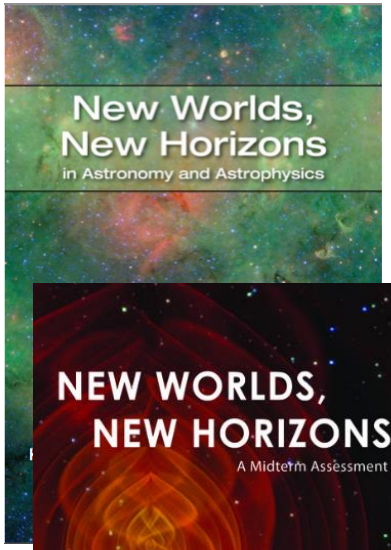
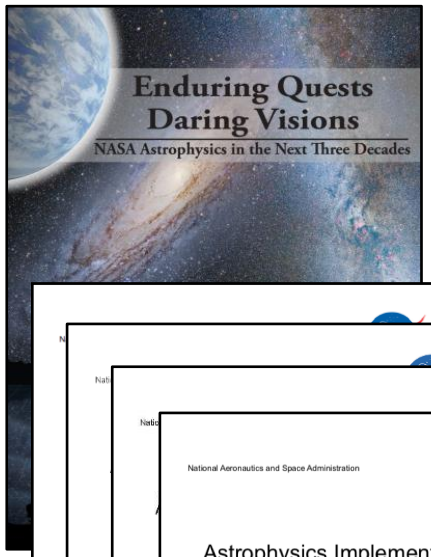
NASA Headquarters Update

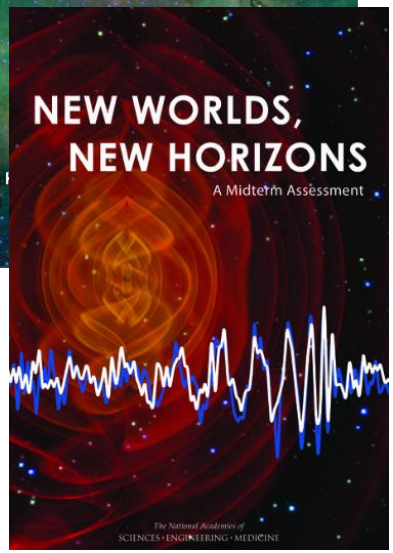
ExoPAG #20 | Seattle, WA | June 23, 2019

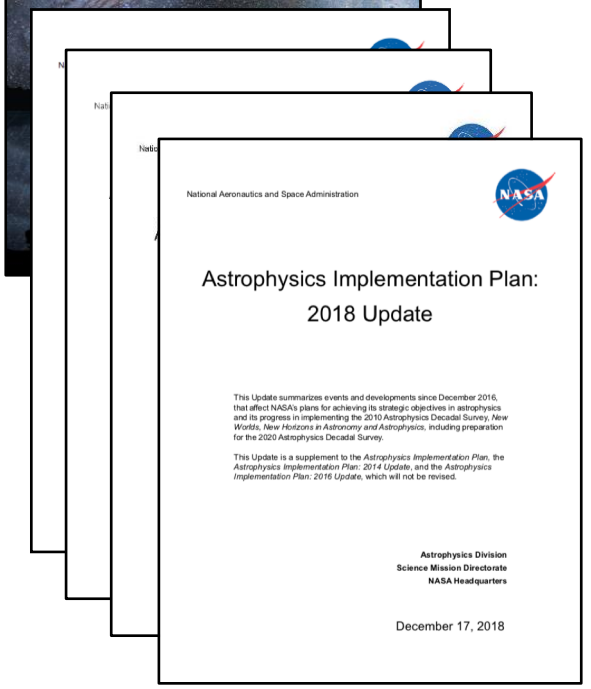
Martin Still (*martin.still@nasa.gov*)
ExoPAG Executive Secretary
Astrophysics Division, Science Mission Directorate

Astrophysics Strategic Planning

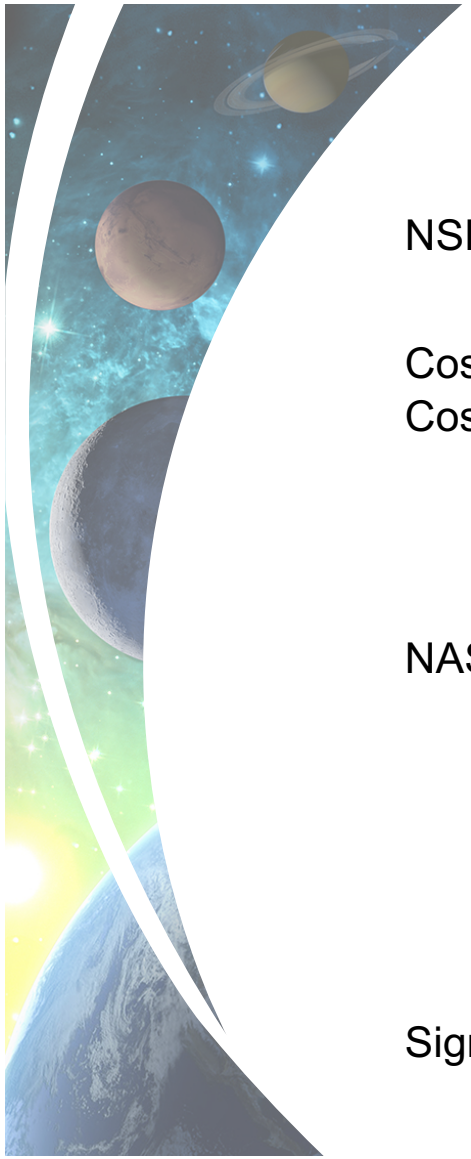








https://science.nasa.gov/about-us/science-strategy
https://science.nasa.gov/astrophysics/documents



