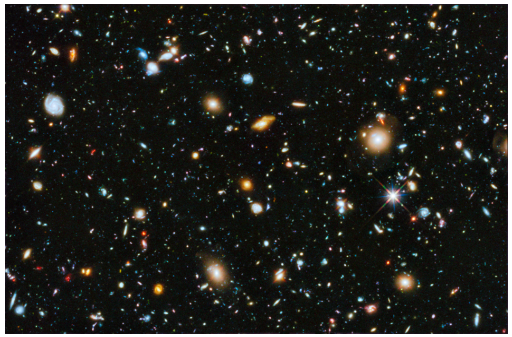
National Aeronautics and Space Administration

NASA

ASTROPHYSICS

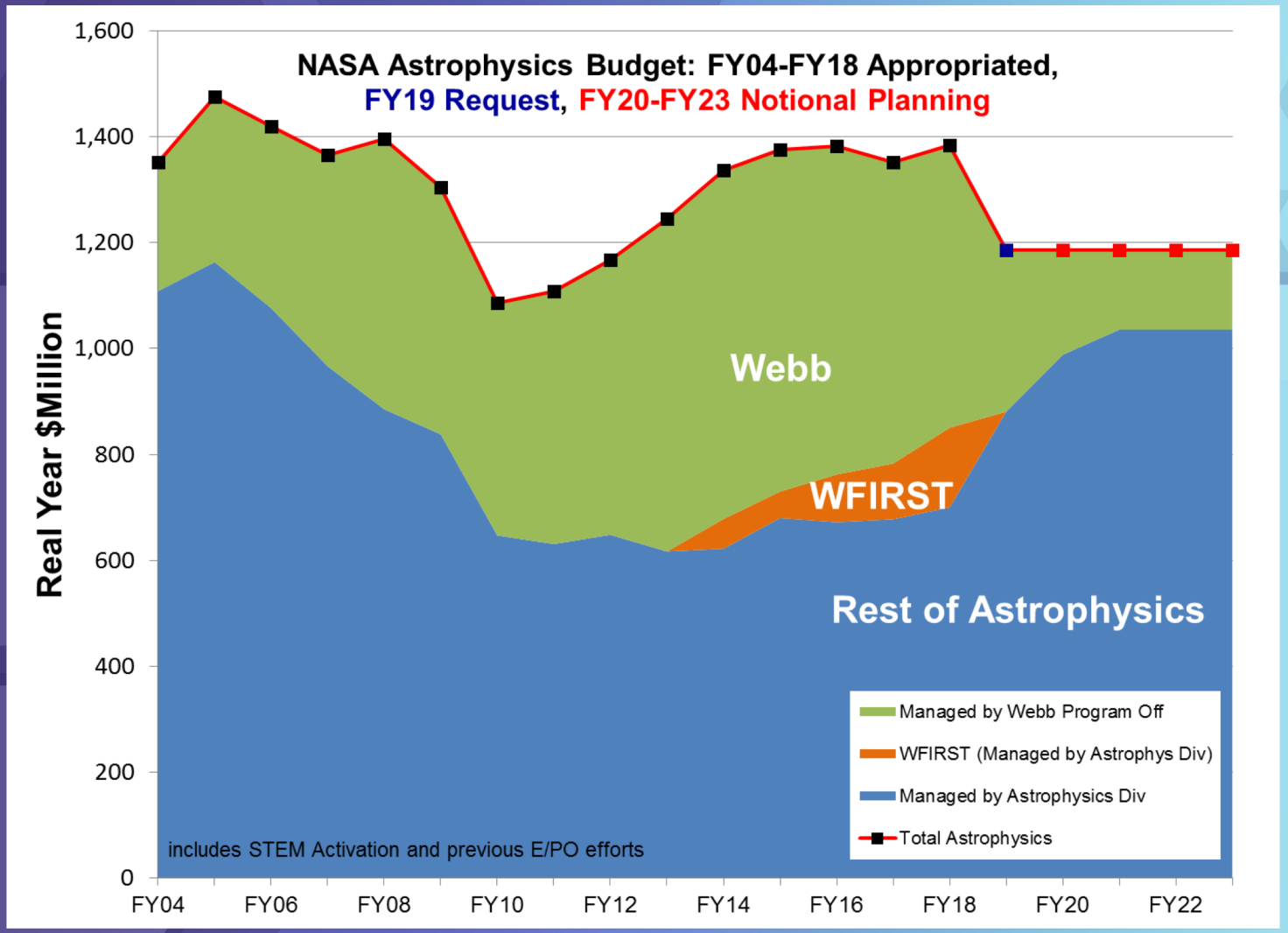



Space Telescope Users Committee

April 19, 2018
STScI

Michael Garcia
HST Program Scientist
Astrophysics Division
Science Mission Directorate
NASA Headquarters

