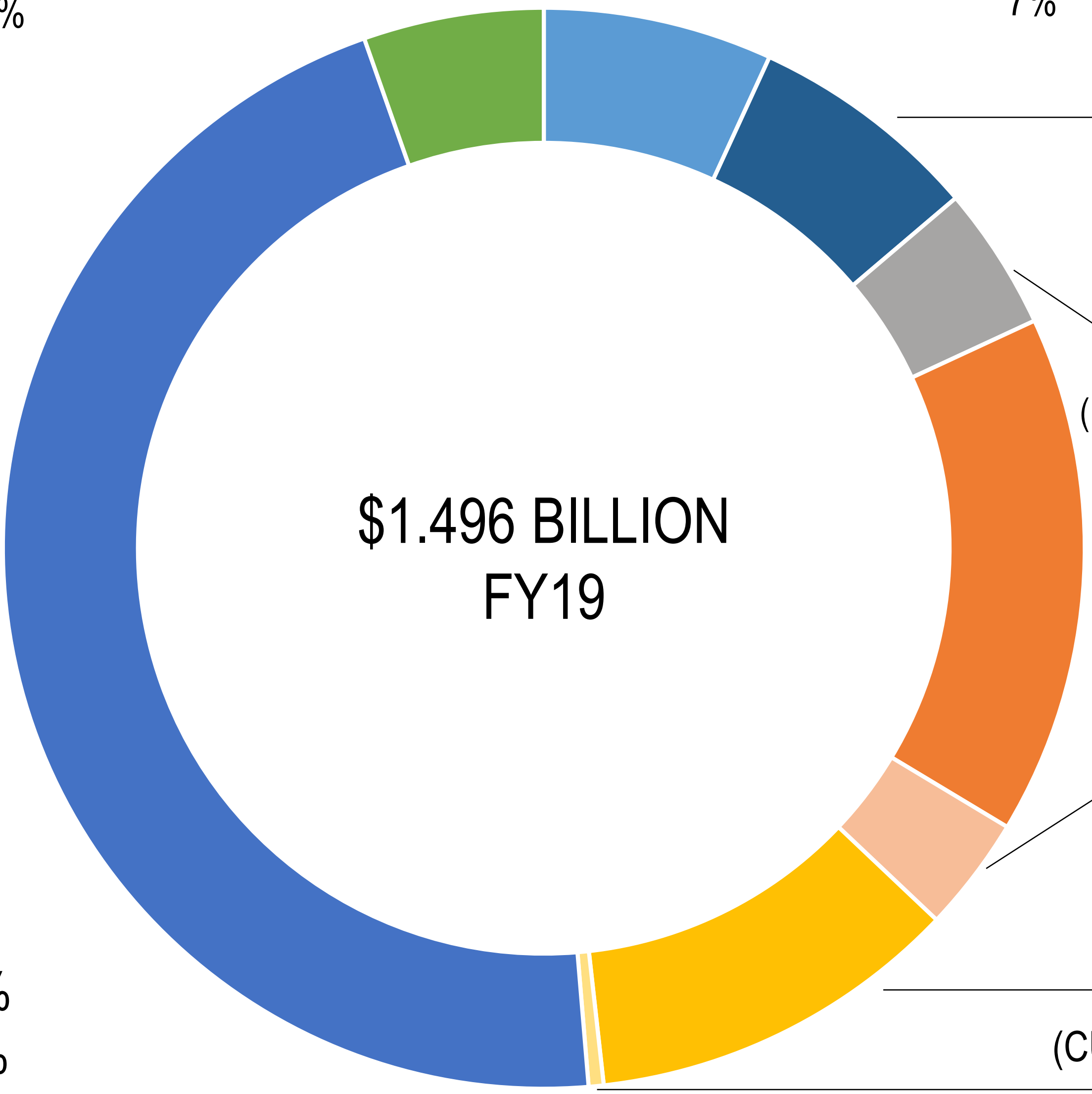
Historically Astrophysics has funded 24 NESSF / FINESST fellows at any given time. With 150-200 proposals received annually, the selection rate has been ~6%.

Community input has led to us doubling the Astrophysics NESSF / FINESST program effective in 2019.

Astrophysics will now be funding 45-48 NESSF / FINESST Fellows at any given time. The selection rate will be ~10%.



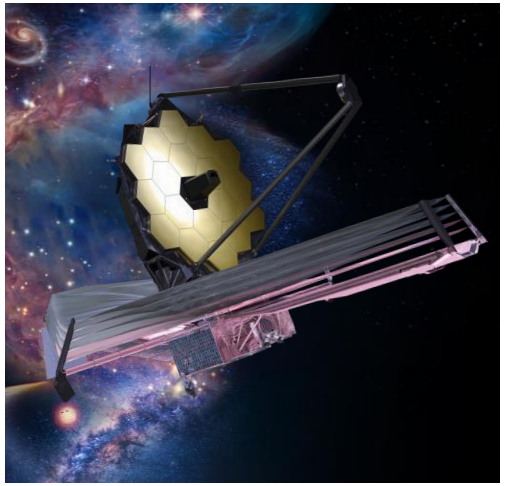
NASA Astrophysics Budget Update

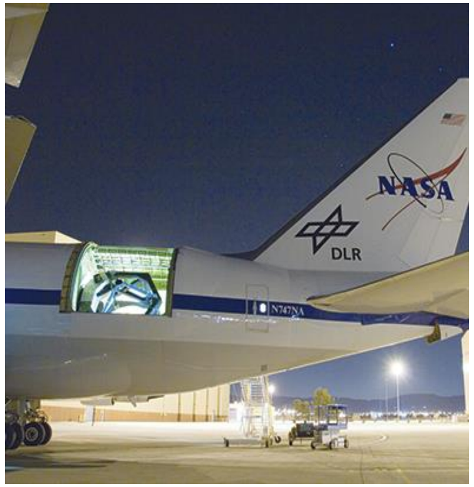


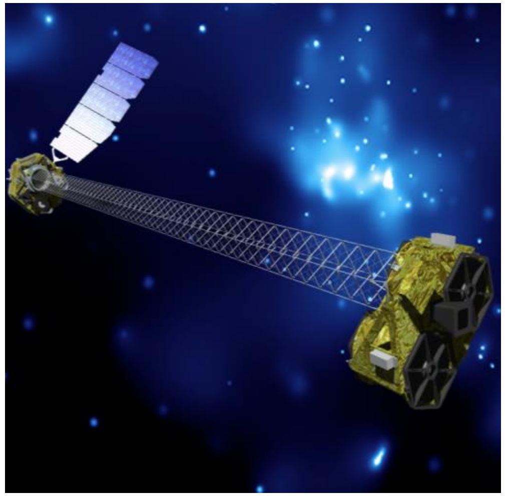
<u>Quick Summary</u>

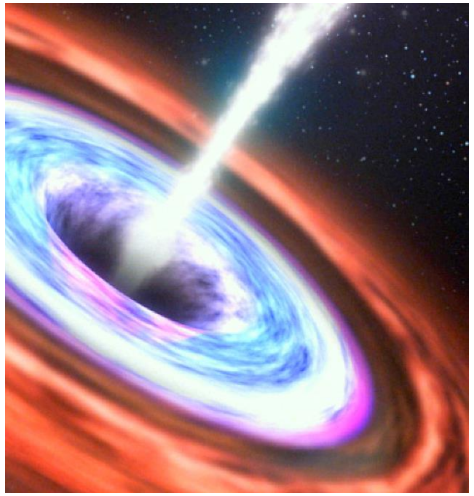
Community support: 20%
Operating missions: 20%
Building missions: 55%
Management: 5%

FY20 Appropriation





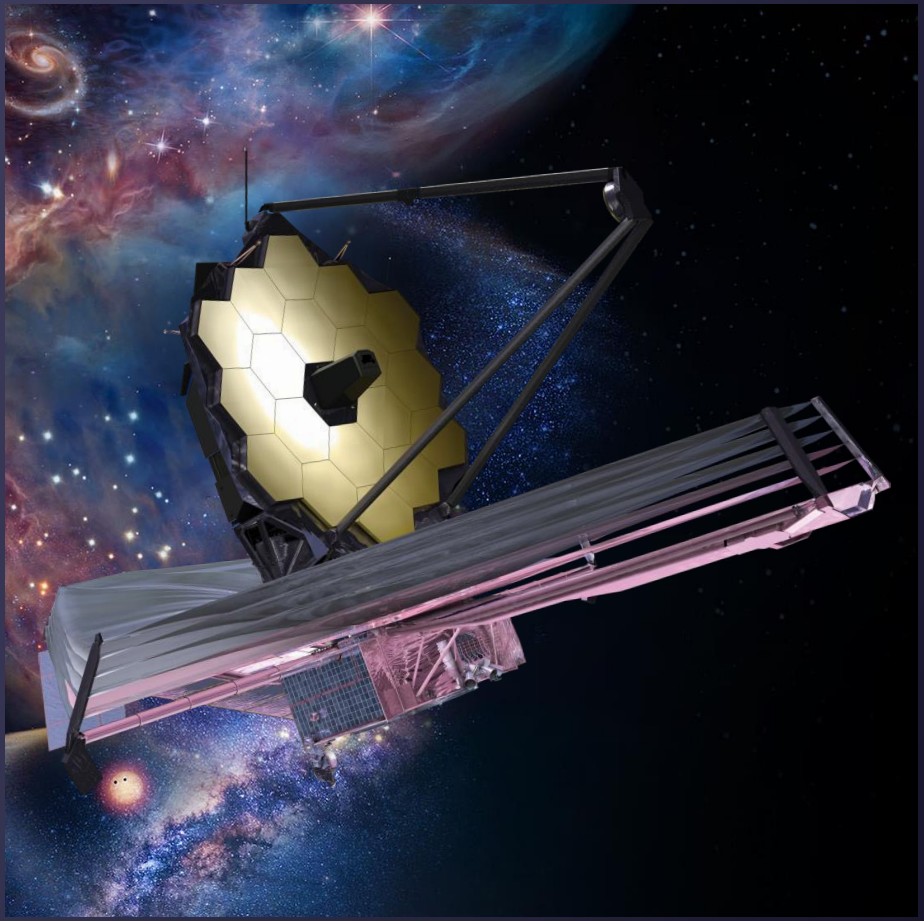




- FY20 appropriation for NASA Astrophysics (including Webb Telescope) is $1.73B; up by $233M from FY19 appropriation and by $532M from FY20 President’s Budget Request
- Fully funds Webb for replan to March 2021 launch date
- Fully funds WFIRST, including the coronagraph technology demonstration instrument, through KDP-C and into Phase C
- Specifies funding levels for Hubble, SOFIA, and the Astrophysics Research Program
- Provides adequate funding to continue with the rest of the planned Astrophysics programs and projects including:
  - Operating missions with GO programs as planned following the Senior Review
  - Development of Explorers missions (IXPE, GUSTO, SPHEREx) and international contributions (Euclid, XRISM, ARIEL, Athena, LISA)
  - Initiation of Phase A studies for selected SMEX and MO proposals from the 2019 Announcement of Opportunity
  - Continued technology development for the future

FY21 Budget Agency Highlights

- One of the strongest budgets in NASA's history, investing more than $25 billion dollars for America's future in space; funding proposed represents an increase of about 12% over last year's request
- Keeps the agency on track to land the first woman and the next man on the Moon by 2024 and enables development of more than 15 science missions (including lunar, Mars, and Heliophysics) that inform Artemis work
- Provides valuable precursor experience for human exploration of Mars with bold new missions such as Mars Sample Return and Ice Mapper
- Implements a balanced and integrated science program with over 40 missions in formulation and development in FY 2021, including over 25 small missions
- Advances compelling science with priorities identified by the National Academies' decadal surveys including the James Webb Space Telescope, Europa Clipper, IMAP, and the first Earth Science Designated Observables mission
- Executes innovative partnerships with commercial and international partners; including through our Commercial Lunar Payload Services initiative, our industry partners will begin in 2021 to deliver science and tech payloads to virtually anywhere on the Moon, including the poles and far side



FY21 Budget Strategy

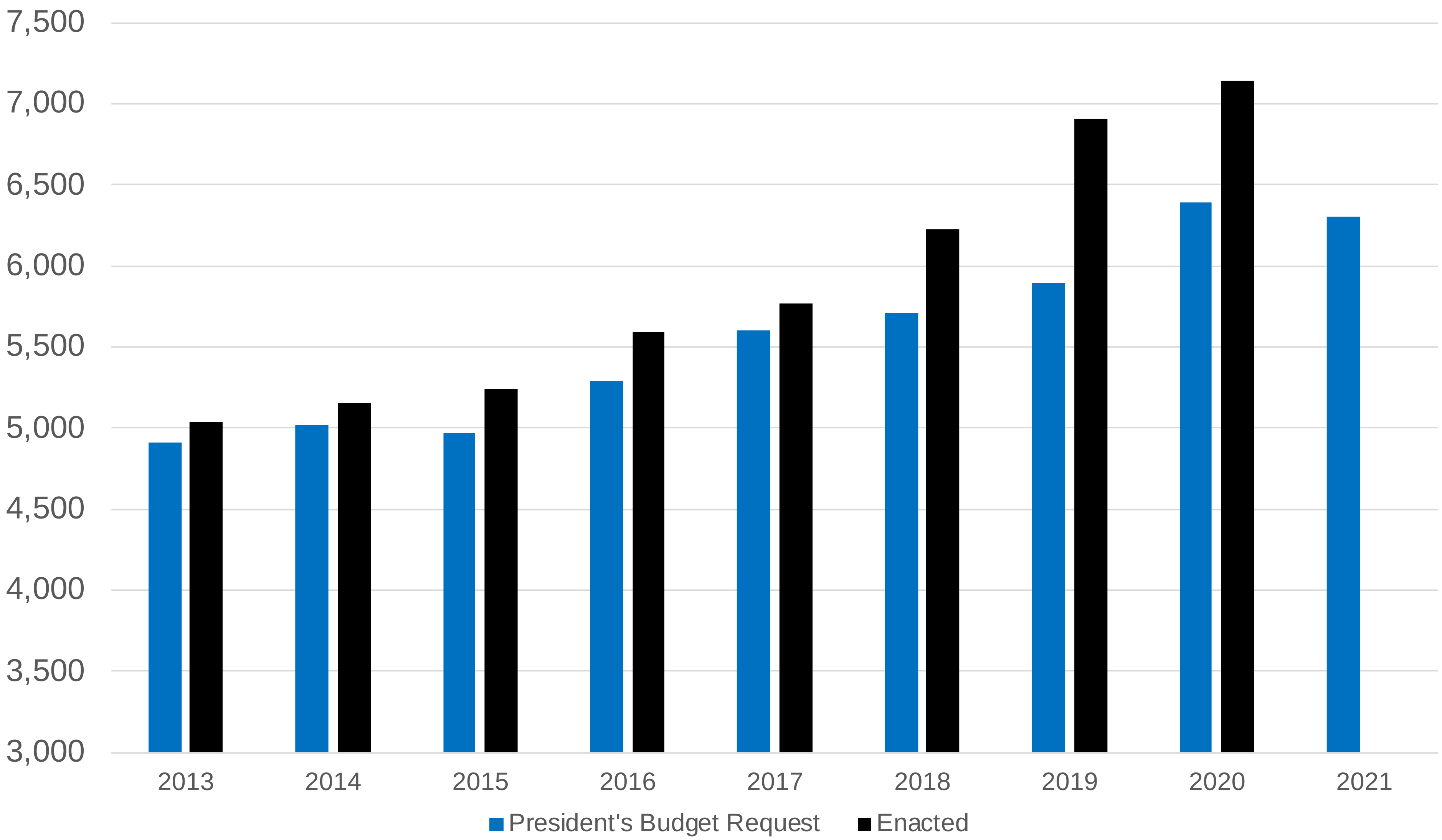
Support Artemis

Implement a Balanced and Integrated Science Program

Advance Compelling Science Program with Highest National Priorities

Execute Innovative Partnerships

President’s Science Budget Request and Enacted



Cost Performance of Recently Launched Missions

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

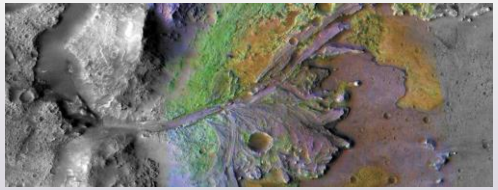
	KDP-C Baseline	Actual/ Estimated	Actual vs. Original
NuSTAR	109.9	116.0	6%
Landsat 8	583.4	502.8	-14%
IRIS	140.7	143.0	2%
LADEE	168.2	188.2	12%
MAVEN	567.2	472.0	-17%
GPM	555.2	484.3	-13%
OCO-2	249.0	320.3	29%
SMAP	485.7	454.3	-6%
MMS	857.3	875.3	2%
Astro-H	44.9	71.2	59%
OSIRIS-REx	778.6	620.8	-20%
CYGNSS	151.1	127.1	-16%
SAGE-III	64.6	88.2	37%
TSIS-1	49.8	19.8	-60%
TESS	323.2	273.4	-15%
InSight	541.8	635.8	17%
GRACE-FO	264.0	238.1	-10%
Parker	1055.7	955.7	-9%
ICESat 2	558.8	713.2	28%
GEDI	91.2	85.5	-6%
OCO-3	62.5	62.2	-1%
ICON	196.0	205.4	5%
Total	7898.7	7652.8	-3%

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

FY21 Budget

Program Highlights

Planetary Science

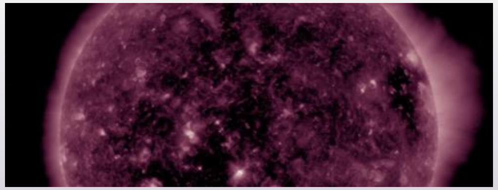


- Lunar Discovery and Exploration grows commercial partnerships and innovative approaches to science, technology, and human exploration objectives
- Enables Mars Sample Return launch in 2026, begin planning Ice Mapper mission
- Supports Europa Clipper on SLS in 2025: proposes commercial launch in 2024 to save ~$1.5 billion