Keep Informed about NASA

NSPIRES mailing list – information about NASA solicitations

https://nspires.nasaprs.com/

Cosmic Origins mailing list, Exoplanet Exploration mailing list, Physics of the Cosmos mailing list – information about NASA missions and science

https://cor.gsfc.nasa.gov/cornews-mailing-list.php

https://exoplanets.nasa.gov/exep/exopag/announcementList/

https://pcos.gsfc.nasa.gov/pcosnews-mailing-list.php

NASA Astrophysics Federal Advisory Committees

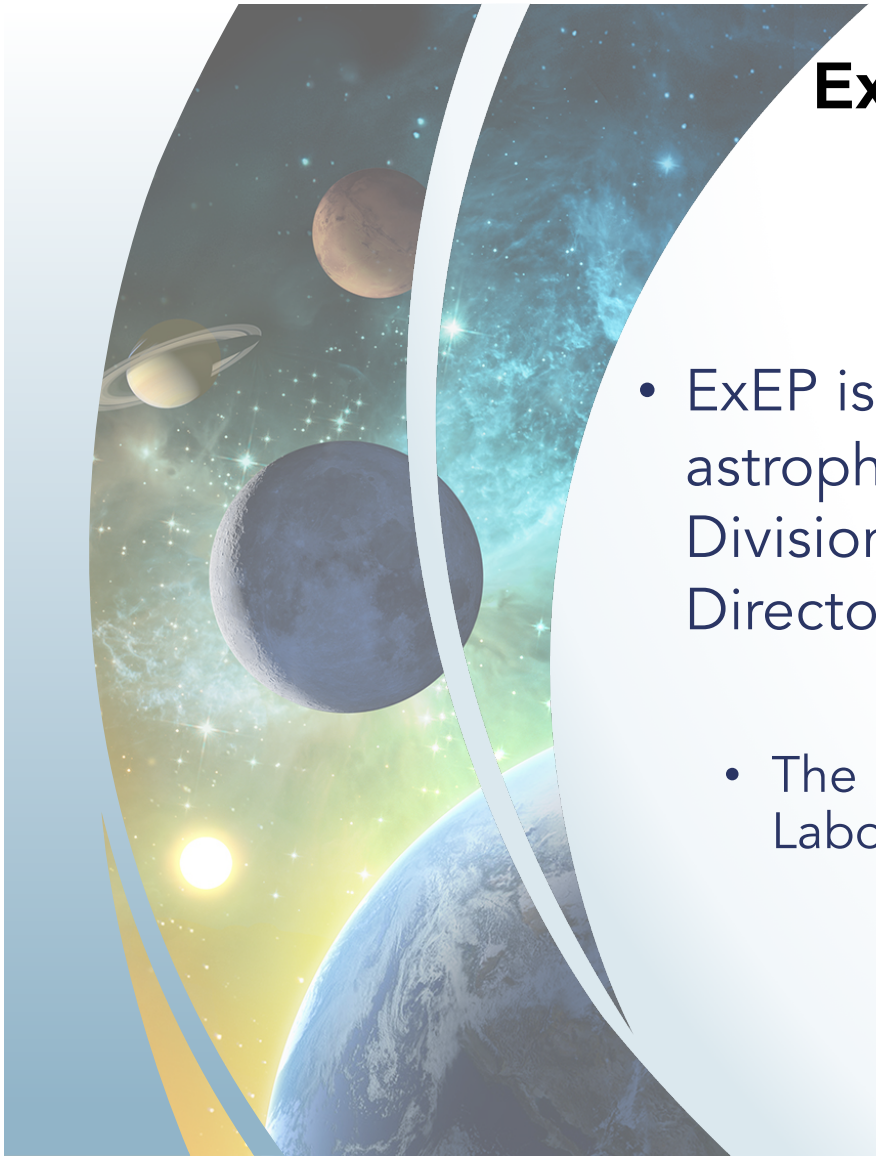
Astrophysics Advisory Committee (APAC)
https://science.nasa.gov/researchers/nac/science-advisory-committees/apac

NAS Committee on Astronomy and Astrophysics (CAA)
http://sites.nationalacademies.org/bpa/bpa_048755

Astronomy and Astrophysics Advisory Committee (AAAC)
https://www.nsf.gov/mps/ast/aaac.jsp

Sign up to be a panel reviewer:

https://science.nasa.gov/researchers/volunteer-review-panels



Exoplanet Exploration Program (ExEP)

https://exoplanets.nasa.gov/exep

- ExEP is one of three broadly-themed astrophysics programs within the Astrophysics Division (APD) of NASA's Science Mission Directorate (SMD).
  - The ExEP Office is based at the Jet Propulsion Laboratory (JPL) and manages ExEP for APD.

The Exoplanet Exploration Program (ExEP)

- 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.

Exoplanet Program Analysis Group (ExoPAG)

https://exoplanets.nasa.gov/exep/exopag/overview

- The Exoplanet Exploration Program Analysis Group (ExoPAG) is 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 for future exploration.
- The ExoPAG reports findings of analyses to the NASA Astrophysics Division Director.

The Exoplanet Program Analysis Group (ExoPAG)

- The ExoPAG could be tasked to carry out one or more of the following:
  - Articulate and prioritize the key scientific drivers for Exoplanet Exploration research;
  - Evaluate the expected capabilities of potential ExEP missions for achieving the science goal of the program
  - Evaluate ExEP goals, objectives, investigations, and required measurements on the basis of the widest possible community outreach;
  - Articulate and prioritize focus areas for needed mission technologies; and
  - Provide findings on related activities that support the program, such as ground-based observing, theory and modeling programs, laboratory astrophysics, suborbital investigations, data archiving, and community engagement.

The Exoplanet Program Analysis Group (ExoPAG)

- The ExoPAG enables direct regular communication between NASA and the community through public meetings that give the community opportunities to provide scientific and programmatic input.

- The ExoPAG consists of all members of the community who participate in these open meetings.

Astrophysics Advisory Committee (APAC)

https://science.nasa.gov/researchers/nac/science-advisory-committees/apac

- The ExoPAG Chair is a member of the APAC.
- The APAC provides community advice and recommendations to the APD Director on programs, policies, plans, and priorities.
- The Director takes APAC advice and recommendations to inform implementational decisions.
- The APAC also provides a forum for the discussion of astrophysics inside and outside NASA.
- The APAC meets 2-4 times per year.