NASA Astrophysics
Program and Budget Update


NASA Astrophysics Budget: FY04-FY18 Appropriated,
FY19 Request, FY20-FY23 Notional Planning
Real Year $Million
1,600
1,400
1,200
1,000
800
600
400
200
0
FY04
FY06
FY08
FY10
FY12
FY14
FY16
FY18
FY20
FY22
Webb
WFIRST
Rest of Astrophysics
includes STEM Activation and previous E/PO efforts
Managed by Webb Program Off
WFIRST (Managed by Astrophys Div)
Managed by Astrophysics Div
Total Astrophysics

Astrophysics Budget Overview

- **The FY18 consolidated appropriation provides funding for NASA astrophysics to continue its planned programs, missions, projects, research, and technology.**
  - Total funding provided for FY18 (Astrophysics including Webb) rises from $1.352B in FY17 to 1.384B in FY18, an increase of ~$32M (2.4%) from FY17.
  - The NASA Astrophysics FY18 appropriation funds Webb for progress toward launch, WFIRST formulation into Phase B, Explorers mission development and SMEX AO, increased funding for R&A, continued operating missions, suborbital missions and CubeSats, technology development, and mission studies.
  - $10M (2.2%) reduction in rest of Astrophysics to accommodate directed spending increases for WFIRST, Hubble, and SOFIA.
- **The FY19 budget request proposes a reduced level of funding for NASA astrophysics.**
  - Total requested funding for FY19 (Astrophysics including Webb) is ~$1.185B, a reduction of $200M (14%) from FY18 appropriation.
  - Webb included as project within Astrophysics budget, integration and testing continues toward launch.
  - **Given its significant cost within a proposed lower budget for Astrophysics and competing priorities within NASA, WFIRST is terminated with remaining WFIRST funding redirected towards competed astrophysics missions and research.**

FY

- The
  app

WFIRST

cost

- Project estimate of cost to Science Mission Directorate has been reduced from ~$3.6B to <$3.2B.
- Changes include the following:
  - Coronagraph Instrument treated as technology demonstration instrument
  - Contribution to coronagraph technology demonstration instrument by NASA Space Technology Mission Directorate
  - Reduced some Wide Field Instrument capabilities
  - Simplified subsystem designs including C&DH box, high gain antenna, telescope door
  - Contributions to mission by international partners
  - Improved budget profile and accelerated schedule; pulls in launch date 6 months
  - Additional mission risk reduction (sparing, testing, parts, etc.)

