National Aeronautics and Space Administration

EXPLORE SOLAR SYSTEM&BEYOND

NASA Town Hall

AAS 236th Meeting | June 1, 2020

Paul Hertz
Director, Astrophysics Division
Science Mission Directorate
@PHertzNASA

Slides posted at http://science.nasa.gov/astrophysics/documents

Outline

- Celebrate Accomplishments
  - Mission Milestones
- Committed to Improving
  - Inspiring Future Leaders
  - Research and Analysis Initiatives
- Research Program Update
  - Research & Analysis, Technology, Fellowships
  - ROSES-2020 Updates, including COVID-19 impacts
- Missions Program Update
  - COVID-19 impact
  - Operating Missions
  - Webb, Roman, Explorers
- Planning for the Future
  - FY21 Budget Request
  - Project Artemis
  - Supporting Astro2020
  - Creating the Future

NASA Events at the

Monday, June 1

115 NASA Town Hall – 1:40 pm EDT; Annie Jump Cannon Meeting Room

Tuesday, June 2

201 Dual-Anonymous Peer Review for NASA Astrophysics Proposals – 11:00 am EDT Annie Jump Cannon Meeting Room

216 STScI Town Hall – 1:40 pm EDT; Annie Jump Cannon Meeting Room

Wednesday, June 3

315 NASA-NSF Exoplanet Observational Research (NN-EXPLORE) Program at the WIYN Observatory – 2:50 pm EDT; Maria Mitchell Room

Monday, June 1 – Wednesday, June 3

Visit the NASA Virtual Booth in the Exhibit Hall

Exhibit webinars 10 times daily at
11:00, 11:30, 12:00, 1:30, 2:00, 2:30, 3:00, 3:30, 4:00, 6:00 EDT

NASA Astrophysics Division

ASTROPHYSICS
NASA's Science Mission Directorate

Division Director

Paul Hertz
Astrophysics Division Director

Jeff Volosin
Astrophysics Division Deputy Director

Program Executives

E. Lucien Cox
SOFIA, GUSTO, XRISM

Shahid Habib
COR, ExEP, PCOS
ARIEL, Athena, Euclid, LISA

Jeff Hayes
Astrophysics Operating Missions

David Jarrett
Roman

Mark Sistilli
Explorers Program
IXPE,SPHEREx
Balloons

Cross Cutting

Eric Smith
Chief Scientist
Webb

Jeanne Davis
Assoc Dir for Flight
ASM Program Manager

Mario Perez
Chief Technologist
SAT, RTF

Not Pictured

Lisa Wainio
Information Manager,
Public Affairs Liaison

Administrative Support

Kelly Johnson
Administrative Assistant

Not Pictured

Mathew Riggs
Administrative Assistant

Not Pictured

Jackie Mackall
Program Support Specialist

Ingrid Farrell
Program Support Specialist

Program Scientists

Dominic Benford
APRA Lead
Roman

Valerie Connaughton
APRA (High Energy)
XRISM

Dan Evans
PCOS Program
NICER
Dual Anon.PR

Michael Garcia
APRA (UV/Optical),
CubeSats/SmallSats
Hubble, Athena

Thomas Hams
APRA (CR, Fund. Phys.)
Rockets/Balloons
GUSTO, LISA

Hashima Hasan
Education/Comms
Citizen Science, Archives
Astro. Advisory Cmte.

Douglas Hudgins
ExEP Program
ADAP Lead
TESS, ARIEL

Stefan Immler
Astrophysics Research
Program Manager
Chandra, XMM

Patricia Knezek
Hubble Fellows
SOFIA

William Latter
APRA (Lab Astro)
Spitzer, SPHEREx, Fermi

Not Pictured

Pamela Marcum
Exoplanet Research
Program (XRP)

Aki Roberge
ASMP, Roman

Rita Sambruna
GSFC
(on detail)

Evan Scannapieco
ATP / TCAN Lead
FINNEST, Swift

Kartik Sheth
COR Program

Linda Sparke
Astrophysics Explorers Program

Eric Tollestrup
APRA (IR/Submm)
Euclid, IXPE

Not Pictured

Future

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

June 1, 2020

Join the Team at NASA Headquarters

One or more program scientists will be hired this summer

Job opening starting June 15 (planned) for 5 days at https://usajobs.gov

- Due to hiring authority used, applications will only be accepted during a 5-day window

AAS Job Register: https://jobregister.aas.org/ad/8d061472

Work as part of a diverse and agile team whose core values include excellence, integrity, transparency, teamwork and a growth mindset toward stewarding the nation's space-based astrophysics program

- NASA encourages applications from candidates with non-traditional career paths, or individuals who are at earlier stages of their careers may have demonstrated experience in different ways.

Candidates are encouraged to contact NASA so they can make a well informed decision on submitting an application during the very short (5 day) window when the job opportunity will be open for applications

Questions about this anticipated opening for an Astrophysics Program Scientist at NASA Headquarters may be directed to Eric Smith, Chief Scientist, Astrophysics Division, eric.p.smith@nasa.gov

NASA Astrophysics Celebrate Accomplishments

NASA Science Plan Released

Science 2020-2024: A Vision for Scientific Excellence at https://science.nasa.gov/about-us/science-strategy

- Implement recommendations of Decadal Surveys in concert with national priorities and needs through creative partnership models that go beyond traditional ways of developing and executing missions
- Challenge assumptions about what is technically feasibly and enable revolutionary scientific discovery through a deliberate focus on innovation, experimentation, and cross-disciplinary research
- Create a more collaborative culture within SMD and across science community, encouraging diversity of thought, sharing best practices, and informed risk-taking to improve operations
- Develop future leaders and inspire learners of all ages through new opportunities and hands-on experiences

Hubble Space Telescope at 30: Awesome
ies and Innovation", Jennifer Wiseman, Senior
roject Scientist (GSFC), AAS webinar: Monday
June 1 @ 2:00 pm EDT, Exhibit Hall

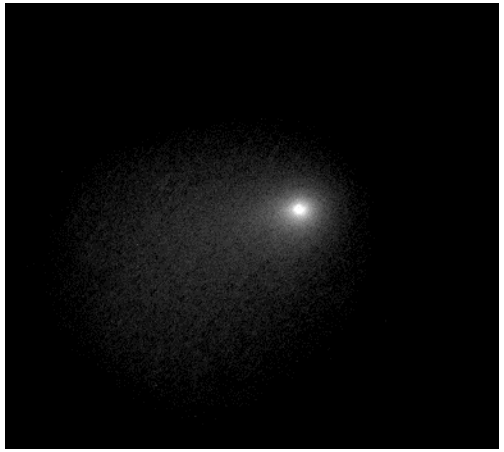
Next for Hubble?", Rachel Osten (STScI), AAS
Wednesday June 3 @ 2:00 pm EDT, Exhibit Hall

https://www.nasa.gov/content/hubbles-30th-anniversary

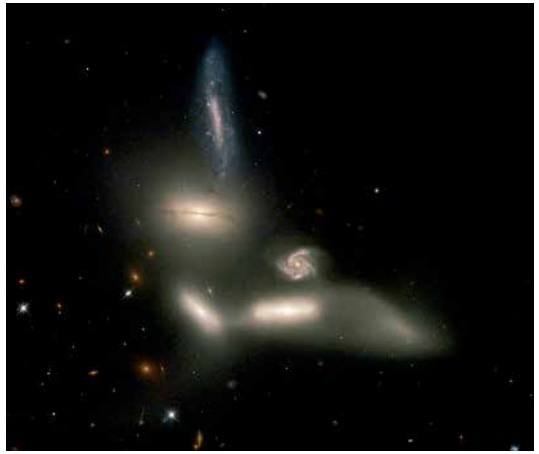
What did Hubble see on your birthday?

Galileo
Zwicky 18

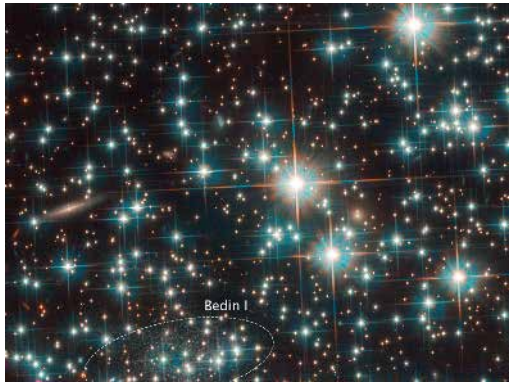
Edwin Hubble
Arp 148



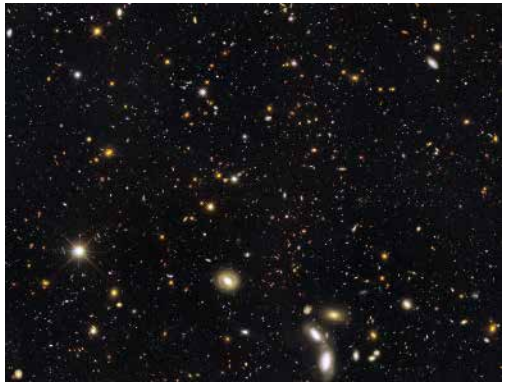
S. Chandrasekhar
Comet Siding Spring



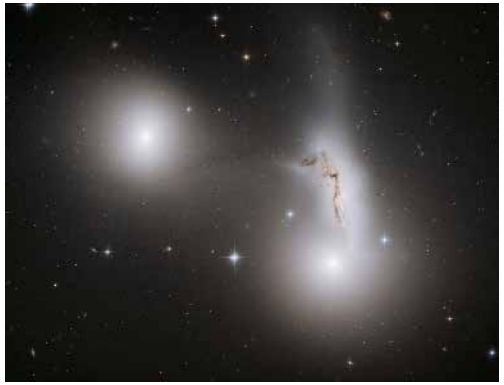
Lyman Spitzer
Seyfert's Sextet



Arthur Compton
NGC 6752



James Webb
GOODS South



Nancy Grace Roman
Hickson Group 90

Vera Rubin
Jupiter

https://www.nasa.gov/content/goddard/what-did-hubble-see-on-your-birthday

After 16.5 yrs of science exploration on the infrared cosmic frontier as one of NASA's Great Observatories, Spitzer ended its mission on Jan 30, 2020, 2:30 PST.

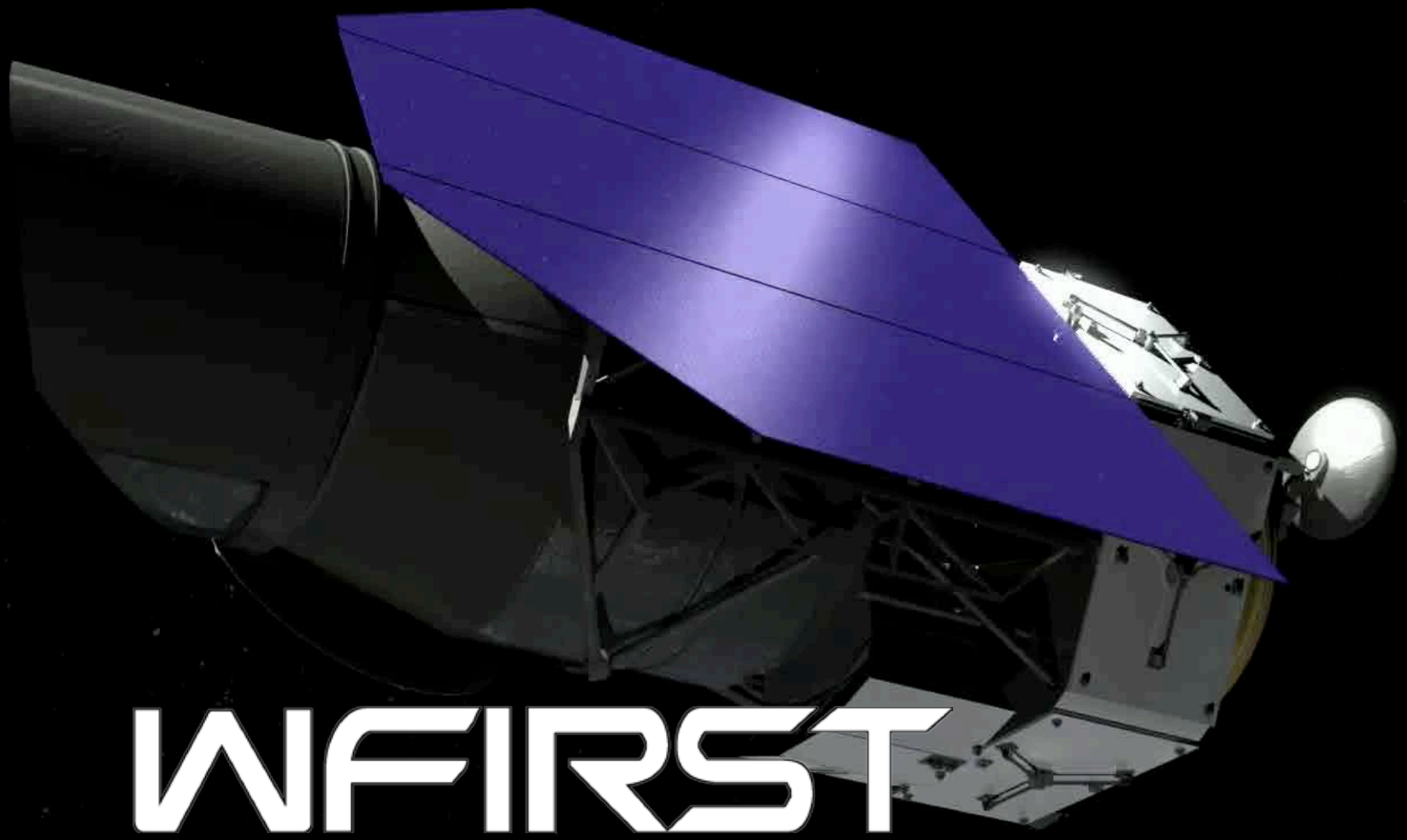
Engineering feats extended mission life post-cryo in 2009 and overcame challenges due to Spitzer's increasing distance from Earth.

Spitzer Space Telescope

Spitzer enabled discovery near and far, to the edge of the universe, yielding 8,800+ refereed papers.

- First detection of light from an exoplanet
- First detection of molecules in exoplanet atmospheres
- Measurement of star formation history of the Universe to z>2, looking back >10 Gyr
- Measurement of the stellar mass of the Universe to z>8, looking back ~13 Gyr

www.spitzer.caltech.edu/final-voyage


WFIRST

The NANCY GRACE ROMAN SPACE TELESCOPE

“Your Next Flagship: the Roman Space Telescope", led by Dominic Benford, Roman Program Scientist, AAS webinar: Monday June 1 @ 3:30 pm EDT, Exhibit Hall

COVID-19: Bottom Line Up Front

Operating Missions & Data Archives: All performing nominally

- Except SOFIA, which is currently not flying

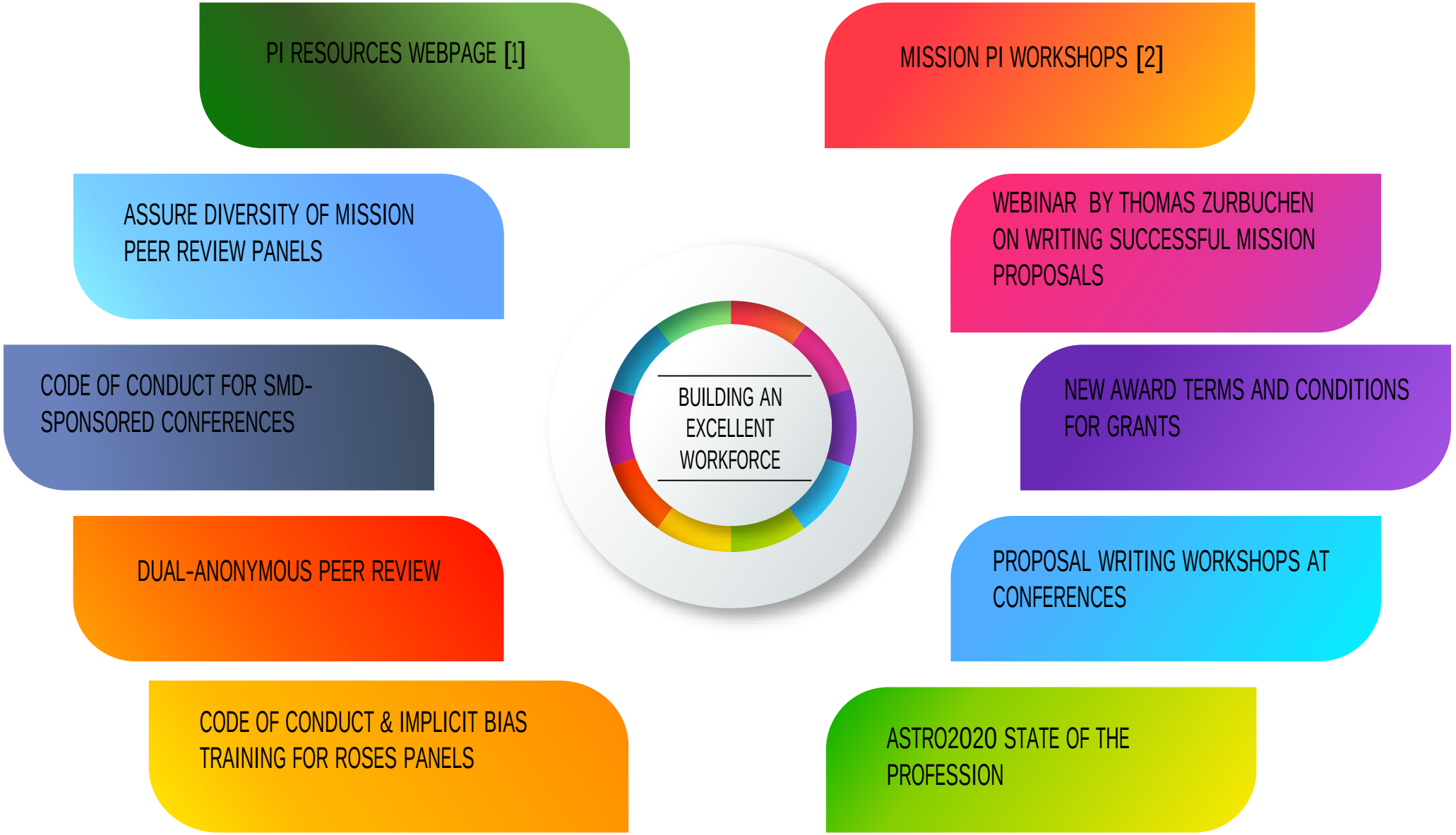
R&A: NASA continues to solicit, review, select, and fund ROSES and GO proposals through telework and virtual reviews

- OMB has provided Agencies with flexibilities to better support proposers and grantees, including soft money researchers and early career researchers
- ADAP-21 is cancelled, ADAP-20 is doubled
- XRP and TCAN proposal due dates are delayed

Missions in development: Each project is impacted differently

- Project teams are doing as much as they can virtually right now
- James Webb Space Telescope continues to be a priority
- Work on NASA missions is being restarted safely at NASA Centers on a case-by-case basis
- Many of NASA's contractors and partners have continued to work

NASA Astrophysics Committed to Improving



[1] https://science.nasa.gov/researchers/new-pi-resources [2] https://science.nasa.gov/researchers/pi-launchpad

Excellence through Diversity

Research shows that excellence of teams and diversity go hand-in-hand, especially in innovative activities

- Excellent teams require diverse opinions and perspectives, and foster a sense of community by encouraging healthy behavior through actions

Team size should match the work required and the skills needed

- Teams should be built with diversity in mind from the beginning, not as an afterthought

Change is hard. It happens incrementally, but it is important that we do what we can right now to tackle these issues

Inspiring Future Leaders

Achieve excellence by relying on diverse teams, both within and external to NASA, to most effectively perform SMD’s work

Attract and retain talent by promoting a culture that actively encourages diversity and inclusion and removes barriers to participation

Encourage development of future leaders, including the next generation of mission principal investigators, through targeted outreach and hands-on opportunities

Support early-career scientists to build careers working with NASA

Engage the general public in NASA Science, including opportunities for citizen scientists

Mission PI Development

Seek to increase the diversity of mission principal investigators and develop the next generation of mission leaders to ensure that new ideas and mission concepts are brought forward

NASA Science has:

Developed a consolidated PI resources webpage at https://science.nasa.gov/researchers/new-pi-resources, which also includes SMD presentation on lessons learned from past selections

Introduced a pre-reviews of mission peer review panels to ensure diversity and reduce conflicts of interest

Included career development positions and associated evaluation criteria as part of AOs

Held first “PI Launchpad”

Hosted “So You Think You Want To Be A NASA Mission PI” town halls

First PI Launchpad

Aimed at researchers and engineers who would like to submit a NASA space mission proposal in the next few years but don’t know where to start

https://science.nasa.gov/researchers/pi-launchpad

Nancy Grace Roman Technology Fellows

2019:
Regina Caputo, NASA GSFC (cosmic rays/gamma-ray)
Sarah Heine, MIT (optics and gratings for polarimeters)
Gregory Mace, UT Austin (optics and spectroscopy)

2018:
Manel Errando, Washington University, St. Louis
Adam McCaughan, NIST/Boulder
Varun Verma, NIST/Boulder

2017:
Abigail Vieregg, University of Chicago
Omid Noroozian, NRAO

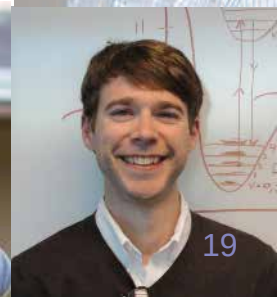
2016:
Erika Hamden, California Institute of Technology
Daniel Cunnane, NASA Jet Propulsion Lab
Eric Schindhelm, Southwest Research Institute

2015:
John Conklin, University of Florida
Brian Fleming, University of Colorado
Tyler Groff, Princeton University

2014:
Not solicited

2013:
Cullen Blake, University of Pennsylvania
Kevin France, University of Colorado

2012:
Judd Bowman, Arizona State University
Michael McElwain, NASA GSFC
Randall McEntaffer, University of Iowa



2020 NASA Hubble Fellows

How does the universe work?
Einstein Fellows

How did we get here?
Hubble Fellows

Are we alone?
Sagan Fellows

https://hubblesite.org/contents/news-releases/2020/news-2020-20
http://www.stsci.edu/stsci-research/fellowships/nasa-hubble-fellowship-program/2020-nhfp-fellows

NASA Hubble Fellowship Program

Fellows are asking for the assurance of parental leave and the option of saving for their eventual retirement with the assistance of their employer.

