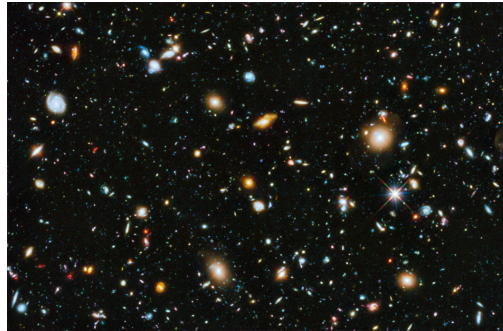


ASTROPHYSICS

National Aeronautics and
Space Administration



NASA Astrophysics Update

Space Telescope Users Committee
November 13, 2018
Space Telescope Science Institute

Martin Still

HST Deputy Program Scientist
Science Mission Directorate
martin.still@nasa.gov



[heic1819 — Photo Release](#)

Hubble reveals cosmic Bat Shadow in the Serpent's Tail

31 October 2018: The NASA/ESA Hubble Space Telescope has captured part of the wondrous Serpens Nebula, lit up by the star HBC 672. This young star casts a striking shadow ...

[READ MORE](#)

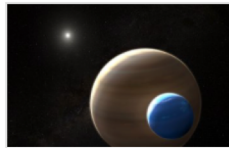


[heic1818 — Photo Release](#)

The ghost of Cassiopeia

25 October 2018: About 550 light-years away in the constellation of Cassiopeia lies IC 63, a stunning and slightly eerie nebula. Also known as the ghost of Cassiopeia, IC 63 is being chased by ...

[READ MORE](#)



[heic1817 — Science Release](#)

Hubble finds compelling evidence for a moon outside the Solar System

3 October 2018: Using the NASA/ESA Hubble Space Telescope and older data from the Kepler Space Telescope two astronomers have found the first compelling evidence for ...

[READ MORE](#)



[heic1816 — Photo Release](#)

BUFFALO charges towards the earliest galaxies

13 September 2018: The NASA/ESA Hubble Space Telescope has started a new mission to shed light on the evolution of the earliest galaxies in the Universe. The BUFFALO survey will observe six ...

[READ MORE](#)



[heic1811 — Photo Release](#)

Cosmic collision lights up the darkness

31 May 2018: Though it resembles a peaceful rose swirling in the darkness of the cosmos, NGC 3256 is actually the site of a violent clash. This distorted galaxy is the relic of a collision between two spiral ...

[READ MORE](#)

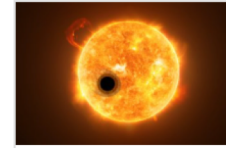


[heic1810 — Photo Release](#)

Hubble shows the local Universe in ultraviolet

17 May 2018: Using the unparalleled sharpness and ultraviolet observational capabilities of the NASA/ESA Hubble Space Telescope, an international team of astronomers has created the most ...

[READ MORE](#)



[heic1809 — Science Release](#)

Hubble detects helium in the atmosphere of an exoplanet for the first time

2 May 2018: Astronomers using the NASA/ESA Hubble Space Telescope have detected helium in the atmosphere of the exoplanet WASP-107b. This is the first time this ...

[READ MORE](#)



[heic1808 — Photo Release](#)

Hubble celebrates 28th anniversary with a trip through the Lagoon Nebula

19 April 2018: This colourful cloud of glowing interstellar gas is just a tiny part of the Lagoon Nebula, a vast stellar nursery. This nebula is a region full of intense activity with ...

[READ MORE](#)

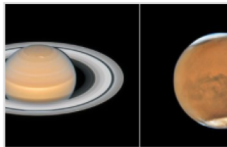


[heic1815 — Photo Release](#)

Hubble observes energetic lightshow at Saturn's north pole

30 August 2018: Astronomers using the NASA/ESA Hubble Space telescope have taken a series of spectacular images featuring the fluttering auroras at the north pole of Saturn. The ...

[READ MORE](#)



[heic1814 — Photo Release](#)

New family photos of Mars and Saturn from Hubble

26 July 2018: In summer 2018 the planets Mars and Saturn are, one after the other, in opposition to Earth. During this event the planets are relatively close to Earth, allowing astronomers ...

[READ MORE](#)

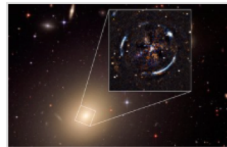


[heic1813 — Science Release](#)

Hubble sees `Oumuamua getting a boost

27 June 2018: The first interstellar object discovered in the Solar System, is moving away from the Sun faster than expected. This anomalous behaviour was detected using the ...

[READ MORE](#)

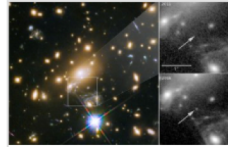


[heic1812 — Science Release](#)

Hubble proves Einstein correct on galactic scales

21 June 2018: An international team of astronomers using the NASA/ESA Hubble Space Telescope and the European Southern Observatory's Very Large Telescope has made the most precise ...

[READ MORE](#)

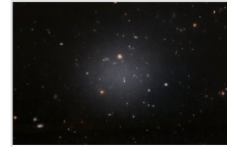


[heic1807 — Science Release](#)

Hubble uses cosmic lens to discover most distant star ever observed

2 April 2018: Astronomers using the NASA/ESA Hubble Space Telescope have found the most distant star ever discovered. The hot blue star existed only 4.4 billion ...

[READ MORE](#)

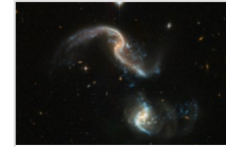


[heic1806 — Science Release](#)

Hubble finds first galaxy in the local Universe without dark matter

28 March 2018: An international team of researchers using the NASA/ESA Hubble Space Telescope and several other observatories have, for the first time ...

[READ MORE](#)

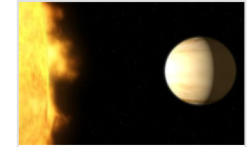


[heic1805 — Photo Release](#)

A peculiar galactic clash

8 March 2018: Galaxies are not static islands of stars — they are dynamic and ever-changing, constantly on the move through the darkness of the Universe. Sometimes, as seen in this encounter the Hubble ...