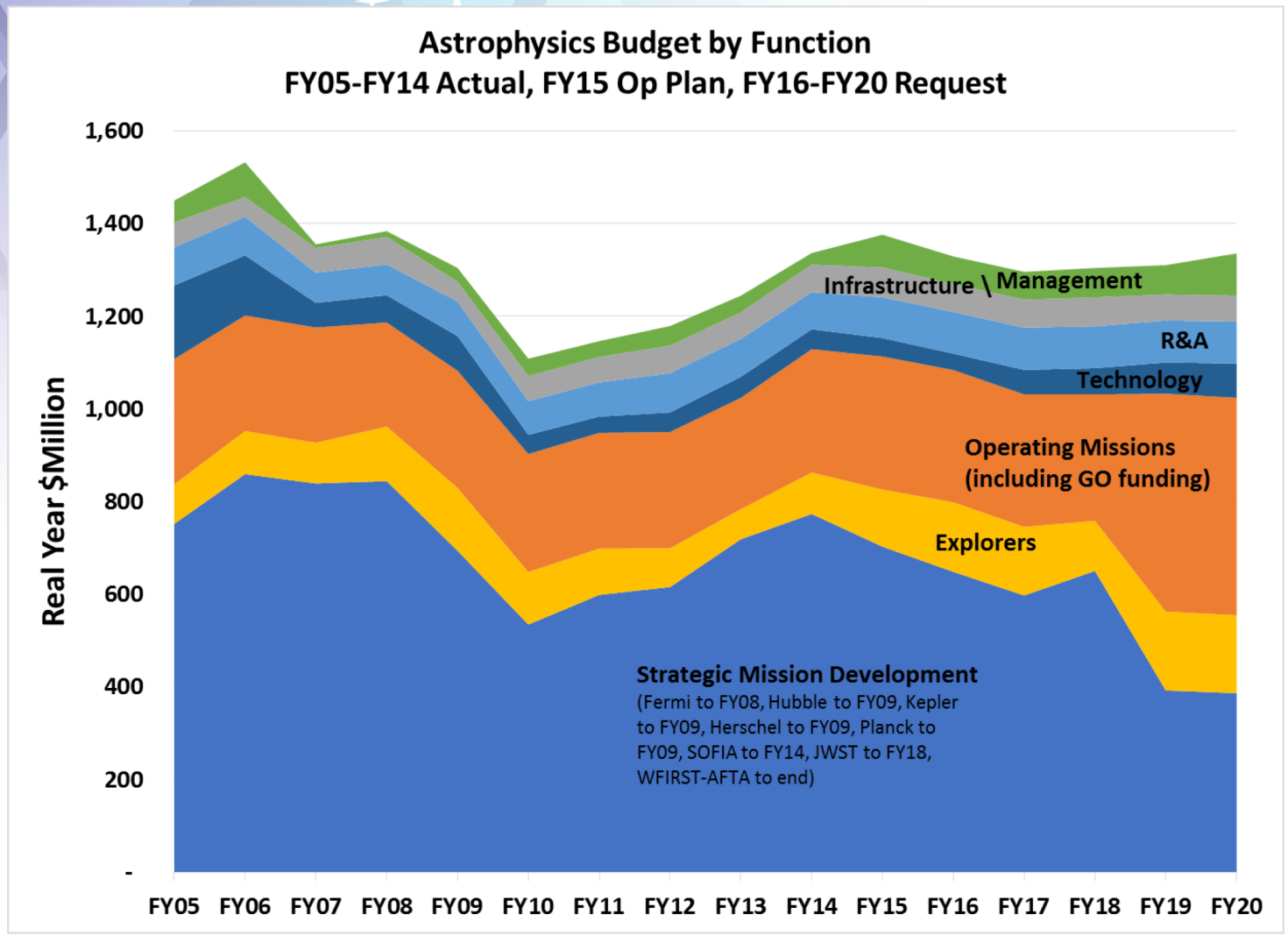
WFIRST
budget

- Given its significant cost within a proposed lower budget for Astrophysics and competing priorities within NASA, WFIRST terminated with remaining WFIRST funding redirected towards competed astrophysics missions and research
- Funds appropriated by Congress in FY18 will allow WFIRST to enter Phase B in April 2018
- If Congress adopts the Administration's request to terminate WFIRST, the funds made available would enable a competed mission AO in FY19

WFIRST

status

- Conducted WFIRST Independent External Technical/Cost/Management Review (WIETR) in response to National Academies' Midterm Assessment
- WFIRST directed by SMD AA to reduce cost and complexity sufficient to have a cost estimate consistent with $3.2B cost target set at the beginning of Phase A.
  - Coronagraph is technology demonstration instrument
  - Independent cost assessment are being conducted to validate the estimated cost of rescoped mission as being consistent with the $3.2B cost target.
- WFIRST moved to (new) Strategic Astrophysics Missions Program
- SRR/MDR completed February 2018.
- KDP-B underway in March/April 2018.


Astrophysics Budget by Function
FY05-FY14 Actual, FY15 Op Plan, FY16-FY20 Request
Real Year $Million
1,600
1,400
1,200
1,000
800
600
400
200
-
FY05
FY06
FY07
FY08
FY09
FY10
FY11
FY12
FY13
FY14
FY15
FY16
FY17
FY18
FY19
FY20
Infrastructure \ Management
R&A
Technology
Operating Missions
(including GO funding)
Explorers
Strategic Mission Development
(Fermi to FY08, Hubble to FY09, Kepler
to FY09, Herschel to FY09, Planck to
FY09, SOFIA to FY14, JWST to FY18,
WFIRST-AFTA to end)

FY18 Omnibus Appropriation

- The Consolidated Appropriations Act of 2018 and the explanatory statement includes the following language:

- This Act includes $6,221,500,000 for Science. The agreement reiterates the importance of the decadal survey process and rejects the cancellation of scientific priorities recommended by the National Academy of Sciences decadal survey process.

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  - Given its significant cost within a proposed lower budget for Astrophysics and competing priorities within NASA, WFIRST is terminated with remaining WFIRST funding redirected towards competed astrophysics missions and research.

FY18 Omnibus Appropriation

- The Consolidated Appropriations Act of 2018 and the explanatory statement includes the following language:

- The agreement further clarifies that NASA shall not undertake any activities during fiscal year 2018 in preparation for any fiscal year 2019 senior review of this program. The agreement notes that SOFIA, which began its prime mission in 2014, has a prime mission lifetime of 20 years.

