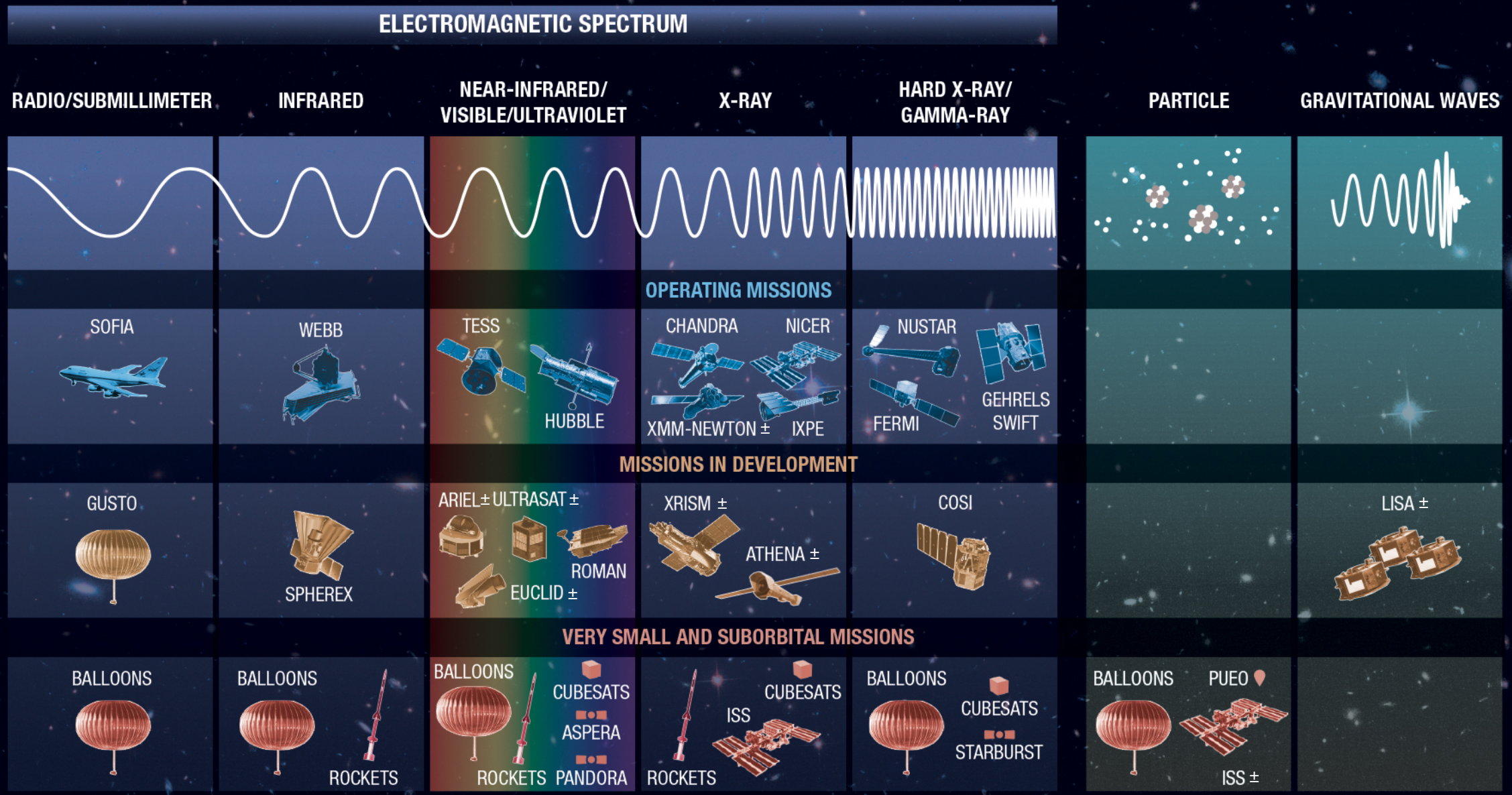
Astrophysics Division Update

Astrophysics Advisory Committee / March 30, 2022

Paul Hertz
Director, Astrophysics Division
Science Mission Directorate

@NASAUniverse @NASAExoplanets

ELECTROMAGNETIC SPECTRUM



5 balloon payloads
2 sounding rocket payloads

2 Pioneers smallsats
6 balloon payloads
2 rocket payloads
3 cubesats

1 Pioneers smallsat
4 balloon payloads
4 sounding rocket payloads
2 cubesats 1 ISS experiment

1 Pioneers balloon
4 balloon payloads
1 ISS experiment

March 2022

± Partner-led mission

NASA Astrophysics Division

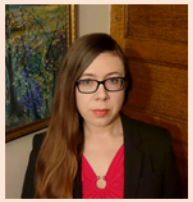
Division Director

Paul Hertz
Astrophysics Division Director

Sandra Cauffman
Astrophysics Division Deputy Director

ASTROPHYSICS
NASA's Science Mission Directorate

Program Executives



Rachele Cocks
Operating Missions
Pioneers

E. Lucien Cox
SOFIA, GUSTO, XRISM, ExEP

Ed Griego
Roman CGI, Operating Missions

Shahid Habib
PCOS/COR, ARIEL, Athena, Euclid, LISA, UltraSat

Janet Letchworth
Roman

Mark Sistilli
Explorers Program
IXPE, SPHEREx, COSI Balloons

Cross Cutting

Eric Smith
Chief Scientist
Webb
Precursor Sci

Jeanne Davis
Assoc Dir for Flight
ASM Program Manager

Mario Perez
Chief Technologist
SAT, RTF, ISFM, Swift

Not Pictured

Lisa Wainio
Information Manager, Public Affairs Liaison

Administrative Support

Kelly Johnson
Administrative Assistant

Vacant

Vacant
Administrative Assistant

Sara Schwartzman
Program Support Specialist

Ingrid Farrell
Program Support Specialist

Program Scientists

Dominic Benford
Roman
APRA Lead

Terri Brandt
COSI Dep
APRA Dep
Pioneers Dep
Precursor Sci Dep

Valerie Connaughton
APRA (High Energy)
XRISM, UltraSat
PCOS Program

Michael Garcia
APRA (UV/Visible), SmallSats/Pioneers
Hubble

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

Hashima Hasan
Education/Comms, Citizen Science, Archives, Advisory Committees, NuSTAR, Keck

Douglas Hudgins
ExEP Program
ADAP Lead
TESS Dep, ARIEL

Stefan Immler
Astrophysics Research Program Mgr, Chandra, ART-XC

Hannah Jang-Condell
XRP, TESS
DEIA Lead

Patricia Knezek
Explorers Program
Astrophysics Probe
SOFIA, Hubble Fellows

William Latter
APRA (Lab Astro)
SPHEREx, Fermi

Sangeeta Malhotra
Roman Dep
ATP/TCAN Dep

Roopesh Ojha
Data Lead, Athena, NICER, HEC, AI/ML

Kartik Sheth
Inclusion Plans
Technical assessments

Linda Sparke
2021 MIDEX/MO, Archives, COSI

Eric Tollestrup
APRA (IR/Submm)
Euclid, IXPE, COR Program

Sanaz Vahidinia
ATP/TCAN Lead

Manuel Bautista

Antonino Cucchiara

Joshua Pepper

Incoming Program Scientists

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

NASA Astrophysics Division

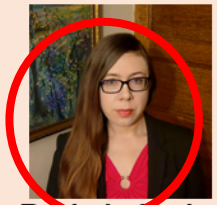
Division Director

Paul Hertz
Astrophysics Division Director

Sandra Cauffman
Astrophysics Division Deputy Director

ASTROPHYSICS
NASA's Science Mission Directorate

Program Executives



Rachele Cocks
Operating Missions
Pioneers

E. Lucien Cox
SOFIA, GUSTO, XRISM, ExEP

Ed Griego
Roman CGI, Operating Missions

Shahid Habib
PCOS/COR, ARIEL, Athena, Euclid, LISA, UltraSat

Janet Letchworth
Roman

Mark Sistilli
Explorers Program
IXPE, SPHEREx, COSI
Balloons

Cross Cutting

Eric Smith
Chief Scientist
Webb
Precursor Sci

Jeanne Davis
Assoc Dir for Flight
ASM Program Manager

Mario Perez
Chief Technologist
SAT, RTF, ISFM, Swift

Not Pictured

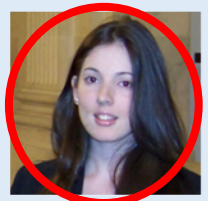
Lisa Wainio
Information Manager,
Public Affairs Liaison

Administrative Support

Kelly Johnson
Administrative Assistant

Vacant

Vacant
Administrative Assistant



Sara Schwartzman
Program Support Specialist

Ingrid Farrell
Program Support Specialist

Program Scientists

Dominic Benford
Roman
APRA Lead

Terri Brandt
COSI Dep
APRA Dep
Pioneers Dep
Precursor Sci Dep

Valerie Connaughton
APRA (High Energy)
XRISM, UltraSat
PCOS Program

Michael Garcia
APRA (UV/Visible),
SmallSats/Pioneers
Hubble

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

Hashima Hasan
Education/Comms, Citizen Science, Archives, Advisory Committees, NuSTAR, Keck

Douglas Hudgins
ExEP Program
ADAP Lead
TESS Dep, ARIEL

Stefan Immler
Astrophysics Research Program Mgr, Chandra, ART-XC

Hannah Jang-Condell
XRP, TESS
DEIA Lead

Patricia Knezek
Explorers Program
Astrophysics Probe
SOFIA, Hubble Fellows

William Latter
APRA (Lab Astro)
SPHEREx, Fermi

Sangeeta Malhotra
Roman Dep
ATP/TCAN Dep

Roopesh Ojha
Data Lead, Athena,
NICER, HEC, AI/ML

Kartik Sheth
Inclusion Plans
Technical assessments

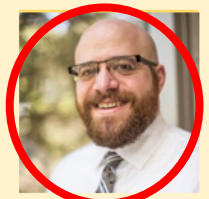
Linda Sparke
2021 MIDEX/MO,
Archives, COSI

Eric Tollestrup
APRA (IR/Submm)
Euclid, IXPE, COR Program

Sanaz Vahidinia
ATP/TCAN Lead

Manuel Bautista

Antonino Cucchiara



Joshua Pepper

Incoming Program Scientists

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

Importance of Inclusion, Diversity, Equity, Accessibility (IDEA)

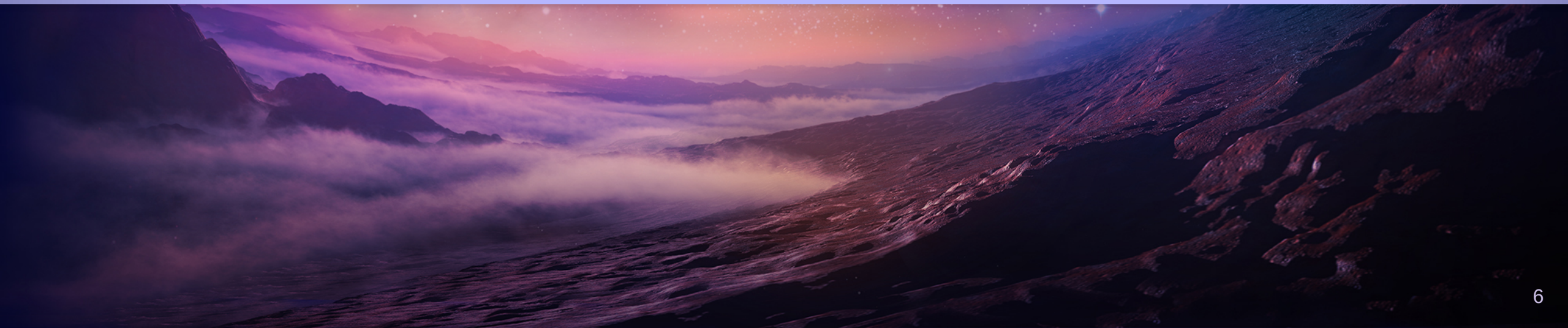
"The panel [on the State of the Profession and Societal Impacts] asserts that fundamentally, the pursuit of science, and scientific excellence, is inseparable from the humans who animate it."

- *Pathways to Discovery in Astronomy and Astrophysics for the 2020s*

NASA is committed to integrating inclusion, diversity, equity, and accessibility (IDEA) into all activities (missions, programs, reviews, internal matters, etc.)

IDEA will be addressed in the Budget Update, the Astro2020 Response Update, and the Program Update of this presentation, as well as the R&A Update on Day 2

Launches Galore



Suborbital Launches

Fall 2021 Balloon Campaign (Ft Sumner, NM)
7 balloon launches plus 34 student payloads

First balloon campaign since Winter 2019 (Antarctica)

Planning for CY22 balloon campaigns includes:

- Spring 2022 (New Zealand) – deployment started
- Spring 2022 (Sweden)
- Fall 2022 (Ft Sumner NM)
- Winter 2022 (Antarctica)

SISTINE, PI K. France (U. Colorado) [Nov 8, White Sands NM]
DXL, PI M. Galeazzi (U. Miami) [Jan 9, Wallops Island VA]

Additional sounding rocket launches planned in CY22

- XQC, PI D. McCammon (U. Wisconsin) June from Australia
- SISTINE, PI K. France (U. Colorado) July from Australia
- DEUCE, PI B. Fleming (U. Colorado) July from Australia
- tREXS, PI R. McEntaffer (Penn State U.) August from White Sands
- Micro-X, PI E. Figueroa (Northwestern U.) September from White Sands

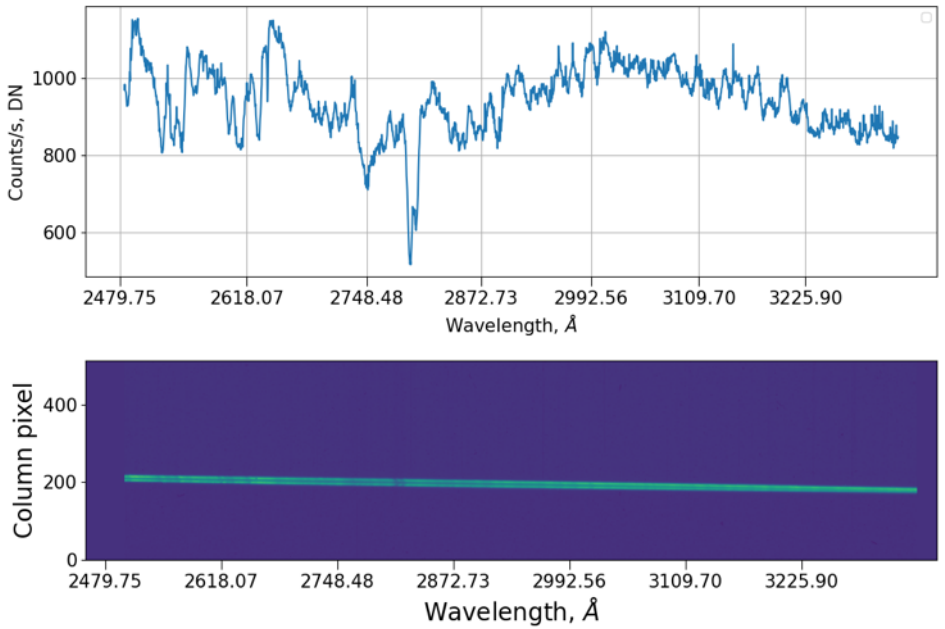
Thomas Hams, Balloon Task Force Update
Day 1 @ 3:20pm ET

Thomas Hams, Sounding Rocket Update
Day 1 @ 3:50 pm ET

Colorado Ultraviolet Transit Experiment (CUTE) in Science Operation

(PI: Kevin France, Colorado U)

- CUTE is a 6U cubesat with an NUV (255 – 330nm) telescope and spectrograph to study transiting planets around bright stars
- Launched September 27, 2021, as a secondary payload on the LANDSAT-9 mission. Spacecraft tracked and communications established within 2 days in coordination with amateur satellite community



- Completed spacecraft and instrument commissioning in February 2022.
- Science operations underway now (*completing 6 transit observations of first Early Release Science target now*).
- Science mission scheduled to complete in December 2022.

Left: Flux calibration spectrum from CUTE (K. France/University of Colorado)
Right: CUTE on secondary payload adapter

LANDSAT-9 launch
Sept 27, 2021

Imaging X-ray Polarimetry Explorer (IXPE)

PI: Martin Weisskopf (NASA/MSFC)

Launch Dec 9

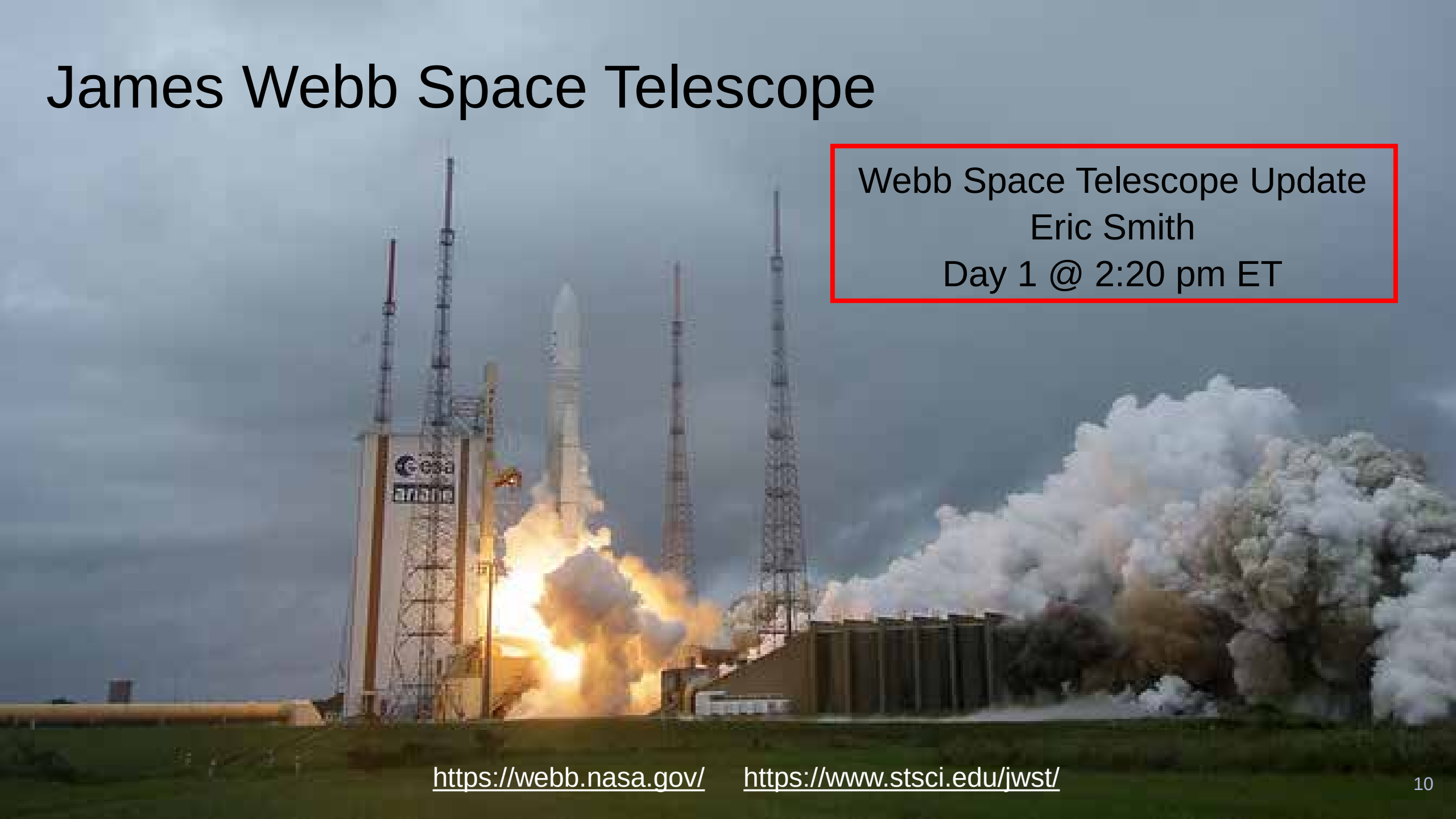
Boom deploy Dec 15

Science start Jan 10

The supernova remnant Cassiopeia A. Colors ranging from cool purple and blue to red and hot white correspond with the increasing brightness of the X-rays. The image was created using X-ray data collected by IXPE between Jan. 11-18, 2022. Credit: NASA

https://xpe.msfc.nasa.gov

James Webb Space Telescope



Webb Space Telescope Update
Eric Smith
Day 1 @ 2:20 pm ET

https://webb.nasa.gov/ https://www.stsci.edu/jwst/

NASA's NICER Telescope Sees Hot Spots Merge on a Magnetar

Released: March 8, 2022

Credit: NASA's Goddard Space Flight Center

Caption: This artist concept shows how NICER tracked brilliant hot spots on the surface of an erupting magnetar – from 13,000 light-years away.

Younes et al 2022 ApJL 924 L27

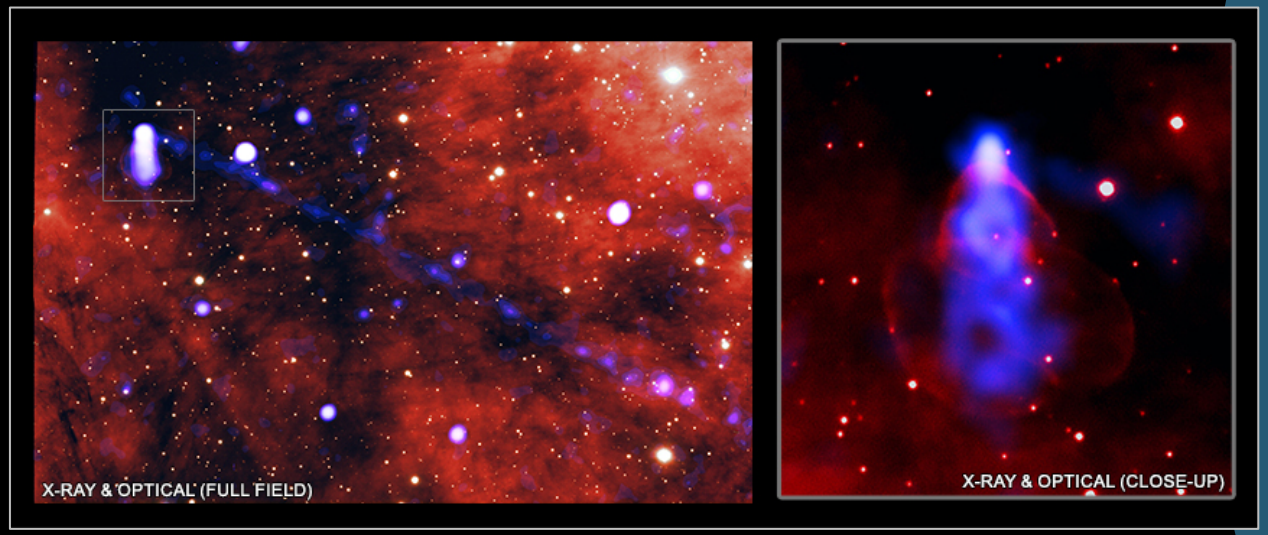
https://www.nasa.gov/nicer

Congratulations NICER Team!

The 2022 Rossi Prize has been awarded to Keith Gendreau, Zaven Arzoumanian, and the NICER Team "for development of the Neutron Star Interior Composition Explorer (NICER) and the revolutionary insights it is providing about the extreme environments of neutron stars and black holes, including the first precise and reliable measurement of a pulsar’s mass and radius from detailed modeling of its pulsed waveform."

