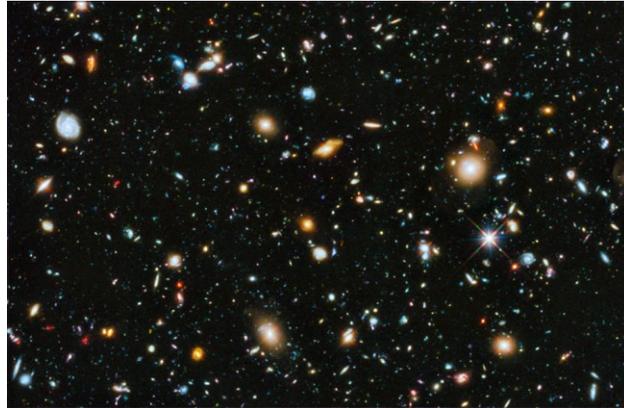


National Aeronautics and
Space Administration



ASTROPHYSICS



NASA Headquarters Update

ExoPAG #18

July 29, 2018

Cambridge, MA

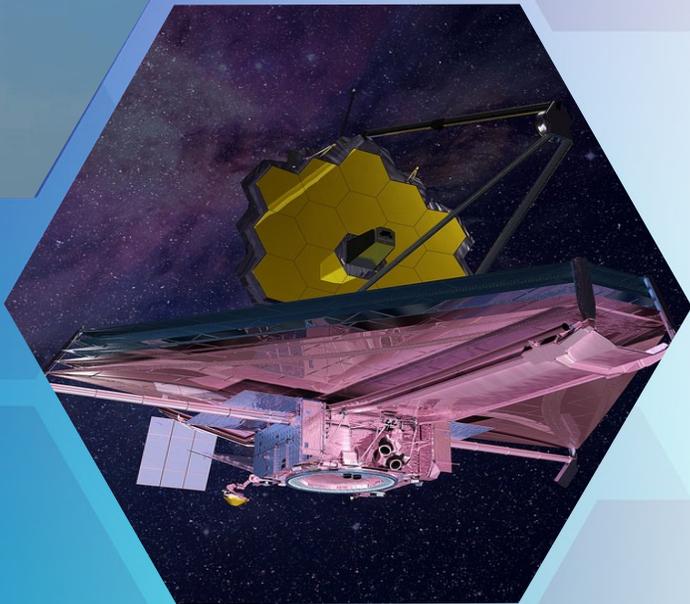
Martin Still

ExoPAG Executive Secretary

Astrophysics Division, Science Mission Directorate

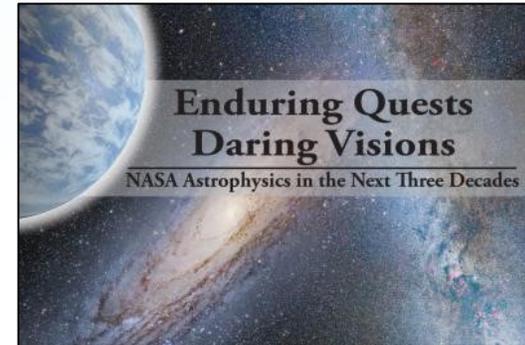
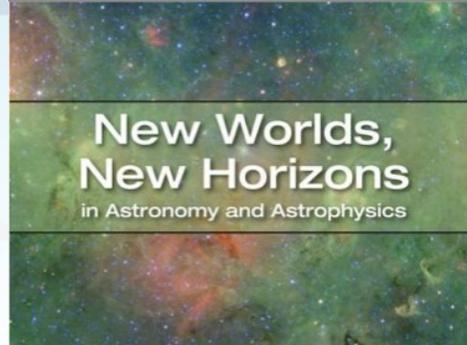
Martin.Still@nasa.gov

