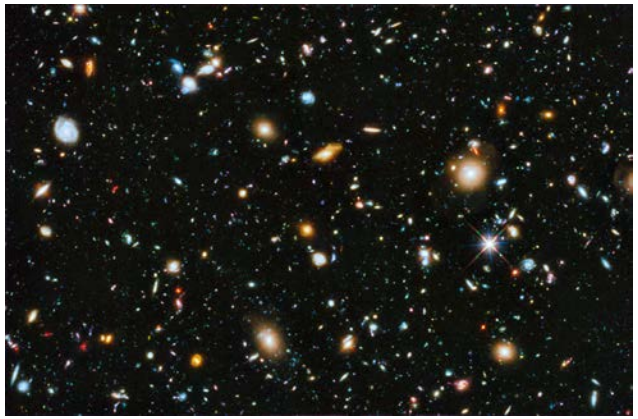
National Aeronautics and Space Administration

NASA

ASTROPHYSICS

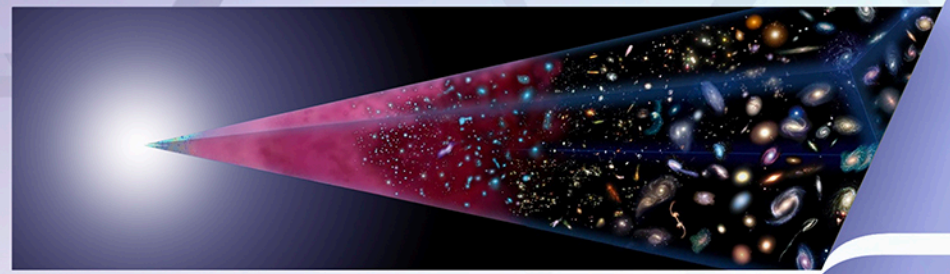
NASA Astrophysics Update

Astrophysics Advisory Committee
July 23-24, 2018
Washington, DC

Paul Hertz

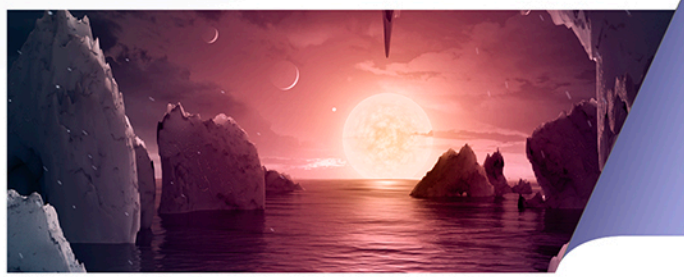
Director, Astrophysics Division
Science Mission Directorate
@PHertzNASA

Why Astrophysics?



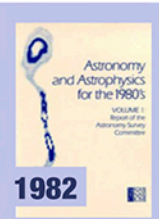
How did our universe begin and evolve?

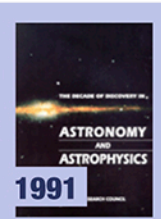
How did galaxies, stars, and planets come to be?



Are we alone?

Enduring National Strategic Drivers

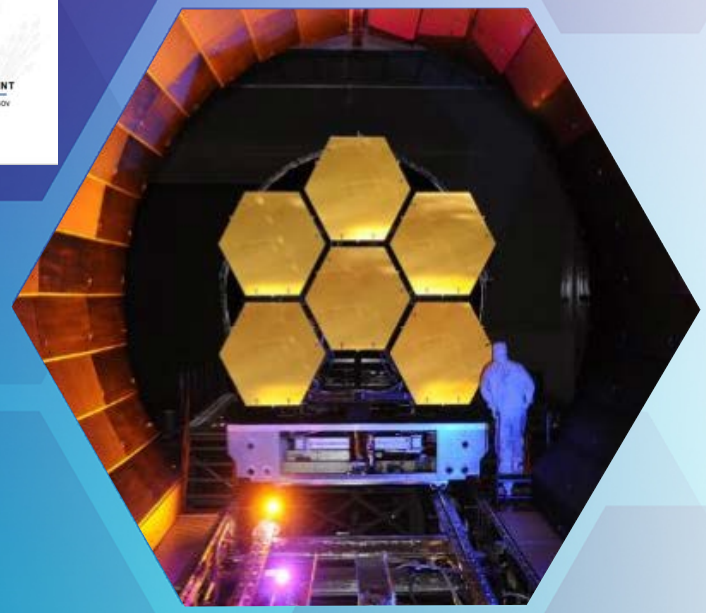




Astrophysics is humankind's scientific endeavor to understand the universe and our place in it.

NASA is seeking an Astrophysics Program Scientist

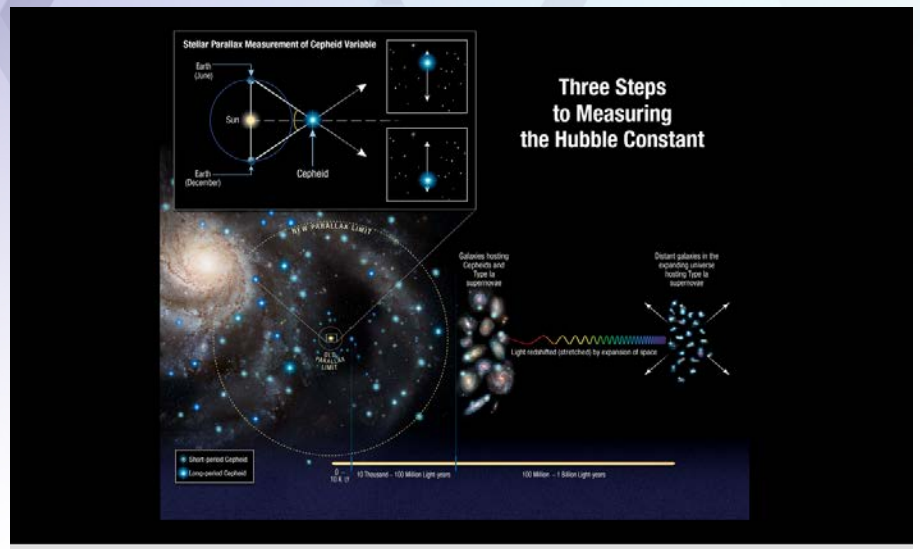
- Astrophysicist to join NASA HQ team that manages execution of astrophysics missions, research, and strategic planning
- Applications will be accepted only through USAJobs.gov
  - Interested scientists should familiarize themselves with USAJobs.gov and begin to develop their resumé within the USAJobs.gov system
- NASA will announce when position is open through Astrophysics program mailing lists (COR, EXEP, PCOS)
  - Alternatively, interested potential applicants can create an alert in USAJobs.gov

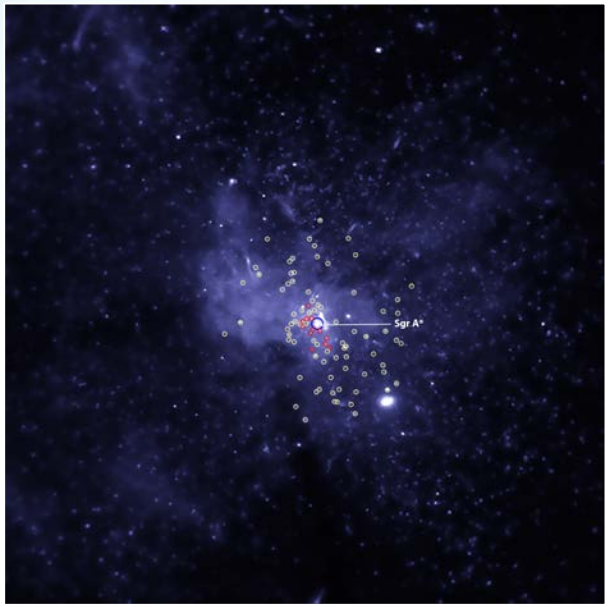


Outline

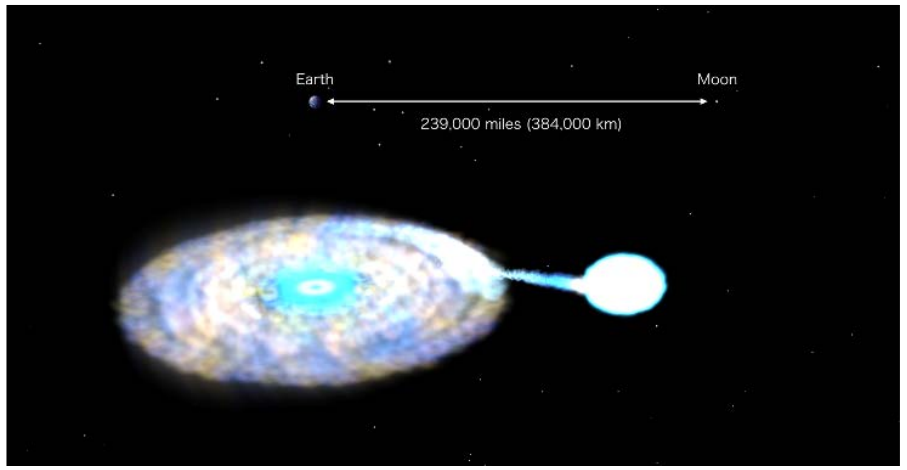
- Program and Budget Update
  - Astrophysics Program Overview
  - Major Accomplishments
  - Budget Update
- Missions Update
  - TESS
  - Webb
  - WFIRST
  - Explorers
  - SmallSats
  - Operating Missions & Senior Review
- Planning for Astro2020
  - Decadal Survey Timing
  - Decadal Survey Planning
- Response to April 2018 APAC Recommendations