[READ MORE](#)



[heic1804 — Science Release](#)

Hubble observes exoplanet atmosphere in more detail than ever before

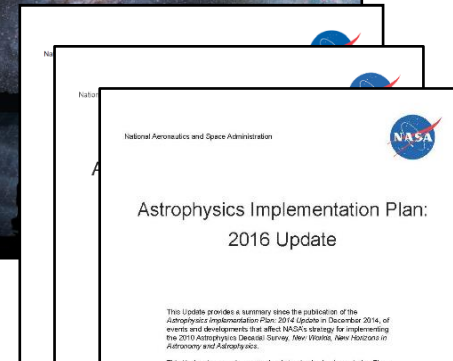
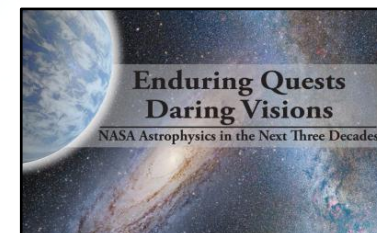
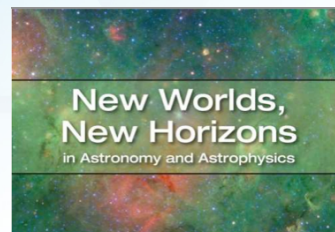
1 March 2018: An international team of scientists has used the NASA/ESA Hubble Space Telescope to study the atmosphere of the hot exoplanet WASP-20b. By ...

[READ MORE](#)

Astrophysics Strategic Planning



To be updated in 2018
(per GPRAMA)



2018 update will include:

- Independent reviews of Webb & WFIRST
- Planning for 2020 Decadal Survey

December 15, 2016

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

Accomplishments August 2018 – Mid 2019

- ✓ TESS entered science operations August 2018
- ✓ Ft. Sumner balloon campaign August-October 2018
- ✓ Euclid sensor chip electronics (SCE) recovery plan approved September 2018
- ✓ SOFIA Operations and Maintenance Review underway October 2018
- ✓ Kepler completed its amazing mission when the fuel exhausted October 2018
- ✓ IXPE will enter Phase C November 2018
- ✓ Astrophysics Decadal Survey will begin November 2018
 - Antarctic balloon campaign will be conducted December 2018 – February 2019
 - Next Astrophysics MDEX and Mission of Opportunity will be downselected January 2019
 - SOFIA Five Year Review will be conducted early 2019
 - Astrophysics Senior Review will be conducted Spring 2019
 - Next Astrophysics SMEX and Mission of Opportunity AO will be released Spring 2019
 - Large Mission Concept Studies will be submitted to Decadal Survey Summer 2019

NASA's 60th Anniversary – October 1, 2018



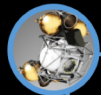
<https://www.nasa.gov/specials/60counting/>



President Dwight Eisenhower (center) presents commissions to T. Keith Glennan (left) and Hugh L. Dryden (right), NASA's first administrator and deputy administrator respectively. In July 1958, Eisenhower had signed the National Aeronautics and Space Act, creating the agency, which opened for business on Oct. 1, 1958.

GATEWAY

A spaceport for human and robotic exploration of the Moon and beyond



HUMAN ACCESS TO & FROM LUNAR SURFACE

Astronaut support and teleoperations of surface assets.



U.S. AND INTERNATIONAL CARGO RESUPPLY

Expanding the space economy with supplies delivered aboard partner ships that also provide interim spacecraft volume for additional utilization.



SAMPLE RETURN

Pristine samples robotically delivered to the Gateway for safe processing and return to Earth.



INTERNATIONAL CREW

International crew expeditions for up to 30 days as early as 2024. Longer expeditions as new elements are delivered to the Gateway.

SCIENCE AND TECH DEMOS

Support payloads inside, affixed outside, free-flying nearby, or on the lunar surface. Experiments and investigations continue operating autonomously when crew is not present.

COMMUNICATIONS RELAY

Data transfer for surface and orbital robotic missions and high-rate communications to and from Earth.



SIX DAYS TO ORBIT THE MOON

The orbit keeps the crew in constant communication with Earth and out of the Moon's shadow.

A HUB FOR FARTHER DESTINATIONS

From this orbit, vehicles can embark to multiple destinations: The Moon, Mars and beyond.