NASA's Astrophysics Program

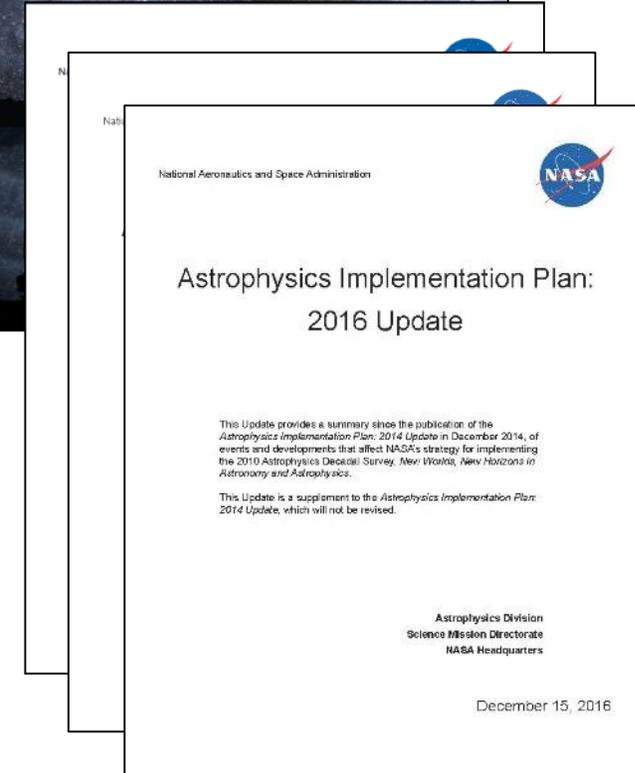
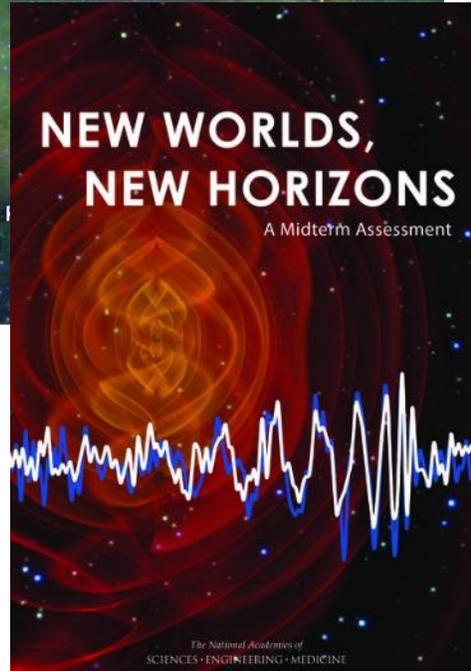


- Strategic Missions
 - Flagships and Probes led by NASA
 - Contributions to Partner-led Missions
- PI-led (competed) Missions
 - Explorers led by NASA
 - Contributions to Partner-led Missions
- Supporting Research and Technology
 - Research and Analysis
 - Technology Development
 - Suborbital Investigations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

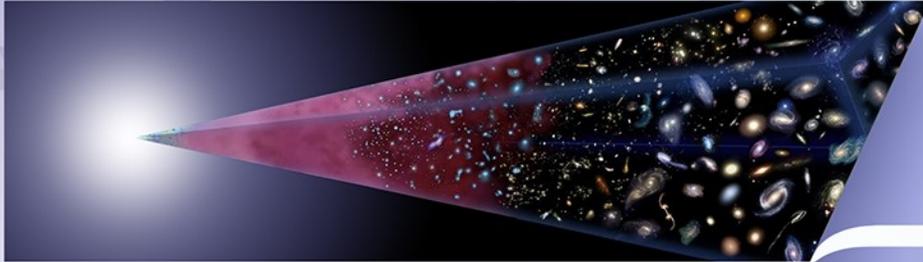
Astrophysics Strategic Planning



To be updated in 2018 (per GPRAMA)



Why Astrophysics?



How did our universe begin and evolve?