Tiny Star Unleashes Gargantuan Beam of Matter and Antimatter

Released: March 14, 2022



Credit: X-ray: NASA/CXC/Stanford Univ./M. de Vries; Optical: NSF/AURA/Gemini Consortium

Caption: X-rays from Chandra (blue) show where particles flowing from the pulsar along magnetic field lines are moving. Optical light data from the Gemini telescope on Mauna Kea in Hawaii appear in red, brown, and black.

De Vries and Romani (2022), https://arxiv.org/abs/2202.03506

SCIENCE HIGHLIGHT

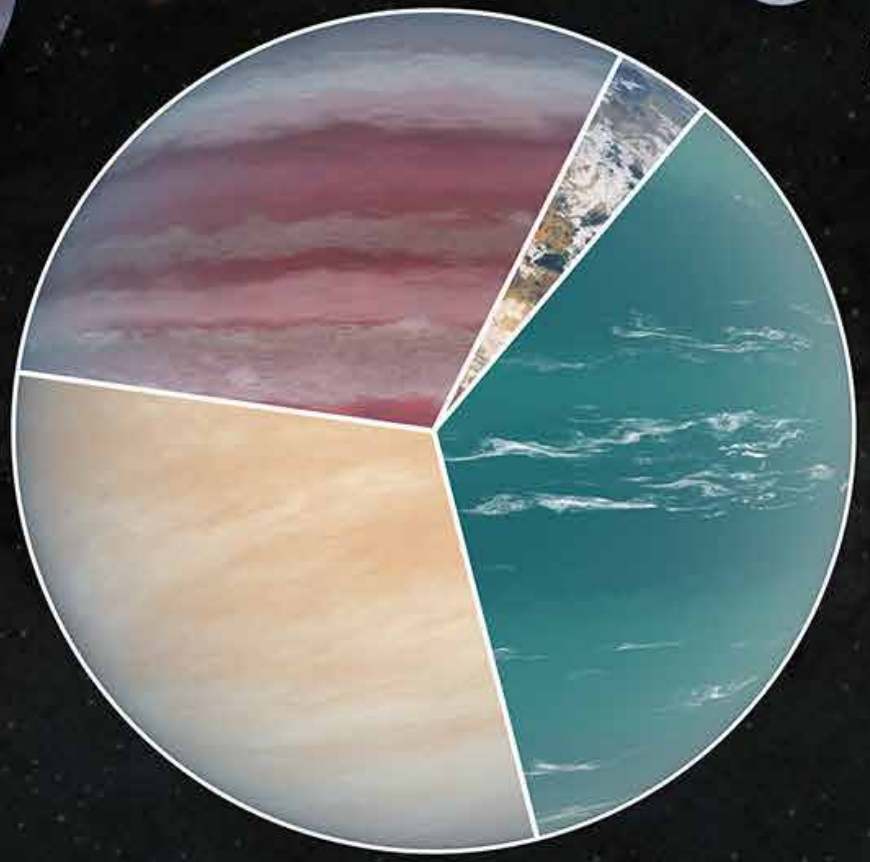
- This image from NASA's Chandra X-ray Observatory and ground-based optical telescopes shows an extremely long beam, or filament, of matter and antimatter extending from a relatively tiny pulsar.
- With its tremendous scale, this beam may help explain the surprisingly large numbers of positrons, the antimatter counterparts to electrons, scientists have detected throughout the Milky Way galaxy.
- The panel on the left displays about one third the length of the beam from the pulsar known as PSR J2030+4415 (J2030 for short), which is located about 1,600 light years from Earth.
- J2030 is a dense, city-sized object that formed from the collapse of a massive star and currently spins about three times per second.
- X-rays from Chandra (blue) show where particles flowing from the pulsar along magnetic field lines are moving at about a third the speed of light. A close-up view of the pulsar in the right panel shows the X-rays created by particles flying around the pulsar itself.
- As the pulsar moves through space at about a million miles an hour, some of these particles escape and create the long filament.
- The vast majority of the Universe consists of ordinary matter rather than antimatter.
- Scientists, however, continue to find evidence for relatively large numbers of positrons in detectors on Earth, which leads to the question: what are possible sources of this antimatter?
- The researchers in the new Chandra study of J2030 think that pulsars like it may be one answer. The combination of two extremes — fast rotation and high magnetic fields of pulsars — lead to particle acceleration and high energy radiation that creates electron and positron pairs.

30%
GAS GIANT

The size of Saturn or Jupiter (the largest planet in our solar system), or many times bigger. They can be hotter than some stars!

4%
TERRESTRIAL

Small, rocky planets. Around the size of our home planet, or a little smaller.



35%
NEPTUNE-LIKE

Similar in size to Neptune and Uranus. They can be ice giants, or much warmer. "Warm" Neptunes are more rare.

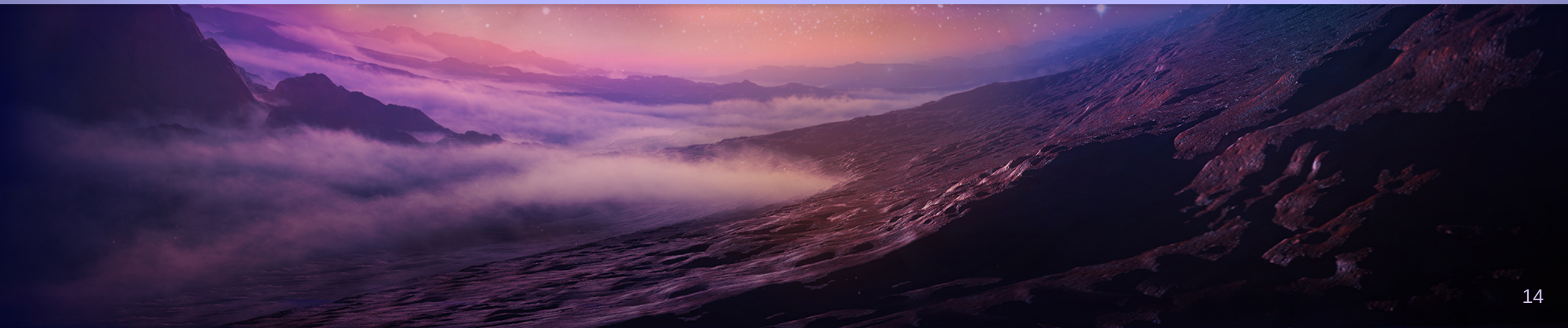
31%
SUPER-EARTH

Planets in this size range between Earth and Neptune don't exist in our solar system. Super-Earths, a reference to larger size, might be rocky worlds like Earth, while mini-Neptunes are likely shrouded in puffy atmospheres.

5000+
PLANETS FOUND

https://exoplanets.nasa.gov

APAC Recommendations



Recommendations from Oct 2021

The APAC requests APD work with the NASA Historian to document fully and completely in a written report the current status of investigation of archival materials, conversations, and other sources that culminated in the Administrator's decision of record to maintain the current memorialization of the NASA next generation infrared space observatory, pending imminent launch, as the James Webb Space Telescope (JWST).	The NASA Historian has confirmed plans to go to the archives and NASA plans to share information about his research after that trip.
The APAC strongly recommends APD critically review whether naming of flagship missions as it has traditionally occurred within the Division over the last few decades is appropriate, or whether APD should align with other SMD divisions in their naming of NASA flight assets	APD accepts this recommendation
The APAC strongly advises the APD work aggressively to more fully fund investigators research and analysis requirements for the JWST Cycle 1 work-efforts and to manage resources to accelerate meeting the full-funding of these efforts to maximize timely and impactful return on the $10B national investment in the flagship mission.	The Webb GO funding has been increased to $60M per year beginning with Cycle 1.
The APAC requests an update on the on-orbit Webb mission status and observing readiness at the committee's next meeting.	Eric Smith on Day 1 @ 2:20 pm ET

Recommendations from Oct 2021

The APAC requests APD establish a target window for the APAC review of the Senior Review report commensurate with the timeline stated in the Senior Review plan.	Senior Review report will be delivered to APAC on (or about) May 6. Special APAC meeting will be shortly thereafter.
The APAC requests a copy of the Senior Review Lessons Learned document prepared by Dan Evans, NASA SMD, prior to its next meeting.	Done
The APAC requests APD provide regular updates on the cost and schedule developments of the Roman Observatory	Julie McEnery on Day 1 @ 2:50 pm ET
The APAC recommends APD provide an update on the cost and schedule developments of the SPHEREx	Included in Paul Hertz's update
The APAC recommends specific inclusion of family situations to help improve work-life balance in DEI initiatives and that regular updates are provided on the status of the DEI pilot program for NASA Centers and civil-servants.	Included in Paul Hertz's update
The APAC requests a presentation on the sounding rocket program at its next meeting.	Thomas Hams on Day 1 @ 3:50 pm ET
The APAC requests an update on SPD-41 policies and implementation activities at its next meeting.	Deferred to summer APAC meeting

Recommendations from Oct 2021

The APAC recommends APD implement a more regular review of the NHSF program on a five-year cycle to assess outcomes and enable adjustments to the programmatic objectives as the dynamics and needs of the astrophysical community evolve.	APD accepts this recommendation
The APAC requests an update on the outcome of the science analysis that the European Space Agency (ESA) is leading related to the 10 arcsecond resolution performance and impacts to key mission science programs.	The ESA reviews are ongoing, and reports are expected within the next few months.
The APAC advises that the Athena project carefully track whether key science objectives may have to be substantially revised in light of the current technology challenges in meeting a key mission-requirements.	NASA is represented on the ESA Athena Science Study Team which has this responsibility for ESA.
The APAC advises APD to strategically identify appropriate cloud-based infrastructure options to facilitate analysis and theoretical modeling of the large data volumes from missions like Euclid by the wide community and undertake a trade study assessing the opportunity cost for this potential up-scope to the US Euclid project.	Presentation on archive modernization by Linda Sparke on Day 2 @ 11:10 am ET

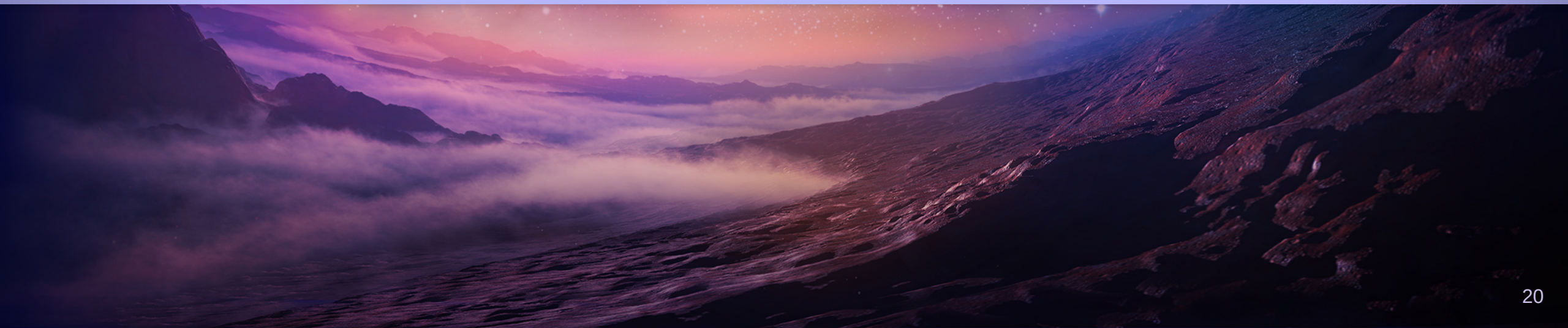
Recommendations from Oct 2021

The APAC suggests APD develop a rudimentary database of either available flight spares from current and/or past NASA missions or of mission concept studies that had substantial investments in enabling technologies (above TRL 5) and some basic characteristics (wavelength, detector pixel-size, etc.) that may indicate what types of spares are available to facilitate new PIs in developing compelling missions within the Pioneers' cost cap.	This is not practical.
The APAC recommends APD insert language in future Pioneers announcement of opportunities (AOs) that alerts potential PIs to the availability of hardware or enabling technologies and provides points of contact for follow-up.	NASA will inform Pioneers proposers of the process for proposing to use NASA spares and will provide POCs to contact.
The APAC requests the leads finalize cross-PAG TOR for the SAG by the next APAC meeting of the committee, which among other issues, reflects any Status-of-the-Profession workforce goals contained within the 2020 Decadal Survey.	Ryan Hickox on Day 2 @ 12:40 pm
The APAC recommends APD invite the Exo-Explorer program developer Tiffany Katrina and their collaborators to present to the committee its next meeting.	Tiffany Kataria on Day 2 @ 1:30 pm ET
The APAC requests a complete debrief on the Inclusion Plan Pilot Program findings at its next meeting.	Presentation on R&A Update by Stefan Immler on Day 2 @ 2:20 pm ET

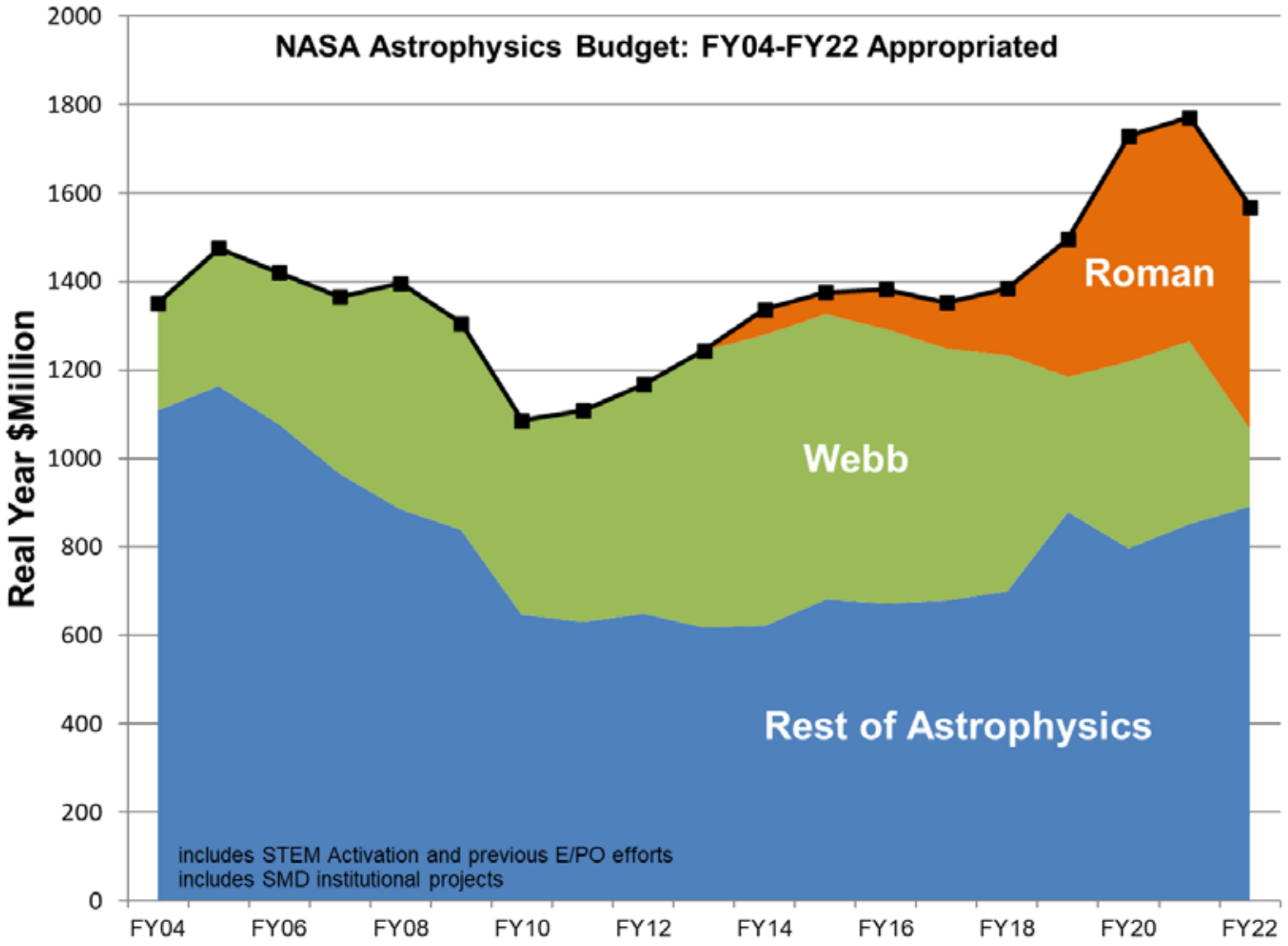
Recommendations from Oct 2021

The APAC advises APD seek continuance of Keck access.	A proposal from the Keck Observatory for NASA support is under review.
The APAC requests APD consider adding any proposal solicitation for continued NASA-funded community access to Keck include a requirement for providing a data management plan (DMP) and archive access plan that aligns with the NASA Science Information Policy (SPD-41 as implemented).	NASA requested that the Keck Observatory include a DMP and archive access plan in its proposal to NASA.
The APAC recommends realigning the scope and duration of the limited use exclusive period for data acquired through NASA-funded Keck access to be consistent with current APD mission practice.	NASA requested that the Keck Observatory include an alignment of exclusive use period for data with current APD mission practice in its proposal to NASA.
The APD advises APD to include terms and requirements in any agreement for community open access to data archives, including all necessary reduction and analysis software algorithms.	NASA requested that the Keck Observatory provide community open access to data archives, including all necessary reduction and analysis software algorithms in its proposal to NASA.
The APAC advises, consistent with SMD expectations, that a Diversity, Equity, and Inclusion (DEI) plan should be reflected in any proposal submitted in response to APD requests.	NASA included having an executable DEI plan as a review criterion for the proposal that the Keck Observatory submitted to NASA.

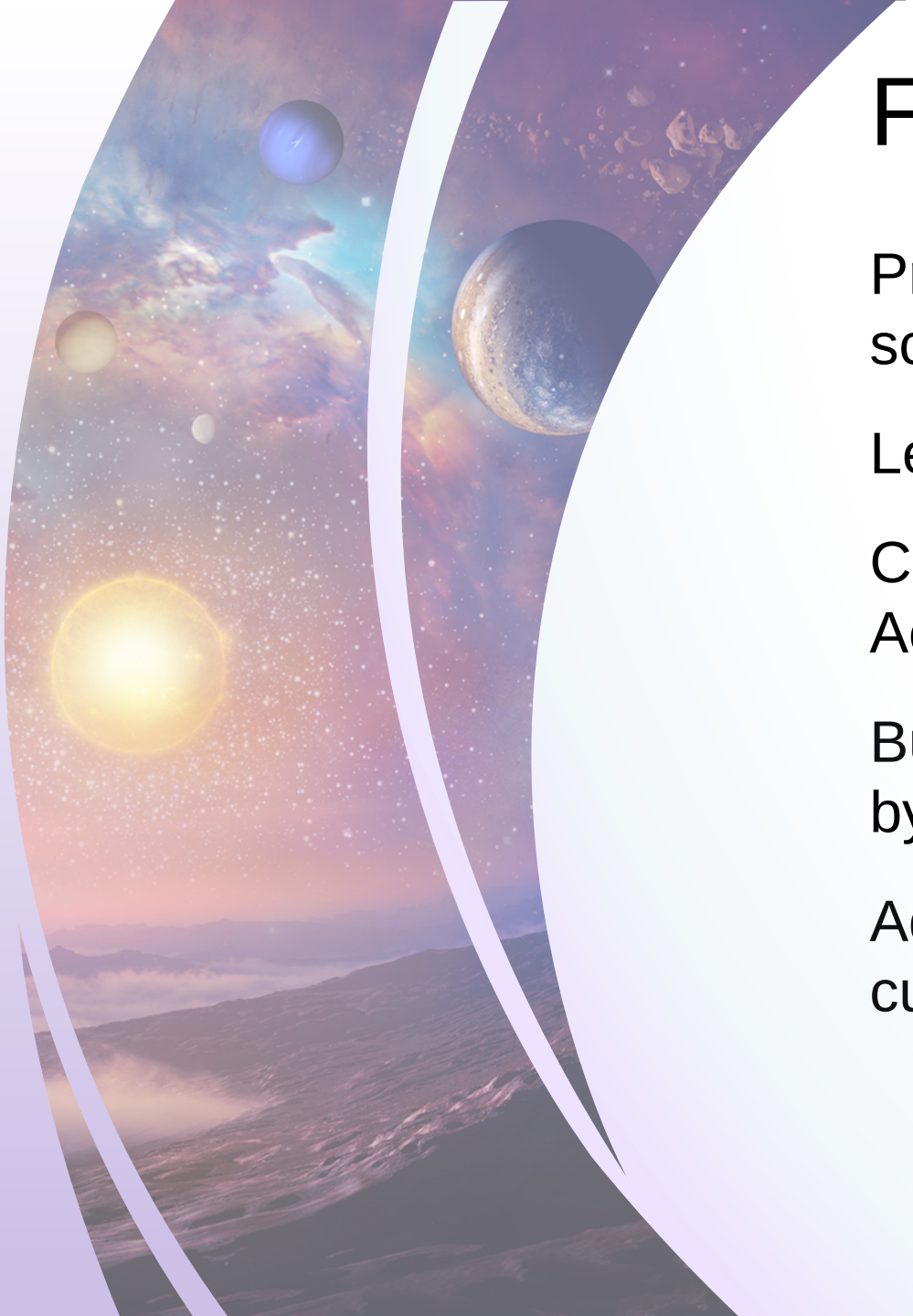
Budget



FY22 Appropriation



- Astrophysics total (including Webb) at $1.57B, down $7M from the request.
- Webb and Roman appropriated at the request, $175M and $502M respectively.
- SOFIA appropriated at $85M (request was zero).
- Science Activation appropriated $51M, down $5M from the request.
- Explanatory statement says,
  - “The agreement notes all recommendations of Astro2020.”
  - “NASA is expected to include appropriate funding for technology maturation in its fiscal year 2023 budget request to ensure continued Astrophysics mission success.”