The ExoPAG Executive Committee (EC)

- The ExoPAG EC helps the ExoPAG Chair:
  - capture and organize community input;
  - keep the community informed of ongoing activities and opportunities within the exoplanet program;
  - oversee ExoPAG analyses; and
  - prepare ExoPAG findings and inputs to the Astrophysics Division.
- EC members are selected to reflect the broad range of scientific disciplines and interests represented in exoplanet exploration.
- New EC members will be selected by the Astrophysics Division Director in the new year.

The ExoPAG Executive Committee (EC)

Name	Home	Year
Vikki Meadows (chair)	Washington	1/3
Eliza Kempton	Grinnell College	3/3
Michael Meyer	Michigan	3/3
Chris Stark	STScI	3/3
Johanna Teske	Carnegie Institution	3/3
Tom Barclay	GSFC	2/3
Jessie Christiansen	Caltech	2/3
Rebecca Jensen-Clem	Berkeley	2/3
Tiffany Kataria	JPL	1/3
Joshua Pepper	LeHigh	1/3
Dmitry Savranski	Cornell	1/3

After 3-year service, EC members Tiffany Glassman, Dimitri Mawet, and Tyler Robinson have rolled off the EC

New member Call for Nominations in Oct 2019

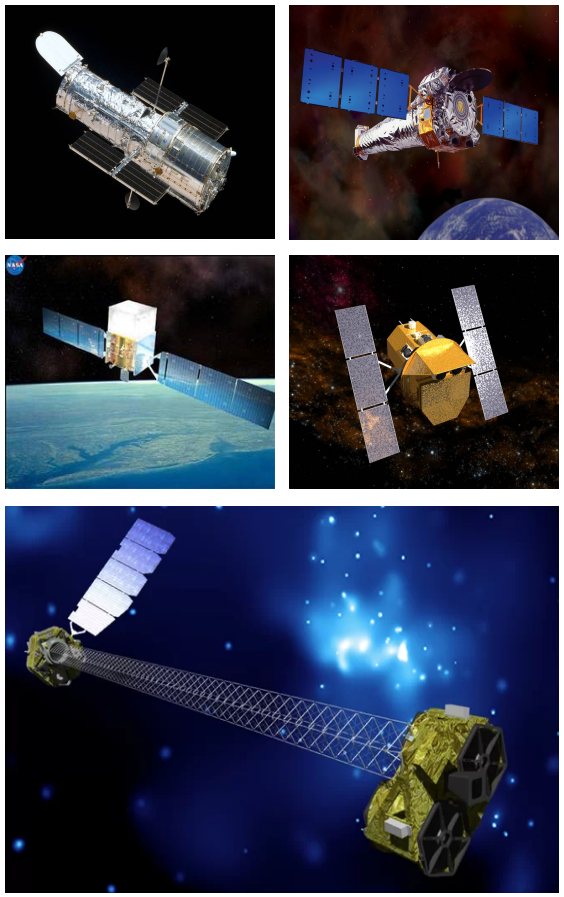
Deadline: Jan, 2020

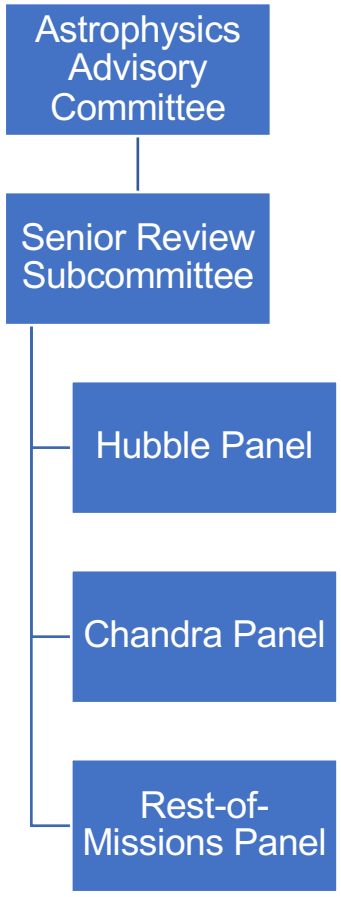
Science Analysis Groups (SAGs) and Science Interest Groups (SIGs)

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

Delivered	SAG	Title	Lead
2015	SAG 9	Exoplanet Probe to Medium Scale Direct-Imaging Mission Requirements and Characteristics	Soummer
2015	SAG 10	Characterizing the Atmospheres of Transiting Planets with JWST and Beyond	Cowan
2014	SAG 11	Preparing for the WFIRST Microlensing Survey	Yee
2017	SAG 12	Scientific potential and feasibility of high-precision astrometry for exoplanet detection and characterization	Bendek
2017	SAG 13	Exoplanet Occurrence Rates and Distributions	Belikov
2017	SAG 15	Exploring Other Worlds: Observational Constraints and Science Questions for Direct Imaging Exoplanet Missions	Apai
2018	SAG 16	Exoplanet biosignatures	Domagal-Goldman
2018	SAG 17	Community Resources Needed for K2 and TESS Planetary Candidate Confirmation	Ciardi
2018	SAG 18	Metrics for Direct-Imaging with Starshades	Glassman, Turnbull
--	SAG 19	Exoplanet Imaging Signal Detection Theory and Rigorous Contrast Metrics	Mawet, Jensen-Clem
--	SAG20	Strategies for Mitigating the Impact of the JWST Delay on Exoplanet Science	Deming, Teske
--	SIG 2	Exoplanet Demographics	Christiansen

Program and Mission Updates





Senior Review 2019

- Chandra X-ray Observatory (Chandra)
- Fermi Gamma-ray Space Telescope (Fermi)
- Hubble Space Telescope (Hubble)
- Neutron star Interior Composition Explorer (NICER)
- Nuclear Spectroscopic Telescope Array (NuSTAR)
- Neil Gehrels Swift Observatory (Swift)
- Transiting Exoplanet Survey Satellite (TESS)
- X-ray Multi-mirror Mission-Newton (XMM-Newton)

