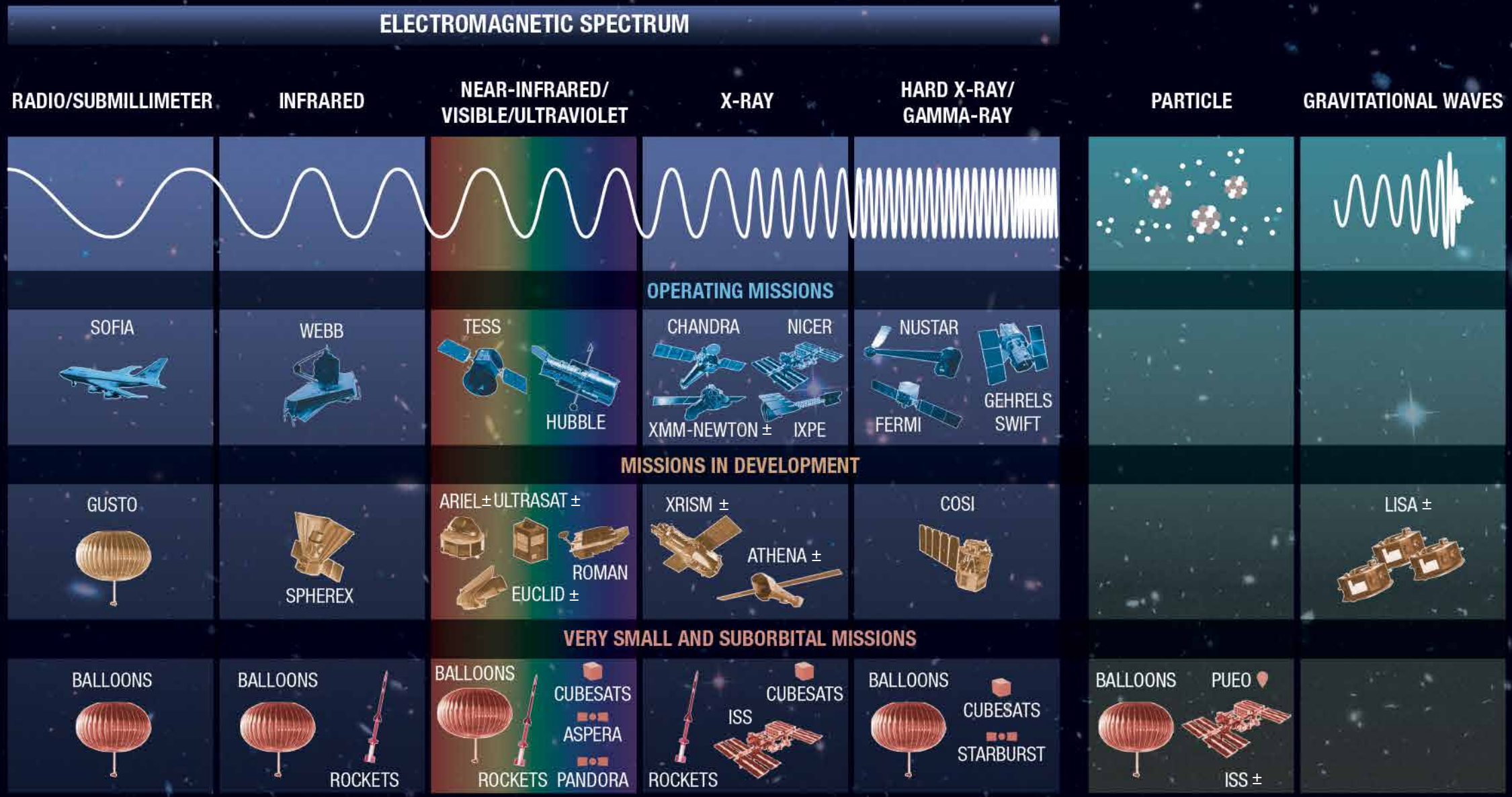
Astrophysics Division Update

Astronomy and Astrophysics Advisory Committee / June 6, 2022

Paul Hertz
Director, Astrophysics Division
Science Mission Directorate

@NASAUniverse @NASAExoplanets

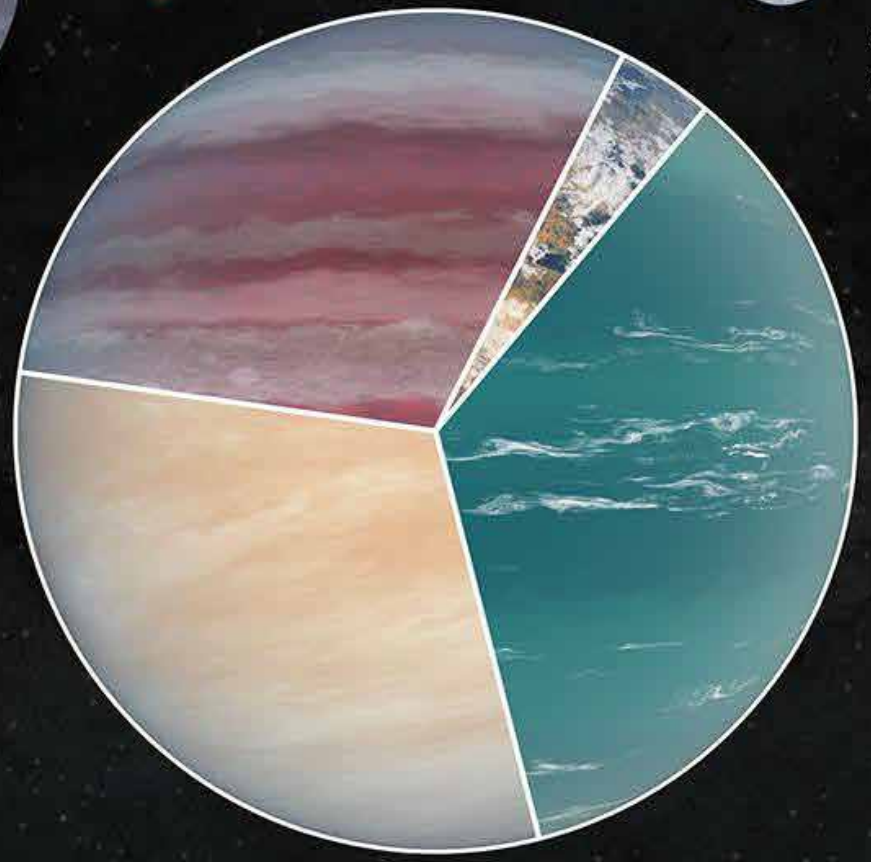

ELECTROMAGNETIC SPECTRUM
RADIO/SUBMILLIMETER
INFRARED
NEAR-INFRARED/ VISIBLE/ULTRAVIOLET
X-RAY
HARD X-RAY/ GAMMA-RAY
PARTICLE
GRAVITATIONAL WAVES
OPERATING MISSIONS
SOFIA
WEBB
TESS
HUBBLE
CHANDRA
NICER
XMM-NEWTON ±
IXPE
NUSTAR
FERMI
GEHRELS SWIFT
MISSIONS IN DEVELOPMENT
GUSTO
SPHEREX
ARIEL ± ULTRASAT ±
ROMAN
EUCLID ±