GATEWAY SPECS



50 kW
Solar Electric
Propulsion



4 Crew
Members



30-90 Day
Crew
Missions



125 m³
Pressurized
Volume



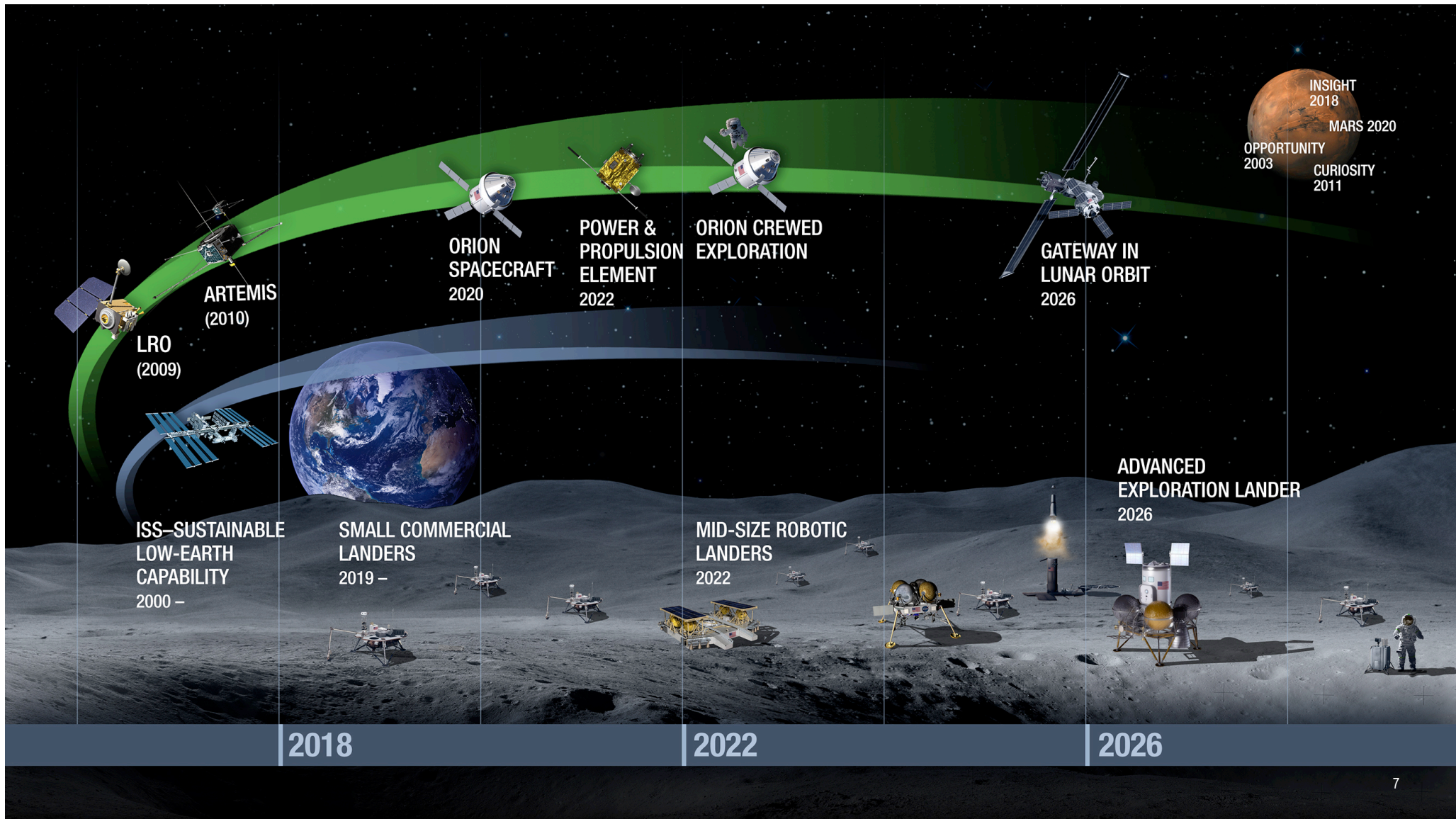
Up to 75 mt
with Orion
docked

ACCESS



384,000 km from Earth

Accessible via NASA's SLS as well as international and commercial ships.



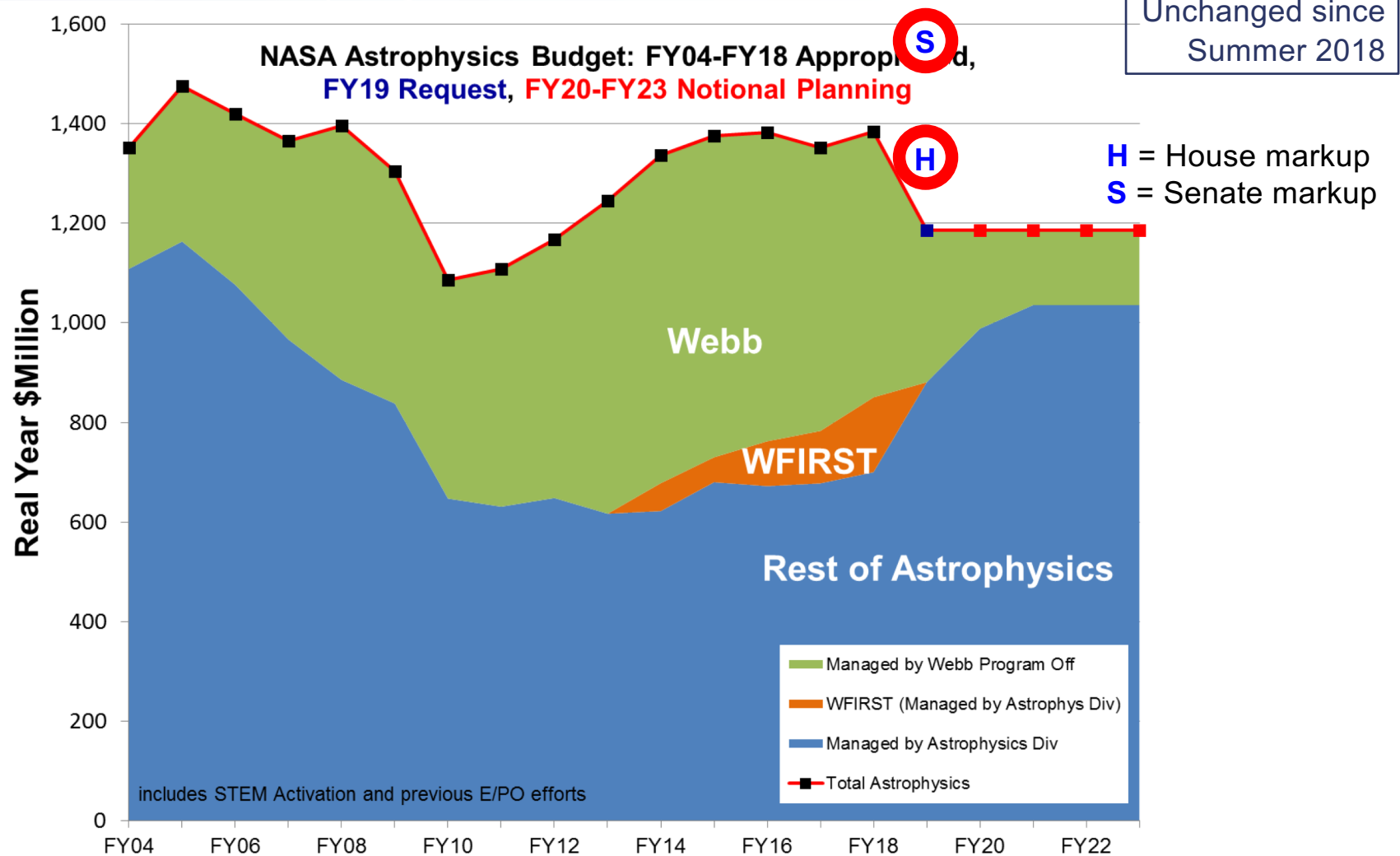


NASA Astrophysics

Budget Update

Astrophysics Budget Overview

- 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
- NASA is operating under a Continuing Resolution (CR) through December 7, 2018
 - All programs and projects will continue according to proposed (requested) plans for FY19
 - MIDEX downselect in January 2019 and SMEX AO in Spring 2019 on track
 - WFIRST will continue to execute the plan approved at KDP-B (enables late 2025 launch within a \$3.2B SMD cost cap) while awaiting FY19 appropriation
- NASA's plans for accommodating Webb's increased budget requirements will be submitted as part of the FY20 budget request



