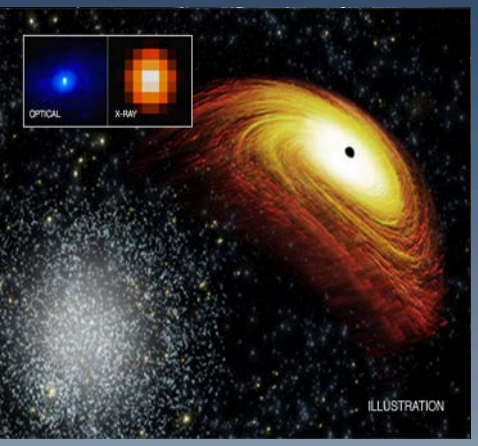
National Aeronautics and Space Administration

Astrophysics





NASA Astrophysics Update

Astronomy and Astrophysics Advisory Committee
September 27, 2017

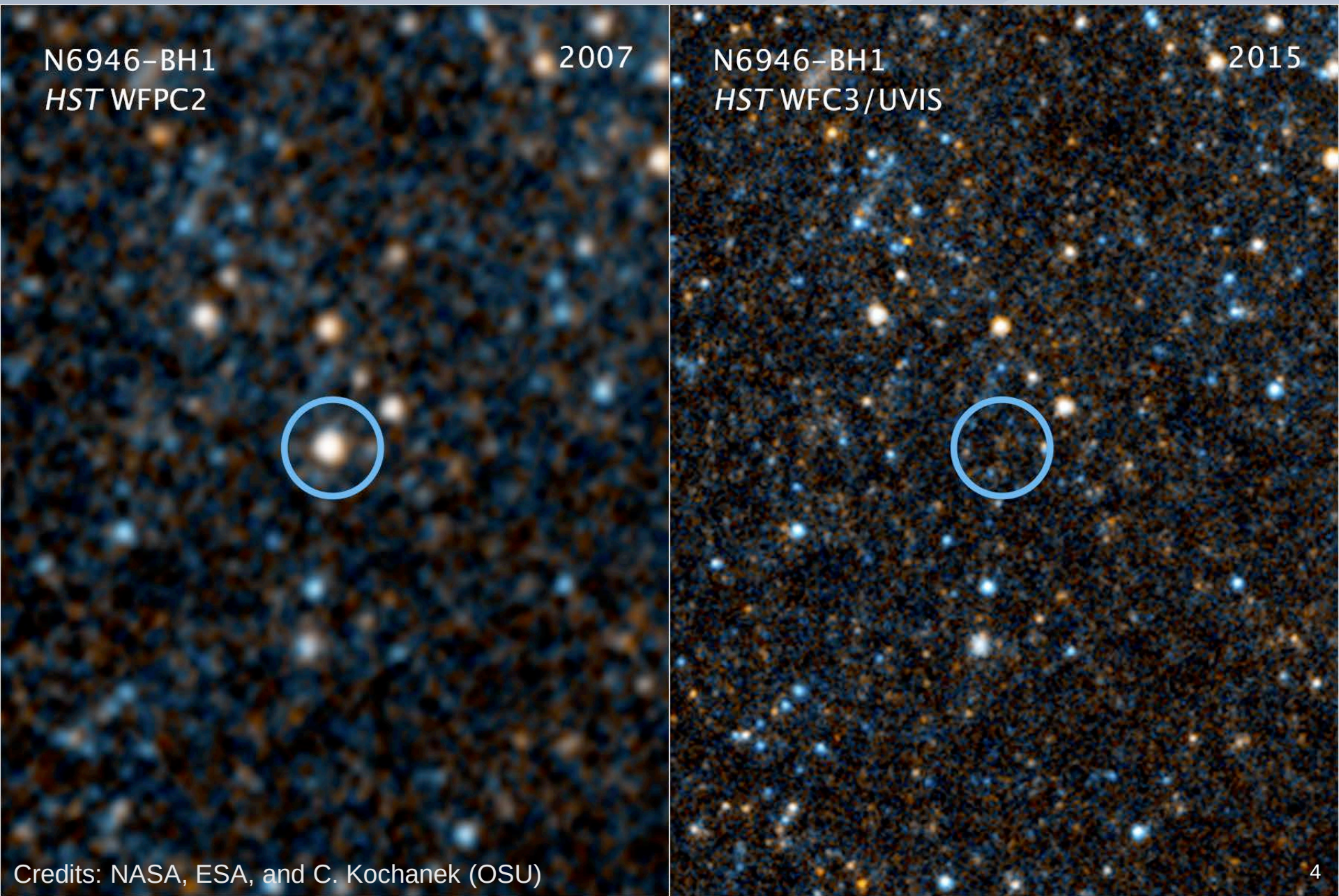
Paul Hertz
Director, Astrophysics Division
Science Mission Directorate
@PHertzNASA

Outline

NASA Astrophysics

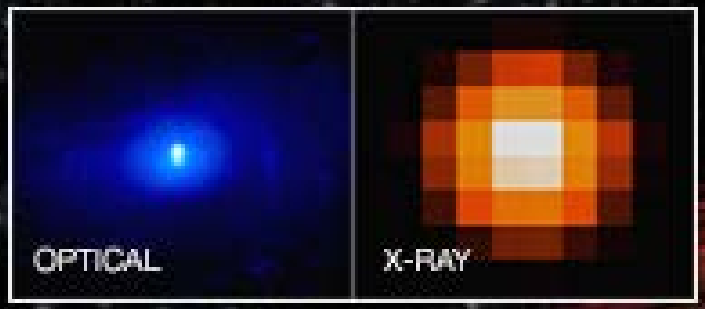
Science Highlights

First “failed supernova” observed



Credits: NASA, ESA, and C. Kochanek (OSU)

Supermassive black hole recoiled away from galaxy core (CXO J101527.2+625911)



ILLUSTRATION

Credit: X-ray: NASA/CXC/NRAO/D.-C.Kim; Optical: NASA/STScI; Illustration: NASA/CXC/M.Weiss

Final Kepler catalog reveals exoplanet demographics

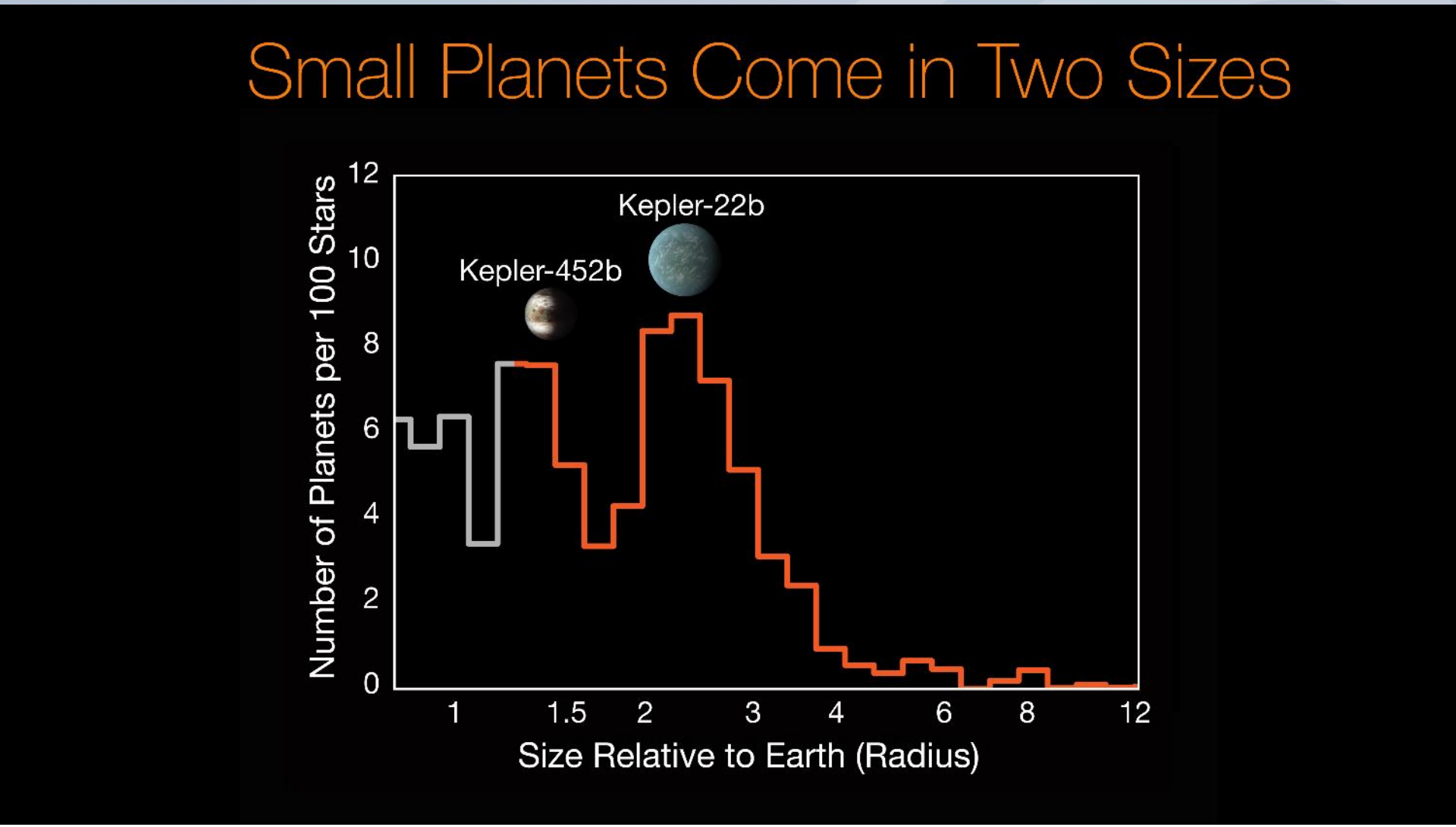
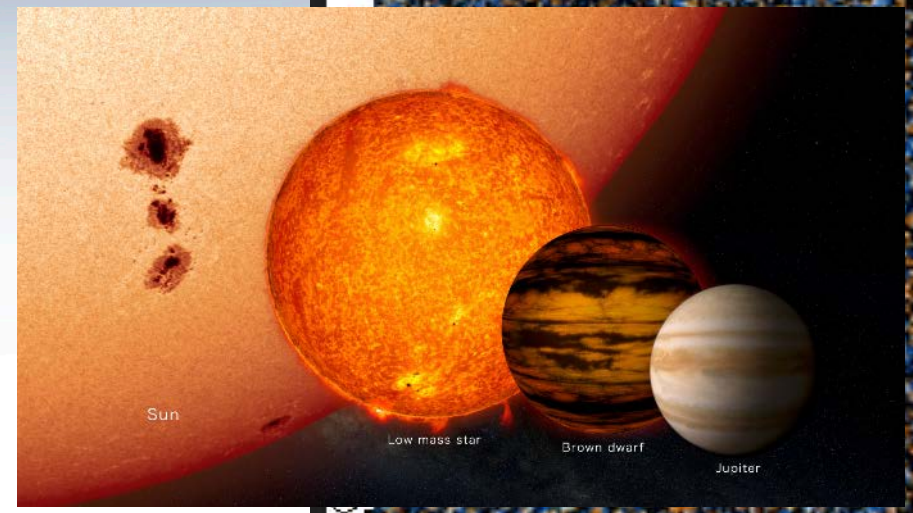


Image credit: NASA/Ames Research Center/Caltech/University of Hawaii/B.J. Fulton

NASA-funded citizen science project discovers brown dwarf in WISE data



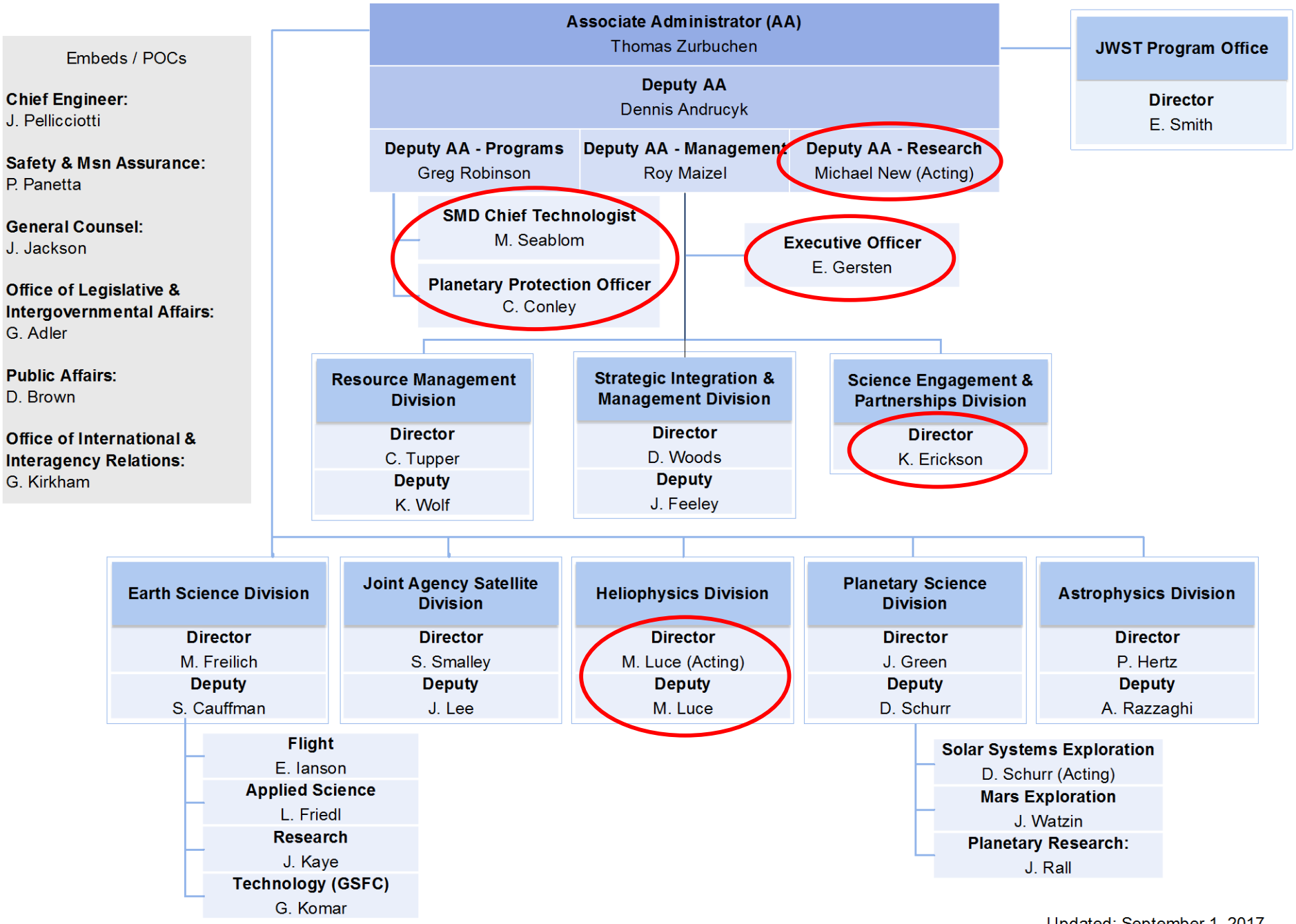
NASA Astrophysics

Big Picture (including budget)