XRISM ±
ATHENA ±
COSI
LISA ±
VERY SMALL AND SUBORBITAL MISSIONS
BALLOONS
BALLOONS
ROCKETS
BALLOONS
CUBESATS
ASPERA
ROCKETS
PANDORA
ROCKETS
CUBESATS
ISS
BALLOONS
CUBESATS
STARBURST
BALLOONS
PUEO
ISS ±
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

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

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

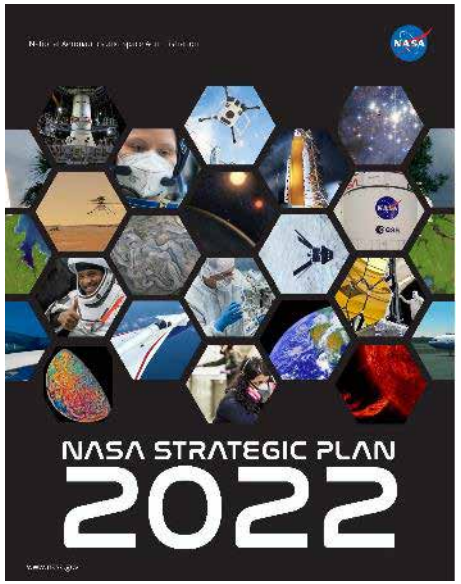
"The panel [on the State of the Profession and Societal Impacts] asserts that fundamentally, the pursuit of science, and scientific excellence, is inseparable from the humans who animate it."