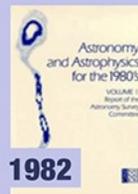
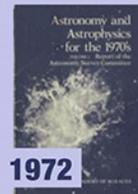
How did galaxies, stars, and planets come to be?

Exoplanet Exploration Program



Are we alone?

Enduring National Strategic Drivers



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

The ExEP and the ExoPAG: Definitions

https://exoplanets.nasa.gov/system/internal_resources/details/original/553_ExoPAG-TOR_2017.pdf

- ExEP serves NASA and the community by acting as a focal point for exoplanet science and technology, managing research and technology initiatives, facilitating access to scientific data, and integrating the results of previous and current missions into a cohesive strategy to enable future discoveries.
- The Exoplanet Exploration Program Analysis Group (ExoPAG) serves as a community-based, interdisciplinary forum for soliciting and coordinating community analysis and input in support of Exoplanet Exploration objectives and of their implications for architecture planning and activity prioritization and for future exploration.
- The ExoPAG reports findings of analyses to the NASA Astrophysics Division Director.

ExoPAG Executive Committee

Name	Home	Year
Vikki Meadows (chair)	Washington	1/3
Tiffany Glassman	Northrop Grumman	3/3
Dimitri Mawet	Caltech/JPL	3/3
+ Tyler Robinson	UC Santa Cruz	3/3
Eliza Kempton	Grinnell College	2/3
Michael Meyer	Michigan	2/3
Chris Stark	STScI	2/3
Johanna Teske	Carnegie Institution	2/3
Thomas Barclay	NASA GSFC	1/3
Jessie Christiansen	Caltech	1/3
Rebecca Jensen-Clem	Berkeley	1/3

After year 3, EC members Daniel Apai, David Ciardi, and Shawn Domagal-Goldman rolled off the EC
New Call for EC Nominations in Oct 2018: <https://exoplanets.nasa.gov/exep/exopag>. Deadline: Jan 2019

Science Analysis Group Status

<https://exoplanets.nasa.gov/exep/exopag/sag>

Delivered	SAG	Title	Lead
2015	8	Requirements and Limits of Future Precision Radial Velocity Measurements	Latham, Plavchan
2015	9	Exoplanet Probe to Medium Scale Direct-Imaging Mission Requirements and Characteristics	Soummer
2015	10	Characterizing the Atmospheres of Transiting Planets with JWST and Beyond	Cowan
2014	11	Preparing for the WFIRST Microlensing Survey	Yee
2017	12	Scientific potential and feasibility of high-precision astrometry for exoplanet detection and characterization	Bendek
2017	13	Exoplanet Occurrence Rates and Distributions	Belikov
--	14	Characterization of Stars Targeted for NASA Exoplanet Missions	Stassun
2017	15	Exploring Other Worlds: Observational Constraints and Science Questions for Direct Imaging Exoplanet Missions	Apai
2018	16	Exoplanet biosignatures	Domagal-Goldman
--	17	Community Resources Needed for K2 and TESS Planetary Candidate Confirmation	Ciardi
--	18	Metrics for Direct-Imaging with Starshades	Glassman, Turnbull
--	19	Exoplanet Imaging Signal Detection Theory and Rigorous Contrast Metrics	Mawet, Jensen-Clem