- Fellows who are employees of their host institutions typically have these benefits.
- Stipendiary fellows to do not receive employee benefits even though the NHFP is willing to pay the full cost of the employee benefits package.

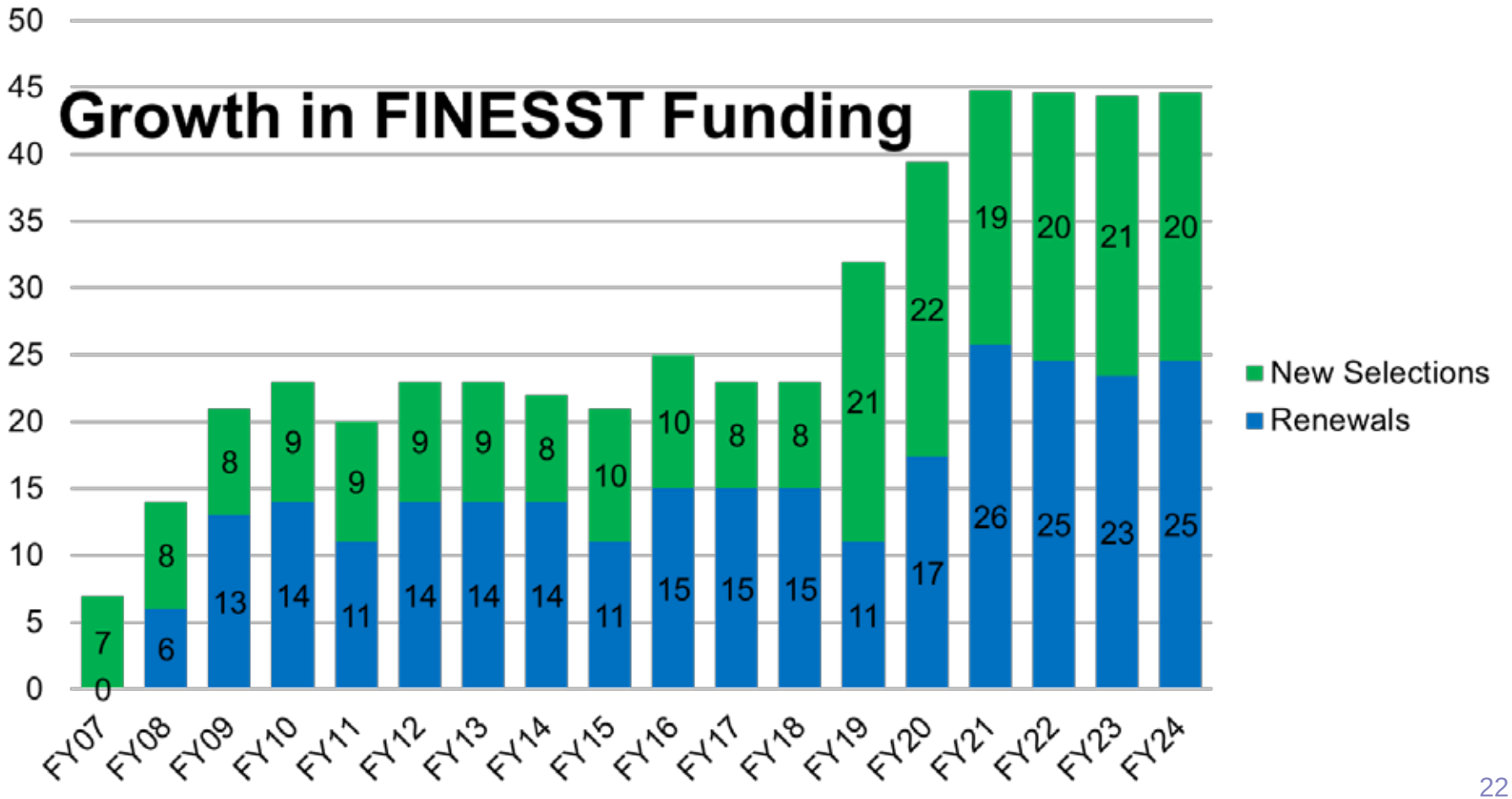
The Space Telescope Science Institute (STScI) has approved a change to the requirements for NHFP host institutions.

- Starting with academic year 2022-2023, host institutions must offer their NHFP Fellows the opportunity to be employees. Employee status is being required to afford NHFP Fellows the same leave, vacation, retirement and health benefits (as applicable) given by these institutions to their postdoctoral fellows hired on grants or contracts as employees.

Direct any questions or comments on this policy to nhfp@stsci.edu

Graduate Student Research Awards

NASA Earth and Space Science Fellowship (NESSF) program name changed to Future Investigators in NASA Earth and Space Science and Technology (FINESST) in 2019 to more accurately capture the nature of awards.



Research and Analysis Initiatives

Dual Anonymous Peer Review

- SMD is strongly committed to ensuring that review of proposals is performed in an equitable and fair manner that reduces the impacts of any unconscious biases [next chart]

High-Risk/ High-Impact (HR/HI)

- To reinforce SMD's interest in High-Risk/High-Impact research, a special review process will be implemented in ROSES 2020 to review and select HR/HI proposals

Proposal Selection Metrics for ROSES 2018

- Overall, just under 50% of selections featured new PIs
- Majority of division selection rates were between 25 – 30%, and we are continuing to evaluate

Dual-Anonymous Peer Reviews in Astrophysics

NASA is strongly committed to ensuring that the review of proposals is performed in an equitable and fair manner that reduces or eliminates unconscious bias.

To this end, motivated by a successful pilot program conducted for the Hubble Space Telescope, all Astrophysics General Observer / General Investigator (GO/GI) proposals will be evaluated using dual-anonymous peer review.

In addition, the NASA Science Mission Directorate will conduct pilot programs in dual-anonymous peer review for non-GO/GI ROSES program elements in 2020.

- One ROSES program element from each Division will be conducted in 2020 using dual-anonymous peer review.
- Proposals submitted to the Astrophysics Data Analysis Program and the Habitable Worlds Program in 2020 will be evaluated using dual-anonymous peer review.

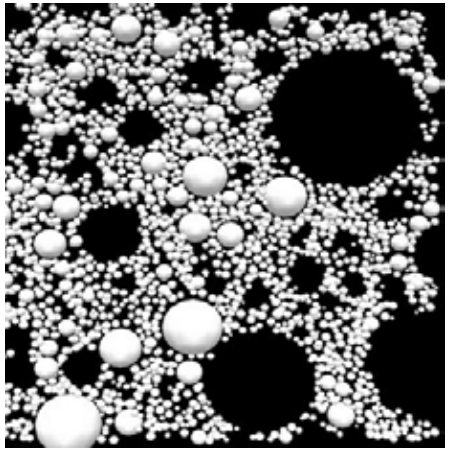
Dual Anonymous Peer Review
Special Session
Tuesday June 2 @ 11:00 am EDT
Annie Jump Cannon Meeting Room

https://science.nasa.gov/researchers/dual-anonymous-peer-review

Rollout of Dual-Anonymous Reviews

Format	Program	Proposal due date
Traditional	NICER Cycle 2	11/13/2019 R
Traditional	TESS Cycle 3	1/16/2020 R
Dual-Anonymous R	NuSTAR Cycle 6	1/24/2020 R
Traditional	Fermi Cycle 13	2/19/2020 R
Dual-Anonymous R	Hubble Cycle 28	3/4/2020 R
Traditional	Chandra Cycle 22	3/17/2020 R
Dual-Anonymous	ADAP	6/30/2020
Dual-Anonymous	Webb Cycle 1	TBD
Dual-Anonymous	Swift Cycle 17	9/25/2020
Dual-Anonymous	NICER Cycle 3	11/12/2020
Dual-Anonymous	TESS Cycle 4	1/15/2021
Dual-Anonymous	NuSTAR Cycle 7	1/22/2021
Dual-Anonymous	Fermi Cycle 14	2/19/2021
Dual-Anonymous	Hubble Cycle 29	~3/2021
Dual-Anonymous	Chandra Cycle 23	~3/2021

Strategic Data Management



- SMD will be implementing changes to enable open data, open source code, and open model
- Informed by community input through multiple workshops, RFI, and NASEM reports
- Recognize that this will be a step wise process with the first changes coming in ROSES 2020 and upcoming Senior Reviews
- Periodic evaluation to ensure effectiveness and consistency with current best practices
- Additional information on SMD's data activities is available at: https://science.nasa.gov/researchers/science-data

Why Volunteer to Serve on a NASA Peer Review Panel?

Personal professional development:

- See how the whole review process works
- Learn what constitutes excellent proposals
- Network with your professional colleagues and NASA scientific staff

Institutional achievement:

- Improve at competing for NASA money
- Increase knowledge of NASA's educational programs and research technology

Investment in the future:

- Help select the most transformative science
- Ensure that all proposals receive a fair and competent review

Sign up to be a panel reviewer:

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

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

NASA Astrophysics Research Program Update

Astrophysics Research by the NUMBERS

R&A PROGRAMS

>1,000 Proposals Received
26% Success Rate
~$100M Awarded Annually

TECHNOLOGY DEVELOPMENT

~$140M Invested Annually

CUBESATS

6 Current Programs
~1 Launch Per Year

NEW PIs

>180 Per Year in R&A Prog
>120 Per Year in GO Prog

SOUNDING ROCKETS

9 Current Programs
3-4 Launches Per Year

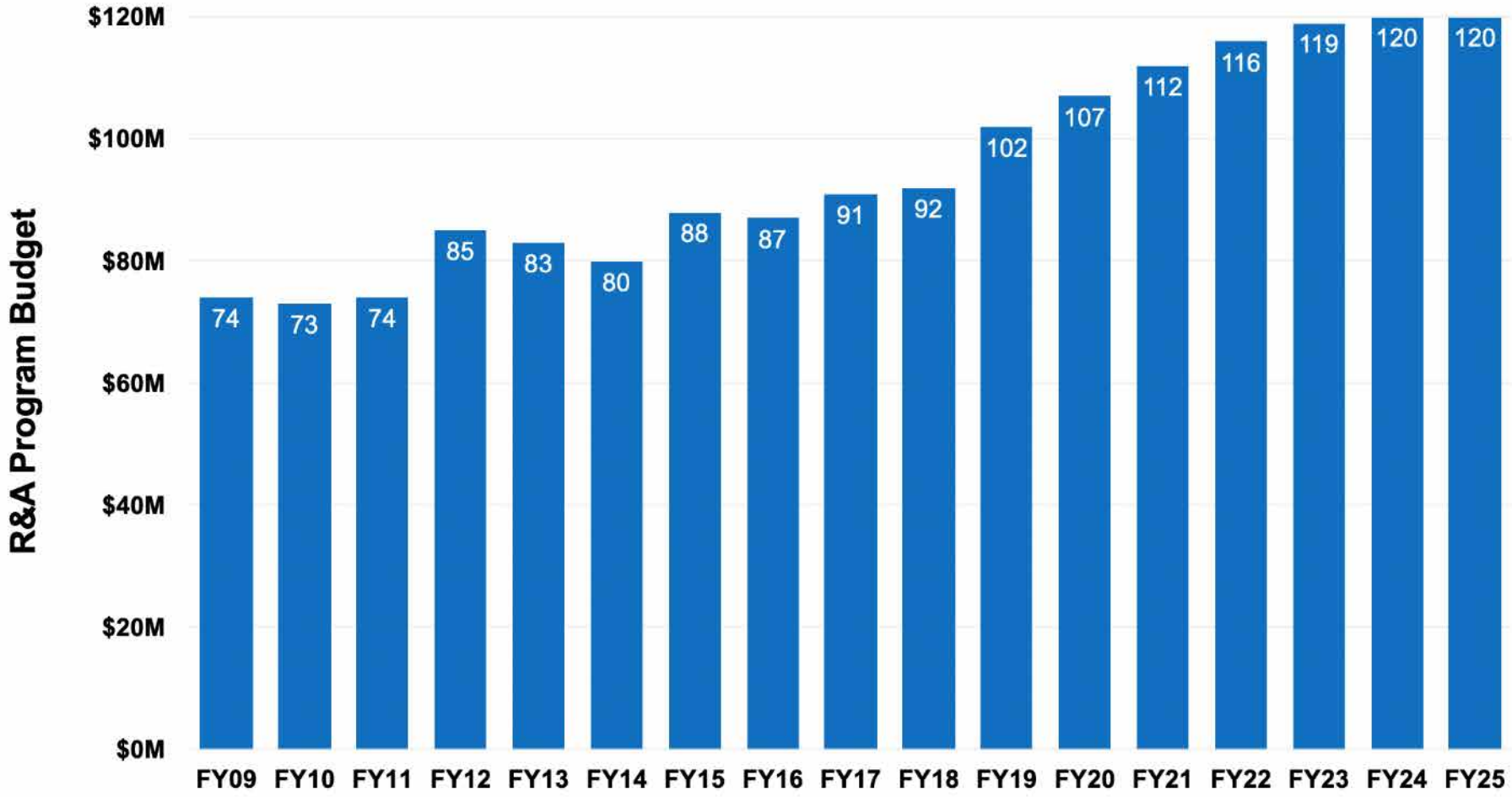
GO PROGRAMS

>2,000 Proposals Received
19% Success Rate
~$70M Awarded Annually

BALLOONS

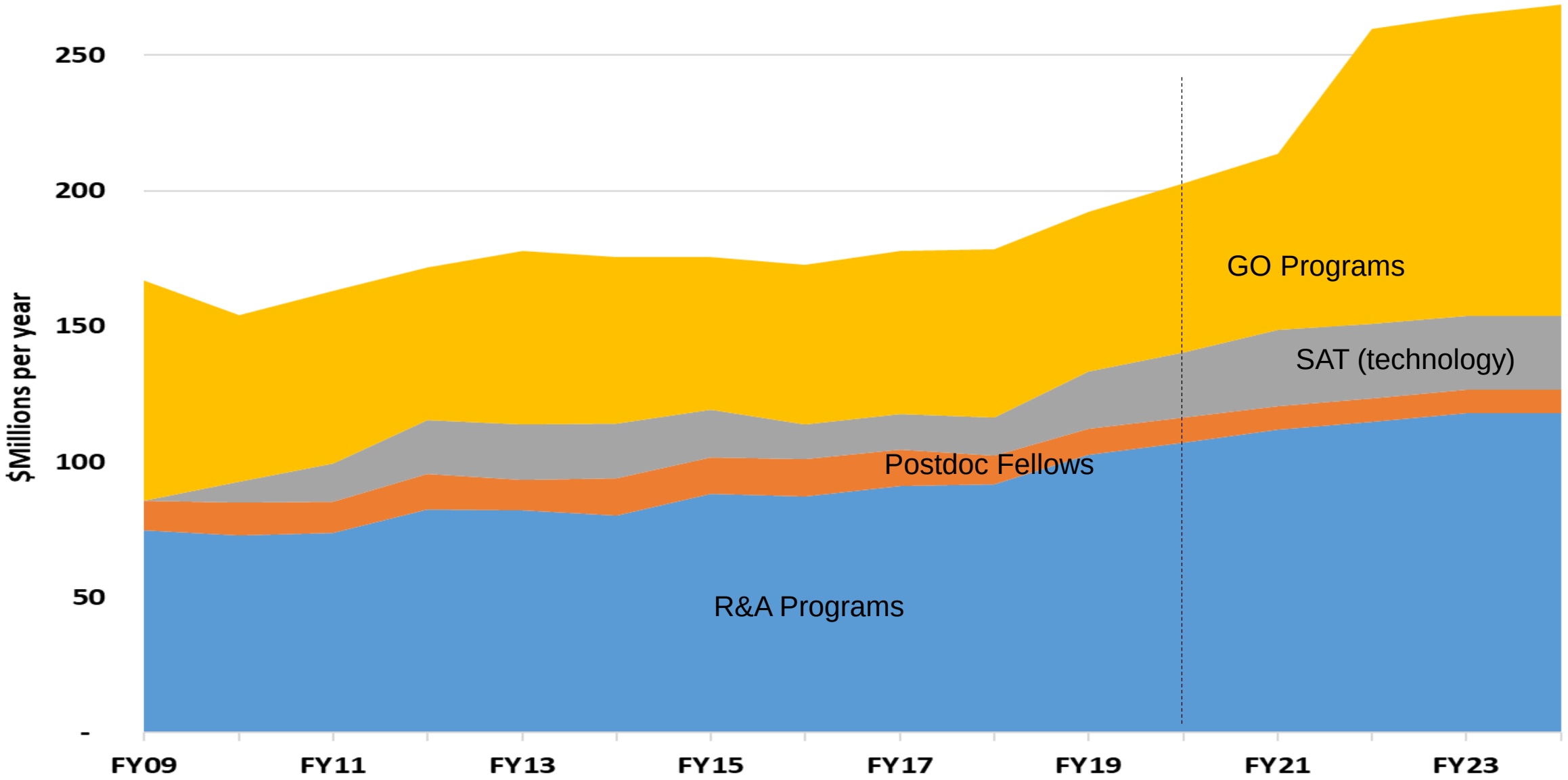
18 Current Programs
3-6 Launches Per Year

R&A Research Funding



- R&A research funding increases by 54% over 17 years.

Astrophysics Community Funding



ROSES-2020 Program Elements

Supporting Research and Technology

- Astrophysics Research & Analysis (APRA), includes Lab Astro equipment
- ~~Strategic Astrophysics Technology (SAT)~~ Canceled this year
- Roman Technology Fellowships (RTF)
- Astrophysics Theory Program (ATP) (biennial, not this year)
- Theoretical and Computational Astrophysics Networks (TCAN) (triennial, this year)
- Exoplanet Research Program (XRP) (cross-div)
- Topical Workshops, Symposia, and Conferences (TWSC)

Data Analysis

- Astrophysics Data Analysis (ADAP)
- GO/GI programs for:
  - Fermi
  - Swift
  - NuSTAR
  - TESS
  - NICER

Mission Science and Instrumentation

- Sounding rocket, balloon, cubesat, and ISS payloads solicited through APRA
- XRISM Guest Scientists
- LISA Preparatory Science
- Astrophysics Explorers U.S. Participating Investigators (triennial, this year)
- Astrophysics Pioneers

Separately Solicited

- GO/GI/Archive/Theory programs for:
  - Chandra
  - Hubble
  - SOFIA
  - Webb
- NASA Hubble Fellowship Program
- NASA Postdoctoral Program
- FINESST Graduate Student Research Awards

New in ROSES-2020:

- SAT canceled in anticipation of the 2020 Decadal Survey
- Lab Astro equipment in APRA (see separate slide)
- Exoplanet Research Program consolidates exoplanet proposals (see separate slide)
- Astrophysics Pioneers (see separate slide)
- Astrophysics participates in cross-divisional TWSC
- XRISM Guest Scientist Program (one time)
- LISA Preparatory Science (one time)
- Astrophysics Explorers U.S. Participation Investigators (APEX USPI)
- Data Management Plan will be evaluated as part of the intrinsic merit of proposals

R&A Accommodation due to COVID-19

SMD is finalizing a process to provide limited adjustments to existing grants. Not all grants can be made whole, however

- The focus will be on mitigating the impacts of the COVID-19 epidemic on the most vulnerable of us: graduate students, post-docs, and early career researchers in soft money positions
- SMD does not want the COVID-19 epidemic to massively derail the careers of future leaders
- Details will be made public by the end of June

SMD is considering options for helping SMD-funded, recently graduated PhDs and post-docs whose appointments are ending to weather the expected freeze in hiring by many research institutions

Review panels have all been converted to virtual events and are functioning well albeit in many cases taking longer than originally planned

- This will be the norm until at least September

R&A Accommodation due to COVID-19

OMB has issued guidance; NASA has instituted a number of grant administration flexibilities to ease the burden on grant recipients during the COVID-19 emergency.