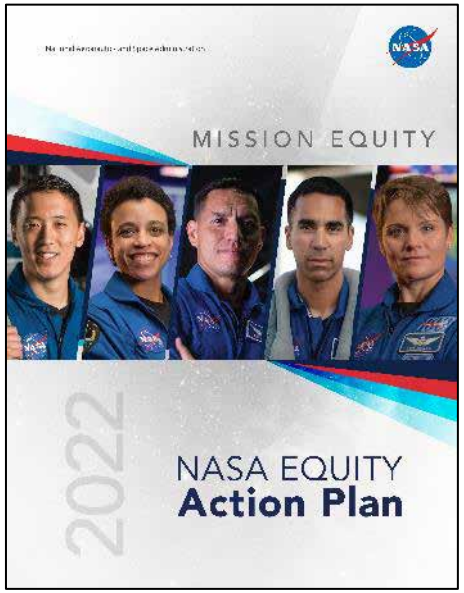
- *Pathways to Discovery in Astronomy and Astrophysics for the 2020s*

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

All NASA's astrophysics programs and projects incorporate IDEA initiatives. All Decadal Survey initiatives incorporate IDEA initiatives.

Inclusion & Diversity of Thought





Strategic Objective 4.1: Attract and develop a talented and diverse workforce. Cultivate a diverse, motivated, and highly qualified workforce through modernizing our Human Capital processes and systems, increasing our workforce agility and flexibilities, and implementing a robust Inclusion, Diversity, Equity, and Accessibility (IDEA) approach to ensure systematic and sustainable fairness, impartiality, and equity in our business practices.

NASA is continuing its journey towards equity. To this end, NASA has established four foundational focus areas:

- Increase Integration and Utilization of Contractors and Businesses from Underserved Communities to Expand Equity in NASA's Procurement Process
- Enhance Grants and Cooperative Agreements to Advance Opportunities, Access, and Representation for Underserved Communities
- Leverage Earth Science and Socioeconomic Data to Help Mitigate Environmental Challenges in Underserved Communities
- Advance External Civil Rights Compliance and Expand Access to Limited English Proficient (LEP) Populations within Underserved Communities

Building Excellent NASA Teams Requires Inclusion and Diversity

- IDEA is infused throughout everything we do. It is not a standalone or separate activity.
- Working on several new initiatives based on Astro2020 Decadal Survey recommendations – embargoed as this is a budgeting activity for FY24 *
- Astrophysics has pioneered and piloted IDEA activities that are now adopted across SMD:
  1. Inclusion Plans adopted in ROSES elements across all SMD divisions *
  2. Code of Conduct now adopted for panel reviews across all SMD divisions
  3. Dual Anonymous Peer Reviews adopted across all SMD divisions
  4. Inclusion Criteria in Senior Reviews of Missions adopted across all SMD divisions *
  5. Increasing diversity of reviewers for all panels expected across all SMD divisions
- Other SMD level initiatives:
  7. Collection, evaluation, and publication of demographics of ROSES proposers and awardees *
  8. Regularly report data on proposal submissions and success rates *
  9. SMD Bridge Program funded for better engagement with MSIs *
  10. National Academies study of barriers to inclusion in mission leadership
  11. Regular participation at meetings such as SACNAS and NSBP
  12. PI Launchpad to incubate next generation of diverse leaders for missions *
  13. IDEA criteria being added to Announcements of Opportunity *

* Responsive to an Astro2020 Decadal Survey recommendation

James Webb Space Telescope Commissioning Status

Commissioning Timeline

The CAST” lays out each step of JWST commissioning.