Astrophysics

- Accommodates Webb re-plan for 2021 launch
- Maintains regular cadence of Astrophysics Explorers and Missions of Opportunity
- Initiates Pioneers, an innovative new line of SmallSats and major balloon missions
- Given significant cost and competing priorities within NASA, provides no funding for WFIRST
- Proposes termination of SOFIA due to its cost and lower productivity than other missions

Heliophysics

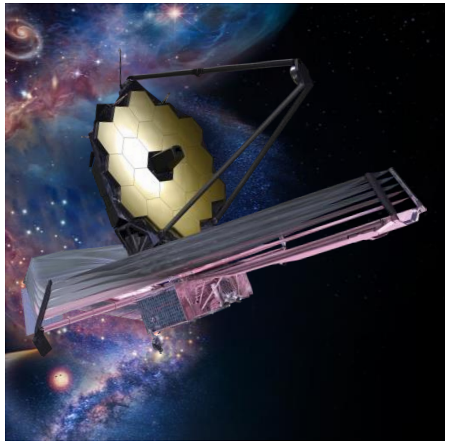
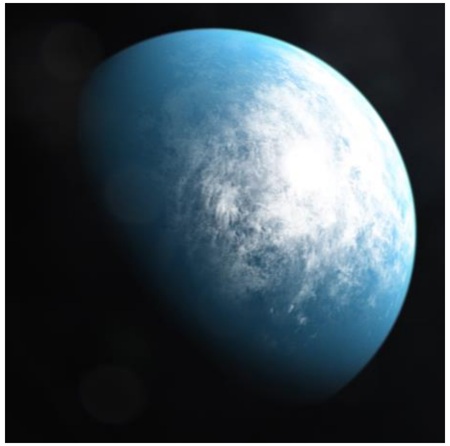
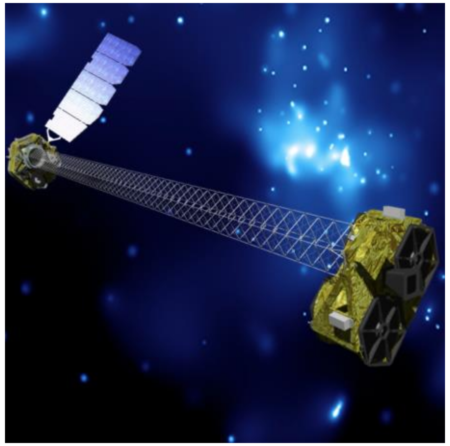
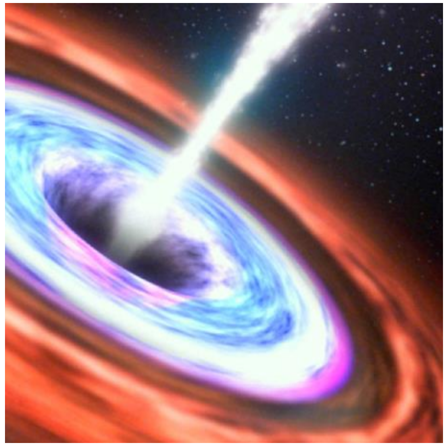


- Space Weather increase strengthens cross-agency collaboration on Research-to-Operations/Operations-to-Research
- Enables launch of Global Dynamics Constellation, the next LWS mission, as early as 2026
- Provides for a balanced Heliophysics portfolio, including enhanced emphasis on small missions, technology development and expanded opportunities for R&A

Earth Science

- Advances focused, balanced Earth science portfolio
- Maintains regular cadence of Venture Class solicitations
- Initiates the first Designated Observable mission from the most recent Decadal Survey
- Enables healthy research and applied science programs, and SmallSat/CubeSat investments

Astrophysics

- Supports Webb launch in 2021
- Maintains decadal cadence of four AOs per decade for Astrophysics Explorers and Missions of Opportunity
- Maintains healthy research program including suborbital-class missions, technology development, data analysis, theoretical and computational investigations, and laboratory astrophysics
- Initiates new class of Astrophysics Pioneers: SmallSats and major balloon missions with reduced management overhead compared to traditional Astrophysics Explorers
- Extends operating missions beyond FY20 following 2019 Senior Review
- Supports formulation of a probe mission as early as 2022
- Supports mission concept studies and technology investments to implement Astrophysics Decadal Survey priorities starting in 2022
- Terminates SOFIA due to high operating costs and lower science productivity to date
- Given its significant cost and competing priorities within NASA, provides no funding for WFIRST space telescope

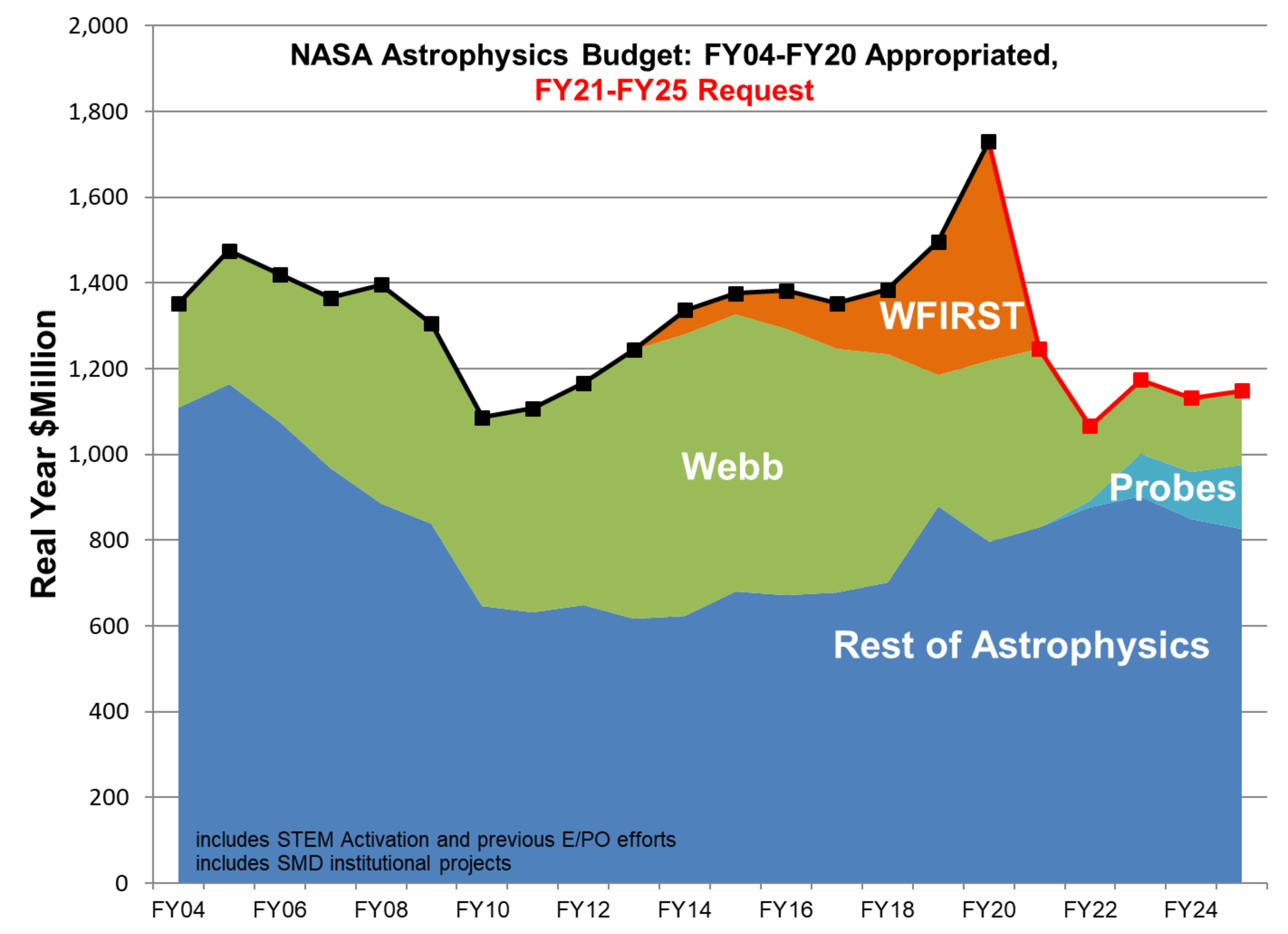
Astrophysics Budget Features

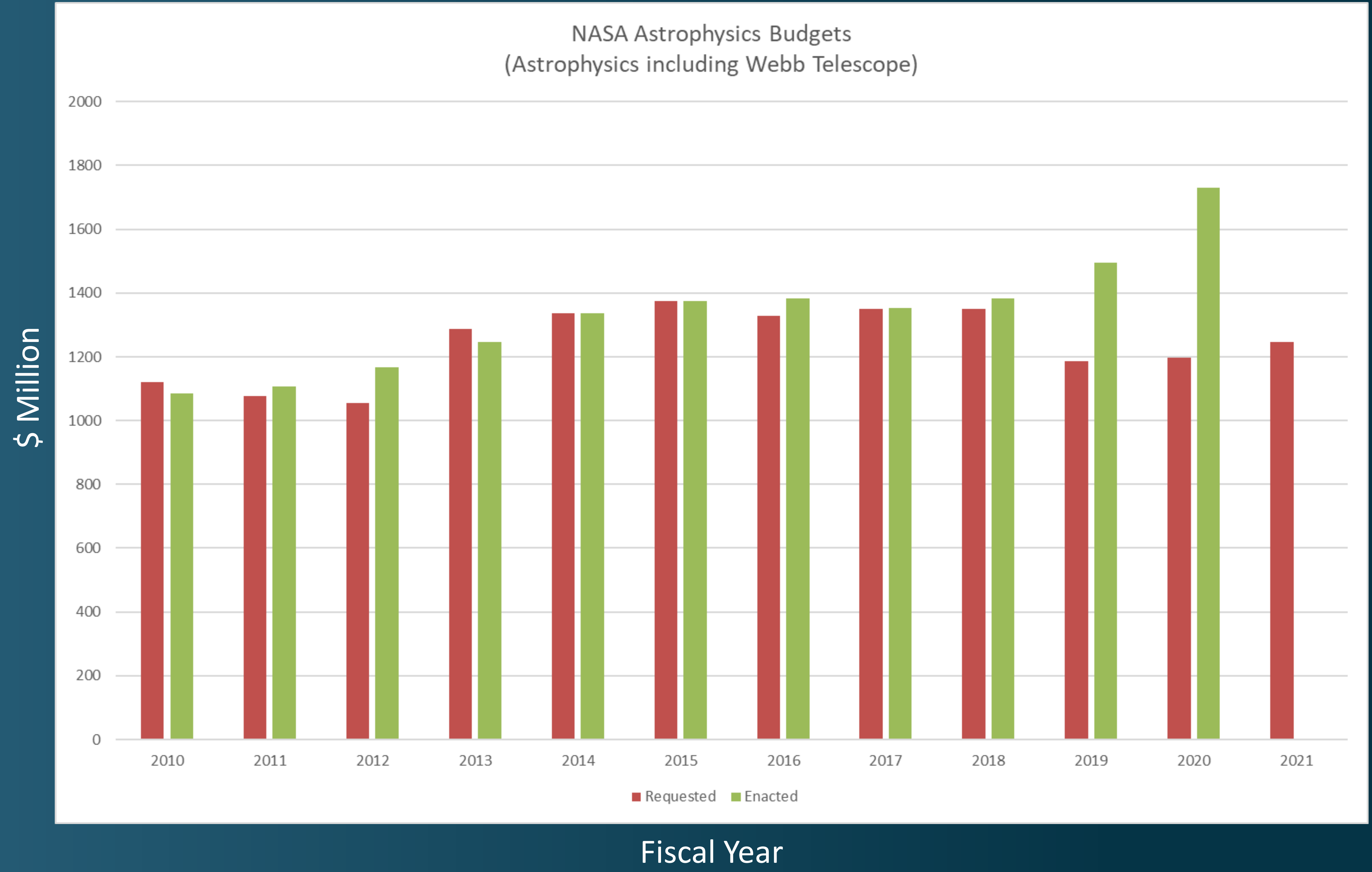
What's Changed

- Astrophysics Pioneers initiated for SmallSats and major balloon missions
- SPHEREx selected as next Astrophysics Medium Explorer
- CASE selected as Explorer Mission of Opportunity on ESA's ARIEL mission
- Extends Fermi, NICER, NUSTAR, Swift, TESS, XMM per 2019 Senior Review
- Proposes termination of SOFIA due to its high cost and lower scientific productivity than other missions

What's the Same

- Webb proceeding toward launch in 2021
- Provides no funding for WFIRST space telescope; instead, focuses on completing Webb
- Spitzer operations ended January 2020
- Hubble, Chandra, and other operating missions continue
- IXPE, GUSTO, XRISM, and Euclid development on track and within budget
- CubeSat initiative and balloon campaigns within healthy research program
- Science Activation at $45.6M/year


NASA Astrophysics Budget: FY04-FY20 Appropriated,
FY21-FY25 Request
Real Year $Million
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
WFIRST
Webb
Probes
Rest of Astrophysics
includes STEM Activation and previous E/PO efforts
includes SMD institutional projects
FY04
FY06
FY08
FY10
FY12
FY14
FY16
FY18
FY20
FY22
FY24


NASA Astrophysics Budgets
(Astrophysics including Webb Telescope)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Requested
Enacted
$ Million
Fiscal Year

Science Budget Request Summary ($M)

	Actual FY 19	Request FY 20	Enacted FY 20	Request FY 21	Out-years FY 22	FY 23	FY 24	FY 25
Science	**6,886.6**	**6,393.7**	**7,138.9**	**6,306.5**	**6,553.5**	**6,575.7**	**6,705.2**	**6,766.9**
Earth Science	**1,931.0**	**1,779.8**	**1,971.8**	**1,768.1**	**1,878.2**	**1,846.1**	**1,834.5**	**1,984.6**
Earth Science Research	454.1	447.9		447.3	471.9	494.1	528.5	530.3
Earth Systematic Missions	932.7	719.2		608.3	706.1	695.6	640.7	797.3
Earth System Science Pathfinder	223.8	275.4		338.9	301.2	251.6	241.8	234.4
Earth Science Data Systems	202.0	214.4		245.4	259.9	263.2	278.7	277.7
Earth Science Technology	63.4	69.6		74.2	82.8	84.6	86.4	86.4
Applied Sciences	55.1	53.3		53.9	56.3	57.0	58.5	58.5
Planetary Science	**2,746.7**	**2,712.1**	**2,713.4**	**2,659.6**	**2,800.9**	**2,714.9**	**2,904.8**	**2,830.7**
Planetary Science Research	276.6	266.2		305.4	288.6	285.1	295.2	286.7
Planetary Defense	150.0	150.0	160.0	150.0	147.2	97.6	98.0	98.0
Lunar Discovery and Exploration	188.0	300.0	300.0	451.5	517.3	491.3	458.3	458.3
Discovery	409.5	502.7		484.3	424.4	434.8	570.1	505.8
New Frontiers	93.0	190.4		179.0	314.3	332.8	326.9	285.0
Mars Exploration	712.7	546.5	570.0	528.5	588.4	671.2	798.7	855.3
Outer Planets and Ocean Worlds	793.6	608.4		414.4	370.7	239.4	192.3	171.7
Radioisotope Power	123.3	147.9	147.9	146.3	150.1	162.8	165.4	169.8
Astrophysics	**1,191.1**	**844.8**	**1,306.2**	**831.0**	**891.2**	**1,000.9**	**959.7**	**975.5**
Astrophysics Research	222.8	250.7		269.7	279.1	327.2	314.9	331.1
Cosmic Origins	222.8	185.3		124.0	123.2	120.0	122.4	122.4
Physics of the Cosmos	151.2	148.4		143.9	160.8	155.3	169.8	154.1
Exoplanet Exploration	367.9	46.4		47.2	50.4	47.6	51.6	52.2
Astrophysics Explorer	226.5	214.1		246.2	277.7	350.8	301.0	315.6
James Webb Space Telescope	**305.1**	**352.6**	**423.0**	**414.7**	**175.4**	**172.0**	**172.0**	**172.0**
Heliophysics	**712.7**	**704.5**	**724.5**	**633.1**	**807.8**	**841.8**	**834.1**	**804.1**
Heliophysics Research	248.9	237.0		230.5	218.7	225.2	224.0	224.5
Living with a Star	135.3	107.6		127.9	134.5	246.4	225.5	233.3
Solar Terrestrial Probes	180.5	177.9	183.2	126.3	262.2	202.6	195.6	115.5
Heliophysics Explorer Program	147.9	182.0	182.0	148.4	192.4	167.6	189.0	230.8

Astrophysics Program Content

	Actual	Request	Enacted	Request	Out-years			
	FY 19	FY 20	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25
Astrophysics	**1,191.1**	**844.8**	**1,306.2**	**831.0**	**891.2**	**1,000.9**	**959.7**	**975.5**
Astrophysics Research	222.8	250.7	250.7	269.7	279.1	327.2	314.9	331.1
Astrophysics Research and Analysis	83.4	86.6		90.2	92.2	94.2	94.2	94.2
Balloon Project	40.2	44.8		44.8	45.8	45.7	46.3	46.3
Science Activation	45.0	45.6	45.6	45.6	45.6	45.6	45.6	45.6
Other Missions and Data Analysis	54.2	73.7		89.1	95.5	141.7	128.8	145.0
Astrophysics Data Curation and Archival	17.9	21.2		24.5	26.3	26.4	28.5	28.7
Astrophysics Data Program	19.1	20.4		21.6	22.6	23.6	23.6	23.6
Astrophysics Senior Review		-				51.2	50.4	49.9
Contract Administration, Audit & QA Svcs	12.7	12.7		17.3	17.3	17.3	17.3	17.3
Astrophysics Directed R&T	4.5	19.4		25.7	29.4	23.3	9.0	25.5
Cosmic Origins	222.8	185.3		124.0	123.2	120.0	122.4	122.4
Hubble Space Telescope	98.3	83.3	90.8	88.3	98.3	98.3	98.3	98.3
SOFIA	85.2	73.0	85.2	12.0				
Other Missions and Data Analysis	39.3	29.0		23.7	24.9	21.7	24.1	24.1
(development / formulation / technology)								
Cosmic Origins SR&T	24.8	17.1		18.4	18.4	18.4	18.4	18.4
Cosmic Origins Future Missions	0.8	2.2		2.7	4.6	1.6	3.8	3.8
(operating)								
Spitzer	13.2	8.5		1.0				
(research and management)								
Astrophysics Strategic Mission Prog Mgmt	0.4	1.2		1.6	1.9	1.7	1.9	2.0