- Allows NASA to remove barriers for faster funding of grantees
- Allows for paying soft-money researchers as well as graduate students, post-docs, and other lab staff during the COVID-19 epidemic, if the institution's own policies allow for it
- Allows for institutions to charge restart costs to their grants
- Provides agencies flexibility with regard to the submission of proposals, including accepting late proposals

FAQs to help you navigate:

- SMD COVID-19 Grants FAQ: https://science.nasa.gov/researchers/sara/library-and-useful-links
- NASA FAQ on Grants and Research during the COVID-19 Epidemic: https://www.nssc.nasa.gov/grants
- OMB guidance in Memo M-20-17: https://www.whitehouse.gov/wp-content/uploads/2020/03/M-20-17.pdf
- NRESS Virtual Panel Meetings Support: https://nspires.nasaprs.com/tutorials/infoPage/virtualSupport.html

Watch the NSPIRES email lists for up-to-the-minute changes in due dates or policies

R&A Accommodation due to COVID-19

R&A management at NASA HQ continues via telework

No ROSES-20 astrophysics solicitations have been canceled due to COVID-19

ADAP will not be offered in 2021 to reduce the community workload next year as we recover from the impacts of COVID-19

Two ROSES-20 solicitations (TCAN, ADAP) have moved proposal due dates into late June to provide proposers additional preparation time

Five Astrophysics R&A peer reviews have already been conducted as virtual reviews since March, with no adverse effect on quality of reviews

All peer reviews until at least September are being conducted virtually

Astrophysics Data Analysis Program

ADAP will not be offered in 2021 to reduce the community workload next year as we recover from the impacts of COVID-19: focus our efforts without reducing opportunity space

- All of the funding planned for selections in both 2020 and 2021 will be committed in 2020 – no reduction in funding to the community
- The number of selected proposals will approximately double
- This allows more awardees to be assured of funding this year
- This reduces the work for both NASA and the community without reducing the opportunity space for community funding
- No change to plan for ADAP to be dual anonymous this year

Proposals due June 30, 2020

Community comment is sought

- COPAG conducted a survey (https://forms.gle/hyrxTzHi8z5UCQGP8 by June 5)
- APAC will discuss at their June 23-24 meeting

Lab Astro Equipment Initiative

Updating and maintaining existing laboratories is a critical need:

- New science requires new and improved laboratory systems.
- The number, complexity, and energy range of NASA lab astro programs and their associated data needs continue to grow.

Starting in ROSES-20, a new Lab Astro Equipment Initiative provides additional funding to support lab equipment proposals.

- This initiative is not intended to support building of new complete labs. The goal is to:
  - Enable new science with new equipment
  - Replace and/or upgrade failing equipment
- Proposals that request Lab Astro equipment upgrades can be submitted through APRA with proposals due on December 17
  - ROSES-20 D.3 APRA will be amended within the next few weeks

Exoplanet Research Program Consolidation

Purpose: combine skills and disciplines from across divisional boundaries and scientific cultures to make the most impact upon strategic and solicited exoplanet science

- Starting in ROSES-20, the scope of Astrophysics ROSES Appendix D is changing to exclude exoplanet research elements from ADAP, ATP, and the Lab Astro component of APRA. Technology development within APRA will not be affected.
- Historical levels of APD exoplanet research funded through ADAP, ATP, and APRA will be maintained, but distributed through XRP.
- In addition to Planetary Science Division, Heliophysics Division and Earth Science Division are now financial partners in XRP, increasing the total funding available to the program.
- As a result, the funding allocation for XRP increases substantially

FY20	FY21	FY22	FY23
$8.9M	$10.2M	$11.6M	$12.7M
	+15%	+30%	+43%

Citizen Science

Citizen Science (CS) is a form of open collaboration in which individuals participate voluntarily in the scientific process

Current projects at https://science.nasa.gov/citizenscience

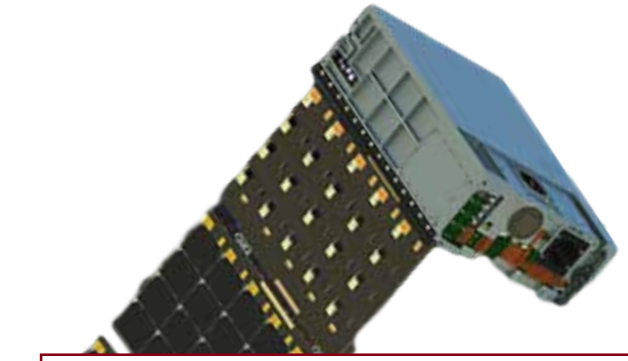
Proposers to any ROSES program element may incorporate citizen science and crowdsourcing methodologies into proposals, where such methodologies advance the proposed investigation

NASA Citizen Science Community Workshop series online every other Wednesday until September 30, 2020, at https://nasacitsci2020.gmri.org/home

NASA's Astrophysics, Heliophysics, and Planetary Science Divisions will release a joint ROSES-20 program element for a Citizen Science Seed Funding Program to fund prototyping of citizen science projects relevant to the three Divisions

NASA Astrophysics CubeSats

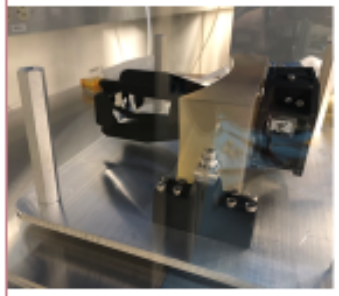
The Astrophysics Division is investing approximately $5M per year in a CubeSat initiative.



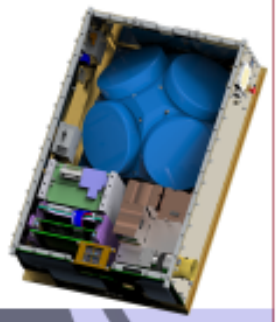
- **HaloSat,** PI: Phil Kaaret, U. Iowa
- **Science Objectives:** HaloSat is mapping soft X-ray oxygen line emission across the sky in order to constrain the mass and spatial distribution of hot gas in the Milky Way.
- **Technologies:** BCT S/C, COTS detectors, collimators with no optics.
- **Deployed**: Jul 13, 2018, from ISS

Astrophysics CubeSats in Development

- **CUTE, PI**: Kevin France, CU
- **Science Objectives:** The Colorado Ultraviolet Transit Experiment (CUTE) will take medium resolution UV spectra of 14 hot Jupiters during transit, in order to measure atmosphere being ablated away.
  Technologies: BCT S/C, COTS telescope and camera.
- **Launch**: 2021 on LandSat-9

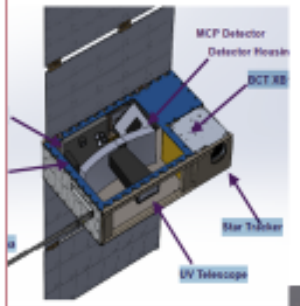


- **BlackCat, PI**: Abe Falcone, Penn St.
- **Science Objectives:** GRB/Transient detection in 0.2-20keV with coded mask.
- **Technologies:** CMOS x-ray CCD
- **Launch**: FY2024



- **BurstCube, PI:** Jeremy Perkins (GSFC)
- **Science Objectives:** Rapid localizations for LIGO/Virgo detections with short GRBs; Search of g-ray transients.
- **Technologies:** Dillingr derived bus, Fermi-GBM like detectors.
- **Launch**: Fall 2021

- **SPRITE, PI**: Brian Fleming, CU
- **Science Objectives:** Determine ionization rate of IGM from galaxies and AGN, trace feedback within galaxies driven by star-forming regions, using low-resolution imaging UV spectrograph.
- **Technologies:** in house S/C, UV coatings, next-gen MCP.
- **Launch**: Fall 2022



CubeSat proposals may be submitted to APRA, due date December 17

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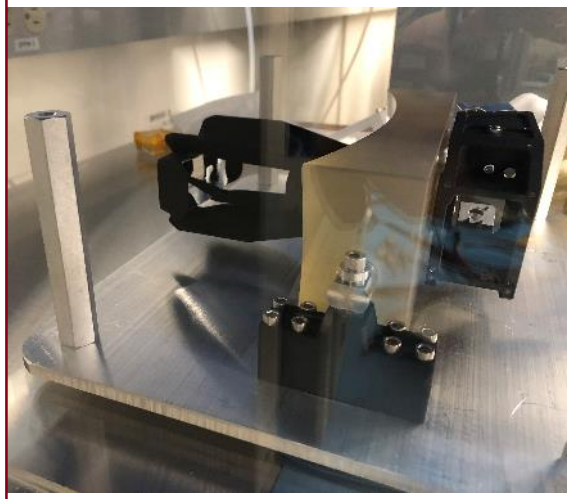

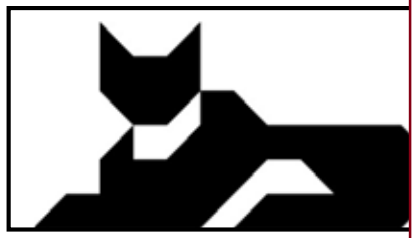

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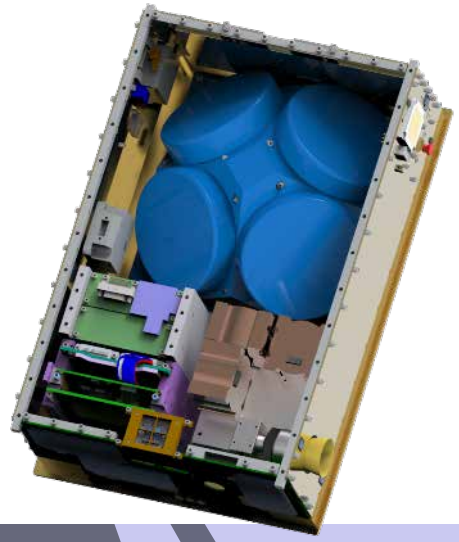

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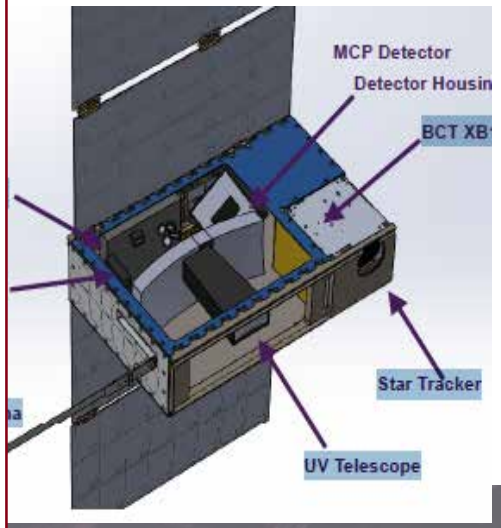


Astrophysics Pioneers

The FY21 President's Budget Request contains a new initiative for Astrophysics – Astrophysics Pioneers: A new class of small missions

Fills the gap between existing ROSES investigations (<$10M for APRA) and existing Explorers MO investigations (<$35M for SmallSats)

- Includes SmallSats, Large CubeSats (> 6U), CubeSat constellations (all as rideshare/secondary payloads), major balloon missions, and ISS attached payloads with a $20M cost cap, not including launch
- Managed as Research and Analysis projects with enhanced oversight, defined gates, and light touch management from NASA, rather than flight project processes appropriate for a SMEX
- NASA will no longer solicit ISS attached payloads within APRA
- NASA will no longer solicit balloon payloads within Explorers MO

Draft released May 14, Comments due June 15 via email to Michael.R.Garcia@nasa.gov

Astrophysics Technology Program Elements

Technology Inception & Experimentation APRA/RTF

- 46 projects awarded in 2019
- Solicitations planned in FY20, delayed 9 months
- Average award: $600K (3-5 years)
- Average selection rate: 28%
- Portfolio:
  - Supporting 19 Balloons and 10 Sounding Rockets Payloads
  - Detectors across wavelengths
  - Mirrors, coatings and gratings

Total: $50 M per year

Technology Maturation SAT & ISFM

Unified solicitation and selection starting in FY19 for the three Astrophysics themes. Portfolio has 49 active projects for a total of $28 M per year.

- 12 new projects awarded in FY19
- Next solicitation planned in FY20, currently TBD
- Average award: $1.6M (3 years)
- Average selection rate: 30% (in FY19, historically is 29%)

Directed Technologies

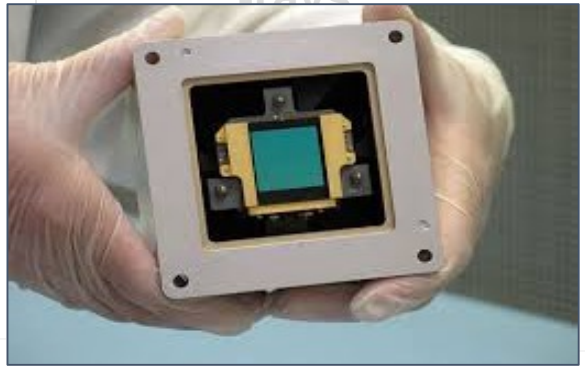
- Roman Coronagraph
- Exoplanets Probes: Exo-C & Exo-S
- LISA
- Athena
- Euclid
- NN-Explore – NEID
- SmallSats and CubeSats

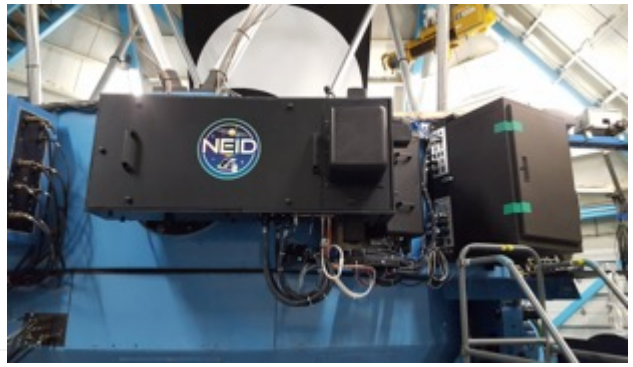
Total: $85 M in FY19

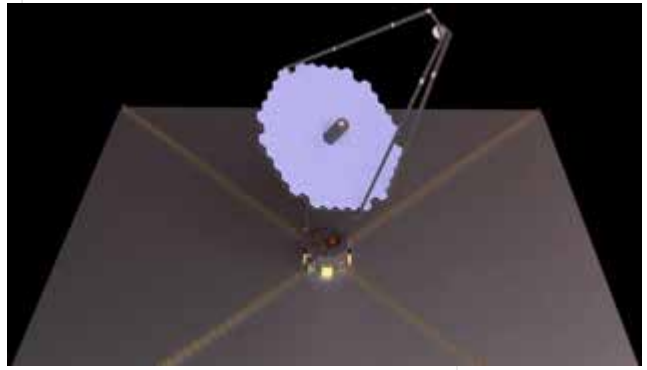
Pre-Decadal Initiatives

- In-Space Assembled Telescope (iSAT)
- Coronagraph and UltraStable Testbeds
- Starshade Technology
- Four Large Mission Concepts – Technology Roadmaps
- Ten Probe Mission Concepts
- Segmented Mirror Telescope Program (STMP)

Total: $25 M in FY19







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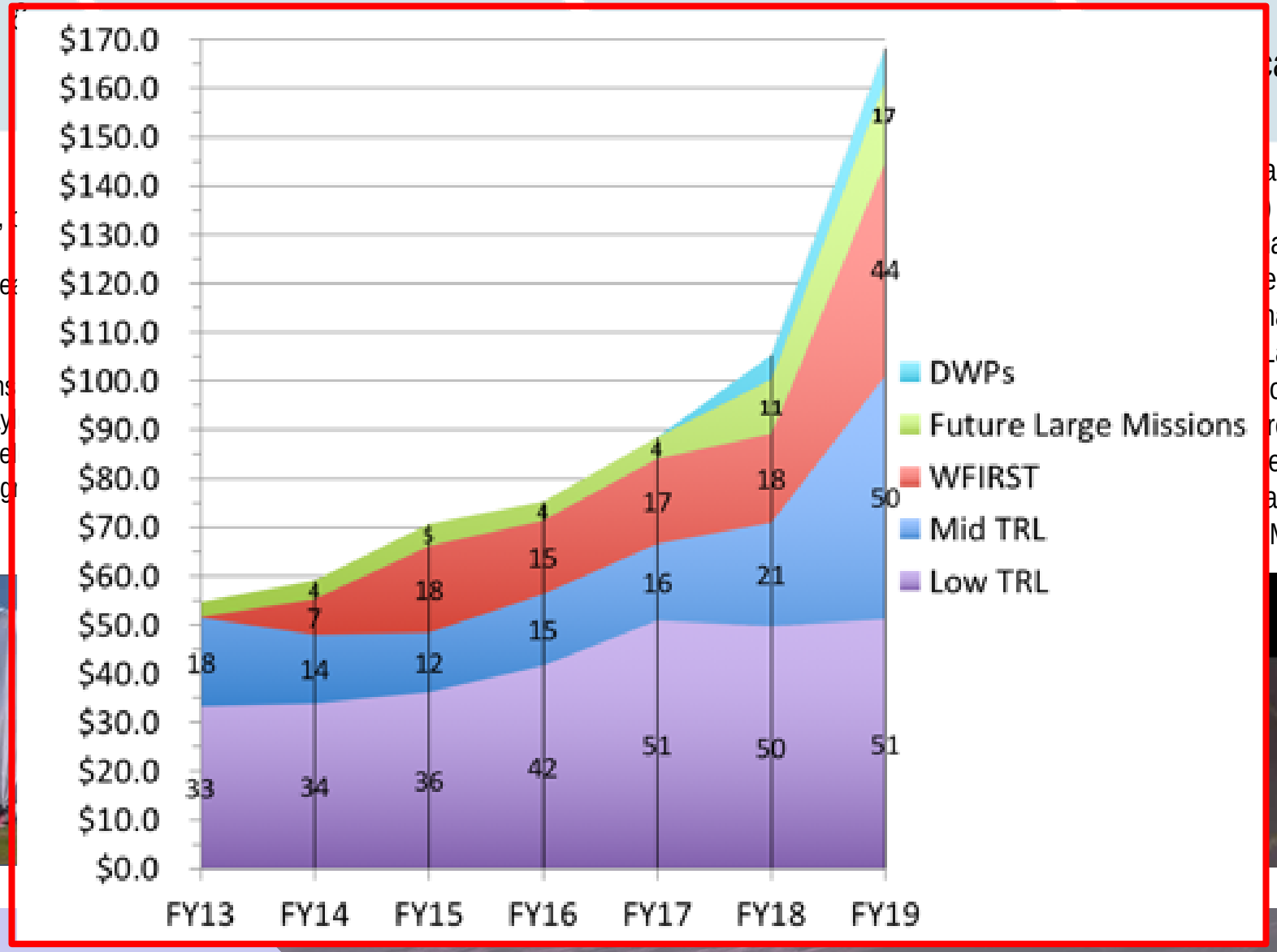