Administrator Nominee

- Jim Bridenstine (R-OK)
  - Representative of Oklahoma's First Congressional District (3rd term)
  - Sponsor of the American Space Renaissance Act (H.R. 4945)
  - Serves on the House Armed Services Committee and the Science, Space and Technology Committee
  - Nine years active duty in the United States Navy
  - Lieutenant Commander in the U.S. Navy Reserve
  - Active member of the Oklahoma Air National Guard
  - Executive Director of the Tulsa Air and Space Museum & Planetarium
  - Business/Economics/Psychology major at Rice University
  - MBA from Cornell University
  - Business experience in real estate, ranching, aerospace, and defense contracting

Source: https://bridenstine.house.gov

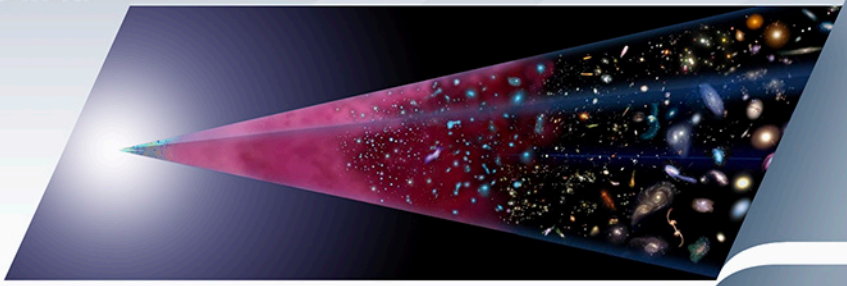


Updated: September 1, 2017

Why Astrophysics?

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

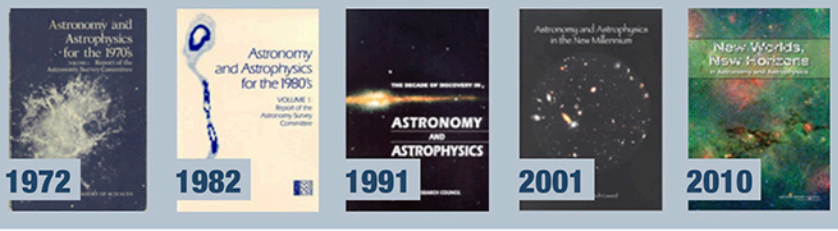
How did our universe begin and evolve?



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

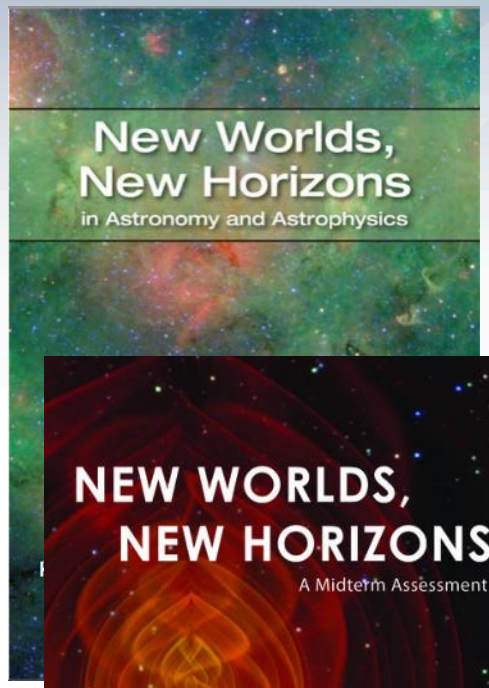
Are we alone?

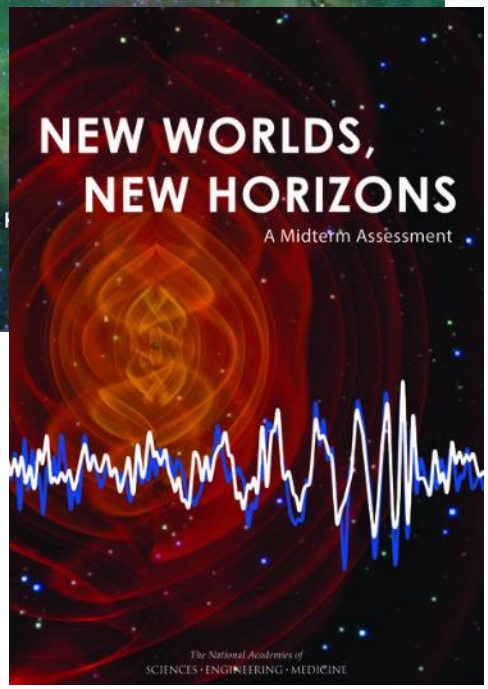
Enduring National Strategic Drivers

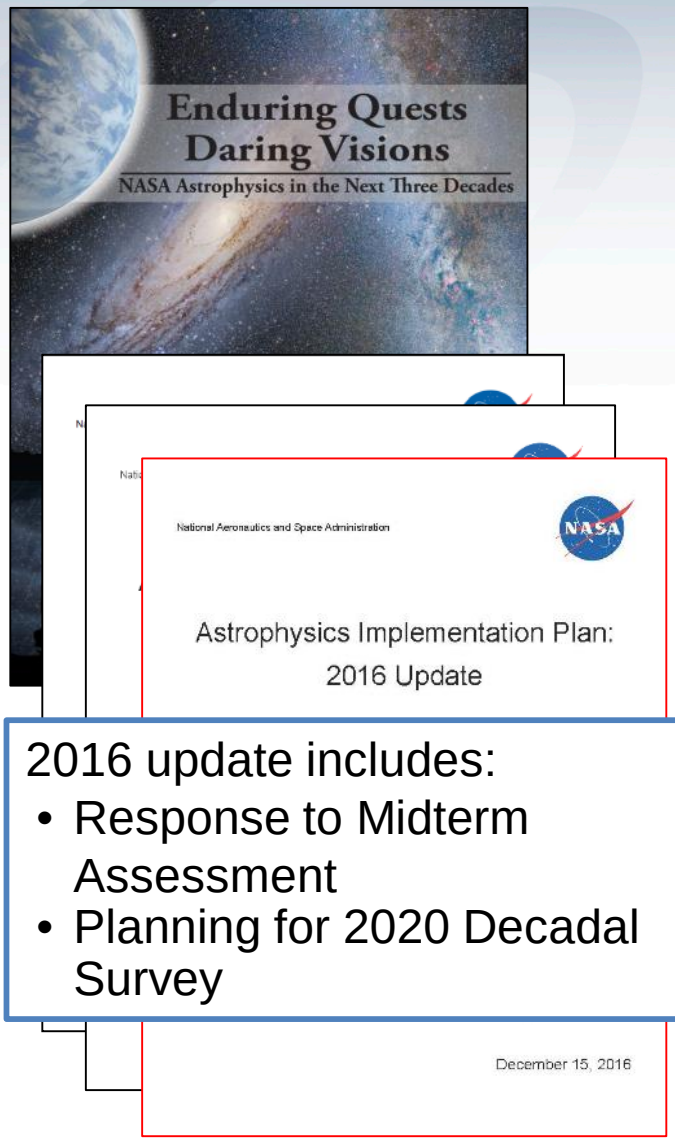


Astrophysics Driving Documents

To be updated in 2018 (per GPRAMA)







2016 update includes:

- Response to Midterm Assessment
- Planning for 2020 Decadal Survey

https://science.nasa.gov/astrophysics/documents

Big Picture (1 of 2)

- **The FY17 appropriation and FY18 budget request provide funding for NASA astrophysics to continue its planned programs, missions, projects, research, and technology.**
  - Total funding (Astrophysics including Webb) remains at ~$1.35B.
  - The NASA Astrophysics budget funds Webb for an October 2018 launch, WFIRST formulation, Explorers mission development, increased funding for R&A, operating missions, suborbital missions and new capabilities, continued technology development and mission studies.
  - FY17 Consolidated Appropriation is less than planning budget; reductions to plans required.
  - FY18 President's Budget Request balances current science and future missions; Congressional markups, if enacted, would put that balance at risk.
- **NASA continues to prioritize implementation of the recommendations of the 2010 Decadal Survey.**
  - National Academies' 2016 Midterm Assessment Report validates NASA's progress.
  - NASA is conducting large and medium mission concept studies for 2020 Decadal Survey.

Big Picture (2 of 2)

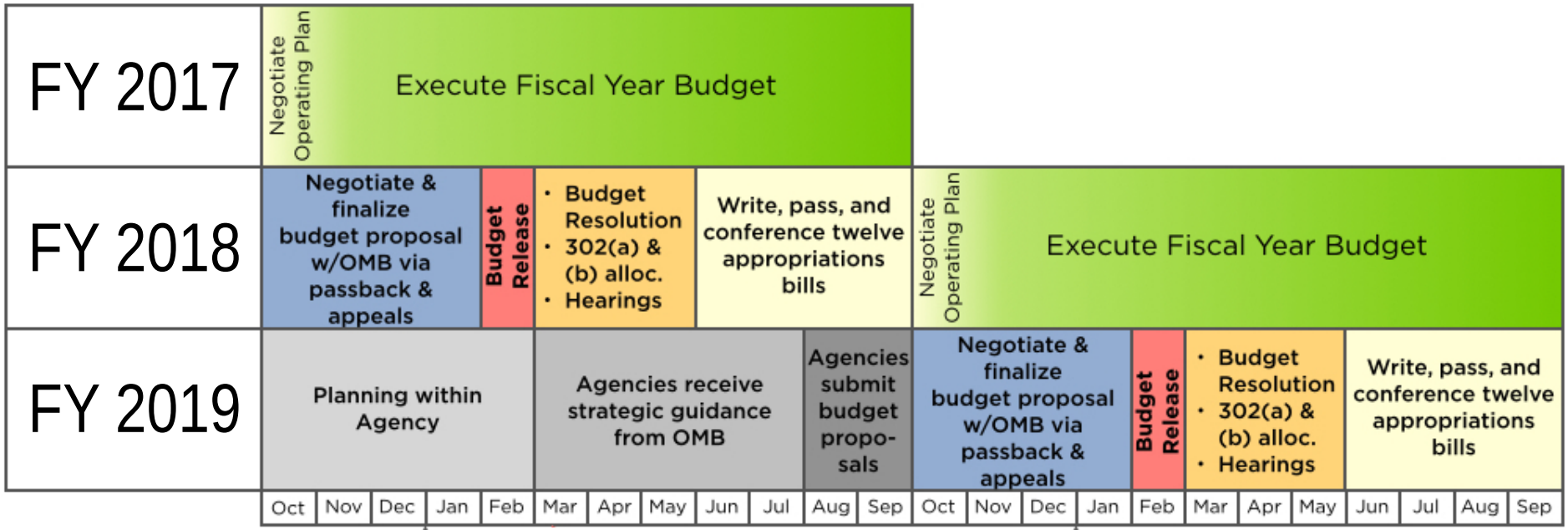
- **The operating missions continue to generate important and compelling science results, and new missions are under development for the future.**
  - Senior Review in Spring 2016 recommended continued operation of all missions (Chandra, Fermi, Hubble, Kepler, NuSTAR, Spitzer, Swift, XMM); next Senior Review is in 2019.
  - SOFIA is adding new instruments: HAWC+ instrument commissioned; HIRMES instrument in development; next gen instrument call planned.
  - ISS-NICER launched on June 3, 2017; ISS-CREAM launched on August 14, 2017.
  - NASA missions under development making progress toward launches: TESS (2018), Webb (2018), IXPE (2021), GUSTO (2021), WFIRST (mid-2020s).
  - Independent WFIRST technical/management/cost review underway; report expected by end of October 2017.
  - Partnerships with ESA and JAXA on future missions create additional science opportunities: Euclid (ESA; 2020), XARM (JAXA; 2021), Athena (ESA; 2028), LISA (ESA; 2034).
  - Explorer AOs are being released every 2-3 years: IXPE downselected in January 2017, GUSTO downselected in March 2017, MIDEX/MO missions selected for Phase A studies in August 2017, next SMEX/MO AO in Spring 2019.

Implementing the Decadal Survey and the Midterm Assessment

Prioritized Recommendation	NASA plans
LARGE ACTIVITIES	
WFIRST	In Phase A, launch in mid-2020s; independent review
Explorers	Planning 4 AOs per decade: SMEX 2014, MIDEX 2016, SMEX 2019, MIDEX 2021; maintain cadence
LISA	Partnering on ESA's LISA gravitational wave observatory; increased US role
IXO	Partnering on ESA's Athena x-ray observatory; no increase to role
MEDIUM ACTIVITIES	
Exoplanet technology	WFIRST coronagraph, Starshade and coronagraph technology development; lower priority than LISA technology
Inflation Probe technology	Balloon-borne technology experiments, detector investments
SMALL ACTIVITIES	
R&A augmentations	R&A increased by reducing Fellowships
Mid-TRL technology	Initiated SAT program, includes competed & directed technologies
Suborbital missions	Initiated ultra long duration balloon capability

"Despite a challenging budget environment, NASA-APD has maintained a balanced portfolio through the first half of the decade and, with the assumption of successful completion of an ambitious Explorer schedule, will do so during the second half of the decade as well. ..." NAS Midterm Assessment, Finding 4-14

Federal Budget Cycle



Start of Calendar Year 2017

We are here.

