National Aeronautics and Space Administration

EXPLORE SCIENCE

NASA Astrophysics Update

Astrophysics Advisory Committee
October 28, 2019

Eric Smith

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Science Mission Directorate
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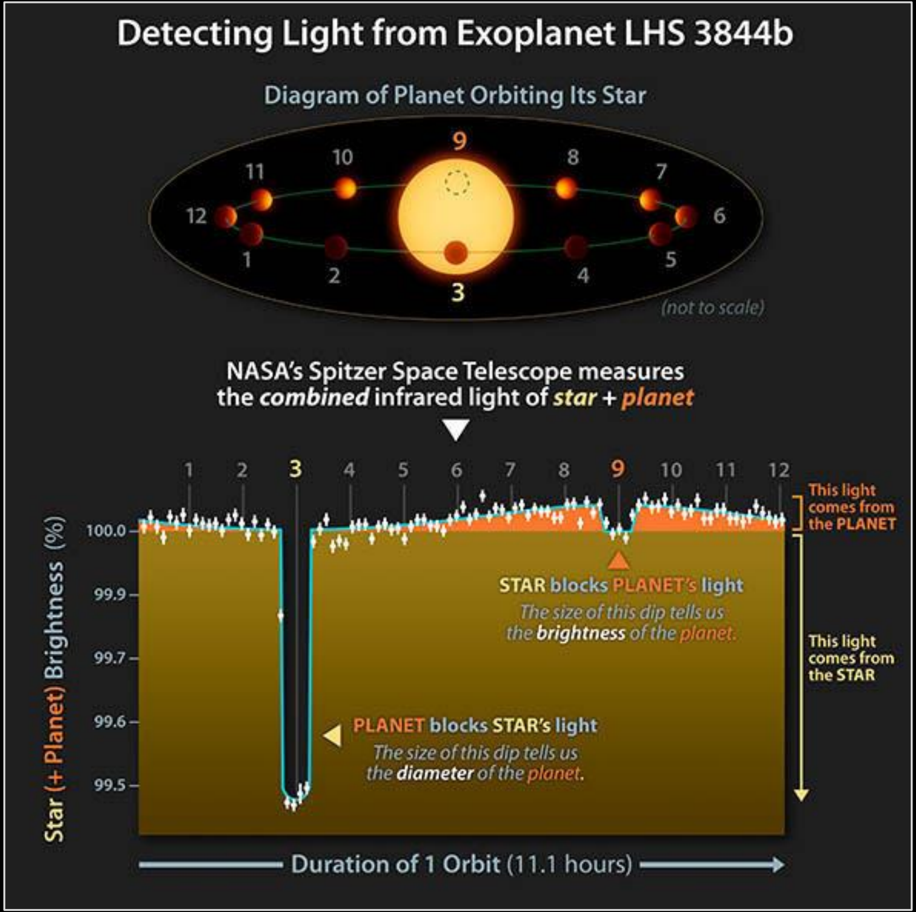
A Rare Look at a Rocky Exoplanet's Surface

Released August 19, 2019



Credit: NASA/JPL-Caltech/L. Kreidberg (Harvard-Smithsonian CfA)

L. Kreidberg et al., 2019 (Nature, 573, pp 87–90)

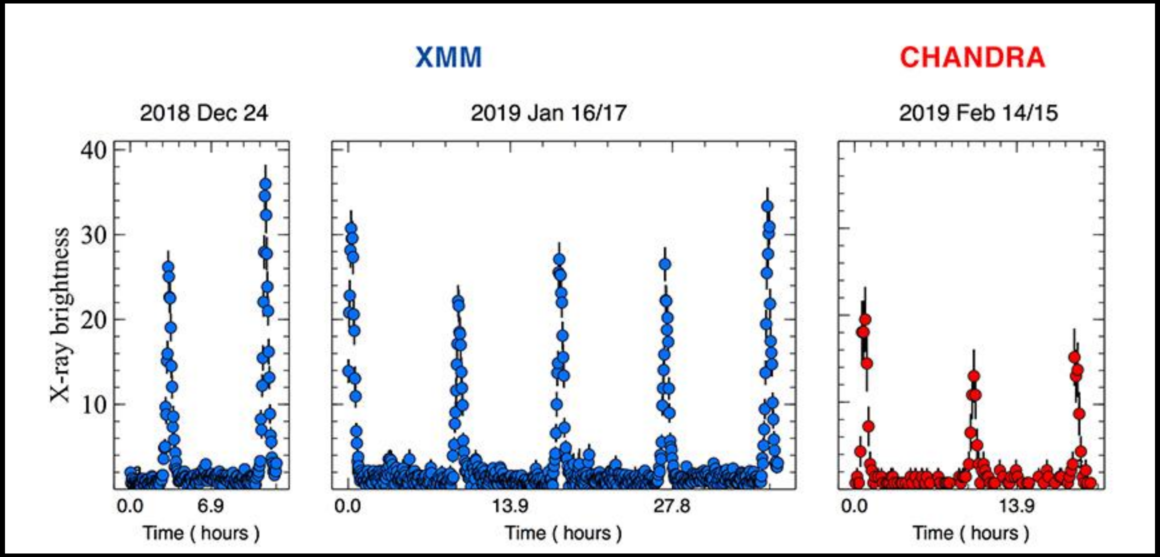
SCIENCE HIGHLIGHT

A new study using data from NASA's Spitzer Space Telescope provides a rare glimpse of conditions on the surface of a rocky planet orbiting a star beyond the Sun.

- Discovered in 2018 by NASA's Transiting Exoplanet Satellite Survey (TESS) mission, planet LHS 3844b is located 48.6 light-years from Earth and has a radius 1.3 times that of Earth.
  - It orbits a small, cool type of star called an M dwarf - the most common and long-lived type of star in the Milky Way galaxy.
  - The planet makes one full revolution around its parent star in just 11 hours.
    - With such a tight orbit, LHS 3844b is most likely "tidally locked," which is when one side of a planet permanently faces the star.
  - The star-facing side, or dayside, is about 1,410 degrees Fahrenheit (770 degrees Celsius). Being extremely hot, the planet radiates a lot of infrared light which Spitzer can see.
  - By measuring the temperature difference between the planet's hot and cold sides, the team found that there is a negligible amount of heat being transferred between the two.
    - If an atmosphere were present, hot air on the dayside would naturally expand and generate winds that would transfer heat around the planet.
- The study shows that the planet's surface may resemble those of Earth's Moon or Mercury: The planet likely has little to no atmosphere and could be covered in the same cooled volcanic material found in the dark areas of the Moon's surface, called mare.

Scientists Discover Black Hole Has Three Hot Meals a Day

Released September 11, 2019



Data from XMM-Newton and Chandra, taken over a span of 54 days, revealed that a supermassive black hole is blasting out X-rays about every nine hours. This indicates that this black hole is consuming significant amounts of material about three times per day. This is the first time such repetitive behavior has been seen in a supermassive black hole.

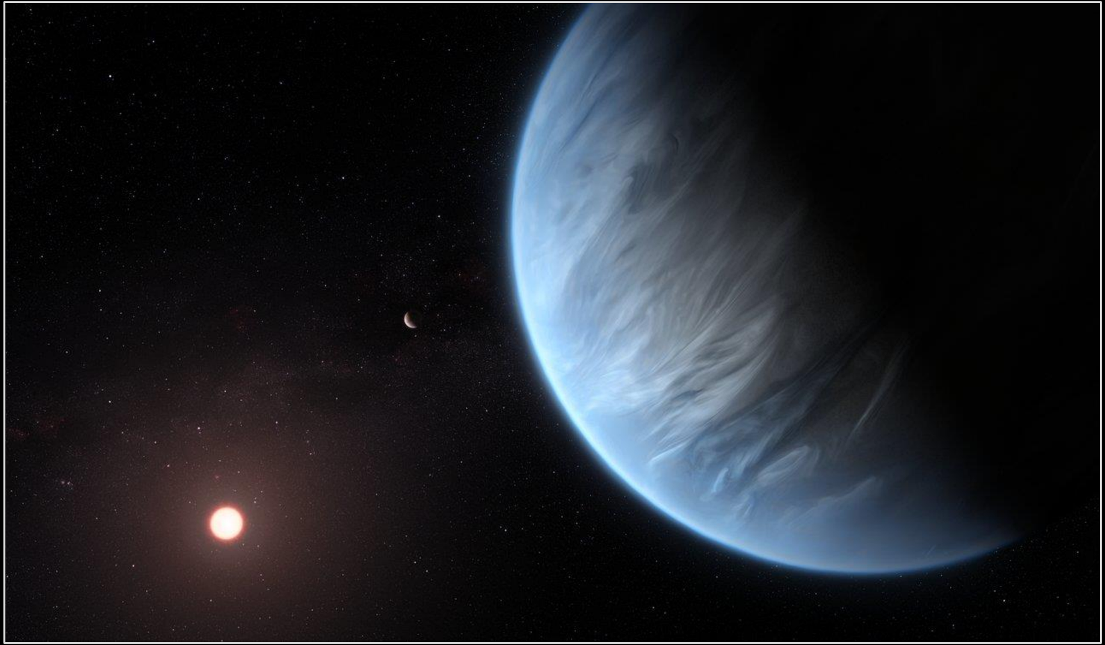
G. Miniutti et al., 2019 (Nature, 573, pp 381–384)