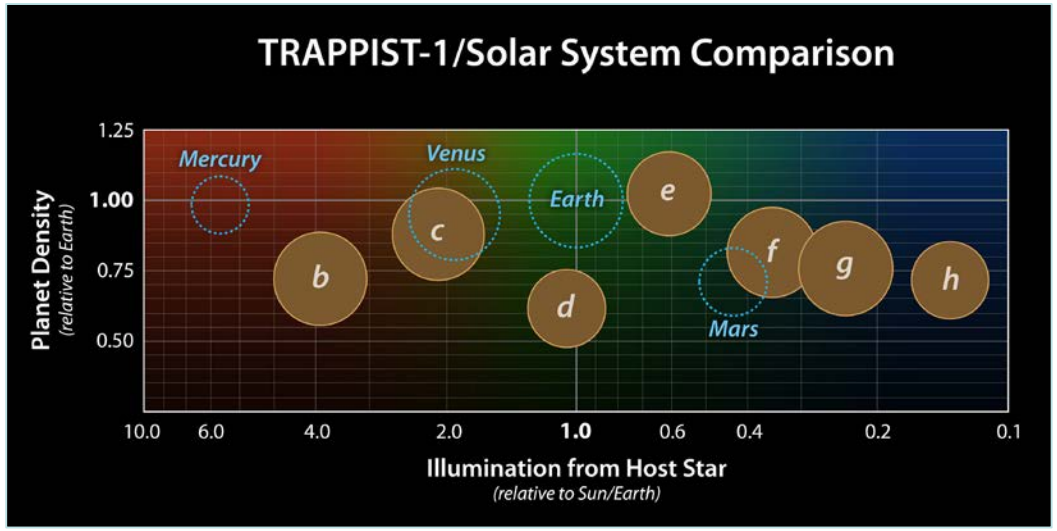
Some NASA Science Stories of 2018



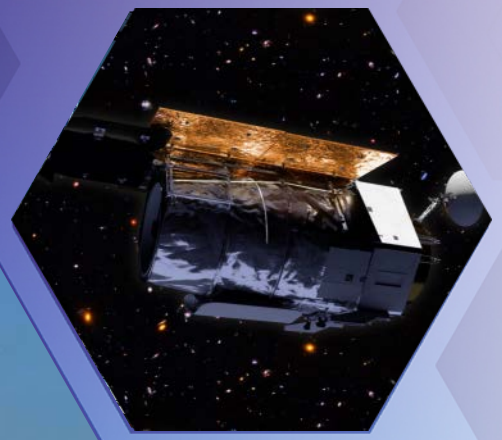


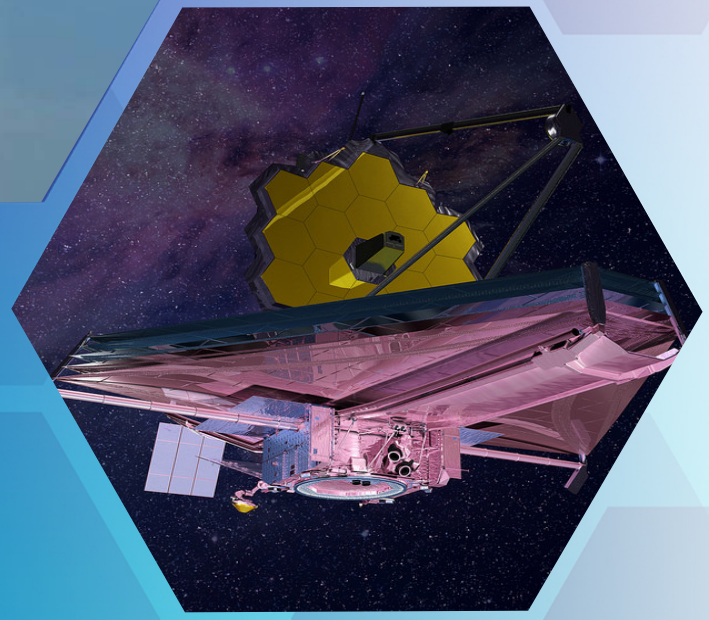
UL:
https://www.nasa.gov/feature/goddard/2018/improved-hubble-yardstick-gives-fresh-evidence-for-new-physics-in-the-universe
UR:
https://www.nasa.gov/mission_pages/chandra/images/black-hole-bounty-captured-in-the-milky-way-center
LL:
https://www.nasa.gov/feature/goddard/2018/nasa-s-nicer-mission-finds-an-x-ray-pulsar-in-a-record-fast-orbit
LR:
https://www.nasa.gov/feature/jpl/new-clues-to-trappist-1-planet-compositions-atmospheres





NASA Astrophysics
Program and Budget Update





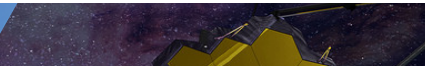
NASA’s Astrophysics Program

- Strategic Missions
  - Flagships and Probes led by NASA
  - Contributions to Partner-led Missions
- PI-led (competed) Missions
  - Explorers led by NASA
  - Contributions to Partner-led Missions
- Supporting Research and Technology
  - Research and Analysis
  - Technology Development
  - Suborbital Investigations (Balloons, Sounding Rockets)
  - CubeSats and ISS-attached Investigations
- Infrastructure and Management
  - Data Archives
  - Mission Studies

NASA's Astrophysics Program

Operating: Hubble, Chandra, XMM-Newton*, Spitzer, Fermi, Kepler, SOFIA
Developing: Webb, XRISM*, Euclid*, WFIRST

Operating: Gehrels Swift, NuSTAR, NICER, TESS
Developing: IXPE, GUSTO



Phase A Study MIDEX: Arcus, SPHEREx
Phase A Study MO: ARIEL*, COSI-X, ISS-TAO
Pre-Phase A Study: Athena*, LISA*
Decadal Survey Study: HabEx, LUVOIR, Lynx, OST

* Contribution to Partner-led Mission

- Strategic Missions
  - Flagships and Probes led by NASA
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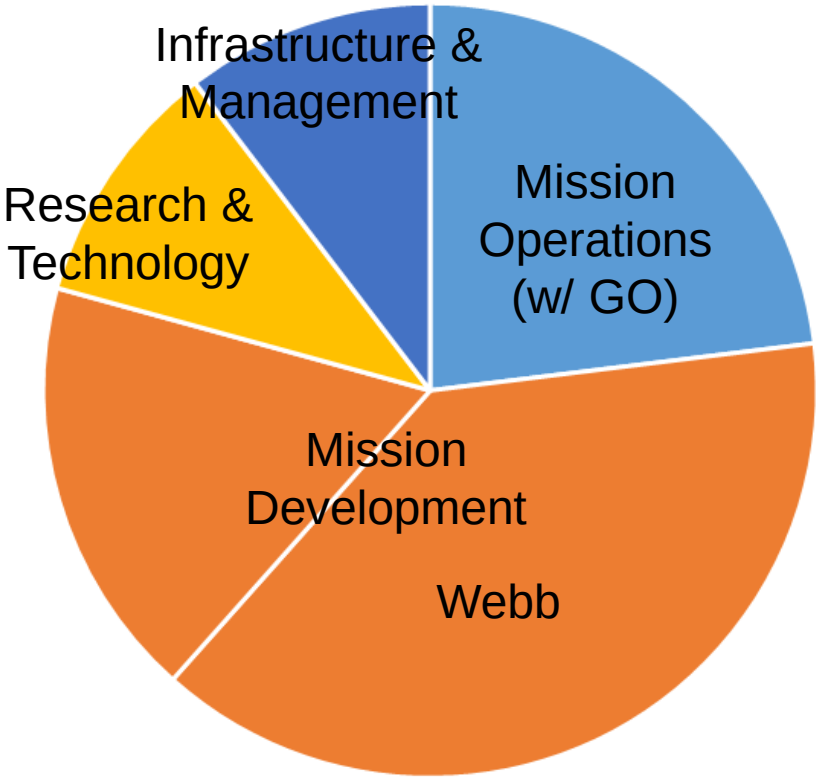
NASA's Astrophysics Program



FY 2018 Budget: $1.38B

- Strategic Missions
  - Flagships and Probes led by NASA
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- PI-led (competed) Missions
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  - Research and Analysis
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  - Suborbital Investigations (Balloons, Sounding Rockets)
  - CubeSats and ISS-attached Investigations
- Infrastructure and Management
  - Data Archives
  - Mission Studies