Astrophysics Program Content

	Actual	Request	Enacted	Request	Out-years			
	FY 19	FY 20	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25
Physics of the Cosmos	151.2	148.4		143.9	160.8	155.3	169.8	154.1
(development / formulation / technology)								
Euclid	17.2	13.7		11.0	8.9	9.9	10.3	9.5
Physics of the Cosmos SR&T	45.7	50.9		45.9	61.2	75.2	87.0	72.1
Physics of the Cosmos Future Missions	0.0	2.0		1.6	4.6	2.0	3.7	3.7
(operating)								
Chandra X-Ray Observatory	61.7	58.4		62.3	62.8	62.8	62.8	62.8
Fermi Gamma-ray Space Telescope	16.5	14.0		13.8	13.9			
XMM	4.5	3.5		3.5	3.5			
(research and management)								
PCOS/COR Technology Office Management	5.6	5.9		5.9	6.0	5.4	6.0	6.0
Exoplanet Exploration	367.9	46.4		47.2	50.4	47.6	51.6	52.2
(development / formulation / technology)								
WFIRST	312.2		510.7					
Exoplanet Exploration SR&T	32.1	29.1		31.5	32.0	31.3	30.5	31.2
Exoplanet Exploration Future Missions	0.7	2.8		1.7	3.5	1.6	5.4	5.4
(operating)								
Keck Operations	6.5	6.7		6.9	7.0	7.2	7.4	7.4
Kepler	8.9	1.3						
(research and management)								
Exoplanet Exploration Technoloy Off Mgmt	7.5	6.5		7.1	7.8	7.4	8.2	8.1

Astrophysics Program Content

	Actual	Request	Enacted	Request	Out-years			
	FY 19	FY 20	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25
Astrophysics Explorer	226.5	214.1		246.2	277.7	350.8	301.0	315.6
(development / formulation / technology)								
SPHEREx	22.2			90.8	109.1	87.7	28.4	13.0
Imaging X-Ray Polarimetry Explorer	57.0	70.2		45.3	7.4	4.5	0.5	
X-Ray Imaging and Spectroscopy Mission	23.2	29.7		25.1	36.3	17.7	15.9	14.4
CASE				11.9	10.2	10.0	6.4	1.0
GUSTO	19.9	11.1		7.8	5.8	1.0		
Astrophysics Explorer Future Missions	2.3	84.8		10.6	58.0	219.2	241.5	278.1
Universe Explorer Prior Hist Projects	70.0							
(operating)								
Transiting Exoplanet Survey Satellite	7.7	5.0		14.7	14.1			
Nuclear Spectroscopic Telescope Array	8.5	7.8		8.6	8.6			
Neil Gehrels Swift Observatory	7.0	5.5		5.8	5.8			
NICER	3.8			4.8	4.4			
(research and management)								
Astrophysics Explorer Program Management	4.9			20.7	18.0	10.7	8.3	9.1
James Webb Space Telescope	**305.1**	**352.6**	**423.0**	**414.7**	**175.4**	**172.0**	**172.0**	**172.0**
Astrophysics + Webb Total	**1,496.2**	**1,197.3**	**1,729.2**	**1,245.7**	**1,066.6**	**1,172.9**	**1,131.7**	**1,147.5**

NASA Astrophysics
Program and Budget Update

Astrophysics Research by the NUMBERS

R&A PROGRAMS

>1,000 Proposals Received
26% Success Rate
~$100M Awarded Annually

TECHNOLOGY DEVELOPMENT

~$140M Invested Annually

CUBESATS

6 Current Programs
~1 Launch Per Year

NEW PIs

>180 Per Year in R&A Prog
>120 Per Year in GO Prog

SOUNDING ROCKETS

9 Current Programs
3-4 Launches Per Year

GO PROGRAMS

>2,000 Proposals Received
19% Success Rate
~$70M Awarded Annually

BALLOONS

18 Current Programs
3-6 Launches Per Year

Research and Analysis Initiatives

Dual Anonymous Peer Review

- SMD is strongly committed to ensuring that review of proposals is performed in an equitable and fair manner that reduces the impacts of any unconscious biases

High-Risk/ High-Impact (HR/HI)

- To reinforce SMD's interest in High-Risk/High-Impact research, a special review process will be implemented in ROSES 2020 to review and select HR/HI proposals

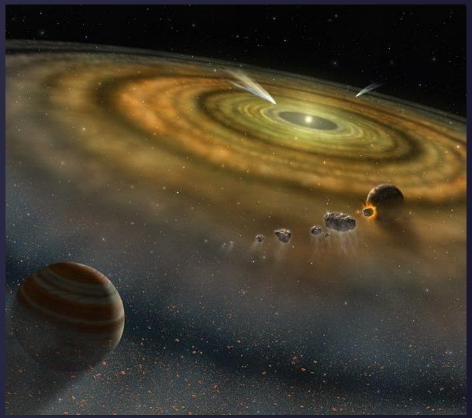
Proposal Selection Metrics for ROSES 2018

- Overall, just under 50% of selections featured new PIs
- Majority of division selection rates were between 25 – 30%, and we are continuing to evaluate

https://science.nasa.gov/researchers/dual-anonymous-peer-review

Request for Information:

Research That Falls in Gap between current SMD Solicitations

- Release Date: Dec 2, 2019
  (Solicitation: NNH20ZDA003L)
- Response Date: Jan 31, 2020
- NASA SMD is soliciting information on research aligned with agency mission and SMD's Science Plan but falls in a gap between current solicitations, possibly because it's interdisciplinary or interdivisional
- Responses will be used by NASA to inform decision as to whether portfolio of current program elements in ROSES needs to be modified and/or expanded to provide the proper avenue for such research
- Full text of RFI and response instructions on the NSPIRES website

Response to “Research Gap” RFI

104 responses submitted

~40% NASA Centers, ~25% universities,~25% science centers/labs, ~10% private sector

Main themes:

- “Earth in context”: Earth / Sun interaction + upper atmosphere, Earth as one of the inner planets, Earth in an exoplanet context, ancient Earth & habitability
- Cross-divisional topics: technology, software & data analysis techniques, lab-astro
- Interdisciplinary / cross-divisional research submitted previously and not funded
- Requests for NASA to support ground based astronomy

Next Steps:

- Each response being reviewed and categorized by a cross-Division team
  - How does research fit within the mission of division / directorate / agency?
  - Can it be submitted within current ROSES elements as written or does it require modification of ROSES language?
  - Are there barriers to acceptance?

Team will present a thorough analysis and recommendations to SMD in a few months

ROSES-2020 R&A Elements

Update this Meeting by Stefan Immler

Supporting Research and Technology

- Astrophysics Research & Analysis (APRA**)**
- Strategic Astrophysics Technology (SAT)
- Roman Technology Fellowships (RTF)
- Astrophysics Theory Program (ATP) (biennial, not this year)
- Theoretical and Computational Astrophysics Networks (TCAN) (triennial, this year)
- Exoplanet Research Program (XRP) (cross-div)
- Topical Workshops, Symposia, and Conferences (TWSC)

Data Analysis

- Astrophysics Data Analysis (ADAP)
- GO/GI programs for:
  - Fermi
  - Swift
  - NuSTAR
  - TESS
  - NICER

Mission Science and Instrumentation

- Sounding rocket, balloon, cubesat, and ISS payloads solicited through APRA
- XRISM Guest Scientists (one time)
- Astrophysics Explorers U.S. Participating Investigators (triennial, this year)
- Pioneers

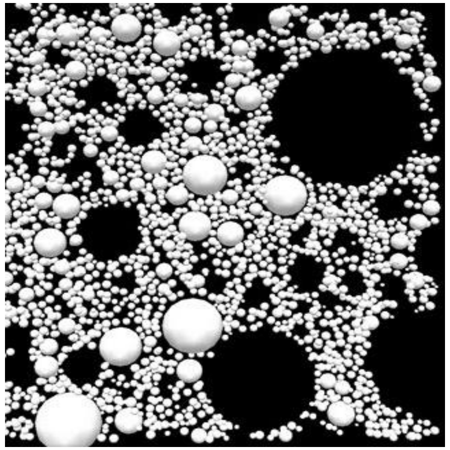
Separately Solicited

- GO/GI/Archive/Theory programs for:
  - Chandra
  - Hubble
  - SOFIA
  - Webb
- NASA Hubble Fellowship Program
- NASA Postdoctoral Program
- FINESST Graduate Student Research Awards

New in ROSES-2020:

- APD participates in cross-divisional TWSC
- XRISM Guest Scientist
- Astrophysics Explorers U.S. Participation Investigators (APEX USPI) (not R&A)
- Pioneers (see presentation by Michael Garcia)
- GO & ADAP proposals will be evaluated dual-anonymously
- Data Management Plan will be evaluated as part of the intrinsic merit of proposals
- High Risk / High Impact: special review process will be implemented
- Announcement that ROSES-2021 will enable open software/code/source/models

Strategic Data Management

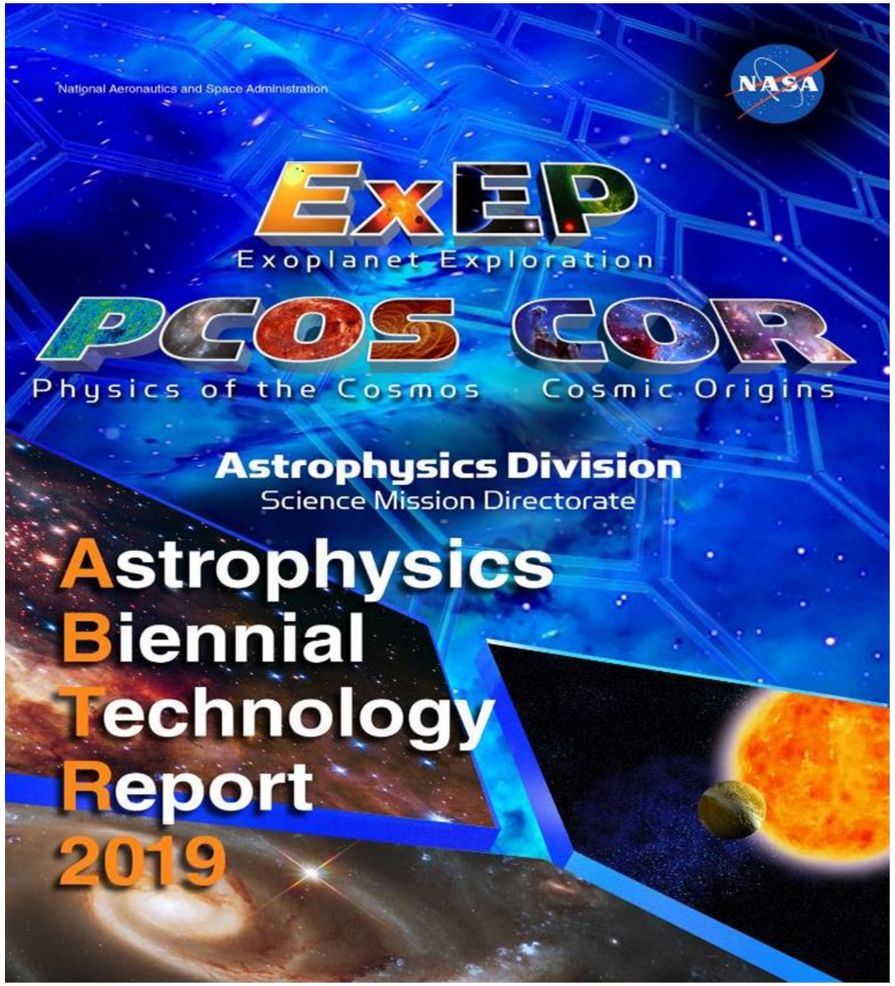


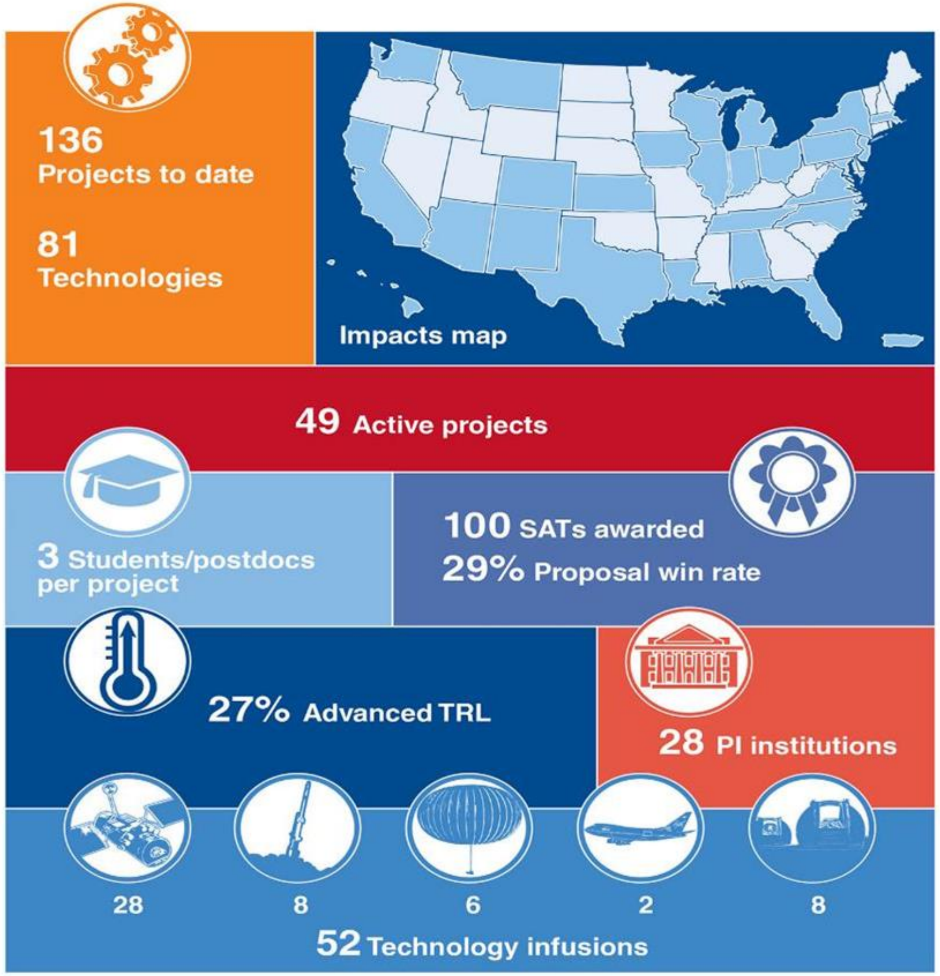
- SMD will be implementing changes to enable open data, open source code, and open model
- Informed by community input through multiple workshops, RFI, and NASEM reports
- Recognize that this will be a step wise process with the first changes coming in ROSES 2020 and upcoming Senior Reviews
- Periodic evaluation to ensure effectiveness and consistency with current best practices
- Additional information on SMD's data activities is available at: https://science.nasa.gov/researchers/science-data

Update this Meeting by Patricia Knezek

https://science.nasa.gov/researchers/science-data

Integrated Strategic Technology Portfolio





Astrophysics Biennial Technology Report: https://apd440.gsfc.nasa.gov/technology.html

Database of Astrophysics technology projects: http://www.astrostrategictech.us/

NASA Astrophysics Missions Update

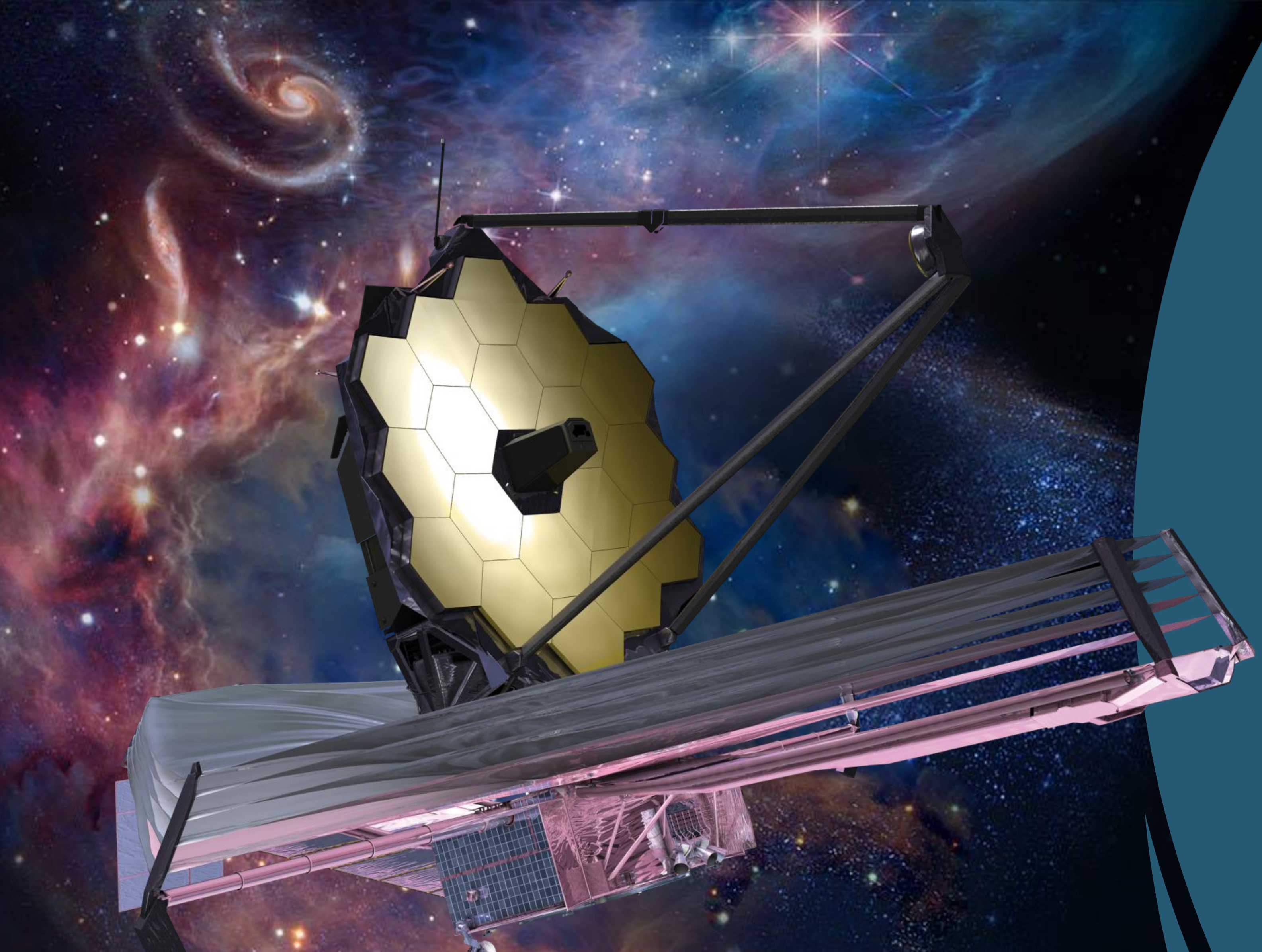
Webb

The James Webb Space Telescope

An international mission to seek first light of stars and galaxies in the early universe and explore distant planets