FY23 SMD Budget Priorities

Promote US leadership in Earth system science and addressing the climate crisis

Lead Artemis Science

Champion Inclusion, Diversity, Equity and Accessibility

Build a balanced and innovative program driven by the highest national priorities

Advance open science for all by leveraging cutting edge data science techniques

FY23 BUDGET HIGHLIGHTS

Promote US leadership in Earth System Science and Addressing the Climate Crisis

- Build the Earth System Observatory to enhance and integrate research, data and applications to support near-term and long-range decisions by local, state, tribal and federal government officials
- Address the top science challenges with innovative tools, explorer missions, cutting edge technologies, and increased commercial partnerships
- Observe Earth’s land, ocean, ice, and atmosphere to understand the drivers and results of the changing climate
- Advance research and models to better our understanding of, and ability to predict, the changing climate and its interactions with human communities
- Expand communication of the drivers (e.g., greenhouse gases) and impacts (e.g., wildfires) of climate change via virtual and physical spaces

FY23 BUDGET HIGHLIGHTS

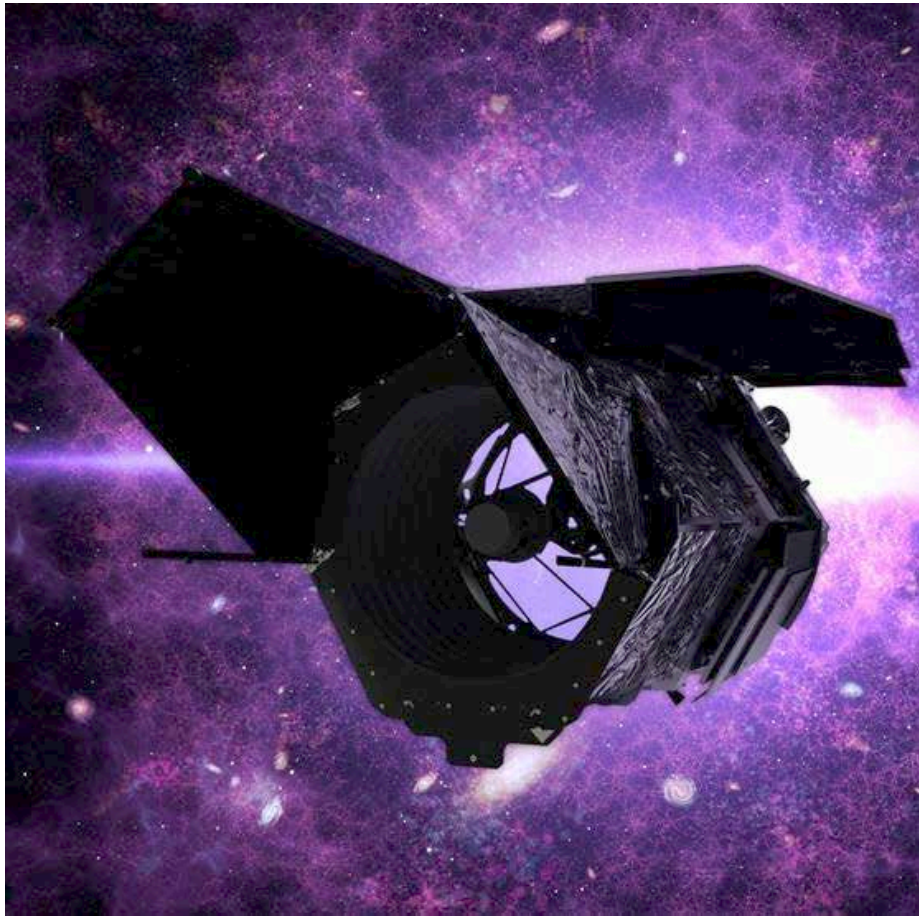
Lead Artemis Science

- Prepare the foundation of Artemis science via establishment of the Artemis III Geology Science Team and development of scientific instruments for Artemis human landing missions
- Conduct lunar science through the innovative Commercial Lunar Payloads Services (CLPS) initiative, leveraging commercial partnerships to deliver science, exploration, and technology payloads to the Moon
- Continue development of the Heliophysics Environmental and Radiation Measurement Experiment Suite (HERMES) for Gateway
- Enable development of more than 15 NASA and commercial missions and investigations (including the Moon, Mars, Biological and Physical Sciences, and Heliophysics) that inform and enable Artemis
- Confirm the presence of volatiles/ice early in FY2024 with the Volatiles Investigating Polar Exploration Rover (VIPER)

FY23 BUDGET HIGHLIGHTS

Champion Inclusion, Diversity, Equity and Accessibility (IDEA)

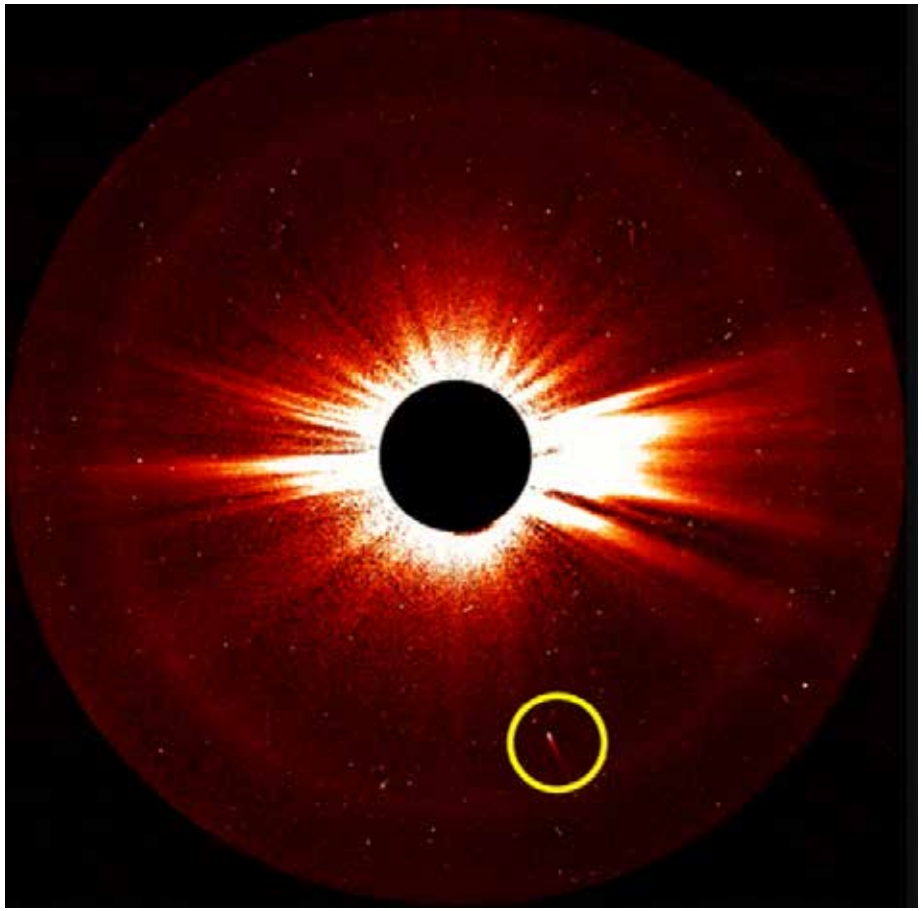
- Implement strategy in alignment with broader agency plan
- Increase requirement of inclusion plans in solicitations
- Continue SMD Bridge Program to increase collaborations between Minority-Serving Institutions, research intensive universities, and NASA Centers
- Develop a co-created HBCU engagement model that is sustainable and organic
- Expand dual-anonymous peer review as the default review method for all ROSES programs
- Engage underrepresented communities via listening workshops, solicitations, data workshops, mentoring and training
- Improve internal processes and missions to ensure accessibility in internal/external projects and programs including adding enforceable Codes of Conduct to science teams



FY23 BUDGET HIGHLIGHTS

Build a Balanced and Innovative Program Driven by the Highest National Priorities

- Support over 45 missions in formulation and development in FY 2023, including over 20 small missions and a balance of competed and directed missions
- Execute program informed by Decadal Surveys and other national priorities including new initiatives in wildfires, orbital debris, and space weather
- Fund development of Roman Space Telescope, Europa Clipper and Mars Sample Return; Operate Webb Space Telescope
- Implement new PI-led missions in Astrophysics and Heliophysics Explorers and Discovery Missions and Earth Ventures



FY23 BUDGET HIGHLIGHTS

Advance Open Science for All by Leveraging Cutting Edge Data Science Techniques

- Advance transparency, inclusivity, access, and reproducibility in scientific data and research
- Expand Open Source Science initiative to update data and software policies to be as open as possible, as closed as necessary
- Establish Transform to Open Science (TOPS), a 5-year activity to change how we do SMD-wide core data and computing services, laying the foundation for advance data analysis techniques

Recent Cost Performance

The 29 Science missions launched after establishment of the 70% JCL requirement (excluding JWST) have underrun their Phase C/D budget commitments by a net 2.3%

Total portfolio overrun is 3.7% when including JWST (assumes first baseline with JCL in 2011)

SMD continues to refine its ability to execute missions within cost commitments by implementing improved management techniques (particularly on large strategic missions) and the use of independent review boards and cost estimates

	KDP-C Dev Baseline $M	Actual $M	Actual vs. Baseline	
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/Hitomi*	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%	
ECOSTRESS*	42.5	36.3	-15%	
GEDI*	91.2	85.5	-6%	
OCO-3*	62.5	62.2	-1%	
ICON	196.0	205.4	5%	
SOC	376.6	275.8	-27%	
Mars 2020	1676.9	1994.5	19%	
Landsat 9	634.2	465.7	-27%	*est.*
Lucy	622.0	565.0	-9%	*est.*
IXPE*	163.0	156	-5%	
DART	258.3	262.4	2%	
JWST	6197.9	7117.1	15%	*est.*
Total with JWST	17,870.0	18,525.2	3.7%	total overrun
Total w/o JWST	11,562.2	11,292.1	-2.3%	total underrun

* No JCL conducted at confirmation

COVID Impacts on Agency Baseline Commitment (ABC) for Confirmed SMD Missions as of February 2022

Key Considerations:

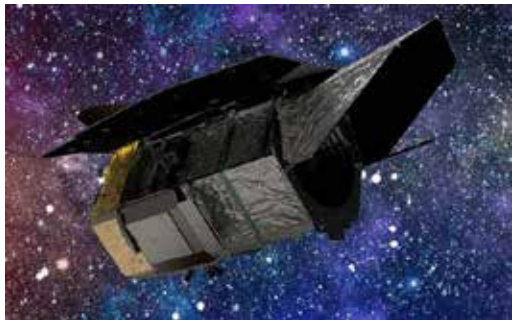
- The table contains SMD Missions impacted by COVID as a function of life cycle phase
- Over half of SMD missions have been able to mitigate COVID impacts within the mission ABC
- COVID impacts have caused some missions to exceed their ABCs for either cost or schedule

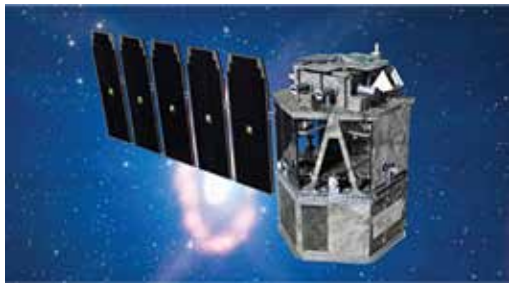
Notes: SMD does not track COVID impacts for NASA/NOAA missions. Webb is scheduled to complete commissioning in Q3 FY22 which is the official start of Phase E.

Missions Reporting COVID-19 Impacts		
Phase C	**Phase D**	**Phase E**
EMIT[1]	NISAR[3]	M2020[1]
GeoCARB[#]	SWOT[2]	DART[1]
MAIA[1]	EUROPA CLIPPER[3]	★ IXPE[2]
★ ROMAN[2]	★ EUCLID	★ JWST[3]
CLARREO-PF[3]	JUICE	LANDSAT 9
PACE[3]	MOMA-MS	LUCY
★ GUSTO	PSYCHE	Sentinel-6 Michael Freilich
AWE	TEMPO[#]	
EscaPADE	★ XRISM	
GLIDE		
IMAP		
MMX (MEGANE)		
PREFIRE		
PUNCH		
★ SPHEREx		
SUNRISE	★ Astrophysics Mission	
VIPER		

LEGEND
Breached ABC
Exceeded ABC
Expected to Exceed ABC
Did Not Exceed ABC
[#] Non-COVID Related
[1]Cost only
[2] Schedule only
[3] Cost & Schedule

Recent Accomplishments





James Webb Space Telescope launched and successfully deployed

- On December 25, 2021, the James Webb Space Telescope was launched from Kourou Space Center to its orbit around the Sun at Sun-Earth L2
- Commissioning is underway, all systems are functioning as expected, and science observations will begin in Summer 2022

Roman Space Telescope continued progress toward a 2027 launch

- In May 2021, the Nancy Grace Roman project was replanned to accommodate the impacts of COVID-19 on the workforce and supply chain
- In September 2021, the Nancy Grace Roman Space Telescope passed its critical design review (CDR) meeting all technical and programmatic commitments, and began fabrication, integration, and test

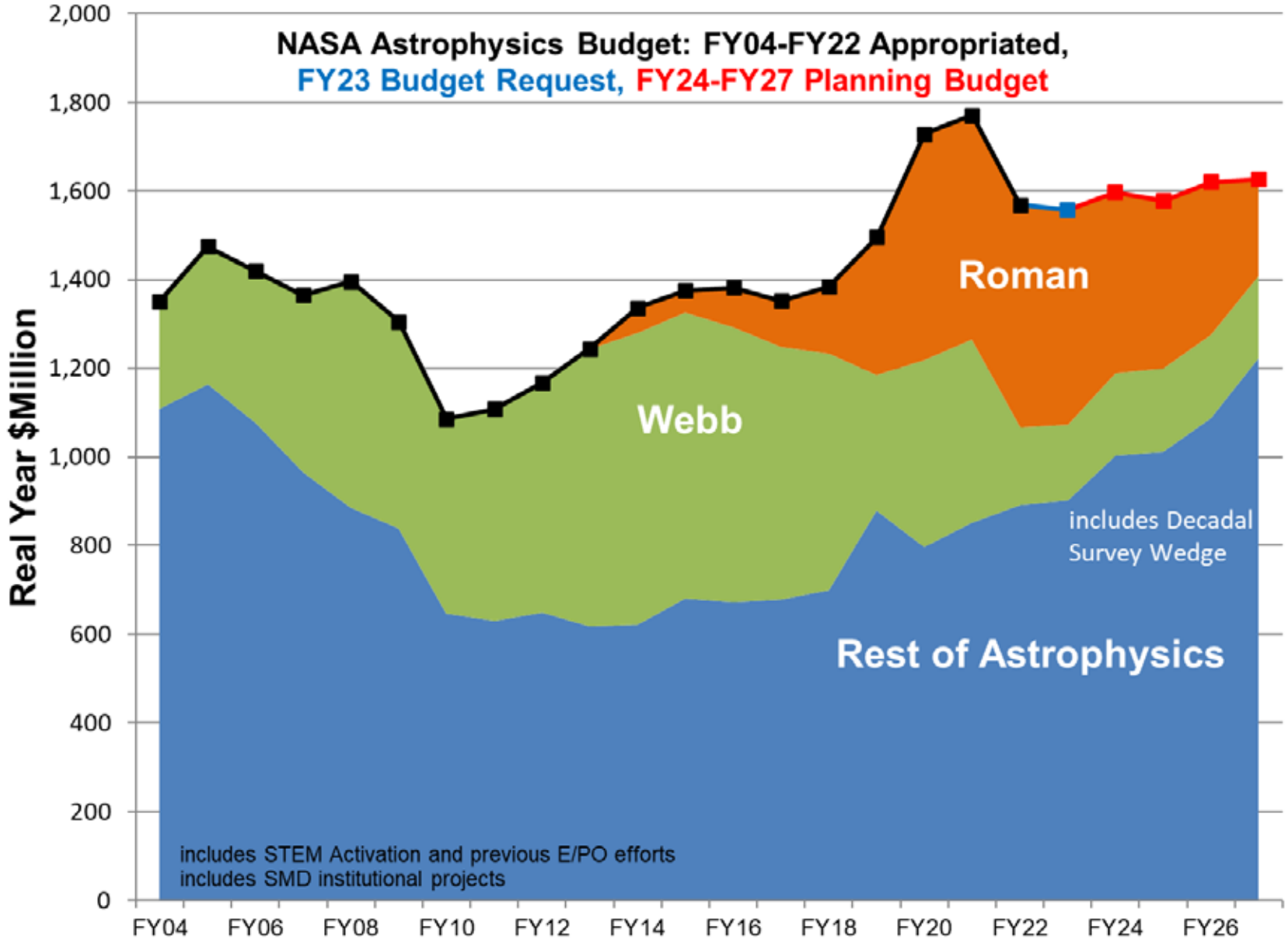
Astrophysics Explorers Program continued progress

- In December 2021, the Imaging X-ray Polarimetry Explorer (IXPE), NASA's newest Astrophysics Small Explorer mission, launched into low Earth orbit
- SPHEREx, the next Astrophysics Medium Explorer mission, passed its critical design review (CDR) in December 2021
- In October 2021, NASA selected the Compton Spectrometer and Imager (COSI) as its next Astrophysics Small Explorer mission.

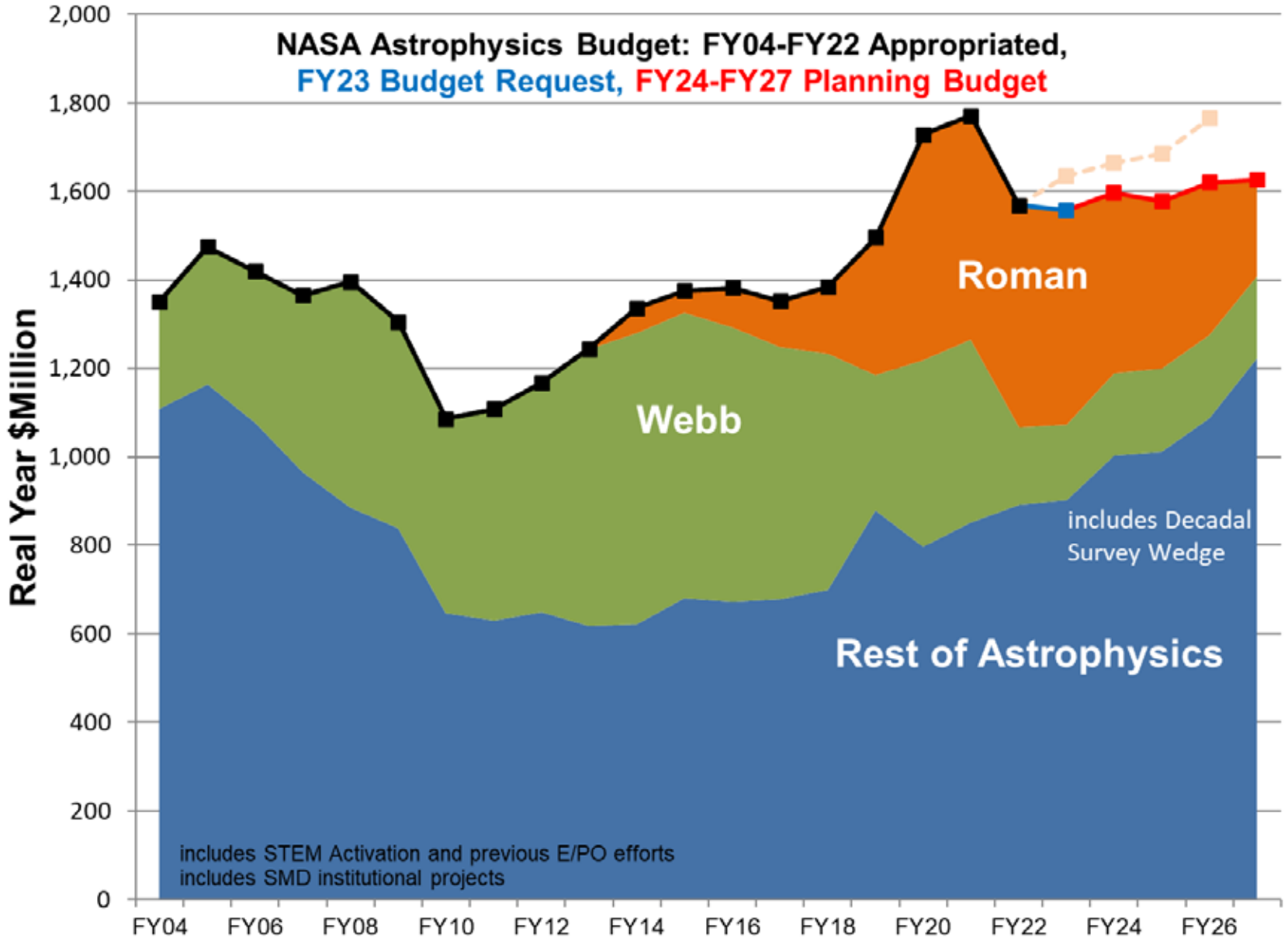
The 2020 Decadal Survey was received from the National Academies

- The Decadal Survey recommends an ambitious and inspiring program of science and missions for the 2020s

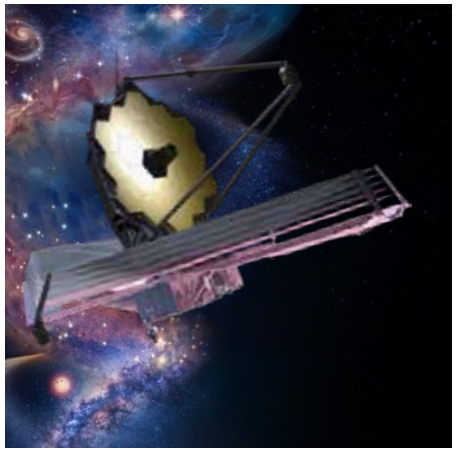
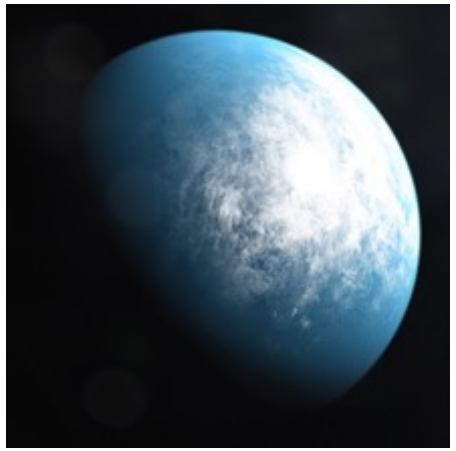
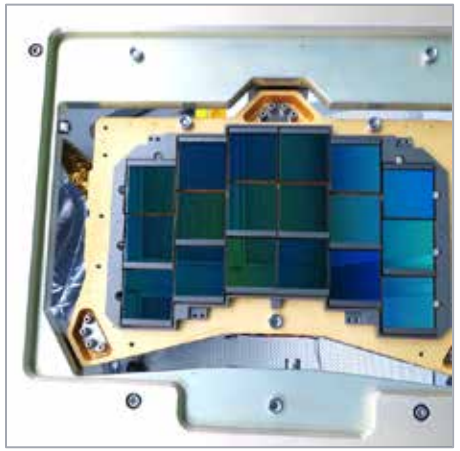
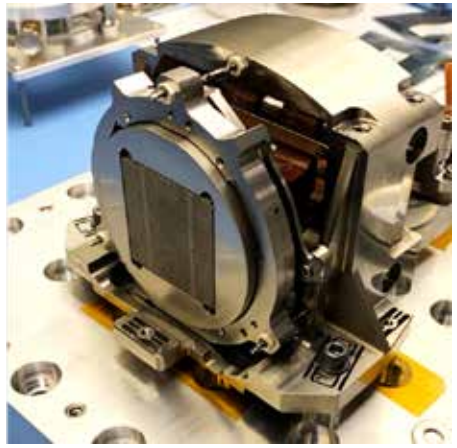
FY23 President's Budget Request