Major Accomplishments: April – July 2018

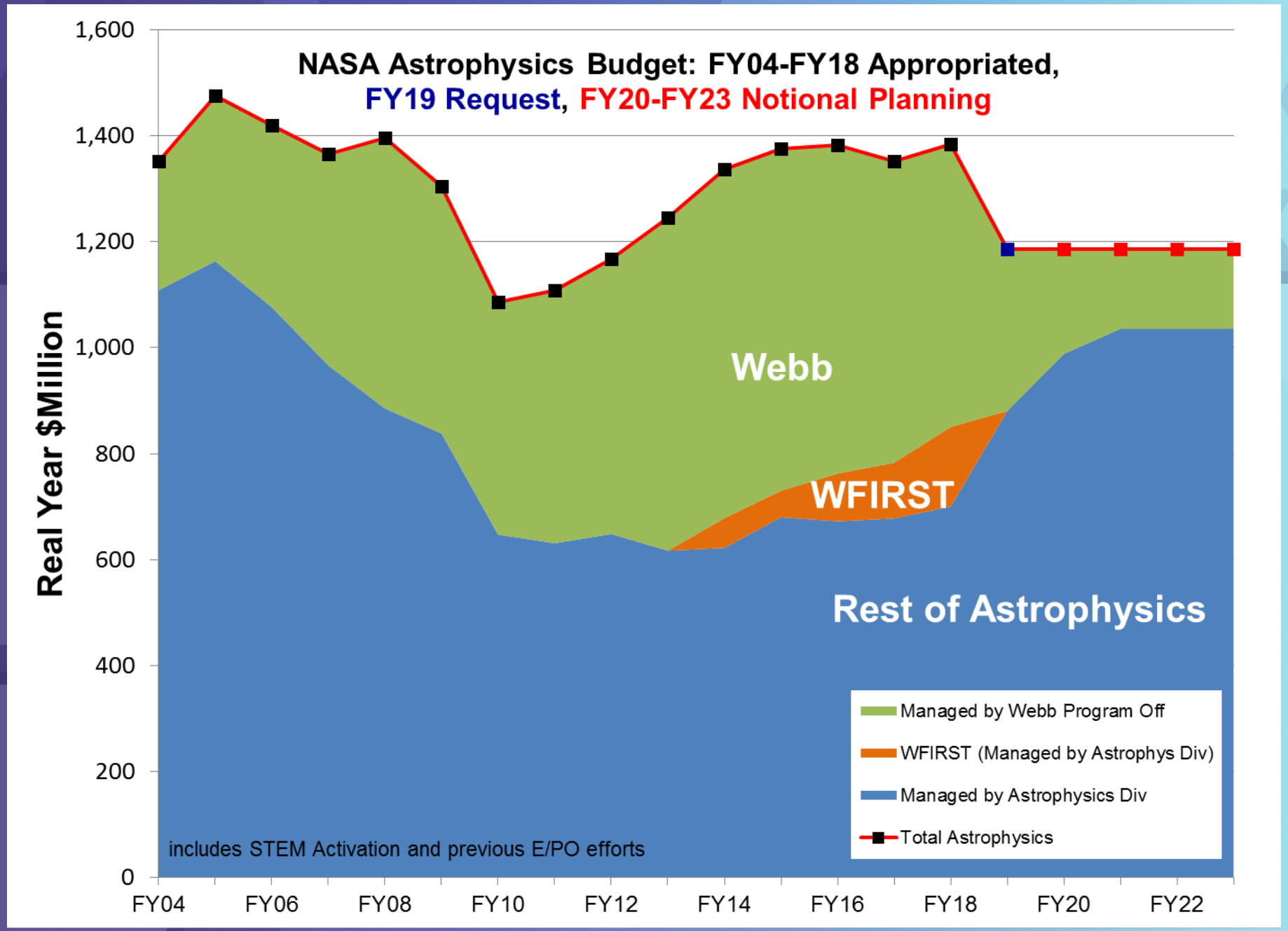
- Transiting Exoplanet Survey Satellite (TESS) launched April 2018 and is now in commissioning
- SOFIA returned to science operations following extended maintenance period May 2018
- GUSTO completed System Requirements Review May 2018
- WFIRST passed KDP-B May 2018 and began preliminary design phase (Phase B); funds appropriated by Congress in FY18 allowed WFIRST to begin Phase B
- Palestine balloon campaign conducted by flying two missions (SuperBIT, ASCOT) May-July 2018
- Sweden balloon campaign conducted by flying three missions (AESOP-lite, HiWIND, PMC Turbo) May-July 2018
- First NASA astrophysics CUbeSat (HaloSat) launched May 2018, deployed July 2018
- IXPE completed Preliminary Design Review June 2018
- NASA submitted Webb replan cost and schedule report to Congress based on results of WIRB report June 2018

Planned Accomplishments July 2018 – June 2019

- TESS will complete commissioning, will conduct a Post Launch Assessment Review, and will enter Phase E July 2018
- Ft. Sumner balloon campaign will be conducted August-October 2018
- IXPE has completed preliminary design review and will enter Phase C September 2018
- Euclid sensor chip electronics (SCE) recovery plan is underway and replan will be approved September 2018
- Antarctic balloon campaign will be conducted December 2018 – February 2019
- Next Astrophysics MIDEX and Mission of Opportunity will be downselected January 2019
- Astrophysics Decadal Survey will begin January 2019
- Astrophysics Senior Review will be conducted Spring 2019
- Next Astrophysics SMEX and Mission of Opportunity AO will be released in Spring 2019
- Large Mission Concept Studies will be submitted Summer 2019

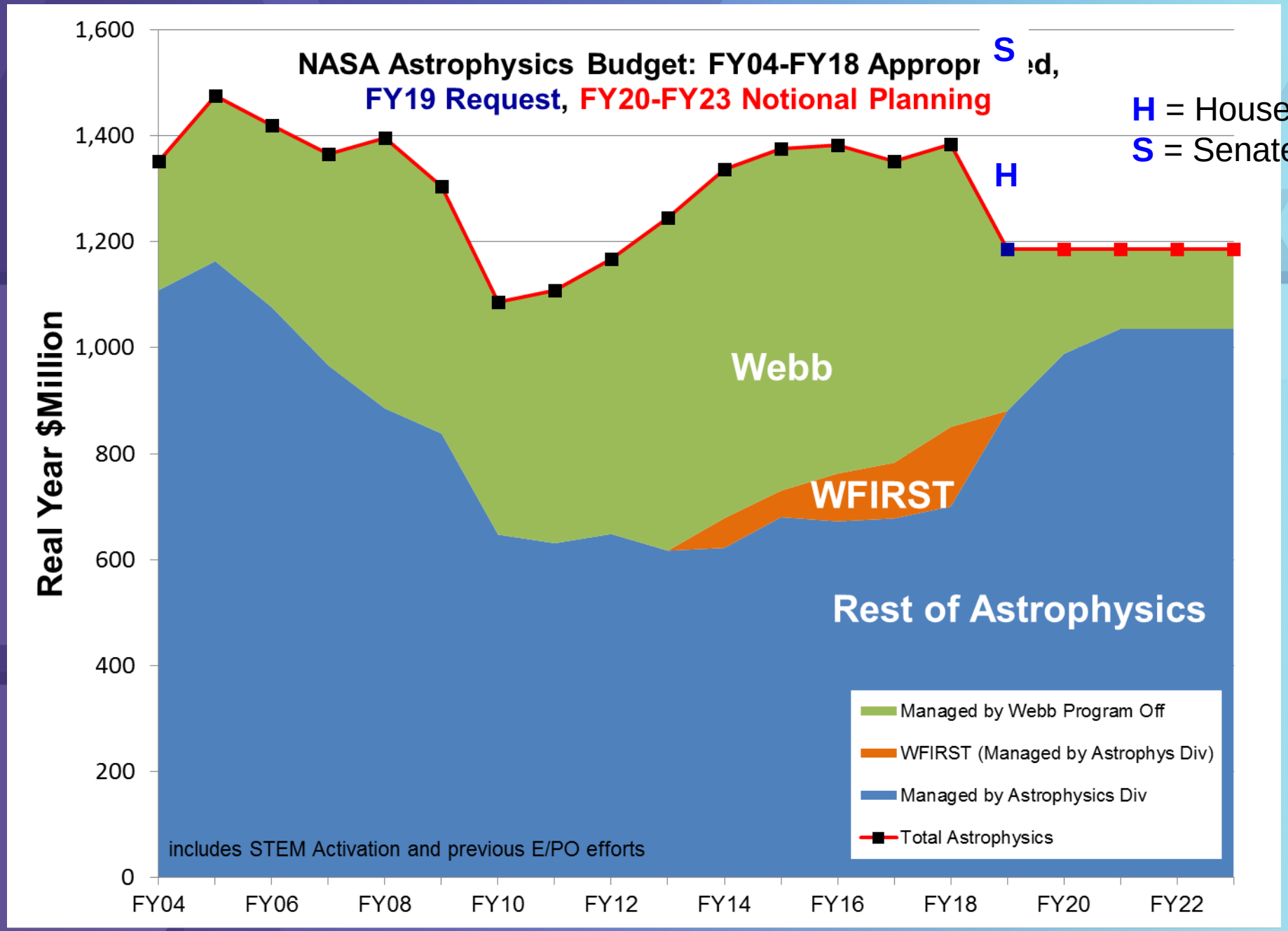
Astrophysics Budget Overview

- The FY18 consolidated appropriation provides funding for NASA Astrophysics to continue its planned programs, missions, projects, research, and technology.
  - Total funding provided for FY18 (Astrophysics including Webb) rises from $1.352B in FY17 to $1.384B in FY18, an increase of ~$32M (2.4%) from FY17.
  - The NASA Astrophysics FY18 appropriation funds Webb for progress toward launch, WFIRST formulation into Phase B, Explorers mission development and SMEX AO, increased funding for R&A, continued operating missions, suborbital missions and CubeSats, technology development, and mission studies.
  - $10M (2.2%) reduction in rest of Astrophysics to accommodate directed spending increases for WFIRST, Hubble, and SOFIA.
  - FY18 Op Plan not yet approved.
- 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 Astrophysics Budget: FY04-FY18 Appropriated,
FY19 Request, FY20-FY23 Notional Planning
Real Year $Million
1,600
1,400
1,200
1,000
800
600
400
200
0
FY04
FY06
FY08
FY10
FY12
FY14
FY16
FY18
FY20
FY22
Webb
WFIRST
Rest of Astrophysics
includes STEM Activation and previous E/PO efforts
Managed by Webb Program Off
WFIRST (Managed by Astrophys Div)
Managed by Astrophysics Div
Total Astrophysics