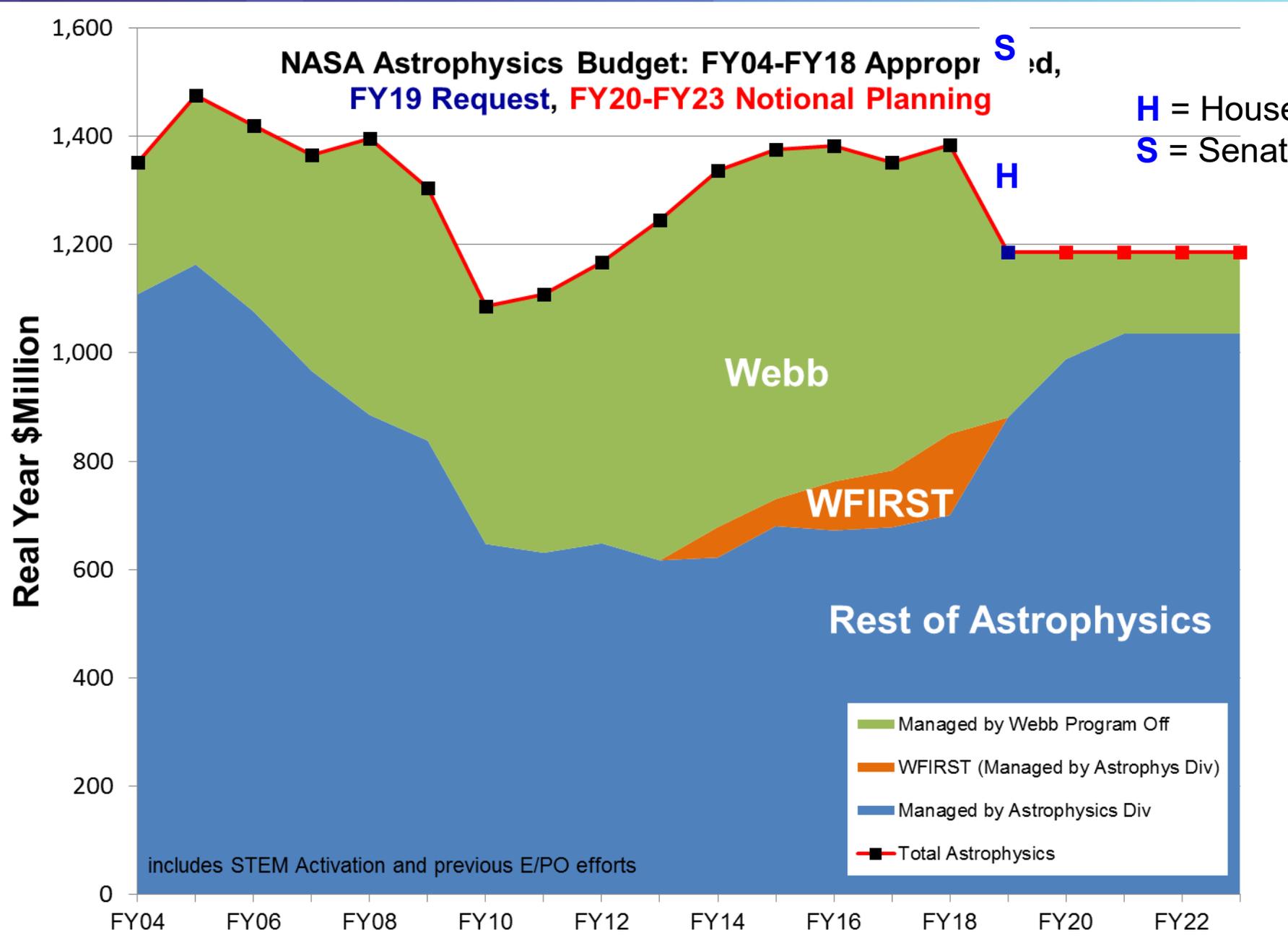


NASA Astrophysics

Program and Budget Update

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.



Respond with white papers to RFI through NSPIRES solicitation# NNH18ZDA015L, or
Send abstract to meeting organizers at <https://www.hou.usra.edu/meetings/technosignatures2018/>

NASA TECHNOSIGNATURES WORKSHOP

Houston, Texas
September 26-28, 2018

#technosigs18

1. Define the current state of the technosignature field:
 - What experiments have occurred?
 - What is the state-of-the-art for technosignature detection?
 - What limits do we currently have on technosignatures?
2. Understand the advances coming near-term in the technosignature field.
 - What existing and planned missions will advance technosignature detection?
3. Understand the future potential of the technosignature field.
 - What new developments would help technosignature detection?
4. What role can NASA partnerships with the private sector and philanthropic organizations play?