FY23 President's Budget Request

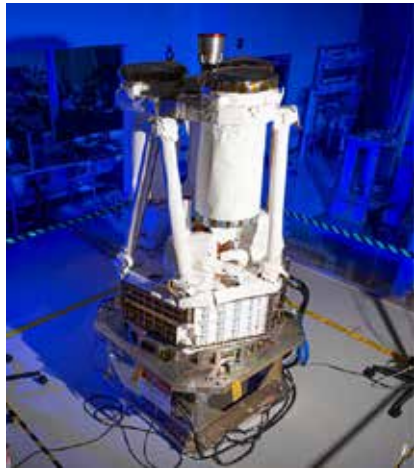


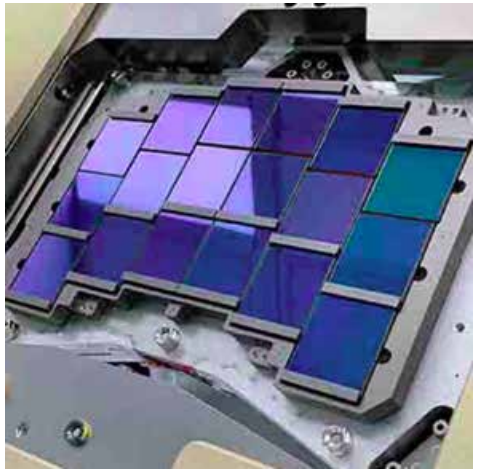
Planned Milestones FY22-23

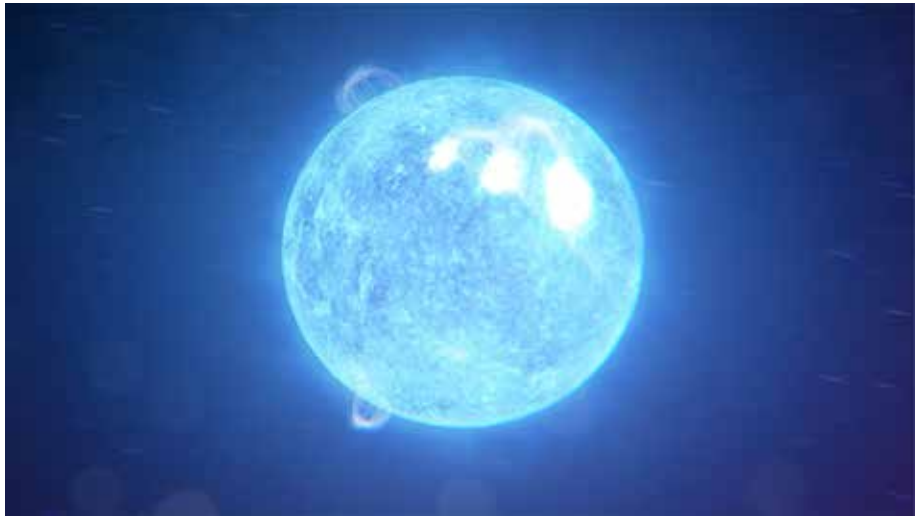





- Initiate Webb Telescope science in FY 2022
- Conduct Senior Review of Operating Missions in FY 2022
- Select MIDEX missions for competitive Phase A studies in FY 2022
- Conduct four scientific balloon campaigns in FY 2022 and four campaigns in FY 2023
- Select Webb Cycle 2 science observations in FY 2023
- Complete integration and test of the Roman Space Telescope's coronagraph technology demonstration instrument in FY 2023
- Initiate precursor science program to advance Astrophysics Decadal Survey priorities in FY 2023
- Participate in launch of JAXA's XRISM mission and ESA's Euclid mission in FY 2023

Astrophysics Budget Features







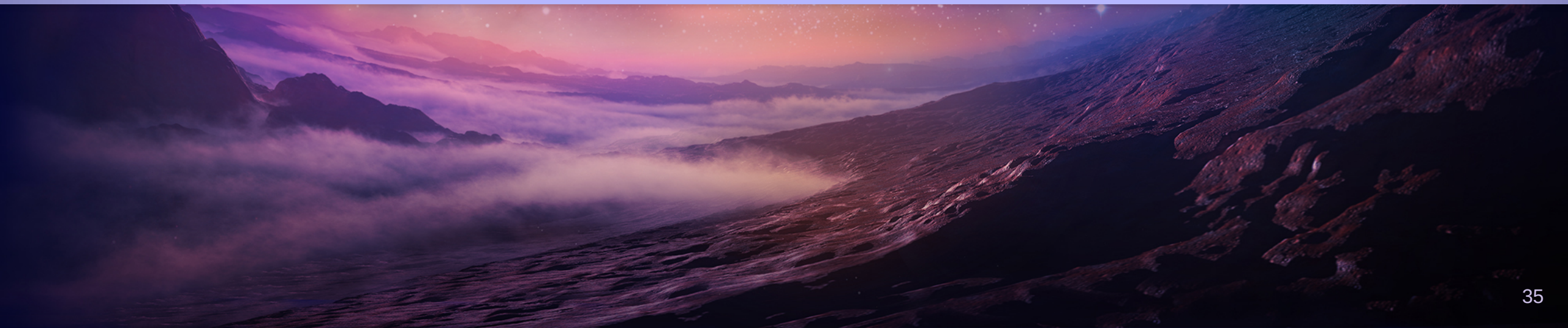
What's Changed

- Webb launch in December 2021
- Additional Webb General Observer funding to enable scientific leadership
- IXPE launch in December 2021
- Roman budget adjustments and 7-month delay, consistent with replan due to COVID impacts
- Additional Pioneer selections and increased cadence of Pioneers missions
- Support Decadal Survey recommendations for Great Observatory Precursor Science and Time Domain Astrophysics infrastructure systems
- Includes bridge partnerships focused on minority serving institutions and Decadal Survey recommendations for increased inclusion
- SOFIA close out in FY23 per Decadal Survey recommendation
- Extended Phase B for COSI, delayed development for next MIDEX
- Compared to the FY 2022 Budget request, delays a future Astrophysics Probe mission; AO release will be delayed from January 2023

What's the Same

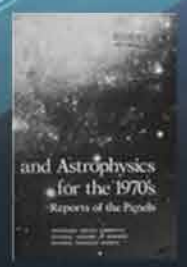
- Heathy R&A program
- Development of Astrophysics Explorers GUSTO and SPHEREx
- Development of contributions for JAXA-, ISA-, and ESA-led missions XRISM, ULTRASAT, Euclid, Ariel, Athena, and LISA
- Operating Missions, including Hubble, Chandra, Fermi, TESS, Gehrels Swift, NuSTAR, NICER, per Senior Review

2020 Decadal Survey

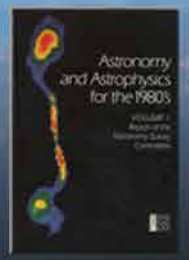


Astrophysics

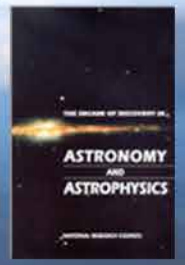
Decadal Survey Missions



1972
Decadal Survey
Hubble



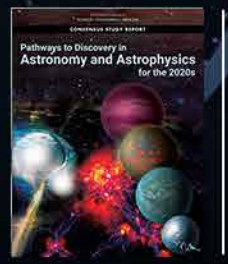
1982
Decadal Survey
Chandra



1991
Decadal Survey
Spitzer

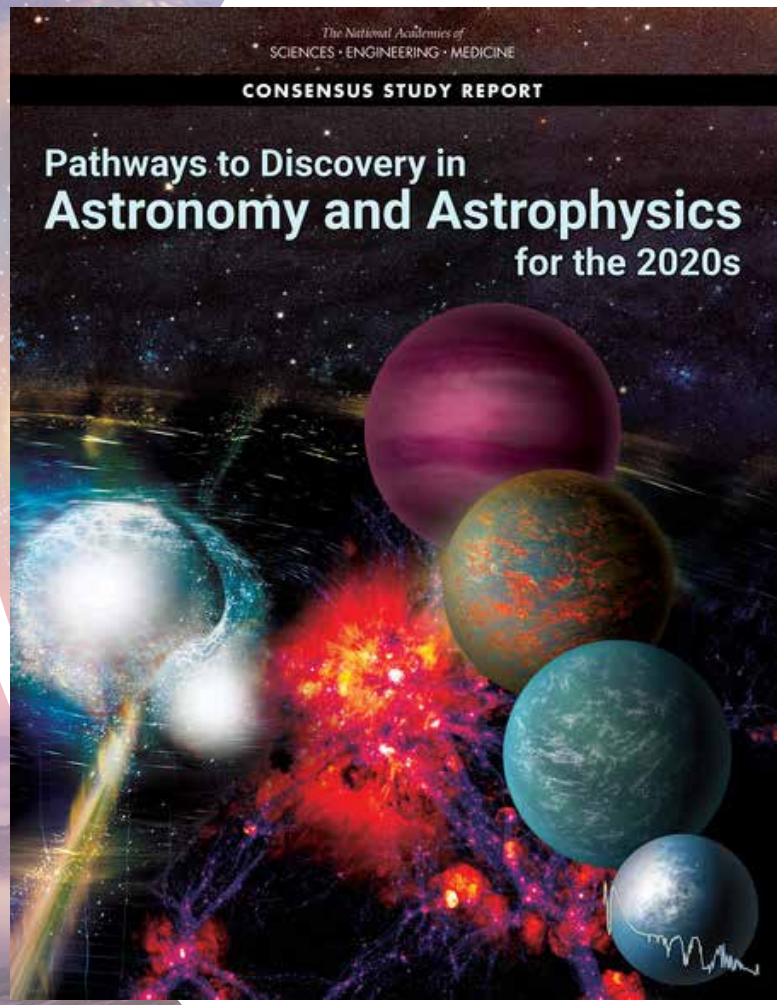
2001
Decadal Survey
Webb

2010
Decadal Survey
Roman



2021
Decadal Survey

NASA and Astro2020



This is an exciting and ambitious plan for the next decade and beyond

- Foundations of the Profession: Addressing inclusion, diversity, training, and the profession
- Research Foundation: Improvements to research and analysis and data centers
- Sustaining the Operating Portfolio: End SOFIA operations by 2023
- Technological Foundation: Improvements to technology development programs and the balloon program
- New Medium Initiative: Time Domain Astrophysics and Multi-Messenger Program
- New Medium Initiative: Astrophysics Probes
- New Large Initiative: Great Observatories Science, Mission and Technology Maturation Program for IR/O/UV, FIR, and X-ray Next Generation Great Observatories
- New Large Initiative: Next Generation Great Observatories, starting with an IR/O/UV Large Mission optimized for exoplanets and astrophysics

We are bound by the budgets that we have

- First budget that is fully informed by the Decadal Survey will be the FY24 budget proposal, which will be formulated by NASA Astrophysics in Spring 2022 and submitted to Congress in February 2023

Preliminary Response to Astro2020

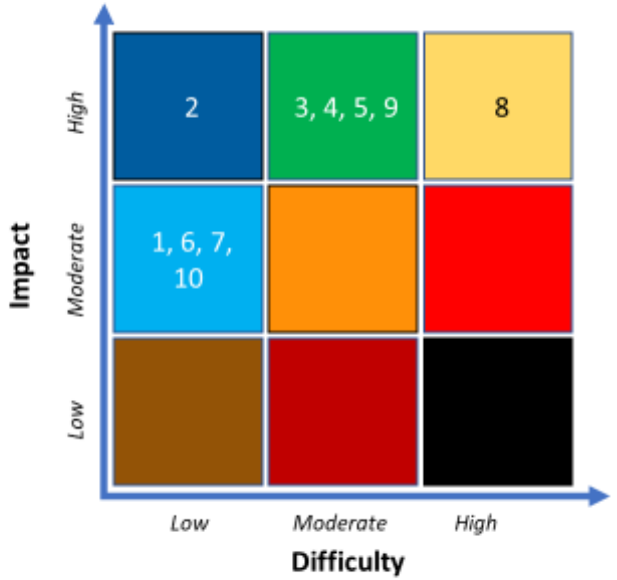
Recommendation	Preliminary response
Great Observatories Maturation pg. 7-11	• NASA conducted a Large Mission Study of lessons learned from the development of large space missions in the past; many of the practices that NASA has committed to in the Large Mission Study Implementation Plan match elements of the Great Observatory Mission and Technology Maturation Plan
IROUV Great Observatory pg. 7-17	• NASA will undertake a three-stage plan leading to a decision to begin formulation of NASA's next great observatory; the first stage has already been initiated

Large Mission Study

https://science.nasa.gov/about-us/large-mission-study

October 2019 – October 2020

Classification of Recommendations from the Large Missions Study



No.	Recommendation Title
1	*Pre-Phase A Team Composition*
2	*Pre-Phase A Architecture Trades and Descope Options*
3	*System Maturity Assessment*
4	*Technology Integration into Complex Systems*
5	*Analytical Tools*
6	*Cost and Schedule Estimation*
7	*Standing Review Boards (SRBs)*
8	*Instrument Selection Process*
9	*SMD Capabilities*
10	*Center Capabilities*

Large Mission Study

https://science.nasa.gov/about-us/large-mission-study

October 2019 – October 2020

SMD Large Missions Study Implementation Plan

No.	Large Missions Study Recommendation	Disposition	Large Missions Study Implementation Plan
1	*Pre-Phase A Team Composition*	Accept	Staffing will be based on needed skill sets and expertise (not based on availability of personnel). An Agency-wide search shall be conducted, followed by a nationwide search, if needed
2	*Pre-Phase A Architecture Trades and Descope Options*	Accept	Program Office will conduct independent assessment of Pre-Phase A architecture trades and descope options for evaluation at KDP-A. Implementation effective immediately.
3	*System Maturity Assessment*	Accept w/Follow-Up	Further action is required. A team, sponsored by the SMD DAA/P and led by the SMD Chief Engineer, will be formed for further investigation.
4	*Technology Integration into Complex Systems*	Partially Accept	Mandate increased scrutiny of technology maturity at reviews and KDPs. Implementation effective immediately. Further action is required - A strategic approach will be developed by the SMD Chief Technologist to identify technology needs and funding sources for technology development.
5	*Analytical Tools*	Partially Accept	Large strategic missions will incorporate common tool sets, when possible, and establish an agreed margin and risk philosophy with partners and providers early in the life cycle.
6	*Cost and Schedule Estimation*	Accept	Life cycle cost estimates shall be communicated in terms of bins for Pre-Phase A and ranges for Phases A and B to set external expectations. Implementation effective immediately.
7	*Standing Review Boards (SRBs)*	Accept	The SMD policy of convening the SRBs prior to MCR, and when required, convening of the Independent Review Boards (IRBs), has already been implemented. Initiating SRB kickoff meetings.
8	*Instrument Selection Process*	Partially Accept w/Follow-Up	Further action is required. A team led by the SMD Deputy AA for Research will be established. Modification of SMD policy may be required.
9	*SMD Capabilities*	Accept	Program Offices of large missions will be adequately staffed early in pre-formulation in order to perform programmatic assessments and oversight. Implementation effective immediately.
10	*Center Capabilities*	Accept	SMD and Centers have ownership and accountability of large strategic missions and will work closely to identify and solve problems. Implementation effective immediately.

The SMD Large Missions Implementation Plan will require an intentional shift in how we approach the development of our missions

Large Mission Study

https://science.nasa.gov/about-us/large-mission-study

October 2019 – October 2020

SMD Large Missions Study Implementation Plan

No.	Large Missions Study Recommendation	Disposition	Large Missions Study Implementation Plan
1	*Pre-Phase A Team Composition*	Accept	Staffing will be based on needed skill sets and expertise (not based on availability of personnel). An Agency-wide search shall be conducted, followed by a nationwide search, if needed
2	*Pre-Phase A Architecture Trades and Descope Options*	★	Program Office will conduct independent assessment of Pre-Phase A architecture trades and descope options for evaluation at KDP-A. Implementation effective immediately.
3	*System Maturity Assessment*	★ w/Fo[illegible]-Up	Further action is required. A team, sponsored by the SMD DAA/P and led by the SMD Chief Engineer, will be formed for further investigation.
4	*Technology Integration into Complex Systems*	Partiall[illegible] Accept ★	Mandate increased scrutiny of technology maturity at reviews and KDPs. Implementation effective immediately. Further action is required - A strategic approach will be developed by the SMD Chief Technologist to identify technology needs and funding sources for technology development.
5	*Analytical Tools*	Partially Accept	Large strategic missions will incorporate common tool sets, when possible, and establish an agreed margin and risk philosophy with partners and providers early in the life cycle.
6	*Cost and Schedule Estimation*	[illegible] ★	Life cycle cost estimates shall be communicated in terms of bins for Pre-Phase A and ranges for Phases A and B to set external expectations. Implementation effective immediately.
7	*Standing Review Boards (SRBs)*	[illegible] ★	The SMD policy of convening the SRBs prior to MCR, and when required, convening of the Independent Review Boards (IRBs), has already been implemented. Initiating SRB kickoff meetings.
8	*Instrument Selection Process*	Partially Accept w/Follow-Up	Further action is required. A team led by the SMD Deputy AA for Research will be established. Modification of SMD policy may be required.
9	*SMD Capabilities*	Accept	Program Offices of large missions will be adequately staffed early in pre-formulation in order to perform programmatic assessments and oversight. Implementation effective immediately.
10	*Center Capabilities*	Accept	SMD and Centers have ownership and accountability of large strategic missions and will work closely to identify and solve problems. Implementation effective immediately.

The SMD Large Missions Implementation Plan will require an intentional shift in how we approach the development of our missions

★ Astro2020 recommendations for the Great Observatories Mission and Technology Maturation Program (aka GOMAP)

Future Great Observatories

Large observatories are a critical component of NASA's astrophysics portfolio

- The Decadal Survey recommends a compelling, feasible, timely portfolio of future great observatories that is part of a balanced Astrophysics program

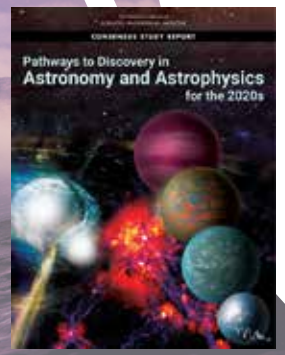
Today NASA's priority is ensuring mission success for Webb and Roman

- Webb has been launched and has begun its 6-month commissioning phase
- Roman successfully passed its Critical Design Review (CDR) and has been replanned to account for COVID impacts; the new launch commitment date is mid-2027 (7 month delay due to COVID)

Now is not the time to start a Future Great Observatory; now is the time to prepare

NASA will take a deliberate, multi-stage planning and strategy approach to the next large observatory mission

- Stage 1 – Focus on enabling science and technology; begin Stage 1 now
- Stage 2 – Begin the Decadal Survey recommended "Great Observatories Maturation Program"; conduct Analysis of Alternatives (AoA) and science / technology / architecture trades; begin Stage 2 in a few years (driven by planning and budget availability)
- Stage 3 – Pre-formulation and decision to start the next Great Observatory; begin after Stage 2 AoA complete (Decadal Survey estimates 6 years for Stages 2 and 3)



STAGE 1 ACTIVITIES

Science	Workshops - compile metrics and science gaps	Update ROSES Call	Determine efforts beyond ROSES	ROSES Selected	Science Gaps Identified for 3 Great Observatories	Begin Precursor Science Funded activities
				SCIENCE DEVELOPMENT		
Science Evaluation	Stand up Team	Develop initial Metrics	Develop initial parameters	Sensitivity study of key parameters	Iterate with SST and TST	Update sensitivity study with new parameters
				TECHNOLOGY DEVELOPMENT		
Technology	Stand up Team	ID Tech Gaps	Develop high level Tech Dev plans	ID tech studies. Trades & study groups	ID long lead tech investments	Begin tech studies

Note: This is not a timeline; some activities within each lane occur in parallel
There is cross-communication and cross-participation between activities in different rows
ROSES call for presursor science investigations anticipated for January 2023

Stage 1 Teams Enable Science and Technology

Director of Astrophysics

Joint Program Astrophysics Collaboration:
Advises Director and coordinates science and technology activities.
Eric Smith, Lead, with HQ & Program Office leadership

Science

Science Strategy Team: Identify, categorize, and iterate community precursor science investigations relevant to successful maturation of Astro2020's three great observatories. Work with Centers, Program Analysis Groups (PAGs), task groups. Eric Smith & Terri Brandt, Leads

Science Evaluation Teams: Develop and run simulation and yield-modeling tools to help inform strategic science and technology decisions. Rhonda Morgan for ExoSET, Jay Falker (acting) for AstroSET, and TBD for later Great Observatories, Leads

Science Development Management Team: Oversee the selected and directed precursor science activities.
Program Scientists, Leads

Precursor Science Investigators

Technology

Technology Strategy Team: Identify the capability needs and corresponding technology gaps for each of the future great observatories. Develop high-level plans to close them. Stand up task groups to develop detailed development plans. Work with Centers, task groups. Nick Siegler & Jay Falker, Leads

Technology Development Management Team: Oversee awarded and directed technology development activities.
Brendan Crill & Rachel Rivera, Leads

Technology Developers

Notes: This is not an org chart, it is just a description of teams
Box size means nothing other than the amount of inscribed text

NASA	NASA & Community	NASA & SMEs	Community

Preliminary Response to Astro2020

Recommendation	Preliminary response
IDEA Incentives pg. 3-14	• Under study by the Astrophysics Division IDEA task force
IDEA Workforce pg. 3-22	• NASA has received funding to start a Bridge Program within the Science Mission Directorate in FY22, with $5M for FY22 and increasing amounts planned for in future years • Partnerships with NASA's Office of STEM Engagement to increase support of HBCUs, TCUs, and other MSIs
Traineeship Funding pg. 3-23	• Under study by the Astrophysics Division IDEA task force • Astrophysics mission design summer school, to help train new PIs, in 2023
Postdoc Fellowships pg. 3-23	• NASA conducted an independent review of the NASA Hubble Fellowship Program in 2021 to assist NASA in increasing the effectiveness of the program and bolstering its excellence, with a focus on diversity, equity, and inclusion of the program. NASA is working on an implementation plan that is responsive to its 32 recommendations
Address Harassment & Discrimination pg. 3-27	• A working group has been established including the Science Mission Directorate, Office of Chief Scientist, and Office of General Counsel

Preliminary Response to Astro2020

Recommendation	Preliminary response
Proposal Demographics pg. 3-29	• NASA is collecting self-reported demographic data through NSPIRES on proposers, co-investigators, awardees, and reviewers • NASA has charged the National Academies with conducting a study that will enumerate the types of data that NASA should be collecting • NASA, NSF, and DOE have engaged with the AAAC to assess the Agencies' current practices in collecting, evaluating, and publicly reporting demographic data
IDEA Evaluation Criterion pg. 3-30	• NASA's ROSES Inclusion Plan initiative started in 2021 • Including diversity and inclusion of teams in evaluation of AO proposals starting in 2022

Preliminary Response to Astro2020

Recommendation	Preliminary response
Proposal Success Rates pg. 4-3	• NASA will continue to release data on proposal success rates, both aggregated and by program element, at every AAS Town Hall and at meetings of the Astrophysics Advisory Committee
Theory Funding pg. 4-10	• Astrophysics Theory Program (ATP) has a 22% selection rate with biannual calls • Increasing the budget by 30% would result in a 28% selection rate for biannual calls, but only a 14% selection rate for annual calls • Keeping in mind that the Decadal Survey states that a 22% success rate "remains low," NASA will consider options for restoring an annual cadence for ATP
Archive Coordination pg. 4-20	• NASA, NSF, and DOE have established a cross-agency working group to improve coordination among U.S. archive centers
Lab Astrophysics Review pg. 4-28	• NASA and NSF have discussed with the AAAC plans to establish a task force of the AAAC to report on prioritized needs for laboratory astrophysics as well as appropriate funding mechanisms for addressing those priorities
SOFIA pg. 5-12	• NASA has removed SOFIA from the 2022 Senior Review • NASA and the German Space Agency (DLR) are working together to determine a joint response to the recommendation that SOFIA operations be terminated at the end of the current mission extension