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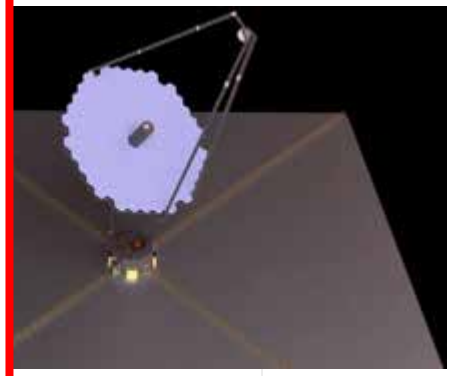
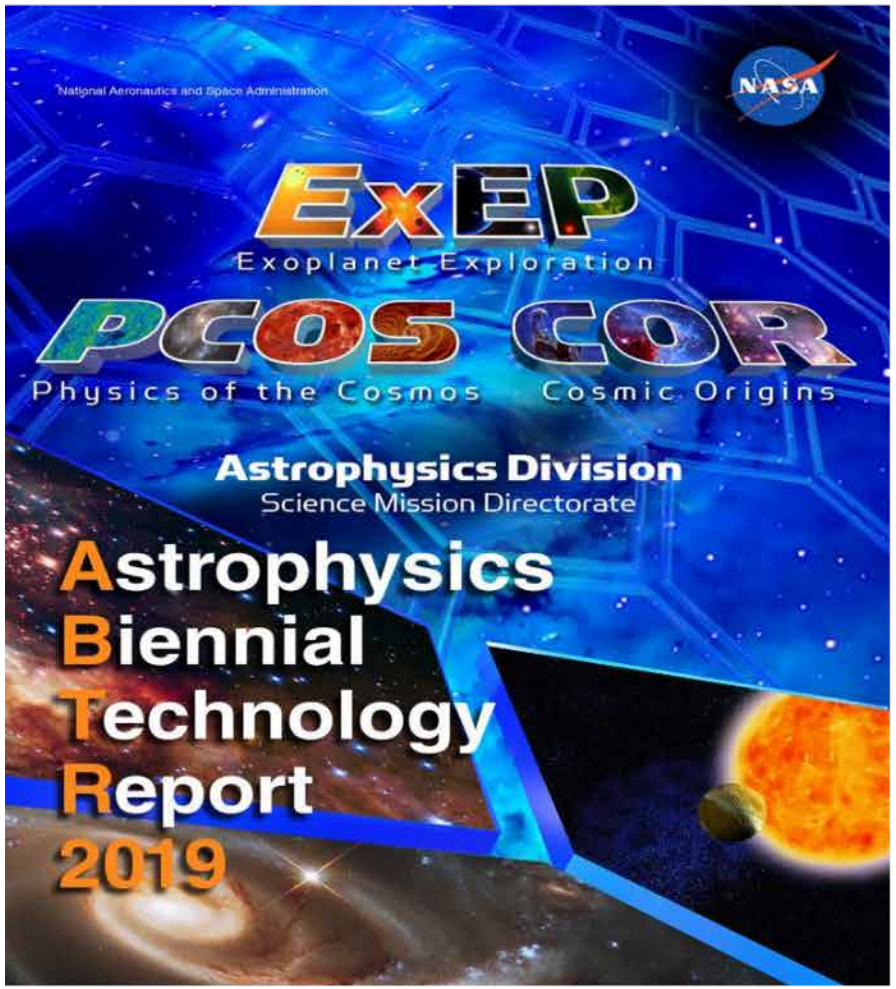
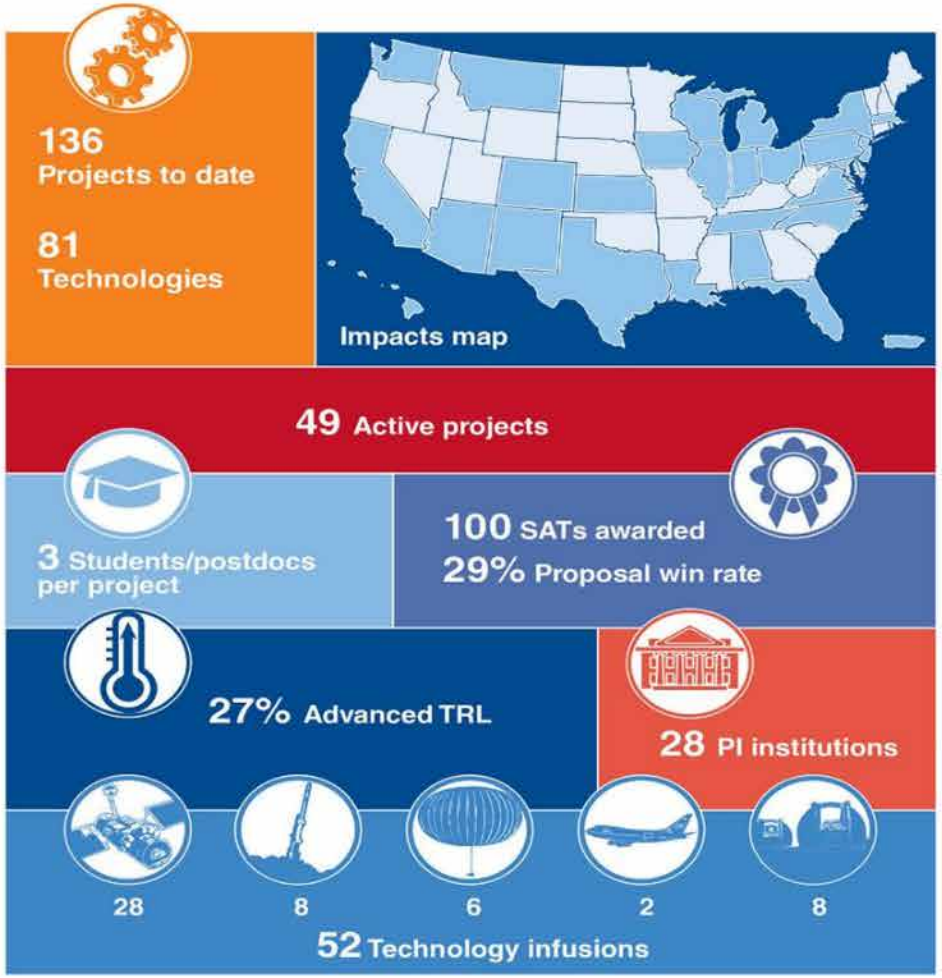


Integrated Strategic Technology Portfolio





Astrophysics Biennial Technology Report: https://apd440.gsfc.nasa.gov/technology.html

Database of Astrophysics technology projects: http://www.astrostrategictech.us/

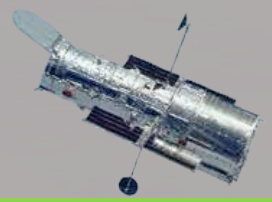
NASA Astrophysics Missions Program Update

Coronavirus (COVID-19) Response – Missions

- Missions in operation continue nominally
  - Most MOC and SOC staff working virtually
  - SOFIA currently grounded, but planned maintenance has resumed
  - Space Communications Program continues to support uplinks/downlinks and has a plan in place if local conditions at network sites affect communications capabilities
- Missions in development are doing as much as they can virtually right now
  - Suspended most hands-on work within NASA, including suborbital research
  - Work is being restarted at NASA Centers on a case-by-case basis when it can be done safely
  - Many of NASA's contractors and partners have continued to work safely
- Prioritizing Mars 2020 as it is close to launch
  - James Webb Space Telescope also continues to be a priority
  - Although the NASA portion of the NASA/NGSS team returned home mid-March, and I&T at NGSS had reduced shifts, NASA staff have now returned to NGSS and two shifts will be started soon; Observatory I&T continues making progress

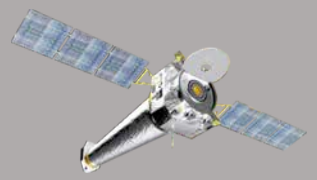
Astrophysics Operating Missions

Hubble 4/90
NASA Strategic Mission



Operations Nominal

Chandra 7/99
NASA Strategic Mission



Operations Nominal

XMM-Newton 12/99
ESA-led Mission

Operations Nominal (ESA)

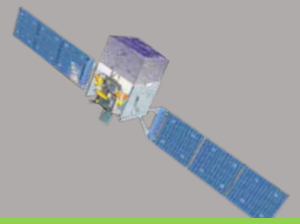
Spitzer 8/03
NASA Strategic Mission

Mission Complete!

Gehrels Swift 11/04
NASA MIDEX Mission

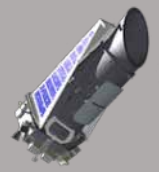
Operations Nominal

Fermi 6/08
NASA Strategic Mission



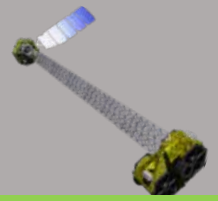
Operations Nominal

Kepler 3/09
NASA Discovery Mission



Mission Complete!

NuSTAR 6/12
NASA SMEX Mission



Operations Nominal

SOFIA 5/14
NASA Strategic Mission

Operations Suspended

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

Operations Nominal

TESS 4/18
NASA MIDEX Mission

Operations Nominal

Data Archives
HEASARC, IPAC, MAST, etc.

Operations Nominal

TESS

Transiting Exoplanet Survey Satellite

https://tess,gsfc.nasa.gov

Observation Sector 25
Orbit 57: May 14 - May 26
Orbit 58: May 27 - June 8

47 confirmed planets
1837 planet candidates

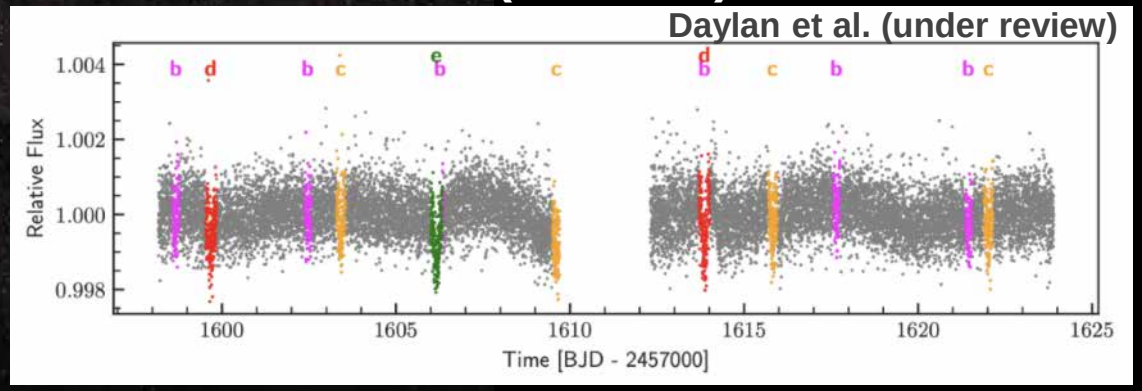
280 publications submitted, 214 peer-reviewed
(53% exoplanets, 47% astrophysics)

Last update: May **22**, 2020

Four-planet system orbiting a bright Sun-like star

HD 108236 (TOI-1233)

Daylan et al. (under review)

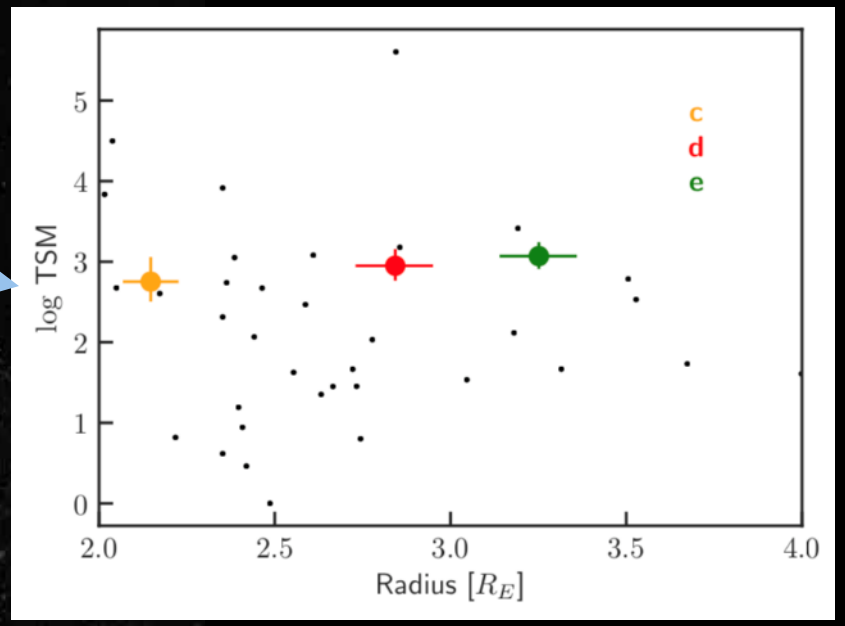


Brightest sun-like star to host 4 transiting planets. Three outer planets are among the best JWST sub-Neptunes for spectroscopy:

Transmission Spectrum Metric TSM

High TSM = great JWST target

Daylan et al. (2020)



SOFIA Stratospheric Observatory for Infrared Astronomy

SOFIA began its extended mission in October 2019, and suspended flight operations in March 2020 due to COVID-19

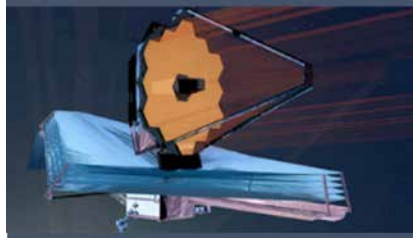
SOFIA Project has implemented major initiatives to improve scientific productivity and impact

- Legacy programs are larger fraction of the total observing time
- Two legacy programs scheduled in Summer 2020 from New Zealand
- Joint project and synergies implemented with other NASA missions and observatories:
  - Mapping water on Moon in support of VIPER/Artemis mission
  - SOFIA Cycle 9 to support JWST ERS programs
  - Joint Hubble-SOFIA pilot demonstration program (exploring)
  - Joint Green Bank Observatory – SOFIA proposals (under final review)
- More strategic use of the Director's Discretionary Time
  - e.g., recent Betelgeuse observing campaign using four SOFIA instruments; Moon pilot legacy program
- Higher program completion rate by moving to a two-year scheduling cycle; potentially increasing observing opportunities

"Community Update", led by Margaret Meixner, Director of SOFIA Science Mission Operations, AAS webinar: Tuesday June 2 @ 3 pm EDT

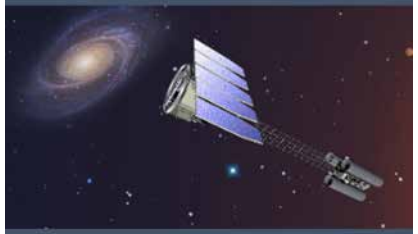
Astrophysics Missions in Development

Webb 2021
NASA Mission



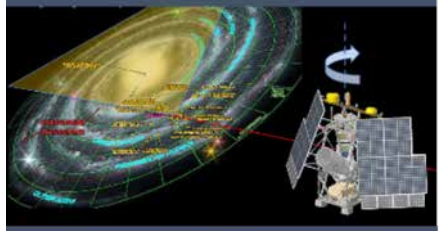
James Webb
Space Telescope

IXPE 2021
NASA Mission



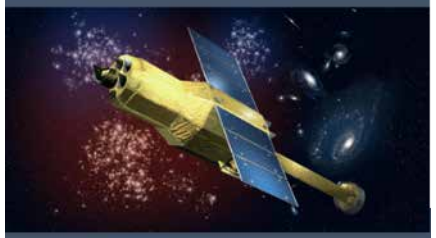
Imaging X-ray
Polarimetry Explorer

GUSTO 2021
NASA Mission



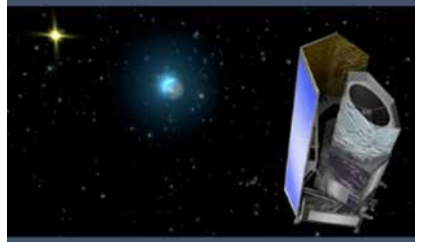
Galactic/ Extragalactic ULDB
Spectroscopic Terahertz Observatory

XRISM 2022
JAXA-led Mission



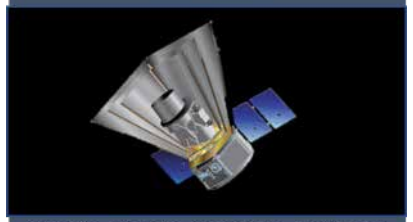
NASA is supplying the SXS
Detectors, ADRs, and SXTs

Euclid 2022
ESA-led Mission



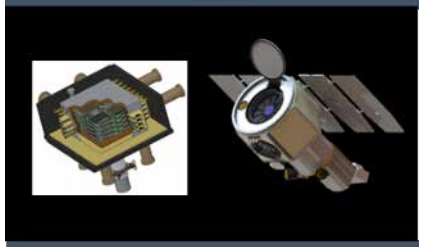
NASA is supplying the NISP
Sensor Chip System (SCS)

SPHEREx 2023
NASA Mission



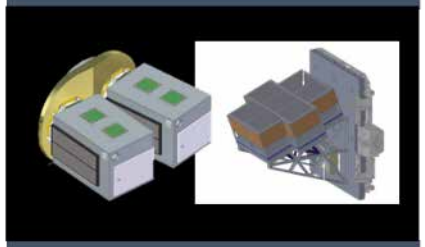
Spectro-Photometer for the History of
the Universe, Epoch of Reionization,
and Ices Explorer

SMEX ~2025
NASA Mission



COSI or ESCAPE

Mission of Opportunity ~2025
NASA Mission



Dorado or LEAP

Roman 2025
NASA Mission

Nancy Grace Roman
Space Telescope

ARIEL 2028
ESA-led Mission

NASA is supplying the CASE
fine guidance instrument

Launch dates are current project working dates; Agency Baseline Commitment launch date could be later; impacts of COVID-19 not yet known

“James Webb Space Telescope Overview",
led by Jonathan Gardner (GSFC) and Klaus Pontoppidan (STScI), AAS webinar:
Tuesday June 2 @ 2:00 pm EDT, Exhibit Hall

The Webb observatory in the clean room in Redondo Beach, CA in August 2019

Webb

The James Webb Space Telescope

2020 Accomplishments

- Work continuing at Northrop, but at lower efficiency due to social distancing practices required by COVID19 response.
- Completing deployment test in preparation for Observatory-level environmental tests
- Conducted several mission rehearsals at the mission operation center (STScI)

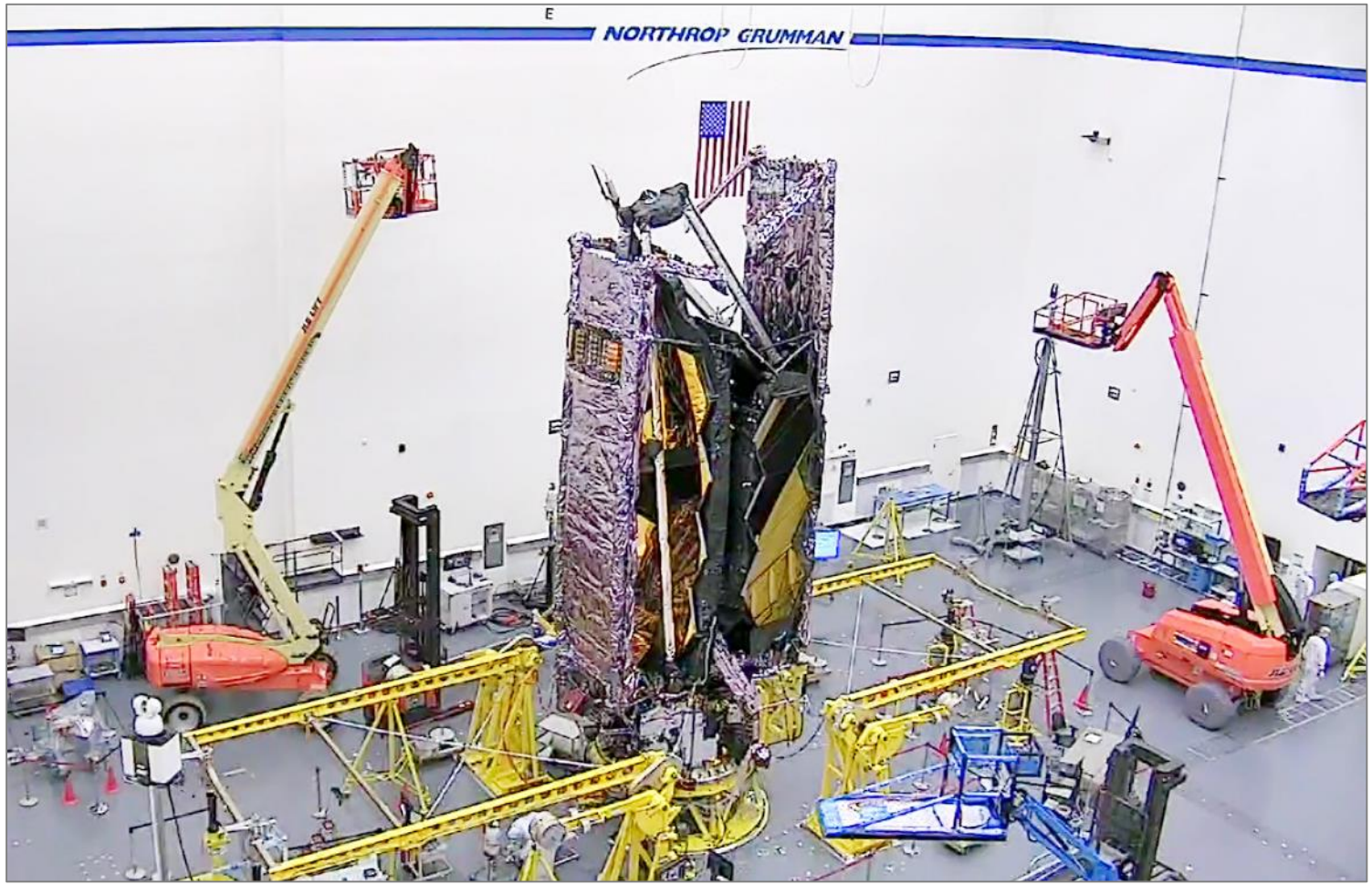
2020 Remaining Plans

- After coming out of COVID19 response restrictions project will formally evaluate schedule
- Observatory-level environmental testing
- Post Observatory-level environmental testing deployments
- Additional mission rehearsals at STScI
- Release of Cycle 1 General Observer call

Webb Final Assembly

Space Telescope Science Institute (STScI) Town Hall: Tuesday June 2 @ 1:40 pm, Annie Jump Cannon Meeting Room

- No schedule for Webb Cycle 1 GO/AR proposals has been announced.
- An update on the schedule will be announced in mid- to late-July.
- At least 12 weeks notice of the proposal deadline will be provided.



The fully assembled and folded observatory at Northrop Grumman, Space Park (May 2020). This is the configuration that Webb will be in when it is mated to the Ariane 5 launch vehicle in 2021. After environmental testing in this configuration it undergoes one more set of deployment testing (primary mirror and sunshield) before a final fold back into this configuration.