- ***Seeking Light from the First Stars and Galaxies***
- ***Exploring Distant Worlds—Exoplanets & the Outer Solar System***

Led by NASA, in partnership with ESA and CSA



Science program defined through peer-review, including future key projects

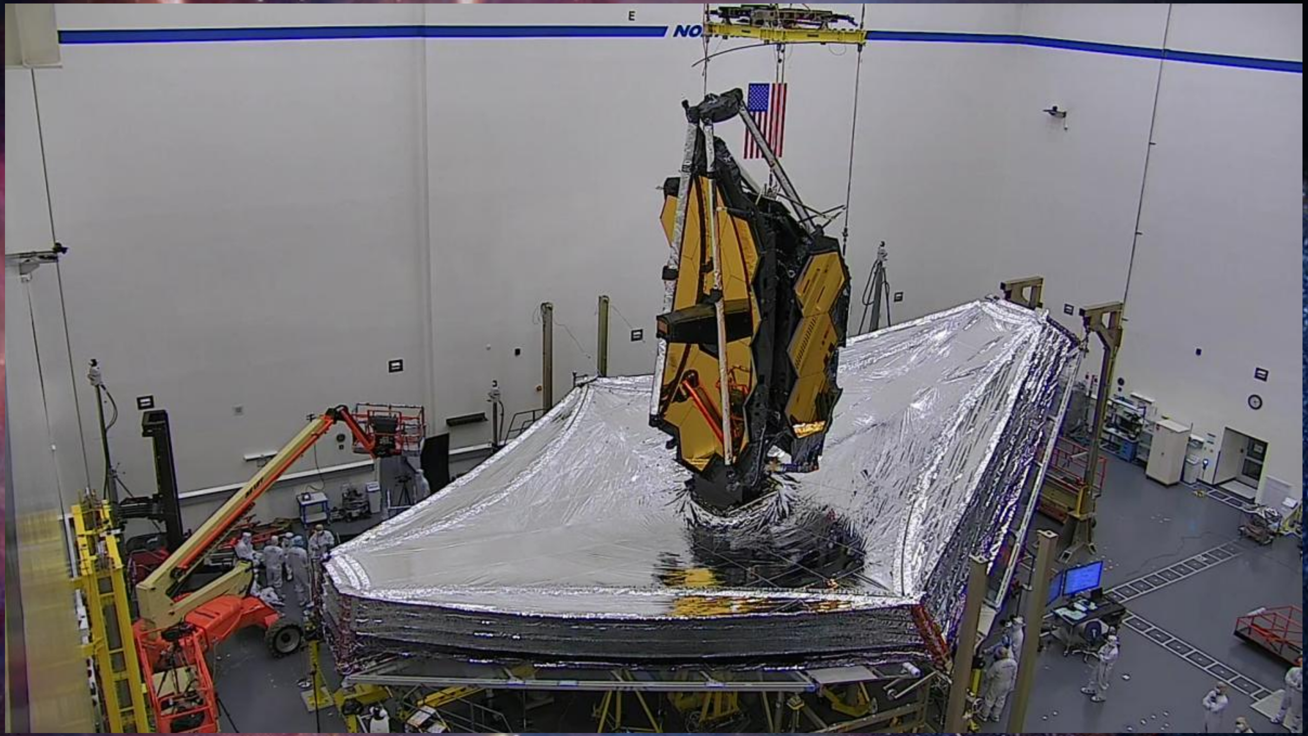
Observations spanning a wide variety of Astrophysics are already in the works through the Guaranteed Time Observers programs and the Early Release Science program

https://webb.nasa.gov/

Webb

The James Webb Space Telescope

- Observatory is fully integrated
- Observatory-level environmental testing (vibration and acoustics) happening this Spring
- Final deployments follow environmental testing through the Summer
- Numerous launch and commissioning exercises occurring through the year at STScI
- Cycle 1 proposals due 1-May-2020
- Launch Readiness Date 31-March-2



The Webb observatory in the clean room in Redondo Beach, CA in August 2019

Wide-Field Infrared Survey Telescope

Science Program

- Cosmology : Dark energy and the fate of the universe – wide field surveys to measure the expansion history and the growth of structure
- Exoplanet Demographics: The full distribution of planets around stars through a microlensing survey
- Astrophysics: Wide-field infrared surveys of the universe through General Observer and Archival Research programs

Technology development for the characterization of exoplanets through a Coronagraph Technology Demonstration Instrument

https://wfirst.gsfc.nasa.gov/

WFIRST: Wide-Field Infrared Survey Telescope

WFIRST is fully funded in FY20

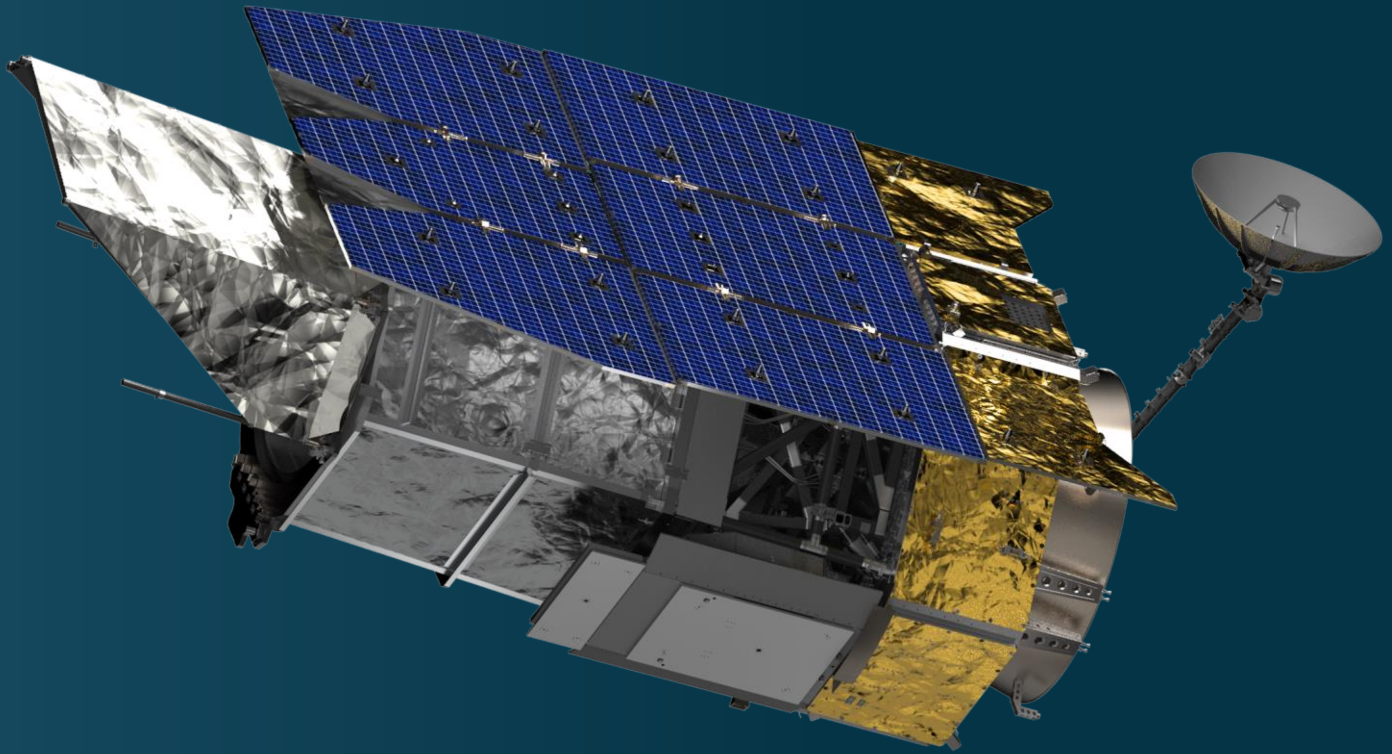
Nov 2019 -– Completed Preliminary Design Reviews

Early 2020 – Complete Confirmation Review and begin Implementation (Phase C)

2020: Flight hardware being developed: mirror being figured, detectors being fabricated, spacecraft subsystems being delivered, coronagraph demo unit in testbed

2021 – Complete Critical Design Reviews

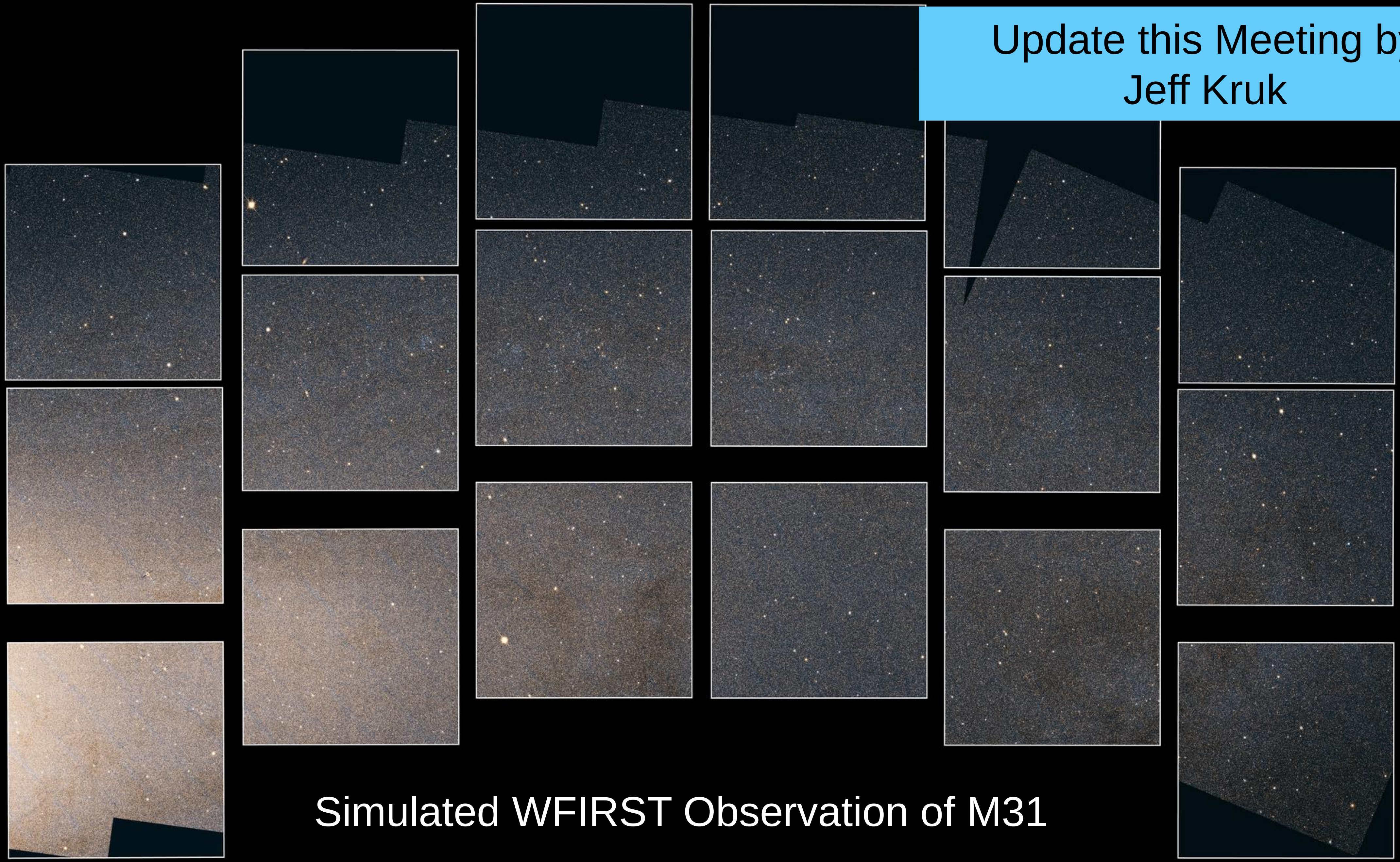
Mid-2020s – Launch



WFIRST field-of-view is 100x Hubble field-of-view

WFIRST is 100 to 1500 times faster than Hubble for large surveys at equivalent area and depth

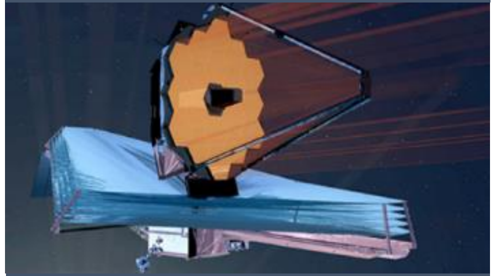
Update this Meeting by Jeff Kruk



Simulated WFIRST Observation of M31

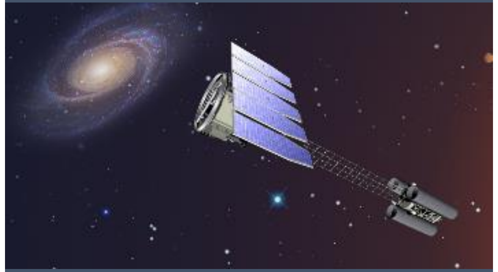
Astrophysics Missions in Development

Webb 2021
NASA Mission



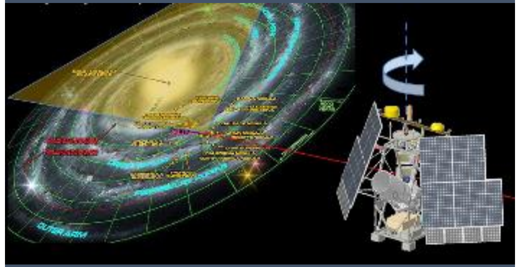
James Webb
Space Telescope

IXPE 2021
NASA Mission



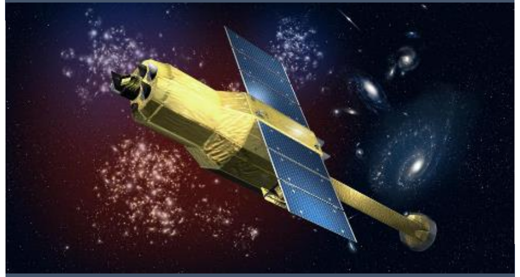
Imaging X-ray
Polarimetry Explorer

GUSTO 2021
NASA Mission



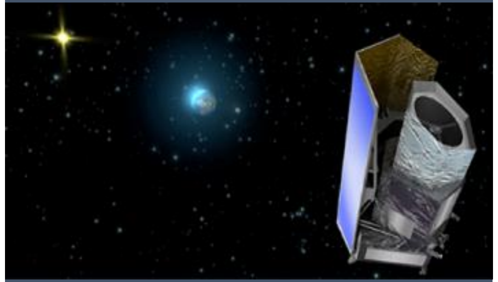
Galactic/ Extragalactic ULDB
Spectroscopic Terahertz Observatory

XRISM 2022
JAXA-led Mission



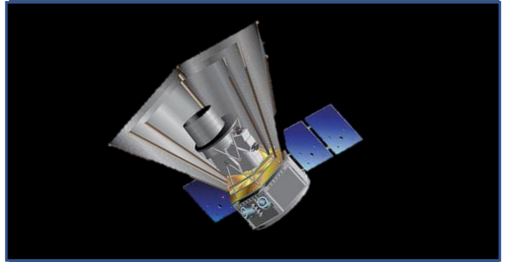
NASA is supplying the SXS
Detectors, ADRs, and SXTs

Euclid 2022
ESA-led Mission



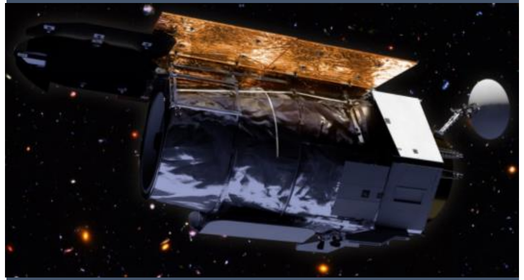
NASA is supplying the NISP
Sensor Chip System (SCS)