FY18 Omnibus Appropriation

- The Consolidated Appropriations Act of 2018 and the explanatory statement provide the following appropriations for Astrophysics (including Webb)

	FY18 PBR	FY18 Appropriation	Direction (paraphrased)
Total Astrophysics	$ 1,350.5 M	$ 1,384.1 M	
Webb	$ 533.7 M	$ 533.7 M	Shall not exceed $8B through development.
WFIRST	$ 126.6 M	$ 150.0 M	Provide within 60 days a life cycle cost including additions needed to make Class A.
Hubble	$ 83.3 M	$ 98.3 M	FY18 Appropriation up $1M from FY17
SOFIA	$ 79.9 M	$ 85.2 M	Shall not prepare for 2019 senior review; prime mission is 20 years starting in 2014. Issue a call for instrument proposals. Undertake at least 100 science flights.
Research & Analysis	$ 74.1 M	$ 74.1 M	Supportive of university-led research into protoplanetary discs and nebulae.
Exoplanet technology			Includes no less than $15M for exoplanet technology development.
Astrophysics observatories			Provide within 180 days NASA's plans for maintaining U.S. leadership in high energy astrophysics following the Chandra and Fermi missions.
Rest of Astrophysics	$ 452.9 M	$ 442.8 M	$10M (2.2%) undistributed reduction.

Astrophysics FY19 Budget Request ($M)

	Actual FY 17	Enacted FY 18	Request FY 19	Notional FY 20	FY 21	FY 22	FY 23
Astrophysics	**1,352.3**	**1,384.1**	**1,185.4**	**1,185.4**	**1,185.4**	**1,185.4**	**1,185.4**
Astrophysics Research	190.1		259.2	280.8	321.5	318.4	310.0
Science Activation	37.0	**44.0**	44.6	44.6	44.6	44.6	44.6
Astrophysics Research and Analysis	73.5	**74.1**	83.4	86.6	90.2	92.2	94.2
Balloon Project	34.0		39.2	41.7	40.4	40.5	40.6
Other Missions and Data Analysis	45.6		92.0	108.0	146.4	141.1	130.7
Astrophysics Data Curation and Archival	15.4		21.2	20.5	21.5	21.5	21.5
Astrophysics Data Program	17.6		19.1	20.4	21.6	22.6	23.6
Astrophysics Senior Review					31.5	33.0	33.0
Contract Administration, Audit & QA Svcs	12.6		12.7	12.7	12.7	12.7	12.7
Astrophysics Directed R&T			39.0	54.4	59.1	51.3	39.9
Cosmic Origins	779.4		491.4	354.5	311.9	312.7	312.7
Hubble Space Telescope	97.3	**98.3**	78.3	88.3	93.3	98.3	98.3
SOFIA	85.2	**85.2**	74.6	39.8	16.6		
James Webb Space Telescope	569.4	**533.7**	304.6	197.2	149.8	150.0	150.0
Other Missions and Data Analysis	27.5		33.9	29.1	52.2	64.4	64.4
Cosmic Origins Future Missions	0.0		2.7	2.2	28.7	43.8	43.8
Spitzer	11.0		11.0	8.0	3.0		
Herschel	1.0						
Cosmic Origins SR&T	12.8		17.6	16.8	18.4	18.4	18.4
Cosmic Origins Program Management	2.7		2.7	2.2	2.2	2.2	2.2

Senior Review Paradigm:

NASA conducts regular reviews of its operating science missions in order to assess their continued science productivity and whether their operations should be continued through approval of a mission extension. The *NASA Authorization Act of 2005 (P.L. 109-155)* states that **"The Administrator shall carry out biennial reviews within each of the Science divisions to assess the cost and benefits of extending the date of the termination of data collection for those missions that have exceeded their planned mission life time."** The *NASA Transition Authorization Act of 2017 (P.L. 115-10)* modified the cadence to be triennial reviews.

These reviews of operating missions are NASA's highest form of peer review, as the subject is not a single science investigation, or even a single space mission, but rather a portfolio of operating missions.

The reviews of operating missions are referred to as senior reviews, in recognition of the high level of the peer review.

Senior Review 2019 (from the TOR):

"The Astrophysics Senior Review Subcommittee is a subordinate group (hereinafter, "Subcommittee") of the Astrophysics Advisory Committee (APAC), a stand-alone advisory group established under the Federal Advisory Committee Act (FACA). The Subcommittee has been established at the discretion of the Director, Astrophysics Division, following consultation with the Associate Administrator, Science Mission Directorate.

The Subcommittee will conduct a senior review for NASA of astrophysics operating missions. The purpose and scope of the senior review is to provide an independent assessment of the cost and benefits of extending the termination date of the suite of operating missions in the NASA Astrophysics portfolio."