Roman Space Telescope
(formerly Wide-Field Infrared Survey Telescope)

Confirmed and entered Phase C on Feb 28, 2020

https://www.nasa.gov/feature/nasa-approves-development-of-universe-studying-planet-finding-mission

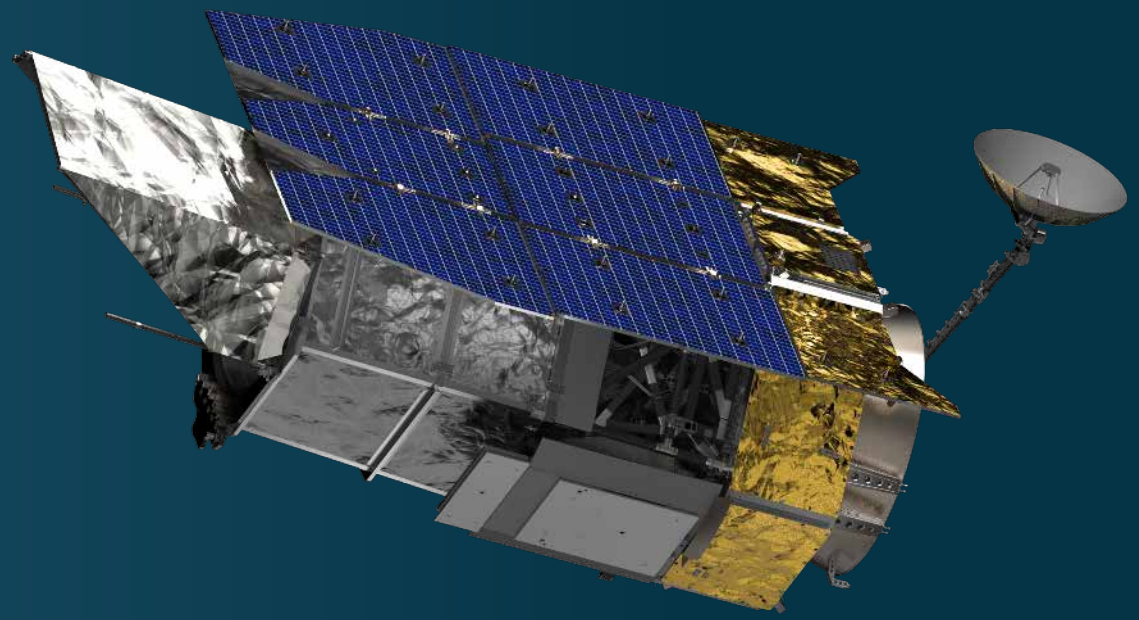
Roman is fully funded in FY20

2020: Flight hardware being developed: mirror being figured, detectors being fabricated, spacecraft subsystems being delivered, coronagraph demo unit in testbed

2021 – Complete Critical Design Reviews

c.2026 – Launch

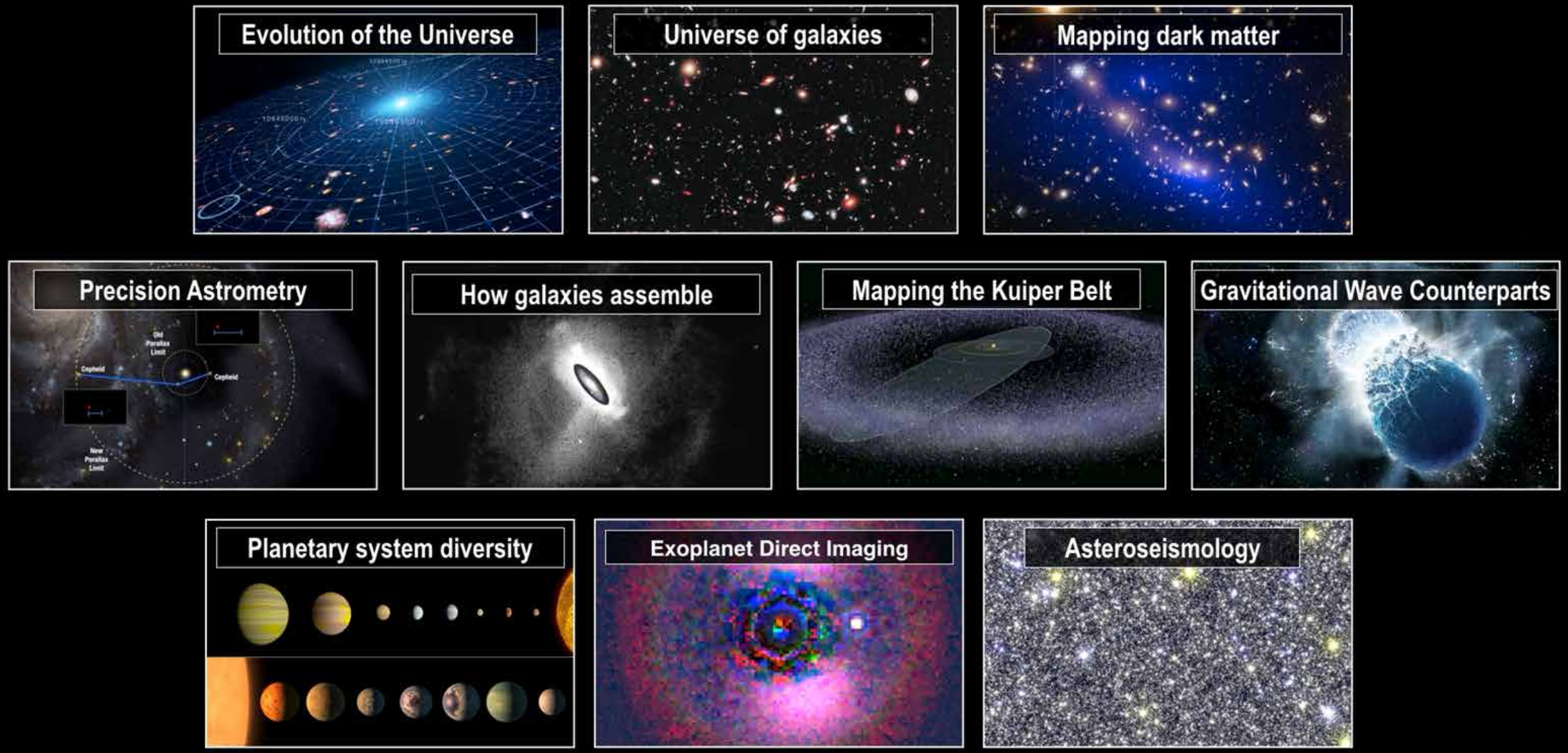
https://www.nasa.gov/press-release/nasa-telescope-named-for-mother-of-hubble-nancy-grace-roman



Roman field-of-view is 100× *Hubble* field-of-view

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

"Your Next Flagship: the Roman Space Telescope", led by Dominic Benford, Roman Program Scientist, AAS webinar: Monday June 1 @ 3:30 pm EDT, Exhibit Hall



Roman **will impact almost every area of astrophysics for almost every astronomer**

Roman Update

On February 28, 2020, *Roman* passed the Confirmation Review (KDP-C) and was approved by the Agency Program Management Council to begin implementation (Phase C in NASA terminology)

Only change is Coronagraph Technology Demonstration Instrument (CGI) programmatic status

- CGI is being managed like other SMD technology demonstration projects (Mars Helicopter, Deep Space Optical Communications)

Roman has an expected development cost of $3.2 billion. Including the cost of five years of operations and science, and CGI ($334M), brings the maximum cost of *Roman* to $3.934 billion.

Cost and schedule commitments are unchanged since initial confirmation in 2018 (KDP-B or Phase B in NASA terminology)

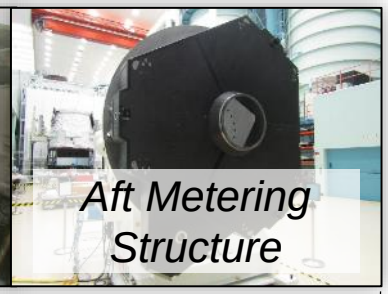
COVID-19 update:

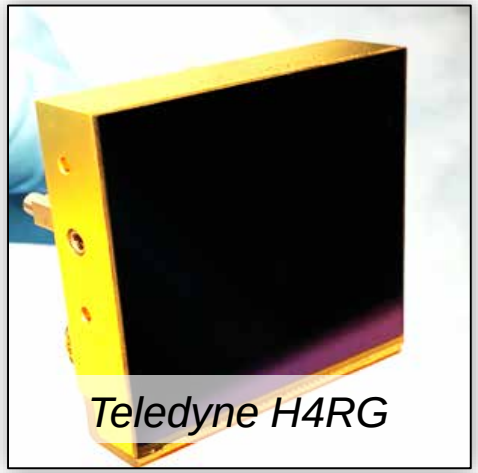
- Currently limited on-site work is taking place at GSFC and JPL per NASA Framework
- Work continues at several contractors, consistent with local situations

Roman Hardware Progress

Primary Mirror - Full Tool Polish (5/19)

Secondary Mirror


Aft Metering Structure


Teledyne H4RG

Photon Counting CCD

Detector readout custom ASIC chip

F158 Filter

Prism assembly

Deformable Mirrors

Telescope

Instruments

Roman is for You

All *Roman* observing time is available through open processes

- Major Legacy Surveys defined using a community-driven open process in the coming year
- Key Projects – science investigations using these surveys – will be openly competed
- *Roman* observing time also available for GO projects using *Roman*'s unique wide-field imaging, spectroscopic, and time domain capabilities
- All data will be available to the community with no period of limited access

Roman observing program will be based on community input

- NASA and STScI have convened community groups to provide input on balance among observing programs and on trades during development, integration, and test

Roman General Observers / Archival Researchers Program

- Use *Roman* for conducting wide-field infrared surveys of the universe
- Use data from *Roman* Legacy Surveys for compelling astrophysics investigations
- Calls for proposals to be issued before launch and subsequently

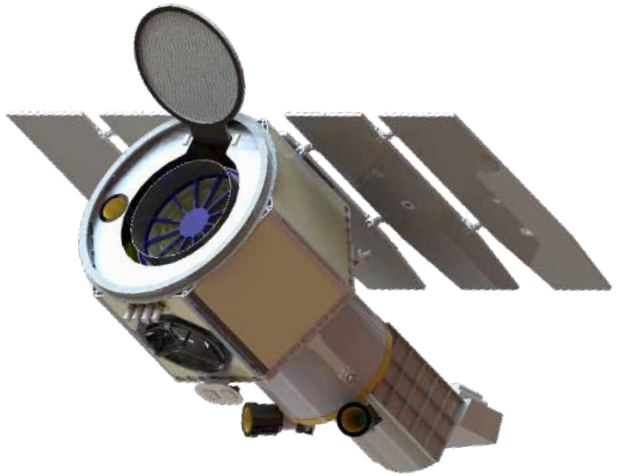
Roman Coronagraph Participating Scientist Program

- Develop observing plans for demonstrating coronagraph capabilities
- Work with instrument team to process data from tech demo observations
- Call for proposals anticipated in the coming year

Astrophysics Explorers in Competitive Phase A

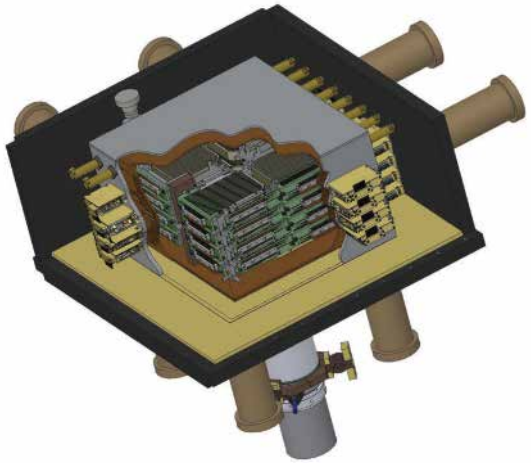
Small Explorers

ESCAPE
PI: K. France, U Colorado



Do extreme ultraviolet stellar flares zap atmospheres of exoplanets in the habitable zone?

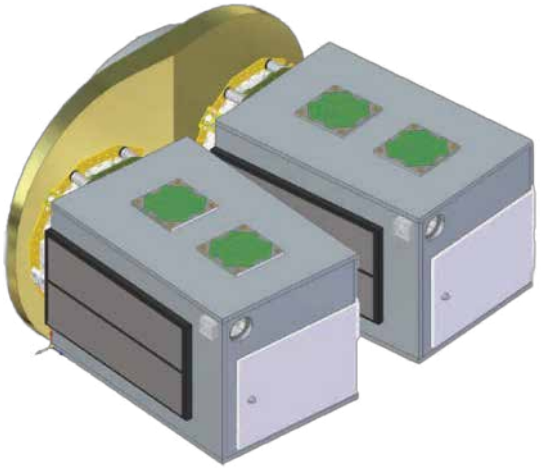
COSI
PI: J. Tomsick/UC Berkeley



MeV gamma-rays trace Milky Way's supernova activity, positron production; polarization in gamma-ray bursts

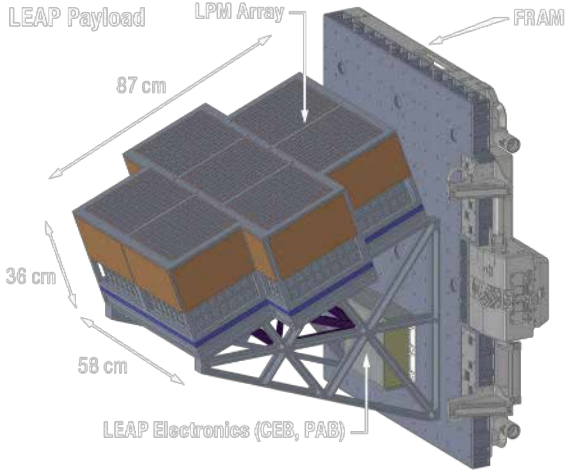
Missions of Opportunity

Dorado
PI: B Cenko/GSFC



Two 12U CubeSats watch for UV light when neutron stars merge

LEAP (on ISS)
PI: M. McConnell/ U New Hampshire



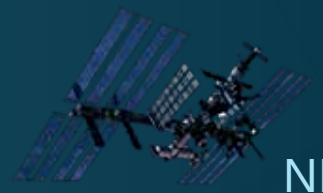
Polarization of gamma-ray bursts sheds light on jet structure

March 16, 2020: https://www.nasa.gov/press-release/nasa-selects-proposals-to-study-volatile-stars-galaxies-cosmic-collisions

Astrophysics Explorers Program

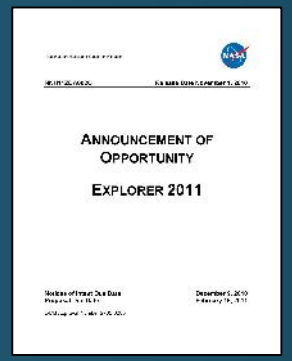
Swift

NuSTAR



NICER

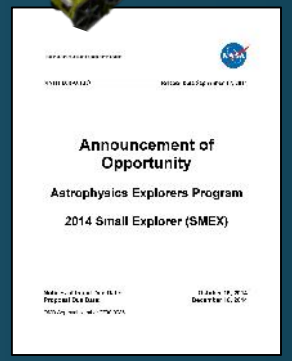
TESS



ANNOUNCEMENT OF OPPORTUNITY

EXPLORER 2011

MIDEX 2011

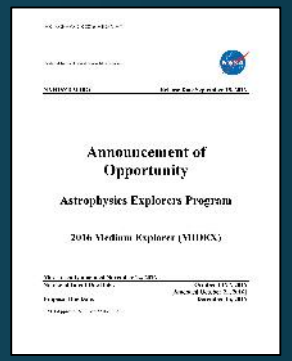


Announcement of Opportunity

Astrophysics Explorers Program

2014 Small Explorer (SMEX)

SMEX 2014

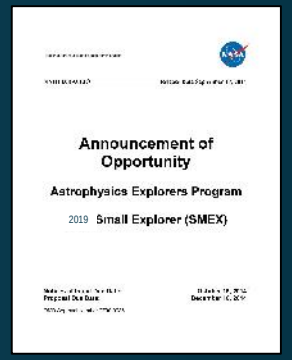


Announcement of Opportunity

Astrophysics Explorers Program

2016 Medium Explorer (MIDEX)

MIDEX 2016

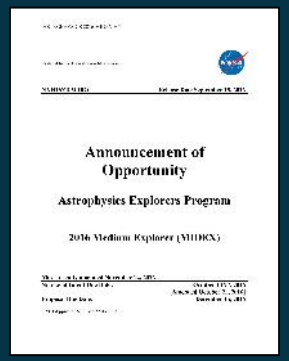


Announcement of Opportunity

Astrophysics Explorers Program

2019 Small Explorer (SMEX)

SMEX 2019



Announcement of Opportunity

Astrophysics Explorers Program

2016 Medium Explorer (MIDEX)

MIDEX 2021

Small and Mid-Size Missions

TESS

IXPE

SPHEREx

ESCAPE
COSI

Directed 2013

Euclid

Missions of Opportunity

NICER

GUSTO

ARIEL

Dorado
LEAP

Directed 2017

XRISM

Explorers Policy Update

NASA establishes partnerships with international space agencies to advance its strategic objectives in science

PI proposed partnerships have not been an effective manner of establishing NASA contributions to partner-led missions

- These are “Partner Mission of Opportunity” (PMO) proposals
- Over the past 10 years, we received 17 PMO proposals, selected only 3 for Phase A, and downselected only 1 for flight (ARIEL)
- Of those 3, all could have been initiated strategically instead of PI-proposed
- Of the other 14, most could have been declined without receiving a proposal
- We have concluded that the PMO process is not a successful or efficient process for establishing partnerships

SMD will no longer solicit PMO proposals

- SMD will still allow PI-led Explorers missions to be proposed that include a partner contribution, generally limited to be <1/3 of the mission per the AO

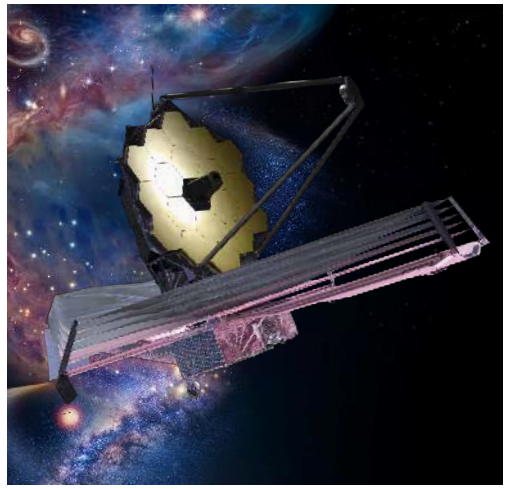
SMD will continue to seek community input on potential partnerships

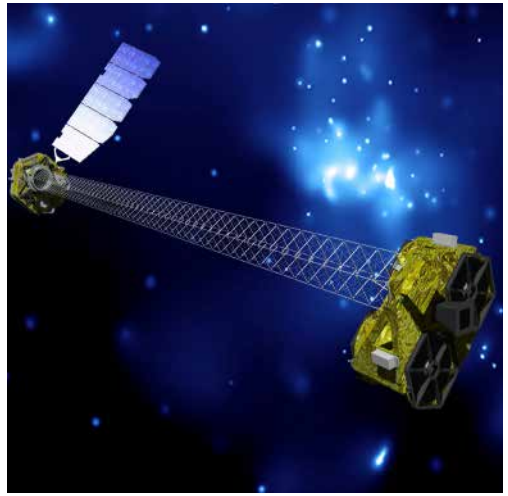
NASA Astrophysics Planning for the Future

NASA Astrophysics Program Summary

Supporting Research & Technology	R&A: ADAP, ATP, XRP, SmallSat Studies, Suborbital & CubeSat Projects	Technology: APRA, SAT, RTF, Future flagship technologies	Research support: Balloon project, Astrophysics archives
Operating Missions	Explorers: Gehrels Swift, NuSTAR, NICER, TESS	International Partnerships: XMM-Newton	Strategic Missions: Hubble, Chandra, Spitzer, Fermi, Kepler, SOFIA
Missions in Development or Under Study	Explorers: IXPE, GUSTO, SPHEREx	International Partnerships: Euclid, XRISM, ARIEL, Athena, LISA	Strategic Missions: Webb, Roman

FY20 Appropriation





FY20 appropriation for NASA Astrophysics (including Webb Telescope) is $1.73B; up by $233M from FY19 appropriation and by $532M from FY20 President's Budget Request

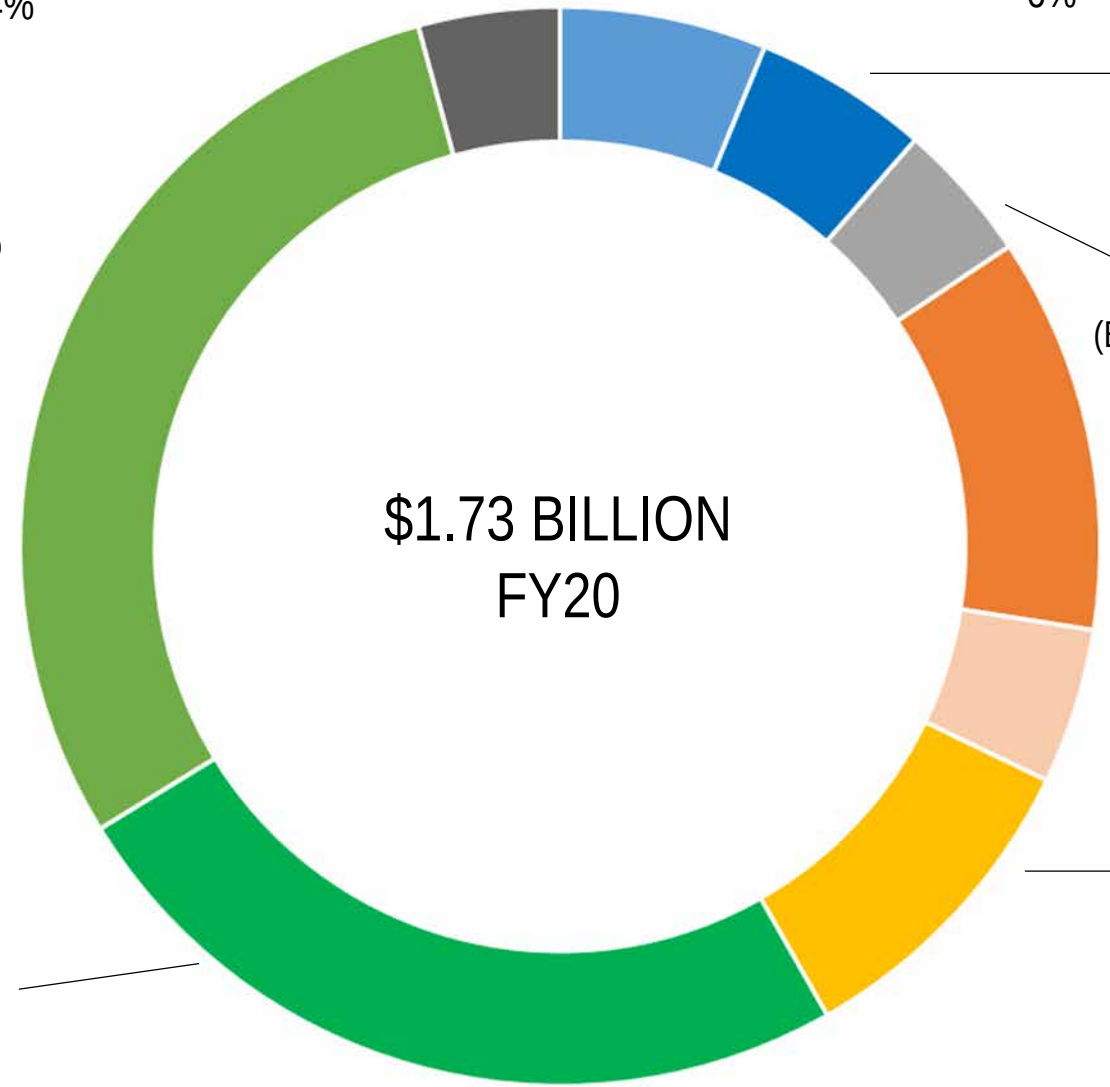
Fully funds Webb for replan to March 2021 launch date