Not in Senior Review: Kepler, SOFIA, Spitzer

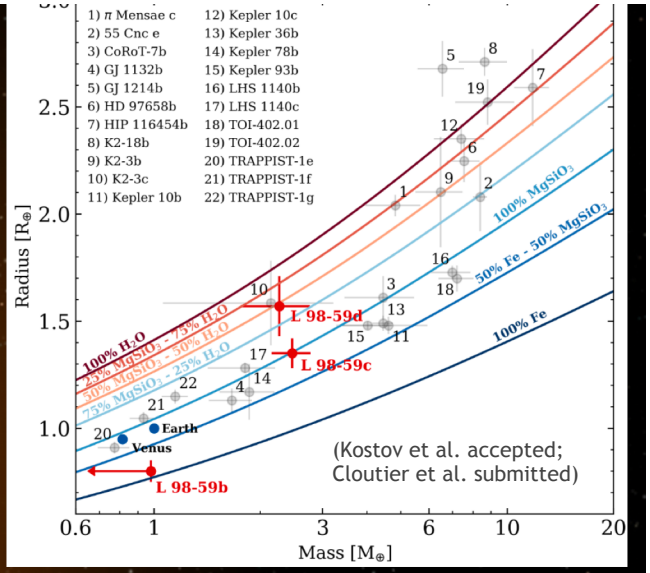
TESS

Transiting Exoplanet Survey Satellite

TESS 3-planet system L98-59

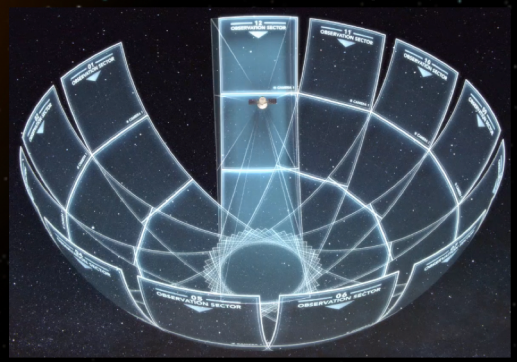
- radii between 0.8 - 1.6 Earth radii
- mass measurements from HARPS
- M3 dwarf at 10.6 parsec (35 ly)

Exciting system for potential atmosphere characterization with HST and JWST

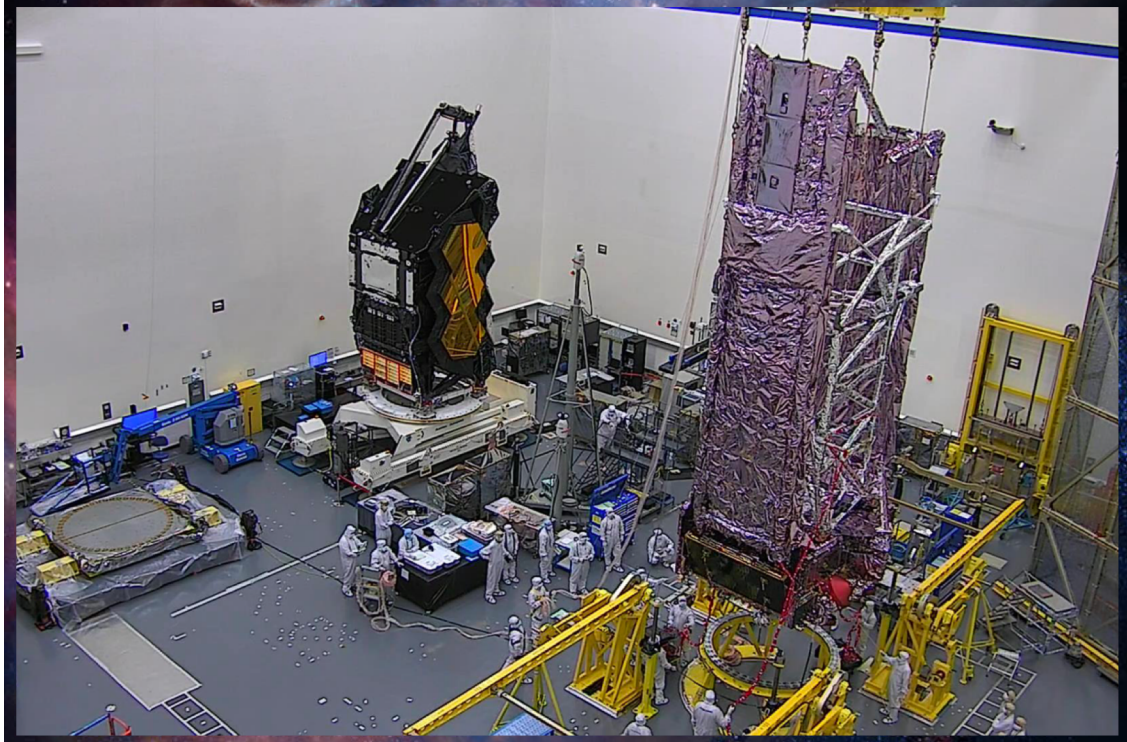


- 685 planet candidates
- 15 confirmed planets
- 137 publications submitted, 82 through peer-review (55% exoplanets, 45% other areas of astrophysics)

Observation Sector 12 in progress



Last update: June 11, 2019



The Webb payload (telescope + instruments, left) and spacecraft element (spacecraft + sunshield, right) in the clean room in Redondo Beach, CA before spacecraft element environmental testing and observatory integration

Webb

The James Webb Space Telescope

- Science payload completed three months cryogenic testing at end of 2017
- Spacecraft and sunshield integration complete January 2018
- Spacecraft element including sunshield completed environmental testing May 2019
- Science payload and spacecraft integration planned for Fall 2019, followed by test deployment of sunshield
- Testing of full observatory begins in 2019 and continues in 2020
- Webb overrun covered using offsets from Astrophysics Probes