Senior Review 2019

- Chandra X-ray Observatory (Chandra)
- Fermi Gamma-ray Space Telescope (Fermi)
- Hubble Space Telescope (Hubble)
- Neutron star Interior Composition ExploreR (NICER)
- Nuclear Spectroscopic Telescope Array (NuSTAR)
- Stratospheric Observatory for Infrared Astronomy (SOFIA) [pending clarification of Congressional language]
- Neil Gehrels Swift Observatory (Swift)
- Transiting Exoplanet Survey Satellite (TESS)
- X-ray Multi-mirror Mission-Newton (XMM-Newton)

Senior Review 2019

NASA Astrophysics Advisory Committee

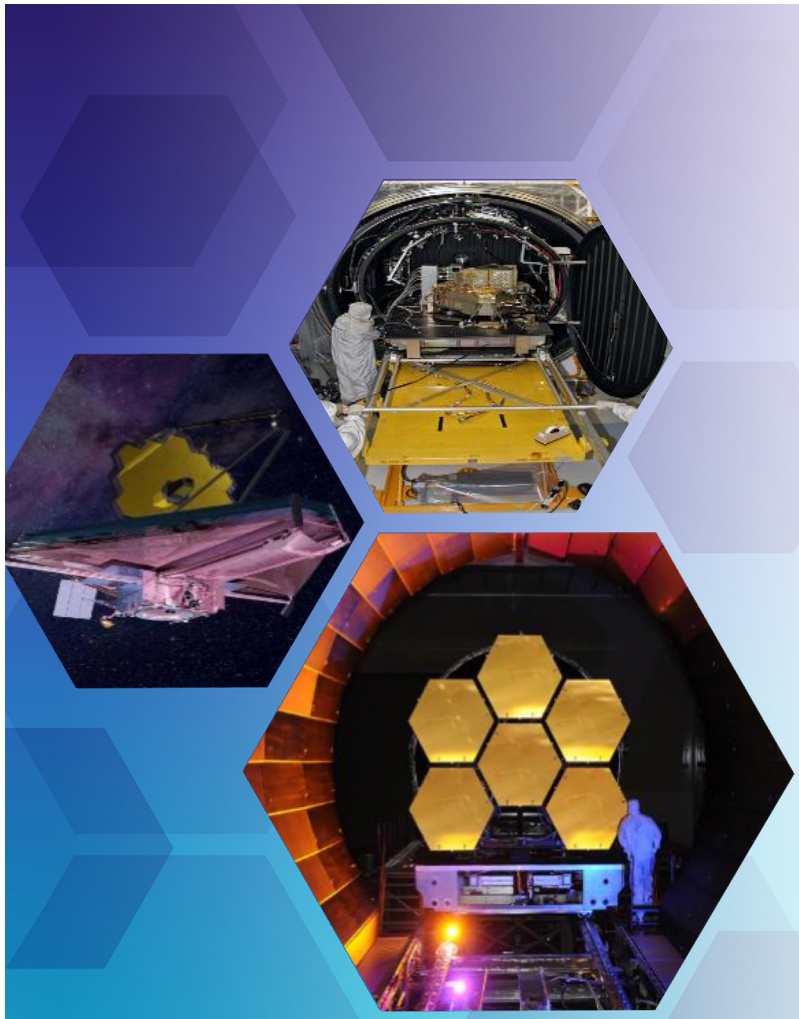
Senior Review Subcommittee

- Rest-of-Missions Panel
- Chandra Panel
- Hubble Panel
- SOFIA Panel [TBC]

Astrophysics FY2019 Budget Features

- What's Changed
  - Webb included as project within Astrophysics budget
  - Given its significant cost within a proposed lower budget for Astrophysics and competing priorities within NASA, WFIRST terminated with remaining WFIRST funding redirected towards competed astrophysics missions and research
  - Euclid budget increased to recover from failed sensor electronics design
  - XARM begun within Explorers program
  - Spitzer ops extended until Webb is operational, consistent with 2016 Senior Review

- What's the Same
  - TESS, IXPE, and GUSTO remain on track and within budget
  - All operating missions continue; next Senior Review in 2019
  - CubeSat initiative and four balloon campaigns within healthy research program



James Webb Space Telescope

- Included as project within Astrophysics starting in FY2019
- Civilization-scale mission to observe first galaxies formed after Big Bang
- Science payload completed three months cryogenic testing at end of 2017
- Spacecraft and sunshield integration completed January 2018
- Independent schedule review completed March 2018
- Independent Review Board report by June 2018
- Science payload and spacecraft integration planned Summer 2018

Webb 18 Month LRD Impact
from October 2018 LRD

- 15 months of technical issues (**impacts do not add linearly**)
  - Spacecraft critical path dominated by the propulsion system – 13 months
    - 3 Months - Transducer problem
    - Dual Thruster Module rework slip of 9 months (much of this was worked in parallel with Sunshield issues)
    - 1 Month - Recovery from incorrect voltage applied to the catalyst bed heater
  - Sunshield Complications – 7 months
    - 4 months – Deploy/Fold/Stow (2 months to go)
    - 2 months – Tear repairs (1 month to go)
    - 1 month – Snag guard implementation (0.5 months to go)
  - Observatory I&T Replan – 3 months
    - 3 months – OTE lessons learned and applied to SCE & reduction in parallel task activities
- 3 months additional funded schedule reserve