Fully funds Roman (WFIRST), including the coronagraph technology demonstration instrument, through KDP-C and into Phase C

Specifies funding levels for Hubble, SOFIA, and the Astrophysics Research Program

Provides adequate funding to continue with the rest of the planned Astrophysics programs and projects including:

- Operating missions with GO programs as planned following the Senior Review
- Development of Explorers missions (IXPE, GUSTO, SPHEREx) and international contributions (Euclid, XRISM, ARIEL, Athena, LISA)
- Initiation of Phase A studies for selected SMEX and MO proposals from the 2019 Announcement of Opportunity
- Continued technology development for the future



Quick Summary

Community support: 20%
Operating missions: 12%
Building missions: 64%
Management: 4%

FY21 Budget Agency Highlights

- One of the strongest budgets in NASA's history, investing more than $25 billion dollars for America's future in space; represents an increase of about 12% over last year's request
- Keeps the agency on track to land the first woman and the next man on the Moon by 2024 and enables development of more than 15 science missions (including lunar, Mars, and Heliophysics) that inform Artemis work
- Provides valuable precursor experience for human exploration of Mars with bold new missions such as Mars Sample Return and Ice Mapper
- Implements a balanced and integrated science program with over 40 missions in formulation and development in FY 2021, including over 25 small missions
- Advances compelling science with priorities identified by the National Academies' decadal surveys including the James Webb Space Telescope, Europa Clipper, IMAP, and the first Earth Science Designated Observables mission
- Executes innovative partnerships with commercial and international partners; including through our Commercial Lunar Payload Services initiative, our industry partners will begin in 2021 to deliver science and tech payloads to virtually anywhere on the Moon, including the poles and far side

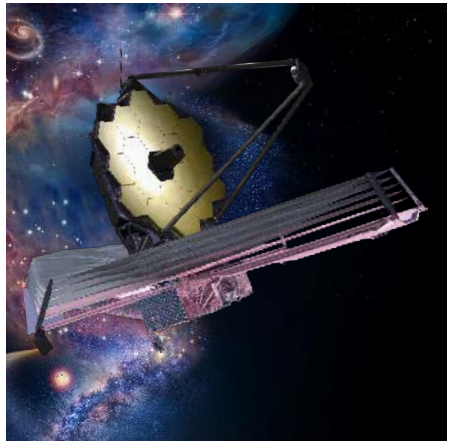
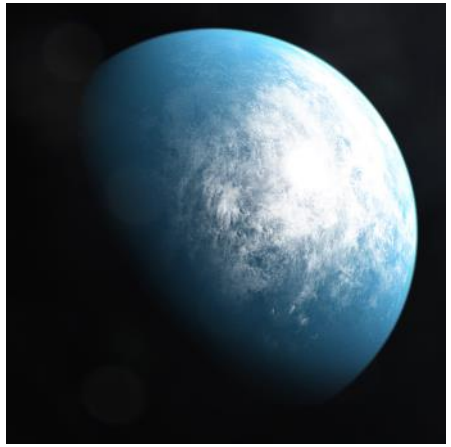
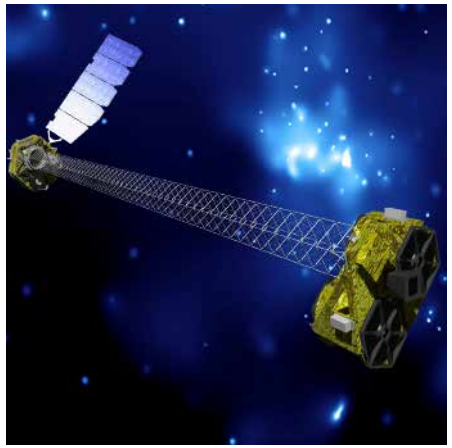
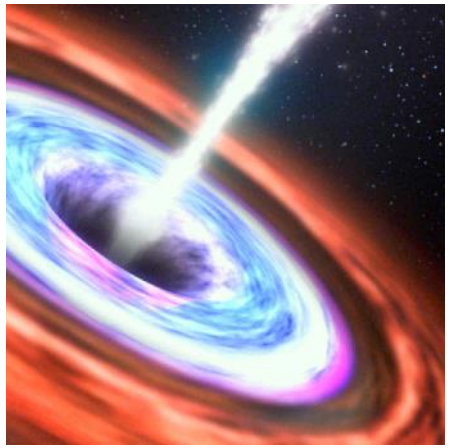
Cost Performance of Recently Launched Missions

NASA Science is providing reliable cost estimates for its missions, contributing to program stability

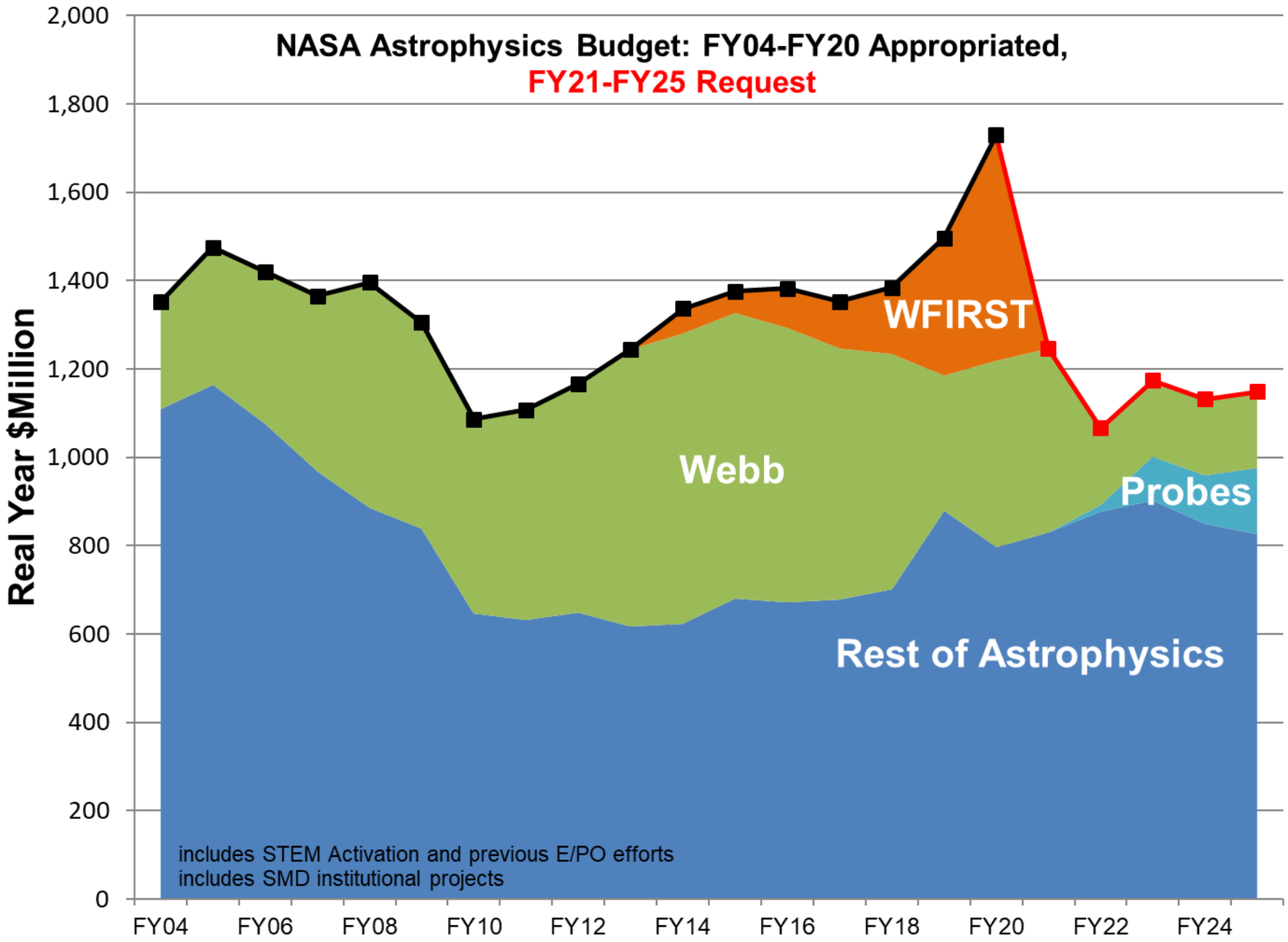
	KDP-C Baseline	Actual/ Estimated	Actual vs. Original
NuSTAR	109.9	116.0	6%
Landsat 8	583.4	502.8	-14%
IRIS	140.7	143.0	2%
LADEE	168.2	188.2	12%
MAVEN	567.2	472.0	-17%
GPM	555.2	484.3	-13%
OCO-2	249.0	320.3	29%
SMAP	485.7	454.3	-6%
MMS	857.3	875.3	2%
Astro-H	44.9	71.2	59%
OSIRIS-REx	778.6	620.8	-20%
CYGNSS	151.1	127.1	-16%
SAGE-III	64.6	88.2	37%
TSIS-1	49.8	19.8	-60%
TESS	323.2	273.4	-15%
InSight	541.8	635.8	17%
GRACE-FO	264.0	238.1	-10%
Parker	1055.7	955.7	-9%
ICESat 2	558.8	713.2	28%
GEDI	91.2	85.5	-6%
OCO-3	62.5	62.2	-1%
ICON	196.0	205.4	5%
Total	7898.7	7652.8	-3%

Science missions launched since the requirement for a 70% JCL have *underrun* Phase C/D budget commitments by a net 3%

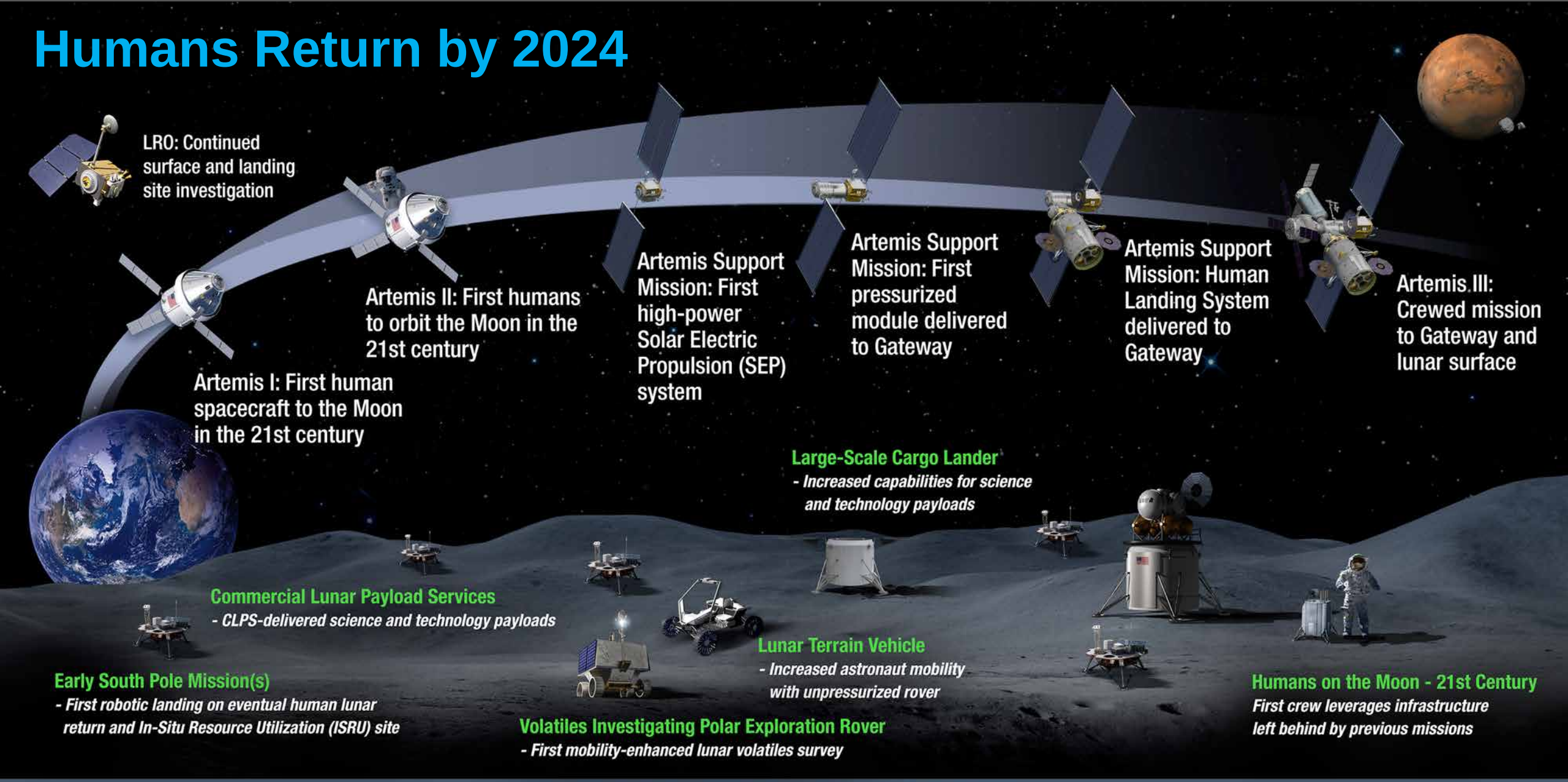
Astrophysics FY21 Budget Request

- Supports Webb launch in 2021
- Maintains decadal cadence of four AOs per decade for Astrophysics Explorers and Missions of Opportunity
- Maintains healthy research program including CubeSats, suborbital missions, technology development, data analysis, theoretical and computational investigations, and laboratory astrophysics
- Initiates new class of Astrophysics Pioneers: SmallSats and major balloon missions with reduced management overhead compared to traditional Astrophysics Explorers
- Extends operating missions beyond FY20 with GO programs following 2019 Senior Review
- Supports formulation of a probe mission as early as 2022
- Supports mission concept studies and technology investments to implement Astrophysics Decadal Survey priorities starting in 2022
- Terminates SOFIA due to high operating costs and lower science productivity to date
- Given its significant cost and competing priorities within NASA, provides no funding for Roman Space Telescope


NASA Astrophysics Budget: FY04-FY20 Appropriated,
FY21-FY25 Request
Real Year $Million
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
FY04
FY06
FY08
FY10
FY12
FY14
FY16
FY18
FY20
FY22
FY24
WFIRST
Webb
Probes
Rest of Astrophysics
includes STEM Activation and previous E/PO efforts
includes SMD institutional projects

Humans Return by 2024

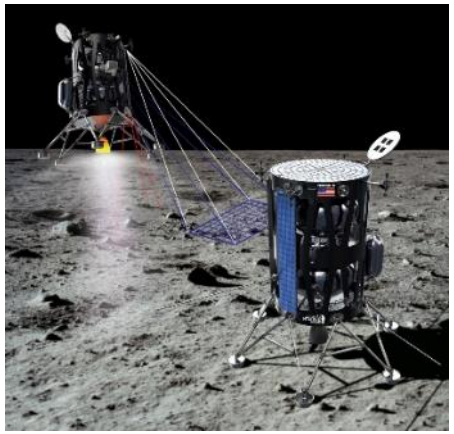


Astrophysics and Artemis

All science opportunities enabled by Project Artemis will include astrophysics

Commercial Lunar Payload Services (CLPS)

- All payload calls include astrophysics; two astrophysics payloads selected
  - Internal NASA call: Low-frequency Radio Observations from the Near Side Lunar Surface instrument (PI: Robert MacDowall, GSFC); manifest through CLPS Task Order 2 on Intuitive Machines Lander for NET October 2021
  - ROSES call: Next Generation Lunar Retroreflectors (PI: Douglas Currie, University of Maryland); to be manifest through CLPS Task Order 19D for ~2022



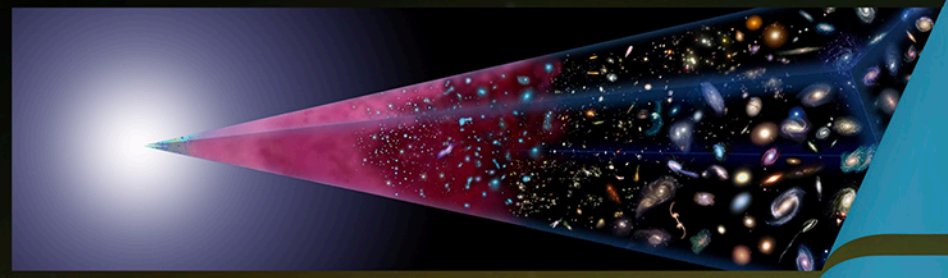
Intuitive Machines Lander

Astrophysics Explorers 2019 Missions of Opportunity

- 2019 AO included opportunities enabled by Project Artemis.
- Future calls will solicit proposals that leverage Artemis capabilities, such as Gateway as a platform and cis-lunar communications infrastructure, to conduct compelling astrophysics investigations.

Most important criterion for all proposals that leverage Artemis remains the astrophysics science merit.

Why Astrophysics?

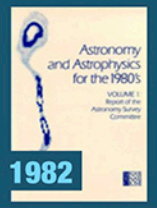


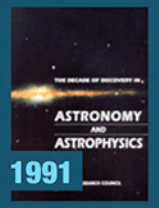
How did our universe begin and evolve?

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.