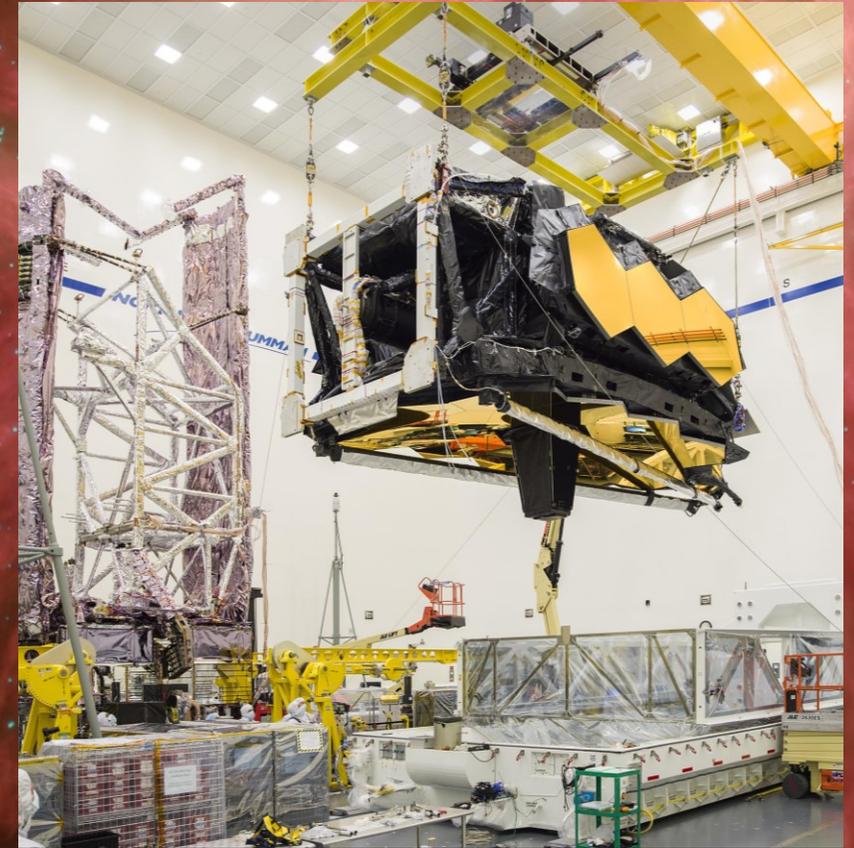


NASA Astrophysics

Missions Update

Webb

The James Webb



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

Summary of IRB Report and Response

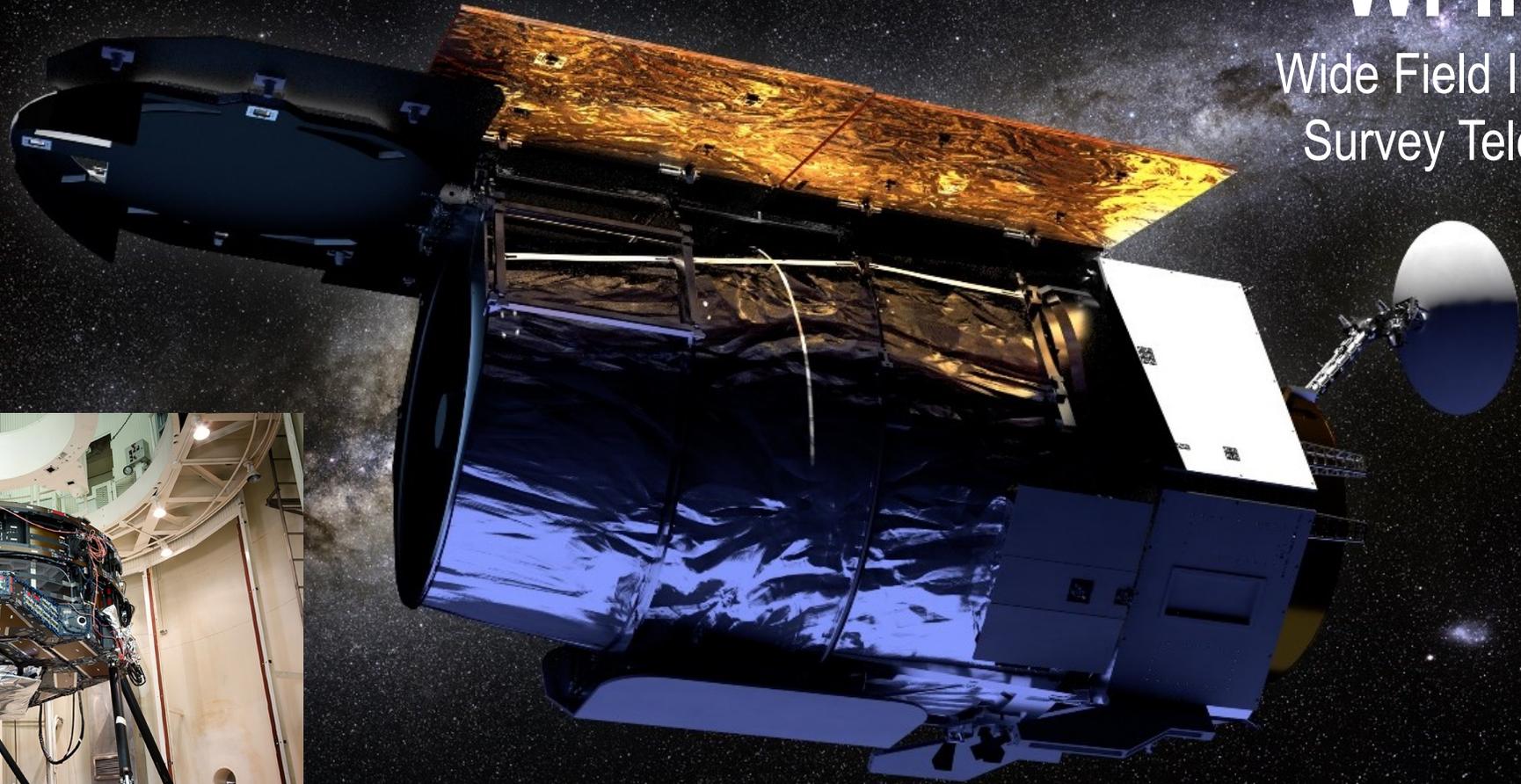
- NASA received report from the Standing Review Board (SRB) and the Independent Review Board (IRB).
- Webb science is world class and compelling.
- Mission success is the driving consideration going forward.
- Technical complexities have greatly impacted the development schedule.
 - + - First of a kind 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.
- The congressionally mandated \$8B development cost cap is exceeded by \$803M.

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
- + • NASA believes that the anticipated cost growth on Webb is likely to impact other science missions
- Principles
 - NASA understands the Decadal Survey priorities
 - NASA will protect R&A and Explorers Program