Standing Review Board Schedule Review Summary

National Aeronautics and Space Administration

Summary of SRB Schedule Risk Assessment

- Summary/Historical view of large, complex NASA SMD program and project schedule overruns
- Analysis of historical JWST I&T schedule margin burn rates since 2011
- SRB Delphi analysis
- SRB Assessment of project's grassroots schedule analysis and threats
- JWST Project SRA model and parametric analysis
- Comparison of similarly complex NGAS "Project X" to JWST I&T work to go

- **Based on the above analyses, the SRB assessment results in a probable JWST LRD range of 1/29/20 to 4/30/20 (increasing probability with latter date)**
- **Caveats:**
  - **NGAS schedule performance improves as planned**
  - **No significant hardware anomalies during remaining I&T**

Steps Taken to Improve Performance

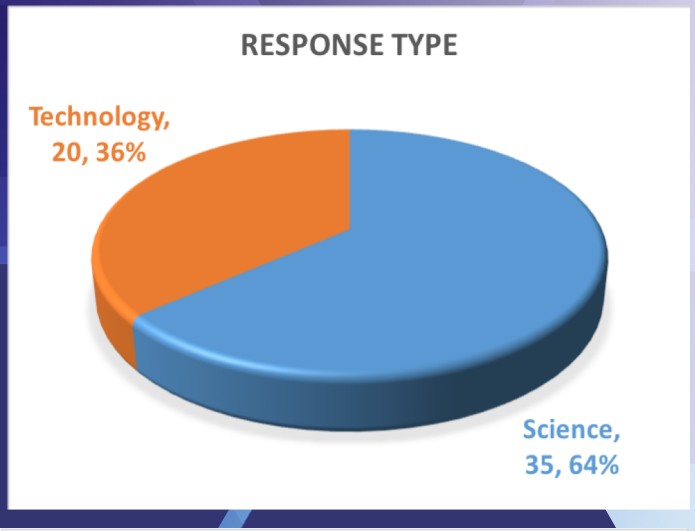
- NASA HQ (Program)
  - ✓ Additional SMD Front office oversight and direct interaction with NGAS senior management (President/COO)
  - ✓ Adding Deputy Associate Administrator of Programs to JWST Program Office
  - ✓ Tracking daily & weekly NGAS I&T reports
  - ✓ Established IRB
- NASA Goddard (Project)
  - ✓ Senior project management resident at NGAS on permanent basis
  - ✓ Additional NASA I&T personnel at NGAS planned for specific activities
  - ✓ Bi-weekly senior NASA/NGAS (HQ, Center Director, President/COO) schedule reviews
  - ✓ JWST Project Manager reporting directly to Deputy Center Director who will actively support the Project Manager
- NGAS (Observatory Contractor)
  - ✓ Project Manager to President/COO direct communication path established
  - ✓ Reporting channels opened to Project & Program (as mentioned above)
  - – I&T personnel and organizational structure changes
  - – Reviewing technical processes/procedures

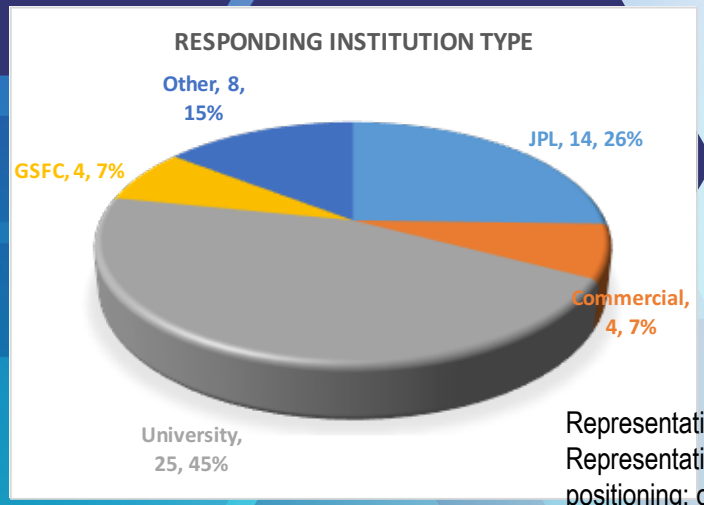
Independent Review Board

- Purpose
  - External team that will evaluate all factors, including
    - Those identified by the SRB
    - Integration and test (I&T) plan
    - Assuming a Ship & Launch Processing window (75 days) and the commissioning (6 months) of the telescope
  - The IRB will
    - Document the results of its review in a presentation and final report
    - The IRB may develop observations, findings, concerns, and recommendations as part of its assessment.
- Final Report to SMD AA ~May 31, 2018
- Chair, Tom Young