(CAST = Commissioning Activity Sequence Timeline)

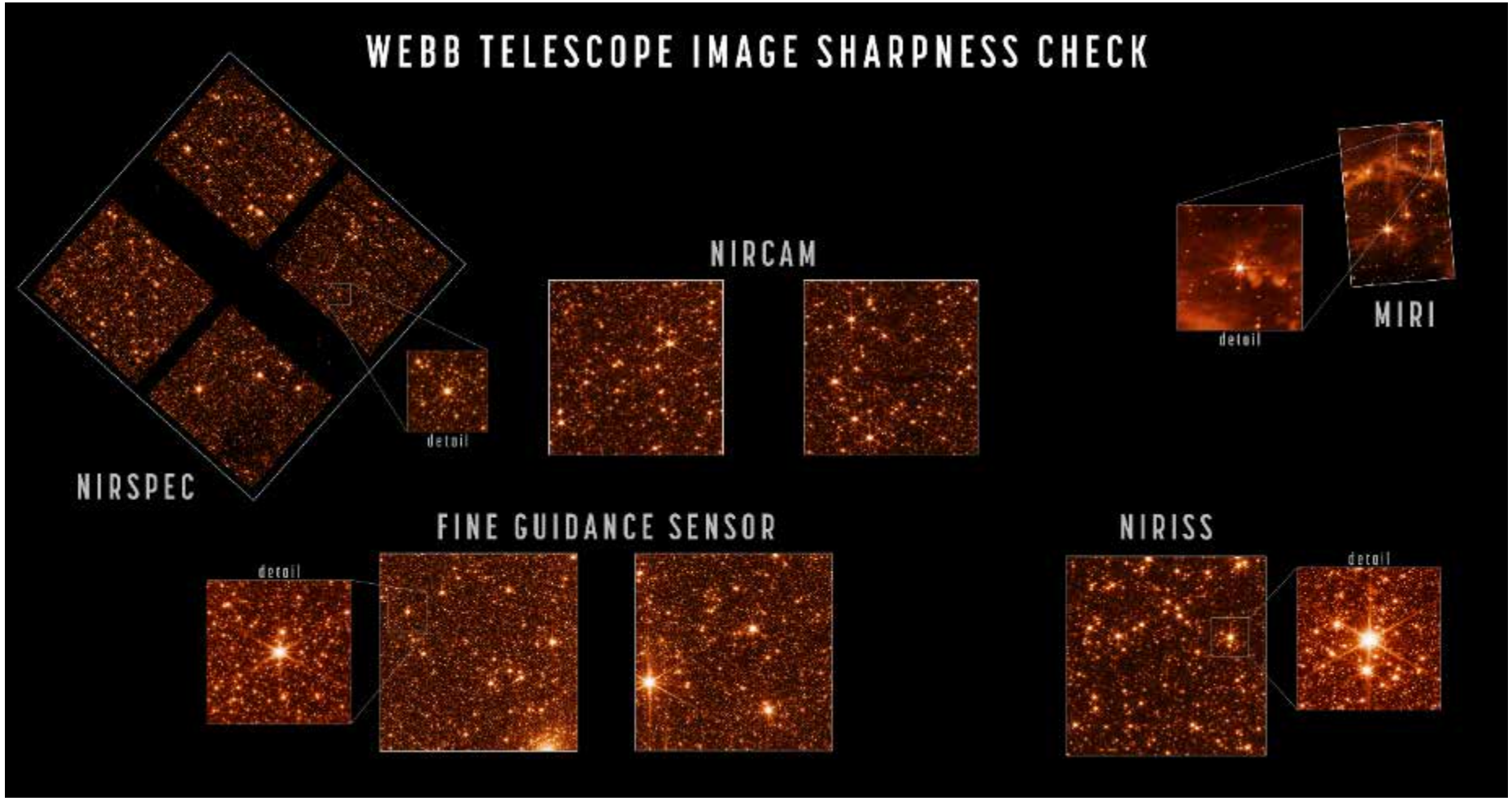
There are 730 high-level steps in the timeline.