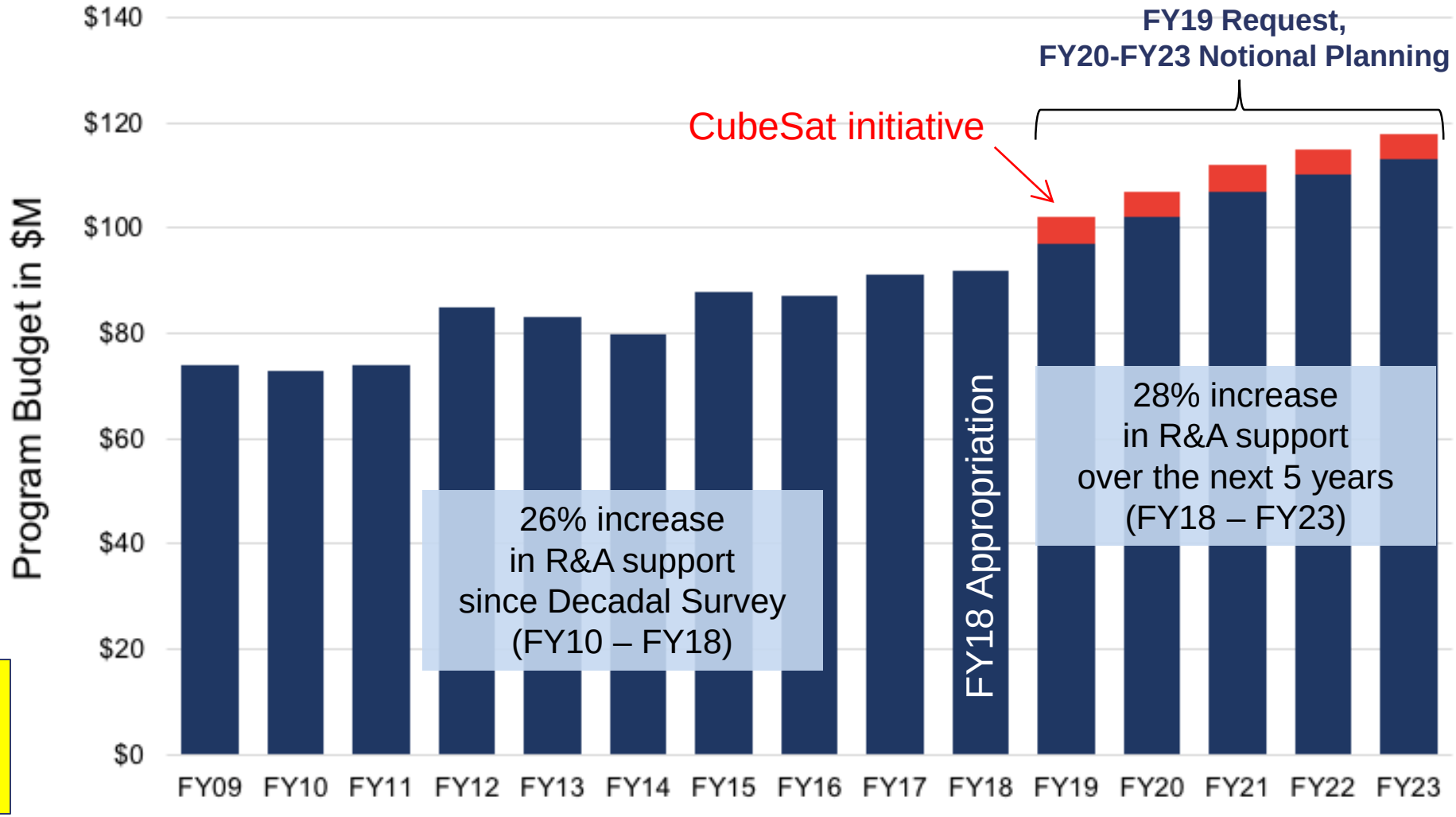
Astrophysics Budget – FY19 Appropriations

($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%)


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

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



R&A Update
Stefan Immler
Tuesday

NASA Astrophysics
Missions Update

Astrophysics Missions in Development

TESS — 4/2018
NASA Mission

Transiting Exoplanet Survey Satellite

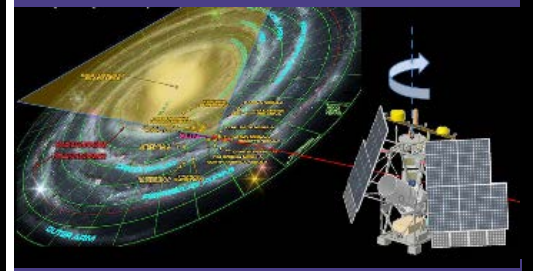
Webb — 2021
NASA Mission

James Webb Space Telescope

IXPE — 2021
NASA Mission

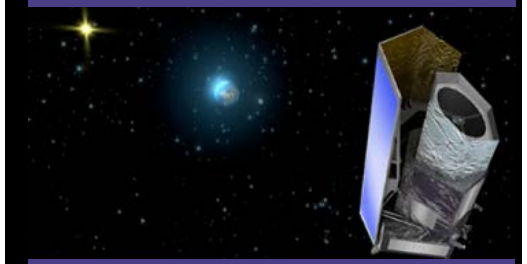
Imaging X-ray Polarimetry Explorer

GUSTO — 2021
NASA Mission



Galactic/ Extragalactic ULDB Spectroscopic Terahertz Observatory

Euclid — 2022
ESA-led Mission



NASA is supplying the NISP Sensor Chip System (SCS)

XRISM/XARM — 2022
JAXA-led Mission

NASA is supplying the SXS Detectors, ADRs, and SXTs

MIDEX/MO — 2022/ 2023
NASA Mission

Arcus or SPHEREx
ARIEL, COSI-X, or ISS-TAO

WFIRST — Mid 2020s
NASA Mission

Wide-Field Infrared Survey Telescope

TESS

Transiting Exoplanet
Survey Satellite

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

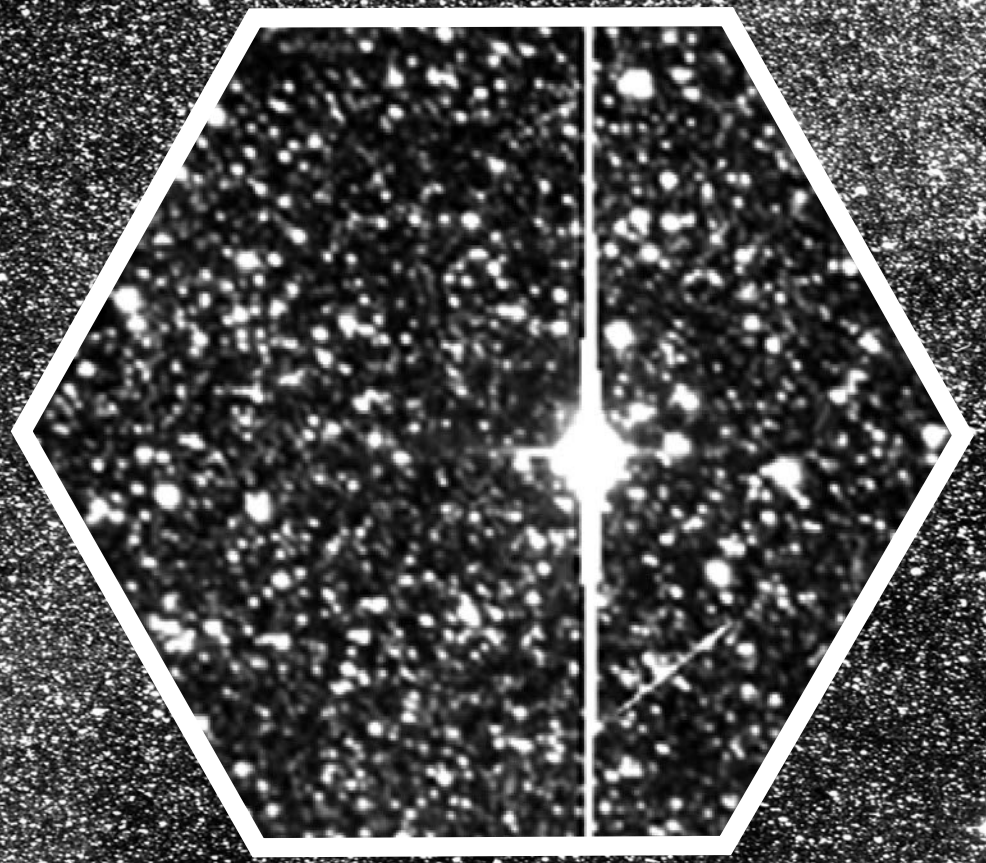
TESS

Transiting Exoplanet Survey Satellite

Launched April 18, 2018

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

TESS 2-sec coarse-point test image



TESS Follow-up Program

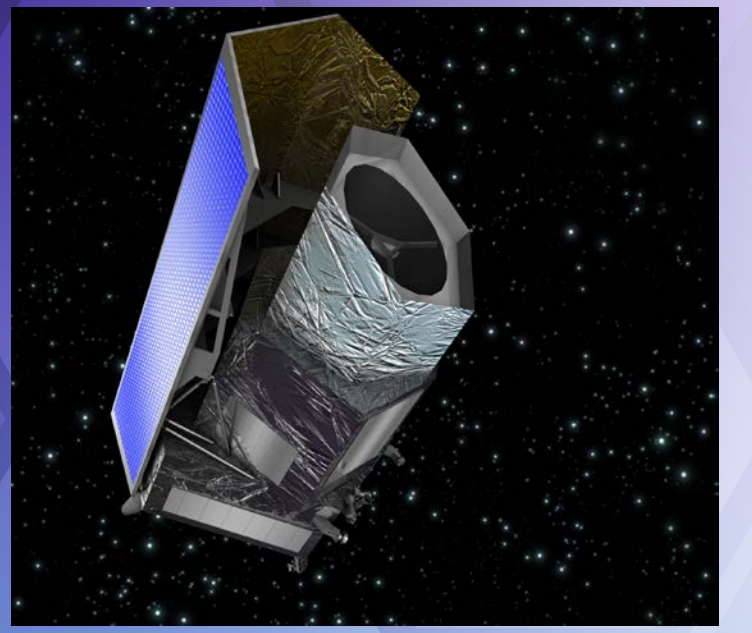
- Ground-based follow-up program required for
  - Confirmation of exoplanet candidates
  - False-positive identification
  - Host star characterization
  - Planet mass determination