SCIENCE HIGHLIGHT

- A team of astronomers using NASA's Chandra X-ray Observatory and ESA's XMM-Newton found X-ray bursts repeating about every nine hours indicating the supermassive black hole located at the center of galaxy GSN 069 is consuming large amounts of material on a regular schedule.
  - While scientists had previously found two "stellar-mass" black holes (that weigh about 10 times the Sun's mass) occasionally undergoing regular outbursts before, this behavior has never been detected from a supermassive black hole until now.
- The black hole at the center of GSN 069, located 250 million light years from Earth, contains about 400,000 times the mass of the Sun.
  - The researchers estimate that the black hole is consuming about four Moons' worth of material about three times a day.
    - That's equivalent to almost a million billion billion pounds going into the black hole per feeding.
- XMM-Newton was the first to observe this phenomenon in GSN 069 with the detection of two bursts on December 24, 2018. Observations by Chandra less than a month later, on February 14, revealed an additional three outbursts.
  - During the outbursts the X-ray emission becomes much brighter than during the quiet times.
  - The temperature of gas falling towards the black hole also climbs, from about one million degrees Fahrenheit during the quiet periods to about 2.5 million degrees Fahrenheit during the outbursts.
- The combination of data from Chandra and XMM-Newton implies that the size and duration of the black hole's meals have decreased slightly, and the gap between the meals has increased. Future observations will be crucial to see if the trend continues.

Hubble Finds Water Vapor on Habitable-Zone Exoplanet for the First Time

Released September 13, 2019



Credits: ESA/Hubble, M. Kornmesser

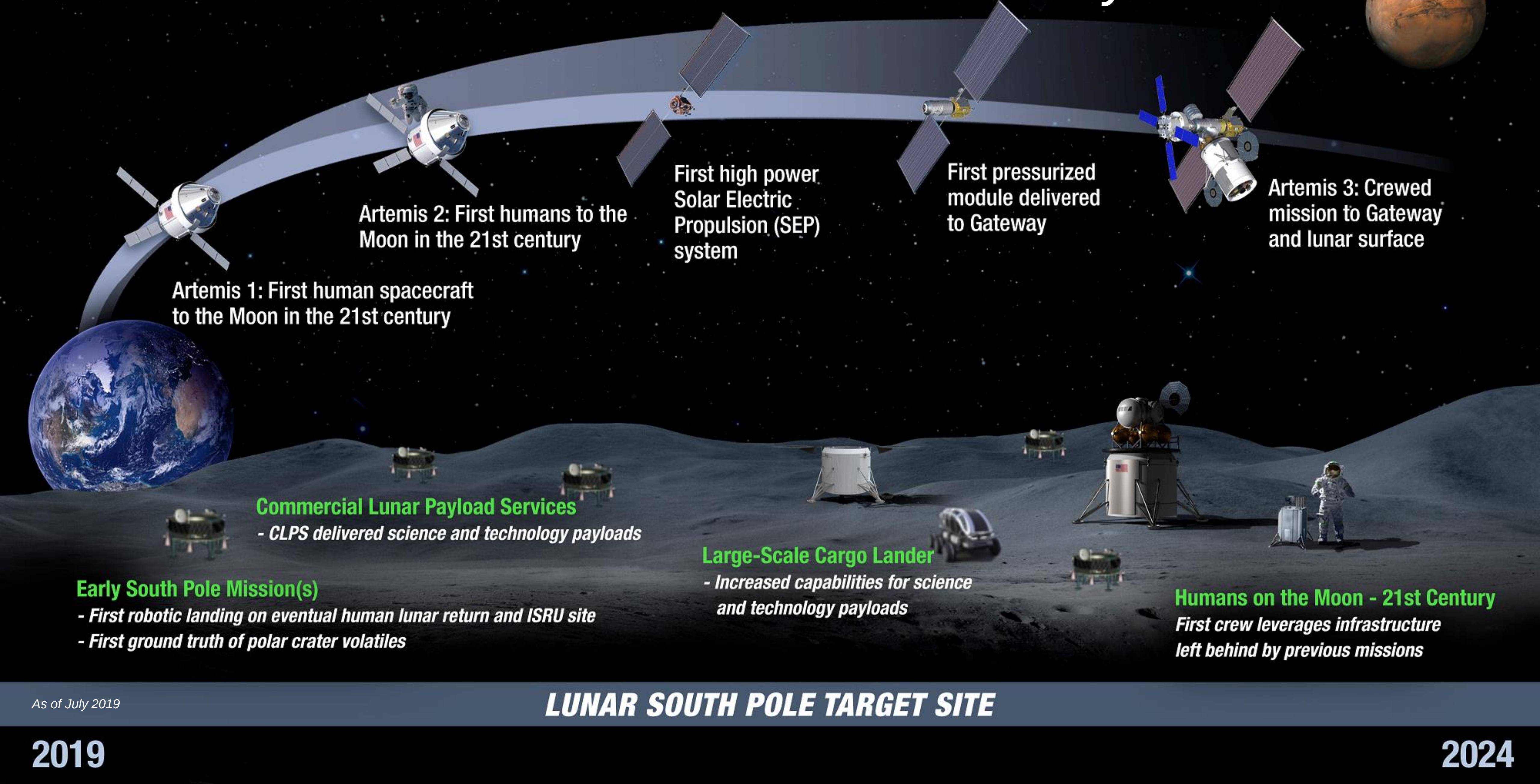
This artist's impression shows the planet K2-18b, its host star and an accompanying planet in this system.

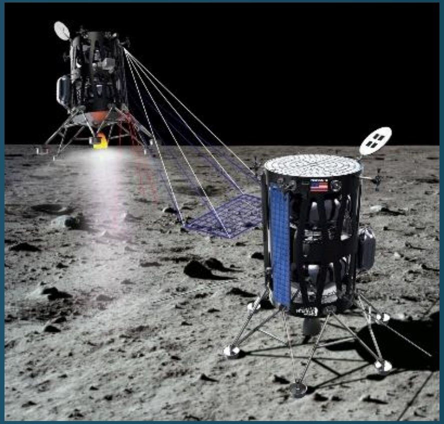
B. Benneke et al. 2019 (arXiv:1909.04642)
A. Tsiaras et al. 2019 (Nature Astronomy, DOI:10.1038/s41550-019-0878-9)

SCIENCE HIGHLIGHT

- Astronomers used data from NASA's Hubble Space Telescope to find water vapor in the atmosphere of K2-18b, an exoplanet orbiting a small red dwarf star about 110 light-years away in the constellation Leo.
  - If confirmed by further studies, this will be the only exoplanet known to have both water in its atmosphere and temperatures that could sustain liquid water on a rocky surface.
    - Liquid water would only be possible if the planet turns out to be terrestrial in nature, rather than resembling a small version of Neptune.
- Given the high level of activity of its red dwarf star, K2-18b may be more hostile to life as we know it than Earth, as it is likely to be exposed to more high-energy radiation.
- The planet, discovered by NASA's Kepler Space Telescope in 2015, also has a mass eight times greater than Earth's.
  - That means the surface gravity on this planet would be significantly higher than on our planet.
- The team used archive data from 2016 and 2017 captured by Hubble and developed open-source algorithms to analyze the host star's light filtered through K2-18b's atmosphere.
  - The results revealed the molecular signature of water vapor, and also suggest the presence of hydrogen and helium in the planet's atmosphere.