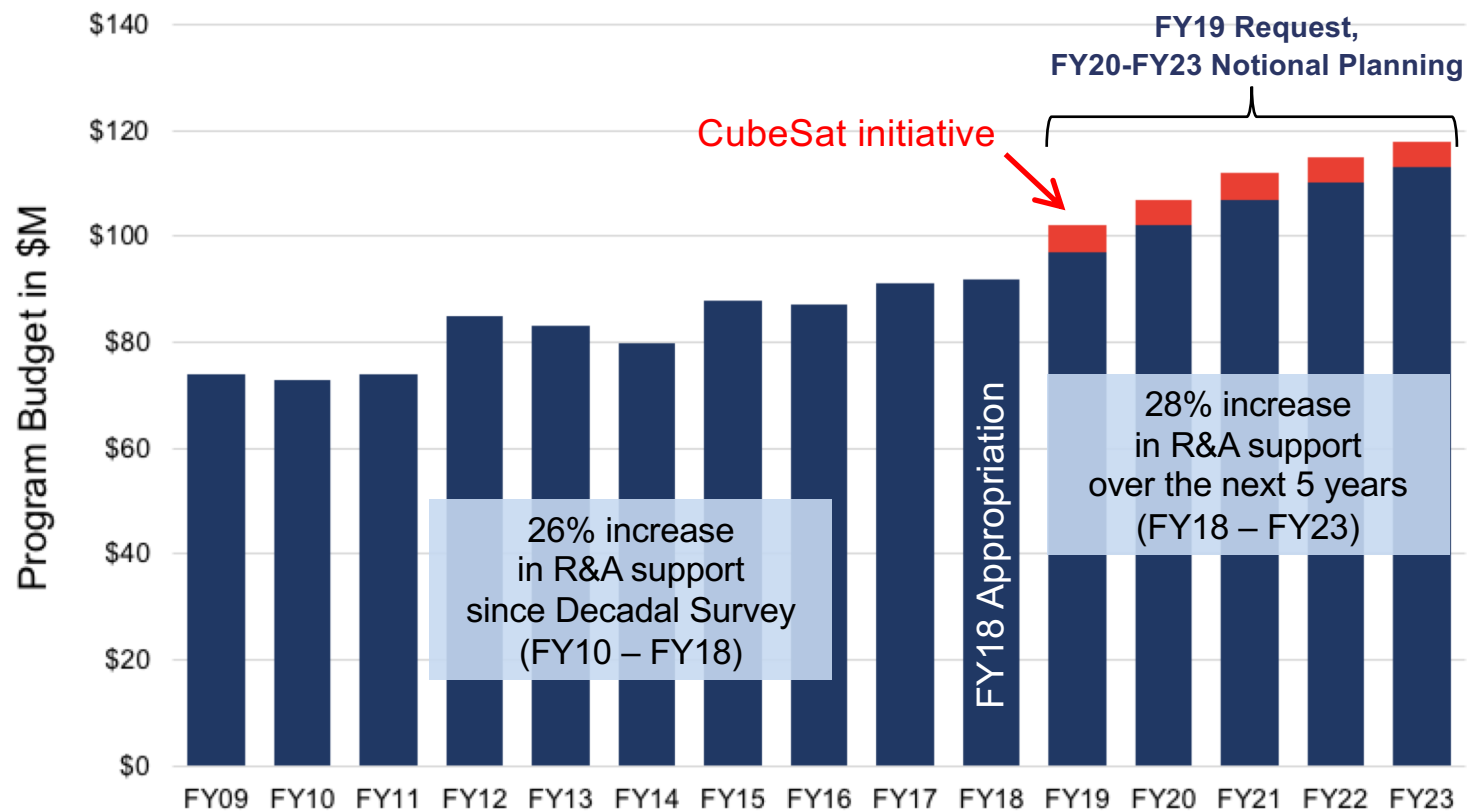


NASA Astrophysics

R&A Update

Planned Growth in R&A Funding

Program	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
R&A	\$74	\$73	\$74	\$85	\$83	\$80	\$88	\$87	\$91	\$92	\$97	\$102	\$107	\$110	\$113
CubeSat											\$5	\$5	\$5	\$5	\$5
Total	\$74	\$73	\$74	\$85	\$83	\$80	\$88	\$87	\$91	\$92	\$102	\$107	\$112	\$115	\$118