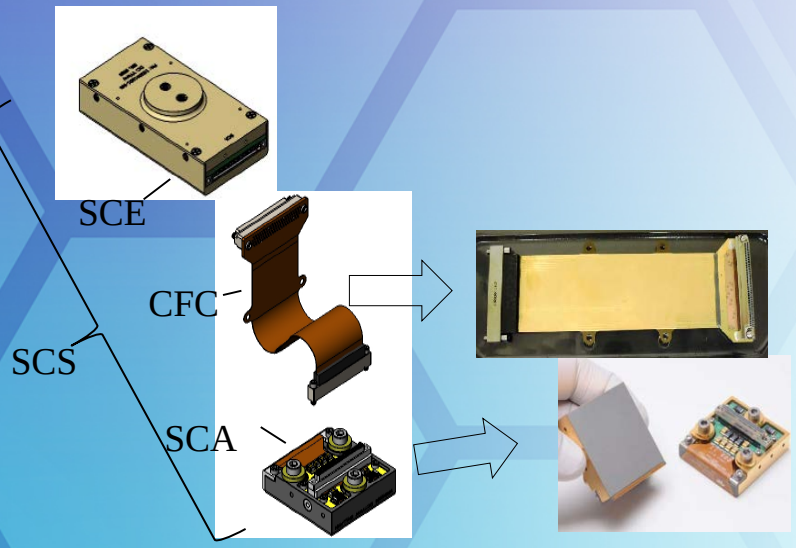
- Space-based follow-up program required for
  - Atmosphere detection
  - Molecule detection and atmosphere characterization for planets down to super-Earth sizes (Webb)

TESS Guest Investigator Program

- The TESS GI program will maximize the science return from the TESS mission, for exoplanet discovery, and many other areas of astrophysics
- TESS Cycle 1 (southern ecliptic hemisphere) GI investigations have been selected
  - Cycle 1 projects cover asteroids, stellar oscillations, flares, exoplanet studies, compact objects, blazars, and more
  - More than 140 proposals received, requesting ~100,000 targets
- There are opportunities for synergy with all of NASA's operating missions
- Cycle 2 (northern ecliptic hemisphere) proposals will be due December 2018

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

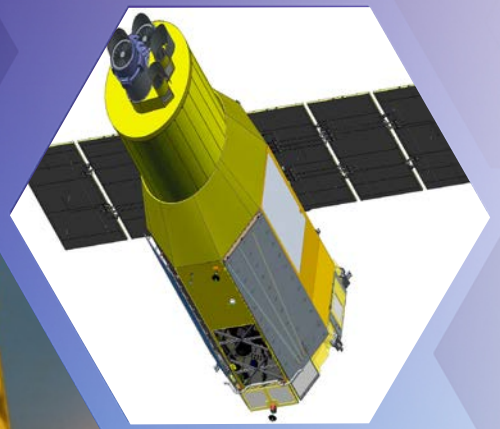


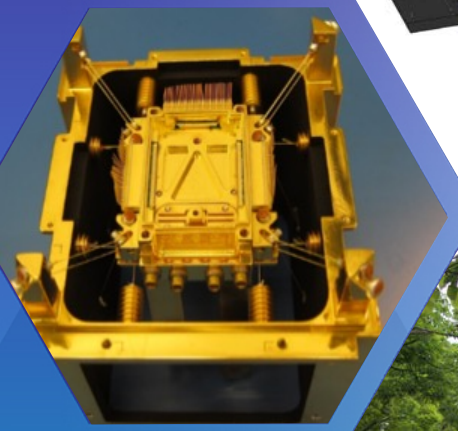


Sensor Chip Assembly (SCA)
Cryo-Flexi Cable (CFC)
Sensor Chip Electronics (SCE)

Euclid

- ESA led dark energy mission with NASA contributions
  - Launch date 2022
- NASA providing
  - 20 Characterized NIR Sensor Chip Systems
  - ~70 U.S. members of Euclid Consortium
  - Euclid NASA Science Center at IPAC
- NASA delivered 20 detectors and cryo-flex cables to ESA
  - Detectors presently under characterization testing in Europe
- NASA is now manufacturing and testing the redesigned sensor chip electronics (readout boards)
  - Engineering models currently in thermal testing
  - 20 SCEs will be delivered to ESA by March 2020



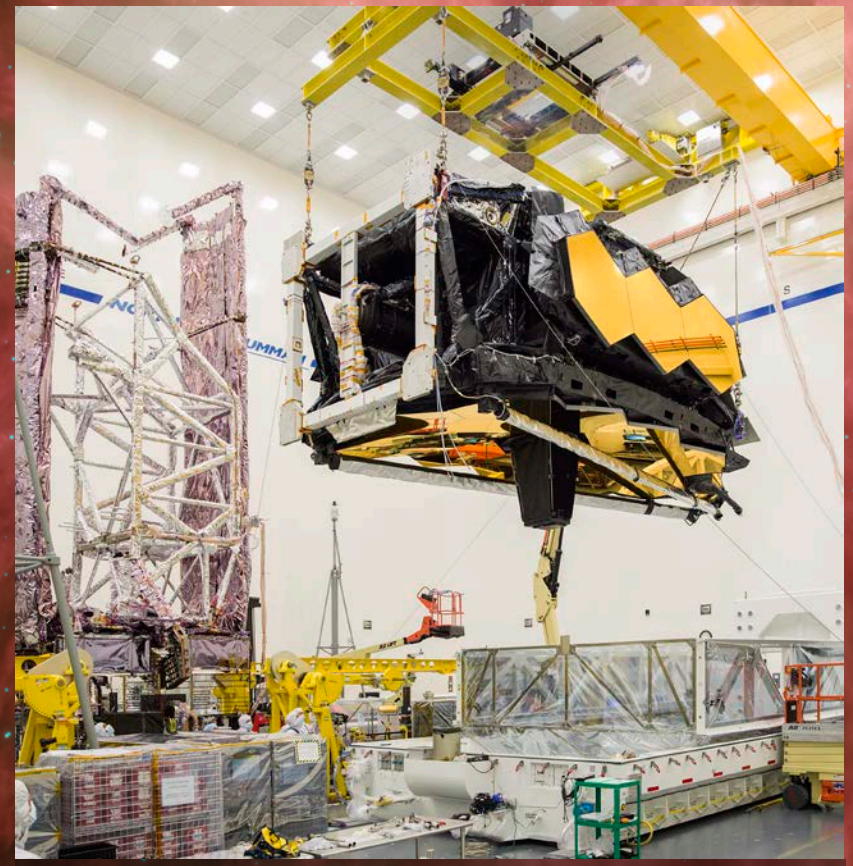


X-ray Imaging and Spectroscopy Mission (XRISM) – formerly XARM

- Name change at JAXA Project Initiation July 2018
- NASA contributing Resolve microcalorimeter and X-ray Mirror Assembly – in Phase C since January 2018
- Canadian Space Agency (CSA) joined NASA team in April 2018 – contributing calibration light source
- Science Team kickoff in Japan May 2018 including NASA Participating Scientists – 5 selected February 2018
- Resolve delivery October 2019 – GSFC team half-way through hardware build
- Launch Readiness Date January 2022
- U.S. Community Involvement
  - U.S. Scientists on Guaranteed Time Observing (GTO) Target Teams: to be selected approx. 1 year before launch
  - General Observing (GO) Program: Open to U.S. scientists starting 6-9 months after launch

Webb

The James Webb Space Telescope



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

Webb Update
Eric Smith
Monday

Summary of IRB Report and Response

- NASA received report from the Standing Review Board (SRB) and the Independent Review Board (IRB).
- Webb science is world class and compelling.
- Mission success is the driving consideration going forward.
- Technical complexities have greatly impacted the development schedule.
  - First of a kind developments.
  - Avoidable technical errors, especially human errors and embedded problems.
- NASA focused on schedule and recommendations for mission success.
- NASA accepts the IRB recommendations.
- NASA & NGAS have initiated process controls and corrective actions to address the IRB recommendations.
- Revised schedule and cost reflect a 80% confidence level; consistent with SRB/IRB.
  - Conservative in accounting for unplanned inefficiencies.
  - UFE may be applied to unknown-unknown issues.
- Proposed total lifecycle budget is within IRB estimation of $1B additional cost.
  - $828M proposed NOA needed + $202M existing UFE = $1.03B.
- The congressionally mandated $8B development cost cap is exceeded by $803M.

Webb Baseline Cost Commitment

- Independent Review Board (IRB) estimates ~$1B additional cost to complete development
  - This is an estimate using a 29-month launch delay at the current burn rate of ~$35M per month through launch and commissioning
  - A detailed estimate by the project agrees with the IRB estimate; the project estimate includes planned work efforts at NGAS/STScI/GSFC, funded unliened schedule reserve, enhancements for mission success, and conservative cost reserves at all levels (NGAS, GSFC/project, HQ/program)
  - Approximately $200M of unexpended reserves offsets this requirement, so additional budget needed to complete Webb development is ~$800M
  - The new baseline cost commitment includes an inflationary adjustment for operations (Phase E) over the 5-year prime mission lifetime

	Prior Baseline	New Baseline	Change
Development	$7.998 B	$8.803 B	+ $805 M
Total Life Cycle Cost	$8.835 B	$9.663 B	+ $828 M
Launch Date	October 2018	March 2021	+ 29 months

Webb Replan Cost

- The new launch date is March 30, 2021 and the new development cost is $8.803B
  - The increased in development cost is $803M through commissioning (September 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 R&A and Explorers Program
- NASA believes that the anticipated cost growth on Webb is likely to impact other science missions

WFIRST

Wide Field Infrared Survey Telescope

Primary mirror assembly / Harris Corporation

WFIRST Update
Jeff Kruk
Monday

WFIRST Update

- Conducted WFIRST Independent External Technical/Cost/Management Review (WIETR) in response to National Academies' Midterm Assessment
- WFIRST directed by SMD AA in November 2017 to reduce cost and complexity sufficient to have a cost estimate consistent with $3.2B cost target set at Phase A beginning
  - Coronagraph is technology demonstration instrument
  - Independent cost assessment validated estimated cost of rescoped mission, consistent with $3.2B cost target
- WFIRST passed SRR/MDR, approved in May 2018 to enter Phase B (preliminary design phase)

WFIRST Update (2)

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

Comparison of Webb and WFIRST Development Risk at KDP-B

Webb @ KDP-B	WFIRST @ KDP-B
Novel, complex segmented Be mirror development	Existing 2.4m monolithic ULE mirror
Numerous technology developments	High TRL: basis of Decadal selection, recent investments
Complex cryo-cooler	Passive Al radiator
ISIM structure materials development (30 K)	Reuse of Webb design in instrument carrier (190K)
IR detector manufacturing problem uncovered after KDP-C	IR detectors presently at TRL-6, flight growth initiated at start of Phase B; Greater maturity and understanding of Webb-derived detector technologies reduces risk of encountering problems late in the WFIRST program
Four highly configurable instruments (inherent complexity), major international roles, separate guider	Single primary instrument + tech demo, no separate guider
Many complex deployments	Standard deployments

WFIRST risks are lower than those retired on Webb, and typical of high TRL missions. Incorporated numerous Webb lessons learned.