Artemis Phase 1: To the Lunar Surface by 2024





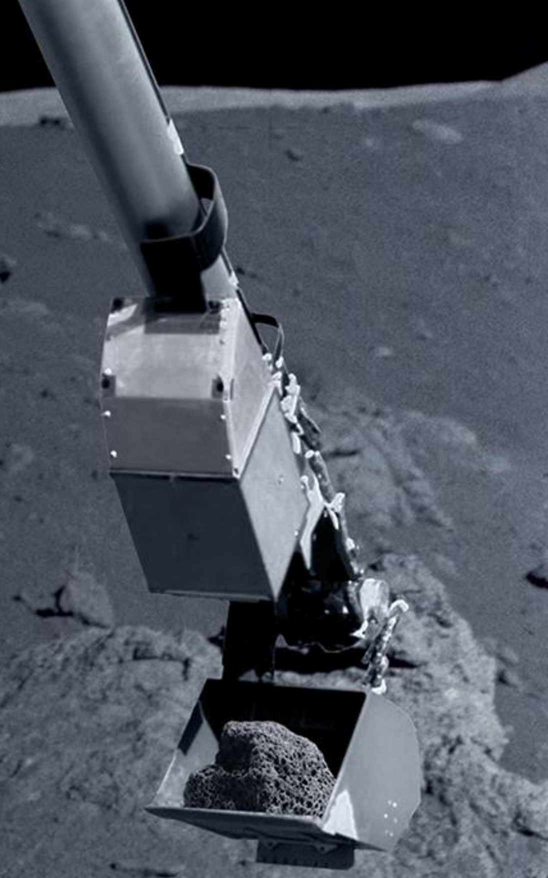
Partnerships in Innovation

- Under Commercial Lunar Payload Services (CLPS), nine U.S. companies selected to bid on specific task orders to develop landers delivering NASA payloads to Moon's surface
  - 12 science instrument payloads announced to be developed at NASA Centers[1]
    - Low-frequency Radio Observations from the Near Side Lunar Surface instrument (PI: Robert MacDowall, GSFC)
  - 12 additional instruments announced to be developed by industry and academia[2]
    - Next Generation Lunar Retroreflectors (PI: Douglas Currie, University of Maryland)
- Two of nine U.S. commercial space transportation services providers are currently under contract with NASA to deliver NASA payloads for Artemis Program
- 13 U.S. companies selected for 19 partnerships to mature industry-developed space technologies which will accelerate capabilities to benefit future NASA missions

[1] https://www.nasa.gov/press-release/nasa-selects-experiments-for-possible-lunar-flights-in-2019

[2] https://www.nasa.gov/press-release/nasa-selects-12-new-lunar-science-technology-investigations

Lunar Science by 2024



Polar Landers and Rovers

- First direct measurement of polar volatiles, improving understanding of lateral and vertical distribution, physical state, and chemical composition
- Provide geology of the South-Pole Aitken basin, largest impact in the solar system

Non-Polar Landers and Rovers

- Explore scientifically valuable terrains not investigated by Apollo, including landing at a lunar swirl and making first surface magnetic measurement
- Using PI-led instruments to generate Discovery-class science, like establishing a geophysical network and visiting a lunar volcanic region to understand volcanic evolution

Orbital Data

- Deploy over a dozen CubeSats with Artemis 1
- Potential to acquire new scientifically valuable datasets through CubeSats delivered by CLPS providers or comm/relay spacecraft
- Global mineral mapping, including resource identification, global elemental maps, and improved volatile mapping

In-Situ Resource Initial Research

- Answering questions on composition and ability to use lunar ice for sustainment and fuel

Science After 2024

Human and Robotic Missions Provide Unique Science Opportunities

On Gateway

- Deep space testing of Mars-forward systems
- Hosts groundbreaking science for space weather forecasting, full-disc Earth observation, astrophysics, heliophysics, lunar and planetary science
- Mars transit testbed for reducing risk to humans

Surface Exploration

- Understanding how to use in-situ resources for fuel and life
- Revolutionizing the understanding of the origin and evolution of the Moon and inner solar system by conducting geophysical measurements and returning carefully selected samples to Earth
- Studying lunar impact craters to understand physics of the most prevalent geologic process in the solar system, impact cratering
- Setting up complex surface instrumentation for astrophysics, heliophysics and Earth observation
- Informing and supporting sustained human presence through partial gravity research in physical and life sciences, from combustion to plant growth

Surface Telerobotics to Provide Constant Science

- Sending rovers into areas too difficult for humans to explore; rovers can be teleoperated from Earth to maximize the scientific return

Building An Excellent Workforce

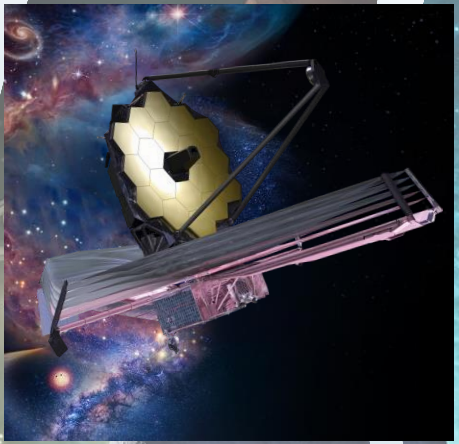
NASA achieves excellence by relying on diverse teams, both within and external to NASA, to most effectively perform NASA's work

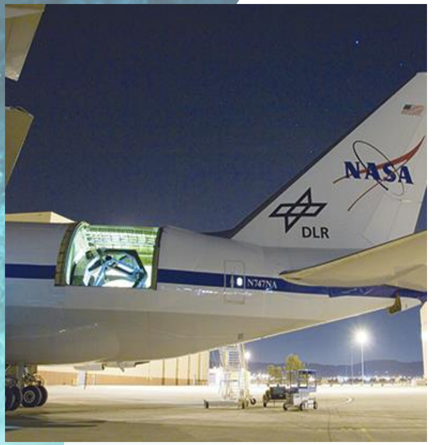
NASA Science Mission Directorate

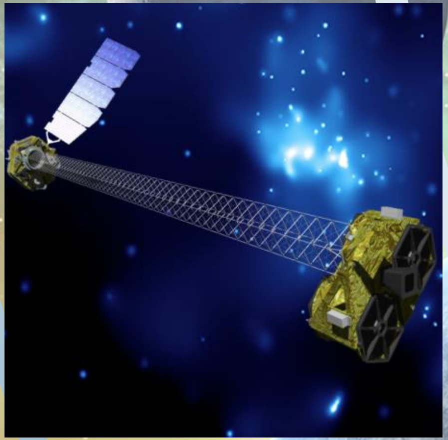
- Developed a PI resources webpage at https://science.nasa.gov/researchers/new-pi-resources
- Introduced pre-reviews of mission peer review panels to ensure diversity
- Added a code of conduct requirement for SMD-funded conferences to ROSES 2019
- Included career development positions and associated evaluation criteria as part of Announcements of Opportunity (AOs)
- Implemented a Code of Conduct and implicit bias training for all ROSES peer reviews
- Adopting dual anonymous reviews for all Guest Observer (GO) programs, and piloting them for other R&A programs, following successful demonstration by STScI for Hubble GO program
- Presented a national symposium by SMD AA Thomas Zurbuchen on lessons learned regarding mission proposal success
- Announced a workshop for potential mission PIs, see https://science.nasa.gov/researchers/pi-launchpad
- Is developing award terms and conditions mandating reporting harassment, similar to that of NSF
- Is presenting information sessions at major conferences, including the Honolulu AAS Meeting, to support people developing their first proposal
- Tasked the Astro2020 Decadal Survey to "Assess the state of the profession. Identify areas of concern and importance [regarding] the future vitality and capability of the astronomy and astrophysics work force. Where possible, provide specific, actionable and practical recommendations to the agencies"

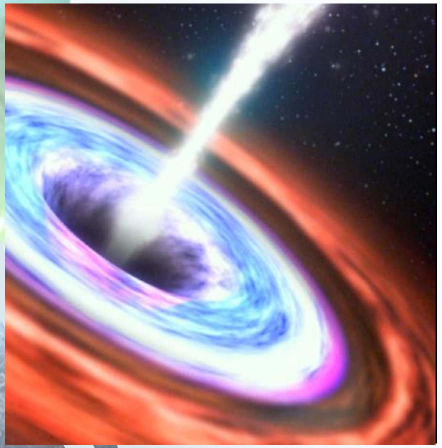
NASA is looking forward to specific, actionable, and practical recommendations