Astrophysics Strategic Planning

To be updated in 2020 (per GPRAMA)

Astro2020 Decadal Survey underway

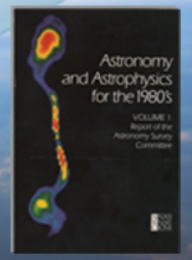
2018 update includes:
- Independent reviews of Webb & WFIRST
- Planning for 2020 Decadal Survey

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

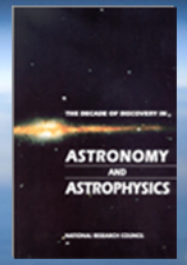
Astrophysics

Decadal Survey Missions

1972
Decadal Survey
Hubble



1982
Decadal Survey
Chandra



1991
Decadal Survey
Spitzer

2001
Decadal Survey
JWST

2010
Decadal Survey
WFIRST

Astro 2020

Decadal Survey on Astronomy and Astrophysics

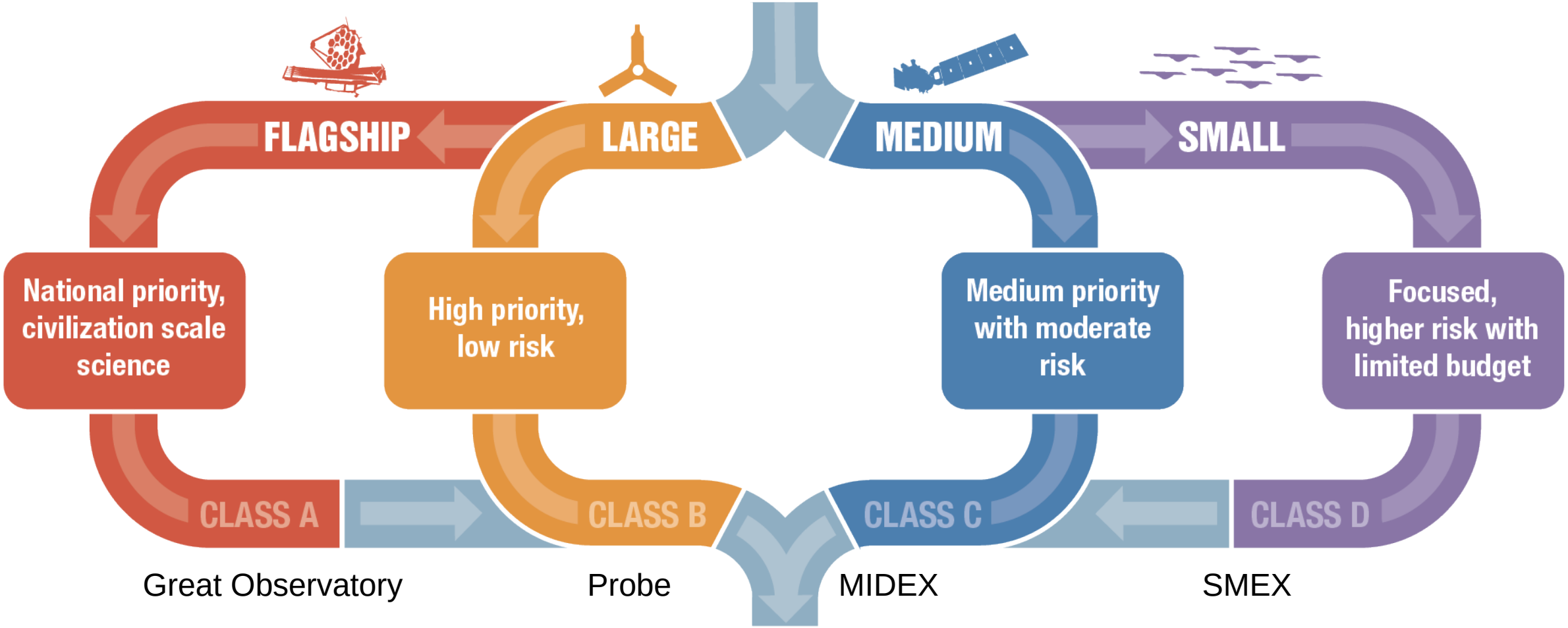
The National Academies of SCIENCES ENGINEERING MEDICINE

Decadal Survey Goal

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

BALANCED MISSION PORTFOLIO



Great Observatory | Probe | MIDEX | SMEX

GREAT SCIENCE

+ SmallSats (Class D Tailored)
  Suborbital-class (Research Class)

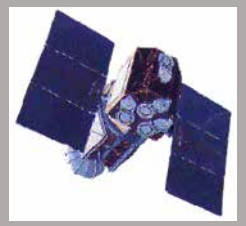
Medium Mission Concepts (Probes)

Probes are strategic missions that have had a strong impact on astrophysics, either through a focused investigation or as a broadly-capable observatory

COBE 11/89
NASA Strategic Explorer

Cosmic Background Explorer

EUVE 06/92
NASA Strategic Explorer



Extreme Ultraviolet Explorer

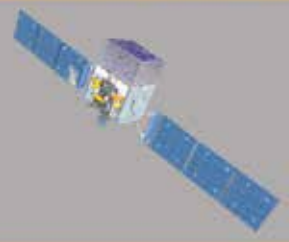
Rossi XTE 12/95
NASA Strategic Explorer

Rossi X-ray Timing Explorer

GP-B 04/04
NASA Strategic Mission

Gravity Probe B The Relativity Mission

Fermi 6/08
NASA Strategic Mission



Fermi Gamma-ray Space Telescope

Kepler 3/09
NASA Discovery Mission

Kepler Space Telescope

NASA funded probe studies are available at https://science.nasa.gov/astrophysics/2020-decadal-survey-planning

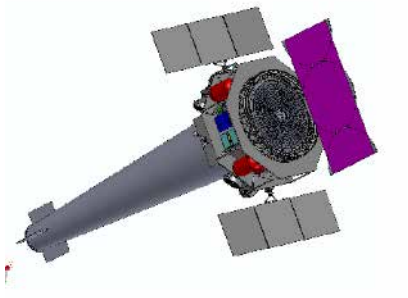
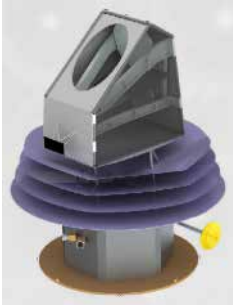
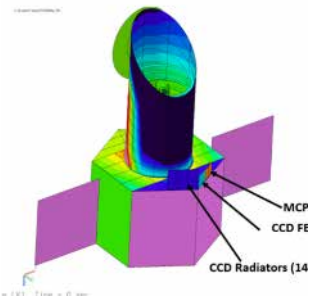
NASA's independent assessment of probe studies by the Probes Cost Assessment Team (PCAT) is available at https://science.nasa.gov/astrophysics/2020-decadal-survey-planning

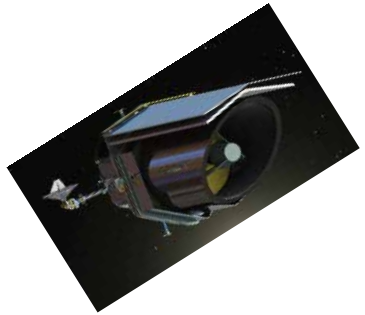
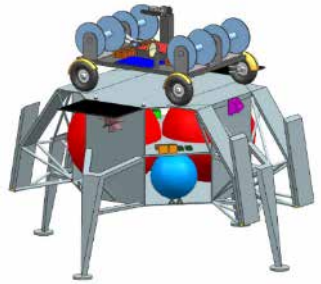
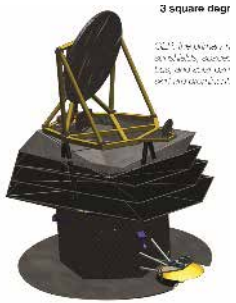
Options for 2020 Decadal Survey

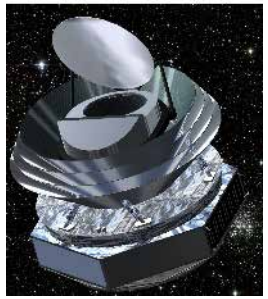
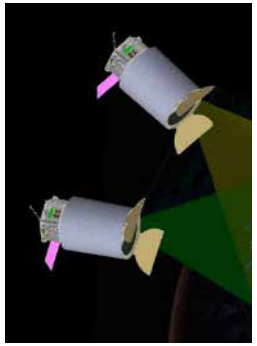
- Do not recommend a medium mission in Astro2020
- Recommend specific probe(s) as medium-size strategic missions
- Recommend several specific science concepts for an AO (similar to New Frontiers)
- Recommend an unconstrained AO (i.e., Super-Explorer)

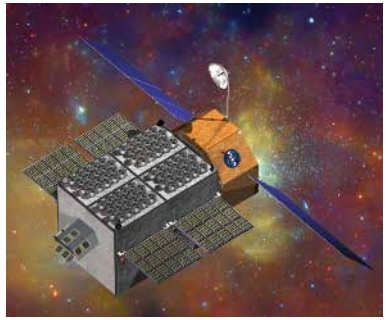
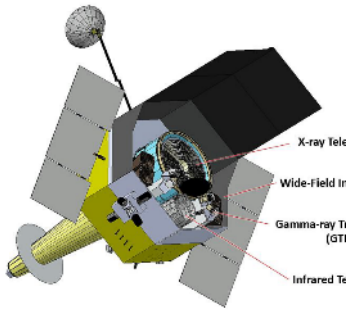
Probe (Medium Mission) Concepts

Probes are strategic missions that have had a strong impact on astrophysics, either through a focused investigation or as a broadly-capable observatory

NASA funded probe studies are available at https://science.nasa.gov/astrophysics/2020-decadal-survey-planning

NASA's independent assessment of probe studies by the Probes Cost Assessment Team (PCAT) is available at https://science.nasa.gov/astrophysics/2020-decadal-survey-planning

Why Flagships

Flagships enable paradigm shifting science

Flagships drive US capabilities and contribute to US leadership

Flagships create stakeholder support that drives the NASA budget

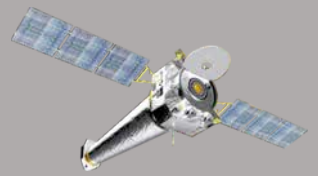
Hubble 04/90
NASA Great Observatory

Hubble Space Telescope

Compton 05/91
NASA Great Observatory

Compton Gamma Ray Observatory

Chandra 09/99
NASA Great Observatory

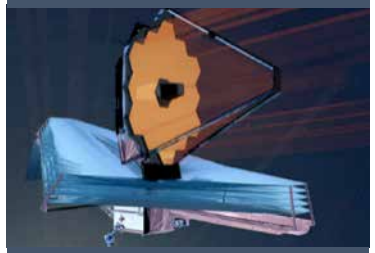


Chandra X-ray Observatory

Spitzer 8/03
NASA Great Observatory

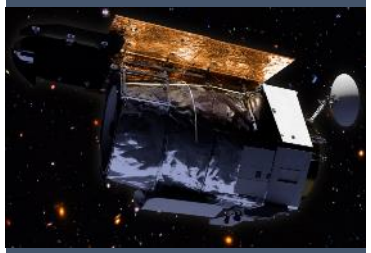
Spitzer Space Telescope

Webb 2021
NASA Mission



James Webb Space Telescope

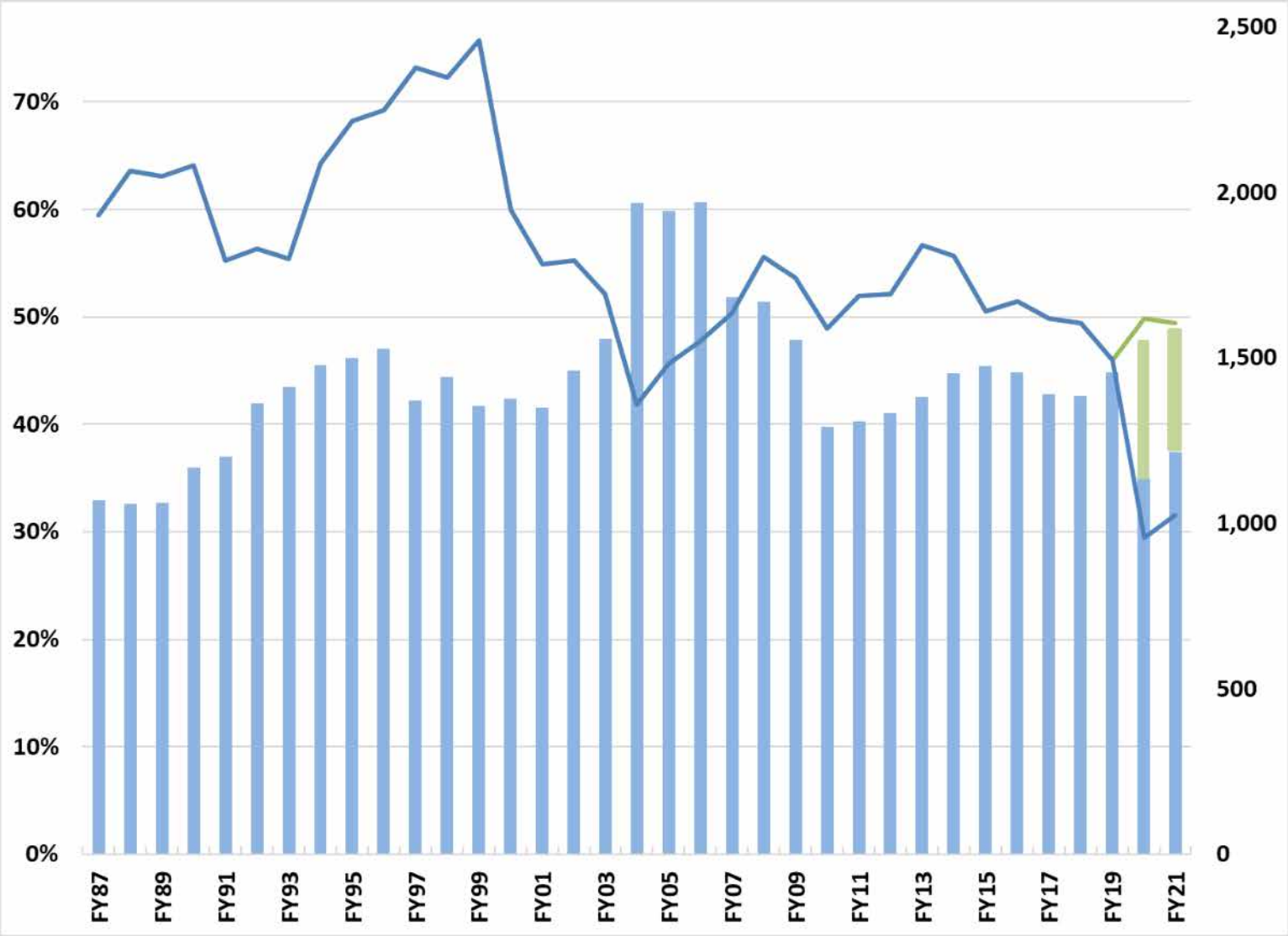
Roman Mid 2020s
NASA Mission



Wide-Field Infrared Survey Telescope

"NASA should continue to plan for large strategic missions as a primary component for all science disciplines as part of a balanced program."
– Powering Science: NASA's Large Strategic Science Missions (NASEM, 2017)

Flagship Fraction of Astrophysics Budget



All dollars inflated to FY18$.
Development only, no ops.

Large mission fraction (left scale)

Inflation adjusted Astrophysics budget (right scale)

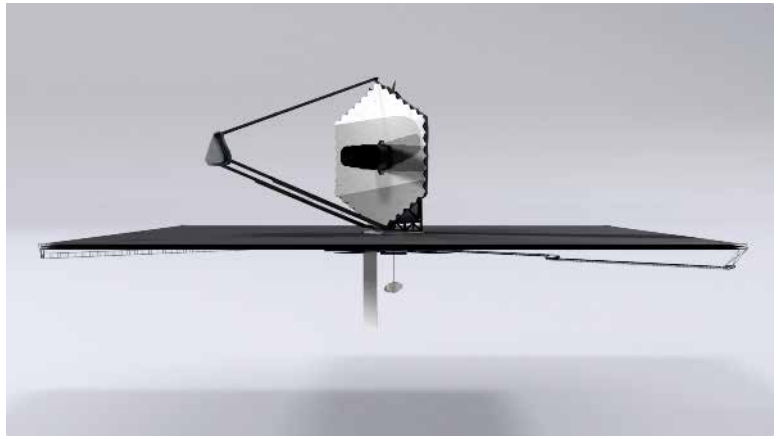
Current planning budget (without Roman beyond FY19)

What if Roman is funded as needed on top of FY20 President's Budget Request?

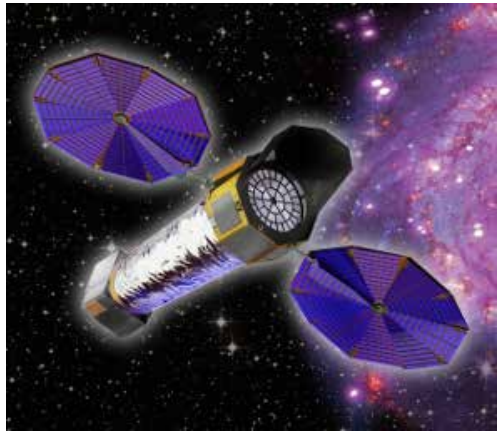
Large Mission Concepts

"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)

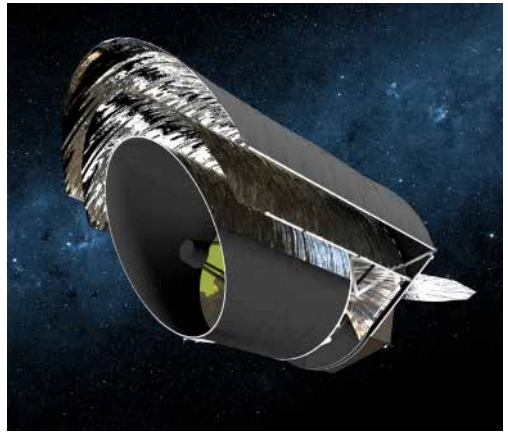
HabEx



LUVOIR



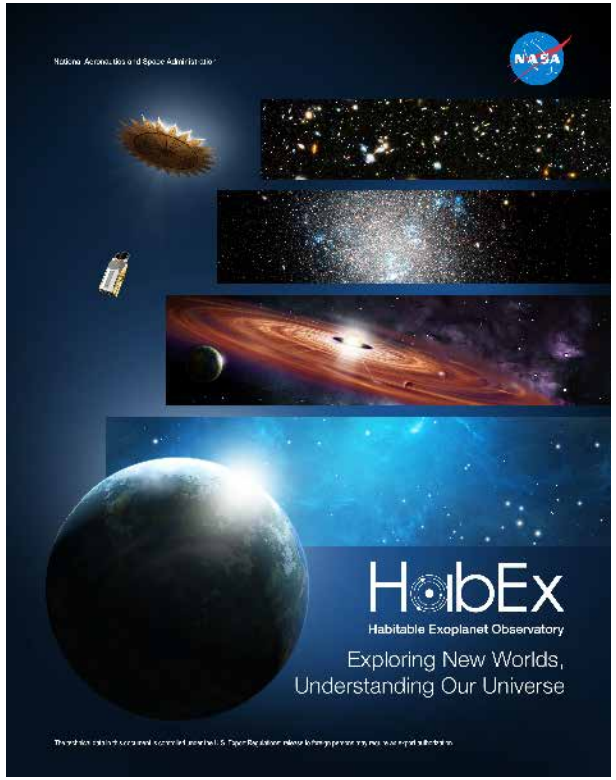
Lynx

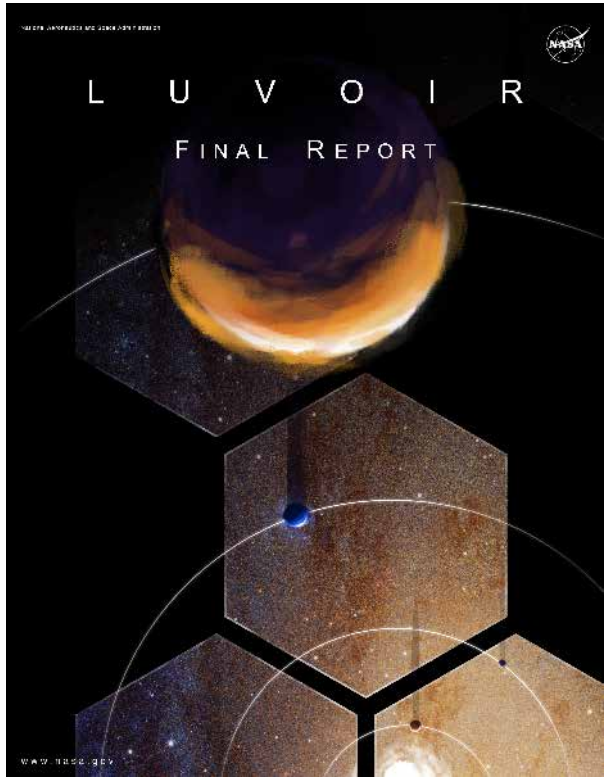


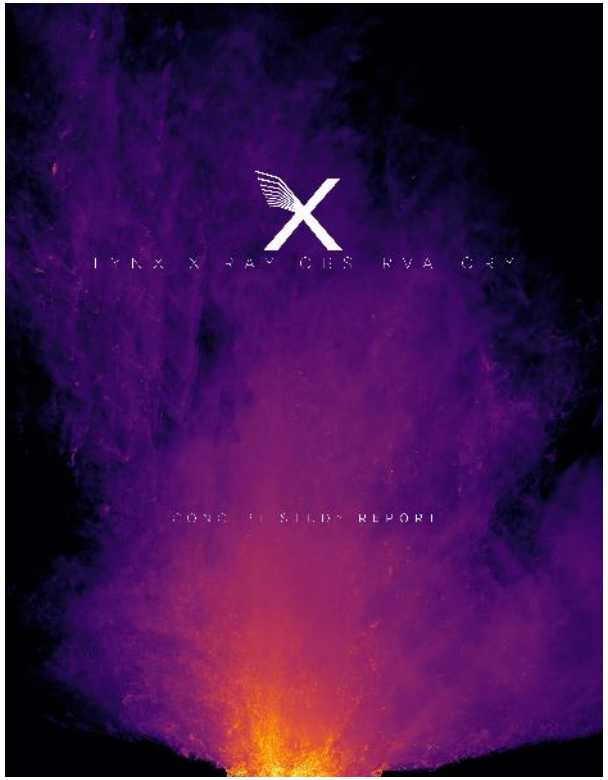
Origins

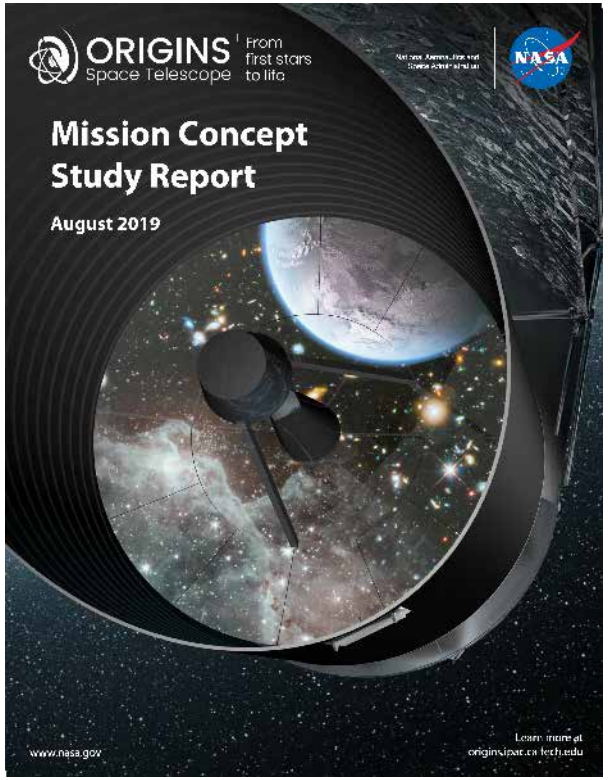
Links to the concept study reports are posted at
https://science.nasa.gov/astrophysics/2020-decadal-survey-planning
and at https://www.greatobservatories.org/