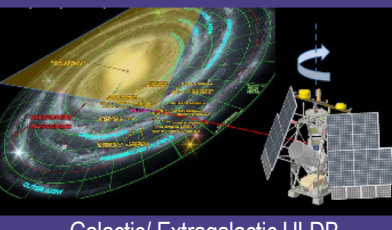





NASA Astrophysics

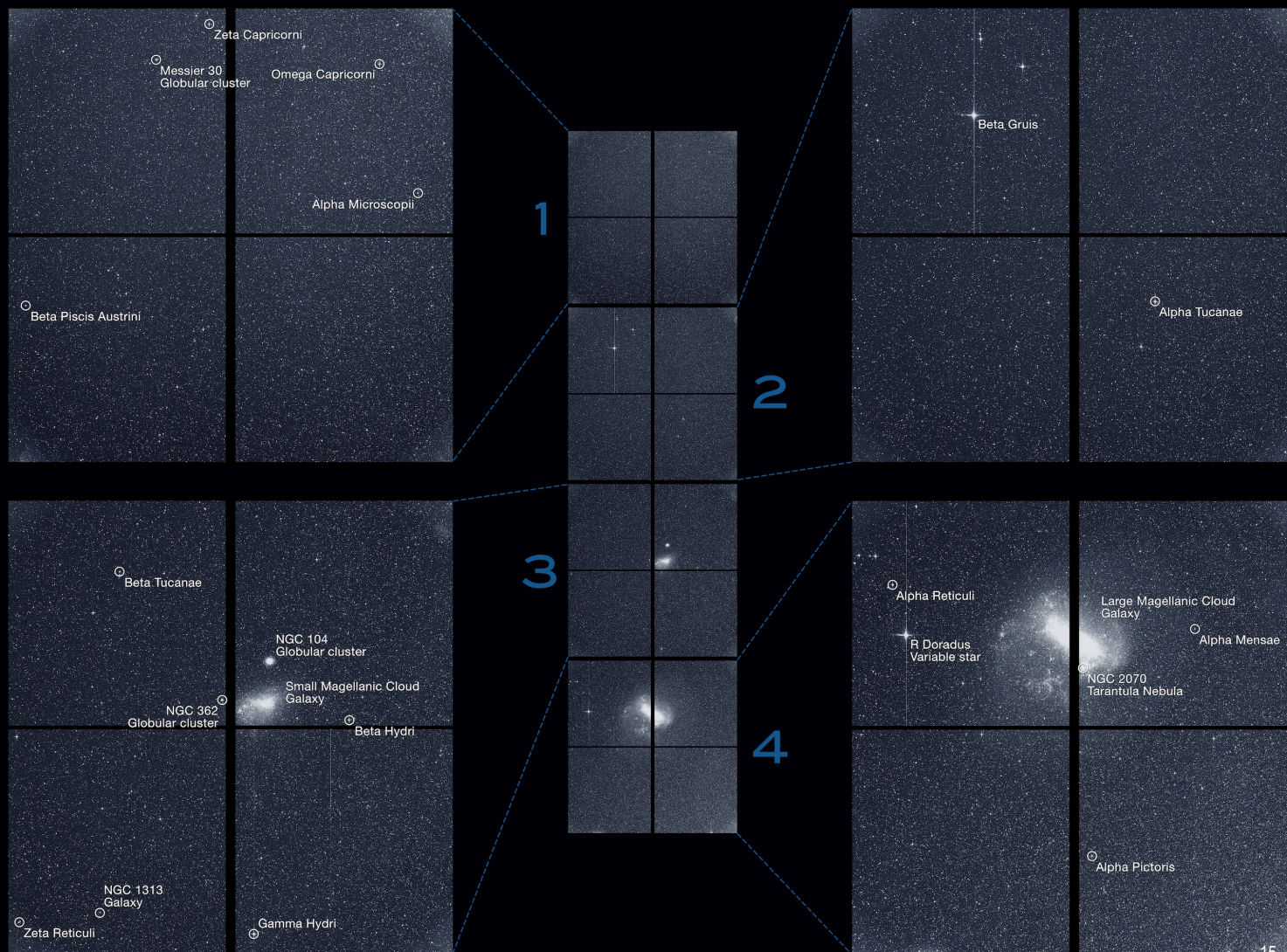
Missions Update

Astrophysics Missions in Development

<p>TESS 4/2018 NASA Mission</p>  <p>Transiting Exoplanet Survey Satellite</p>	<p>Webb 2021 NASA Mission</p>  <p>James Webb Space Telescope</p>	<p>IXPE 2021 NASA Mission</p>  <p>Imaging X-ray Polarimetry Explorer</p>	<p>GUSTO 2021 NASA Mission</p>  <p>Galactic/ Extragalactic ULDB Spectroscopic Terahertz Observatory</p>
<p>Euclid 2022 ESA-led Mission</p>  <p>NASA is supplying the NISP Sensor Chip System (SCS)</p>	<p>XRISM/XARM 2022 JAXA-led Mission</p>  <p>NASA is supplying the SXS Detectors, ADRs, and SXTs</p>	<p>MIDEX/MO 2022/2023 NASA Mission</p>  <p>Arcus or SPHEREx ARIEL, COSI-X, or ISS-TAO</p>	<p>WFIRST Mid 2020s NASA Mission</p>  <p>Wide-Field Infrared Survey Telescope</p>