Budget Update



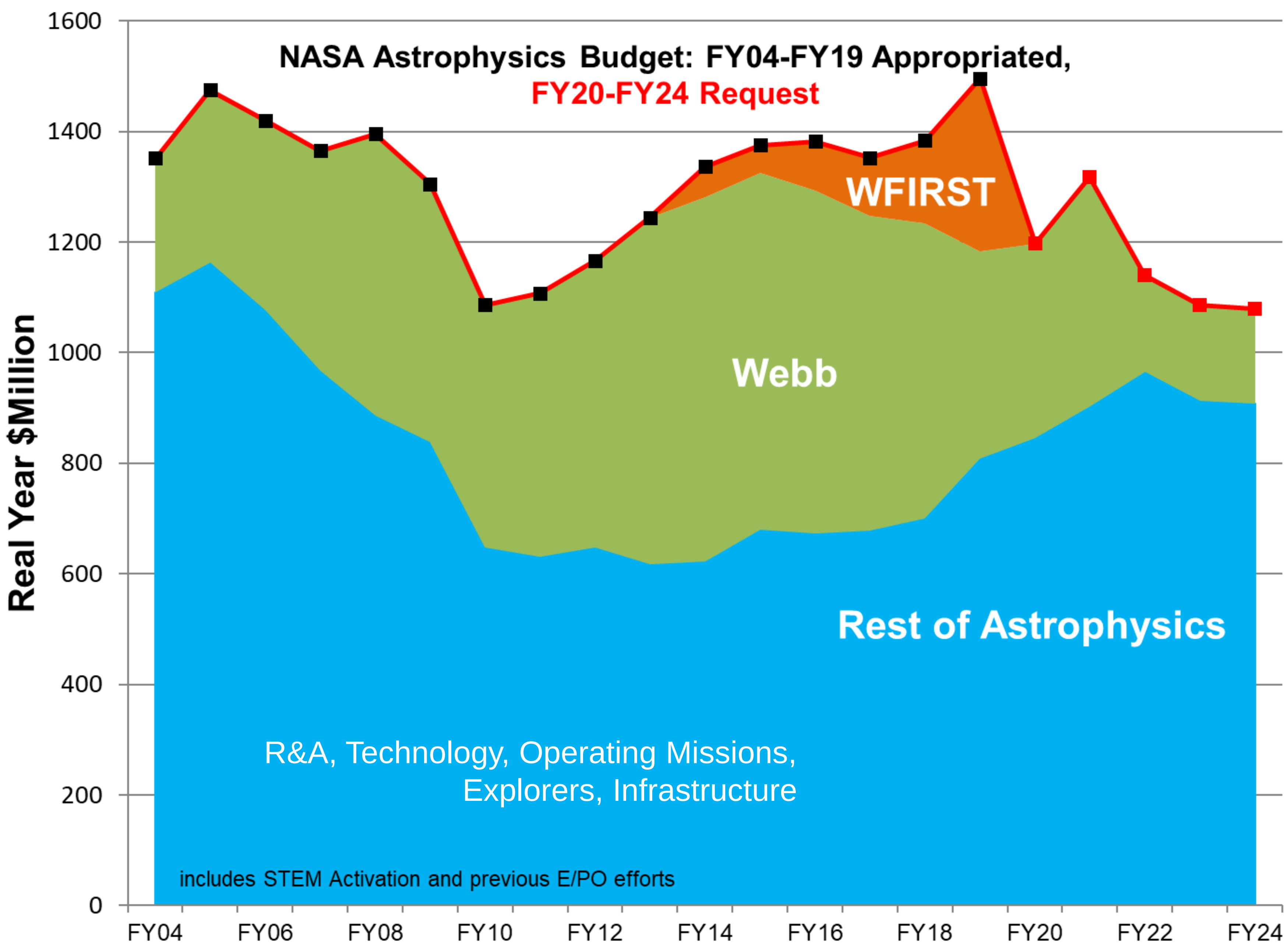






FY20 Budget Request

- Accommodates Webb replan to March 2021 LRD
- Given its significant cost within proposed lower budget for Astrophysics and competing priorities within NASA, WFIRST terminated with remaining WFIRST funding redirected towards completing Webb
- Supports formulation of a probe mission as early as 2022, conditional on Decadal Survey recommendations
- Maintains decadal cadence of four AOs per decade for Astrophysics Explorers and Missions of Opportunity
- Funds SOFIA for three years beyond end of prime mission in FY19 at reduced budget; two alternate reviews conducted in 2019 in lieu of inclusion in 2019 Senior Review
- Extends operating missions (other than Hubble and Chandra) at reduced budget beyond FY20 following 2019 Senior Review
- Supports mission concept studies and technology investments starting in 2022 to respond to Astrophysics Decadal Survey priorities


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

FY 2020 Budget – NASA Science Mission Directorate

($K)	President's Request	House	House Delta	Senate	Senate Delta
Science	6,393,700	7,161,300	767,600	6,905,600	511,900
Earth Science	1,779,792	2,023,100	243,308	1,945,000	165,208
Planetary Science	2,712,103	2,713,400	1,297	2,631,000	(81,103)
Astrophysics	844,754	1,367,700	522,946	1,171,600	326,846
Heliophysics	704,501	704,500	(1)	735,000	30,499
James Webb Space Telescope	352,550	352,600	0	423,000	70,450

House Markup of FY20 Budget Request

House has marked up NASA's FY20 budget request

- WFIRST is funded at $510.7M, with $65M for the coronagraph technology demonstration instrument; this is $510.7M above the request
- SOFIA is funded at $85.2M; this is $12.2M above the request
- Webb is funded at $352.6M; this is the request and supports the replan to a 2021 launch
- Astrophysics including Webb is funded at $1,720.3M; this is $522.9M above the request and supports the planned Astrophysics programs

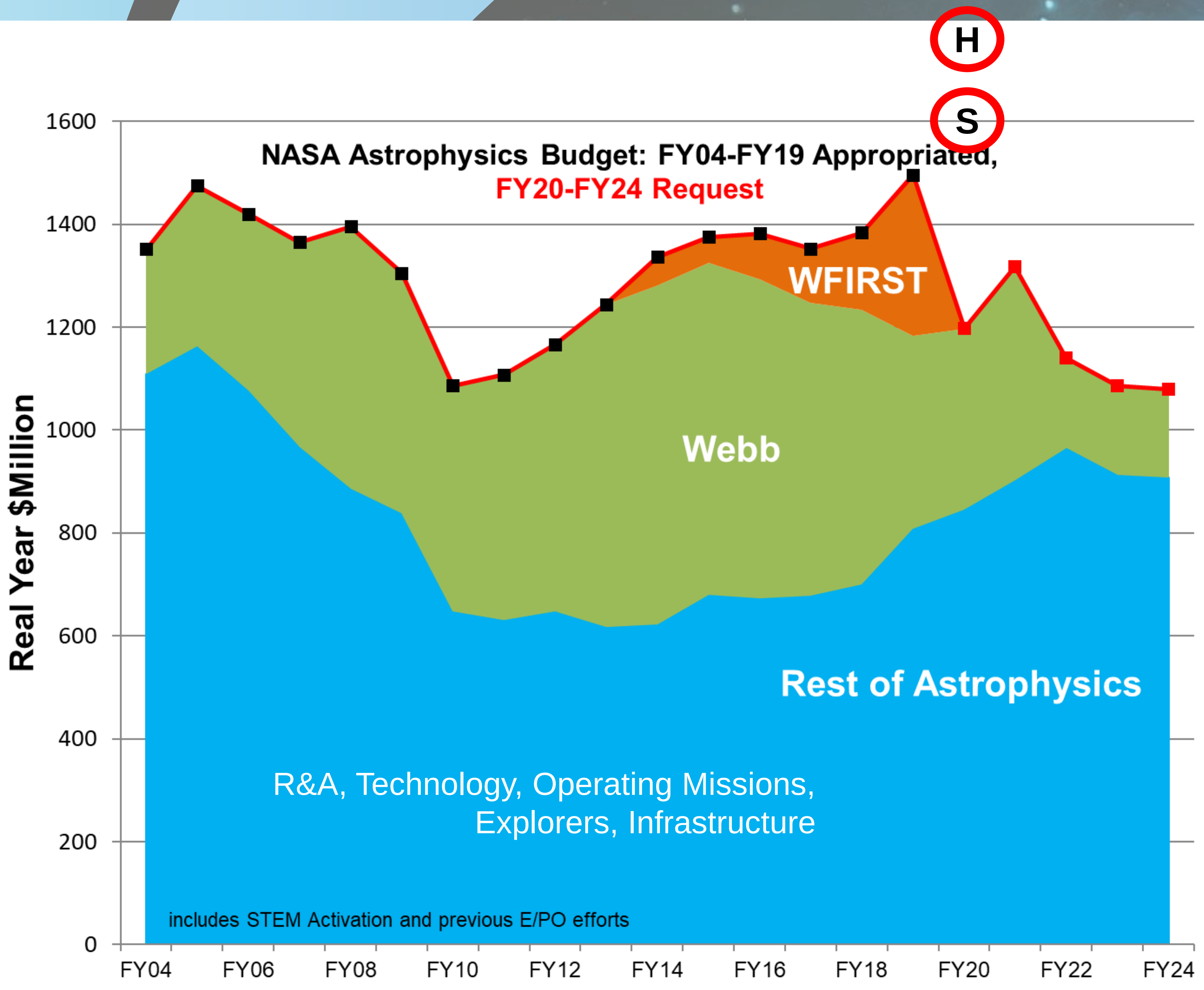
Senate Markup of FY20 Budget Request

Senate has marked up NASA's FY20 budget request

- WFIRST is funded at $445.7M; this is $445.7M above the request
  - Language expects firm cost cap of $3.2B
- Hubble is funded at $98.3M; this is $10M above the request
- Webb is funded at $423.0M; this is $70.4M above the request and supports the replan to a 2021 launch
- Research Program is funded at $250.7M; this is the request
- Astrophysics including Webb is funded at $1,594.5M; this is $397.2M above the request
  - Would require a $133.9M (29%) cut to rest of astrophysics

Congressional Markup of Astrophysics FY20 Budget

($M)	Request	House	Senate	Comment
Webb	352.6	352.6	423.0	
WFIRST	0	510.7	445.7	House: Includes CGI Senate: $3.2B cost cap
Hubble	83.3		98.3	
SOFIA	73.0	85.2		
Astrophysics Research Program	250.7		250.7	
Science Activation	45.6		45.6	
Rest of Astrophysics (House)	772.8	771.8		House: $1M undistributed cut
Rest of Astrophysics (Senate)	465.2		331.3	Senate: $133.9M undistributed cut
Total	1,197.4	1,720.3	1,594.6	