WFIRST Surveys and Community Access

- Unlike all prior flagship missions, WFIRST is a survey telescope; the core surveys encompass a large amount of time and will be broadly useful to the wider community.
- NASA working with WFIRST FSWG to explore mechanisms to solicit and facilitate community engagement. Current status quo:
  - All WFIRST data will be immediately public (no propriety period).
  - There will be a call for new WFIRST Science Teams around September 2021.
  - Mission capabilities are being designed to enable notional surveys addressing three key science pillars (Dark Energy, Exoplanets, Great Observatory Astrophysics).
  - Final allocation of WFIRST observing time will be decided through open-access, nonproprietary, peer-reviewed competition of programs addressing scientific imperatives.
  - Observing time will be allocated as close to the mission time as is reasonable (balancing the evolving scientific landscape with the need to plan large surveys in advance).
- Ideas being discussed for facilitating community input:
  - Investigate alternate ways of gathering and incorporating community input to the primary survey teams.
  - Create community science working groups for ancillary survey science beyond the three pillars.
  - Establish openly-competed “Early Release Demonstration Programs” performed at start of operations to inform the time allocation process during the prime mission.

Astrophysics Program Offices

Astrophysics Division

Flight Programs

Astrophysics Strategic Missions @ HQ	Astrophysics Explorers @ GSFC
WFIRST Webb* SOFIA**	TESS IXPE GUSTO Euclid XARM

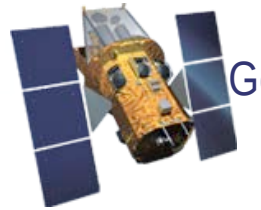
Supporting Research and Technology Programs

Research & Analysis @ HQ	PCOS/COR @ GSFC	EXEP @ JPL	Balloons @ WFF
APRA ADAP ATP TCAN XRP	SAT Athena LISA Telescope Tech	TDEM Starshade Tech LBTI NExScI	

* after commissioning
** after Senior Review

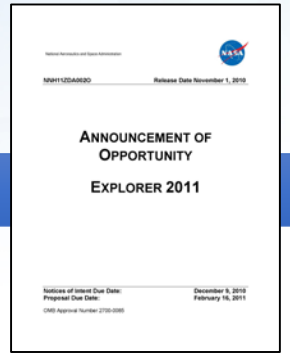
lists of SRT&T projects are not complete

Astrophysics Explorers Program



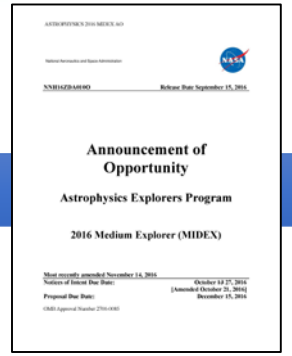
Gehrels-Swift

NuSTAR



MIDEX 2011

SMEX 2014

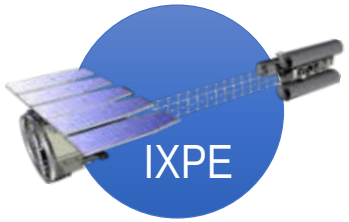


MIDEX 2016

SMEX 2019 (planned)

Small and Mid-Size Missions

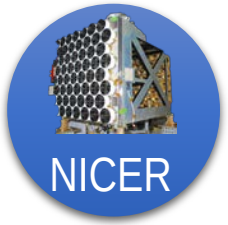
TESS



IXPE

Arcus
SPHEREx

Missions of Opportunity



NICER

GUSTO

ARIEL
COSI-X
ISS-TAO

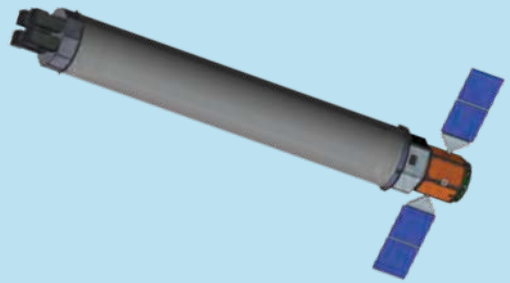
Directed 2017

XRISM

(formerly XARM)

Astrophysics Explorers in Competitive Phase A

Arcus
PI: R. Smith/SAO



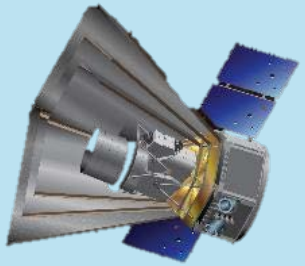
High resolution x-ray spectroscopy to explore the origin of galaxies

FINESSE
PI: M. Swain/JPL

Study terminated following ESA's selection of ARIEL

NIR transit spectroscopy to explore exoplanet atmospheres

SPHEREx
PI: J. Bock/Caltech



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

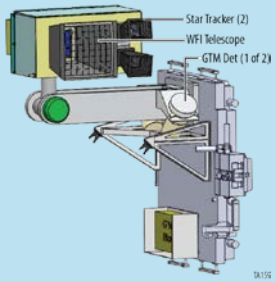
ARIEL
PI: M. Swain/JPL

Contribution of detectors to ESA's ARIEL

COSI-X
PI: S. Boggs/UCB

ULDB balloon mission to study origin of elements in the galaxy

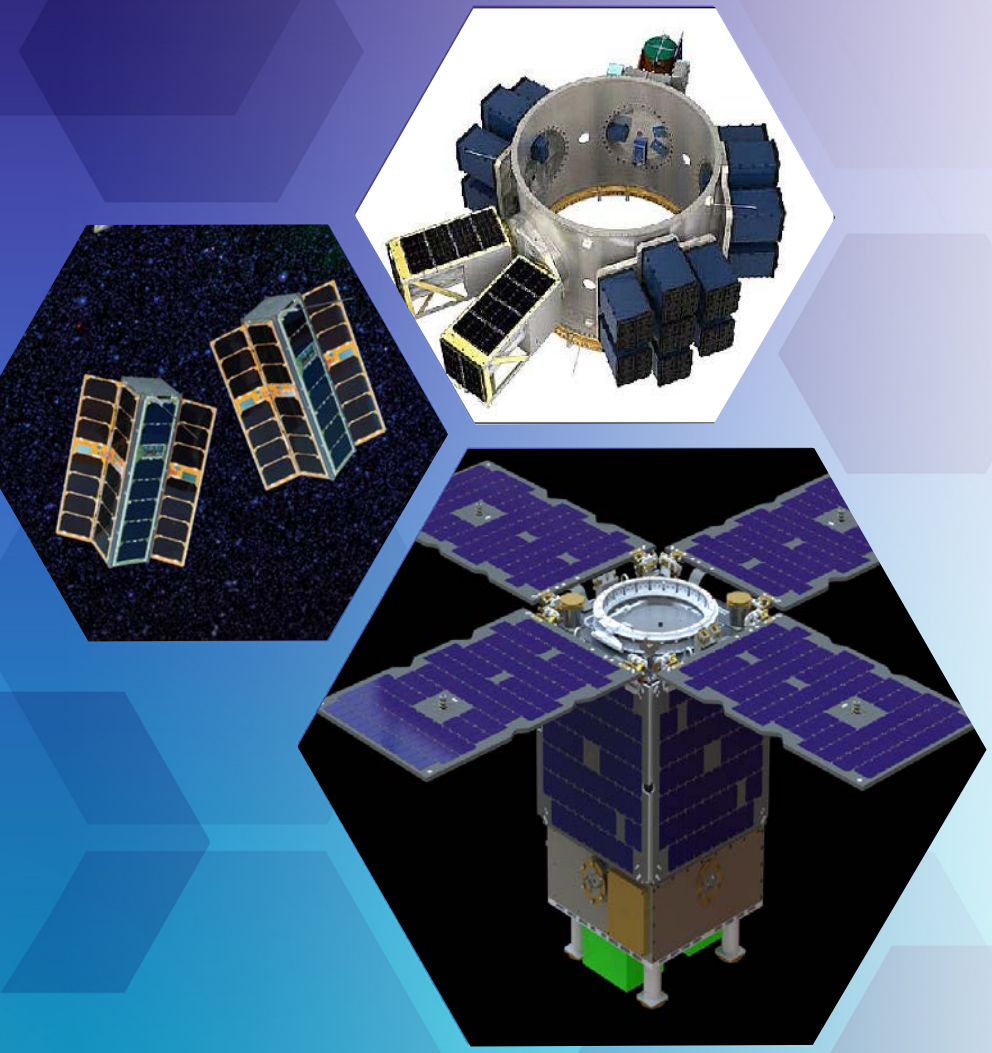
ISS-TAO
PI: J. Camp/GSFC



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

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, New Missions with Existing Spacecraft MOs, Small Complete Mission MOs
  - PI-managed Cost Cap: $35M for: Suborbital-class MOs, SmallSat MOs
- Community Announcement issued in June 2018
- Draft AOs planned for late 2018



Astrophysics SmallSats

Step 1: Funded mission concept studies

- NASA will conduct funded SmallSat mission concept studies (via ROSES) in advance of the 2019 SMEX AO
- 38 proposals received July 13

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

- New class of MO: SmallSats ($35M cost cap)
- NASA will find launch for standard CubeSat and ESPA*-ring forms

* EELV Secondary Payload Adapter

HaloSat
A CubeSat to study the Hot Galactic Halo

- **PI:** Phil Kaaret, U Iowa, Co-I WFF, GSFC, JHU, CNRS
- **Science**: HaloSat will map the distribution of hot gas in the Milky Way via the X-ray O VII and O VIII emission lines, and determine whether it fills an extended and thus massive halo, or whether the halo is compact and thus does not contribute significantly to the total mass of the Milky Way.