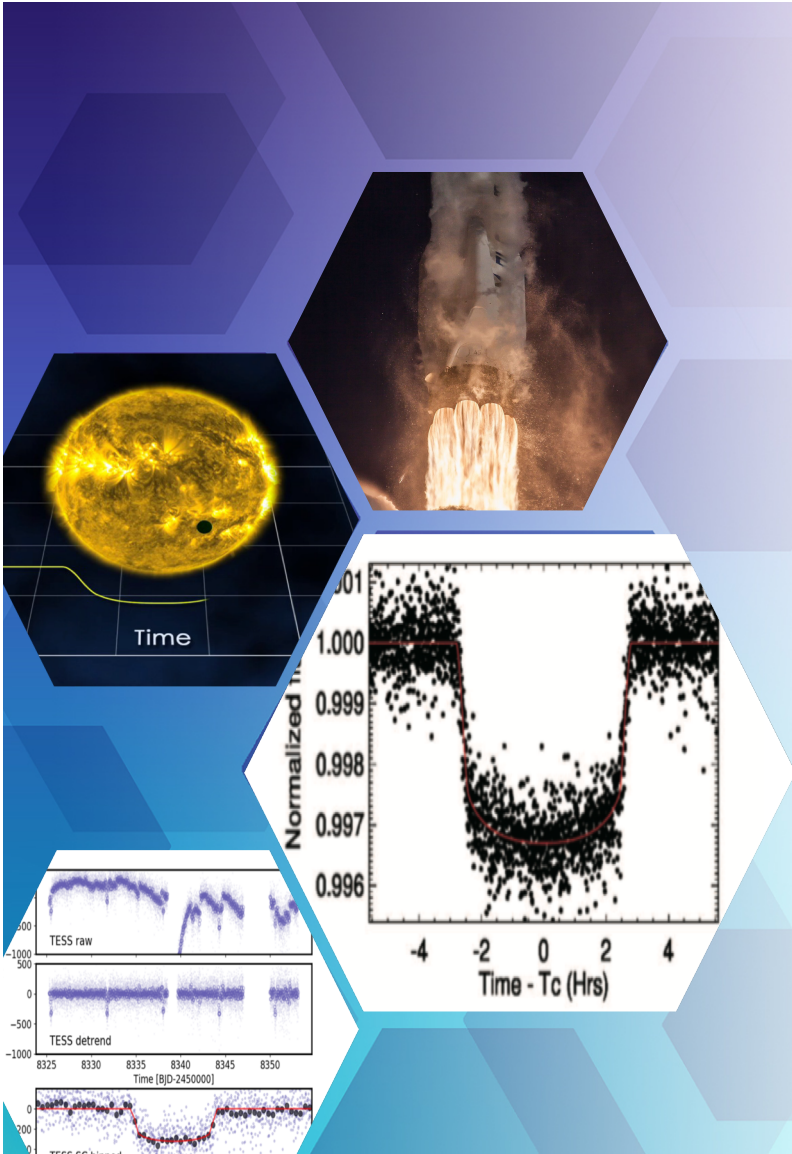
TESS First Light

September 17, 2018



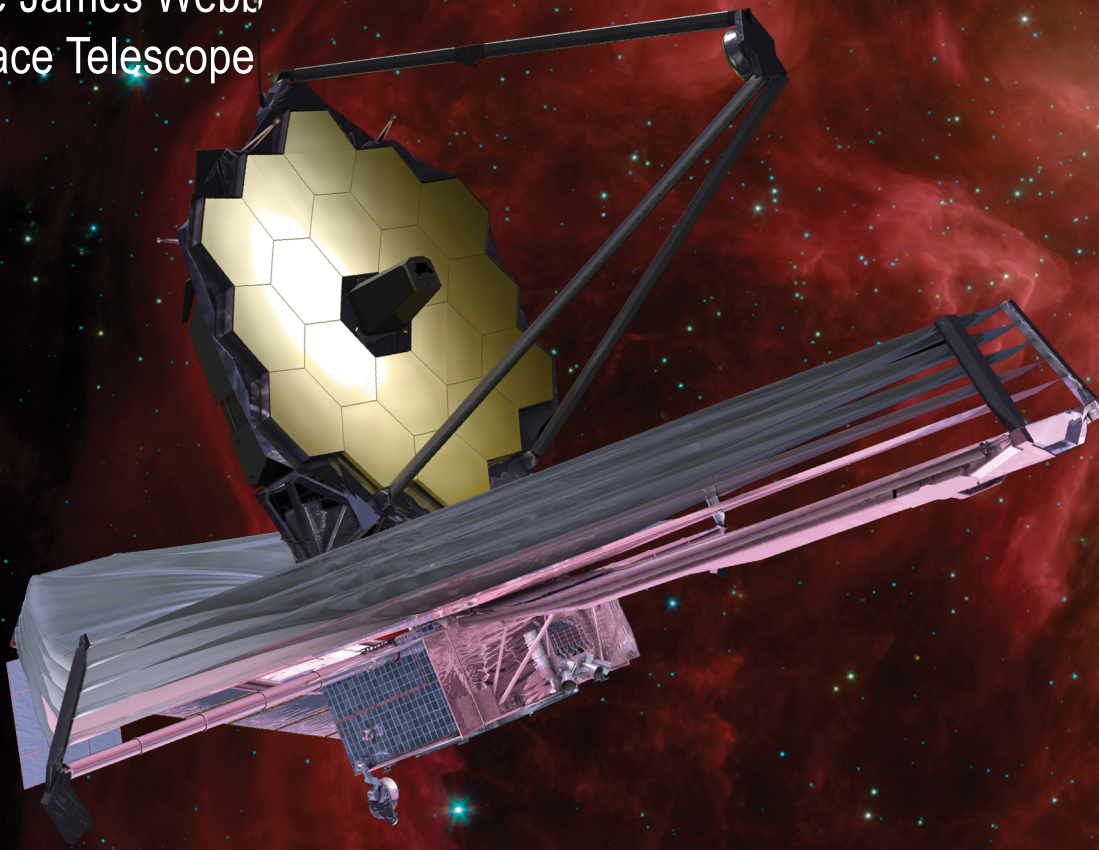
TESS Status

- Launch: April 18, 2018
- Science Operations began: July 25, 2018 (Sector 1)
- Currently collecting data for Sector 3
- Extended TESS science community receiving transit alerts
 - 73 candidate transit initial alerts
 - Enables follow-up ground-based observations while TESS field remains in the nighttime sky
- Preliminary pixel data from TESS Objects of Interest are public at the MAST
- Operations Team working towards steady-state data delivery
- First detection and planet validation work submitted to journals for publication
 - Pi Men c, LHS 3844 b, HD 202772A b



Webb

The James Webb
Space Telescope



March 2018, Webb prepares for additional testing at Northrop Grumman in Redondo Beach, CA

Latest Webb Update

Programmatic

- Implemented Independent Review Board recommendations, final meeting with the board scheduled for last week of Nov., first week of Dec.
- Held normal status updates with GAO annual audit team

Spacecraft Element

- Spacecraft Element has been repaired and returned to environmental testing configuration.
- Testing resumes the week of 28-Oct with acoustics retesting, followed about one week later with vibration testing

Payload Element (Optical Telescope + Integrated Science instruments)

- Completed additional “get ahead” warm functional tests of telescope commanded by the spacecraft electronics

Science and Operations

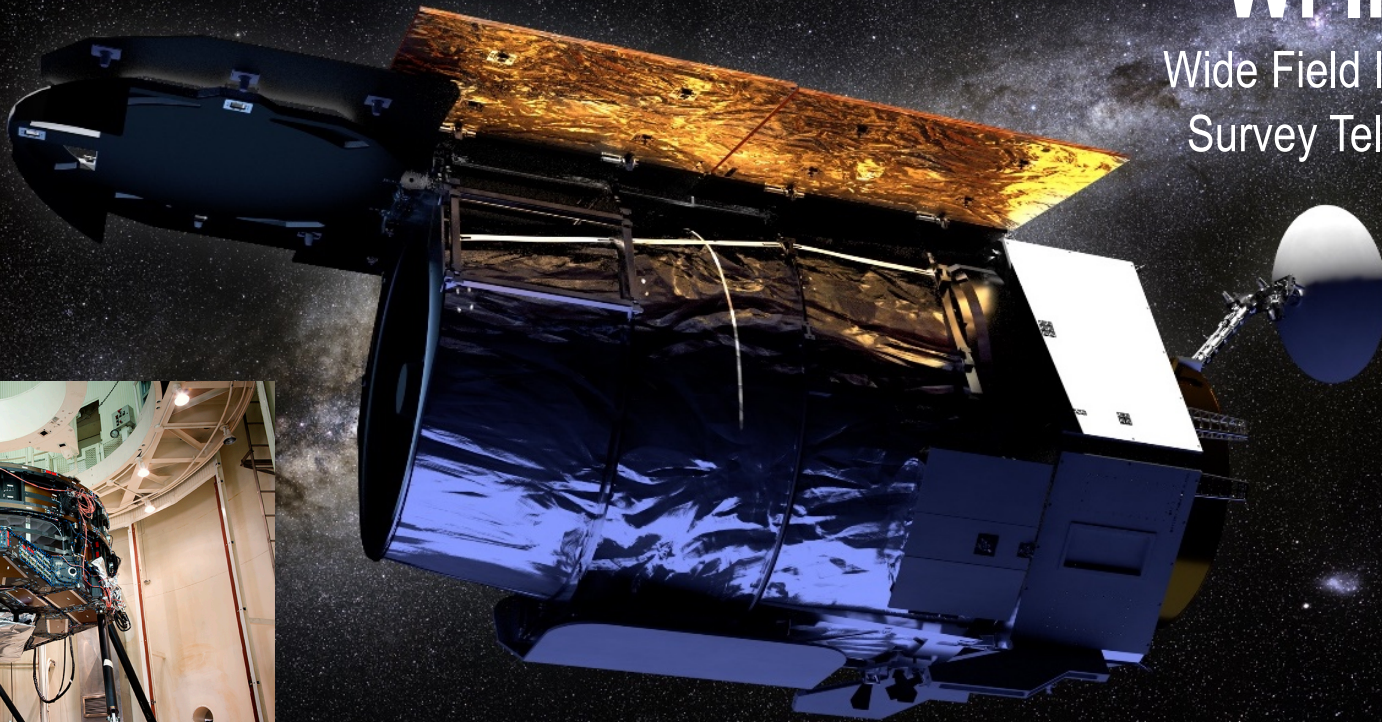
- Ground segment testing and operations rehearsals continuing