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NASA Astrophysics Budget: FY04-FY19 Appropriated,
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Real Year $Million
1600
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WFIRST
Webb
Rest of Astrophysics
R&A, Technology, Operating Missions,
Explorers, Infrastructure
includes STEM Activation and previous E/PO efforts
FY04
FY06
FY08
FY10
FY12
FY14
FY16
FY18
FY20
FY22
FY24

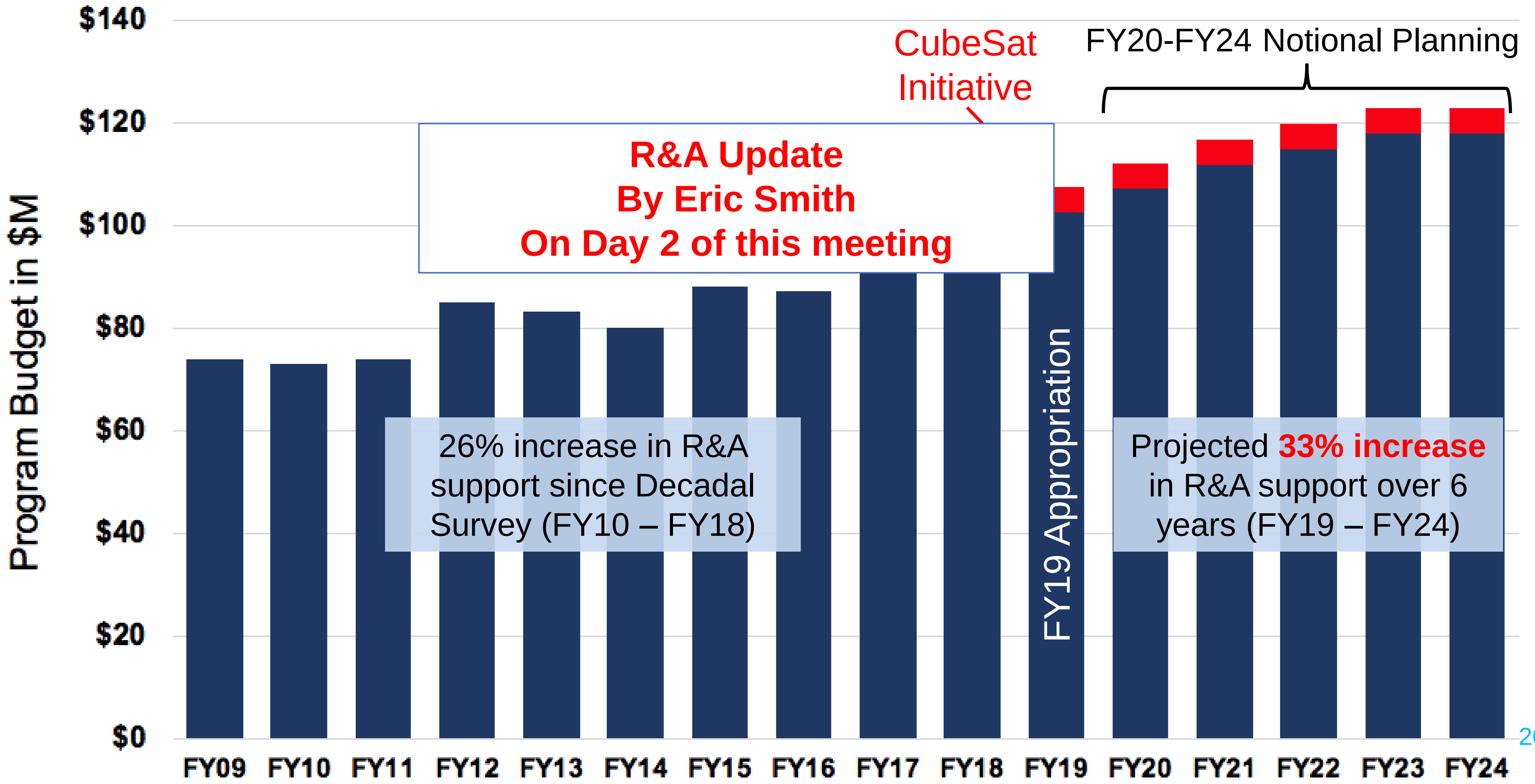
Program Update

Program of Record (Current Program)

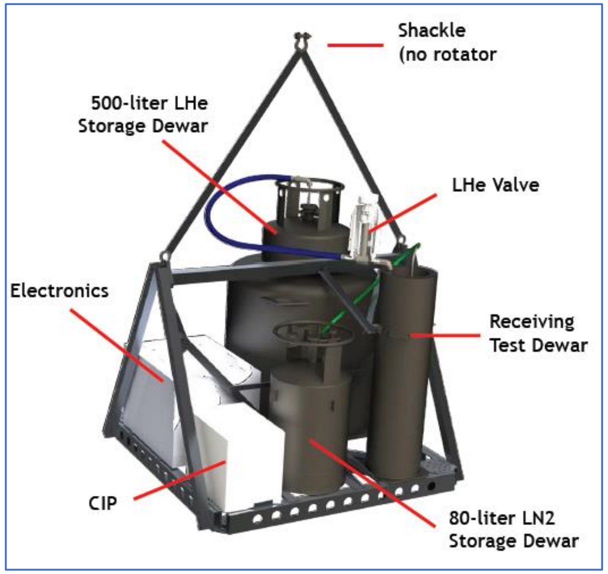
Supporting Research & Technology	**R&A**: ADAP, ATP, TCAN, XRP, Hubble Fellows, GO programs	**Technology**: APRA, SAT, Roman Fellows, Future flagship technologies	**Research support**: Keck, Balloon project, Astrophysics archives
Operating Missions	**Explorers**: Gehrels Swift, NuSTAR, NICER, TESS	**International Partnerships**: XMM-Newton	**Strategic Missions**: Hubble, Chandra, Spitzer, Fermi, SOFIA
Missions in Development or Under Study	**Explorers**: IXPE, GUSTO, SPHEREx, AO2019, AO2021, etc.	**International Partnerships**: Euclid, XRISM, Athena, LISA	**Strategic Missions**: Webb, WFIRST

Growth in R&A Funding ($M)

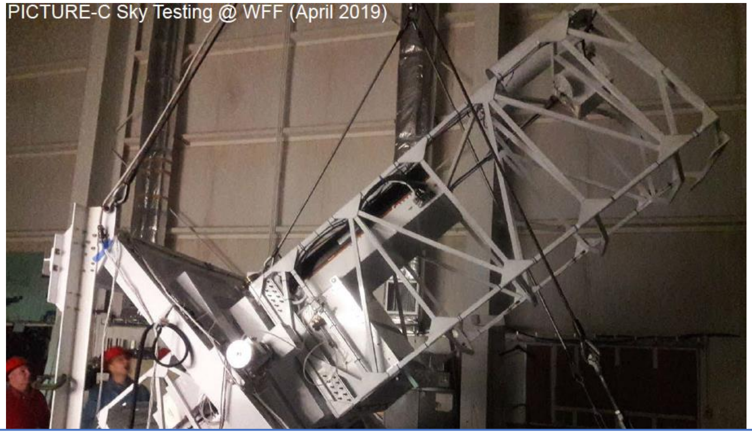
Program	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24
R&A	$74	$73	$74	$85	$83	$80	$88	$87	$91	$92	$103	$107	$112	$115	$118	$118
CubeSat											$5	$5	$5	$5	$5	$5
Total	$74	$73	$74	$85	$83	$80	$88	$87	$91	$92	$108	$112	$117	$120	$123	$123



Balloon Program - Fort Sumner Campaign



BOBCAT *- (Kogut/GSFC) develops technology to improve far-IR sensitivity by a factor of 1000,000 compared to ground-based facilities or SOFIA. BOBCAT-1 is a technology demo of liquid nitrogen and liquid helium cryogen transfer. BOBCAT-2 is a demo of ultra-light balloon dewars.*


PICTURE-C Sky Testing @ WFF (April 2019)

Balloon Update
By Debra Fairbrother
On Day 1 of this meeting

five nearby star systems to search for dust and debris disks. PICTURE-C will demonstrate a balloon-based clear aperture telescope with low order wave front control, high performance vector vortex coronagraph, and a microwave kinetic inductance detector.

PIPER - *(Kogut/GSFC) will attempt to measure CMB polarization in order to search for primordial gravity waves.*

HQ review of Leak Campaign on Aug 12 led to approval to proceed with Ft. Sumner campaign. Wallops review gave authority-to-proceed with campaign Aug 13.

Campaign with Astrophysics, Heliophysics, and Earth Science missions, as well as engineering test flights, completed.

8 out of 8 successful launches.