NASA Astrophysics
Missions Update

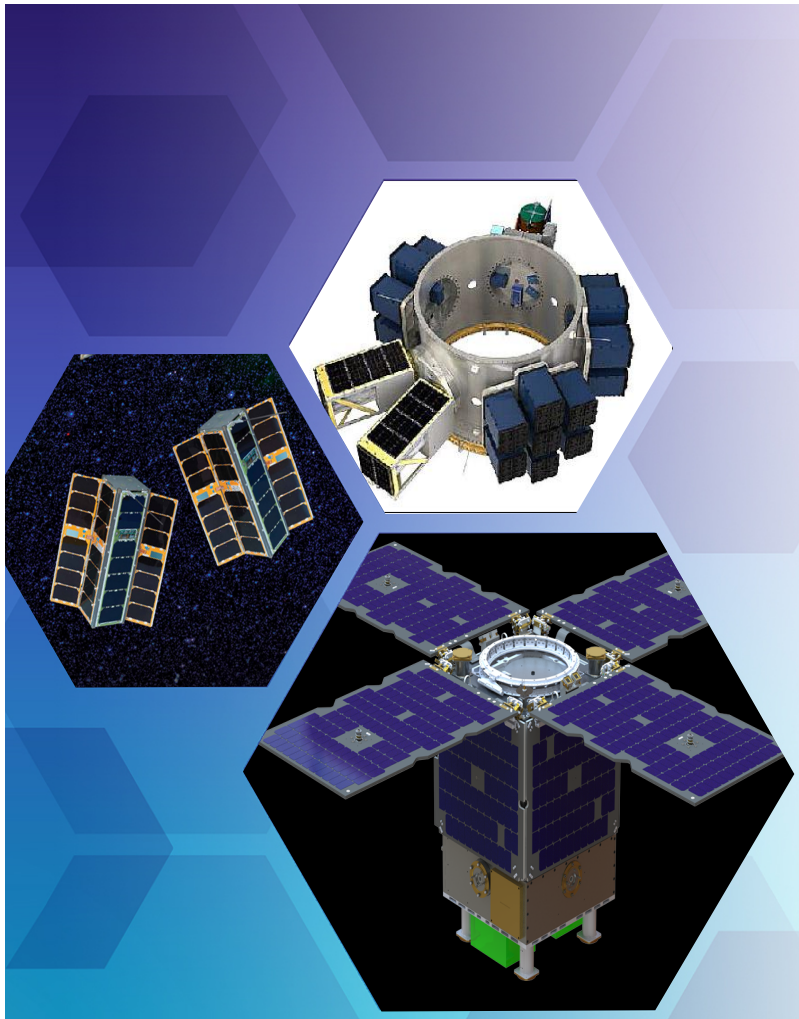
Astrophysics SmallSats





- SMD is interested in exploring ways that CubeSats/SmallSats can do highly valued science for lower price points.
- Astrophysics RFI for SmallSats asked for ideas to do high priority Astrophysics science projects at a price point between typical R&A and Explorer MOO projects ($10M-$35M).
- The RFI also asked for advanced mission concepts for which “significant” investments in instrument and/or platform technologies would be required, without budget constraints, in order to inform future STMD solicitations.
- 55 replies were responsive to Astrophysics science and/or technology.

Representative Science Areas: Exoplanets, GRM/EM Counterparts, UV/X-ray Surveys, WHIM, 21cm
Representative Technology Areas: Power systems, antennas, miniaturized cryo-coolers, communication; positioning; on-board processing, and advanced propulsion systems for formation flying



Astrophysics SmallSats

Step 1: Funded mission concept studies

- NASA will conduct funded SmallSat mission concept studies (via ROSES) in advance of the 2019 SMEX AO

Step 2: NASA is considering adding SmallSats to the 2019 Explorer Mission of Opportunity PEA (Program Element Appendix of the SALMON-3 AO)

- Potential new class of MO: SmallSats ($35M cost cap)
- NASA would offer to find launch for standard CubeSat and ESPA*-ring forms

* EELV Secondary Payload Adapter

Planned Accomplishments FY18-19

- TESS will launch April 2018
- Funds appropriated by Congress in FY18 will allow WFIRST to enter Phase B in April 2018
- IXPE will complete preliminary design review and enter Phase C Fall 2018
- Next MIDEX and Mission of Opportunity missions will be downselected by January 2019
- Decadal Survey will begin January 2019
- Webb will complete observatory integration in 2019
- Senior Review will be conducted Spring 2019
- If Congress approves the Administration's request to terminate WFIRST, the funds made available would enable a competed mission AO in FY19

NASA Astrophysics

Backup

Science FY19 Budget Request Summary ($M)