WFIRST

Wide Field Infrared
Survey Telescope



Primary mirror assembly / Harris Corporation

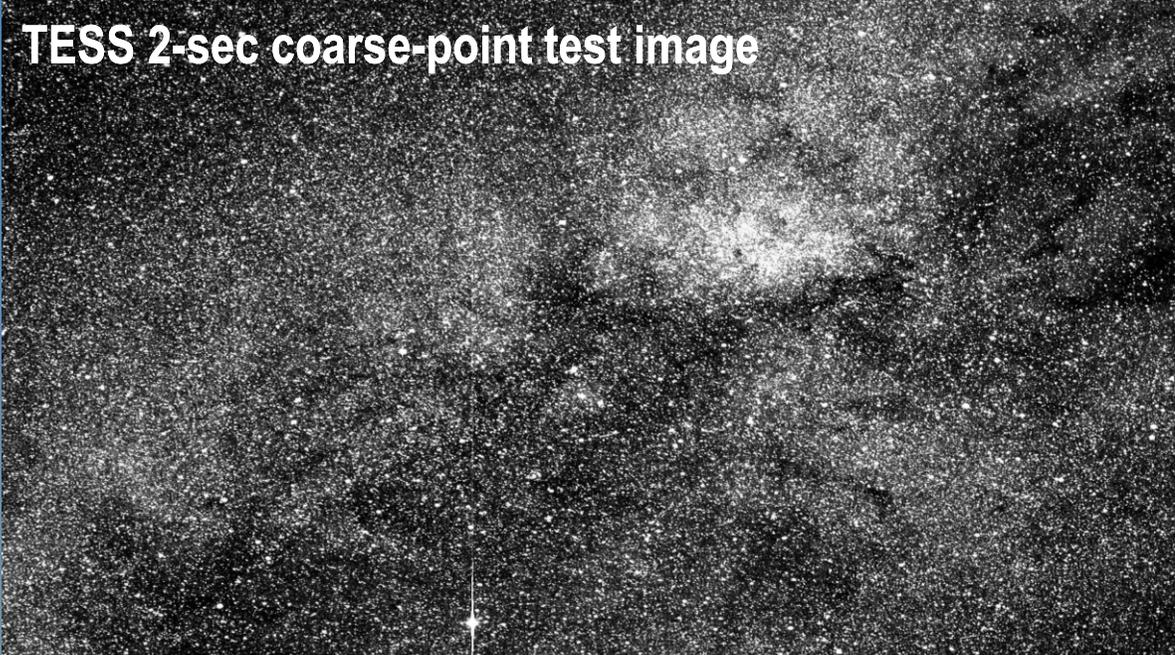
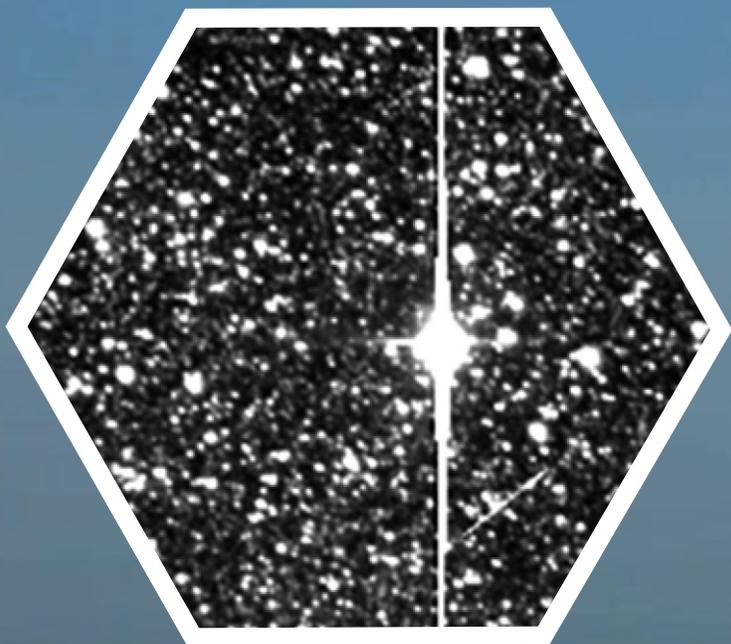
WFIRST Update

- 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 rescope mission, consistent with \$3.2B cost target
- WFIRST passed Systems Requirements Review/Mission Definition Review, approved in May 2018 to enter Phase B (preliminary design phase)