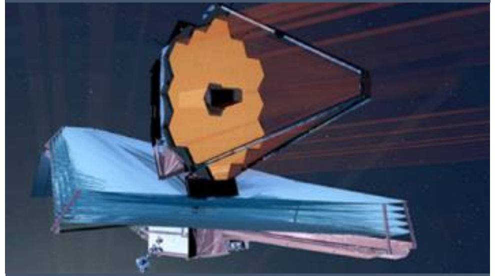
Ft. Sumner manifest

Kogut / GSFC / BOBCAT [Astrophysics] 08/22 SUCCESS
CSBF / 11MCF Piggyback [Engineering] 09/04 SUCCESS
Guzik / LSU / HASP [Student flight projects] 09/05 SUCCESS
Gopalswamy / GSFC / BITSE [Heliophysics] 09/18 SUCCESS
Fields / CSBF / LDB test [Engineering] 09/23 SUCCESS
Chakrabarti / UMass / PICTURE-C [Astrophysics] 09/28 SUCCESS
Toon/JPL/Remote / Bailey/VATech/GLO [Earth Science] 10/07 SUCCESS
Kogut / GSFC / PIPER [Astrophys] 10/14 Flight SUCCESS / P/L anomaly
+3 hand launches:
Thai-Spice (Astrophysics) 10/16 SUCCESS
Reck-Tang (Planetary) 10/17 SUCCESS
SWITCH (Earth) NOT ACCOMPLISHED

Missions in Development or Under Study

Webb
2021

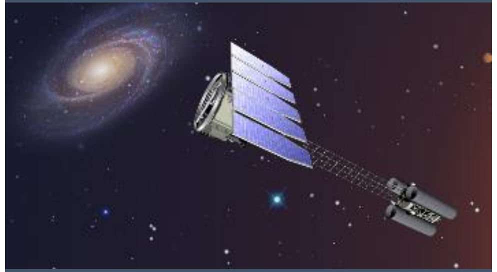
NASA Strategic Mission



James Webb
Space Telescope

IXPE
2021

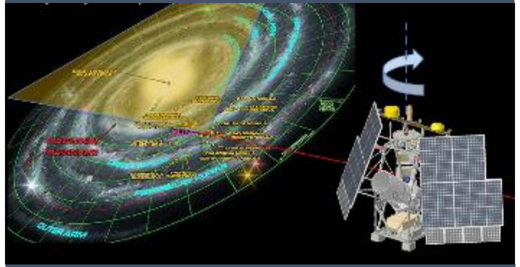
NASA Explorers Mission



Imaging X-ray
Polarimetry Explorer

GUSTO
2021

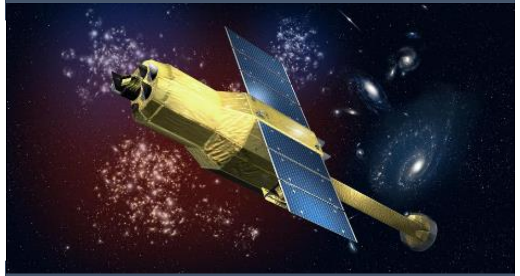
NASA Explorers Mission



Galactic/ Extragalactic ULDB
Spectroscopic Terahertz Observatory

XRISM
2022

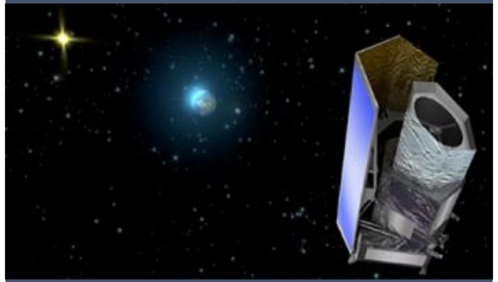
JAXA-led Mission



NASA is supplying the Resolve
detector and X-ray mirrors

Euclid
2022

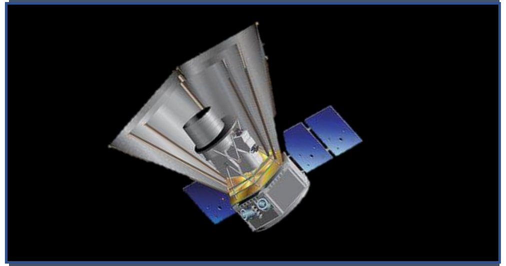
ESA-led Mission



NASA is supplying the NISP
sensor chip system

SPHEREx
2023

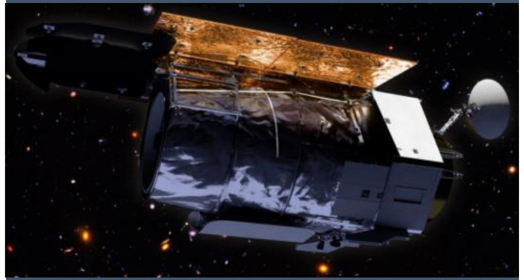
NASA Explorers Mission



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

WFIRST
Mid 2020s

NASA Strategic Mission



Wide Field Infrared
Survey Telescope

Athena / LISA
2030s

ESA-led Missions

NASA is supplying instrument
and mission systems

Webb

The James Webb Space Telescope

Webb Update
By Greg Robinson
On Day 2 of this meeting

- Spacecraft element successfully completed it's environmental testing
- Science payload and spacecraft ement have been integrated
- nshield deployment and tensioning mpleted
- Two spacecraft bus electronic components will be replaced prior to Observatory level environments testing
- FY2020 is the year of Observatory level testing in preparation for the 2021 launch

The Webb observatory in the clean room in Redondo Beach, CA after spacecraft element environmental testing and observatory deployments

Wide Field Infrared Survey Telescope

WFIRST Update
By Jeff Kruk
On Day 2 of this meeting

Work continues with FY19 funding

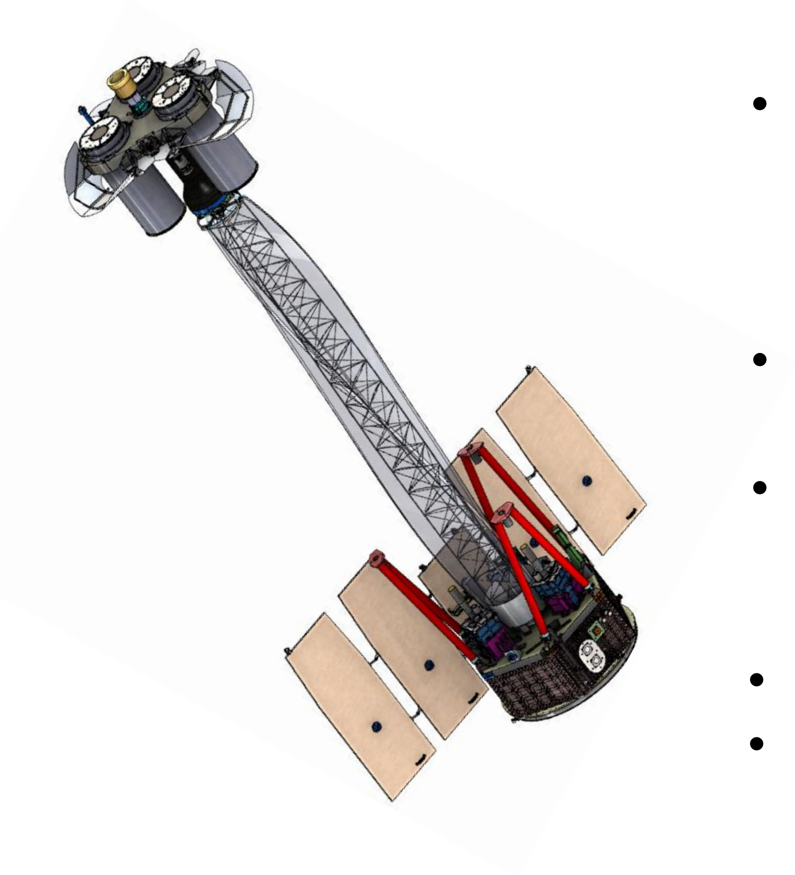
- 2016 – Completed Mission Concept review and began Phase A
- 2018 – Completed Mission Design review / System requirements Review and began Phase B
- 2019 – Completing Preliminary Design Reviews
- 2020 – Complete Confirmation Review and begin Phase C
- 2021 – Call for Core Surveys
- Mid-2020s – Launch

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

Science Program includes

- Dark energy and the fate of the universe through surveys measuring the expansion history of the universe and the growth of structure
- The full distribution of planets around stars through a microlensing survey
- 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

Imaging X-ray Polarimetry Explorer (IXPE)