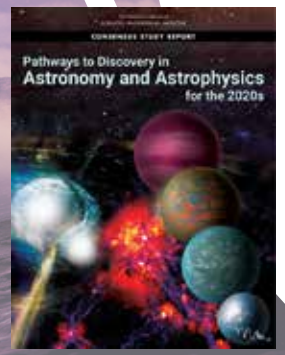
Preliminary Response to Astro2020

Recommendation	Preliminary response
APRA Technology Funding pg. 6-4	• NASA will consider increases as part of its FY24 budget formulation process
SAT Criteria pg. 6-5	• NASA amended ROSES 2021 on July 8, 2021, to expand the scope of the Strategic Astrophysics Technology (SAT) program element to include technology maturation targeted in strategic areas identified for the competed Probe class missions
Balloon Review pg. 6-8	• NASA will be discussing the formation of a Balloon Program Review task force with the APAC at its Spring 2022 meeting
Explorer Cadence pg. 6-9	• NASA has maintained a cadence of Astrophysics Explorer AOs every 30 months (4 per decade) since 2011
Astrophysics Probes pg. 7-20	• NASA issued a community announcement on January 11, 2022, with details regarding a planned AO for an Astrophysics Probe mission that is responsive to the Decadal Survey report
Roman Science Program Review pg. 7-35	• NASA asked the CAA to conduct a non-advocate review of the Roman Space Telescope's science program; the CAA working group held its first meeting in February 2022
Time Domain Program pg. 7-19	• NASA is committed to realizing the science of the recommended Time Domain Astronomy and Multi Messenger Astrophysics (TDAMM) program • A TDAMM workshop is planned for August 2022

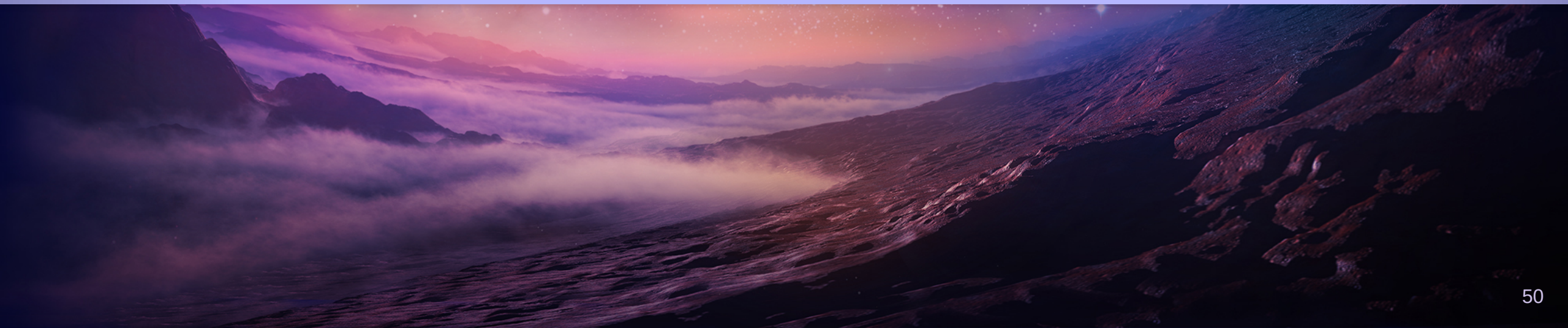
Time Domain & Multi-Messenger Program

Actions are being developed to address Time Domain Astrophysics and Multi Messenger (TDAMM) recommendations of the 2020 Decadal Survey; NASA's current thinking is

- A panchromatic, multi-messenger program enabled by current and upcoming ground- and space-based facilities will require coordination and broad community involvement
- In addition to new flight missions, the program must involve multi-mission, interagency, and international coordination in the areas of data archives, data standards, transient alerts, and community research opportunities
- Existing and future (in development) NASA missions will continue to make valuable contributions to TDAMM, and upcoming NASA missions and partnerships promise to do likewise
- This will be a program with extensive international cooperation, shaped using broad community input
  - TDAMM workshop August 22 – 26, Annapolis MD. Please contact: TDAMM-Workshop@bigbang.gsfc.nasa.gov
- NASA has invited its international partners and NSF to participate in the necessary cooperation



Program Updates



Importance of Inclusion, Diversity, Equity, Accessibility (IDEA)

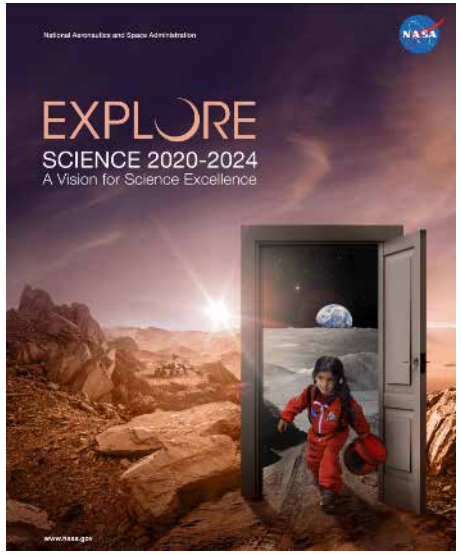
"The panel [on the State of the Profession and Societal Impacts] asserts that fundamentally, the pursuit of science, and scientific excellence, is inseparable from the humans who animate it."

- *Pathways to Discovery in Astronomy and Astrophysics for the 2020s*

NASA is committed to integrating inclusion, diversity, equity, and accessibility (IDEA) into all activities (missions, programs, reviews, internal matters, etc.)

Inclusion is a core value at NASA

Inclusion – NASA is committed to a culture of diversity, inclusion, and equity, where all employees feel welcome, respected, and engaged. To achieve the greatest mission success, NASA embraces hiring, developing, and growing a diverse and inclusive workforce in a positive and safe work environment where individuals can be authentic. This value will enable NASA to attract the best talent, grow the capabilities of the entire workforce, and empower everyone to fully contribute.



Strategy 4.1: Increase the diversity of thought and backgrounds represented across the entire SMD portfolio through a more inclusive and accessible environment.

ROSES: SMD's goals are to develop a workforce and scientific community that reflects the diversity of the country and to instill a culture of inclusion across its entire portfolio.

Building an Excellent Workforce

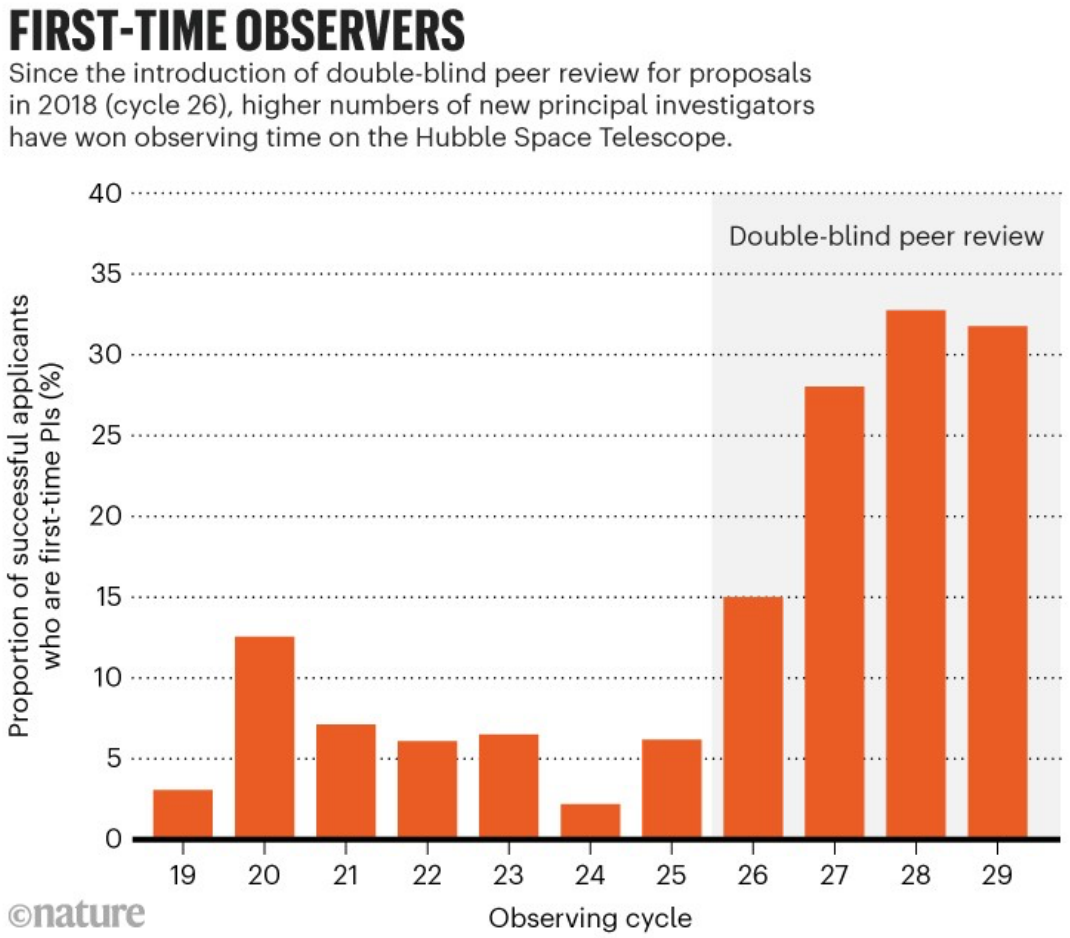
- PI RESOURCES WEBPAGE
- MISSION PI WORKSHOPS
- BRIDGE PROGRAM
- IDEA WORKING GROUPS
- DUAL-ANONYMOUS PEER REVIEW
- AWARD TERMS AND CONDITIONS
- IMPLICIT BIAS TRAINING FOR ROSES PANELS
- NO DUE DATE SOLICITATIONS
- CODES OF CONDUCT
- INCLUSION PILOTS IN R&A

Supporting Work-Life Balance

- SMD recognizes the importance of balancing one's work with the requirements of one's family, friends and personal physical and mental health
- We have created a web page to inform SMD-funded researchers about NASA-provided wellness resources and leave options that may be available

  https://science.nasa.gov/researchers/work-life-balance
- The web page discusses resources and flexibilities for
  - Recipients of NASA grants and cooperative agreements
  - NASA Civil Servant Scientists
  - NASA on-site contractors
  - NASA Postdoctoral Program Fellows
- The resources that one may access depend on one's relationship with NASA (above) and one's institution's policies
- One's first step, regardless of your relationship to NASA, should be to contact your institution's Office of Sponsored Programs, Human Resources or Human Capital Office to determine your employer's policies
  - NPP Fellows should contact their NPP Center Representative
- Please help us improve this webpage by sending suggestions, questions and feedback to sara@nasa.gov

SMD Inclusion, Diversity, Equity, Accessibility (IDEA) Initiatives



- University – Center – Minority Serving Institutions (MSI) bridge programs and learning workshops
- Implementing IDEA requirements in Announcement of Opportunities
- Enhanced student programs to improve access to underserved populations (Student Airborne Research Program, Rock On, data science internships)
- NASA SMD requested the National Academies examine the space mission proposal system in a study titled "Increasing Diversity and Inclusion in the Leadership of Competed Space Missions"

"double-blind peer review" is another name for "dual anonymous peer review"

2022 Astrophysics Research Program Elements

ROSES-22

Supporting Research and Technology

- Astrophysics Research & Analysis (APRA) *
- Strategic Astrophysics Technology (SAT) *
- Theoretical and Computational Astrophysics Networks (TCAN) *
- Roman Technology Fellowships (RTF)
- Astrophysics Decadal Survey Precursor Science (ADSPS) */** New

Data Analysis

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

Mission Science and Instrumentation

- Astrophysics Pioneers (suborbital science investigations) *
- Suborbital payloads solicited through APRA *
- LISA Preparatory Science *
- Roman Research and Opportunities (moved from ROSES-2021) New
- XRISM Guest Scientist (XGS, moved from ROSES-2021) ** New

Cross Divisional

- Exoplanets Research Program (XRP) **
- Topical Workshops, Symposia and Conferences (TWSC)
- Citizen Science Seed Funding Program
- Graduate Student Research Awards (FINESST)

Solicited Separately

- GO/GI/Archive/Theory programs for JWST, Hubble, Chandra, SOFIA **
- NASA Hubble Fellowship Program (NHFP)
- NASA Postdoctoral Program (NPP)
- Support for XMM-Newton U.S. PIs selected by ESA

Not solicited in ROSES-22

- Astrophysics Theory Program (ATP), every other year
- Astrophysics Explorers U.S. PIs (APEX USPI) is no longer solicited separately, now part of Astrophysics Research & Analysis (R&A)

Notice:

ROSES-22 was released on February 14, 2022

* Proposals will require an inclusion plan for creating and sustaining a positive and inclusive working environment. Stay tuned for future announcement

** Proposals evaluated using dual-anonymous peer reviews

R&A Update by Stefan Immler
Day 2 @ 2:20 pm ET

ROSES Inclusion Plans Initiative

Inclusion plans are required with selected ROSES elements.

Year 1 – ROSES-21

- Only Astrophysics Theory Program & PRISM (inclusion plan pilot)
- Inclusion plans evaluated for adequacy and completeness; feedback provided to the proposers; feedback not folded into the adjectival ratings or selection recommendations
- White paper published (https://science.nasa.gov/astrophysics/documents)

Year 2 – ROSES-22

- Seven astrophysics ROSES elements + at least one in each division
- Inclusion plans evaluated for adequacy and completeness; feedback provided to the proposers; feedback not folded into the adjectival ratings or selection recommendations; selected proposals will not be funded until unacceptable inclusion plans are remedied

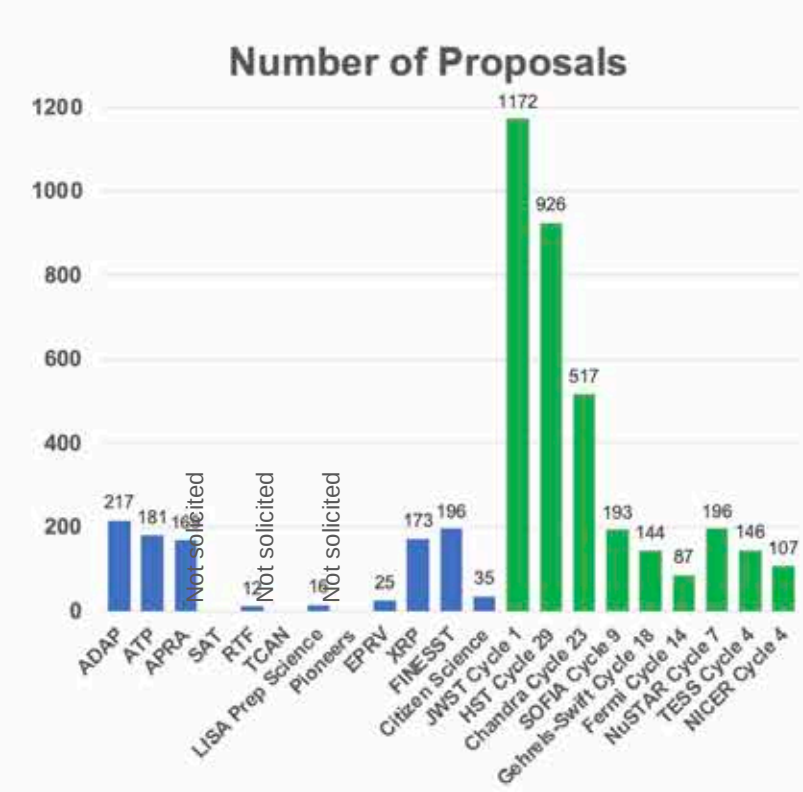
Year 3 – ROSES-23

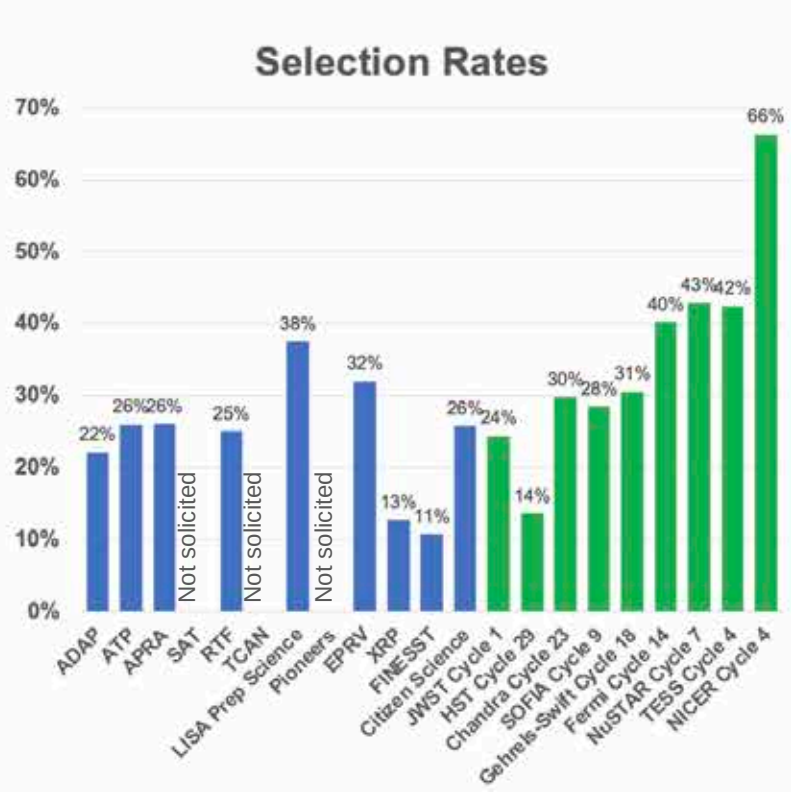
- Inclusion plans evaluated for adequacy and completeness; feedback provided to the proposers; feedback not folded into the adjectival ratings; proposals with unacceptable inclusion plans will not be selected

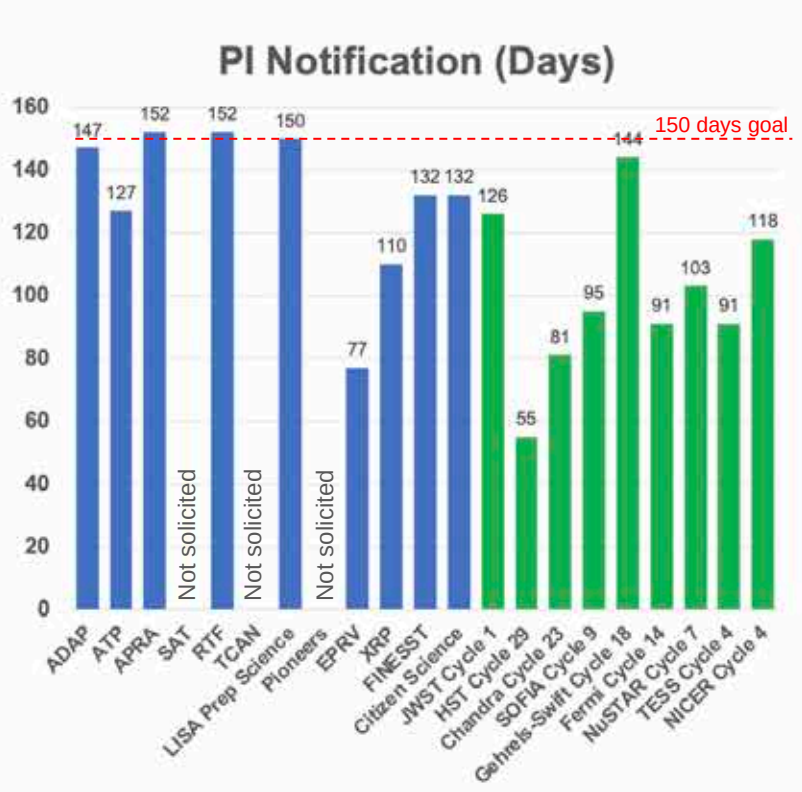
“NASA … should consider including diversity … in the evaluation of funding awards … .” (Astro2020, p. 3-30)

Astrophysics R&A Selection Rates

March 2021-2022







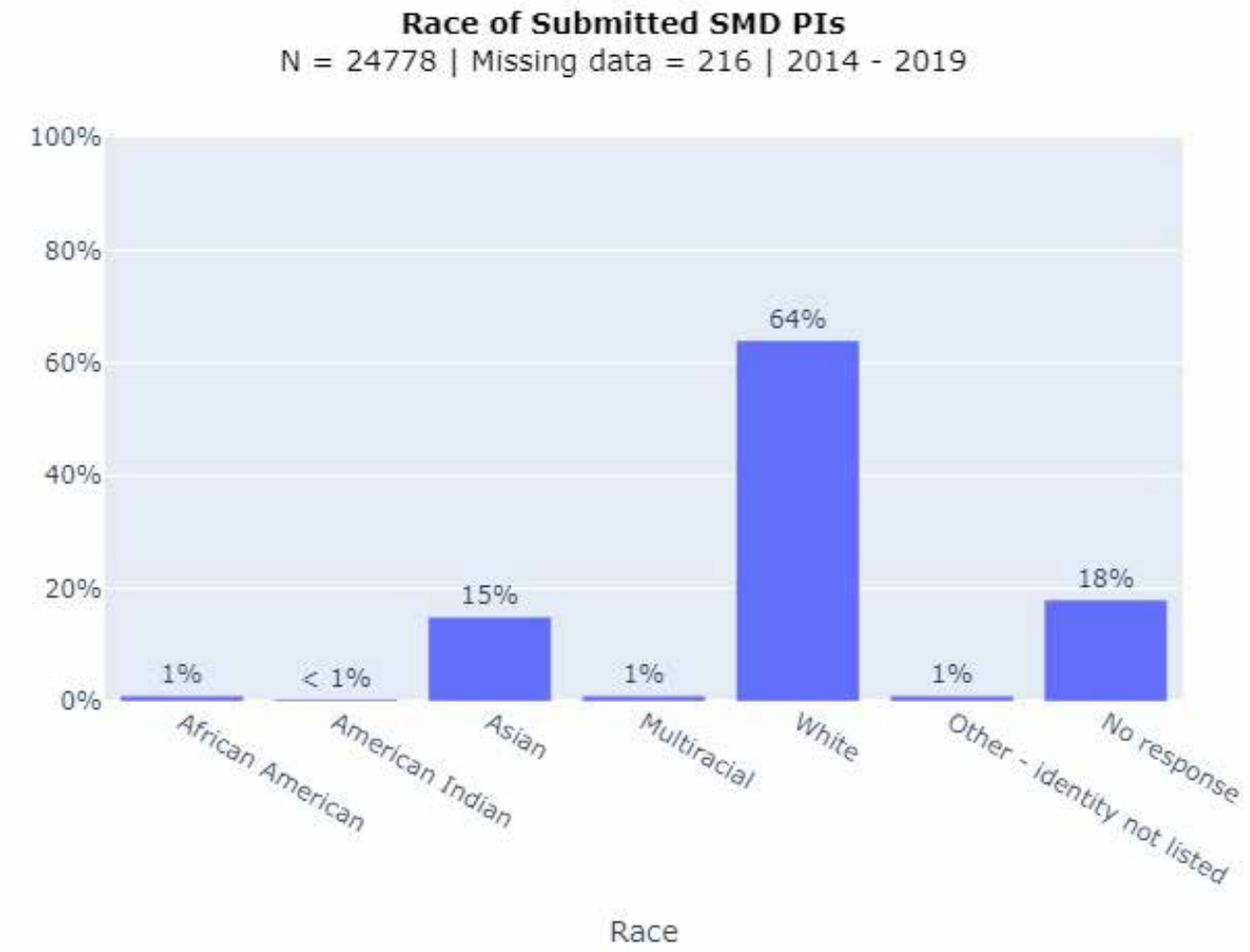
R&A: 1,024 proposals
GO/GI: 3,4988 proposals
Total: 4,532 proposals