SPHEREx 2023
NASA Mission



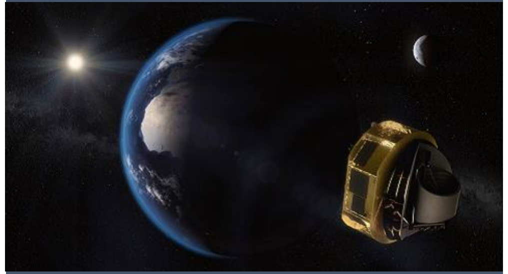
Spectro-Photometer for the History of
the Universe, Epoch of Reionization,
and Ices Explorer

WFIRST 2025
NASA Mission



Wide-Field Infrared
Survey Telescope

ARIEL 2028
ESA-led Mission

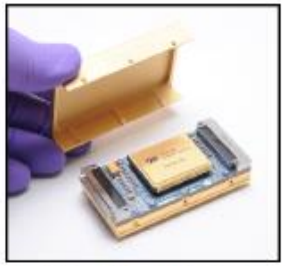


NASA is supplying the CASE
fine guidance instrument

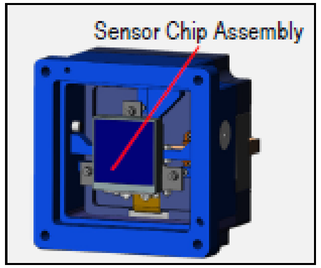
Launch dates are current project working dates; Agency Baseline Commitment launch date could be later

Partner Mission of Opportunity: ARIEL

Contribution to ARIEL Spectroscopy of Exoplanets
PI Mark Swain (JPL)

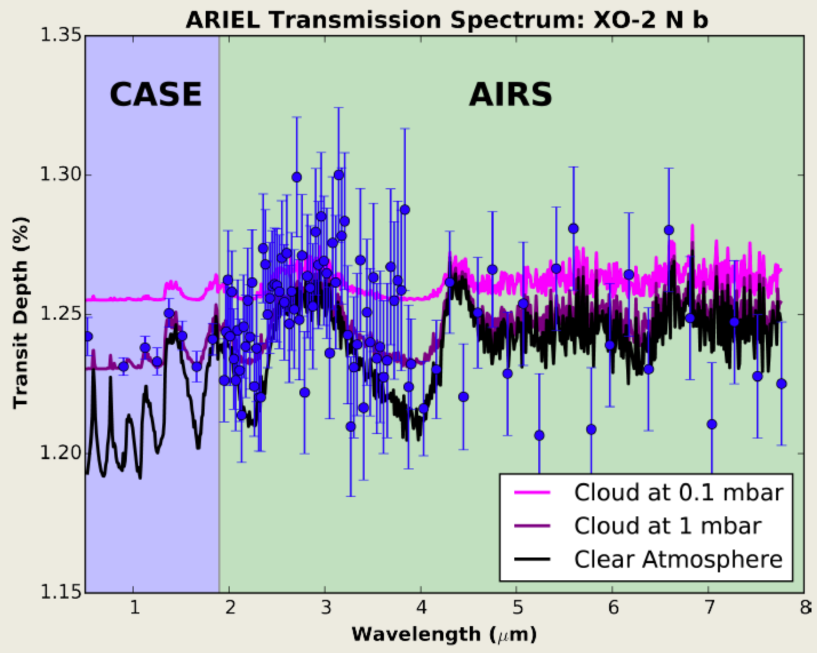


Cold Front End Electronics

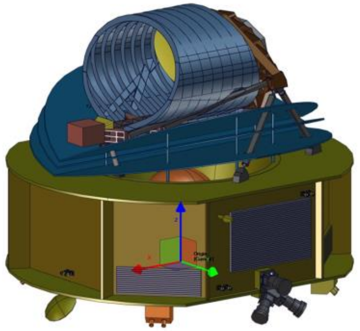


Focal Plane Module

CASE detectors and electronics would provide fine guidance for ARIEL; blueward data (0.5μm-2μm) enables studies of aerosols (clouds and hazes) which are important for the energy budget of the atmosphere.



CASE breaks the degeneracy between clear and cloudy atmospheres present at longer wavelengths. The blue dots are simulated, single-transit observations by CASE and AIRS, the two ARIEL instruments. Both instruments observe the object simultaneously. The target is a hot Jupiter planet with simulated clouds at 1 mbar.



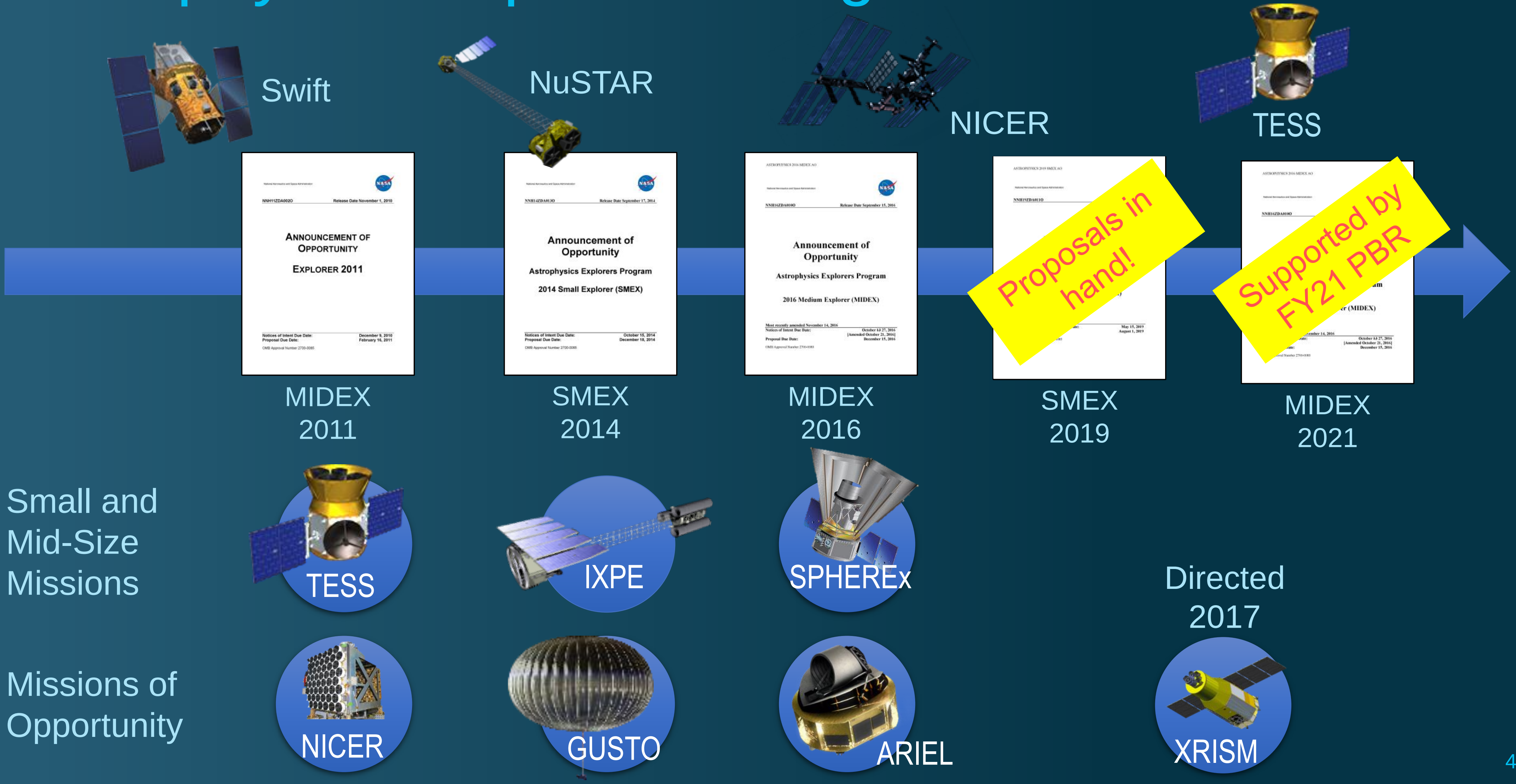
ARIEL: ESA M4 mission for Infrared Spectroscopy of Exoplanet Atmospheres
PI Giovanna Tinetti (UK)

Launch in 2028 to L2 for 4-yr mission; primary mirror 1.1m x 0.7m; CASE photometry complements AIRS spectroscopy 2μm-8μm.

ARIEL is next step beyond Kepler and TESS; will obtain spectra of hundreds of warm transiting exoplanets to study atmospheric chemistry and energy budget

https://arielmission.space/

Astrophysics Explorers Program



Astrophysics Pioneers

- The FY21 President's Budget Request contains a new initiative for Astrophysics – A new class of small missions

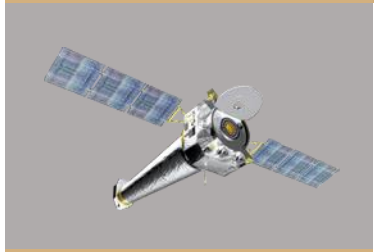
- Astrophysics Pioneers
  - Fill in the gap between existing ROSES investigations (<$10M for APRA) and existing Explorers MO investigations (<$35M for SmallSats)
  - Managed as Research and Analysis projects with enhanced oversight
  - Will be solicited through ROSES; relieves burden of writing full Explorers MO proposal
  - Will include SmallSats, Large CubeSats, CubeSat constellations (all as rideshare/secondary payloads), major balloon missions, and ISS attached payloads

Update this Meeting by Michael Garcia

Astrophysics Operating Missions

Hubble 4/90
NASA Strategic Mission

Hubble Space Telescope

Chandra 7/99
NASA Strategic Mission

Chandra X-ray Observatory

XMM-Newton 12/99
ESA-led Mission

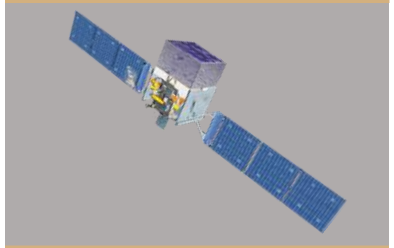
X-ray Multi Mirror - Newton

Spitzer 8/03
NASA Strategic Mission

Mission Complete!

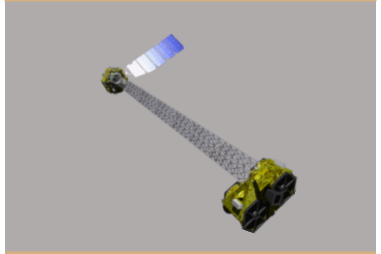
Gehrels Swift 11/04
NASA MIDEX Mission

Neil Gehrels Swift Gamma-ray Burst Explorer

Fermi 6/08
NASA Strategic Mission

Fermi Gamma-ray Space Telescope

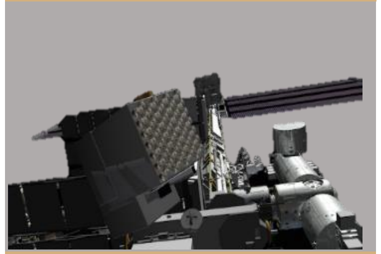
Kepler 3/09
NASA Discovery Mission

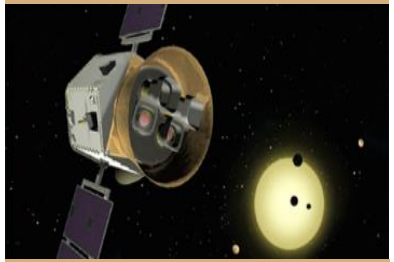
Mission Complete!

NuSTAR 6/12
NASA SMEX Mission

Nuclear Spectroscopic Telescope Array

SOFIA 5/14
NASA Strategic Mission

Stratospheric Observatory for Infrared Astronomy

ISS-NICER 6/17
NASA Explorers Miss. of Oppty

Neutron Star Interior Composition Explorer

TESS 4/18
NASA MIDEX Mission

Transiting Exoplanet Survey Satellite

Stratospheric Observatory for Infrared Astronomy (SOFIA)

https://www.sofia.usra.edu/

Update this Meeting by Naseem Rangwala

- Given its significant operating cost and lower science productivity to date, this budget request proposes to terminate SOFIA in FY21 and provides only close out funding in FY21
- This is a budget proposal for FY21. SOFIA is fully funded in the current year (FY20). NASA awaits the discussion by the Congress that will lead to an appropriation for FY21.
- While that Federal budget process plays out, the SOFIA project has been directed to continue operating as planned during FY20 and to realize the science planned for FY20.
- In the summer of 2019, as SOFIA approached the end of its five year prime mission, NASA conducted independent, external reviews of SOFIA's aircraft and science operations. These reviews provided recommendations on how SOFIA's science productivity could be increased in the future.
- The SOFIA project is also directed to continue implementing the recommendations of these review reports during FY20, as that will increase SOFIA's science productivity during FY20 while it is fully funded.

Currently Funded Astrophysics Suborbital Scientists

Balloons

APT	Jim Buckley	WA Univ St Louis
ASTHROS	Jorge Pineda	JPL
BLAST-TNG	Mark Devlin	U Penn
COSI	Stephen Boggs	UC Berkeley
CPC	Julie McEnery	GSFC
EUSO-SPB2	Angela Olinto	Univ of Chicago
EXCLAIM	Eric Switzer	GSFC
FIREBall-2	Chris Martin	Caltech
GAPS	Chuck Hailey	Columbia Univ
GRAPE	Mark McConnell	U New Hampshire
HELIX	Scott Wakely	Univ of Chicago
PICTURE-C	Supriya Chakrabarti	U Mass Lowell
PIPER	Al Kogut	GSFC
Spider	William Jones	Princeton
SuperBIT	William Jones	Princeton
SuperTIGER	Brian Rauch	WA Univ St Louis
THAI-SPICE	Eliot Young	SWRI Boulder
TIM	Joaquin Vieira	Univ Illinois
XL-Calibur	Henric Krawczynski	Washington Univ

Sounding Rockets

CIBER-2	Michael Zemcov	RIT
DEUCE	James Green	CU Boulder
DUST	Joe Nuth	GSFC
DXL	Massimiliano Galeazzi	Univ Miami
FORTIS	Stephan McCandliss	JHU
Micro-X	Tali Figueroa	Northwestern U
OGRE	Randall McEntaffer	Penn State U
SISTINE	Kevin France	CU Boulder
TREXS	Randall McEntaffer	Penn State U
XQC	Dan McCammon	Univ Wisc

CubeSats

BlackCat	Abe Falcone	Penn St.
BurstCube	Jeremy Perkins	GSFC
CUTE	Kevin France	CU Boulder
HaloSat	Phil Kaaret	U Iowa
SPARCS	Evgenya Shkolnik	AS
SPRITE	Brian Fleming	CU Boulder

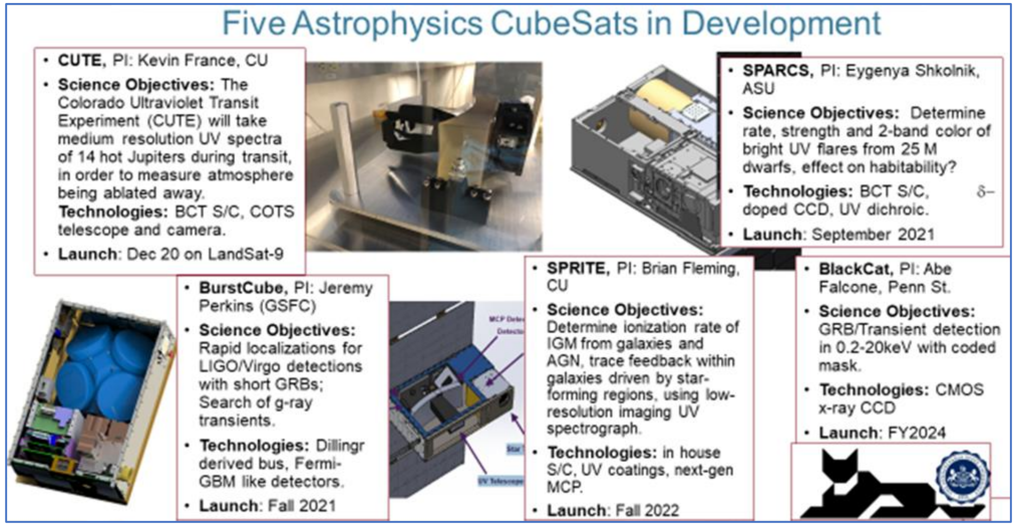
ISS

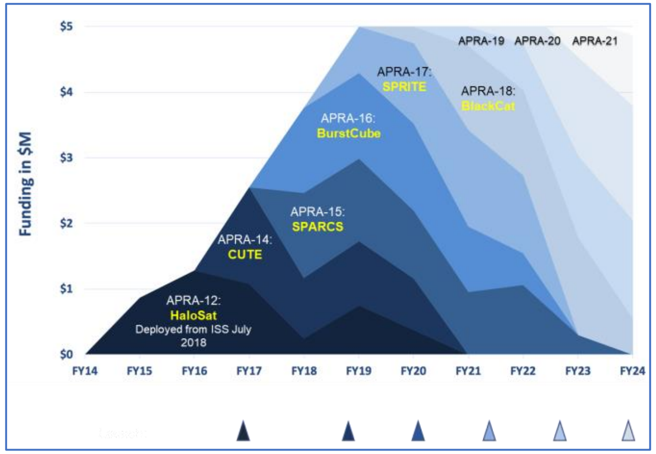
CALET	Greg Guzik	LA State Univ

Other

Glowbug	Eric Grove	NRL

SmallSats and CubeSats



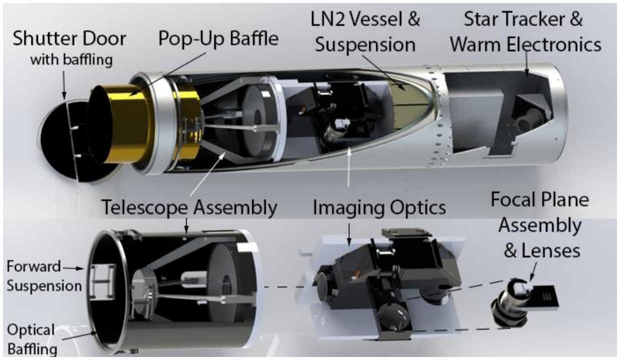


- NASA selected 9 Astrophysics Science SmallSat Studies in ROSES 2018. These studies were reported out at a special session of the June 2019 AAS meeting in St. Louis
- The 2019 Astrophysics Explorers Mission of Opportunity AO includes SmallSats and CubeSats launched using rideshare on ESPA or ESPA Grande; proposals are currently under evaluation along with other Small Explorer and Explorer Mission of Opportunity proposals
- A second Astrophysics Science SmallSat Studies solicitation is included in ROSES 2019; proposals are currently under evaluation
- NASA has selected 6 Astrophysics CubeSats through ROSES/APRA

Upcoming APD Sounding Rocket Launches

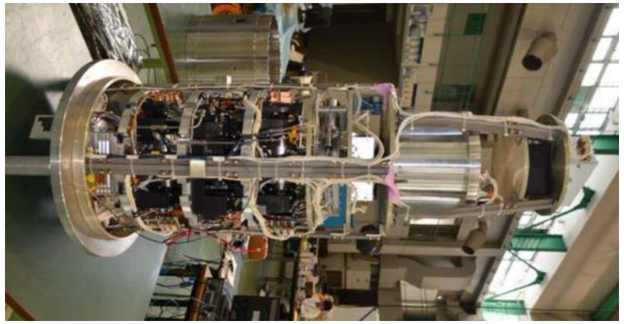
CIBER-2 (Cosmic Infrared Background ExpeRiment 2)

PI - **M. Zemcov** / RIT (WSMR) **TBD NET April 2020**
Measuring the Cosmic Near-Infrared Extragalactic Background Light.