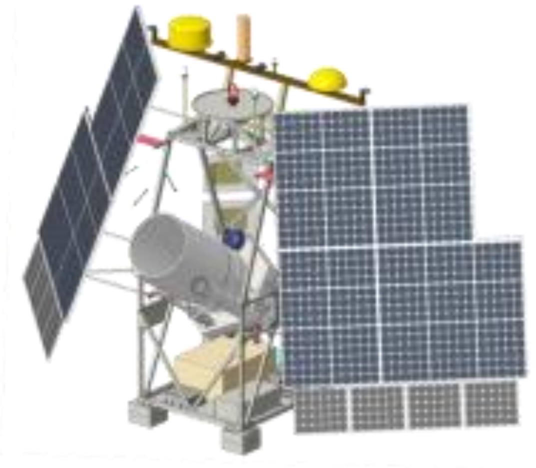
- IXPE Project successfully completed Critical Design Review (CDR) held on June 25-28 at Ball Aerospace.
- SpaceX Falcon 9 chosen as the launch vehicle for IXPE mission.
  - Falcon 9 launch from KSC (~28.5 degree latitude) will execute a major orbital plane change to IXPE science-required zero degree orbital inclination.
- Crit… engineering Modular Mirror Ass… ed at MSFC.
- Dev… units (DU) is ongoing, with the delivery of engineering DU in July 2019.
  - Delivery of first flight DU planned for December 2019
- Instrument and spacecraft integration beginning in Spring 2020
- Launch currently planned for April 2021

IXPE Update
By Martin Weisskopf
On Day 2 of this meeting

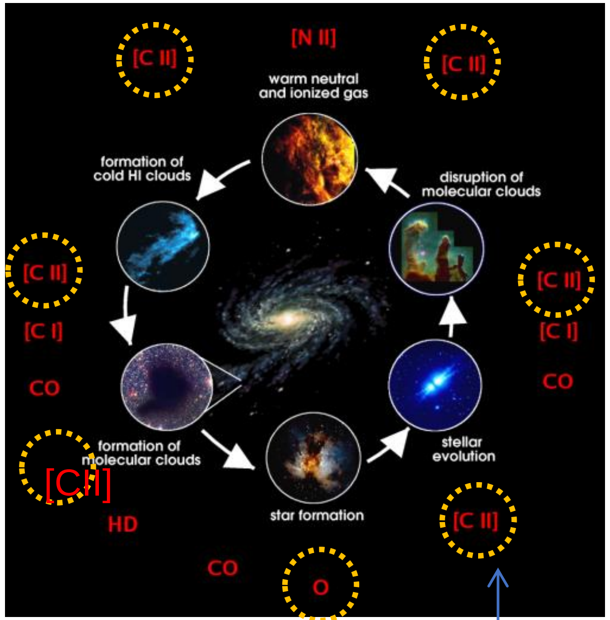
GUSTO Suborbital Explorer

GUSTO (Galactic/Extragalactic ULDB Spectroscopic Terahertz Observatory), led by PI Chris Walker (University of Arizona), is an Astrophysics Explorer (MO) balloon mission and is an advanced version of the STO-2 balloon payload.

GUSTO uses large-scale surveys & spectral diagnostics of the Interstellar Medium (ISM) to answer key questions about the full Life Cycle of the ISM and massive star formation.



GUSTO Payload



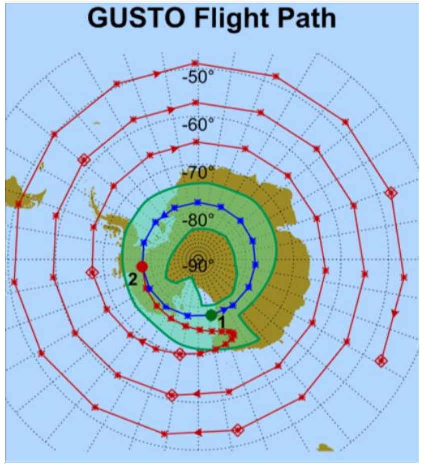
GUSTO Lines

Brightest Line in the Far-IR over cosmic times.

~300 dedicated SOFIA flights would be required to equal the GUSTO survey

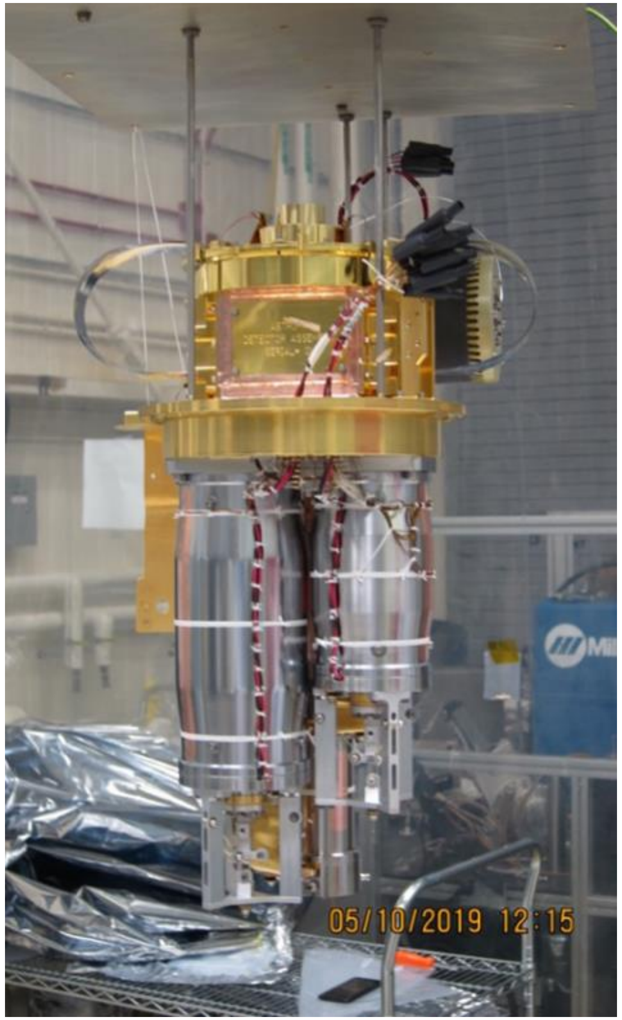
<u>Milestones:</u>

- ✓ Mission Preliminary Design Review: Nov 15, 2018
- ✓ Confirmation Review (KDP-C): Mar 12, 2019
- ✓ Mission Critical Design Review (CDR): Oct 2019
- Launch from McMurdo Station, Antarctica: Dec 2021



Flight Strategy, Launch (Dec 2021) from McMurdo on a superpressure balloon and allow payload to leave the continent. Instrument recovery preferred, but optional. Target survey duration 75 day, accept-able base-line 20 days, cryogenic for 100 days.

XRISM: X-ray Imaging and Spectroscopy Mission



- Resolve instrument currently integrated in test Dewar at GSFC, undergoing performance testing.
    - Pre-Ship Review completed Sep 18-19 at GSFC.
    - U.S.-built hardware to be delivered to JAXA in stages beginning November 2019.
- Preparations are in progress for the Mission Critical Design Review planned for December 2019 in Japan.

- XRISM science team meeting Oct 7-10 in Japan; continue process of target selection for Performance Verification phase of mission.
- Call for U.S. Performance Verification phase Participating Scientists anticipated in ROSES 2020.
- XRISM launch, by JAXA, currently planned for early 2022.

Euclid

Near Infrared Spectrometer and Photometer - fully populated focal plane includes NASA provided 16 (2K x 2K each) Sensor Chip Systems

Science Program Includes

- Dark Energy and Dark Matter
- Initial conditions of the Universe
- Conduct deep NIR survey to explore high redshift
- Relationship between dark matter and baryons

ESA led mission with NASA partnership

- Completed mission CDR in November 2018
- NASA completed all flight hardware Sensor Chip Systems deliveries in June 2019 for the NISP instrument focal plane
- Mission In Assembly, Integration and Test phase
- Mission Launch ~ June 2022

Science Participation

- U.S. Euclid Science teams integrated into Euclid Consortium science planning activities
- General U.S. science participation to be through archival data research after Euclid data products release

Spectro-Photometer for the History of the Universe Epoch of Reionization and Ices Explorer (SPHEREx)

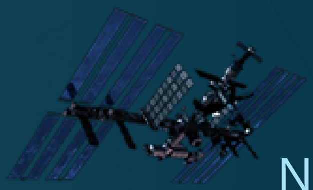
- Awarded: February 2019
- PI: James Bock (Caltech)

- Currently in Phase B
- PDR ~April 2020
- Confirmation ~June 2020
- Launch in 2023
- Prime Mission is 2 Years
- Archival research program will be enabled during prime mission

Science Highlights include:

- Survey the entire sky every 6 months
- Optical and infrared survey mission (96 bands/pixel)
- Observe hundreds of millions of galaxies
  - Measure redshifts to probe the statistical distribution of inflationary ripples
  - Measure spatial fluctuations in the Extragalactic Background Light to support studies of the origin and history of galaxy formation.
- Survey Galactic Molecular Clouds for water and organic molecules (H_2O, CO, CO_2, CH_3OH)

Astrophysics Explorers Program



4 AOs per decade

ANNOUNCEMENT OF OPPORTUNITY
EXPLORER 2011

MIDEX 2011

Announcement of Opportunity
Astrophysics Explorers Program
2014 Small Explorer (SMEX)