Continuing resolution through December 8

Start of Calendar Year 2018

Adapted by Kevin Marvel (AAS)
https://aas.org/files/budgetprocess_adaptedfromaaas.jpg
from budget presentation by Matt Hourihan (AAAS)
http://www.aaas.org/page/presentations

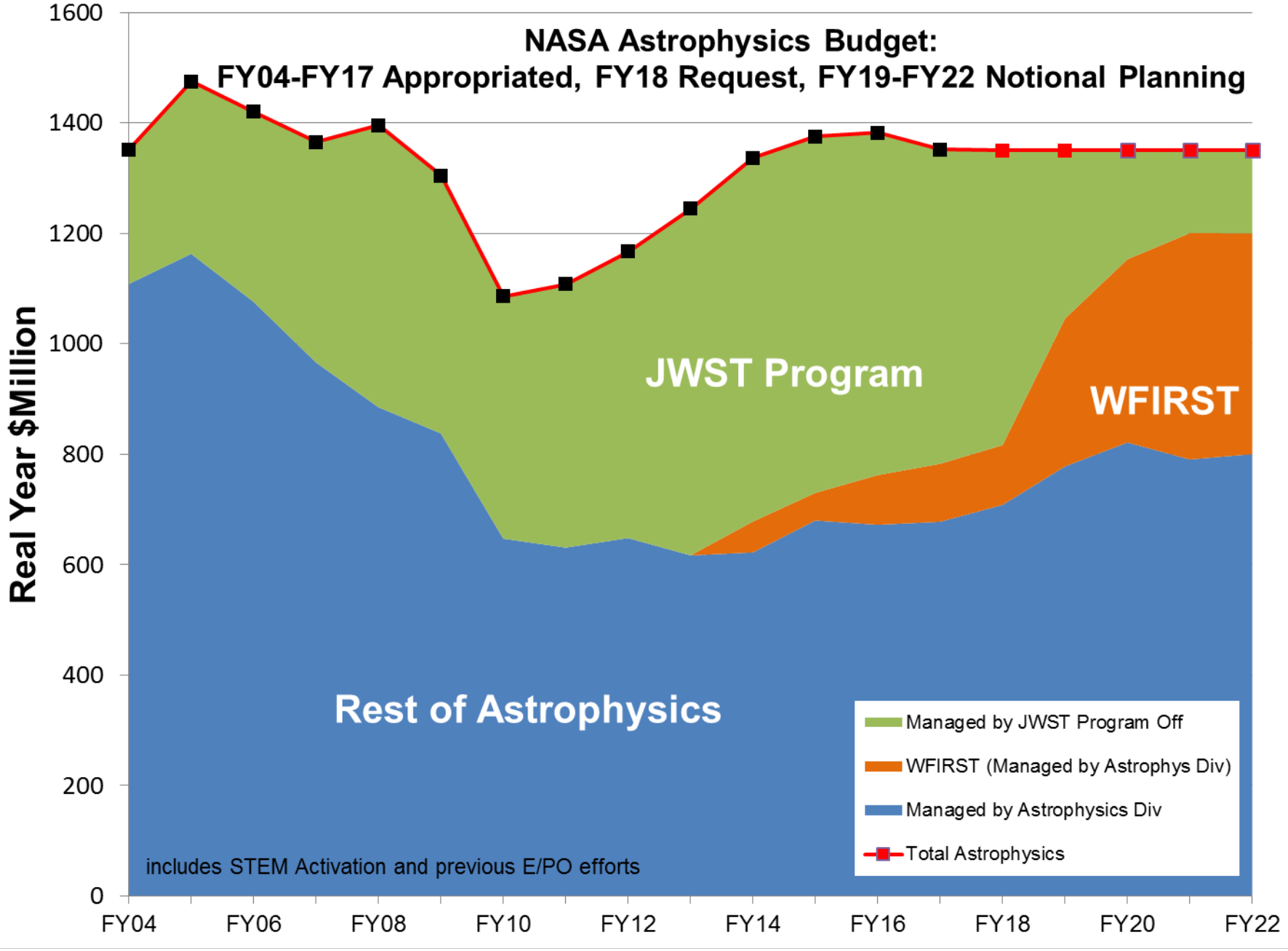
FY17 Final Budget

$M	FY17 Request	FY17 Actual	Delta	
Total	1,350.9	1,352.3	+1.4	Reduction of $31.5M in total offset by cost sharing of STEM Activation
Webb	569.4	569.4	---	Set by Appropriation
WFIRST	90.0	105.0	+15.0	Set by Appropriation; Appropriation caps WFIRST LCC at $3.5B through prime mission
SOFIA	83.8	85.2	+1.4	Set by Appropriation
Hubble	97.3	97.3	---	
STEM Activation	25.0	37.0	+12.0	Set by Appropriation but costs shared across Divisions
TESS	89.0	74.0	-15.0	Deferred launch vehicle payment until FY18; reduction in HQ-held reserves in FY18 to accommodate
Balloon Project	37.0	34.0	-3.0	Defer upgrades in Antarctica
Rest of Astrophysics			-9.0	Rephasing and reduction in many programs and projects

FY18 President's Budget Request

$M	FY16 Actual	FY17 Actual	FY18 Request	Change from FY16	Change from FY17
NASA	19,285	19,653	19,092	-1.0 %	-2.9%
SMD	5,584	5,765	5,712	+2.3 %	-0.9 %
Earth Science	1,927	1,908	1,754	-9.0 %	-8.1 %
Heliophysics	647	675	678	+4.8 %	+0.4 %
Planetary Science	1,628	1,828	1,930	+18.6 %	+5.6 %
Astrophysics (including Webb)	1,382	1,352	1,350	-2.3%	-0.1 %

- Supports an SMD-wide CubeSat/SmallSat initiative that uses smaller, less expensive satellites to advance science in a cost-effective manner.
- Reflects more efficient operations of the Hubble Space Telescope, without impact to science.
- Reflects efficiencies realized by the SOFIA in the past few years. SOFIA will participate in the 2019 Astrophysics Senior Review.
- Does not include WFIRST review recommendations.


NASA Astrophysics Budget:
FY04-FY17 Appropriated, FY18 Request, FY19-FY22 Notional Planning
Real Year $Million
1600
1400
1200
1000
800
600
400
200
0
FY04
FY06
FY08
FY10
FY12
FY14
FY16
FY18
FY20
FY22
JWST Program
WFIRST
Rest of Astrophysics
includes STEM Activation and previous E/PO efforts
Managed by JWST Program Off
WFIRST (Managed by Astrophys Div)
Managed by Astrophysics Div
Total Astrophysics

FY18 Appropriation Markups

- Both Markups
  - Follow the Decadal Survey
  - Webb must be $533.7M (= requested) but do not overrun
  - STEM Activation must be $44.0M (= request); other language
- House Markup
  - Core R&A must be $74.1M (= request)
  - SOFIA must be $85.2M (+$5.3M over request, = FY17 level); other language
  - WFIRST must be $126.6M (= request) but spend $20M on starshade technology
  - Language on high energy observatories, astrophysics probes, finding target(s) for interstellar probe
- Senate Markup
  - WFIRST must be $150.0M (+23.4M over request); review; data w/ Hubble, Webb
  - Hubble must be $98.3M (+$15M over request)
  - At least $10M on “life detection technology”; consistent with request (maybe)

	FY18 PBR	FY18 Markups	
Total Astrophysics	$ 1,350.5 M	$ 1,350.5 M	
Earmarked Projects	$ 941.6 M	$ 995.3 M	Webb, WFIRST, Hubble, SOFIA, R&A, STEM, Starshade ($10M) *
Rest of Astrophysics	$ 408.9 M	$ 365.2 M	$43.7M (13%) reduction

* Combined House and Senate markups

FY18 Budget – House Markup

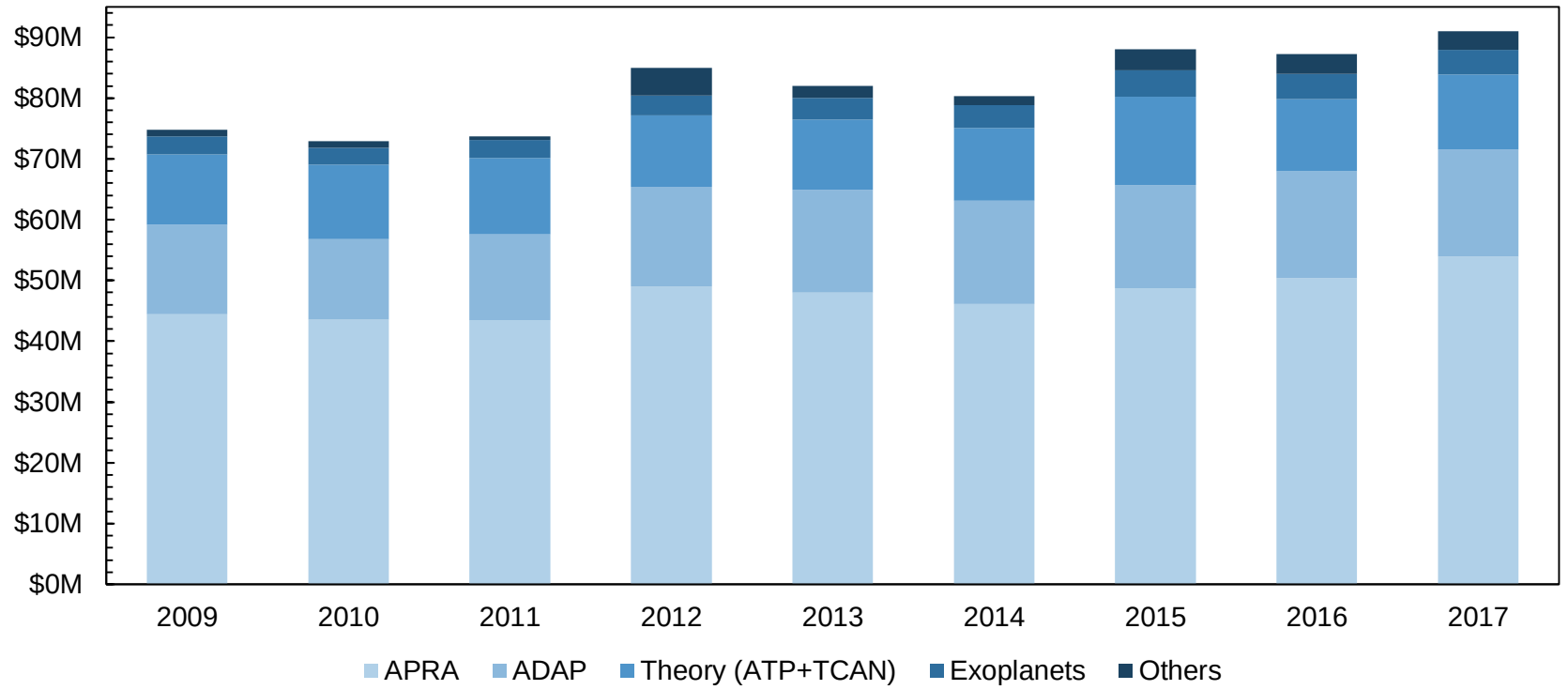
- Astrophysics (including Webb) receives $1,355.7M, an increase of $5.3M over the request
  - WFIRST receives $126.6M (as requested)
    - Within amounts provided for WFIRST, $20M is for continued development of the Starshade technology demonstration effort. The Committee expects WFIRST to accommodate the Starshade technology demonstration mission. The Starshade, in tandem with WFIRST, will enable NASA to identify the nearest Earth-like planet around the nearest star, and thereby identify a target or multiple targets for the interstellar mission discussed later in this report.
    - The Committee also directs NASA to accelerate work on Starshade and WFIRST to ensure that WFIRST is Starshade compatible, and that Starshade will launch and be capable of working with WFIRST to identify the nearest Earth-like planet that shows evidence of extant life.
    - The Committee directs NASA to include a section in the interstellar propulsion technology report which details NASA's plan to make WFIRST Starshade compatible and what size, design and funding requirements are necessary for Starshade and WFIRST to resolve the planet from the star and spectrographically analyze the atmosphere of rocky Earth-like planets in the habitable zones of stable, long-lived stars out to a distance of 10 parsecs.
    - NASA is encouraged to collaborate with the National Academies of Sciences to create a permanent Decadal Survey for Exoplanet Exploration for the next decade and beyond, and NASA is directed to follow the recommendations of this new Exoplanet Exploration Decadal Survey in developing America's long-term plans for systematic interstellar exploration missions to Earth-like planets harboring life in our galactic neighborhood.