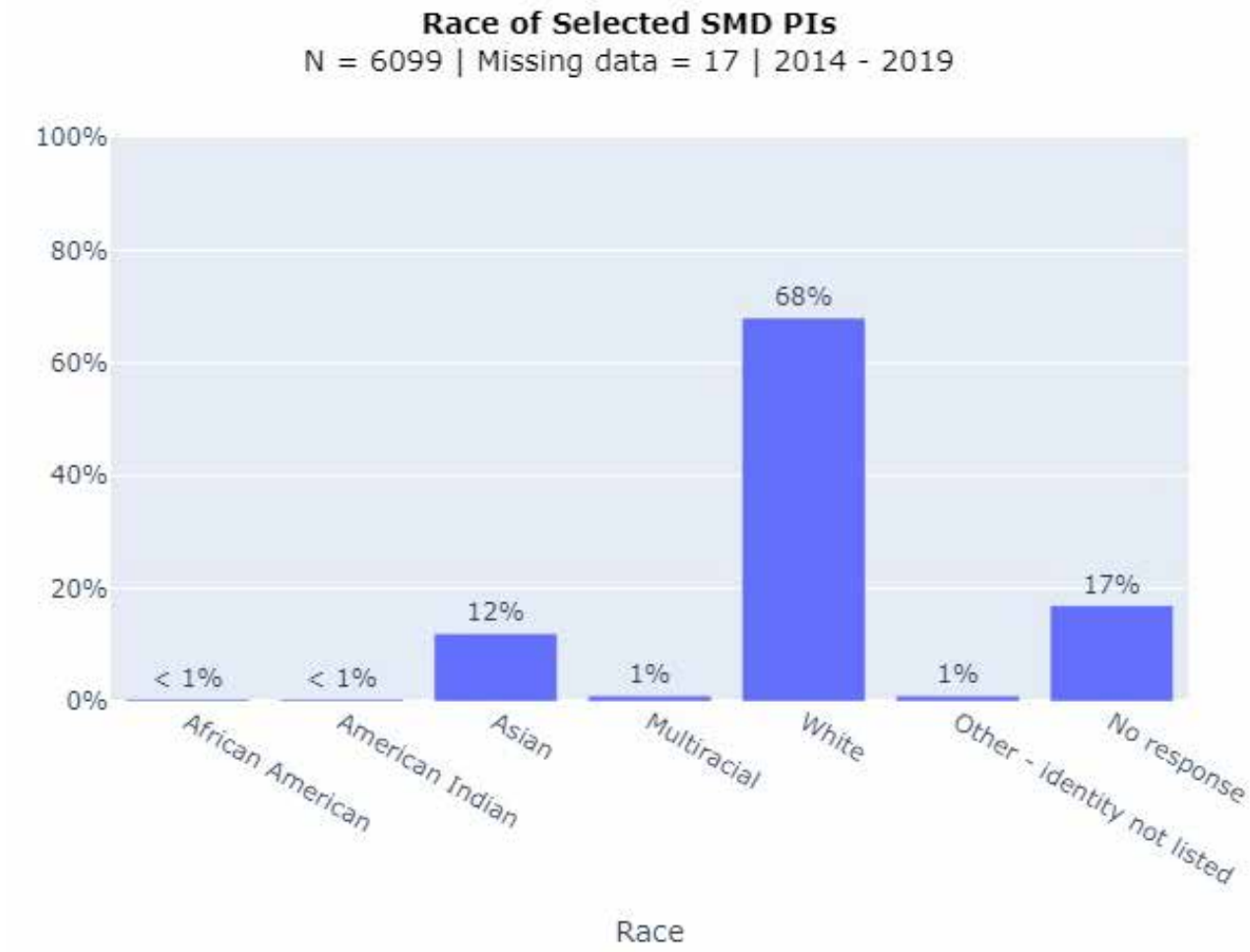
R&A: 20%
GO/GI: 27%
Average: 25%

80% of PI notification:
R&A: 147 days
GO/GI: 119 days

* Only programs with selections made and PIs notified

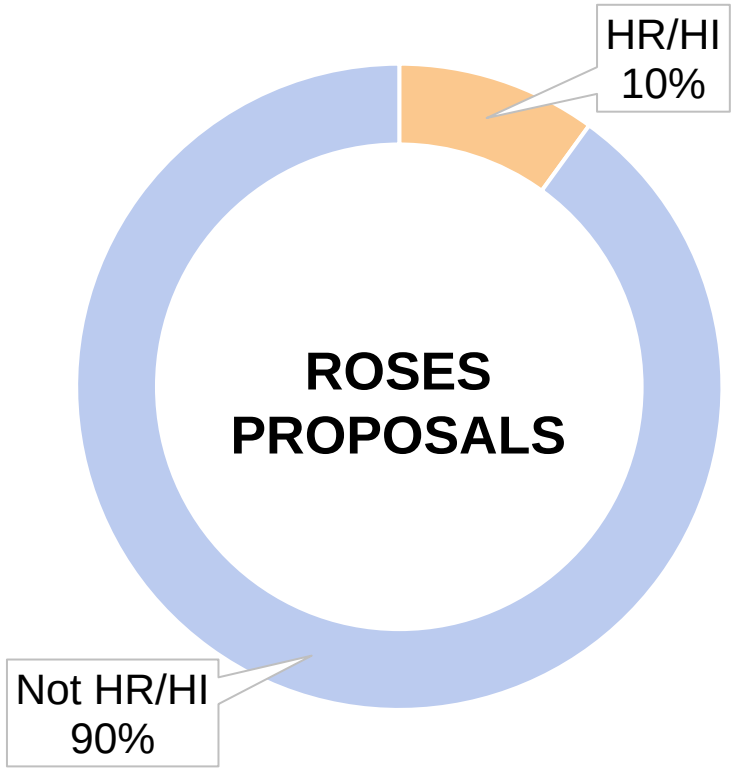
Sample of demographics: PI-identified race, aggregated over SMD 2014-2019

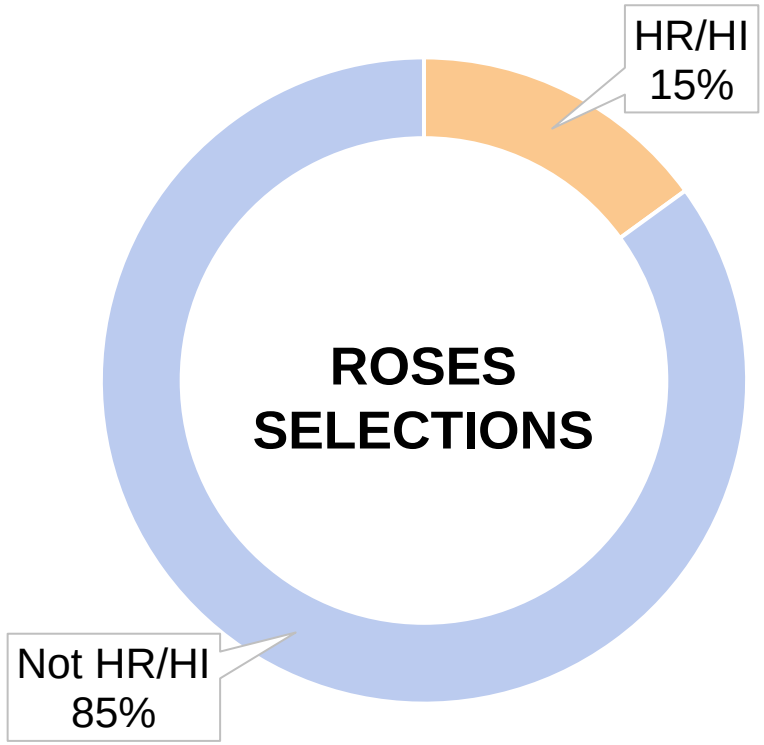




High Risk and High Impact Proposals

SMD funds high-risk/high-impact proposals in excess of the rate received





NANCY GRACE ROMAN SPACE TELESCOPE

Roman Update
Julie McEnery
Day 1 @ 2:50 pm ET

https://roman.gsfc.nasa.gov/

NASA launch commitment date remains May 2027. Roman is fully funded in FY22 appropriation and in the FY23 President's Budget Request.

CAA is studying the balance of Astro2010 surveys vs. future surveys (as per Astro2020 recommendation); report expected in 1-2 months.

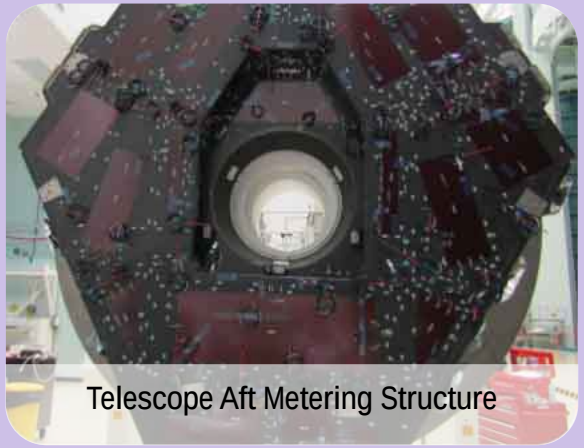
Project continues to make progress in spite of continued COVID inefficiencies at NASA, subcontractors, and partners; schedule reserves are adequate to cope with this.

Flight hardware in fabrication/testing. Focal plane array for the Wide Field Instrument is assembled; detectors for coronagraph are received. All major spacecraft procurements are made; launch vehicle procurement anticipated to be made summer 2022. Anticipate completing telescope late 2022.

Opportunities for participation in Roman Space Telescope research and support are offered in ROSES-2022; draft solicitation out soon.

NANCY GRACE ROMAN SPACE TELESCOPE

Optical Telescope Assembly Hardware



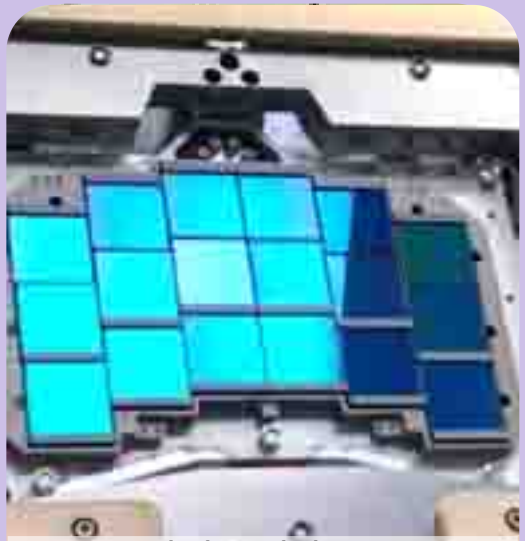
Telescope Aft Metering Structure

Primary Mirror undergoing environmental testing

Tertiary OptoMechanical Assembly

Wide Field Instrument Hardware

Instrument Structure readied for Vibration Testing

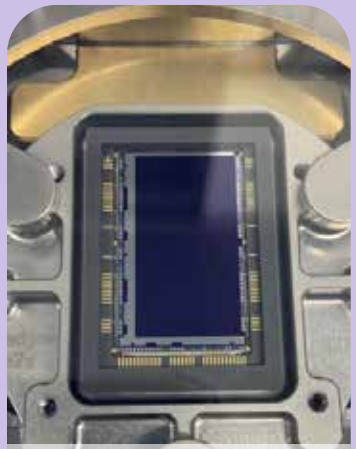


300Mpixel Focal Plane Array Flight Assembly – all 18 detectors!

Coronagraph Instrument Technology Demonstration Hardware

Deformable Mirrors completed fine polishing

Flight Masks (Pupil)



Engineering Unit EMCCD Detector

Roman Proposal Opportunities

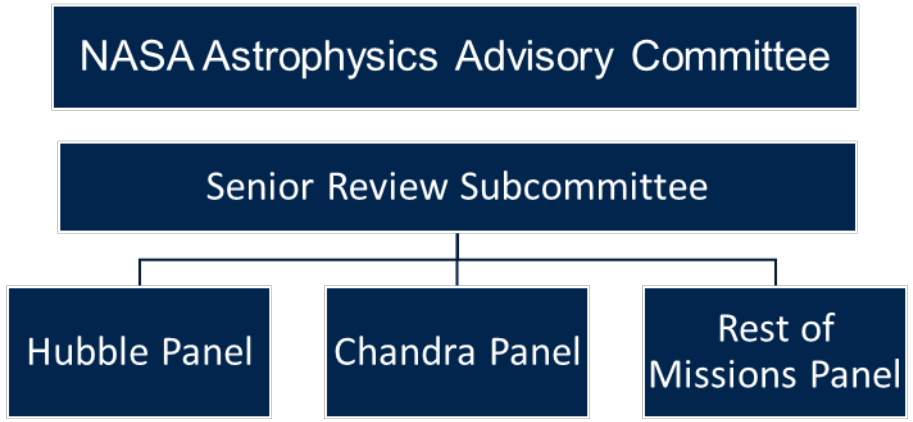
- Nancy Grace Roman Space Telescope Research and Support Opportunities will be solicited as part of ROSES-2022 (deferred from ROSES-2021).
- Includes opportunities for Coronagraph community participation, Wide Field Instrument preparatory science, and key project infrastructure teams.
    - Coronagraph Community Participation Program: Investigators to work with the coronagraph instrument team to plan and execute tech demo observations
    - Wide Field Science: Investigators to work on science preparation activities related to mission performance verification and/or science operations preparation
    - Project Infrastructure Teams: Science teams to support scientific investigations using the data from the core community surveys

---

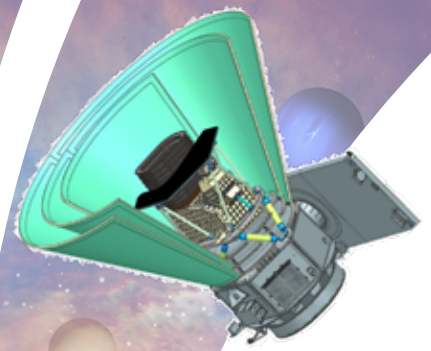
Astro2020 Recommendation: NASA Astrophysics Division should hold a non-advocate review of the Roman Space Telescope's science program to set the appropriate mix of survey time devoted to the weak lensing, baryon acoustic oscillations, supernovae, and microlensing programs relative to guest investigator-led observing programs during the primary 5-year mission.

NASA has asked the Committee on Astronomy and Astrophysics (CAA) to conduct a non-advocate review of the Roman Space Telescope's science program. The National Academies appointed a CAA working group to conduct the review, and the working group held its first meeting in February 2022.

Senior Review Update

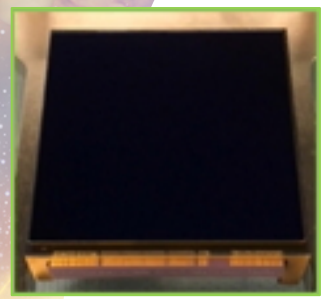


Activity	Date
Final Call for Proposals issued	September 30, 2021
Proposals due	February 11, 2022
Hubble panel meeting (virtual)	March 15, 16, 17, 2022
Rest-of-Missions panel (virtual)	March 29-April 1, 2022
Chandra panel meeting (virtual)	April 5, 6, 7, 2022
Panel reports to Senior Review Subcommittee	April 15, 2022
Senior Review Subcommittee meeting in Washington	May 4-5, 2022
Senior Review Subcommittee report to APAC	May 6, 2022 (TBC)
Special APAC meeting	May TBD, 2022
NASA Response/Direction to projects	May-June 2022



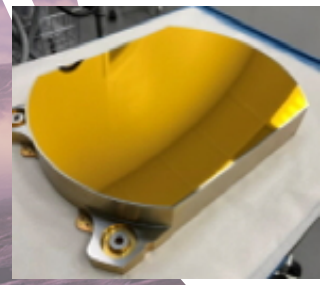
SPHEREx

Spectro-Photometer for the History of the Universe, Epoch of Re-ionization, and Ices Explorer Mission
PI: James Bock (Caltech)



Detector

Mirrors



Programmatic

- SPHEREx Project successfully completed the Critical Design Review (CDR) on January 18-21, 2022
- SPHEREx CDR design has ample technical margins with respect to the SPHEREx Level 1 requirements
- SPHEREx PI Cost Cap and PI launch date adjusted for COVID impacts only at SMD Program Management Council meeting on March 22, 2022; no change to Agency commitments

Schedule

- SPHEREx Agency launch readiness date (LRD) remains April 2025
- Next major SPHEREx milestone of Systems Integration Review (SIR) of December 2023 will include a Joint Cost and Schedule Confidence Limit (JCL) estimate; KDP-D follows SIR

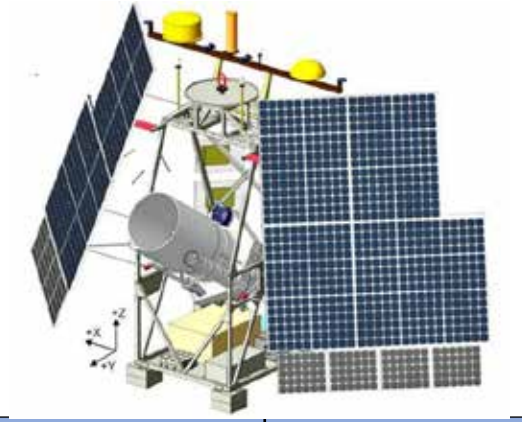
Cost

- Total SPHEREx Life Cycle Cost (LCC) remains unchanged at $451M
- PI Cost Cap (PICC) increased to incorporate cost impacts due to COVID

Technical Progress

- All 6 flight detectors delivered from Teledyne
- Flight telescope mirrors tested and coated at Ball Aerospace

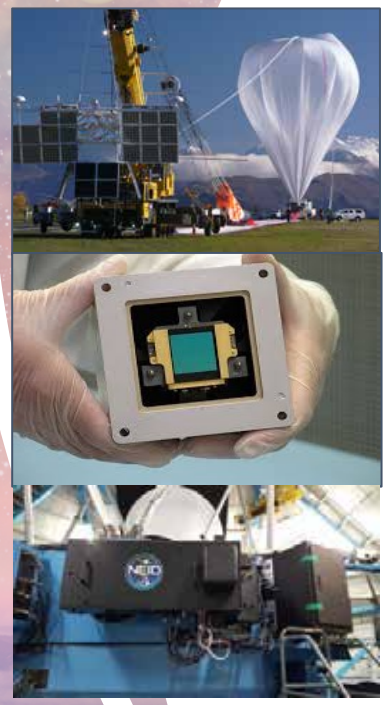
GUSTO

Science Description	
GUSTO will provide the first complete study of the interstellar medium through all phases of the stellar life cycle, from the formation of molecular clouds, through star birth and evolution, to the formation of gas clouds and the re-initiation of the cycle. GUSTO provides 500 times the angular and 1,000 times the velocity resolution of previous surveys of the Galaxy in [CII], [OI], and [NII].	

Project Description	Key Information	Payload	Partners
Sub-orbital Balloon-borne 0.9 m Cassegrain telescope launched from Antarctica to study the Milky Way and the Large Megellanic Cloud.	**Mission Phase:** C **Launch Date:** TBD **Mission Life:** 75 days **Category:** 3 **Class:** D Streamlined **Launch Vehicle:** Zero Pressure Balloon	• 0.9M Cassegrain telescope • TeraHertz heterodyne array receivers at 1.4, 1.7, and 4.7 THz • Payload provided by University of Arizona	• Principle Investigator: Christopher Walker (UA) • Project Management: JHU/APL • **Gondola:** JHU/APL • Mission Ops: JHU/APL • Science Ops: University of Arizona (UA)

Status: Negative schedule margin; payload missed date for shipping from UA to APL
Launch has been cancelled for Dec 2022; other payloads will go to Antarctica
Termination/Continuation review scheduled for May 2022

Astrophysics Technology Study

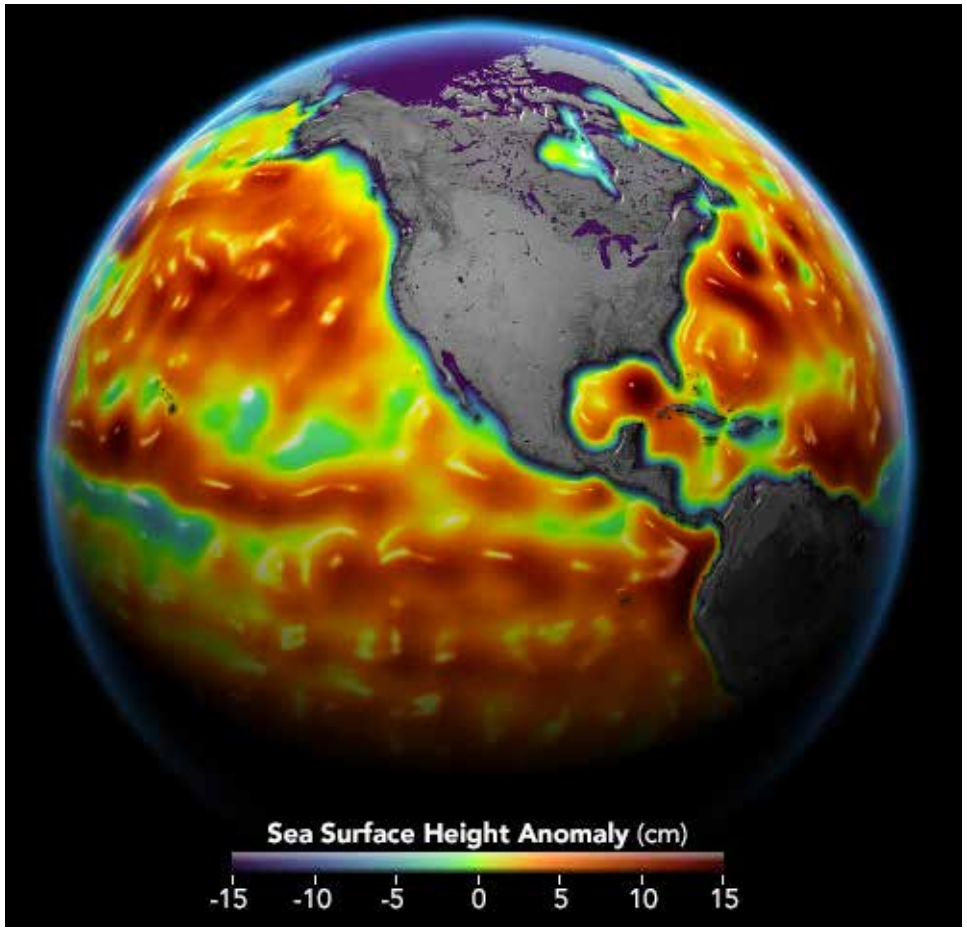


Aerospace Corp. conducted an independent, comprehensive Astrophysics Technology Heritage Study for a decade of awards (2010-2020)

- *The purpose of the study was to understand the overall impact on astrophysics technology advancement by the funding issued by Astrophysics Division.*
- *The study included 801 awards, 404 unique Pis, and 120 unique organizations. Over 300 technology PI surveys were completed and analyzed.*
- *Astrophysics awards fund a healthy portfolio of technologies that resulted in a 62% infusion rate, including sub-orbital missions (31%) and space-based missions (12%). Suborbital missions provide ample science and technology maturation, infusion, and transition opportunities.*
- *Other significant benefits included the development and training of students, postdocs, staff, and the support of laboratories and infrastructure.*
- *The top three grantee organizations were GSFC, JPL, and U. Colorado-Boulder (total of 23%). Fewer than 22% of awards went to NASA Centers.*