Wide-Field Infrared Survey Telescope

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

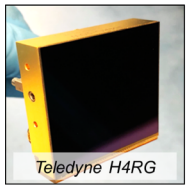
Mid-2020s – Launch

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

Science Program includes

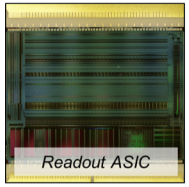
- Dark energy and the fate of the universe through surveys measuring the expansion history of the universe and the growth of structure
- The full distribution of planets around stars through a microlensing survey
- Wide-field infrared surveys of the universe through General Observer and Archival Research programs
- Technology development for the characterization of exoplanets through a Coronagraph Technology Demonstration Instrument

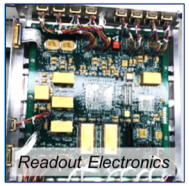
WFIRST Progress

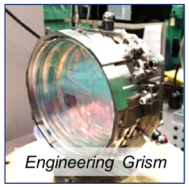

Teledyne H4RG

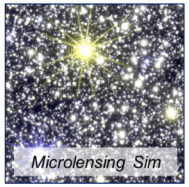

Detector First Light

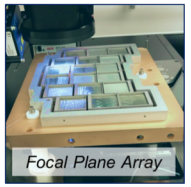
Wide Field Instrument

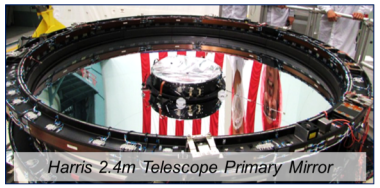

Readout ASIC


Readout Electronics


Engineering Grism


Microlensing Sim


Focal Plane Array


Harris 2.4m Telescope Primary Mirror

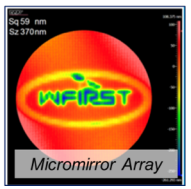
Telescope

Coronagraph Technology Demonstration Instrument

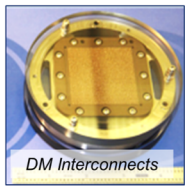

Mirror Figuring


Telescope Contract

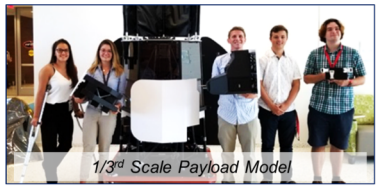

EMCCD Detector



Micromirror Array

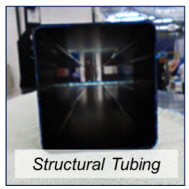

DM Interconnects

- WFIRST included in final FY19 appropriation
- NASA continuing work on WFIRST as planned
- Core survey science teams anticipated to be selected in 2021 by open competition
- All mission elements making excellent technical progress; expecting to go through Preliminary Design Reviews Jun-Oct 2019
- Mission being prepared for review to enter Implementation phase in early 2020

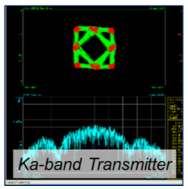

1/3rd Scale Payload Model

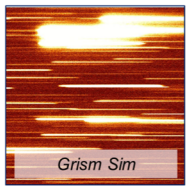
Spacecraft/Observatory

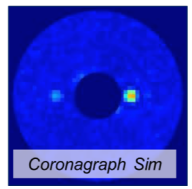
Science Preparation

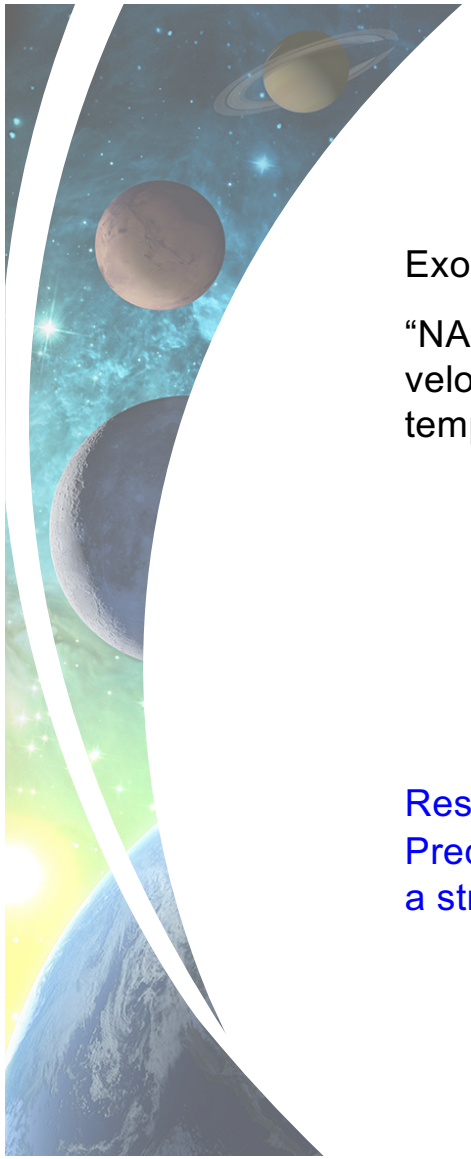

Structural Tubing


Flight Recorder


Ka-band Transmitter


Grism Sim


Coronagraph Sim



NASEM Exoplanet Science Strategy
Extreme Precision Radial Velocity Initiative

Exoplanet Science Strategy Recommendation:

"NASA and NSF should establish a strategic initiative in extremely precise radial velocities (EPRVs) to develop methods and facilities for measuring the masses of temperate terrestrial planets orbiting Sun-like stars"

- Combine efforts in instrumentation, survey execution, and data analysis techniques involving stellar astrophysics and heliophysics
- Undertake the coordinated, sustained effort to tackle the myriad of error terms that currently limit RV precision
- Assess ultimate goal to control systematics at ~1 cm/s, accounting for stellar variability and tellurics

Response: NASA and NSF have jointly commissioned a community-based "Extreme Precision Radial Velocity (EPRV) Working Group" (EPRV-WG) to develop a blueprint for a strategic EPRV initiative.