NASA Astrophysics

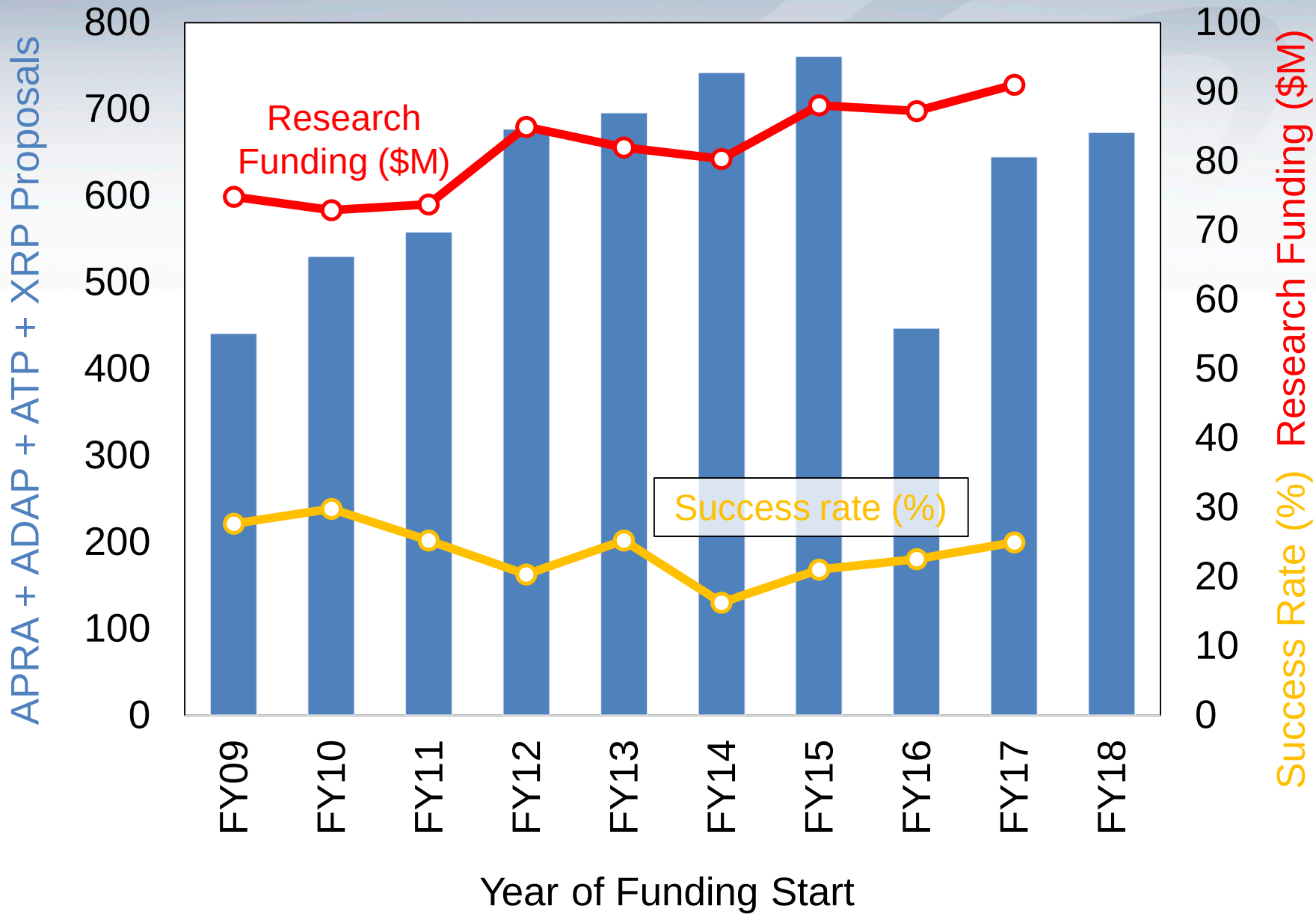
Research and Analysis Update

Historical R&A Budget Trends

Program	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17
APRA	$44 M	$44 M	$43 M	$49 M	$48 M	$46 M	$49 M	$50 M	$54 M
ADAP	$15 M	$13 M	$14 M	$16 M	$17 M	$17 M	$17 M	$18 M	$18 M
Theory (ATP+TCAN)	$11 M	$12 M	$13 M	$12 M	$12 M	$12 M	$15 M	$12 M	$12 M
Exoplanets	$3 M	$3 M	$3 M	$3 M	$4 M	$4 M	$4 M	$4 M	$4 M
Others	$1 M	$1 M	$1 M	$5 M	$2 M	$1 M	$3 M	$3 M	$3 M
Total	**$75 M**	**$73 M**	**$74 M**	**$85 M**	**$82 M**	**$80 M**	**$88 M**	**$87 M**	**$91 M**

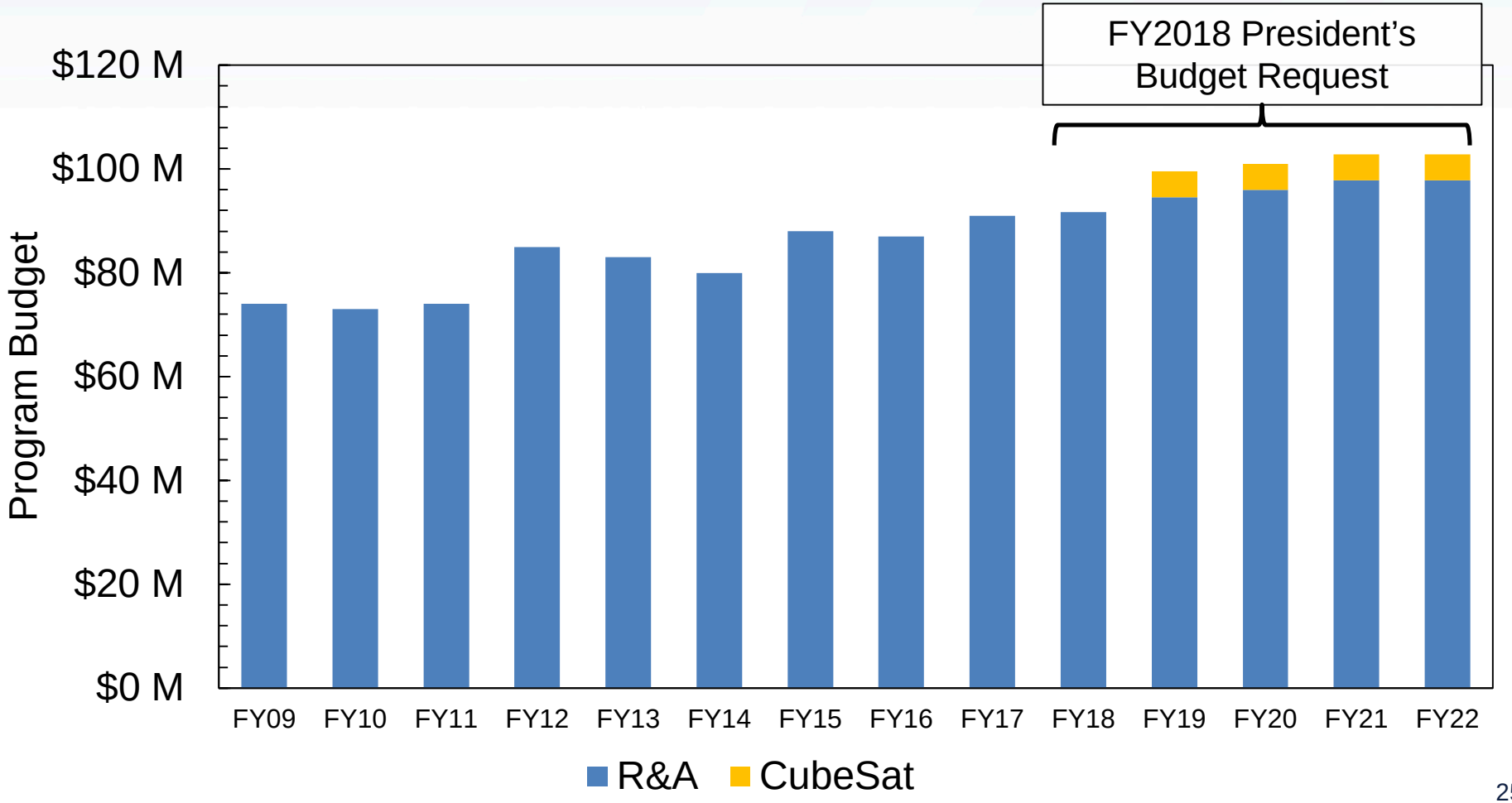


R&A Proposal Pressure



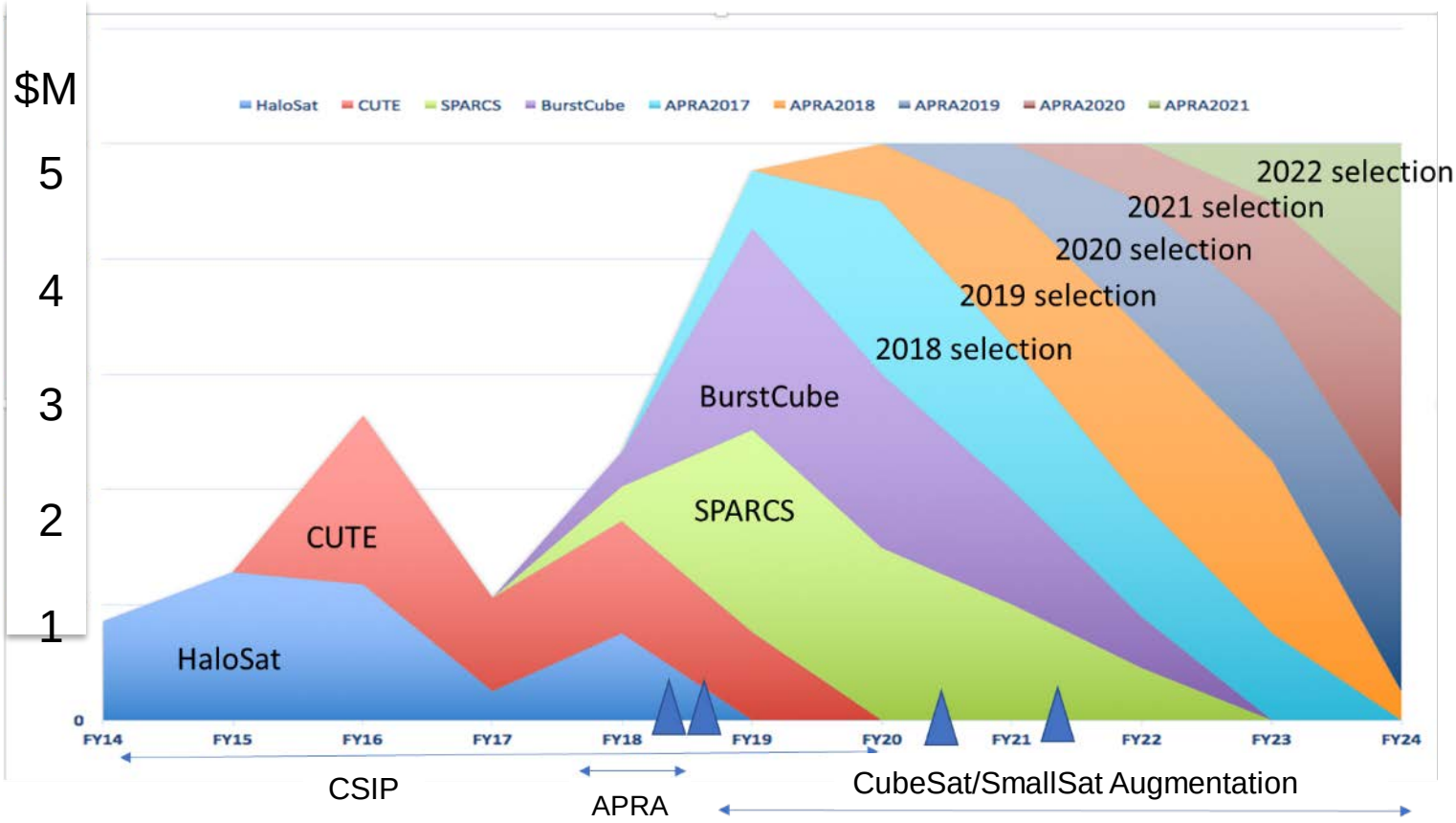
Proposed R&A Future Budget

Program	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
R&A	$74 M	$73 M	$74 M	$85 M	$83 M	$80 M	$88 M	$87 M	$91 M	$92 M	$95 M	$96 M	$98 M	$98 M
CubeSat											$5 M	$5 M	$5 M	$5 M
Total	**$74 M**	**$73 M**	**$74 M**	**$85 M**	**$83 M**	**$80 M**	**$88 M**	**$87 M**	**$91 M**	**$92 M**	**$100 M**	**$101 M**	**$103 M**	**$103 M**



Astrophysics CubeSats

- Astrophysics CubeSats are implemented as part of the R&A program
  - CubeSat proposals are submitted just like proposals for balloon payloads and sounding rocket payloads
- Astrophysics selected two CubeSats under the CubeSat Initiative Program (CSIP)
- The CubeSat/SmallSat augmentation will support ~1 astrophysics CubeSat selection per year



NASA Hubble Fellowship Program (NHFP)

https://nhfp.stsci.edu/

- A single fellowship program that selects ~24 fellows annually whose science spans the breadth of NASA astrophysics.
  - Same length of fellowship + salary and benefits as before.
- NHFP administered for NASA by STScI. Management of program collaboratively between STScI, NExScI/IPAC, and CXC.
- Awards through host institutions. Starting in 2018 an institution may only host 5 fellows at any one time + no more than 2 in a given year.
- Single review with multiple science-based panels in DC.
- To leverage past experience and preserve legacy from three previous programs, fellows after selection will be divided into three sub-categories corresponding to NASA's "big questions":
  - *How does the Universe work?* – Einstein Fellows
  - *How did we get here?* – Hubble Fellows
  - *Are we alone?* – Sagan Fellows