- **Technologies:** 6U CubeSat advancing science, using COTS technologies. Blue Canyon Technologies bus, WFF design and assembly, Amptex commercial X-ray detectors.
- **Budget:** $4.6M, 3 years from start to launch, 1 year of operations
- **Launched:** May 21, 2018, 4:44 am EDT on OA-9 ISS resupply from WFF
- Deployed: July 13, 2018, 4:05 am EDT

http://halosat.physics.uiowa.edu/

Astrophysics Missions in Pre-Formulation

Athena

Late 2020s

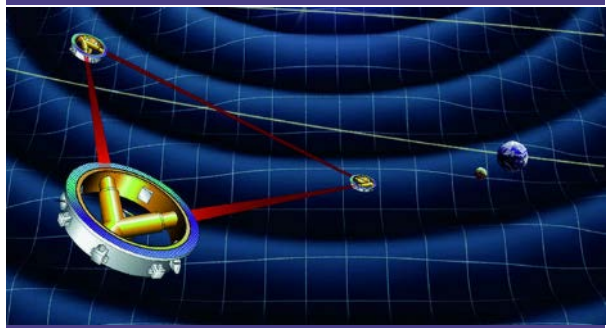
ESA-led Mission

NASA is supplying elements for both instruments

LISA

Mid 2030s

ESA-led Mission



NASA is developing technology for both the payload and the mission

Selected Mission Updates

- Athena
  - NASA planning for a hardware contribution, plus a U.S. GO program and a U.S. data center.
  - NASA will contribute to both the X-IFU and the WFI instruments.
  - NASA and U.S. community participating in Athena Science Study Team (including its Science Working Groups) and Instrument Teams.
  - Transitioning to a NASA project in 2018/2019.
- LISA
  - NASA has established a LISA Study Office at GSFC.
  - NASA is funding five US-based technologies with the aim of reaching TRL 5/6 by Adoption.
  - NASA and U.S. community participating in LISA Science Study Team and the LISA Consortium.
  - NASA established a NASA LISA Study Team to interface with NASA LISA Study Office, LISA Consortium, and Decadal Survey.
  - NASA issued call for LISA Preparatory Science proposals in ROSES.
  - Transitioning to a NASA project in 2018/2019.

Prospects and Challenges

- 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

Astrophysics Missions in Operation

Hubble 4/90
NASA Strategic Mission

Hubble Space Telescope

Chandra 7/99
NASA Strategic Mission

Chandra X-ray Observatory

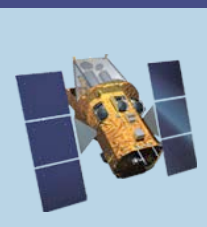
XMM-Newton 12/99
ESA-led Mission

X-ray Multi Mirror - Newton

Spitzer 8/03
NASA Strategic Mission

Spitzer Space Telescope

Gehrels-Swift 11/04
NASA MIDEX Mission

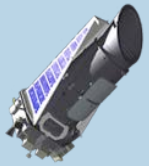


Swift Gamma-ray Burst Explorer

Fermi 6/08
NASA Strategic Mission

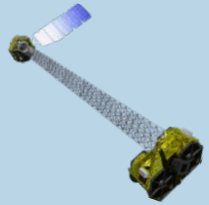
Fermi Gamma-ray
Space Telescope

Kepler 3/09
NASA Discovery Mission



Kepler Space Telescope

NuSTAR 6/12
NASA SMEX Mission

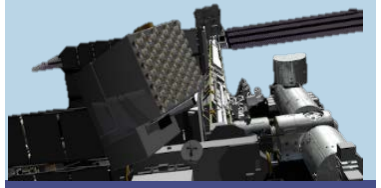


Nuclear Spectroscopic
Telescope Array

SOFIA 5/14
NASA Strategic Mission

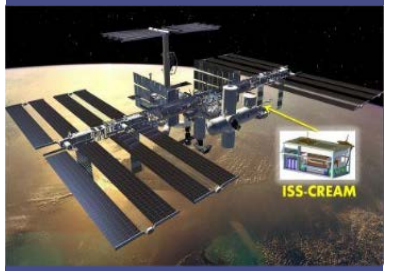
Stratospheric Observatory
for Infrared Astronomy

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



Neutron Star Interior
Composition Explorer

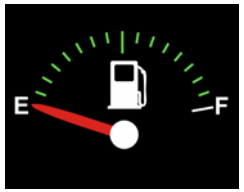
ISS-CREAM 8/17
NASA Research Mission



Cosmic Ray Energetics
And Mass

TESS 4/18
NASA MIDEX Mission

Transiting Exoplanet
Survey Satellite



SOFIA

Stratospheric Observatory for Infrared Astronomy

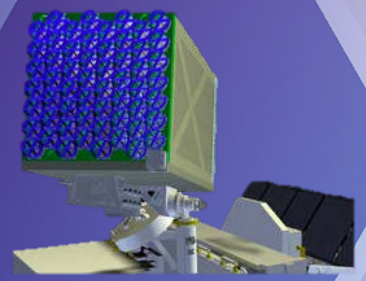
- Cycle 6 began in May (delayed 3 months)
- Extremely successful deployment to NZ
- Instrumentation Enhancements:
  - All HAWC+ Cycle 5 data released to GOs
  - GSFC building HIRMES -- delivery anticipated early 2019
  - Next Gen Instrumentation proposal deadline Aug 1

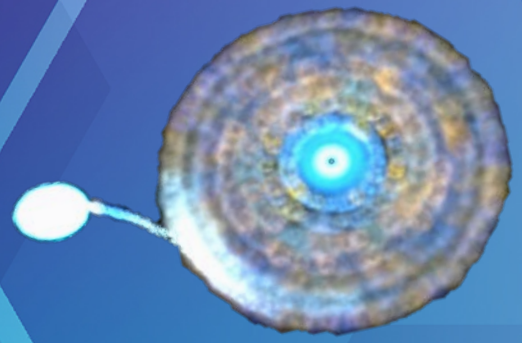
SOFIA Update
Harold Yorke
Tuesday

- SOFIA Cycle 6 started late due to the extended maintenance period.
- NWNH in 2010 said “SOFIA, which has operations costs of $70 million per year, will be subject to a senior review after 5 years of operations.”
  - SOFIA was expected to fly in 2012 at that time.
  - FY18 Consolidated Appropriations Explanatory Statement excludes SOFIA from 2019 Senior Review

ISS-NICER

Neutron star Interior Composition Explorer





- Launched in June 2017 with a mission lifetime of 18 months
  - The instrument is working flawlessly and has already led to numerous discoveries (e.g., binary with the shortest period).
  - The NICER data are public as of February 2018 and can be accessed through the HEASARC.
  - As of now, 9 peer review papers have been published on NICER data by the Science Team in peer-reviewed journals. One PhD Thesis using NICER data was completed.
- NICER is now past mid-point. NASA is holding an independent review of the Mission Progress towards fulfilling the Level 1 science and technical requirements.
  - Contingent on results of review, NICER will be approved for a short mission extension (~6 months) until the Senior Review

Senior Review 2019

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

Senior Review 2019 Schedule

2018:

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

2019:

- Senior Review proposals due
- Rest-of-missions, Chandra, Hubble, and SOFIA* panels meet
- Reports from Rest-of-missions, Chandra, Hubble, and SOFIA* 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

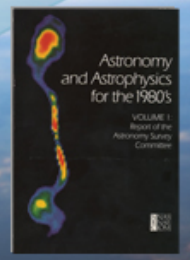
** Pending clarification of Congressional language*

NASA Astrophysics
Planning for Astro2020

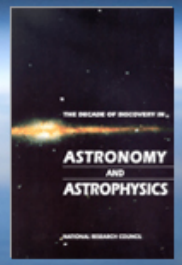
Astrophysics

Decadal Survey Missions

1972
Decadal Survey
Hubble



1982
Decadal Survey
Chandra



1991
Decadal Survey
Spitzer, SOFIA

2001
Decadal Survey
JWST

2010
Decadal Survey
WFIRST

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 understanding of the universe.

- There are two areas where NASA has recently worked to ensure an ambitious Decadal Survey:
  - The timing of the Decadal Survey.
  - The scope of the large mission studies.