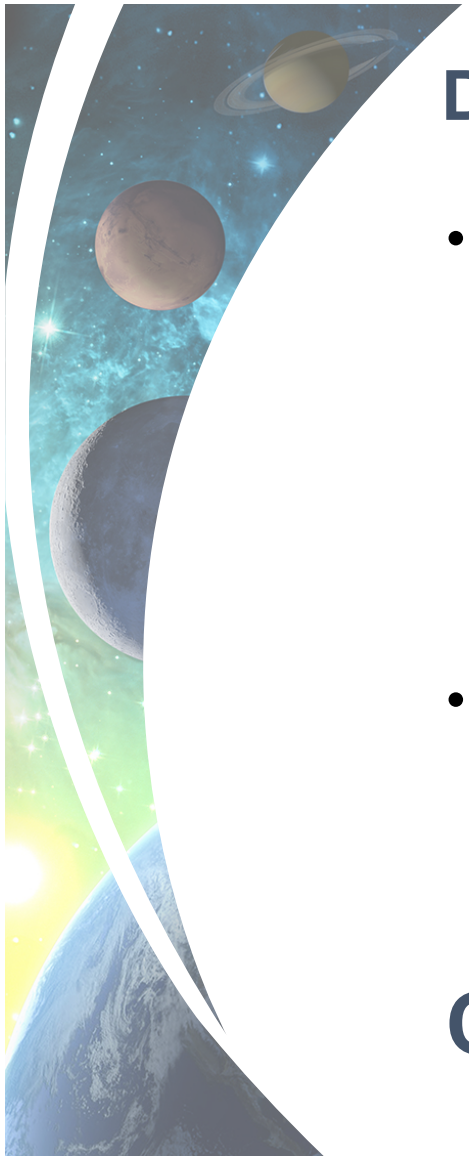
- Working Group formed, first in-person workshop June 13-14, 2019
- EPRV-WG to submit a candidate program architecture by Feb 2020 for consideration by Agencies during annual budget formulation process

Exoplanet Research Program (XRP)

Within ROSES-19, proposals submitted to the Exoplanet Research Program (XRP, E.3) will be selected jointly by all four divisions of SMD in caucus: Astrophysics, Planetary Sciences, Heliophysics, and Earth Sciences.

- Combines resources across the divisions to make greater strides more efficiently
- Encourages cross-cutting investigations that approach exoplanet research with fresh, broader perspectives
- Advances our understanding of exoplanetary systems and the Agency's strategic goals more effectively

NASA Astrophysics Preparation for 2020 Decadal Survey



Decadal Survey Planning

- NASA's highest aspiration for the 2020 Decadal Survey is that it be ambitious
  - The important science questions require new and ambitious capabilities
  - Ambitious missions prioritized by previous Decadal Surveys have always led to paradigm-shifting discoveries about the universe
- If you plan to a shrinking budget, you get a shrinking program.
  - Great visions inspire (and justify) great budgets.

Carpe Posterum – Seize The Future

Large Mission Concepts

"NASA should ensure that robust mission studies that allow for trade-offs (including science, risk, cost, performance, and schedule) on potential large strategic missions are conducted prior to the start of a decadal survey. These trade-offs should inform, but not limit, what the decadal surveys can address." – Powering Science: NASA's Large Strategic Science Missions (NASEM, 2017)

Why Flagships?

- Open new windows of scientific inquiry and answer many of the most compelling scientific questions
- Develop and deepen humanity's understanding of the universe
- Capture science data that cannot be obtained in any other way
- Provide new technology that can benefit future small, medium, and large missions
- Support the workforce, the industrial base, and technology development
- Maintain U.S. leadership in space
- Maintain U.S. scientific leadership
- Produce discoveries that capture the public's imagination and encourage science and technical careers
- Receive a high degree of external visibility, often representing NASA's science program as a whole
- Provide greater opportunities for international participation, cooperation, and collaboration

Preparing for the 2020 Decadal Survey Technology Development

HabEx

Starshade Petal Deployment Position Accuracy, Starshade Petal Shape and Stability, Large Mirror Fabrication, Large Mirror Coating Uniformity, Coronagraph Architecture, Low-order wavefront Sense/Control, Deformable Mirrors, Starshade Edge Scattering, Starshade Starlight Suppression and Modeling, Starshade Lateral Formation Sensing, Microthrusters, Laser Metrology, electron multiplication CCDs, near-IR avalanche photodiodes

LUVOIR

Coronagraph Architecture, Deformable Mirrors, LOWFS/OBWFS, UV & Red-enhanced EMCCDs, Mirror Segment Substrate, Mirror Segment Metrology, Picometer Rigid Body Actuators, Far-UV Broadband Coating, Active Dynamic Isolation, Thermal Sensing & Control, Ultra-stable System Architecture, Large-format CMOS Arrays, GaN Microchannel Plates, Next-generation Microshutter Arrays

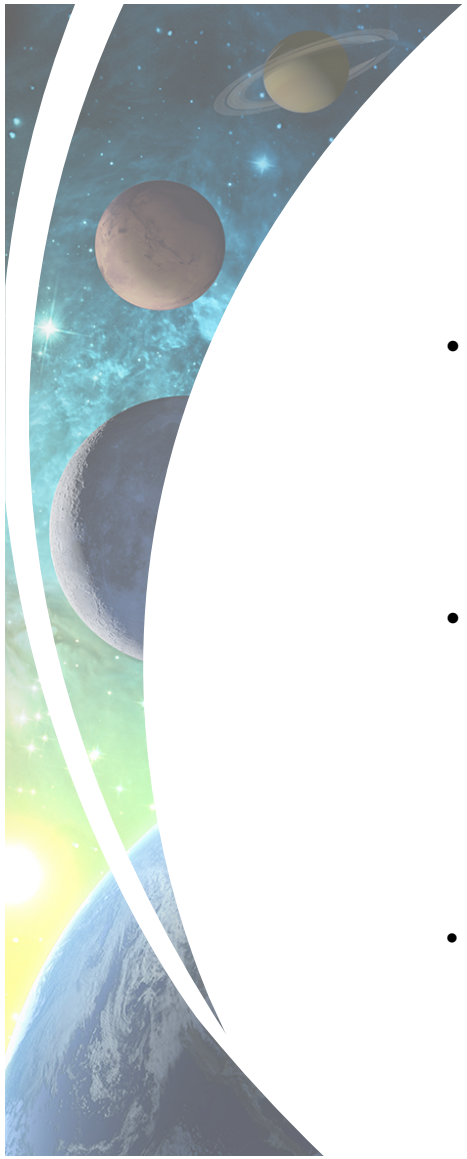
Lynx X-ray Surveyor

High-resolution, lightweight X-ray optics, low-stress X-ray reflecting coatings, megapixel X-ray imaging detectors, large-format, high resolution X-ray detectors, X-ray grating arrays