ATP: Astrophysics Theory Program

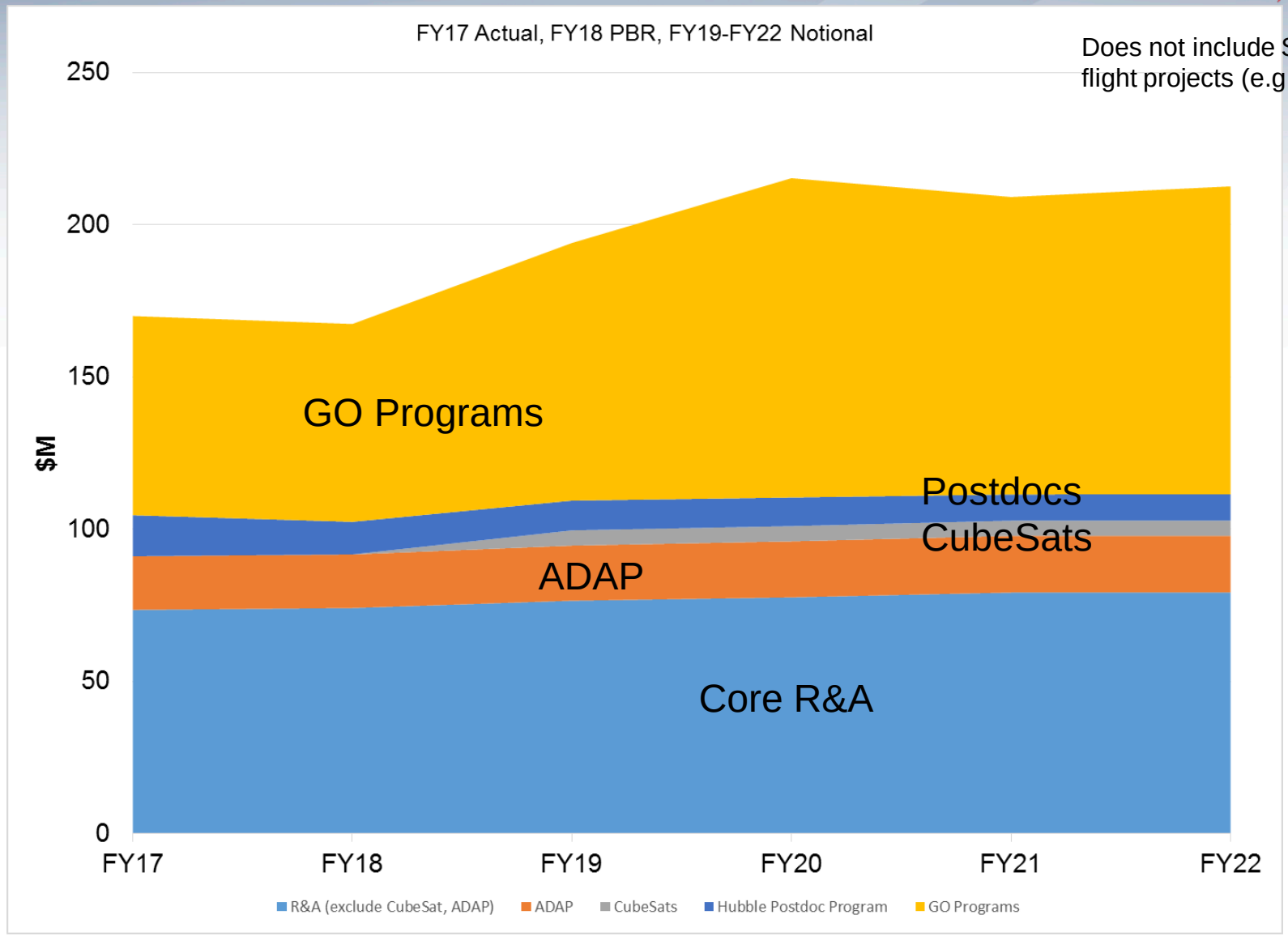
To address the problem of low selection rates, the Astrophysics Division now competes ATP in alternate years. The program budget remains the same. This should increase the selection rate close to that recommended in the 2015-6 report of the Astronomy and Astrophysics Advisory Committee.

With an annual ATP competition in 2010-16, only about 17% of the requested year-1 funding could be awarded. We had to decline almost half of the E/VG proposals.

Competing the ATP program only in even years: roughly $8.5M in year-1 funding will be available for ATP-17, or 26% of the request. We could likely fund all the E and E/VG proposals, and some VG proposals.

This change also reduces the burden on reviewers and proposers alike.

Total Community Support



GO programs funded from Chandra, Fermi, Hubble, Kepler/K2, NuSTAR, SOFIA, Spitzer, Swift, TESS, Webb, XARM, XMM; does not include possible extensions following the 2019 Senior Review.

NASA Astrophysics Diversity and Inclusion

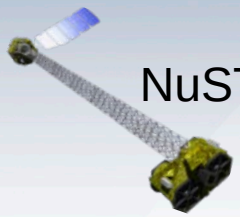
- The NASA Astrophysics Division is actively taking steps to advance diversity, inclusion, and equal opportunity in the NASA workforce and among NASA grantee institutions.
- NASA Astrophysics is committed to:
  - Setting the expectancy of diversity and inclusion in the composition of: proposal teams, peer review panels, science and technology definition teams, and mission and instrument teams.
  - Working with the Office of the Chief Scientist to produce a short video on unconscious bias in peer reviews for future distribution to panelists.
  - Discussing best practices in peer reviews with other agencies.
  - Recruiting a diverse Astrophysics Division staff.
  - Performing detailed statistical analyses of the demographics of R&A proposers and awardees.
  - Promoting diversity on HQ-selected groups (e.g., APAC, PAGs, etc.)
- The Spring 2018 APAC meeting should expect a detailed report on these aspects.

NASA Astrophysics

Selected Mission Updates

Current and Future Explorer AOs

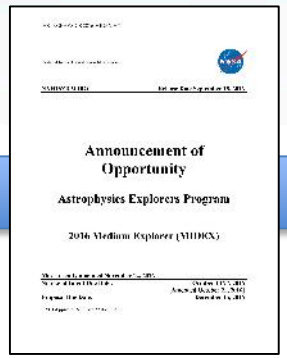
Swift



NuSTAR

MIDEX
2011

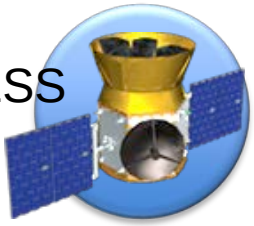
SMEX
2014

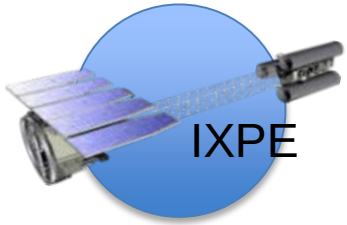


MIDEX
2016

SMEX
2019
(planned)

TESS

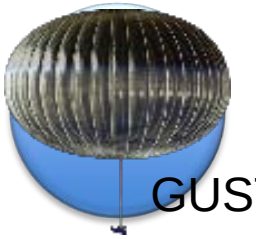




IXPE

Arcus
FINESSE
SPHEREx

NICER



GUSTO

CASE
COSI-X
ISS-TAO

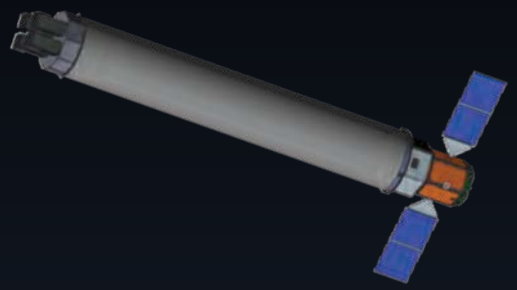
XARM

Current and Future Explorer AOs

- NASA is maintaining a cadence of 4 Astrophysics Explorers AOs per decade, as recommended by Decadal Survey and validated by Midterm Assessment.
  - Midterm Assessment Recommendation 4-3: “NASA’s Astrophysics Division should execute its current plan, as presented to the committee, of at least four Explorer Announcements of Opportunity during the 2012-2021 decade, each with a Mission of Opportunity call, and each followed by mission selection.”
- Most recent Astrophysics Explorers Program AO, released in September 2016, was for a MIDEX and Mission of Opportunity (MO).
  - Three MIDEX mission proposals and three Mission of Opportunity proposals selected in August 2017 for 9-month competitive Phase A studies
  - Down-selection: Early 2019 (target)
  - MIDEX launch readiness date no later than December 2023
  - MO launch readiness date no later than December 2022, except for Partner MOs whose launch date is set by the host mission.
- Next Astrophysics Explorers Program AO will be for a SMEX and MO and is targeted for release in early 2019.
- Subsequent Astrophysics Explorers Program AO is for a MIDEX and MO and is targeted for release in late summer 2021.

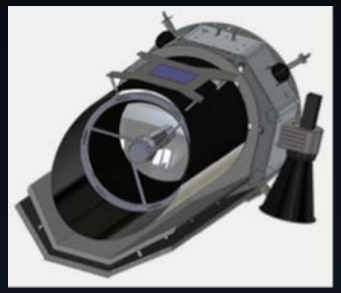
Astrophysics Explorers in Competitive Phase A

Arcus
PI: R. Smith/SAO



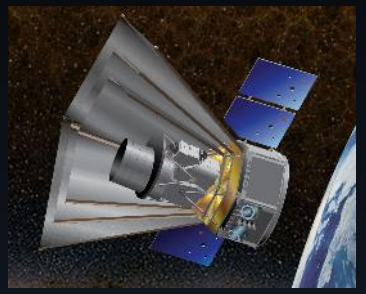
High resolution x-ray spectroscopy to explore the origin of galaxies

FINESSE
PI: M. Swain/JPL



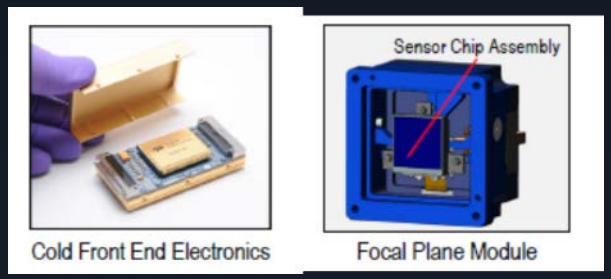
NIR transit spectroscopy to explore exoplanet atmospheres

SPHEREx
PI: J. Bock/Caltech



NIR spectral survey addressing cosmology, galaxy evolution, and origin of ices

CASE
PI: M. Swain/JPL

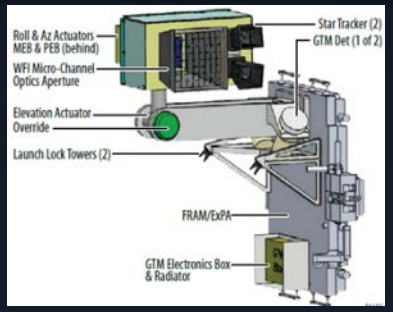


Contribution of detectors to ESA's ARIEL

COSI-X
PI: S. Boggs/UCB

ULDB balloon mission to study origin of elements in the galaxy

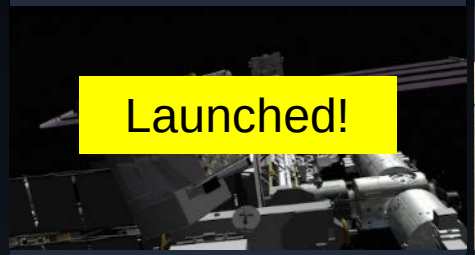
ISS-TAO
PI: J. Camp/GSFC



All-sky x-ray survey to study transients and search for GW sources

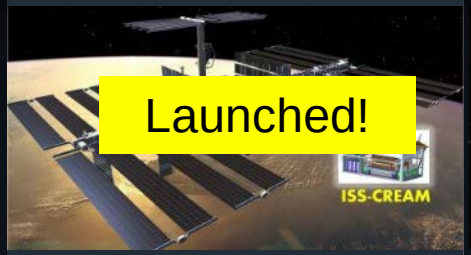
Astrophysics Missions in Development

ISS-NICER
6/2017
NASA Mission



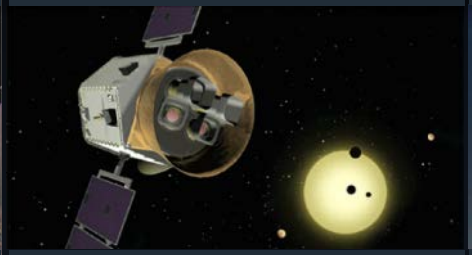
Neutron Star Interior Composition Explorer

ISS-CREAM
8/2017
NASA Mission



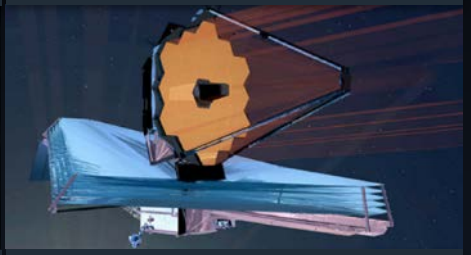
Cosmic Ray Energetics And Mass

TESS
3/2018
NASA Mission



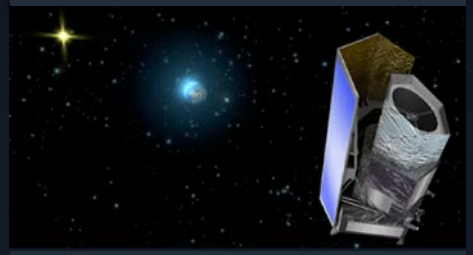
Transiting Exoplanet Survey Satellite

Webb
10/2018
NASA Mission



James Webb Space Telescope

Euclid
2020
ESA-led Mission

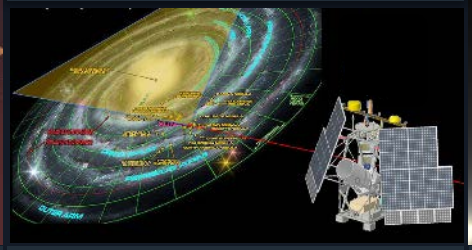


NASA is supplying the NISP Sensor Chip System (SCS)