TESS

Transiting Exoplanet Survey Satellite

Launched April 18, 2018



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

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 were 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>

2017 Explorers AO: Competitive Phase A Studies

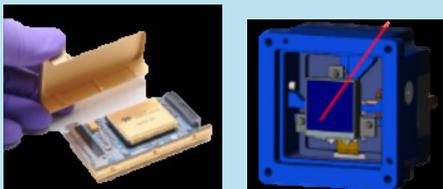
Arcus



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

ARIEL

PI: M. Swain/JPL



Contribution of detectors to ESA's ARIEL

FINESSE

PI: M. Swain/JPL

Study terminated following ESA's selection of ARIEL

NIR transit spectroscopy to explore exoplanet atmospheres

COSI-X

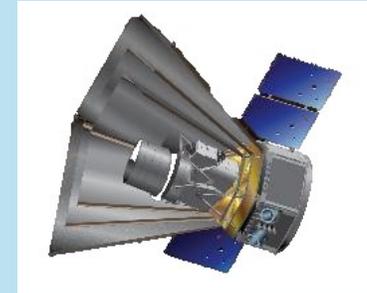
PI: S. Boggs/UCB



ULDB balloon mission to study origin of elements in the galaxy

SPHEREx

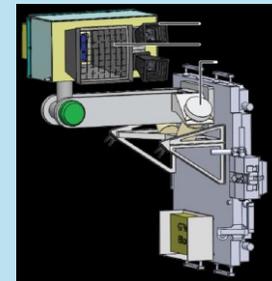
PI: J. Bock/Caltech



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

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



NASA Astrophysics

2018 Senior Review for Operating Missions

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*

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)



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
 - Main purpose is to provide the Decadal Survey Committee with several well-defined mission concepts to facilitate their deliberations
 - 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
- 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 architectures 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:

- + - 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)

Take Aways

- R&A opportunities increasing
- Small mission opportunities increasing
- Explorers AOs and launches proceeding at Decadal Survey cadence
- TESS science mission began 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

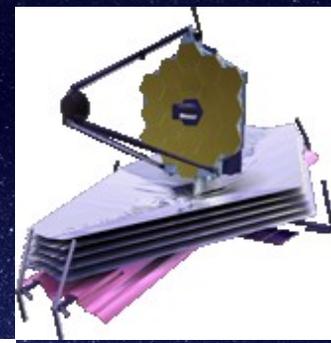


Kepler
3/7/2009

- Formulation
- Implementation
- Primary Ops
- Extended Ops



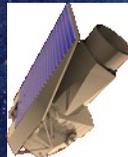
WFIRST
Mid 2020s



Webb
2021



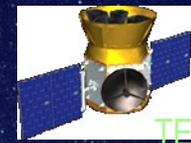
Chandra
7/23/1999



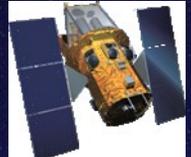
Euclid (ESA)
2022



XMM-Newton (ESA)
12/10/1999



TESS
4/18/2018



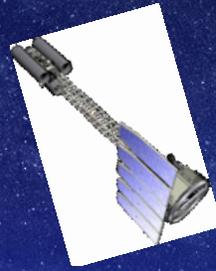
Swift
11/20/2004



NuSTAR
6/13/2012



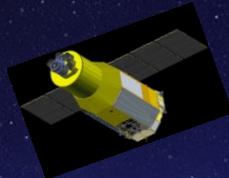
Fermi
6/11/2008



IXPE
2021



Hubble
4/24/1990



XRISM (XARM) (JAXA)
2022



GUSTO
2021



SOFIA
Full Ops 5/2014



ISS-NICER
6/3/2011

HEAM

8/14/2017

Revised
July 18, 2018
Consistent with FY18 Appropriation

+ Athena (late 2020s),
LISA (mid 2030s)