Webb Replan Cost

- The new launch date is Mar 30, 2021 and the new development cost is \$8.803B
 - The increased in development cost is \$805M through commissioning (Sep 30, 2021)
 - + – Existing ops budget through FY21 is ~\$310M, so need ~\$490M additional funding in FY20-FY21
- Principles
 - NASA understands the Decadal Survey priorities
 - NASA will protect the Explorer and R&A Programs
- NASA believes that the anticipated cost growth on Webb is likely to impact other science missions
 - NASA's plans for accommodating Webb's increased budget requirements will be submitted as part of the FY20 budget request

WFIRST

Wide Field Infrared
Survey Telescope



Primary mirror assembly / Harris Corporation

WFIRST Update (Programmatic)

- Given its significant cost within a proposed lower budget for Astrophysics and competing priorities within NASA, the President's FY19 Budget Request proposed that WFIRST be terminated with remaining WFIRST funding redirected towards competed astrophysics missions and research
- Funds appropriated by Congress in FY18 allowed WFIRST to begin Phase B in May 2018
- Given Congressional markups in Summer 2018 that would fund WFIRST in FY19, during the FY19 CR NASA is continuing to make progress on WFIRST consistent with the budget profile planned at Phase B start
- National Academies' Exoplanet Science Strategy Report recommends that NASA launch WFIRST "to conduct its microlensing survey of distant planets and to demonstrate the technique of coronagraphic spectroscopy on exoplanet targets" ²¹



WFIRST Update (Technical)

- WFIRST passed SRR/MDR, approved in May 2018 to enter Phase B (preliminary design phase)
 - Phase B baseline incorporates recommendations of WFIRST Independent External Technical/Management/Cost Review (WIETR) and maintains project cost management agreement of \$3.2B for SMD (Phases A – E; excludes contributions & HQ reserves)
 - Requires the approved budget profile that allows for efficient development and lower cost
- Completed System Requirements Reviews for all primary mission elements (Wide Field Instrument, Coronagraph, Optical Telescope Assembly, Spacecraft, Ground System, Instrument Carrier)
- Established / establishing contracts with Ball Aerospace for the Wide Field Instrument, Teledyne Scientific & Imaging for infrared detectors, and Harris Corporation for the telescope



Prospects and Challenges for Athena and LISA

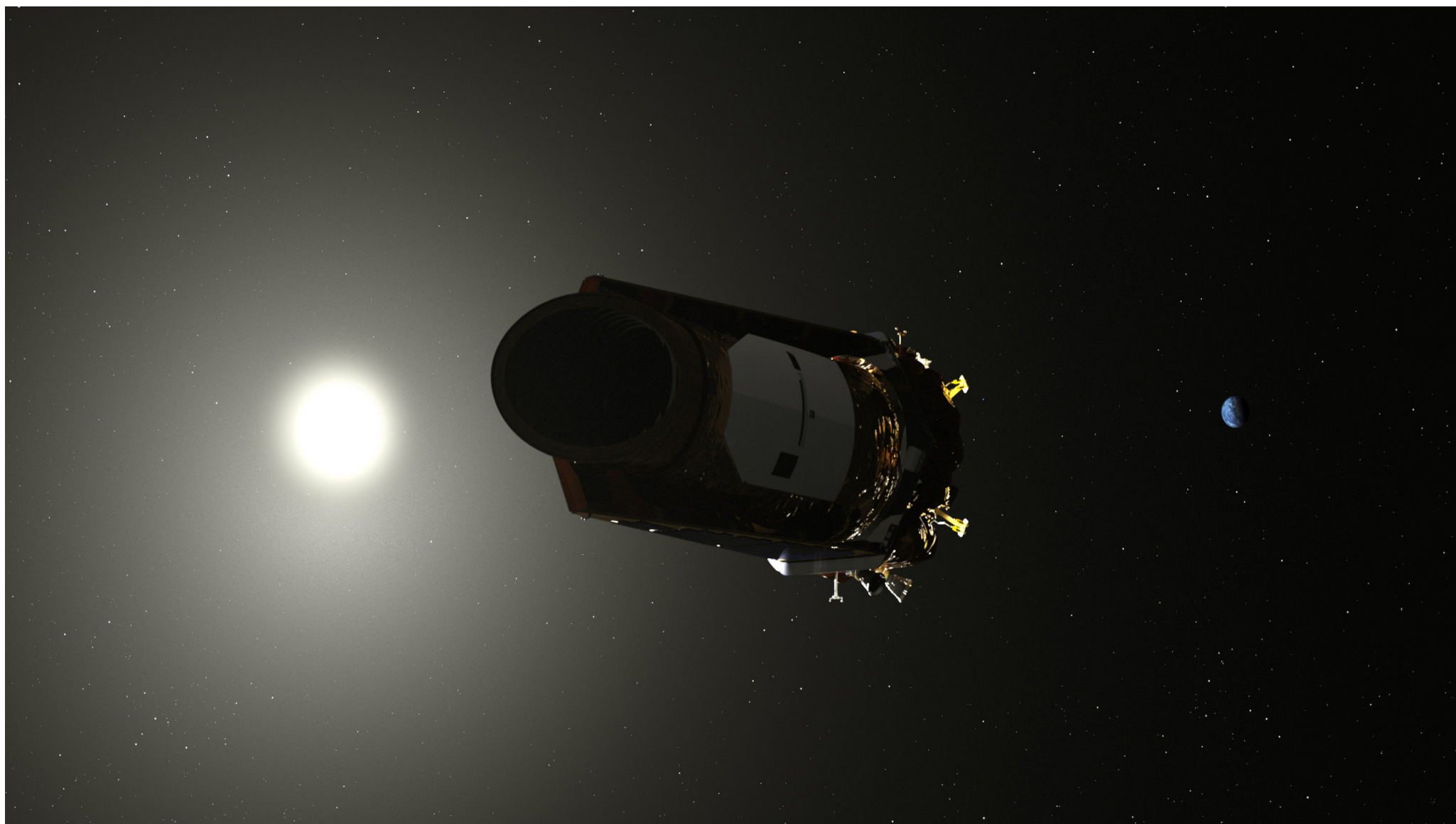
- NASA is proceeding toward Athena and LISA in close partnership with ESA
- ESA has announced intent to accelerate adoption of both missions, and request budget sufficient to have both operating together
- However, NASA's progress is budget limited
 - The planning budget for NASA Astrophysics is down by 14% due to the proposed termination of WFIRST
 - The replan of the James Webb Space Telescope requires additional funding, and this is likely to have an impact on NASA's astrophysics portfolio
 - Accelerating NASA-funded technology maturation for LISA may require prioritization among the five U.S. technology development efforts