IXPE
2021
NASA Mission

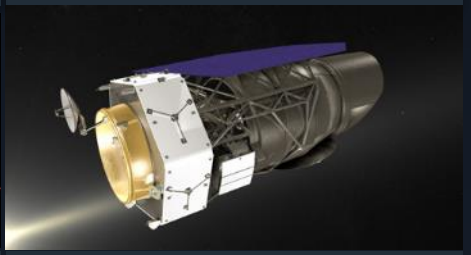
Imaging X-ray Polarimetry Explorer

GUSTO
2021
NASA Mission



Galactic/ Extragalactic ULDB Spectroscopic Terahertz Observatory

WFIRST
Mid 2020s
NASA Mission

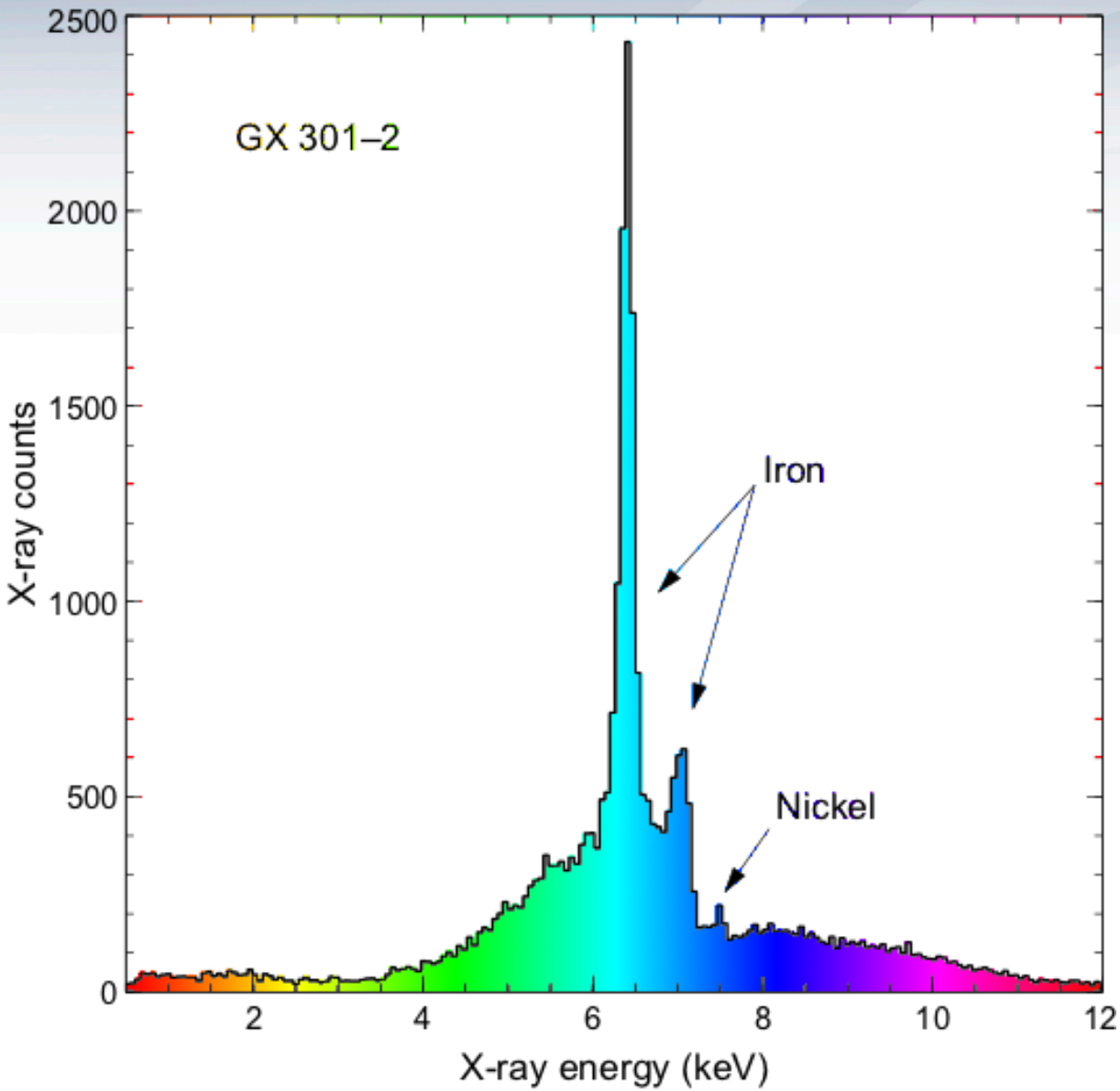


Wide-Field Infrared Survey Telescope

NICER Launch: June 3, 2017

- ✓ Launch June 3, 2017
- ✓ ISS Arrival June 5, 2017
- ✓ Deploy June 11, 2017
- ✓ Checkout June 2017
- ✓ Start science July 2017

NICER Spectrum of GX 301-2



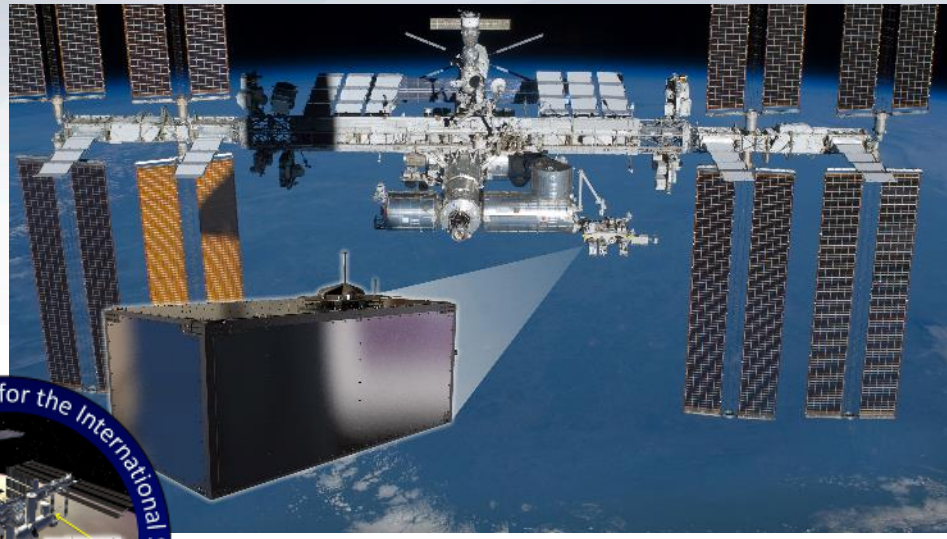
Credits: NASA

ISS-CREAM

Cosmic Ray Energy and Mass

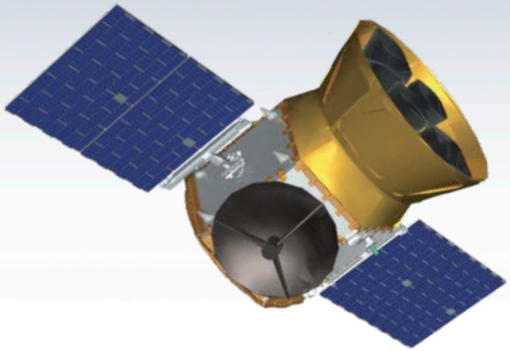
http://cosmicray.umd.edu/iss-cream/

Launched August 14, 2017



Hurricane Harvey

TESS
Transiting Exoplanet Survey Satellite



CURRENT STATUS:

- Both instrument and spacecraft bus completed and integrated.
  - Ka transmitter, being delivered late, is critical path
- Observatory environmental testing started in Sept. 2017. Completion planned by the end of Fall 2017.

SCHEDULE:

- ✓ July 2017 – SIR
- ✓ August 2017 – KDP-D
- Late January 2018 – Delivery to KSC payload processing facility
- March 2018 – Launch readiness date from Cape Canaveral FL

Medium Explorer (MIDEX) Mission

PI: G. Ricker (MIT)

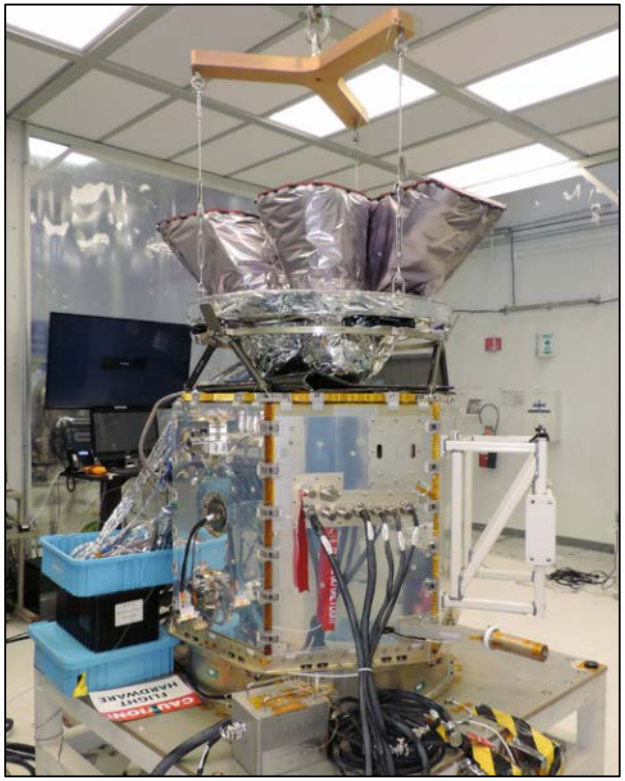
Mission: All-Sky photometric exoplanet mapping mission.

Science goal: Search for transiting exoplanets around the nearby, bright stars.

Instruments: Four wide field of view (24x24 degrees) CCD cameras with overlapping field of view, operating in the Visible-IR spectrum (0.6-1 micron).

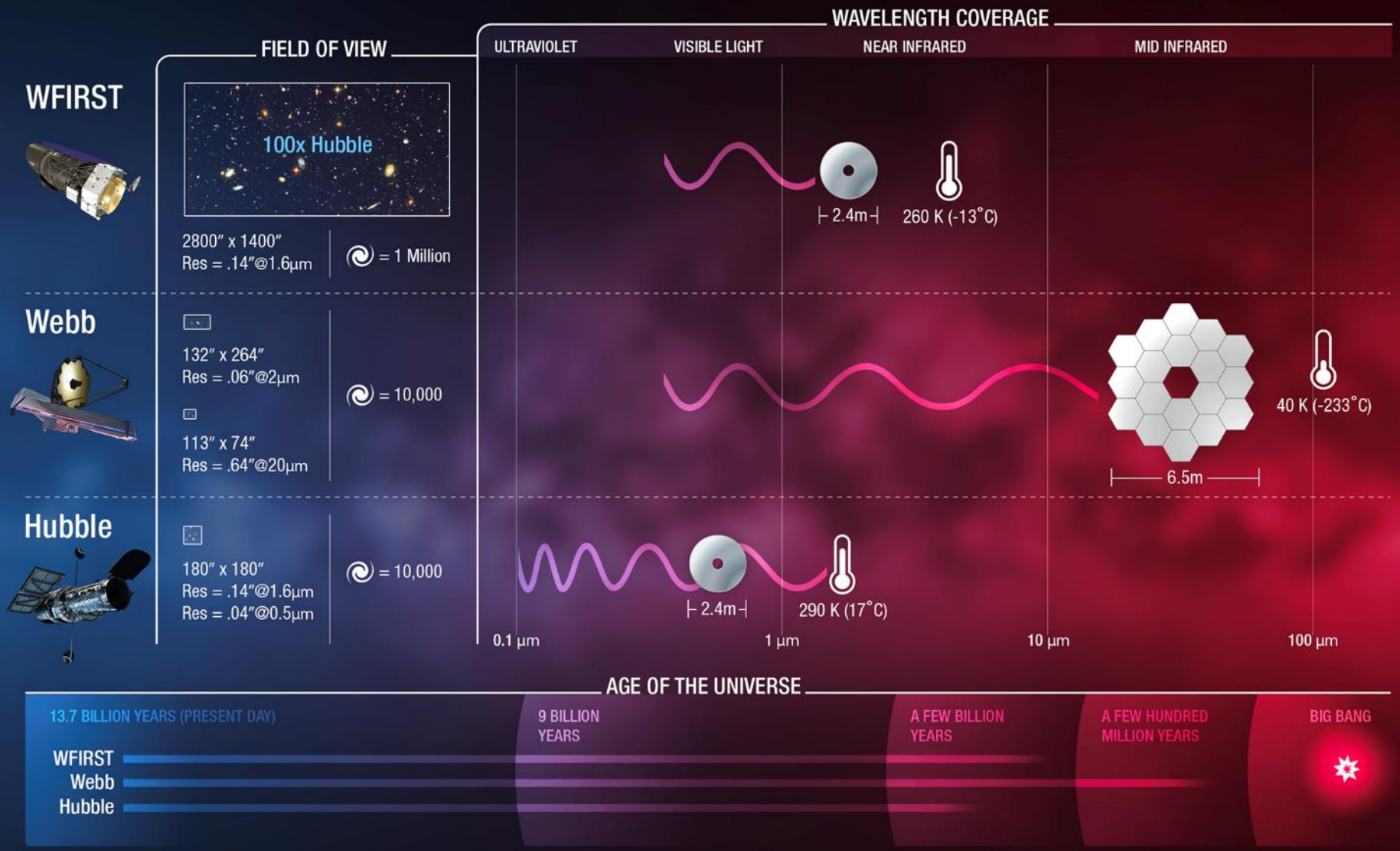
Operations: NLT June 2018 launch with a 3-year prime mission including 2 years of spacecraft operations and an additional 1 year ground-based observations and analysis. High-Earth elliptical orbit (17 x 58.7 Earth radii).

https://tess.gsfc.nasa.gov/



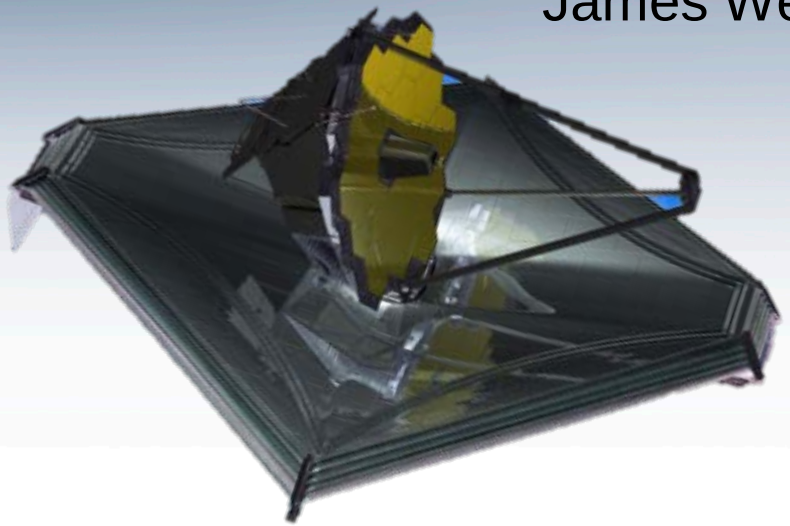
Credit: Orbital ATK

GREAT OBSERVATORIES



Webb

James Webb Space Telescope



Large Infrared Space Observatory

Top priority of 2000 Decadal Survey

Science themes: First Light; Assembly of Galaxies; Birth of Stars and Planetary Systems; Planetary Systems and the Origins of Life