A more detailed presentation by Aerospace Corp on Day 2 @ 1 pm ET

Open-Source Science Accomplishments

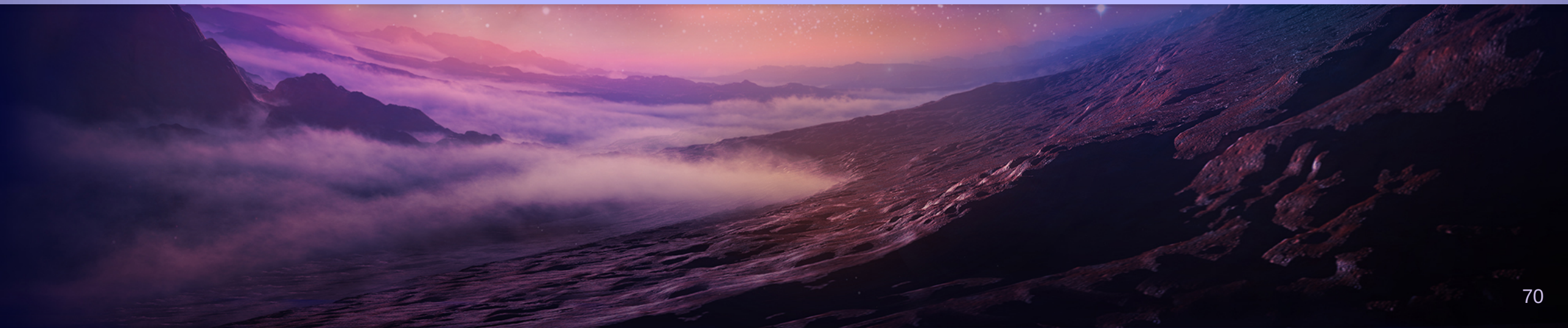


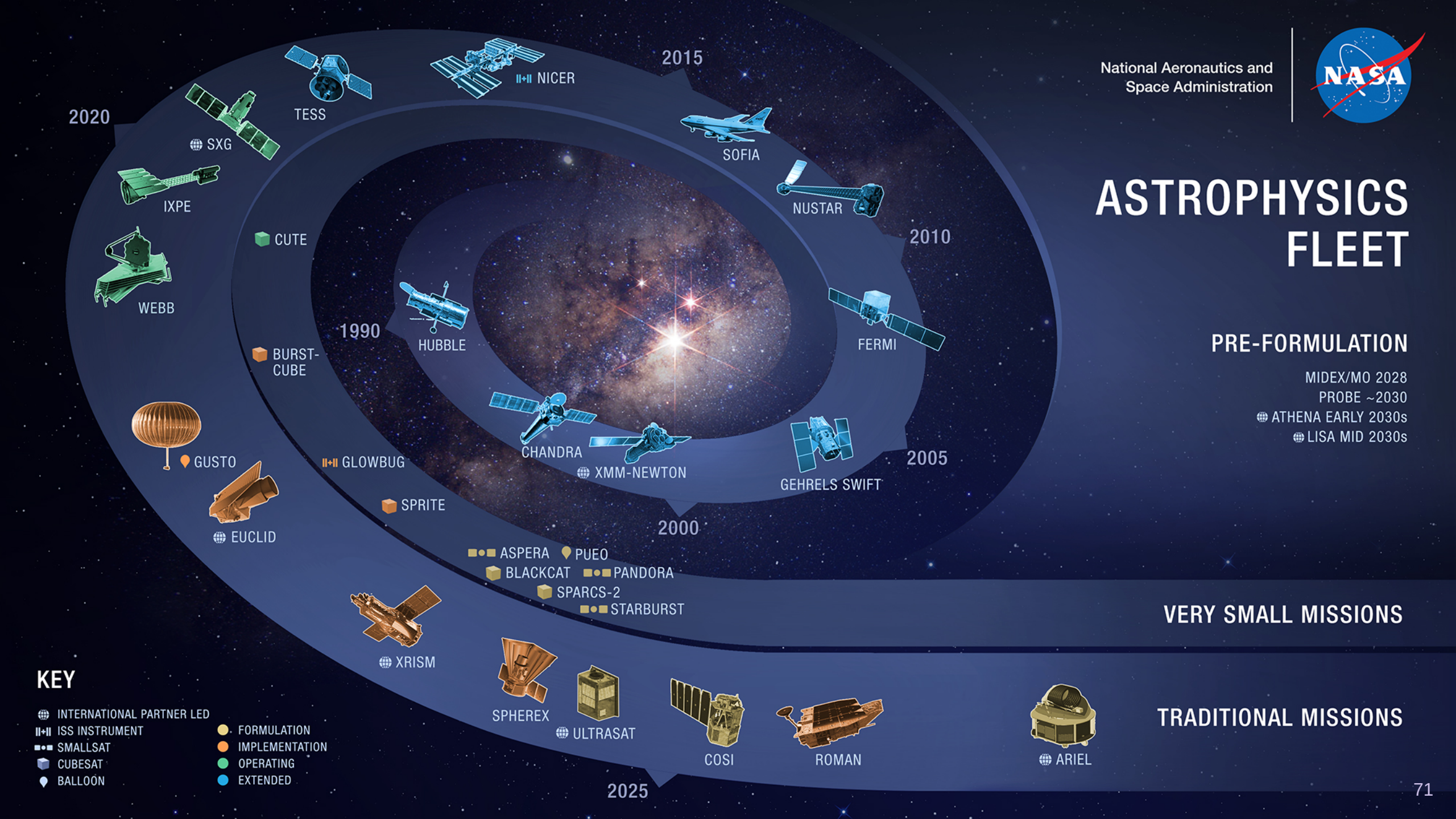
- Initiated the common SMD data catalog project to enable cross-divisional data search and discovery
- Expanded access to free and open journals by modifying the Astrophysics Data System (ADS) journal database to include Planetary Science and Heliophysics
- Updated SMD's data information policy (SPD-41) to support open science by requiring missions to release scientific data, publications and software openly

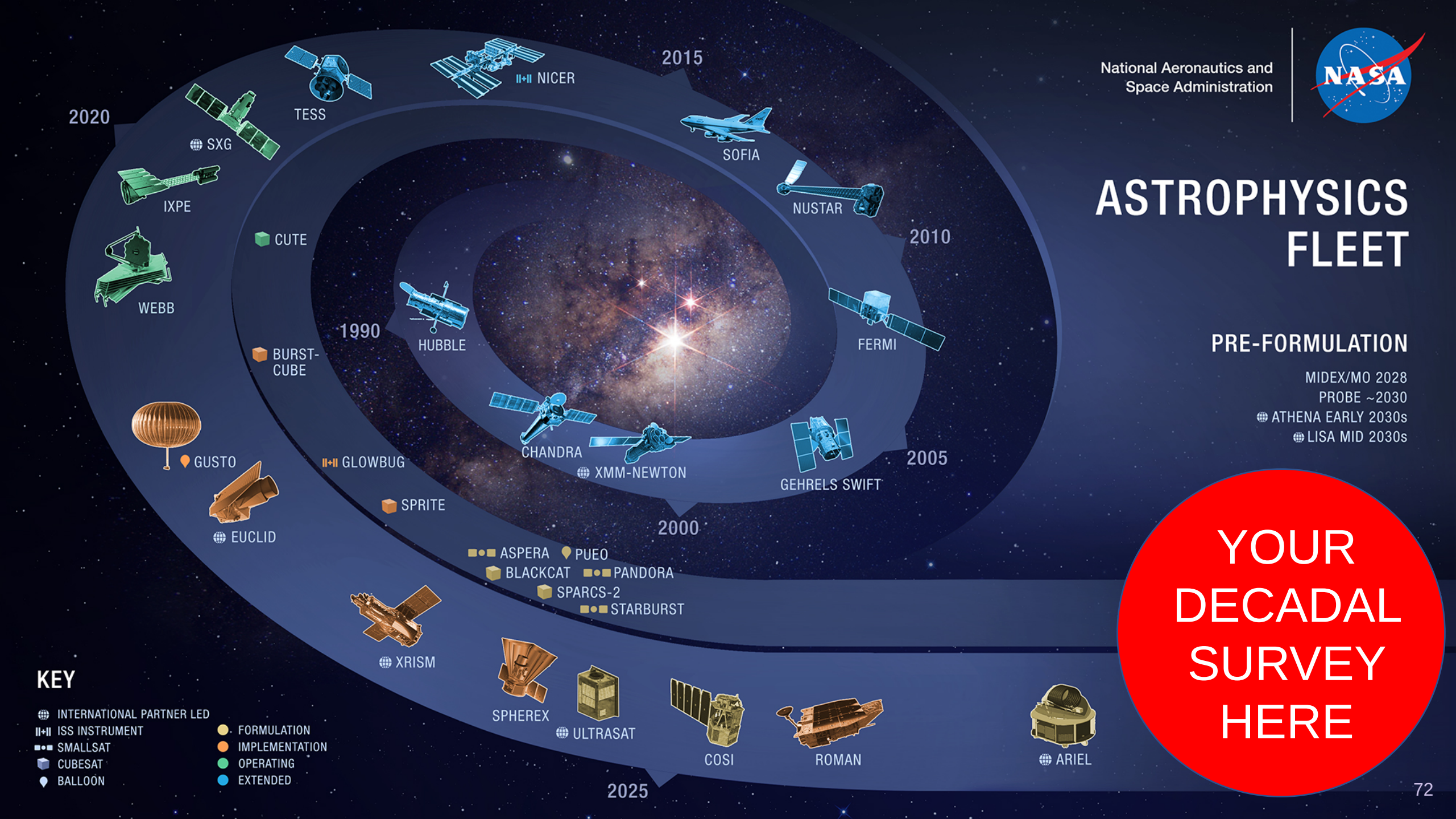
NASA Hubble Fellowship Program (NHFP) Review

- Report was publicly released in January 2022, available at https://science.nasa.gov/astrophysics/documents
- NASA Astrophysics has put together an “internal” Implementation Plan Working Group to to develop a plan and timeline for discussing and implementing selected recommendations from the NHFP review report 32 recommendations
  - Consists of the NHFP Program Scientist, NHFP Leads, Hubble Program Scientist, Hubble Senior Project Scientist, Hubble Deputy Project Scientist, Hubble Project Manager, and several Astrophysics Program Scientists
  - Will incorporate input from our community about their priorities and implementation suggestions
- Some recommendations are already being implemented:
  - New rubric with specific emphasis on Leadership & Diversity was used in 2022 NHFP Selection
  - Tracking diversity in both applicants who apply and selected fellows began with selection of the class of 2021
  - Alumni demographics survey performed to give a baseline; voluntary, covered things like gender, race, career path
  - Fellows-organized application workshop held to promote accessibility for underrepresented minorities and institutions
  - Fellows are creating a mentoring program for underrepresented groups
  - Specific job advertising outreach to SACNAS, NSBP, AWIS, Twitter, Facebook, MinorityPostDoc
  - New policy implemented requiring availability of employee status with full benefits
  - Policy changed to allow Fellows at NASA Centers; working on process
- Community Outreach and Next Steps
  - Internal group is prioritizing near-, mid-, and long- term implementation steps, including steps that need funding
  - Splinter session for January AAS converted to a webinar held on Feb. 22, 2022
  - Seeking community input on priorities, web form coming, for now send to patricia.m.knezek@nasa.gov
  - Submitted a hybrid splinter session proposal for June AAS to solicit community input on priorities

Big Finish

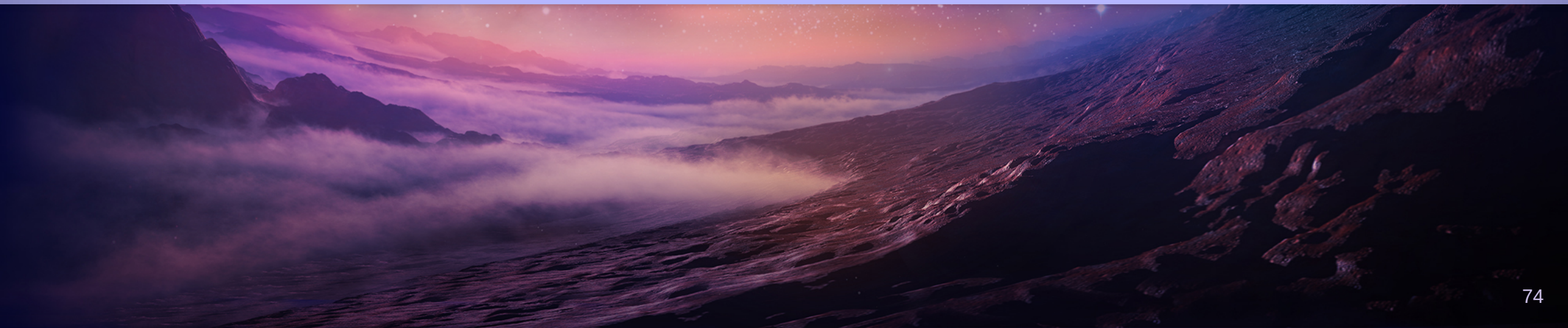



National Aeronautics and Space Administration
NASA
ASTROPHYSICS FLEET
PRE-FORMULATION
MIDEX/MO 2028
PROBE ~2030
ATHENA EARLY 2030s
LISA MID 2030s
2015
2020
2010
1990
2005
2000
2025
NICER
TESS
SXG
SOFIA
IXPE
NUSTAR
CUTE
WEBB
HUBBLE
FERMI
BURST-CUBE
CHANDRA
XMM-NEWTON
GEHRELS SWIFT
GUSTO
GLOWBUG
SPRITE
EUCLID
ASPERA
PUEO
BLACKCAT
PANDORA
SPARCS-2
STARBURST
VERY SMALL MISSIONS
XRISM
SPHEREX
ULTRASAT
COSI
ROMAN
ARIEL
TRADITIONAL MISSIONS
KEY
INTERNATIONAL PARTNER LED
ISS INSTRUMENT
SMALLSAT
CUBESAT
BALLOON
FORMULATION
IMPLEMENTATION
OPERATING
EXTENDED


National Aeronautics and Space Administration
NASA
ASTROPHYSICS FLEET
PRE-FORMULATION
MIDEX/MO 2028
PROBE ~2030
ATHENA EARLY 2030s
LISA MID 2030s
2020
2015
2010
2005
2000
1990
2025
TESS
NICER
SXG
SOFIA
IXPE
NUSTAR
CUTE
WEBB
HUBBLE
FERMI
BURST-CUBE
CHANDRA
XMM-NEWTON
GEHRELS SWIFT
GUSTO
GLOWBUG
SPRITE
EUCLID
ASPERA
PUEO
BLACKCAT
PANDORA
SPARCS-2
STARBURST
XRISM
SPHEREX
ULTRASAT
COSI
ROMAN
ARIEL
KEY
INTERNATIONAL PARTNER LED
ISS INSTRUMENT
SMALLSAT
CUBESAT
BALLOON
FORMULATION
IMPLEMENTATION
OPERATING
EXTENDED
YOUR DECADAL SURVEY HERE


Carpe Posterum

BACKUP

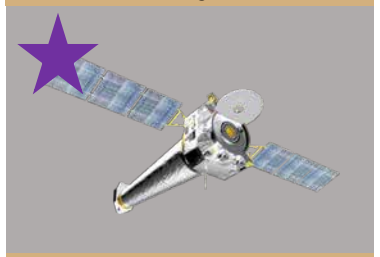


Astrophysics Missions in Operations

Hubble 4/90
NASA Strategic Mission

Hubble Space Telescope

Chandra 7/99
NASA Strategic Mission



Chandra X-ray Observatory

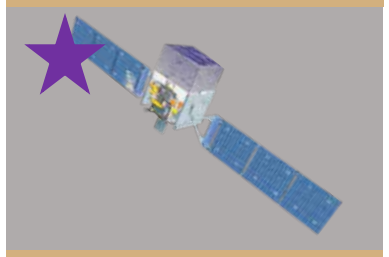
XMM-Newton 12/99
ESA-led Mission

X-ray Multi Mirror - Newton

Gehrels Swift 11/04
NASA MIDEX Mission

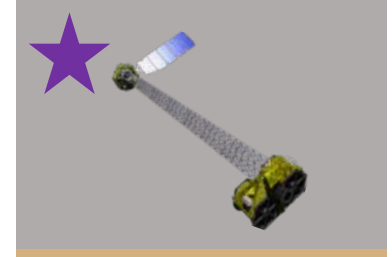
Neil Gehrels Swift Gamma-ray Burst Explorer

Fermi 6/08
NASA Strategic Mission



Fermi Gamma-ray Space Telescope

NuSTAR 6/12
NASA SMEX Mission



Nuclear Spectroscopic Telescope Array

SOFIA 5/14
NASA Strategic Mission

Stratospheric Observatory for Infrared Astronomy

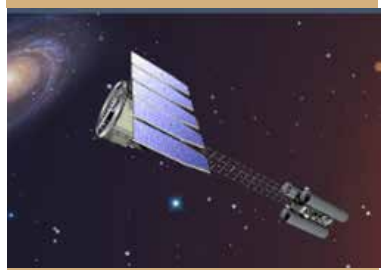
ISS-NICER 6/17
NASA Explorers Miss. of Oppty

Neutron Star Interior Composition Explorer

TESS 4/18
NASA MIDEX Mission

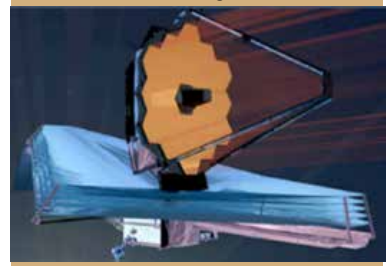
Transiting Exoplanet Survey Satellite

IXPE 12/21
NASA SMEX Mission



Imaging X-ray Polarimetry Explorer

Webb 12/21
NASA Strategic Mission



James Webb Space Telescope

Balloon Program
Four Campaigns per Year

Managed by the Astrophysics Division

★ Senior Review of Operating Missions in Spring 2022

Astrophysics Missions in Development

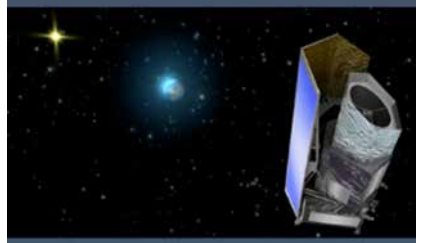
IXPE 2021
NASA Mission

Imaging X-ray Polarimetry Explorer

Webb 2021
NASA Mission

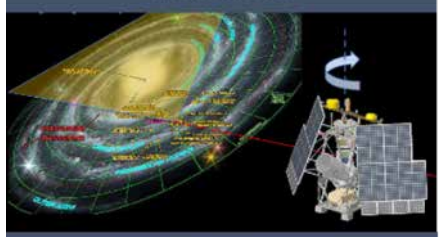
James Webb Space Telescope

Euclid 2023?
ESA-led Mission



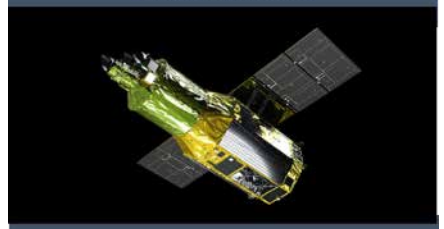
NASA is supplying the NISP Sensor Chip System (SCS)

GUSTO 2023?
NASA Mission



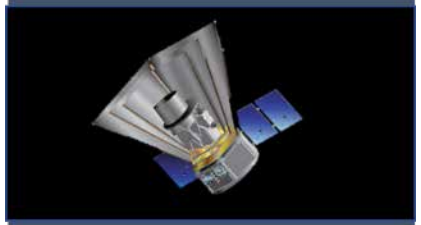
Galactic/ Extragalactic ULDB Spectroscopic Terahertz Observatory

XRISM 2023
JAXA-led Mission



NASA is supplying the SXS Detectors, ADRs, and SXTs

SPHEREx 2025
NASA Mission



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

COSI 2025
NASA Mission

Compton Spectrometer and Imager

Roman 2027
NASA Mission

Nancy Grace Roman Space Telescope

MIDEX/MO 2028
NASA Missions

Medium-class Explorer Explorer Mission of Opportunity

ARIEL 2029
ESA-led Mission

NASA is supplying the CASE fine guidance instrument

Launch dates are current project working dates through XRISM; Agency Baseline Commitment launch date could be later

Does not include Pioneers or CubeSats

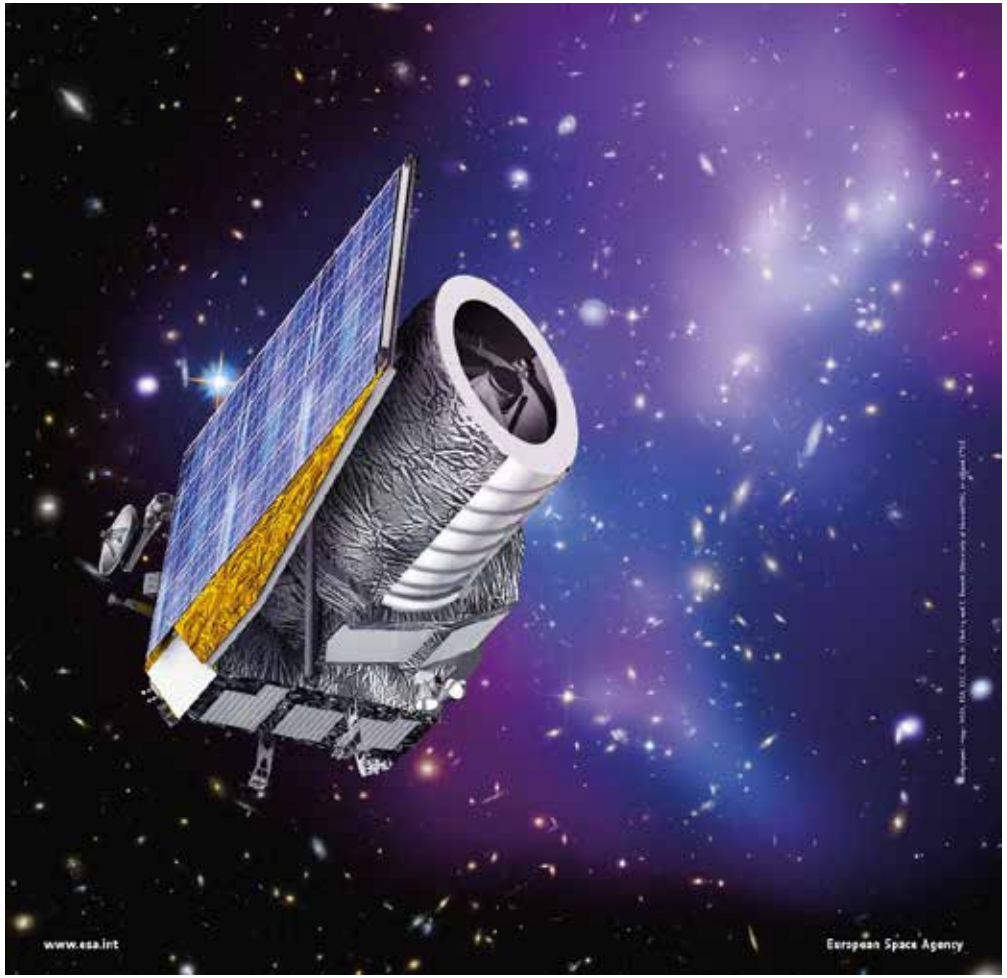
Euclid

Mission is an ESA and NASA partnership

- Euclid will study the nature of Dark Energy, Dark Matter and General Theory of Relativity
- NASA delivered Sensor Chip System (includes 16 Flight and 4 Spare Sensor Chip Systems) for the Near Infrared Spectrometer Photometer instrument
- Euclid NASA Science Center at IPAC an integral part of mission and will serve the US community plus over 70 US Science Team members