2019 Explorers AOs: SMEX and Missions of Opportunity

- Next Astrophysics Explorers AOs will be issued in Spring 2019
- Small Explorers (SMEX) missions
 - PI-managed Cost Cap: \$195M (FY20\$) including launch
 - NASA-provided launch (ELV or ISS) for \$50M charge
 - PI-provided alternative access to space permitted
- Missions of Opportunity
 - PI-managed Cost Cap: \$75M (FY20\$) for: Partner MOs, Small Complete Mission MOs
 - PI-managed Cost Cap: \$35M for: Suborbital-class MOs, SmallSat MOs
- Community Announcement issued in June 2018
- Draft AOs released November 2018

Astrophysics Missions in Operation

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  Spitzer Space Telescope	Gehrels-Swift 11/04 NASA MIDEX Mission  Swift Gamma-ray Burst Explorer	Fermi 6/08 NASA Strategic Mission  Fermi Gamma-ray Space Telescope
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	ISS-CREAM 8/17 NASA Research Mission  Cosmic Ray Energetics And Mass	TESS 4/18 NASA MIDEX Mission  Transiting Exoplanet Survey Satellite	



Senior Review 2019

Astrophysics
Advisory
Committee

Senior Review
Subcommittee

Hubble Panel

Chandra
Panel

Rest-of-
Missions
Panel

- 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)
- Neil Gehrels Swift Observatory (Swift)
- Transiting Exoplanet Survey Satellite (TESS)
- X-ray Multi-mirror Mission-Newton (XMM-Newton)

Not in Senior Review: SOFIA, Spitzer



Senior Review 2019 Schedule

2018:

- ✓ APAC approves Terms of Reference for the Senior Review Subcommittee
- ✓ Establish Senior Review Subcommittee
- ✓ Draft call for proposals issued
- ✓ Final call for proposals issued
- Appointment of subcommittee members compliant with FACA

2019:

- Senior Review proposals due
- Rest-of-missions, Chandra, and Hubble panels meet
- Reports from Rest-of-missions, Chandra, and Hubble panels due to Senior Review Subcommittee
- Senior Review Subcommittee meets
- Senior Review Subcommittee reports to APAC
- APAC delivers formal recommendations to NASA
- NASA responds to Senior Review and provides direction to projects



NASA Astrophysics

Planning for Astro2020

Decadal Survey Planning

- NASA has initiated studies for large (Flagship) and medium (Probe) size mission concepts to inform the 2020 Decadal Survey Committee in an organized and coherent way
- Specifically, NASA is:
 - Sponsoring 4 community-based Science and Technology Definition Teams (STDTs) to partner with a NASA Center-based engineering team and study large (strategic) mission concept studies selected from the NASA Astrophysics 30-year Visionary Roadmap, a community-based report, and the 2010 Decadal Survey. Main purpose is to provide the Decadal Survey Committee with several well-defined mission concepts to facilitate their deliberations
 - Supporting 10 PI-led Study Teams for Probe-size mission concept studies, selected competitively
 - Supporting several other planning activities / studies / white papers including: Balloon Program Roadmap; Evolution of NASA Data Centers; In-Space Servicing/In-Space Assembly.
 - Investing in next-generation technologies, including ultrastable telescope technology, starshades, coronagraphs, x-ray mirrors, detectors, etc.
- Material related to NASA's 2020 Decadal Survey planning activities are posted at <https://science.nasa.gov/astrophysics/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.

Take Away

- R&A opportunities increasing
- Small mission opportunities increasing
- Explorers AOs and launches proceeding at Decadal Survey cadence
- TESS science mission has begun
- Webb executing to new plan; cost growth on Webb is likely to impact other missions
- WFIRST executing to approved plan; awaiting FY19 appropriation
- Senior Review and SOFIA review(s) underway
- Decadal Survey planning proceeding with goal of an ambitious science program in the 2020s



Backup Slides

Unchanged since
Summer 2018

Astrophysics Budget – FY19 Appropriations

(\$M)	Admin Request	House Markup	Senate Markup	Comments
Astrophysics (w/ Webb)	1,185.4	1,333.6	1,547.8	Senate: Start Astro2020 on time
Webb	304.6	304.6	304.6	Both: \$8B cost cap
Hubble	78.3		98.3	Senate: Reject cutting costs
SOFIA	74.6	85.2		House: No Senior Review Senate: Encourage Senior Review
WFIRST	0.0	150.0	352.0	House: \$20M for starshade tech Both: \$3.2B cost cap
R&A	83.4	83.4		
Science Activation	44.6	44.0	45.0	
Technosignatures	0.0	10.0		
Search for Life Tech	>>15.0		15.0	
Rest of Astrophysics	678.2	656.4		-21.8 (-3.2%)
Rest of Astrophysics	757.9		747.9	-10.0 (-1.3%)