Mission: 6.5m deployable, segmented telescope at L2, passively cooled to <50K behind a large, deployable sunshield

Instruments: Near IR Camera, Near IR Spectrograph, Mid IR Instrument, Near IR Imager and Slitless Spectrograph

Operations: 2018 launch for a 5-year prime mission

Partners: ESA, CSA

RECENT ACCOMPLISHMENTS:

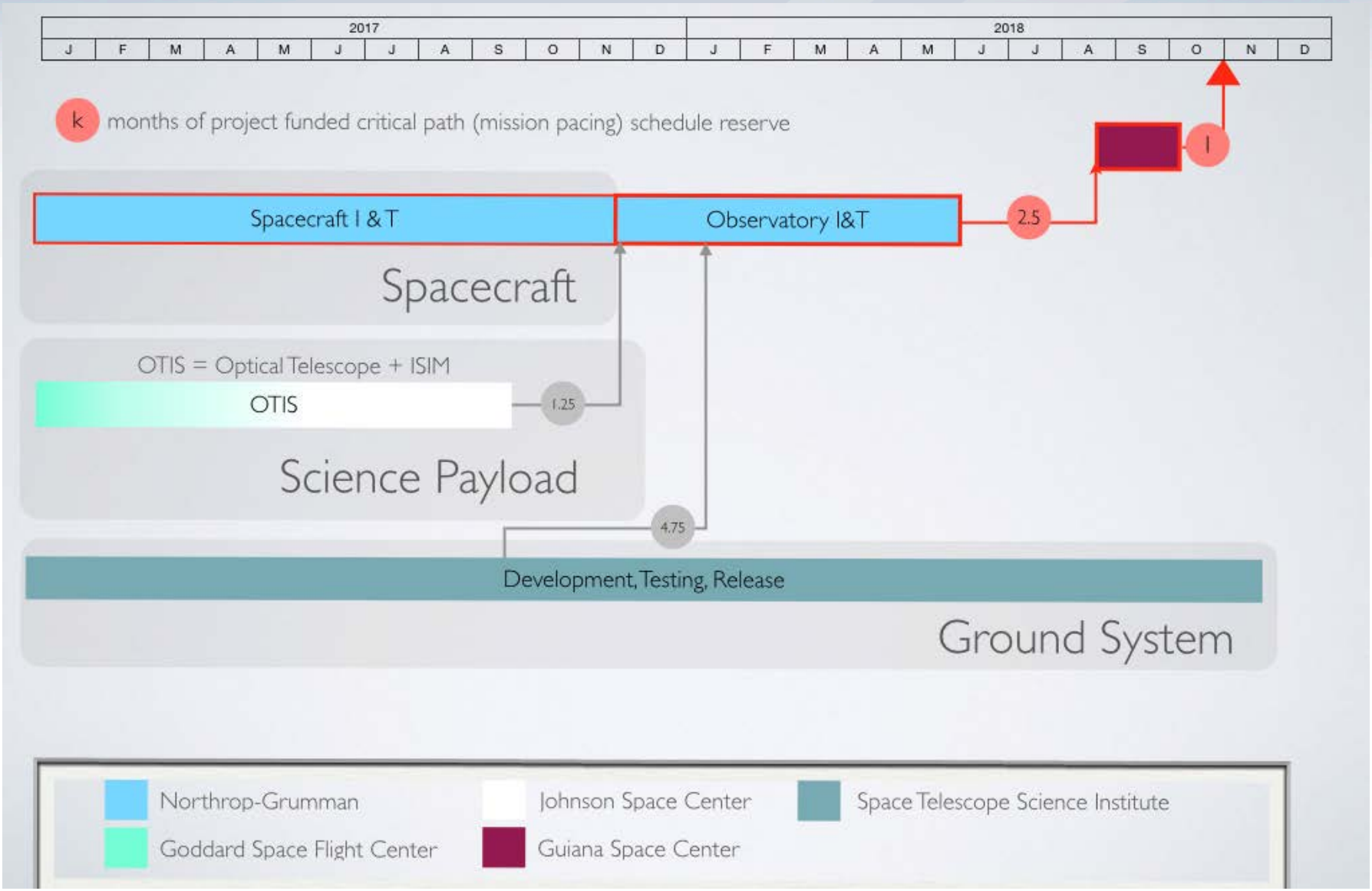
- Completed spacecraft bus integration with sunshield forming the spacecraft element (SCE)
- Conducted first deployment test of SCE
- Started cryovacuum testing of the science payload (~80% done)
- Received 106 proposals for Early Release Science programs

2017- early 2018 Plans:

- Complete cryovacuum test of science payload and ship to Northrop-Grumman
- Environmental testing of SCE
- Integration of SCE and science payload
- Observatory level deployment and environmental testing

https://jwst.nasa.gov/

Simplified JWST Schedule



OTIS (Telescope + Instruments)

OTIS @ JSC

OTIS is in day 76 of a 93-day planned cryovacuum test and in its warm-up phase

SPACECRAFT ELEMENT

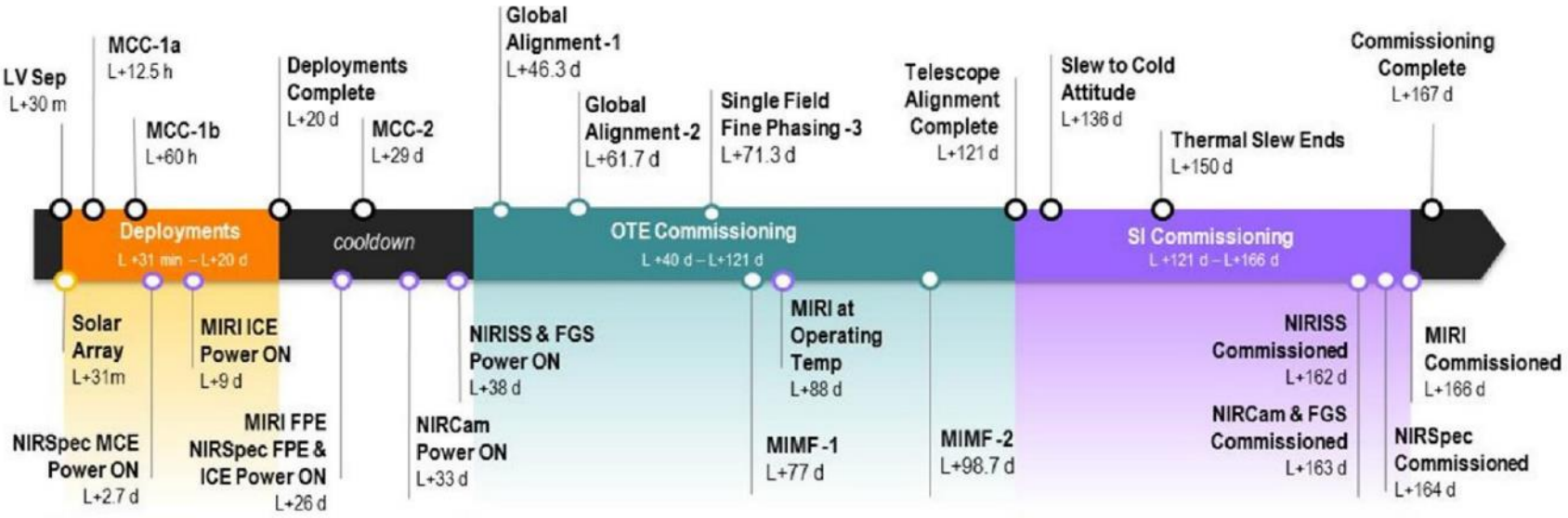
- Spacecraft and sunshield integration complete (refered to as spacecraft element)
- All components delivered except for some flight actuators (not planned for delivery yet)

5 layer sunshield positioned to begin folding with supporting mechanical equipment

5 layer sunshield folded into the unitized pallet structures

COMMISSIONING TIMELINE

- Soon after launch the spacecraft is controlled from the Mission Operations Center at STScI
- Telescope commissioning will take almost 3 months
- Commissioning of the science instruments will start 4 months after launch and is completed in 1.5 months.
- 0.5 months are held on reserve to the nominal start of Cycle 1 science

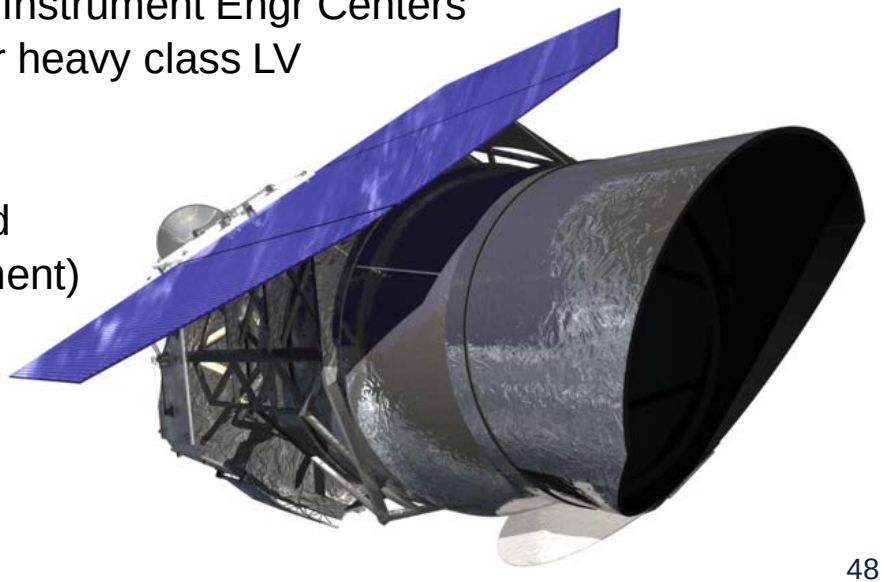


Wide Field Infrared Survey Telescope (WFIRST) Independent External Technical/Management/Cost Review (WIETR)

Update

Mission Overview

- **WFIRST:** Wide-Field InfraRed Survey Telescope
- **Objectives:**
  - Characterize the history of cosmic acceleration and structure growth
  - Understand how planetary systems form and evolve and determine the prevalence of planets in the colder outer regions
  - Understand the compositions and atmospheric constituents of a variety of planets around nearby stars and to determine the properties of debris disks around nearby stars
  - A peer-reviewed Guest Observer program.
- **Orbit:** Sun-Earth L2
- **Ground Stations:** NEN, DSN, potential foreign contribution
- **Ground System:** MOC/Science Center/Instrument Engr Centers
- **Launch Vehicle:** Falcon Heavy or other heavy class LV
- **Launch Site:** Eastern Range
- **Launch Date:** Mid-2020's
- **Current Phase:** Phase A (Concept and Technology Development)
- **Began Formulation:** February 2016



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

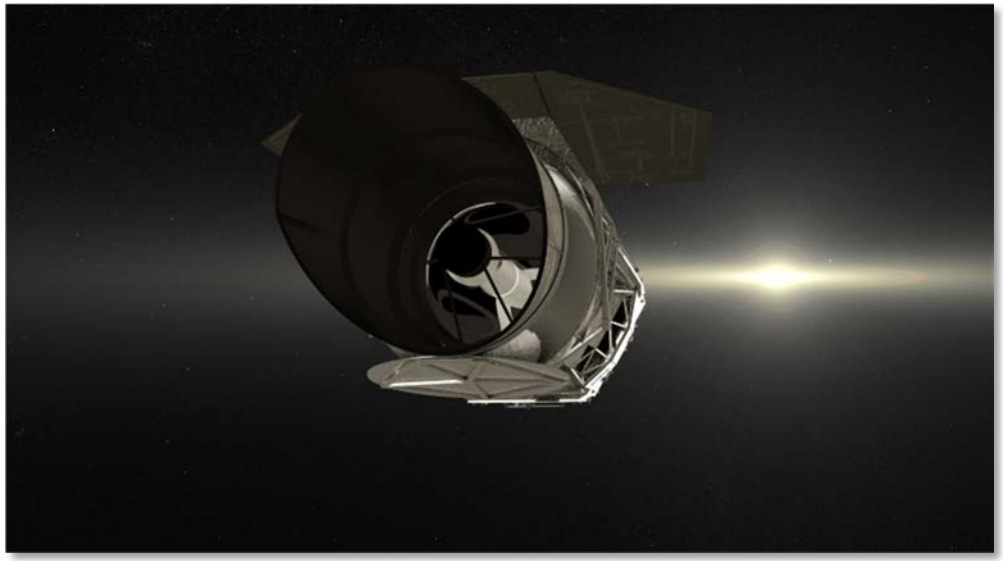
Why is NASA doing a WIETR?