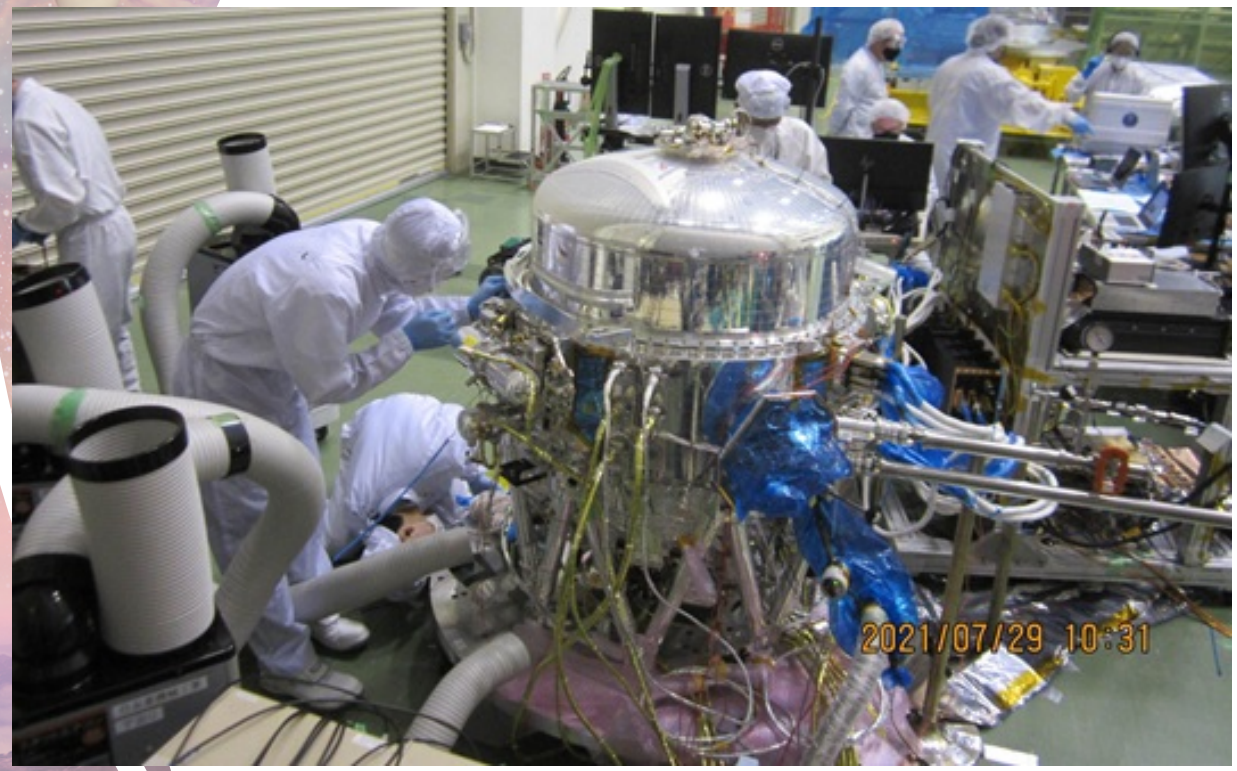
Status

- Payloads are with Thales-Alenia in Italy for spacecraft integration
- IPAC science ground segment software deliveries on track
- Launch on a Soyuz rocket from Kourou is impacted due to Ukraine conflict; ESA is considering alternate arrangements to launch in 2023



XRISM

X-ray Imaging and Spectroscopy Mission

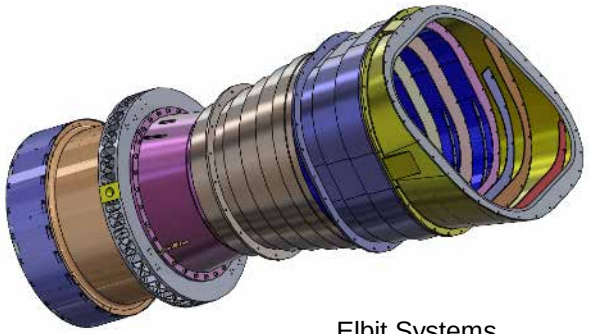


- Travel of NASA personnel resumed after COVID-related restrictions by Japan in the New Year.
- Testing of Resolve instrument prior to integration with spacecraft continues:
  - Successful testing with the gate valve open to verify low-energy performance
  - Cryogen-free operation also successful
- Delivery of dewar to spacecraft April 2022.
- X-ray Mirror Assemblies delivered for “fit check” in March 2022 – final delivery in June.
- XRISM Guest Scientist program for broader US participation in Performance Verification phase solicited through ROSES-22 – release of amendment imminent.
- Special session on XRISM held at HEAD 2022
- Integrated system CDR April 2022

ULTRASAT

- ULTRASAT: a wide-field (>200 sq deg) UV survey & transient detection mission by the Israel Space Agency & Weizmann Institute of Science
  - NASA providing commercial launch ~late 2024/early 2025 for a 3-yr prime mission in geosynchronous orbit
  - Data public at IPAC following 12-mo exclusive data use period
- Science: Main focus on gravitational wave sources, supernovae, variable and flare stars, and time domain astronomy. Public alerts within 20-min of trigger.
- Status
  - Israel Space Agency ULTRASAT mission CDR in April 2022
  - NASA-ISA MOU NASA concurrence process
  - US Participating Scientist program is initiated via ROSES announcement in 2022

ULTRASAT Concept
Source: Israel Aerospace Industries (IAI)



Elbit Systems

Compton Spectrometer and Imager (COSI)

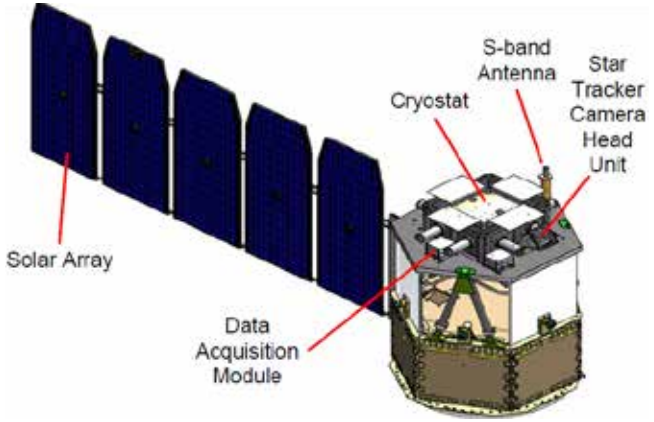
PI: John Tomsick, University of California, Berkeley

COSI is Compton imaging spectrometer with cryogenic Ge detectors for 0.1-5 MeV gamma-rays. It has an energy resolution of 0.4% FWHM @ 1.8 MeV, an angular resolution of 2.0º FWHM @ 1.8 MeV and would cover 100% of the sky every day; COSI builds on heritage from successful balloon campaigns and operates at a Near-equatorial orbit at 550km altitude

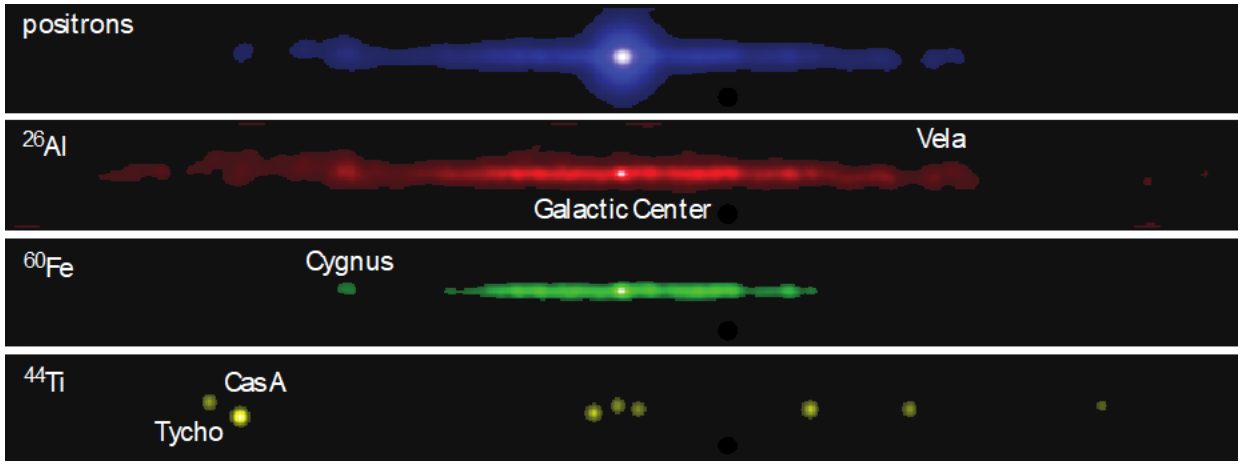
COSI will provide an understanding of the positron excess; map ^{26}Al (half-life 60yr) to study element formation; make the first map of ^{60}Fe (half-life 2.6Myr, only source is core-collapsed SN) to trace past core collapse supernovae; and discover new young supernovae in ^{44}Ti (half-life 0.7Myr).

In addition, COSI will gain insight into extreme environments with polarization, such as accreting black holes (AGN and Galactic) and γ-ray bursts (GRBs). COSI can also localize the γ-ray counterparts to GW events (short GRBs) and detect high-energy neutrino counterparts.

Launch Readiness Date: December 2025



Simulated Radioactive Milky Way



Ariel

Atmospheric Remote-sensing Infrared Exoplanet Large survey

ESA and NASA partnership

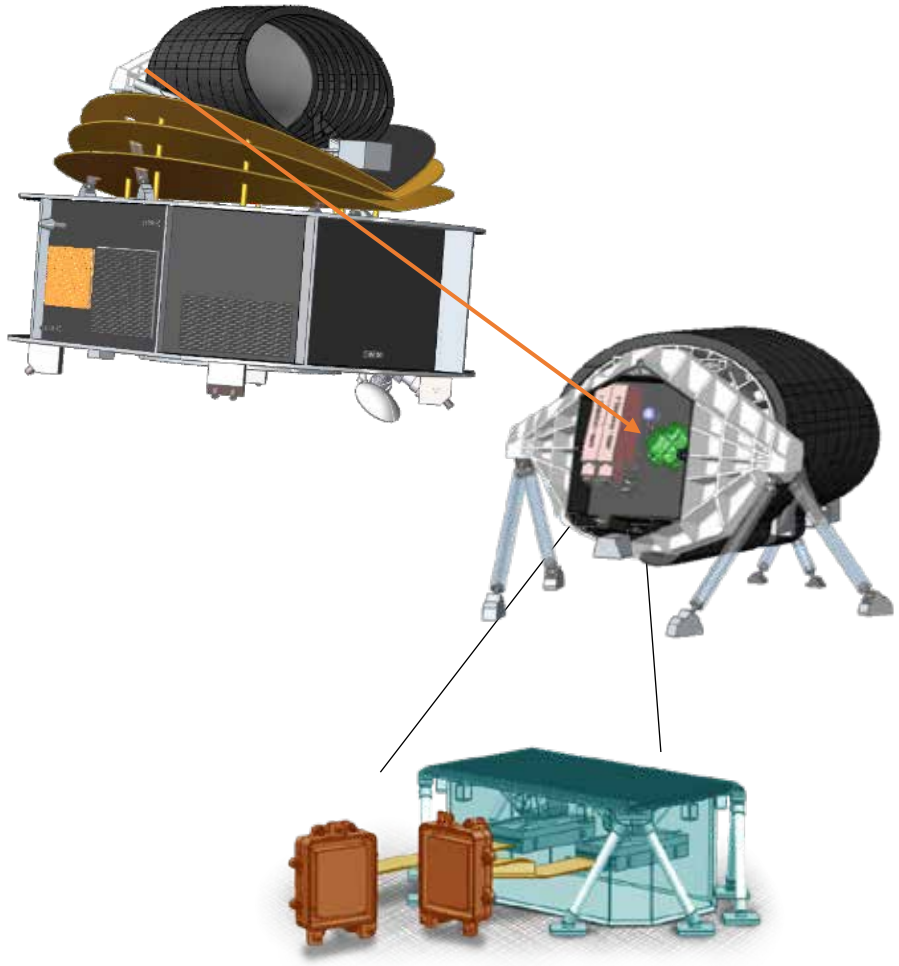
- Observe ~1000 planets
- Survey and characterize exoplanet atmospheres

NASA contribution (CASE) includes detectors and cold front-end electronics, packaging, thermal management, and cryoflex cables for Ariel Fine Guidance System

Provides US participation in science team, mission survey design, and scientific discoveries

STATUS:

- MOU draft is under review
- Fall 2022 – NASA CASE PDR
- Nov 2022 – NASA CASE KDP-C
- Fall 2023 – NASA CASE CDR
- Hardware deliveries late 2024 to 2025
- Launch ~2029



CASE
Contribution to Ariel Spectroscopy of Exoplanets

Athena

Advanced Telescope for High Energy Astrophysics

ESA and NASA partnership

Athena will map hot gas structures determining their physical properties and search for supermassive black holes in the Hot and Energetic Universe

NASA contributions:

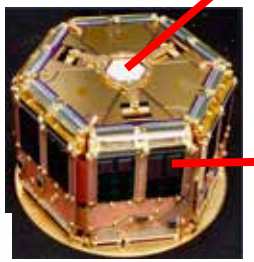
- X-IFU Focal Plane Array (GSFC lead)
- Use of NASA Testing Facilities (MSFC XRCF facility) for mirror calibration
- Vibration Isolation System
- WFI VERITAS ASIC design for detector readout and WFI background analysis model
- US Athena Science Center
- Science grant program for US Co-Is and General Observers

STATUS:

- Reports from the Athena Science Team and ESA's Independent Study reviewing 10" mirror PSF resolution expected circa end of March/April 2022
- Detector pixel pitch changed from 275 microns to 317 microns changing the number of pixels from 3,168 to 2,376. Reduces complexity but no impact on the field of view. Detector and SQUID TRL-5 development continues
- ESA mission adoption ~ June 2023
- Launch ~ 2034

Vibration Isolation System

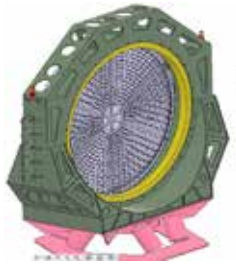
Focal Plane Array



Sensor Assembly

Readout

X-IFU Focal Plane Array



XRCF Mirror Assembly

LISA

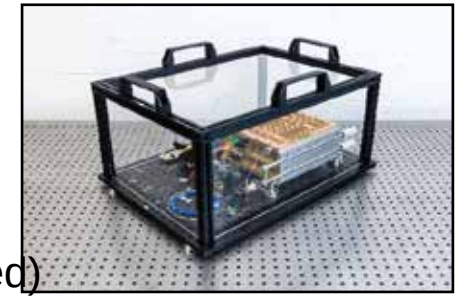
Laser Interferometer Space Antenna

ESA and NASA partnership

- LISA will observe the universe in the millihertz gravitational wave band, detecting tens of thousands of sources ranging from white dwarf binaries in the Milky Way to massive black hole mergers at high redshift.

NASA contributions

- Interferometric Telescopes (GSFC, L3 Harris)
- Laser Systems (GSFC)
- Charge Management Device (U. Florida, Fibertek)
- TBD contributions to data analysis & science (concept study initiated)
- Contributions to European-led mission and instrument systems engineering



TRL4 laser brassboard

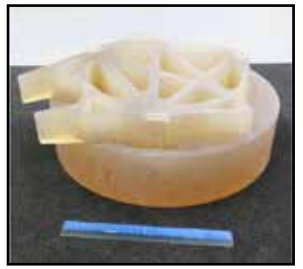
TRL5 Charge Management Unit

STATUS

- NASA in pre-Phase A Study managed by GSFC. Systems engineering & science support from JPL & MSFC.
- ESA completed Mission Formulation Review on Dec 3, 2021, and moves to phase B1
- NASA delivered in 2021 TRL-4 laser to ESA lab in Switzerland (CSEM) for performance testing

All dates approximate

- September 2023 –



Primary mirror blank and polished

Astrophysics Science Program Content ($M)

	Actual FY21	Enacted FY22	Request FY23	Out-Years FY24	FY25	FY26	FY27
Astrophysics	**$1,770.9**	**$1,568.9**	**$1,556.0**	**$1,597.0**	**$1,578.5**	**$1,620.5**	**$1,625.6**
Astrophysics Research	$249.3		$329.8	$350.8	$345.5	$348.4	$350.1
Astrophysics Research and Analysis	*$91.1*		*$111.0*	*$113.0*	*$114.1*	*$115.2*	*$116.4*
Balloon Project	*$44.8*		*$45.7*	*$46.3*	*$46.3*	*$46.3*	*$46.3*
Science Activation	*$45.6*		*$55.6*	*$55.6*	*$55.6*	*$55.6*	*$55.6*
Other Missions and Data Analysis (research and management)	*$67.8*		*$117.6*	*$135.9*	*$129.5*	*$131.2*	*$131.9*
Astrophysics Directed R&T	$0.0		$0.0	$9.0	$0.0	$0.0	$0.0
Contract Administration, Audit & QA Svcs	$17.7		$17.3	$19.6	$19.6	$19.6	$19.6
Astrophysics Senior Review	$0.0		$48.3	$52.5	$53.1	$53.7	$54.1
Astrophysics Data Program	$21.6		$23.6	$23.8	$24.0	$24.3	$24.5
Astrophysics Data Curation and Archival	$28.5		$28.4	$31.0	$32.7	$33.7	$33.7
Cosmic Origins	$618.5		$298.5	$316.5	$316.3	$316.6	$316.6
James Webb Space Telescope	*$414.7*		*$172.5*	*$187.0*	*$187.0*	*$187.0*	*$187.0*
Webb Science	$1.2		$51.0	$60.0	$60.0	$60.0	$60.0
James Webb Space Telescope	$413.5		$121.5	$127.0	$127.0	$127.0	$127.0
Hubble Space Telescope (HST)	*$93.3*		*$93.3*	*$98.3*	*$98.3*	*$98.3*	*$98.3*
Other Missions and Data Analysis	*$110.5*		*$32.7*	*$31.2*	*$31.0*	*$31.3*	*$31.3*

Astrophysics Science Program Content ($M)

	Actual FY21	Enacted FY22	Request FY23	Out-Years FY24	FY25	FY26	FY27
Cosmic Origins	$618.5		$298.5	$316.5	$316.3	$316.6	$316.6
(development/formulation/technology)							
Cosmic Origins SR&T	$18.3		$13.9	$21.4	$21.4	$21.4	$21.4
Cosmic Origins Future Missions	$1.2		$2.1	$3.0	$3.0	$3.0	$3.0
(operating)							
Stratospheric Observ for Infrared Astron	$85.2		$10.0	$0.0	$0.0	$0.0	$0.0
(research and management)							
Astrophysics Strategic Mission Prog Mgmt	$5.8		$6.8	$6.9	$6.7	$6.9	$7.0
Physics of the Cosmos	$146.4		$159.9	$188.1	$182.4	$182.2	$177.6
Other Missions and Data Analysis	*$146.4*		*$159.9*	*$188.1*	*$182.4*	*$182.2*	*$177.6*
(development/formulation/technology)							
Physics of the Cosmos SR&T	$45.6		$75.2	$101.1	$98.6	$98.4	$94.1
Euclid	$7.7		$9.9	$10.3	$9.9	$9.7	$9.1
Physics of the Cosmos Future Missions	$0.1		$1.3	$3.0	$3.0	$3.0	$3.0
(operating)							
Fermi Gamma-ray Space Telescope	$15.9		$0.0	$0.0	$0.0	$0.0	$0.0
Chandra X-Ray Observatory	$66.8		$64.0	$64.0	$64.0	$64.0	$64.0
XMM	$4.0		$0.0	$0.0	$0.0	$0.0	$0.0
(research and management)							
PCOS/COR Technology Office Management	$6.2		$9.4	$9.8	$6.9	$7.2	$7.4

Astrophysics Science Program Content ($M)

	Actual FY21	Enacted FY22	Request FY23	Out-Years FY24	FY25	FY26	FY27
Exoplanet Exploration	$552.4		$522.2	$450.2	$423.0	$388.4	$258.0
Nancy Grace Roman Space Telescope	*$505.2*		*$482.2*	*$407.3*	*$380.0*	*$345.7*	*$216.6*
Other Missions and Data Analysis (development/formulation/technology)	*$47.2*		*$40.0*	*$42.9*	*$43.0*	*$42.7*	*$41.4*
Exoplanet Exploration SR&T	$32.2		$23.3	$23.9	$24.1	$23.7	$22.4
Exoplanet Exploration Future Missions	$0.0		$1.3	$3.0	$10.5	$10.5	$10.5
(operating)							
Keck Operations	$7.5		$7.5	$7.4	$0.0	$0.0	$0.0
(research and management)							
Exoplanet Exploration Technoloy Off Mgmt	$7.5		$7.8	$8.6	$8.5	$8.5	$8.6
Astrophysics Explorer	$204.4		$245.6	$291.4	$311.3	$385.0	$523.2
SPHEREx	*$68.5*		*$78.7*	*$75.0*	*$24.0*	*$6.0*	*$0.1*
Other Missions and Data Analysis (development/formulation/technology)	*$135.8*		*$166.9*	*$216.4*	*$287.3*	*$379.0*	*$523.1*
X-Ray Imaging and Spectroscopy Mission	$16.8		$36.2	$28.3	$16.9	$14.1	$2.0
Contribution to Ariel Spectroscopy of Ex	$18.0		$10.3	$8.9	$4.0	$2.2	$2.9
Pioneers	$0.0		$23.4	$23.8	$32.1	$35.0	$40.2
Compton Spectrometer and Imager	$0.0		$51.3	$87.4	$71.0	$28.4	$5.3
Astrophysics Explorer Future Missions	$5.2		$23.9	$53.9	$155.0	$284.8	$460.7

Astrophysics Science Program Content ($M)

	Actual	Enacted	Request	Out-Years			
	FY21	FY22	FY23	FY24	FY25	FY26	FY27
Astrophysics Explorer Cont.	$204.4		$245.6	$291.4	$311.3	$385.0	$523.2
(operating)							
Neutron Star Interior Composition Explor	$4.8		$0.0	$0.0	$0.0	$0.0	$0.0
Transiting Exoplanet Survey Satellite	$15.2		$0.0	$0.0	$0.0	$0.0	$0.0
Imaging X-Ray Polarimetry Explorer	$38.8		$6.9	$0.7	$0.0	$0.0	$0.0
Galactic/Extragalactic ULDB Spectroscopi	$8.8		$1.0	$0.0	$0.0	$0.0	$0.0
Neil Gehrels Swift Observatory	$6.4		$0.0	$0.0	$0.0	$0.0	$0.0
Nuclear Spectroscopic Telescope Array	$8.6		$0.0	$0.0	$0.0	$0.0	$0.0
(research and management)							
Astrophysics Explorer Program Management	$13.3		$14.0	$13.5	$8.2	$14.5	$12.1