Origins Space Telescope

Far IR Detectors, Cryogenic Readouts for Far IR Detectors, Warm readout electronics for large format Far IR detectors, Mid IR detectors, Sub-Kelvin Coolers, 4.5 K cryocoolers

- Each study identified technology gaps and developed a technology maturation roadmap
- Most technology gaps are being addressed through NASA astrophysics technology development programs
- A well-planned technology roadmap and aggressive technology development reduces the risk for the next mission

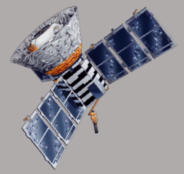
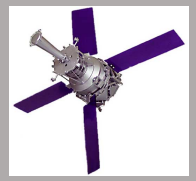
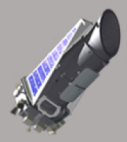


NASA Assessment: Large Mission Concept Studies

- NASA has assembled a Large Mission Concept Independent Assessment Team (LCIT) to conduct a technical, risk, and cost assessment of the four large-scale mission concept studies
  - The LCIT includes experienced technical and cost reviewers with expertise in large space missions and in science, instrumentation, and technology
- The purpose of the LCIT is twofold:
  - Provide feedback to the STDTs that can be used to improve the Final STDT Reports that will be presented to the Decadal Survey
  - Provide NASA Headquarters confidence in the science, technical, cost, and risk conclusions of the Final STDT Reports that will be presented to the Decadal Survey
- The Terms of Reference for the LCIT are posted at https://science.nasa.gov/astrophysics/2020-decadal-survey-planning

Medium Mission Concepts (Probes)

Probes have had a strong impact on some areas of astrophysics

COBE 11/89 NASA Strategic Explorer	EUVE 06/92 NASA Strategic Explorer	Rossi XTE 12/95 NASA Strategic Explorer	GP-B 04/04 NASA Strategic Mission	Fermi 6/08 NASA Strategic Mission	Kepler 3/09 NASA Discovery Mission
					
Cosmic Background Explorer	Extreme Ultraviolet Explorer	Ross X-ray Timing Explorer	Gravity Probe B The Relativity Mission	Fermi Gamma-ray Space Telescope	Kepler Space Telescope

Ten Probes are under study as input to 2020 Decadal Survey

Options for 2020 Decadal Survey

- Recommend specific probe(s) as medium-size strategic missions
- Recommend several specific concepts for an AO (New Frontiers)
- Recommend an unconstrained AO (Super-Explorer)

NASA Assessment: Probe Concept Studies

- NASA has requested GSFC and JPL's costing offices perform independent cost assessments of the Probe mission concepts that used the resources of their respective Centers
- In order to provide an independent, non-advocate assessment of the costing offices' results, NASA is assembling an independent Probes Concept Assessment Team (PCAT)
  - The PCAT will validate the cost estimates provided by the costing offices, the design labs, and the PI-led studies
  - The PCAT is composed of scientists and subject matter experts who will work with the costing offices and the study teams
- The purpose of conducting a cost and technical validation of the Probe mission concept studies is to provide NASA Headquarters confidence in the science, technical, cost, and risk conclusions of the Probe Mission Concept Reports that will be presented to the Decadal Survey
- The Terms of Reference for the PCAT are posted at https://science.nasa.gov/astrophysics/2020-decadal-survey-planning

Budget

FY19 Budget Appropriation

The FY19 appropriation (Feb 2019) provides an increased level of funding for NASA Astrophysics

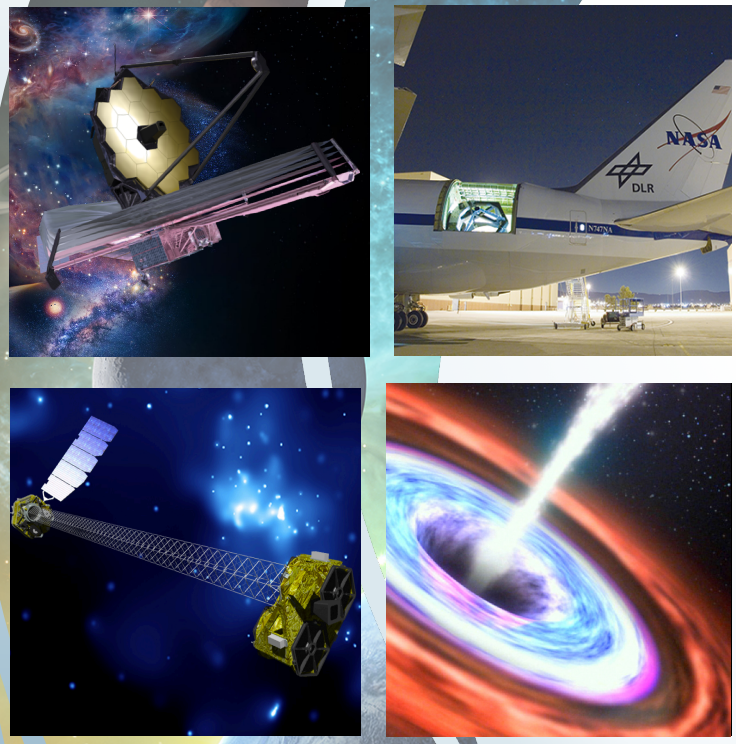
- Total appropriated funding for FY19 (Astrophysics including Webb) is ~$1.496B, an increase of $112M (8%) from FY18 appropriation
- Webb funded as requested at $305M, request submitted before 2018 replan
  - Webb is reauthorized at 2018 replan level of $8.8B for development
- WFIRST funded at $312M, proposed termination not supported by Congressional appropriation
- Hubble and SOFIA received appropriations above requested levels
  - NASA is prohibited from including SOFIA in the 2019 Senior Review
- All other programs supported as proposed