Decadal Survey Timing

- NASA AA for Science Thomas Zurbuchen expressed concern about whether an ambitious and forward-looking Decadal Survey could take place during a period of uncertainty regarding Webb and WFIRST
  - He charged the community with considering whether there was any alternative to delaying the Decadal Survey
- National Academies Astro2020 consultation group and leadership of CAA, SSB, and BPA discussed the issue.
  - Considered input from the community survey conducted by NASA's Program Analysis Groups https://cor.gsfc.nasa.gov/copag/rfi/copag-rfi.php
- Academies group recommended that the start of the Astro2020 Decadal Survey not be delayed
- On May 24, Zurbuchen accepted the recommendation
  - Zurbuchen explained in blog entry at https://blogs.nasa.gov/drthomasz/

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
  - Main purpose is to provide the Decadal Survey Committee with several well-defined mission concepts to facilitate their deliberations
- 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
  - Supporting 10 PI-led Study Teams for Probe-size mission concept studies, selected competitively
  - Supporting several other planning activities / studies / white papers
- All material related to NASA's 2020 Decadal Survey planning activities are posted at https://science.nasa.gov/astrophysics/2020-decadal-survey-planning

Decadal Survey Planning
Large Mission Concept Studies

- All four STDTs have submitted interim reports to NASA
  - The Interim Reports have been reviewed by an independent review team.
  - Feedback was provided to the STDTs to allow them to improve their final reports
- The interim reports contain each STDT's Architecture A
- NASA has directed the STDTs to develop a less costly Architecture B during the next year
  - This will provide the Decadal Survey with ranges of scientific scope for their missions, as well as a range of science goals at different budget levels
  - This was recommended by the NAS study "Powering Science" (2017)
  - All were already considering a less costly Architecture B
- NASA expects that all of the architecture may be submitted to the Decadal Survey for consideration

Decadal Survey Planning
Other NASA-sponsored Input

NASA HQ is sponsoring, planning, or contemplating several additional studies as input

- These are independent of studies being initiated and conducted by NASA scientists at NASA Centers without HQ sponsorship

- Balloon Program Roadmap
  - Conducted by community-based Roadmap team chaired by Peter Gorham (U Hawaii)
- Evolution of NASA Data Centers
  - In planning stage, draws on efforts including STScI study on big data, NASA Big Data Task Force on adapting archives to technology, IPAC led study of joint data processing from LSST/Euclid/WFIRST, SMD study on strategic data management
- SmallSats
  - RFI for Astrophysics science and technology concepts; ROSES call for Science Concept Studies
- In-Space Servicing/In-Space Assembly
  - NASA-led study initiated, joint SMD/STMD/HEOMD
- System-Level Segmented Telescope Technology Program
  - Initial selections announced March 2018 (selected teams led by Ball Aerospace and Lockheed Martin)
- NASA asked the CAA to provide input on its Decadal Planning activities by Sep 2018

Decadal Survey Status

- Statement of Task is being finalized between the Agencies (NASA, NSF, DOE) and the National Academies.
- National Academies is preparing a proposal to the Agencies.
- Start by late 2018, with public roll out at January 2019 AAS meeting, is still planned.
- Final Decadal Survey report should be delivered by early 2021.

NASA Astrophysics

Response to APAC April 2018 Recommendations

Response to April 2018 Recommendations - 1

- Recommendation: The APAC unanimously recommends approval of the new PhysPAG SAG 3: Multimessenger Astrophysics.

  Action closed

- Recommendation: The APAC unanimously recommends approval of COPAG SAG 10: Great Observatories.

  Action closed

- Recommendation: The APAC unanimously recommends approval of the Senior Review Terms of Reference.

  Action closed

Response to April 2018 Recommendations - 2

- Recommendation: Members of the APAC suggested that the senior review subcommittee be populated with the membership of the "rest of missions" panel to insure balance and fairness by the subcommittee as they develop recommendations and write a report. As this was not part of our final “actions and recommendations” discussion at the end of the last day, we suggest simply that this topic be discussed at the next APAC meeting.

  Discussion Topic

- Recommendation: The APAC suggests that SOFIA should undergo a comprehensive review within the next two years, and would like to have input into the terms of reference of that review.

  Response: NASA is awaiting clarification from Congress

Response to April 2018 Recommendations - 3

- Recommendation: The APAC recommends that Michael New continues to work with the NASA Centers to communicate and coordinate with them about what SMD is learning about the pathways taken by successful women PI's, and what approaches they are taking to increase the pool if necessary. The APAC further encourages him to communicate directly with Center Division Directors and Branch Heads/Lab Chiefs, as these individuals have direct influence on the make-up of project teams.

  Response: Work in progress.

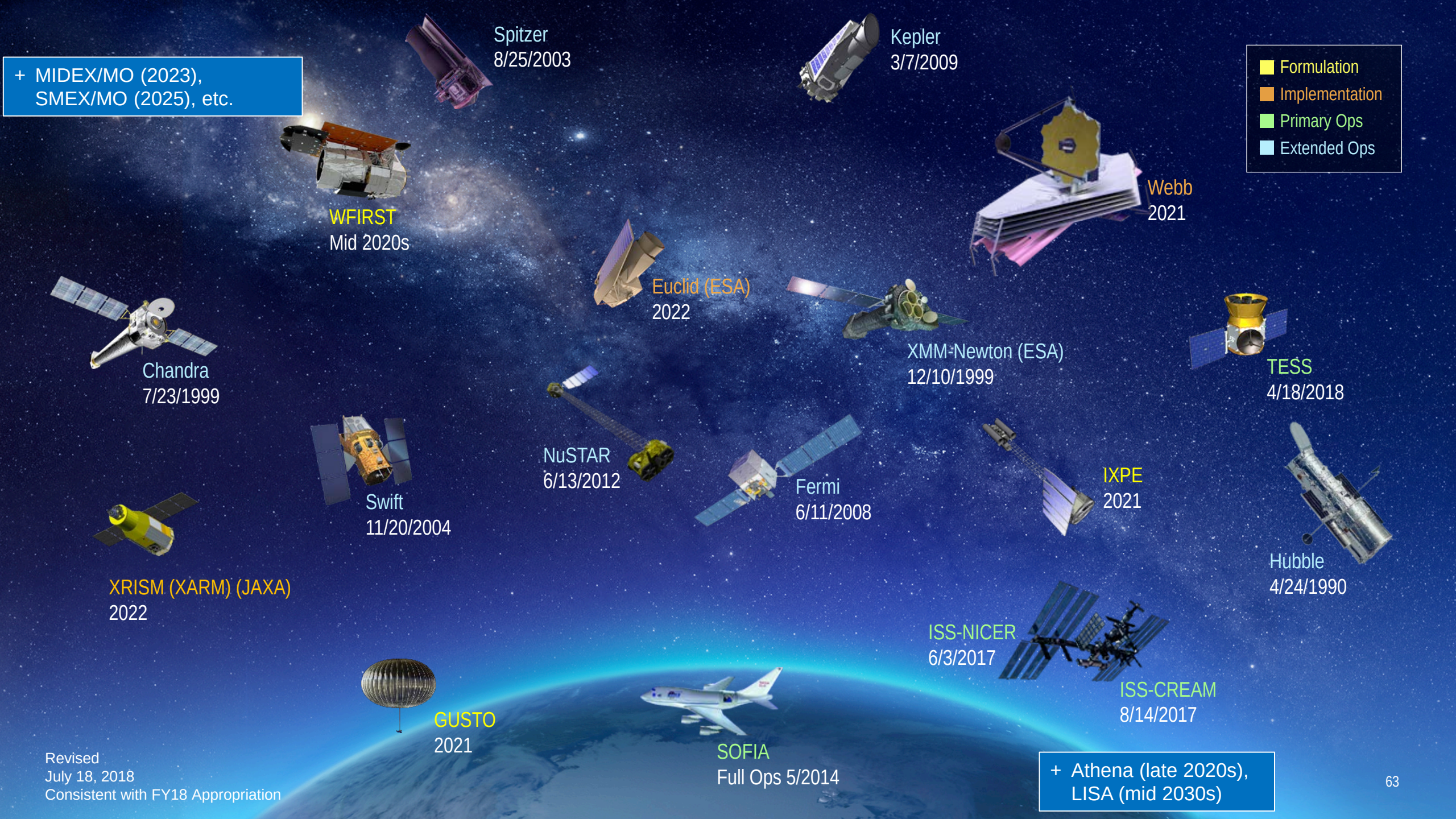
Response to April 2018 Recommendations - 4

- Recommendation: The APAC concluded that there is a need for more high risk/high reward (HR/HR) programs in all areas to be funded, including technological, observational, and theoretical R&A programs, although there was no consensus on whether this should be taken from existing funding, or whether additional funding should devoted to HR/HR proposals. Similarly, there was no consensus on the need for additional funding for interdisciplinary or interdivisional proposals.
- Recommendation: APAC recommends that we wait until the outcome of the experiment by the SMD become clear, namely:
  - "We are now asking peer review panels to identify HR/HR proposals (started recently)."
  - "After a year or two we can show some statistics (e.g., do proposals that the panel think are HR/HR have lower average grades?)"

  Response: NASA is developing a strategy on HR/HR programs in response to APAC and other Committees' input. Work in progress.

Take Away

- R&A opportunities increasing
- Small mission opportunities increasing
- Explorers AOs and launches proceeding at Decadal Survey cadence
- TESS science mission begins this month
- Webb independent review has led to new launch date and new cost commitment; the cost growth on Webb is likely to impact other missions
- WFIRST beginning Phase B
- Decadal Survey planning proceeding with goal of an ambitious science program in the 2020s


+ MIDEX/MO (2023), SMEX/MO (2025), etc.
Spitzer 8/25/2003
Kepler 3/7/2009
Formulation
Implementation
Primary Ops
Extended Ops
WFIRST Mid 2020s
Webb 2021
Euclid (ESA) 2022
Chandra 7/23/1999
XMM-Newton (ESA) 12/10/1999
TESS 4/18/2018
NuSTAR 6/13/2012
Swift 11/20/2004
Fermi 6/11/2008
IXPE 2021
Hubble 4/24/1990
XRISM (XARM) (JAXA) 2022
ISS-NICER 6/3/2017
ISS-CREAM 8/14/2017
GUSTO 2021
SOFIA Full Ops 5/2014
Revised July 18, 2018 Consistent with FY18 Appropriation
+ Athena (late 2020s), LISA (mid 2030s)