- In 2013, NASA commissioned a study by the National Academies to assess whether WFIRST, with enhancements such as a 2.4-m telescope and a coronagraph, was faithful to the intent of *NWNH*
  - The committee, led by Fiona Harrison, affirmed the scientific value represented by the 2.4-m telescope and coronagraph
  - The committee also warned that if WFIRST were to compromise the "program balance" within NASA Astrophysics, then WFIRST would be "inconsistent with the rationale" for the mission's high priority in *NWNH*
  - The Harrison committee recommended that NASA charter an independent review of WFIRST, *"independent of NASA's internal process,"* to ensure consistency between the likely cost of the mission and the available resources
- In the summer of 2016, the National Academies published their Midterm Assessment of NASA's progress in implementing *NWNH*
  - The Midterm Assessment echoed the Harrison committee's concerns about WFIRST's potential impact on program balance
  - The Midterm Assessment also echoed the Harrison committee's call for an independent review, specifically calling for an "independent technical, management, and cost assessment"
- In direct response to these National Academy recommendations, the WIETR was commissioned by the SMD Associate Administrator on April 27, 2017

Terms of Reference

The WIETR will answer the following questions about WFIRST:

1. Are the technical requirements understood and reasonable?
2. Are the scope and cost/schedule understood and aligned?
3. Are the management processes in place adequate for a project of this scope and complexity?
4. Are the benefits of the coronagraph to NASA objectives commensurate with the cost and cost risk of development?



https://wfirst.gsfc.nasa.gov

WIETR Panel Membership

- **Dr. Peter Michelson**, Stanford University (Co-Chair, Science), Stanford, California
- **Mr. Orlando Figueroa**, NASA Headquarters and Goddard Space Flight Center – Retired (Co-Chair, Program), Washington
- **Dr. Roger Brissenden**, Smithsonian Astrophysical Observatory, Cambridge, Massachusetts
- **Dr. David Charbonneau**, Harvard University, Cambridge, Massachusetts
- **Ms. Eileen Dukes**, Systems Engineer Consultant, Pine, Colorado
- **Dr. Daniel Eisenstein**, Harvard University, Cambridge, Massachusetts
- **Mr. Dave Kusnierkiewicz**, Applied Physics Laboratory, Laurel, Maryland
- **Mr. Pete Theisinger**, Jet Propulsion Laboratory – Retired, Pasadena, California
- **Mr. Bill Green**, Jet Propulsion Laboratory – Retired, Pasadena, California
- **Dr. Lynne Hillenbrand**, California Institute of Technology, Pasadena, California
- **Dr. Anne Kinney**, W. M. Keck Observatory, Waimea, Hawaii
- **Dr. James Lloyd**, Cornell University, Ithaca, New York
- **Dr. Dimitri Mawet**, California Institute of Technology, Pasadena, California
- **Mr. Mark Saunders**, NASA Headquarters – Retired, Hampton, Virginia
- **Mr. Bob Bitten**, Aerospace Corporation, El Segundo, California

https://www.nasa.gov/mission_pages/GLAST/team/Michelson-bio.html

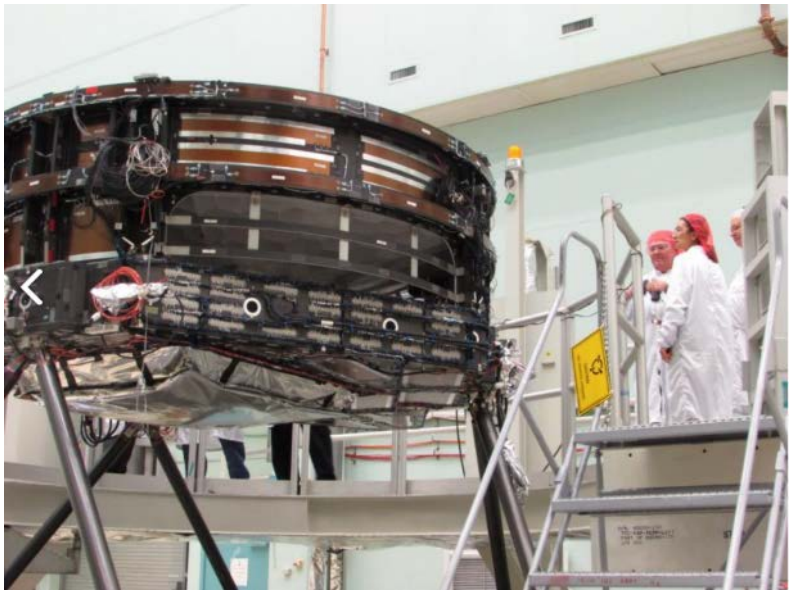
Peter Michelson

https://www.nasa.gov/mission_pages/mars/news/Figueroabio.html

Orlando Figueroa

Subpanel Structure

- The WIETR Panel is divided into six sub-panels:
  - Coronagraph and Exoplanet Science
  - Wide Field and Dark Energy Survey Science
  - Science Operations, STScI/IPAC Science Data Center(s)
  - Telescope
  - Robotic Servicing, Star Shade Readiness and Technology
  - Programmatic Assessment
- The WIETR panel will conduct plenary meetings to discuss findings of the sub-panels



https://wfirst.gsfc.nasa.gov

WIETR Schedule

WIETR Announced	April 27, 2017
Panel Members Announced	June 22, 2017
Kickoff Meeting at GSFC	August 7 – 10, 2017
Site Visits by Subpanels	August 14 – 31, 2017
Formulation, Discussion, and Documentation of Findings	September 2017
Informal Report to Center, Program, and Project	Late September 2017
Draft Report to SMD	Early October 2017
Final Report	Mid-October 2017

WFIRST Project Approach

- Project continues to work on requirements development, technology advancement, and other Phase A activities while WIETR is underway
- System Requirements Review and Mission Definition Review (SRR/MDR) postponed from original date of July 11, 2017
- After receiving the WIETR report, NASA will formulate a plan to respond to WIETR findings and recommendations before defining milestones for the remainder of WFIRST Phase A
- Key Decision Point B (KDP-B) is provisionally planned to occur during first quarter of Calendar Year 2018, following a rescheduled SRR/MDR
- Project milestone reviews such as SRR/MDR will be conducted by a Standing Review Board (SRB), per NASA's standard practices
  - The WIETR panel is separate from the SRB
  - The WIETR panel will be disbanded after delivering its report
- WIETR process is expected to increase NASA's level of confidence in its KDP-B cost estimate for WFIRST
- NASA's official cost and schedule commitments for WFIRST will be formalized at KDP-C, currently planned for 2020

NASA Astrophysics

Selected Studies Updates

Astrophysics Missions under Study

XARM
2021

JAXA-led Mission

NASA is supplying the SXS Detectors, ADRs, and SXTs

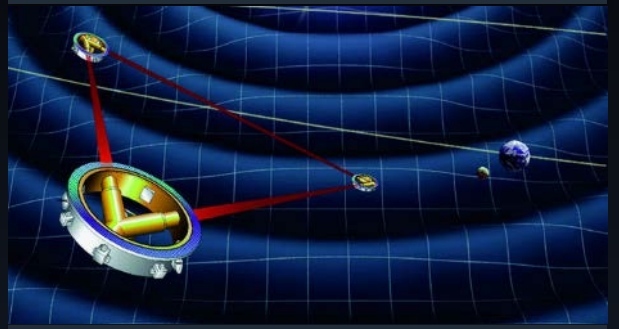
Athena
Late 2020s

ESA-led Mission

NASA is supplying elements for both instruments

LISA
Mid 2030s

ESA-led Mission



NASA is developing technology for both the payload and the mission

X-ray Astronomy Recovery Mission (XARM)

- US Community Participation in XARM
  - Participating Scientists: JAXA and NASA will each appoint a small number of Participating Scientists to the XARM Science Team; NASA will have an open solicitation in 2017. The Science Team consists of the researchers who directly contribute to the development, operation, and management of the project. As members of the XARM Science Team, Participating Scientists will have full access to Performance Verification (PV) phase data.
    - Solicitation released September 12 as ROSES-17 Appendix D.14: Mandatory Step-1 deadline October 24; Step-2 deadline December 13.
  - PV Phase Target Team Participation: JAXA and NASA will enable broad scientific participation in the early operation of XARM. Approximately one year before launch the Agencies will openly solicit additional community members to participate in the analysis of targets observed in the PV phase of the mission that are led by the XARM Science Team. Each PV Target Team member will become a member of an object-specific team, and will receive access to the PV data for that object.
  - General Observer Program: Following the conclusion of the PV phase of the mission approximately six to nine months after launch, XARM observing time will be dedicated to General Observations allocated through an open solicitation process.

Large Interferometer Space Antenna (LISA)

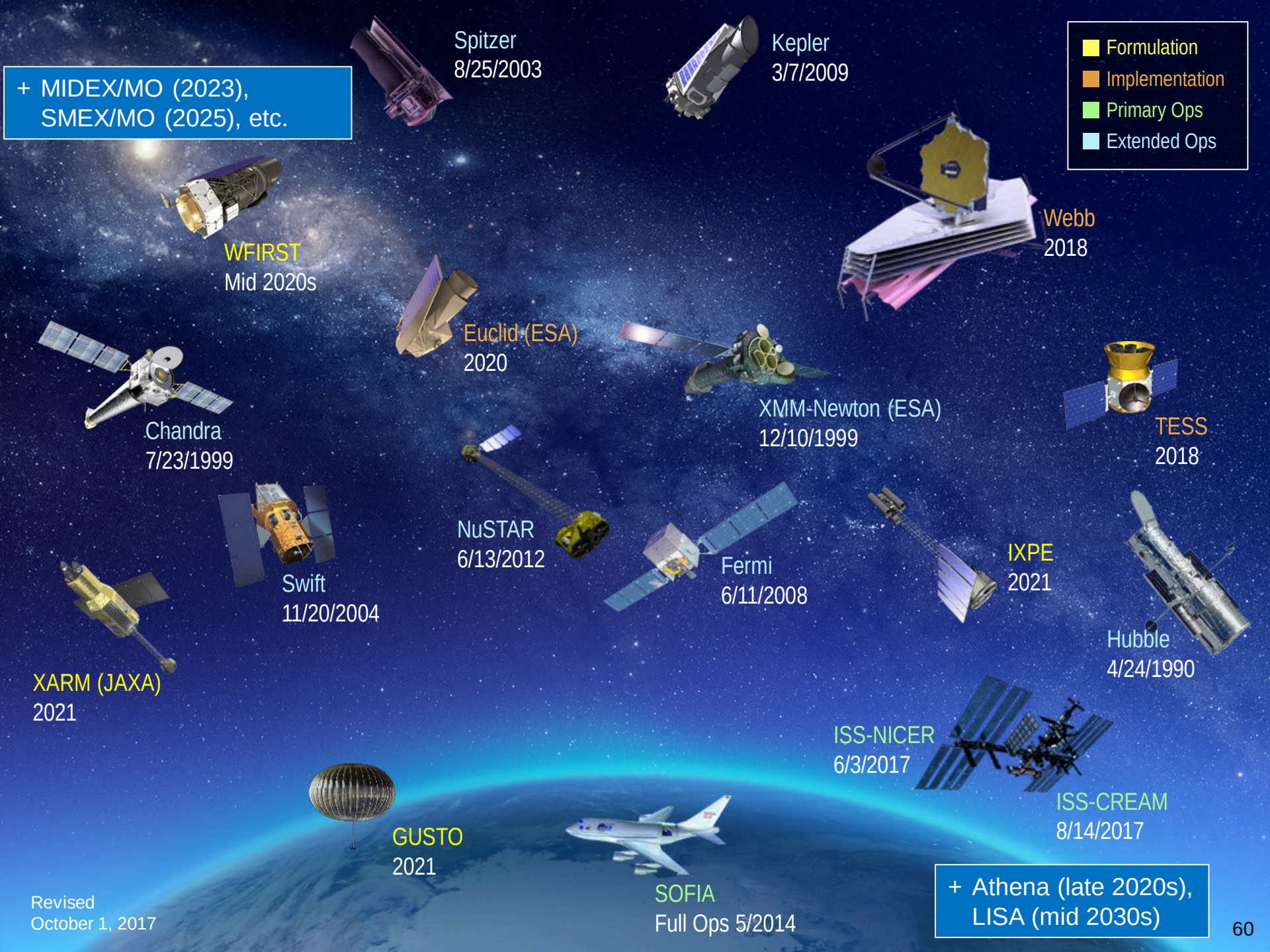
- The ESA SPC selected LISA as the Large 3 observatory of its Cosmic Vision Programme and has started Phase 0 (June – December 2017) with a series of technical meetings to study the payload trades. Phase A will start January 2018.
- NASA has established a LISA Study Office at GSFC. The LISA Study Office serves as a liaison with the ESA LISA project. The LISA Study Office is attending ESA Phase 0 design runs and will attend the September 28 interim report.
- NASA and ESA discussions for US contributions to LISA are advanced. NASA is funding five US-based technologies with the aim of reaching TRL 5/6 by Adoption (nominally 2022). The candidate technologies are managed by the LISA Study Office.
- ESA formed the LISA Study Science Team (SST) and asked NASA to nominate 2 members of the US astrophysics community. The first meeting of the ESA LISA SST was held September 21-22. The NASA Program and Study Scientists attended.
- The NASA L3 Study team (L3ST) had its final face-to-face meeting on July 12 in Pasadena. The L3ST was then disbanded.
- In August, NASA issued a call for nominations for the US LISA Study Team (ST) and for NASA-nominated members of the ESA LISA SST. The NASA LISA ST will
  - Prepare a report to the 2020 Decadal Survey re-stating the science case for US participation in LISA;
  - Provide a NASA-endorsed interface with the European-led LISA Consortium;
  - Support the NASA LISA Study Office with analysis on scientific and technical issues.
- 60 applications were received by NASA, including a significant number from non-gravitational wave astrophysicists. Selections will be announced by October 2017.

Preparing for the 2020 Decadal Survey

- Large Mission Concept Studies
  - Habitable Exoplanet Imaging Mission
  - Large UV/O/IR Surveyor
  - Lynx (X-ray Surveyor)
  - Origins Space Telescope (Far Infrared Surveyor)
- Astrophysics Probes / Medium Mission Concepts
  - Cosmic Dawn Intensity Mapper (A. Cooray)
  - Cosmic Evolution through UV Spectroscopy Probe (W. Danchi)
  - Galaxy Evolution Probe (J. Glenn)
  - High Spatial Resolution X-ray Probe (R. Mushotzky)
  - Inflation Probe (S. Hanany)
  - Multi-Messenger Astrophysics Probe (A. Olinto)
  - Precise Radial Velocity Observatory (P. Plavchan)
  - Starshade Rendezvous Mission (S. Seager)
  - Transient Astrophysics Probe (J. Camp)
  - X-ray Timing and Spectroscopy Probe (P. Ray)

What else should the community be studying? What else should NASA be supporting?

Decadal Survey Committee begins meeting in early 2019


+ MIDEX/MO (2023), SMEX/MO (2025), etc.
Formulation
Implementation
Primary Ops
Extended Ops
Spitzer
8/25/2003
Kepler
3/7/2009
Webb
2018
WFIRST
Mid 2020s
Euclid (ESA)
2020
Chandra
7/23/1999
XMM-Newton (ESA)
12/10/1999
TESS
2018
NuSTAR
6/13/2012
Swift
11/20/2004
Fermi
6/11/2008
IXPE
2021
Hubble
4/24/1990
XARM (JAXA)
2021
ISS-NICER
6/3/2017
ISS-CREAM
8/14/2017
GUSTO
2021
SOFIA
Full Ops 5/2014
+ Athena (late 2020s), LISA (mid 2030s)
Revised
October 1, 2017