Large Mission Concepts





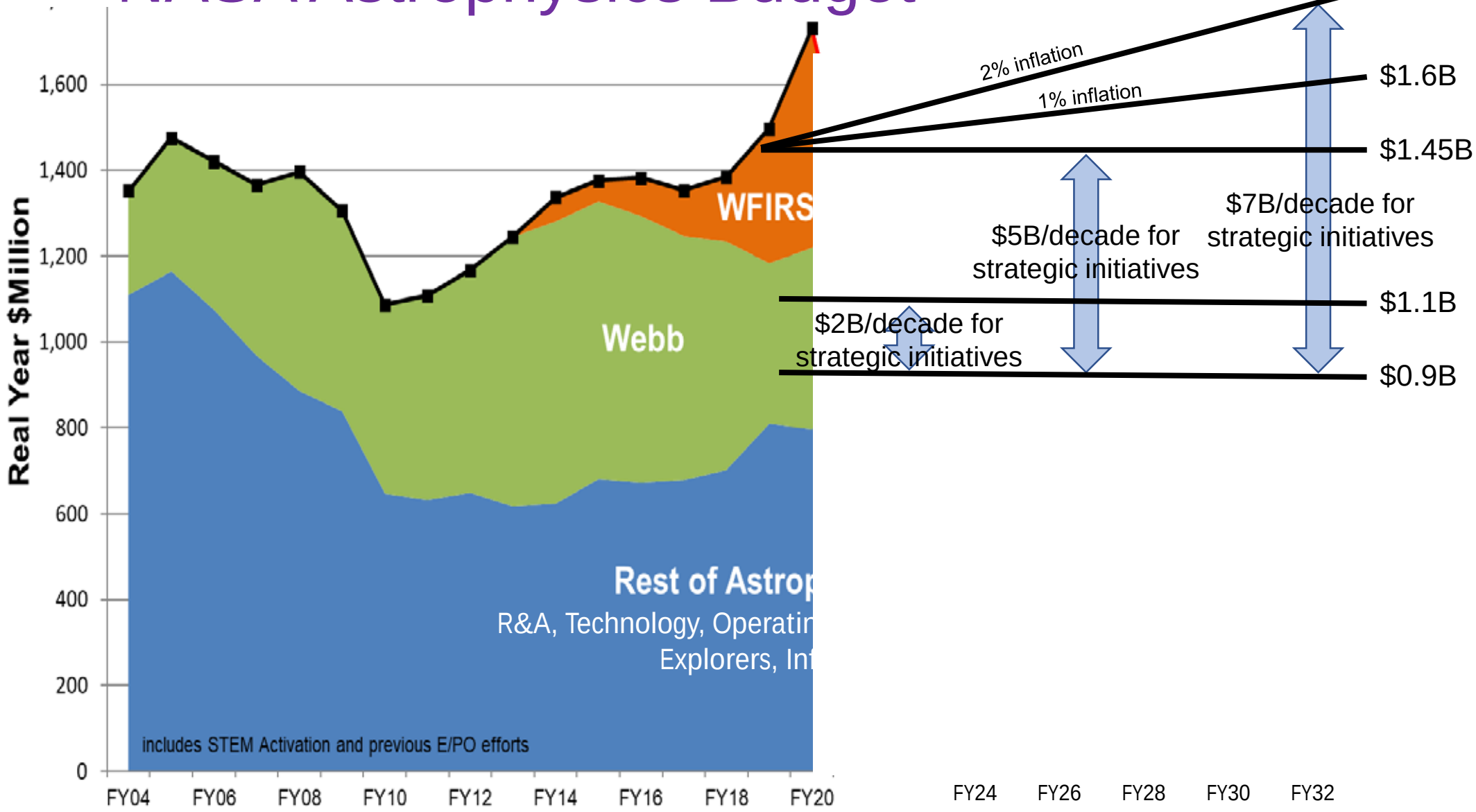




NASA's independent assessment by the Large Mission Concept Independent Assessment Team (LCIT) is available at https://science.nasa.gov/astrophysics/2020-decadal-survey-planning

Links to the concept study reports are posted at https://science.nasa.gov/astrophysics/2020-decadal-survey-planning and at https://www.greatobservatories.org/

NASA Astrophysics Budget



Average of recent* appropriations plus inflation

Average of recent* appropriations

Runout of FY20 Budget Proposal

Current program including Webb operations and 4 Explorers/decade

* Does not include FY20 appropriation

Decadal Survey Goal

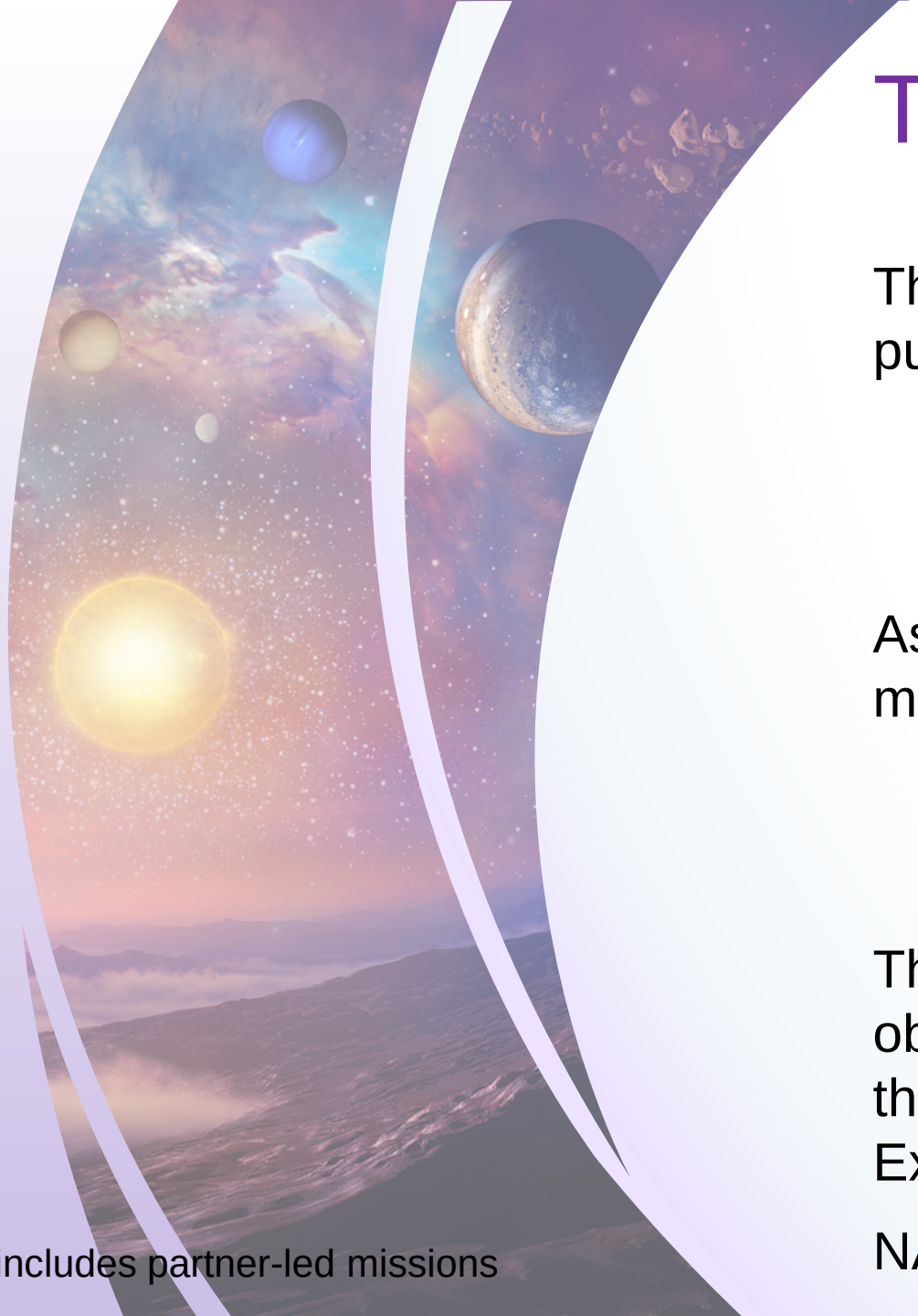
NASA's highest aspiration for the 2020 Decadal Survey is that it be ambitious

- 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 diminishing budget, you get a diminishing program

- Great visions inspire great budgets

Carpe Posterum



The Future

This is an exciting time for Astrophysics – we are pursuing the answers to the biggest questions

- How did the universe begin and evolve?
- How did galaxies, stars, and planets come to be?
- Are we alone?

Astrophysics is multiwavelength and multimessenger

- NASA has 10 operating astrophysics missions*
- NASA is developing 10 astrophysics missions* and studying 4 for downselect

The community will select NASA's future observatories through the 2020 Decadal Survey and through peer review of competed missions (like Explorers)

NASA is ready to realize the community's priorities

* includes partner-led missions

Slides posted at
http://science.nasa.gov/astrophysics/documents

BACKUP

Revised February 28, 2020

Science Budget Request Summary ($M)

	Actual FY 19	Request FY 20	Enacted FY 20	Request FY 21	Out-years FY 22	FY 23	FY 24	FY 25
Science	**6,886.6**	**6,393.7**	**7,138.9**	**6,306.5**	**6,553.5**	**6,575.7**	**6,705.2**	**6,766.9**
Earth Science	**1,931.0**	**1,779.8**	**1,971.8**	**1,768.1**	**1,878.2**	**1,846.1**	**1,834.5**	**1,984.6**
Earth Science Research	454.1	447.9		447.3	471.9	494.1	528.5	530.3
Earth Systematic Missions	932.7	719.2		608.3	706.1	695.6	640.7	797.3
Earth System Science Pathfinder	223.8	275.4		338.9	301.2	251.6	241.8	234.4
Earth Science Data Systems	202.0	214.4		245.4	259.9	263.2	278.7	277.7
Earth Science Technology	63.4	69.6		74.2	82.8	84.6	86.4	86.4
Applied Sciences	55.1	53.3		53.9	56.3	57.0	58.5	58.5
Planetary Science	**2,746.7**	**2,712.1**	**2,713.4**	**2,659.6**	**2,800.9**	**2,714.9**	**2,904.8**	**2,830.7**
Planetary Science Research	276.6	266.2		305.4	288.6	285.1	295.2	286.7
Planetary Defense	150.0	150.0	160.0	150.0	147.2	97.6	98.0	98.0
Lunar Discovery and Exploration	188.0	300.0	300.0	451.5	517.3	491.3	458.3	458.3
Discovery	409.5	502.7		484.3	424.4	434.8	570.1	505.8
New Frontiers	93.0	190.4		179.0	314.3	332.8	326.9	285.0
Mars Exploration	712.7	546.5	570.0	528.5	588.4	671.2	798.7	855.3
Outer Planets and Ocean Worlds	793.6	608.4		414.4	370.7	239.4	192.3	171.7
Radioisotope Power	123.3	147.9	147.9	146.3	150.1	162.8	165.4	169.8
Astrophysics	**1,191.1**	**844.8**	**1,306.2**	**831.0**	**891.2**	**1,000.9**	**959.7**	**975.5**
Astrophysics Research	222.8	250.7		269.7	279.1	327.2	314.9	331.1
Cosmic Origins	222.8	185.3		124.0	123.2	120.0	122.4	122.4
Physics of the Cosmos	151.2	148.4		143.9	160.8	155.3	169.8	154.1
Exoplanet Exploration	367.9	46.4		47.2	50.4	47.6	51.6	52.2
Astrophysics Explorer	226.5	214.1		246.2	277.7	350.8	301.0	315.6
James Webb Space Telescope	**305.1**	**352.6**	**423.0**	**414.7**	**175.4**	**172.0**	**172.0**	**172.0**
Heliophysics	**712.7**	**704.5**	**724.5**	**633.1**	**807.8**	**841.8**	**834.1**	**804.1**
Heliophysics Research	248.9	237.0		230.5	218.7	225.2	224.0	224.5
Living with a Star	135.3	107.6		127.9	134.5	246.4	225.5	233.3
Solar Terrestrial Probes	180.5	177.9	183.2	126.3	262.2	202.6	195.6	115.5
Heliophysics Explorer Program	147.9	182.0	182.0	148.4	192.4	167.6	189.0	230.8

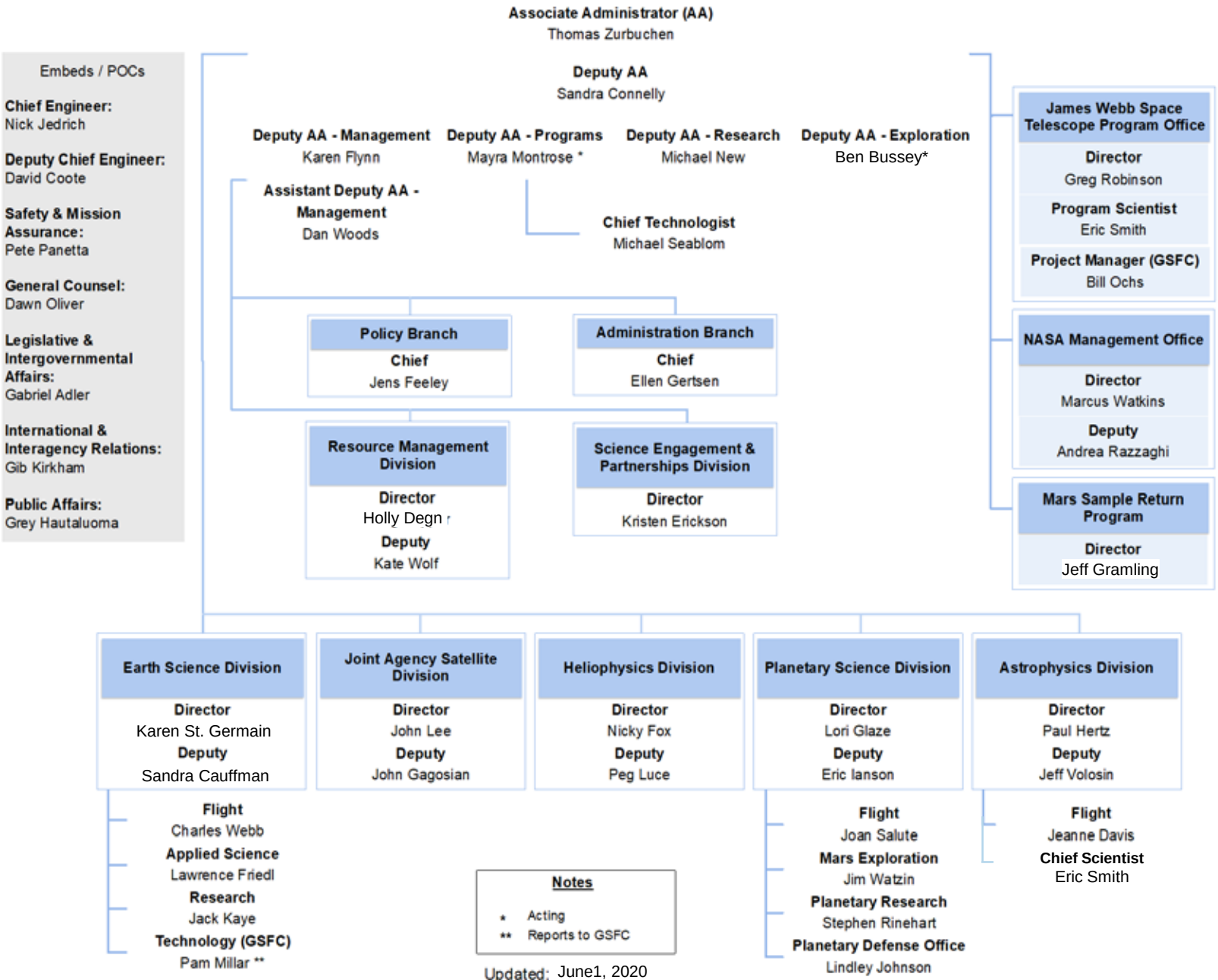
Astrophysics Program Content

	Actual FY 19	Request FY 20	Enacted FY 20	Request FY 21	Out-years FY 22	FY 23	FY 24	FY 25
Astrophysics	**1,191.1**	**844.8**	**1,306.2**	**831.0**	**891.2**	**1,000.9**	**959.7**	**975.5**
Astrophysics Research	222.8	250.7	250.7	269.7	279.1	327.2	314.9	331.1
Astrophysics Research and Analysis	83.4	86.6		90.2	92.2	94.2	94.2	94.2
Balloon Project	40.2	44.8		44.8	45.8	45.7	46.3	46.3
Science Activation	45.0	45.6	45.6	45.6	45.6	45.6	45.6	45.6
Other Missions and Data Analysis	54.2	73.7		89.1	95.5	141.7	128.8	145.0
Astrophysics Data Curation and Archival	17.9	21.2		24.5	26.3	26.4	28.5	28.7
Astrophysics Data Program	19.1	20.4		21.6	22.6	23.6	23.6	23.6
Astrophysics Senior Review		-				51.2	50.4	49.9
Contract Administration, Audit & QA Svcs	12.7	12.7		17.3	17.3	17.3	17.3	17.3
Astrophysics Directed R&T	4.5	19.4		25.7	29.4	23.3	9.0	25.5
Cosmic Origins	222.8	185.3		124.0	123.2	120.0	122.4	122.4
Hubble Space Telescope	98.3	83.3	90.8	88.3	98.3	98.3	98.3	98.3
SOFIA	85.2	73.0	85.2	12.0				
Other Missions and Data Analysis	39.3	29.0		23.7	24.9	21.7	24.1	24.1
(development / formulation / technology)								
Cosmic Origins SR&T	24.8	17.1		18.4	18.4	18.4	18.4	18.4
Cosmic Origins Future Missions	0.8	2.2		2.7	4.6	1.6	3.8	3.8
(operating)								
Spitzer	13.2	8.5		1.0				
(research and management)								
Astrophysics Strategic Mission Prog Mgmt	0.4	1.2		1.6	1.9	1.7	1.9	2.0

Astrophysics Program Content

	Actual FY 19	Request FY 20	Enacted FY 20	Request FY 21	Out-years FY 22	FY 23	FY 24	FY 25
Physics of the Cosmos	151.2	148.4		143.9	160.8	155.3	169.8	154.1
(development / formulation / technology)								
Euclid	17.2	13.7		11.0	8.9	9.9	10.3	9.5
Physics of the Cosmos SR&T	45.7	50.9		45.9	61.2	75.2	87.0	72.1
Physics of the Cosmos Future Missions	0.0	2.0		1.6	4.6	2.0	3.7	3.7
(operating)								
Chandra X-Ray Observatory	61.7	58.4		62.3	62.8	62.8	62.8	62.8
Fermi Gamma-ray Space Telescope	16.5	14.0		13.8	13.9			
XMM	4.5	3.5		3.5	3.5			
(research and management)								
PCOS/COR Technology Office Management	5.6	5.9		5.9	6.0	5.4	6.0	6.0
Exoplanet Exploration	367.9	46.4		47.2	50.4	47.6	51.6	52.2
(development / formulation / technology)								
WFIRST	312.2		510.7					
Exoplanet Exploration SR&T	32.1	29.1		31.5	32.0	31.3	30.5	31.2
Exoplanet Exploration Future Missions	0.7	2.8		1.7	3.5	1.6	5.4	5.4
(operating)								
Keck Operations	6.5	6.7		6.9	7.0	7.2	7.4	7.4
Kepler	8.9	1.3						
(research and management)								
Exoplanet Exploration Technoloy Off Mgmt	7.5	6.5		7.1	7.8	7.4	8.2	8.1

Astrophysics Program Content

	Actual FY 19	Request FY 20	Enacted FY 20	Request FY 21	Out-years FY 22	FY 23	FY 24	FY 25
Astrophysics Explorer	226.5	214.1		246.2	277.7	350.8	301.0	315.6
(development / formulation / technology)								
SPHEREx	22.2			90.8	109.1	87.7	28.4	13.0
Imaging X-Ray Polarimetry Explorer	57.0	70.2		45.3	7.4	4.5	0.5	
X-Ray Imaging and Spectroscopy Mission	23.2	29.7		25.1	36.3	17.7	15.9	14.4
CASE				11.9	10.2	10.0	6.4	1.0
GUSTO	19.9	11.1		7.8	5.8	1.0		
Astrophysics Explorer Future Missions	2.3	84.8		10.6	58.0	219.2	241.5	278.1
Universe Explorer Prior Hist Projects	70.0							
(operating)								
Transiting Exoplanet Survey Satellite	7.7	5.0		14.7	14.1			
Nuclear Spectroscopic Telescope Array	8.5	7.8		8.6	8.6			
Neil Gehrels Swift Observatory	7.0	5.5		5.8	5.8			
NICER	3.8			4.8	4.4			
(research and management)								
Astrophysics Explorer Program Management	4.9			20.7	18.0	10.7	8.3	9.1
James Webb Space Telescope	**305.1**	**352.6**	**423.0**	**414.7**	**175.4**	**172.0**	**172.0**	**172.0**
Astrophysics + Webb Total	**1,496.2**	**1,197.3**	**1,729.2**	**1,245.7**	**1,066.6**	**1,172.9**	**1,131.7**	**1,147.5**

SMD Organization Chart