SMEX 2014

Announcement of Opportunity
Astrophysics Explorers Program
2016 Medium Explorer (MIDEX)

MIDEX 2016

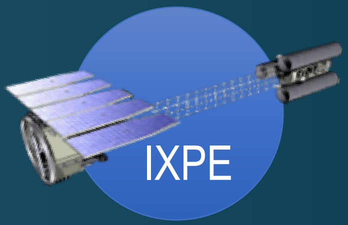
Proposals received August 1

SMEX 2019

Announcement of Opportunity
Astrophysics Explorers Program
2016 Medium Explorer (MIDEX)

MIDEX 2021

Small and Mid-Size Missions



Missions of Opportunity

MO TBD

Explorers Mission of Opportunity AO includes new opportunities:

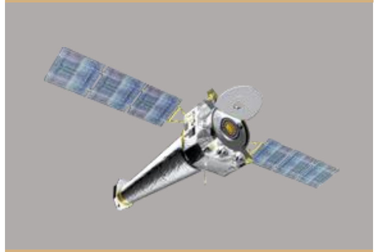
- NASA-provided RideShare
- SmallSat Secondary Payloads
- Opportunities enabled by the Artemis Program

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

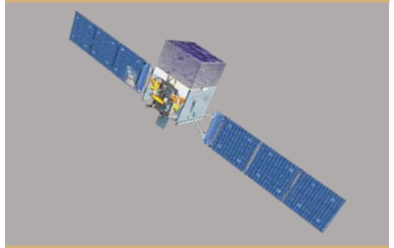
Mission ending Jan 31, 2020

Spitzer Space Telescope

Gehrels Swift — 11/04
NASA MIDEX Mission

Neil Gehrels Swift Gamma-ray Burst Explorer

Fermi — 6/08
NASA Strategic Mission

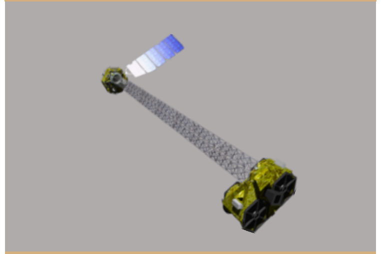


Fermi Gamma-ray Space Telescope

Kepler — 3/09
NASA Discovery Mission

Mission Complete!

NuSTAR — 6/12
NASA SMEX Mission

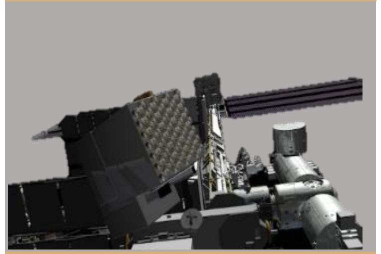


Nuclear Spectroscopic Telescope Array

SOFIA — 5/14
NASA Strategic Mission

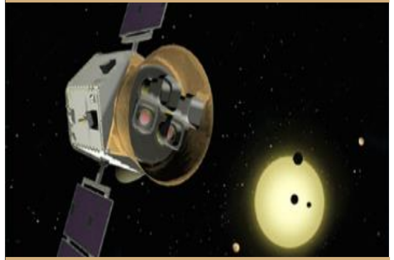
Stratospheric Observatory for Infrared Astronomy

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

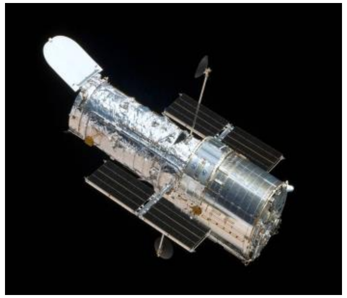


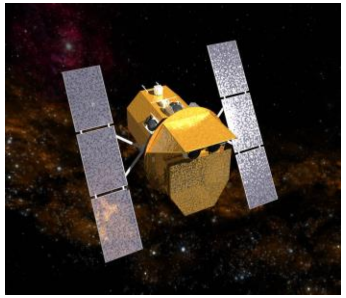
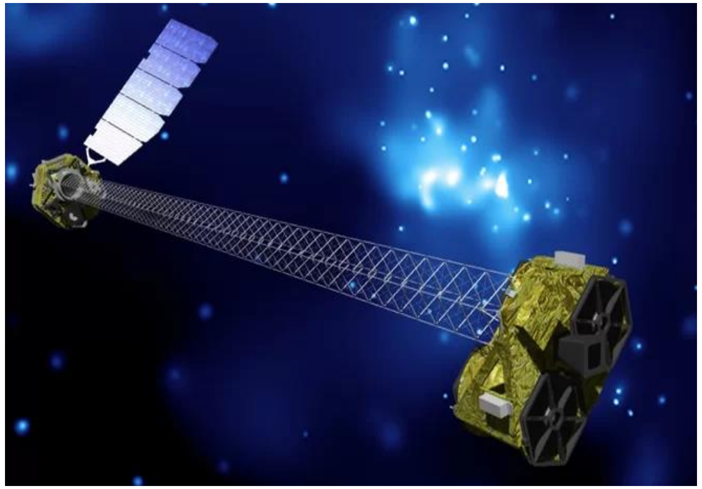
Neutron Star Interior Composition Explorer

TESS — 4/18
NASA MIDEX Mission



Transiting Exoplanet Survey Satellite



Senior Review 2019

- Hubble — No change to budget guideline
- Chandra — Selected overguides: Audit fees, labor & GO (inflation)
- TESS — Extended mission w/ full funding & continued GO program
- Swift — Selected overguides: New tools for Targets of Opportunity (TOO) and Ultraviolet-Optical Telescope (UVOT)
- Fermi — Ops w/out Department of Energy (DOE)
- NICER — Extended mission w/ reduced ops & new GO program
- NuSTAR — Phase out legacy science for GO science
- XMM-Newton — No change

Not in Senior Review: Kepler, SOFIA, Spitzer

SOFIA

Stratospheric Observatory for Infrared Astronomy

- SOFIA's 5-year prime mission will be completed at the end of FY19
- Given that the program has finished 5 years of operations, NASA has conducted two reviews of the SOFIA project to make changes directed at increasing the science productivity of SOFIA in FY20 and beyond
  - Review of SOFIA's maintenance and operations paradigm
  - Review of SOFIA's science progress and science prospects
- Based on the reviews, NASA will I
  SOFIA project to improve SOFIA's
  responsiveness to community scie
  - Complete transition of SOFIA
    more productive science operations mode
  - SOFIA will fly more frequently to obtain more science hours
  - SOFIA will primarily fly shorter (~8 hour) flights to immediately get to higher altitudes
- HIRMES, the next SOFIA science instrument, continues development
  - Expected delivery date is Dec 2020

SOFIA Update
By Kartik Sheth / Naseem Rangwala / Harold Yorke
On Day 1 of this meeting

Summary of reviews and NASA response posted at: https://science.nasa.gov/astrophysics/documents

Status of the Decadal Survey

First public meeting of Decadal Survey Steering Committee occurred on Jul 15-16 @ WDC

Decadal survey has established 13 Panels to review white papers and provide findings/recommendations to the Steering Committee

Science Panels

- Cosmology – Daniel Eisenstein (date TBD)
- Galaxies - Daniela Calzetti (Oct 15-17)
- Interstellar Medium and Star and Planet Formation – Lee Hartmann (date TBD)
- Stars, the Sun, and Stellar Populations – Sarbani Basu (Oct 8-10)
- Compact Objects and Ene ... ct 15-17)
- Exoplanets, Astrobiology, a ... ct 21-23)

Astro2020 Update
By Fiona Harrison / Rob Kennicut
On Day 2 of this meeting

Program Panels

- Electromagnetic Observations from Space 1 – Marcia Rieke (Nov 19-21 @ Irvine CA)
- Electromagnetic Observations from Space 2 – Steven Kahn (Nov 5-7)
- Optical and Infrared Observations from the Ground – Timothy Heckman (Oct 29-31)
- Radio, Millimeter, and Submillimeter Observations from the Ground – Andrew Baker (Nov 4-6)
- Particle Astrophysics and Gravitation – John Beacom & Laura Cadonati (date TBD)
- An Enabling Foundation for Research – David Spergel (Oct 22-24)

State of the Profession Panel

- State of the Profession and Societal Impacts – Margaret Hanson & Enrico Ramirez-Ruiz (Nov 20-22)

Second public meeting of Decadal Survey Steering Committee is Dec 9-11 @ Irvine CA

https://sites.nationalacademies.org/DEPS/astro2020/

+ SMEX/MO (2025), MIDEX/MO (2028), etc.
Spitzer 8/25/2003
Formulation
Implementation
Primary Ops
Extended Ops
WFIRST Mid 2020s
Euclid (ESA) 2022
SXG 7/13/2019
Webb 2021
Chandra 7/23/1999
XMM-Newton (ESA) 12/10/1999
TESS 4/18/2018
NuSTAR 6/13/2012
Fermi 6/11/2008
IXPE 2021
Swift 11/20/2004
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 August 1, 2019