	Actual	Enacted	Request	Notional			
	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23
Science	5,762.2	6,221.5	5,895.0	5,859.9	5,841.1	5,822.4	5,803.6
Earth Science	1,907.7	1,921.0	1,784.2	1,784.2	1,784.2	1,784.2	1,784.2
Earth Science Research	462.0		451.4	457.4	483.8	507.7	537.8
Earth Systematic Missions	929.7		788.1	729.5	689.1	646.5	595.0
Earth System Science Pathfinder	208.8		235.0	273.7	268.2	274.3	287.7
Earth Science Multi-Mission Operations	204.9		196.9	208.7	225.0	231.6	237.1
Earth Science Technology	62.9		59.7	61.6	64.2	67.8	69.6
Applied Sciences	39.4		53.1	53.3	53.9	56.3	57.0
Planetary Science	1,827.5	2,227.9	2,234.7	2,199.6	2,180.8	2,162.1	2,143.3
Planetary Science Research	230.1		258.0	247.6	247.6	247.6	247.6
Planetary Defense	60.0		150.0	150.0	150.0	150.0	150.0
Lunar Discovery and Exploration	19.0		218.0	218.0	218.0	218.0	218.0
Discovery	194.6	335.8	381.2	476.6	375.0	355.6	348.5
New Frontiers	134.0	90.0	130.2	163.7	245.0	327.6	388.4
Mars Exploration	647.0	660.0	601.5	529.7	371.9	290.8	215.3
Outer Planets and Ocean Worlds	359.5		285.6	213.8	373.3	372.5	375.5
Technology	183.3		210.2	200.2	200.0	200.0	200.0
Astrophysics	1,352.3	1,384.1	1,185.4	1,185.4	1,185.4	1,185.4	1,185.4
Astrophysics Research	190.1		259.2	280.8	321.5	318.4	310.0
Cosmic Origins	779.4		491.4	354.5	311.9	312.7	312.7
Physics of the Cosmos	106.2		136.8	139.1	113.3	108.3	105.0
Exoplanet Exploration	152.6		52.4	44.5	44.6	44.4	44.9
Astrophysics Explorer	124.1		245.6	366.5	394.0	401.6	412.8
Heliophysics	674.7	688.5	690.7	690.7	690.7	690.7	690.7
Heliophysics Research	180.8		242.7	234.3	226.7	217.9	220.6
Living with a Star	368.4		247.8	103.4	83.5	93.2	127.8
Solar Terrestrial Probes	38.8		91.0	89.9	177.7	175.6	247.9
Heliophysics Explorer Program	86.7		109.2	263.1	202.9	204.1	94.4

Astrophysics FY19 Budget Request ($M) (cont'd)

	Actual	Enacted	Request	Notional			
	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23
Physics of the Cosmos	106.2		136.8	139.1	113.3	108.3	105.0
Euclid	12.9		20.2	16.4	9.4	9.5	8.9
Physics of the Cosmos Future Missions	0.1		2.3	3.4	3.7	4.0	4.4
Chandra X-Ray Observatory	50.7		58.9	58.4	58.4	58.4	58.4
Fermi Gamma-ray Space Telescope	12.5		15.5	14.0			
XMM	3.5		3.5	3.5			
Planck	0.6						
Physics of the Cosmos SR&T	23.3		33.5	41.1	39.4	34.1	30.9
Physics of the Cosmos Program Mgmt	2.6		2.9	2.4	2.4	2.4	2.4
Exoplanet Exploration	152.6		52.4	44.5	44.6	44.4	44.9
WFIRST	105.0	**150.0**					
Exoplanet Exploration Future Missions	0.9		1.5	1.6	1.4	1.2	1.0
Kepler	11.0		7.9	1.3			
Keck Operations	6.1		6.5	6.7	6.9	7.0	7.2
Large Binocular Telescope Interferometer	2.6						
Exoplanet Exploration SR&T	21.2		28.5	27.2	28.4	28.3	28.3
Exoplanet Exploration Program Mgmt	5.9		8.0	7.8	8.0	7.9	8.3

Astrophysics FY19 Budget Request ($M) (cont'd)

	Actual FY 17	Enacted FY 18	Request FY 19	Notional FY 20	FY 21	FY 22	FY 23
Astrophysics Explorer	124.1		245.6	366.5	394.0	401.6	412.8
Transiting Exoplanet Survey Satellite	74.0		27.5	3.8	0.0		
Imaging X-Ray Polarimetry Explorer	11.3		65.9	67.3	40.7	5.0	4.2
Other Missions and Data Analysis	38.8		152.2	295.5	353.3	396.6	408.6
GUSTO	2.4		13.2	11.6	7.5	3.5	
Astrophysics Explorer Future Missions	15.2		112.1	262.9	334.1	385.2	398.5
Nuclear Spectroscopic Telescope Array	5.0		8.3	7.0			
Swift	5.5		5.4	5.5			
NICER	4.6		2.4				
Astrophysics Explorer Program Mgmt	6.1		10.9	8.5	11.8	7.9	10.1