FY20 Budget Request

The FY20 President's Budget Request requests a decreased level of funding for NASA Astrophysics

Total funding requested for FY20 (Astrophysics including Webb) is ~1.197B, a decrease of $187M (14%) from the FY18 appropriation and a decrease of $299M (20%) from the FY19 appropriation

https://nasa.gov/budget



FY20 Budget Request

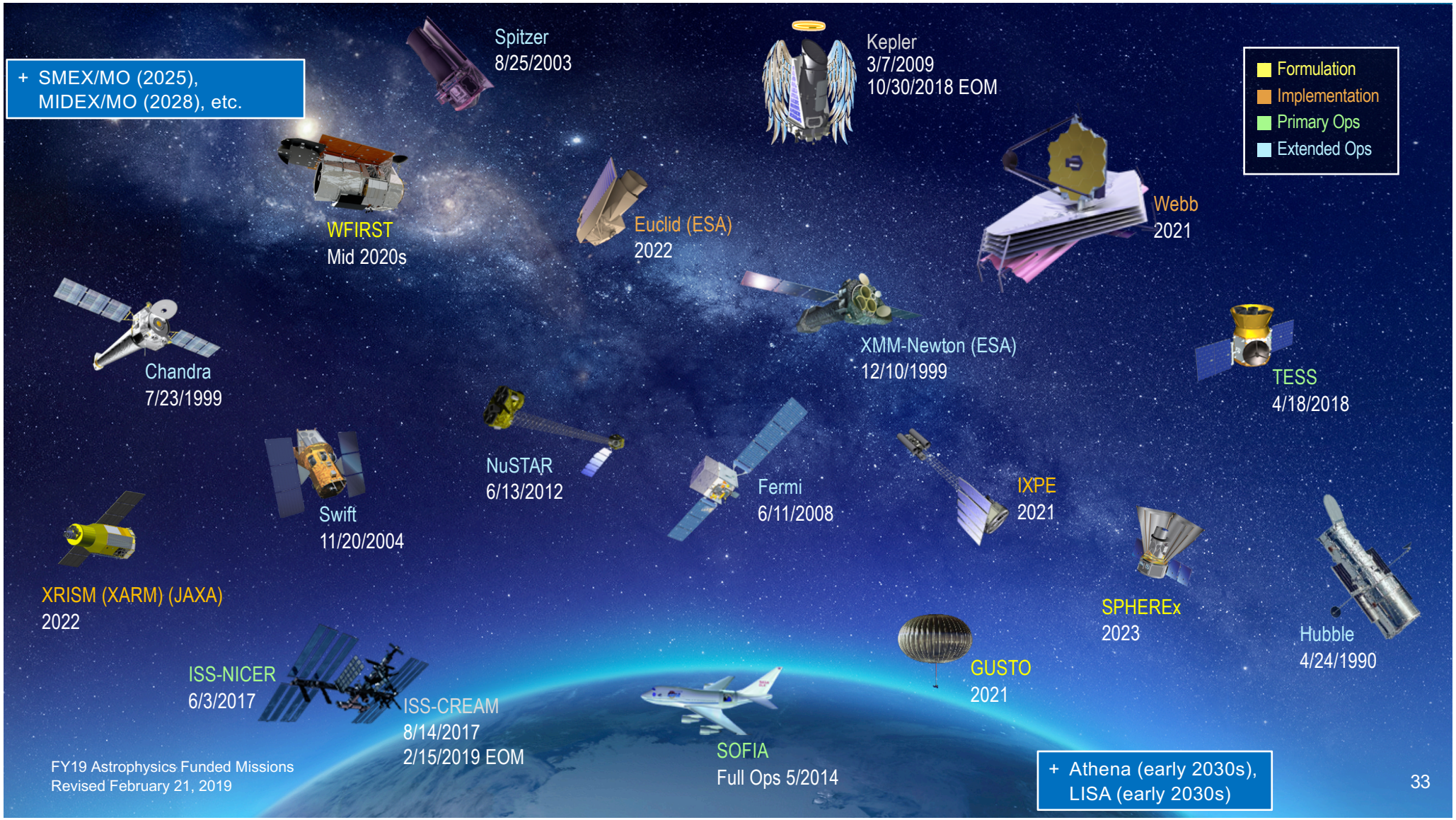
- Accommodates Webb replan to March 2021 LRD
- Given its significant cost within proposed lower budget for Astrophysics and competing priorities within NASA, WFIRST terminated with remaining WFIRST funding redirected towards completing Webb
- Supports formulation of a probe mission as early as 2022, 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 are underway 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

Congressional Markup of FY20 Budget Request

House Appropriations Committee 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 will mark up NASA's budget later (probably July)



FY19 Astrophysics Funded Missions
Revised February 21, 2019

Backup Slides

NASA Astrophysics Division

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Paul Hertz
Astrophysics Division Director

Jeff Volosin
Astrophysics Deputy Division Director (Acting)

ASTROPHYSICS
NASA's Science Mission Directorate

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SOFIA, GUSTO

Shahid Habib
COR, ExEP, PCOS Programs
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Astrophysics Operating missions

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WFIRST, XRISM

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Cross Cutting

Eric Smith
Astrophysics Chief Scientist
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Administrative Assistant

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Administrative Assistant

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Program Support Specialist

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Euclid, IXPE

Others Not Pictured:

- **Larry Petro**
- **Panayiotis Tzanavaris**

Astrophysics Program Abbreviations: ASM – Astrophysics Strategic Missions; COR – Cosmic Origins; ExEP – Exoplanet Exploration Program; PCOS - Physics of the Cosmos