DUST (Determining Unknown yet Significant Traits)

PI - **J. NUTH** / NASA/GSFC (WSMR) **October 1, 2020**
Measure infrared spectrum of analog dust grains during formation and agglomeration in microgravity, to determine variables in the end-to-end process of grain formation in circumstellar outflows around AGB stars.



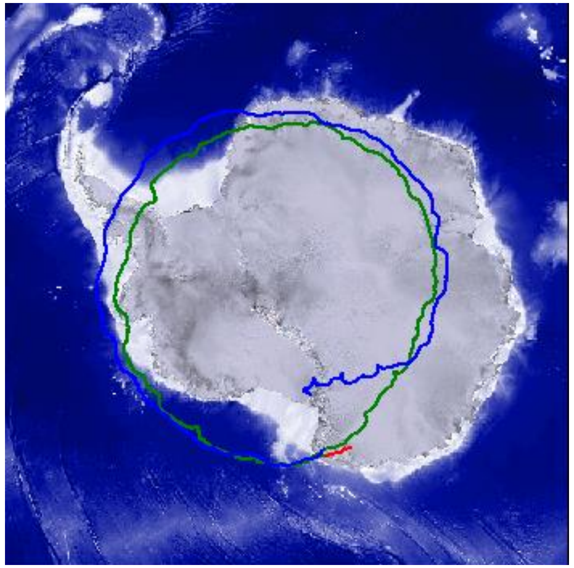
Micro-X

PI - **E. Figueroa** / Northwestern Univ. (WSMR) **TBD November 2020**
Characterizing plasma conditions in Puppis A SNR using Transition-Edge Sensors.

2019-2020 Antarctic Balloon Campaign

The Super Trans-Iron Galactic Element Recorder (SuperTIGER) instrument is used to study the origin of cosmic rays and was launched on Dec. 15, 2019. (Photo courtesy SuperTIGER team)

(Video courtesy SuperTIGER team)



Total Float Time
32 Days 11 hours 4 minutes

- **Upcoming balloon campaigns**: Winter 2019-2020 Antarctica, Spring 2020 New Zealand, Summer 2020 Palestine TX, Fall 2020 Fort Sumter NM, Winter 2020-2021 Antarctica

- **Upcoming sounding rocket campaigns**: 2020 White Sands Missile Range NM, 2021 Australia

https://www.csbf.nasa.gov/antarctica/ice.htm

Antarctica Recoveries 2019-2020

X-Calibur(Flown in FY19)

All CSBF components and X-Calibur mirror recovered this season. Remaining components will attempt to be recovered next season. Impact location is difficult to reach.

BLAST (Flown in FY20)

All items (CSBF and BLAST) have been recovered. Including the ~$1M mirror, which was crated and then slung below helicopter.

SuperTIGER (Flown in FY20)

All CSBF components and piggyback payloads recovered. Two science modules will remain on site for next year recovery. Basler recovery proposed to prevent damage to modules.

2020 New Zealand Superpressure Balloon (SPB) Campaign (launch planned for ~mid April 2020)

Prior SPB launch from Wanaka, NZ

- SPB design incorporates redesign and testing done since last SPB flight from New Zealand (NZ) in 2017 which was terminated over the Pacific Ocean due to leak issue.
- SPB fabrication is scheduled for completion in ~mid-March 2020, with delivery to NZ in ~early April 2020.
- SPB launch operations will also incorporate balloon collar-release lessons-learned from 2019 Ft. Sumner and Antarctica campaigns.
- SPB test flight will also include a payload mission of opportunity; specifically, the **Compton Spectrometer and Imager (COSI) gamma-ray telescope**
- Expect NZ Government approval in March 2020 of NASA SPB flight license request.

Wanaka, NZ

Super Pressure Balloon (SPB) Test Flight *Brian Hall, Wallops Flight Facility* **& Compton Spectrometer and Imager (COSI, Piggyback)** *Dr. Steven Boggs, Univ. of California, San Diego (formerly UC Berkeley)*

SPB Test Flight is a qualification flight for the SPB platform slated for the FY22 GUSTO launch from Antarctica and contains significant instrumentation and cameras to assess the balloon performance.

COSI is a gamma ray detector that will map gamma-ray lines from Galactic disk, detect and measure polarization from gamma-ray bursts, and detect gamma-ray point sources and is being flown as a mission of opportunity.

Schedule:

- Payload integration ongoing at CSBF.
- Compatibility testing is on schedule for 2/13/2020.
- Initial deployment of CSBF employees 2/16/2020.
- Payload to be air shipped by 2/24/2020.
- Balloon to be air shipped on 3/18/2020.
- Initial deployment of NASA employees 3/23/2020.
- Large contingent of NASA employees leave 3/30/2020.

Balloon Wanaka

Full Recommendation:

APAC also requests an update on the Wanaka site in the near future.

NASA Response:

For the FY20 Wanaka campaign, to accommodate the hardware and personnel required for the Super Pressure Balloon / COSI gondola and personnel a second aircraft hangar is being leased. The option of putting a temporary structure with higher interior height next to this leased hangar is being investigated. The Balloon Program Chief plans to visit with the Queenstown Airport Corporation personnel in April, 2020 while in New Zealand.   During that visit, the temporary and as well as potential permanent building will be discussed.

Balloon Palestine

Full Recommendation:

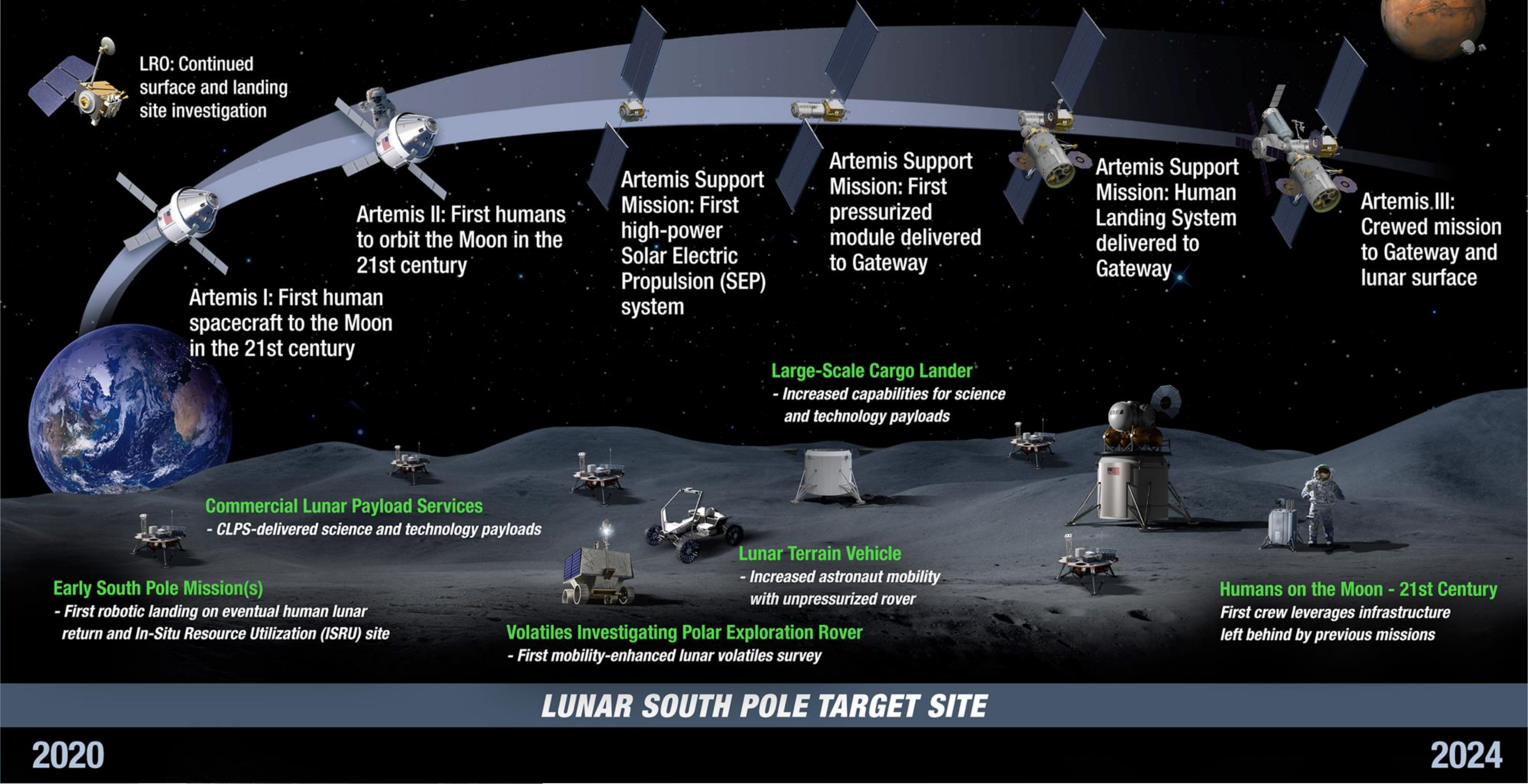
APAC recommends that the balloon program start evaluating alternate sites to Palestine, in light of the increasing restrictions due to population growth in the area, and limited ability to alter the risk posture. Specifically, the new site(s) should be evaluated on the feasibility of evening launches, which is required by some science cases, and is a capability uniquely offered in Palestine at this time.

NASA Response:

- The potential operational area for launching out of Burns, Oregon has been provided to WFF Safety for analysis.
- In addition, the BPO is developing a cost estimate for the additional activities required to fully assess the site for launch operations (Environmental Assessment, site-visit, pi-ball test program, etc.).

NASA Astrophysics
Planning for the Future

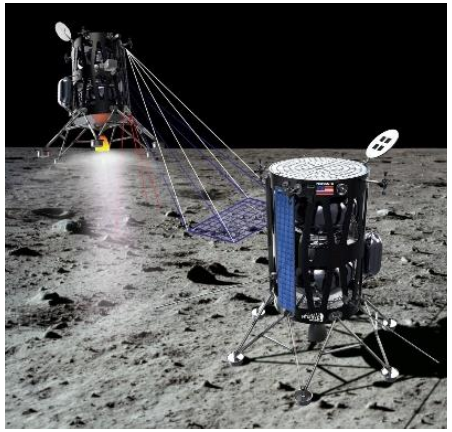
Humans Return by 2024



Astrophysics and Artemis

All science opportunities enabled by Project Artemis will include astrophysics

- Commercial Lunar Payload Services (CLPS)
  - 14 U.S. companies selected to bid on specific task orders to deliver NASA payloads to Moon's surface.
  - All payload calls include astrophysics; two astrophysics payloads selected to date
    - Internal NASA call: Low-frequency Radio Observations from the Near Side Lunar Surface instrument (PI: Robert MacDowall, GSFC); manifest through CLPS Task Order 2 on Intuitive Machines Lander for NET July 2021
    - ROSES call: Next Generation Lunar Retroreflectors (PI: Douglas Currie, University of Maryland); to be manifest through CLPS Task Order 19D for 2022
- Astrophysics Explorers Missions of Opportunity
  - 2019 AO included opportunities enabled by Project Artemis.
  - Future calls will solicit proposals that leverage Artemis capabilities, such as Gateway as a platform and cis-lunar communications infrastructure, to conduct compelling astrophysics investigations.



Intuitive Machines Lander

Most important criterion for all proposals that leverage Artemis remains the astrophysics science merit.

Astro 2020

Decadal Survey on Astronomy and Astrophysics

The National Academies of SCIENCES ENGINEERING MEDICINE

Response to October 2019 Recommendations - 1

- **Recommendation:** APAC would like to see a plan from Dr. Hertz for publicizing PI Launchpad and other efforts to increase diversity within NASA Astrophysics and to increase engagement from the broader community. APAC also requests a report on the success metrics, quantified to track outcomes resulting in the division-wide efforts to lower participation barriers for early-and mid-career investigators across a span of institutions and NASA Centers. APAC requests that APD track the impact of these programs on the diversity of Astrophysics missions, programs, and proposals submitted to the Astrophysics Division.

  ***Response:** Addressed by Paul Hertz in his presentation*

- **Request:** APAC also requests a report on the success metrics, quantified to track outcomes resulting in the division-wide efforts to lower participation barriers for early- and mid-career investigators across a span of institutions and NASA Centers. APAC requests that APD track the impact of these programs on the diversity of Astrophysics missions, programs, and proposals submitted to the Astrophysics Division.

  ***Response:** Addressed by Stefan Immler in his presentation*

Response to October 2019 Recommendations - 2

- **Request:** APAC requests the full SOMER and FMR reports prior to its next meeting. Any information that cannot be made public can be redacted.

  Response: *Redacted reports have been provided.*

- **Request:** APAC requests immediate action on the most urgent recommendations: separating the flight and science operations and increasing the flight hours at stratospheric altitudes.

  Response: *Addressed by SOFIA Project in presentation by Naseem Rangwala.*

- **Request:** APAC requests a written response from the SOFIA team, prior to the next meeting, on (i) the change in the flight operations that were implemented and whether they follow exactly the SOMER and FMR recommendations and (ii) the metrics of success the team will be judged by and how these compare quantitatively to the SOMER and FMR recommendations .

  Response: *Provided by SOFIA Project.*

- **Request:** APAC requests at its next meeting a presentation of a progress-status update for implementing the specific recommendations outlined in the SOMER and FMR reports.

  Response: *Addressed by SOFIA Project in presentation by Naseem Rangwala.*

Response to October 2019 Recommendations - 3

- **Request:** APAC also requests that the chairs of the SOMER and FMR reviews be present for that status report. In the event that SOFIA leadership declines to implement or substantially modifies a recommended action, or where progress has not been made, the APAC requests a report justifying those variances. The APAC further finds that the implementation of the SOMER and FMR recommendations, coupled with the metrics of the scientific output of the program after their implementation, should be presented in the context of the first SOFIA Senior Review. The continuation of the mission should be contingent upon meeting those metrics.

    ***Response:** SOMER and FMR Chairs in attendance.*

- **Recommendation:** APAC recommends that the balloon program start evaluating alternate sites to Palestine, in light of the increasing restrictions due to population growth in the area, and limited ability to alter the risk posture. Specifically, the new site(s) should be evaluated on the feasibility of evening launches, which is required by some science cases, and is a capability uniquely offered in Palestine at this time. APAC also requests an update on the Wanaka site in the near future.

    ***Response:** Addressed by Paul Hertz in his presentation.*

Response to October 2019 Recommendations - 4

- **Request:** The committee also asks the Astrophysics Division to consider how the information that could be relevant for other Divisions (such as the state of the profession findings) could be shared with them.

__Response:__ The Decadal Survey, including the report from the State of the Profession Panel, will be a published report.

- **Recommendation:** The committee would like to hear back in its upcoming meeting on the fairing depressurization remedy the JWST team implements with the launch provider, the success of the TWTA and CTA#2 swap-outs, as well as frequent updates on the schedule reserve.

__Response:__ Addressed by Eric Smith in presentation

Response to October 2019 Recommendations - 5

- **Recommendation:** The recommends providing many opportunities for proposers to be trained in the submission of an anonymous proposal that meets the guidelines. Townhalls at AAS meetings as well as webinars would be an important component of this training. APAC also notes the potential difficulty of implementing anonymity in programs that require long-term development of capabilities and techniques, such as lab astrophysics and theory programs involving large computational codes. The committee recognizes that the APD is already having discussions on how to best approach dual anonymous reviews in these areas and invites further discussion on the topic. The committee also supports a "Dear Colleague" letter from Dr. Hertz to the community to explain the changes, the roadmap for implementation, and the training opportunities for the proposers.

  Response: *Addressed by Stefan Immler in his presentation.*

- **Recommendation:** APAC supports Dr. Hertz's efforts to get a "Dear colleague" letter to the community for the Hubble fellowship program that explains the requirements to ensure that Hubble Fellows are offered employee benefits in their host institutions.

  Response: *Addressed by Paul Hertz in his presentation.*


+ SMEX/MO (2025), MIDEX/MO (2028), etc.
Spitzer
8/25/2003
1/30/2020
Formulation
Implementation
Primary Ops
Extended Ops
WFIRST
Mid 2020s
Euclid (ESA)
2022
SXG (RSA)
7/13/2019
Webb
2021
Ariel (ESA)
2028
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
SPHEREx
2023
Hubble
4/24/1990
ISS-NICER
6/3/2017
GUSTO
2021
SOFIA
Full Ops 5/2014
+ Athena (early 2030s), LISA (early 2030s)
Revised January 30. 2020

BACKUP

SMD Organization Chart

Associate Administrator (AA)
Thomas Zurbuchen

Embeds / POCs

Chief Engineer:
Nick Jedrich

Deputy Chief Engineer:
David Coote

Safety & Mission Assurance:
Pete Panetta

General Counsel:
Dawn Oliver

Legislative & Intergovernmental Affairs:
Gabriel Adler

International & Interagency Relations:
Gib Kirkham

Public Affairs:
Grey Hautaluoma

Deputy AA
Sandra Connelly

Deputy AA - Management
Karen Flynn

Deputy AA - Programs
Mayra Montrose *

Deputy AA - Research
Michael New

Deputy AA - Exploration
Steve Clarke

Assistant Deputy AA - Management
Dan Woods

Chief Technologist
Michael Seablom

Policy Branch
Chief
Jens Feeley

Administration Branch
Chief
Ellen Gertsen

Resource Management Division
Director
Craig Tupper
Deputy
Kate Wolf

Science Engagement & Partnerships Division
Director
Kristen Erickson

James Webb Space Telescope Program Office
Director
Greg Robinson
Program Scientist
Eric Smith
Project Manager (GSFC)
Bill Ochs

NASA Management Office
Director
Marcus Watkins
Deputy
Andrea Razzaghi

Mars Sample Return Program
Director
(Vacant)

Earth Science Division
Director
Sandra Cauffman *
Deputy
Paula Bontempi *
Flight
Charles Webb *
Applied Science
Lawrence Friedl
Research
Jack Kaye
Technology (GSFC)
Pam Millar **

Joint Agency Satellite Division
Director
John Lee
Deputy
John Gagosian

Heliophysics Division
Director
Nicky Fox
Deputy
Peg Luce

Planetary Science Division
Director
Lori Glaze
Deputy
Eric Ianson
Flight
Joan Salute
Mars Exploration
Jim Watzin
Planetary Research
Stephen Rinehart
Planetary Defense Office
Lindley Johnson

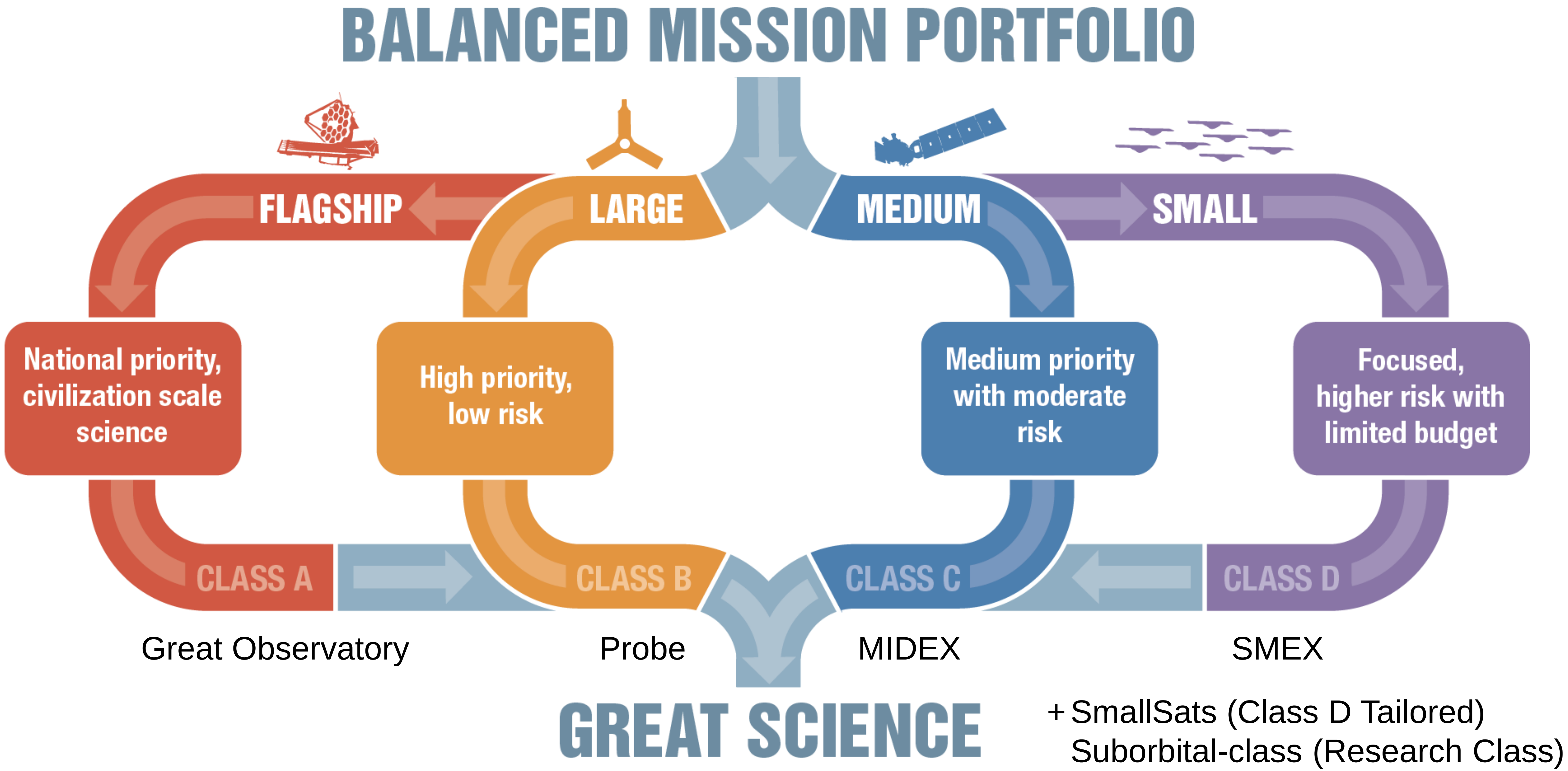
Astrophysics Division
Director
Paul Hertz
Deputy
Jeff Volosin
Flight
Jeanne Davis
Chief Scientist
Eric Smith

Notes
* Acting
** Reports to GSFC

Updated: February 19, 2020

Decadal Survey Planning

- NASA's highest aspiration for the 2020 Decadal Survey is that it be ambitious
  - The important science questions require new and ambitious capabilities
  - Ambitious missions prioritized by previous Decadal Surveys have always led to paradigm shifting discoveries about the universe


BALANCED MISSION PORTFOLIO
FLAGSHIP
LARGE
MEDIUM
SMALL
National priority, civilization scale science
High priority, low risk
Medium priority with moderate risk
Focused, higher risk with limited budget
CLASS A
CLASS B
CLASS C
CLASS D
Great Observatory
Probe
MIDEX
SMEX
GREAT SCIENCE
+ SmallSats (Class D Tailored)
Suborbital-class (Research Class)

Why Flagships

Flagships enable paradigm shifting science

Flagships drive US capabilities and contribute to US leadership

Flagships create stakeholder support that drives the NASA budget

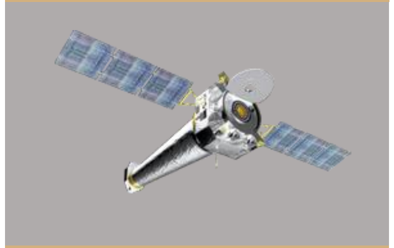
Hubble 04/90
NASA Great Observatory

Hubble Space Telescope

Compton 05/91
NASA Great Observatory

Compton Gamma Ray Observatory

Chandra 09/99
NASA Great Observatory

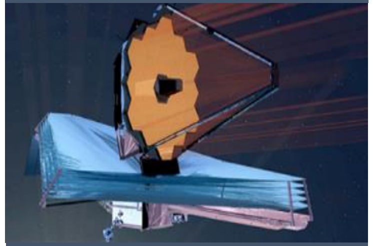


Chandra X-ray Observatory

Spitzer 8/03
NASA Great Observatory

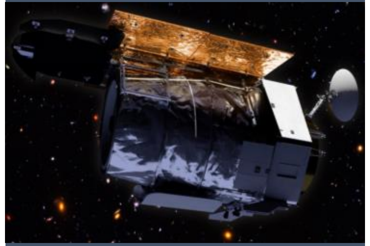
Spitzer Space Telescope

Webb 2021
NASA Mission



James Webb Space Telescope

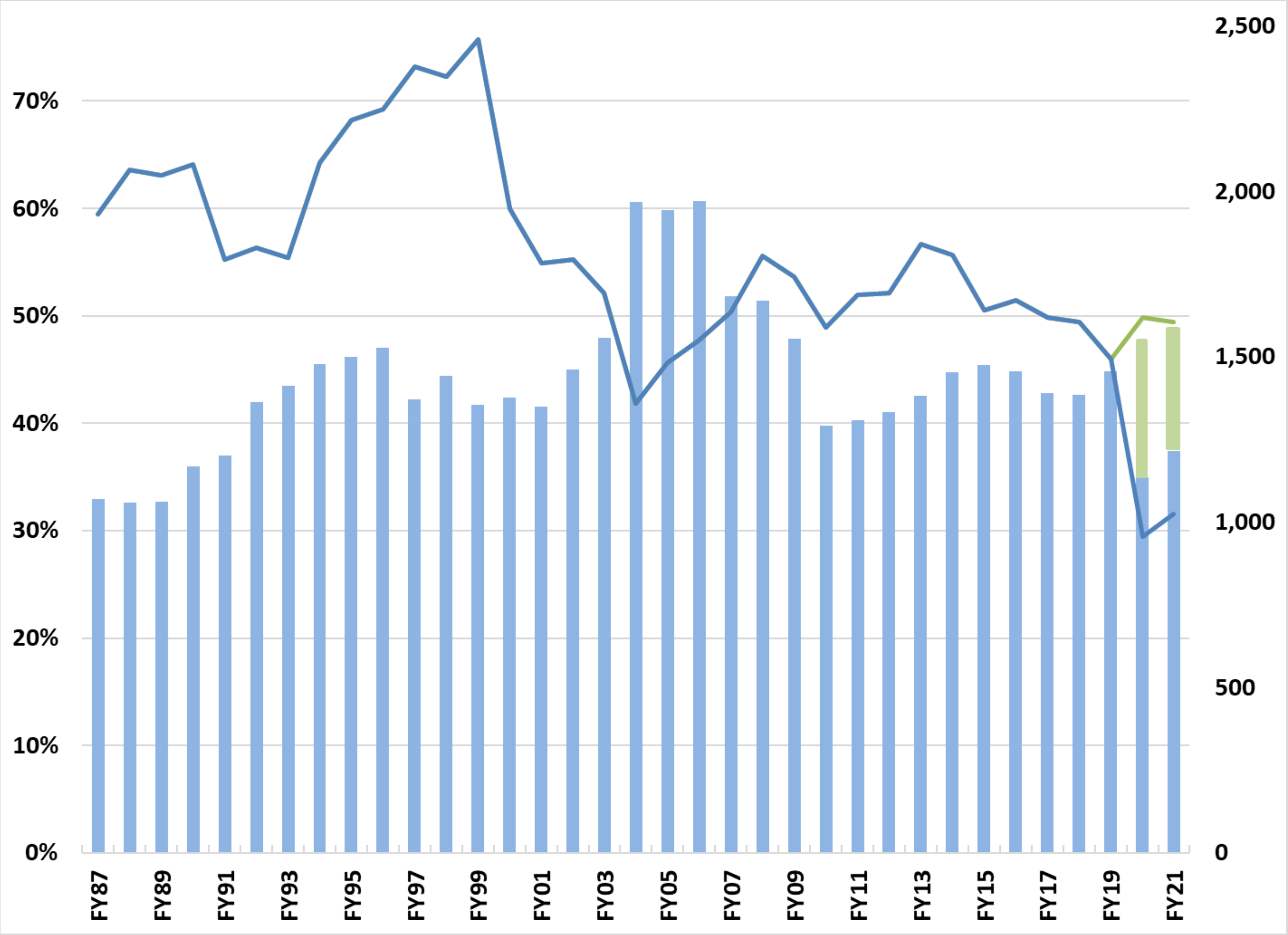
WFIRST Mid 2020s
NASA Mission



Wide-Field Infrared Survey Telescope

“NASA should continue to plan for large strategic missions as a primary component for all science disciplines as part of a balanced program.”
– Powering Science: NASA's Large Strategic Science Missions (NASEM, 2017)

Flagship Fraction of Astrophysics Budget



All dollars inflated to FY18$.
Development only, no ops.

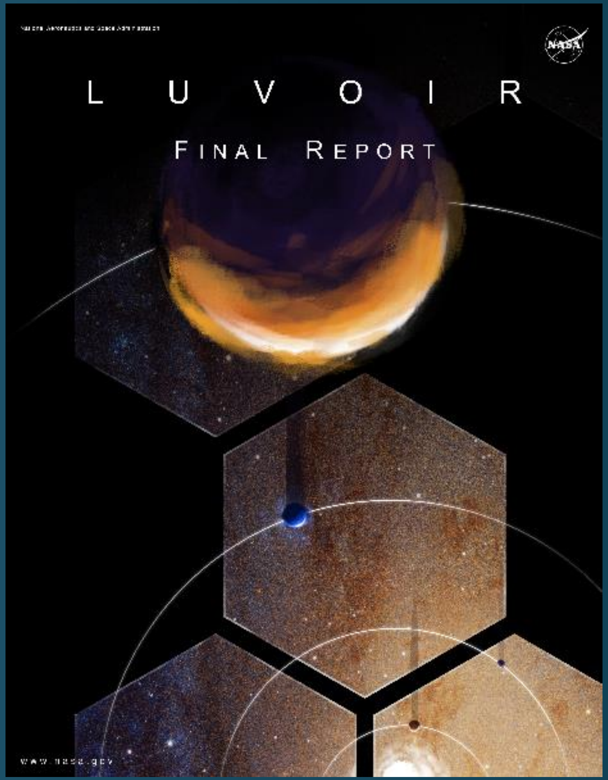
Large mission fraction (left scale)

Inflation adjusted Astrophysics budget (right scale)

Current planning budget (without WFIRST beyond FY19)

What if WFIRST is funded as needed on top of FY20 President's Budget Request?

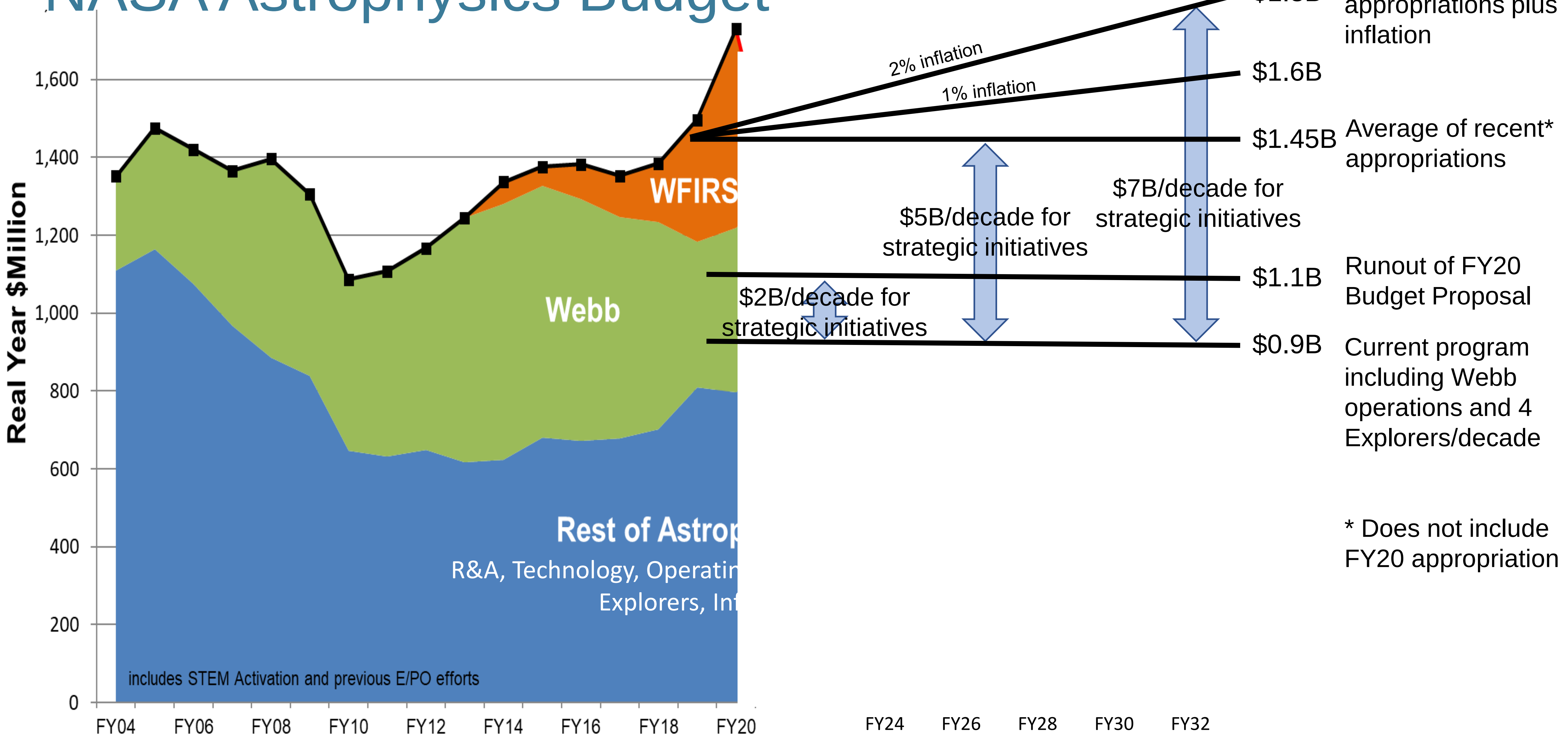
Large Mission Concepts



NASA's independent assessment of large mission concept studies by the Large Mission Concept Independent Assessment Team (LCIT) is available at https://science.nasa.gov/astrophysics/2020-decadal-survey-planning

Links to the concept study reports are posted at https://science.nasa.gov/astrophysics/2020-decadal-survey-planning and at https://www.greatobservatories.org/

NASA Astrophysics Budget



* Does not include FY20 appropriation

The Future

This is an exciting time for Astrophysics – we are pursuing the answers to the biggest questions

- How did the universe begin and evolve?
- How did galaxies, stars, and planets come to be?
- Are we alone?

Astrophysics is multiwavelength and multimessenger

- NASA has 10 operating astrophysics missions*
- NASA is developing 11 astrophysics missions*

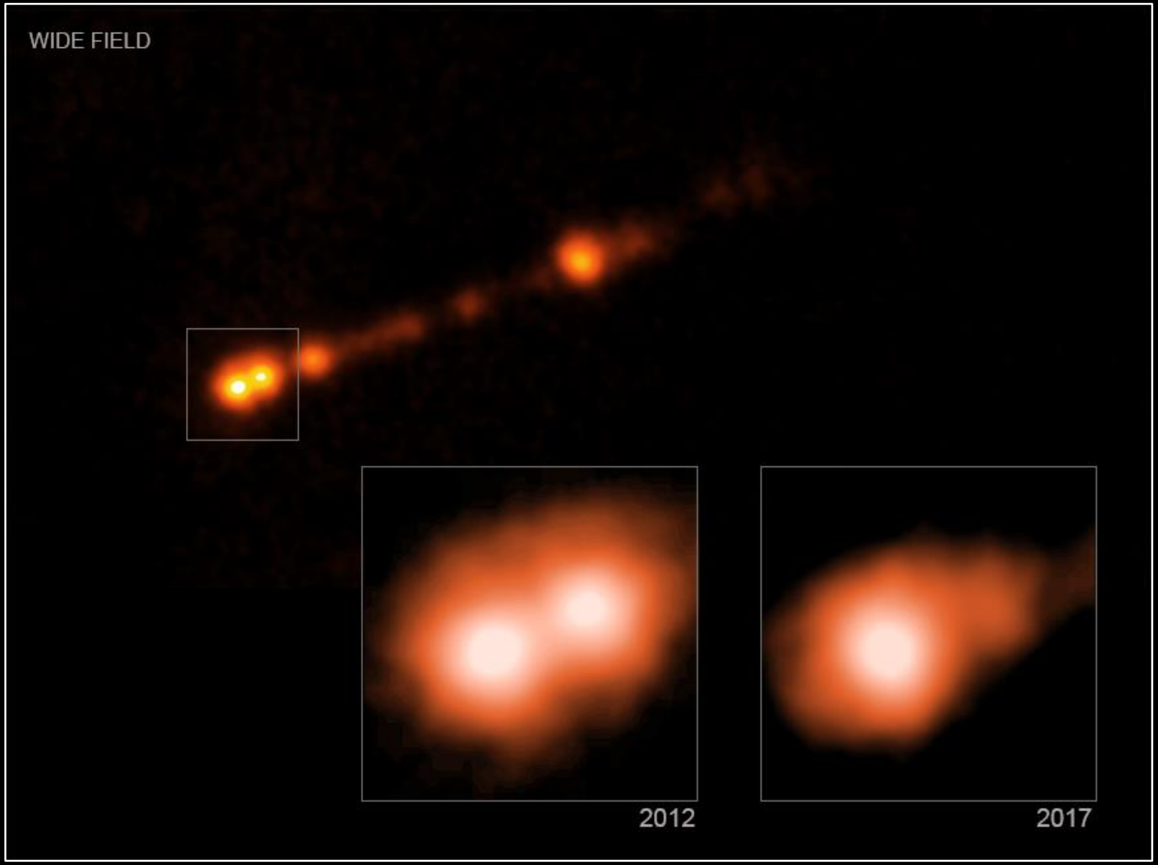
The community will select NASA's future observatories through the 2020 Decadal Survey and through peer review of competed missions (like Explorers)

NASA is ready to realize the community's priorities

* includes partner-led missions

Famous Black Hole Has Jet Pushing Cosmic Speed Limit

Released January 6, 2020



Credits: NASA/CXC/SAO/B. Snios et al.

SCIENCE HIGHLIGHT

- These images from NASA's Chandra X-ray Observatory show evidence that the black hole in the galaxy Messier 87 (M87) is blasting particles out at over 99% the speed of light.
  - While astronomers have observed features in the M87 jet blasting away from its black hole this quickly at radio and optical wavelengths for many years, this provides the strongest evidence yet that actual particles are travelling this fast.
- The main graphic shows the entire length of M87's jet (over 18,000 light years) seen by Chandra.
  - Meanwhile the insets contain snapshots of one zoomed in region, or "knot," of X-ray emission observed by Chandra in 2012 and 2017.
  - Movement and fading of this knot and another farther along the jet provided the researchers the evidence that parts of the jet are traveling at remarkable speeds.
- By comparing how far these knots moved over the five-year interval, the team of astronomers was able to determine the closer knot has an apparent speed of 6.3 times the speed of light for the X-ray knot, while the other looks like it is moving at 2.4 times the speed of light.
  - This is an example of superluminal motion, which occurs when objects are traveling close to the speed of light along a direction that is close to Earth's line of sight.
  - The jet travels almost as quickly towards us as the light it generates, giving the illusion that the jet's motion is much more rapid than the speed of light.

Hubble Surveys Gigantic Galaxy

Released January 6, 2020

SCIENCE HIGHLIGHT

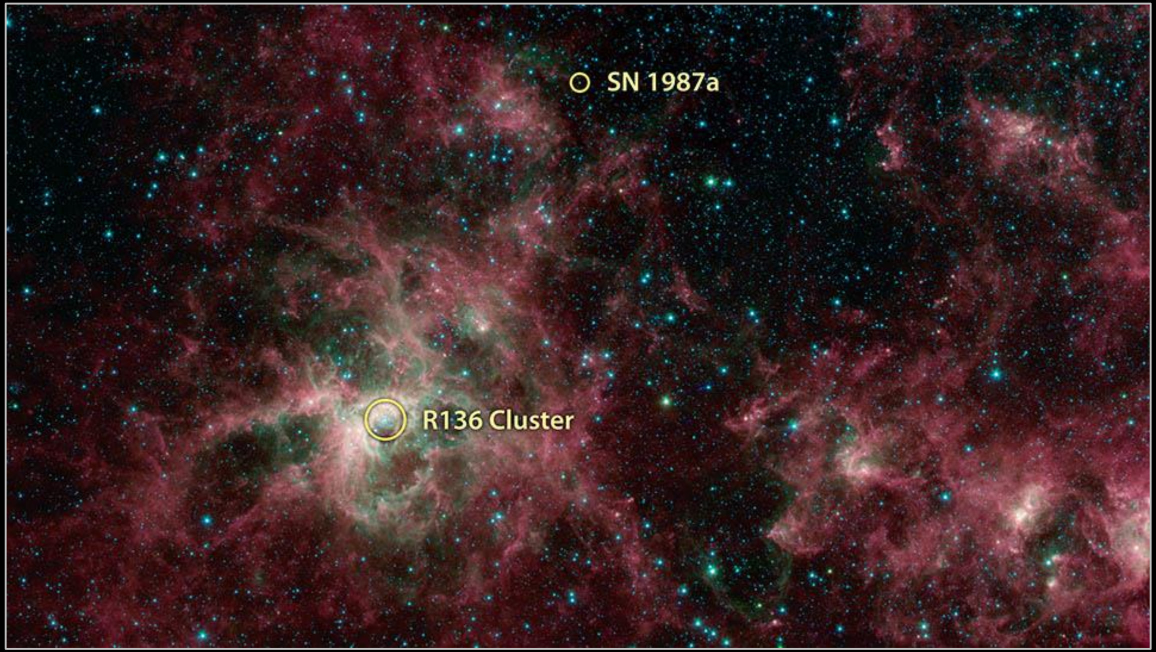
Credits: NASA, ESA, and B. Holwerda (University of Louisville)

Caption: A number of foreground stars in our Milky Way can be seen in the image, identified by their diffraction spikes. The brightest appears to sit on top of the galaxy's disc, though UGC 2885 is really 232 million light-years farther away. The giant galaxy is located in the northern constellation Perseus.

- The Hubble Space Telescope has imaged the majestic spiral galaxy UGC 2885, which may be the largest known galaxy in the local universe.
  - It is 2.5 times wider than our Milky Way and contains 10 times as many stars.
- Despite its gargantuan size, researchers are calling it a "gentle giant" because it looks as if it has been sitting quietly over billions of years, possibly sipping hydrogen from the filamentary structure of intergalactic space.
  - This is fueling modest ongoing star birth at a rate half that of our Milky Way.
  - Its supermassive central black hole is a sleeping giant; because the galaxy does not appear to be feeding on much smaller satellite galaxies, it is starved of infalling gas.
- Researchers are still seeking to understand what led to the galaxy's monstrous size.
  - One clue is that the galaxy is fairly isolated in space and doesn't have any nearby galaxies to crash into and disrupt the shape of its disc.
  - Did the monster galaxy gobble up much smaller satellite galaxies over time? Or did it just slowly accrete gas to make new stars?

Tarantula Nebula Spins Web of Mystery

Released January 27, 2020



Credits: NASA/JPL-Caltech

Caption: This image shows the Tarantula Nebula in three wavelengths of infrared light, each represented by a different color. The magenta-colored regions are dust composed of molecules called polycyclic aromatic hydrocarbons (PAHs). The PAHs emit in multiple wavelengths, so the magenta color is a combination of red (corresponding to an infrared wavelength of 8 micrometers) and blue (3.6 micrometers). The green color in this image shows the presence of particularly hot gas emitting infrared light at a wavelength of 4.5 micrometers. The stars in the image are mostly a combination of green and blue. White hues indicate regions that radiate in all three wavelengths.

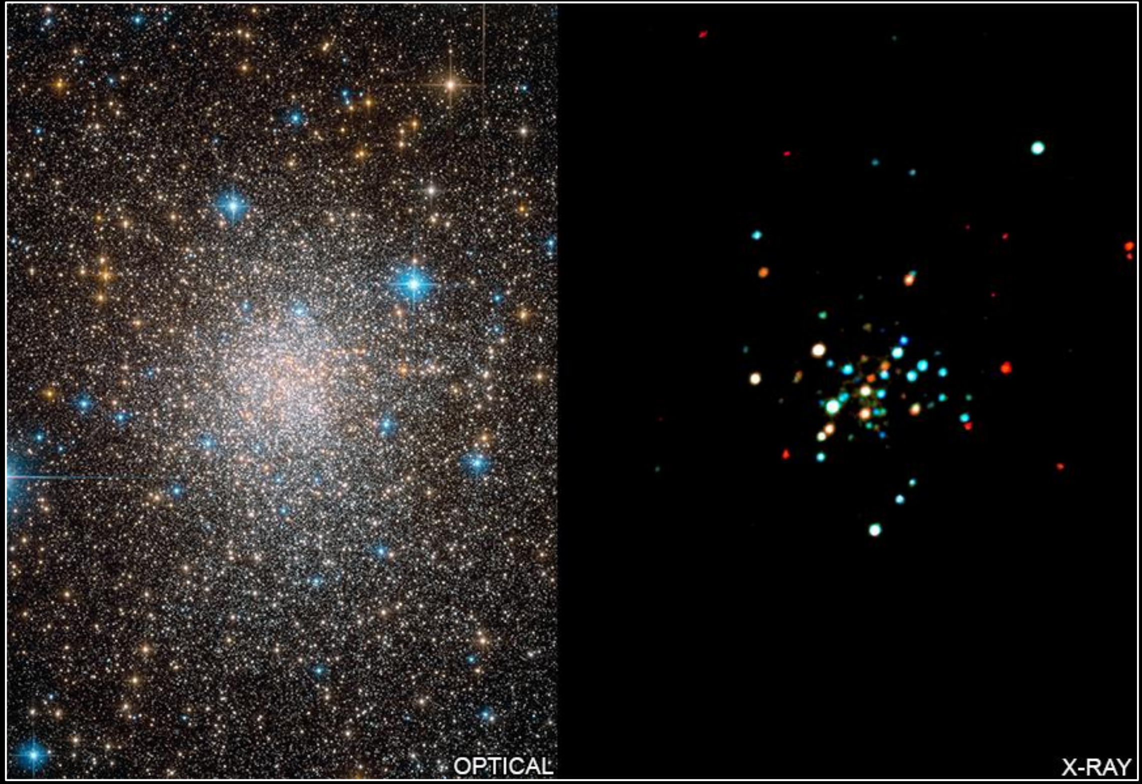
SCIENCE HIGHLIGHT

- The Tarantula Nebula, seen in this image by the Spitzer Space Telescope, was one of the first targets studied by the infrared observatory after its launch in 2003. The telescope has revisited it many times since.
  - With Spitzer retiring on Jan. 30, 2020, scientists have generated a new view of the nebula including new data from Feb. and Sept. of 2019.
- Located in the Large Magellanic Cloud - a dwarf galaxy gravitationally bound to our Milky Way galaxy - the Tarantula Nebula is a hotbed of star formation.
- The nebula hosts R136, a "starburst" region, where massive stars form in extremely close proximity and at a rate far higher than in the rest of the galaxy.
  - Within R136, in an area less than 1 light-year across (~6 trillion miles, or 9 trillion kilometers), there are more than 40 massive stars, each containing at least 50 times the mass of our Sun.
  - By contrast, there are no stars within 1 light-year of our Sun.
  - How these starburst regions arise remains a mystery.
- On the outskirts of the Tarantula Nebula, you can also find one of astronomy's most-studied stars that exploded in a supernova called SN 1987A.
  - The exploded star burned with the power of 100 million Suns for months.
  - The shockwave from that event continues to move outward into space, encountering material ejected from the star during its dramatic death.

A Cosmic Jekyll and Hyde

Released February 20, 2020

SCIENCE HIGHLIGHT



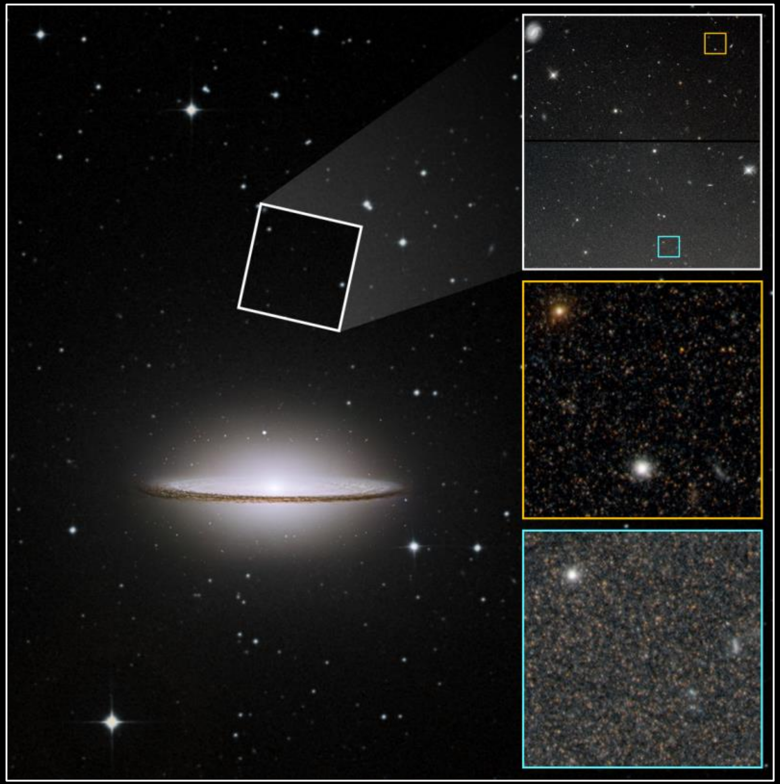
Credit: NASA/CXC/Univ. of Amsterdam/N.Degenaar, et al.

Caption: In this new image of the Terzan 5 globular cluster (right), low, medium and high-energy X-rays detected by Chandra are colored red, green and blue respectively. On the left, an image from Hubble shows the same field of view in optical light.

- Astronomers observed a binary system with a neutron star (the extremely dense remnant left behind by a supernova explosion) in orbit with a low-mass companion acting in an unusual way.
- Using X-ray data from the Chandra X-ray Observatory and data from the National Science Foundation's Karl F. Jansky Very Large Array, researchers saw that Terzan 5 CX1 had traits of a "low-mass X-ray binary" before it started behaving like a millisecond pulsar, and then years later returned to its original role.
- Terzan 5 CX1 is located in a globular cluster about 19,000 light years from Earth in the Milky Way galaxy.

Beyond the Brim, Sombrero Galaxy's Halo Suggests a Turbulent Past

Released February 20, 2020



Credit: NASA, ESA, and R. Cohen and P. Goudfrooij (STScI)

Caption: On the left is an image of the entire galaxy that includes a portion of the much fainter halo far outside its bright disk and bulge. Hubble photographed two regions in the halo (one of which is shown by the white box). The images on the right zoom in to show the level of detail Hubble captured. The orange box, a small subset of Hubble's view, contains myriad halo stars. The stellar population increases in density closer to the galaxy's disk (bottom blue box). Each frame contains a bright globular cluster of stars, of which there are many in the Sombrero's halo.

SCIENCE HIGHLIGHT

- Like a desperado in the Wild West, the broad "brim" of the Sombrero (M104) galaxy's disk may conceal a turbulent past.
- The story of its structure becomes stranger with new evidence from the Hubble Space Telescope indicating the Sombrero is the result of major galaxy mergers, though its smooth disk shows no signs of recent disruption.
- The galaxy's faint halo offers forensic clues. It's littered with innumerable stars that are rich in heavier elements (called metals), because they are later-generation stars.
  - Such stars are usually only found in a galaxy's disk.
  - They must have been tossed into the halo through mergers with mature, metal-rich galaxies in the distant past.
- The iconic galaxy now looks a bit more settled in its later years. It is now so isolated, there is nothing else around to feed on.
- This finding offers a new twist on how galaxies assemble themselves in our compulsive universe.