These are broken down into:

- ~2800 steps for deployments and spacecraft ✓
- ~5400 steps for the telescope ✓
- ~1500 steps for the science instruments

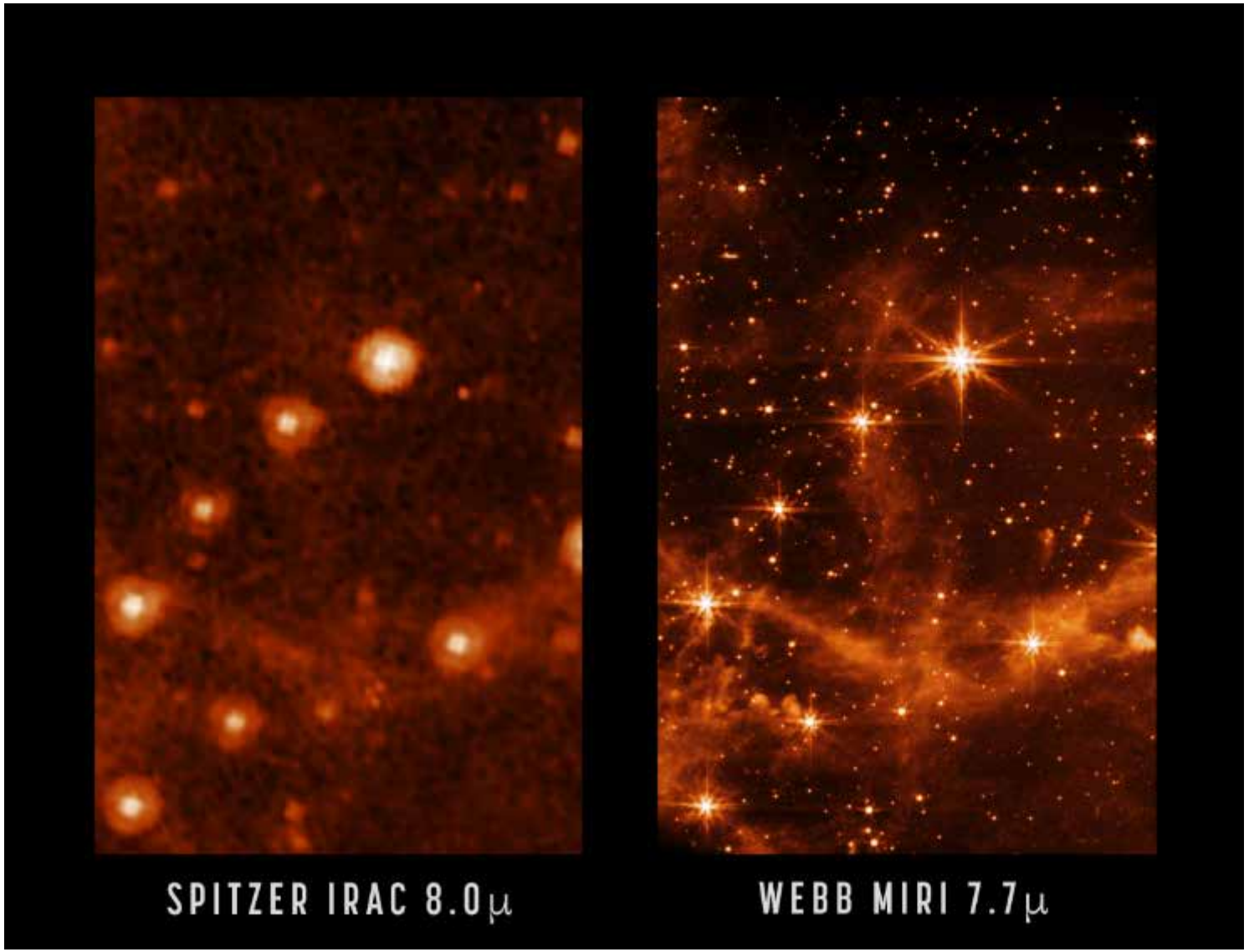
Slide courtesy J. Rigby, GSFC

Webb In Full Focus



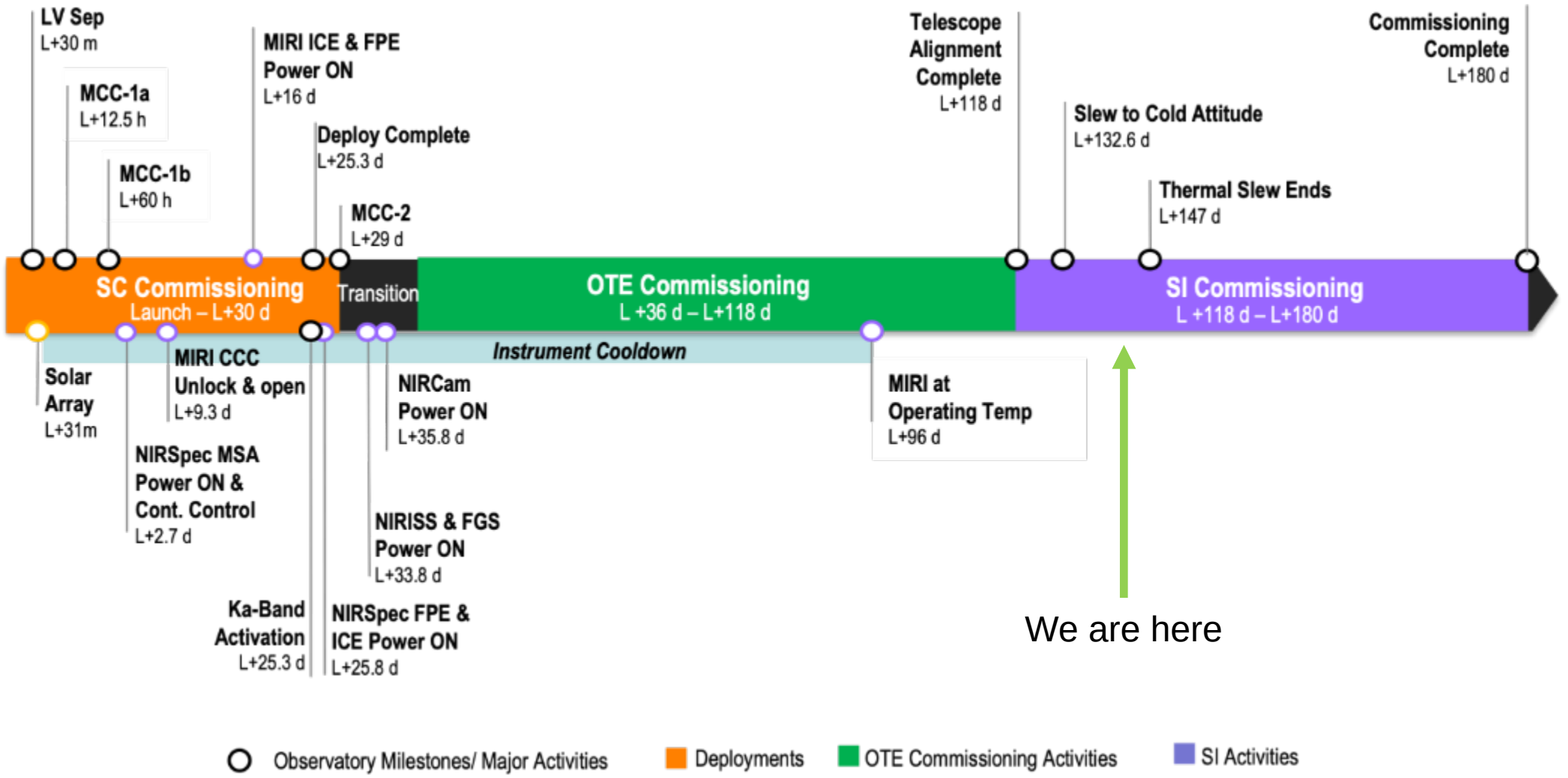
NIRCam (2 micron), NIRSpec (1.1 micron), NIRISS (1.5 micron), and MIRI (7.7 micron)

Improvements in the Mid-Infrared



Credit: NASA/JPL-Caltech (left), NASA/ESA/CSA/STScI (right)

Commissioning Status



JWST Cycle 1 Long Range Plan

The Cycle 1 Long Range Plans was released to the public the week of 18-April.
It is a dynamic plan that will change with execution times as run, spacecraft anomalies ToO's, etc.

LRP Cycle 1 Dates: 27-June-2023 to 2-July-2023

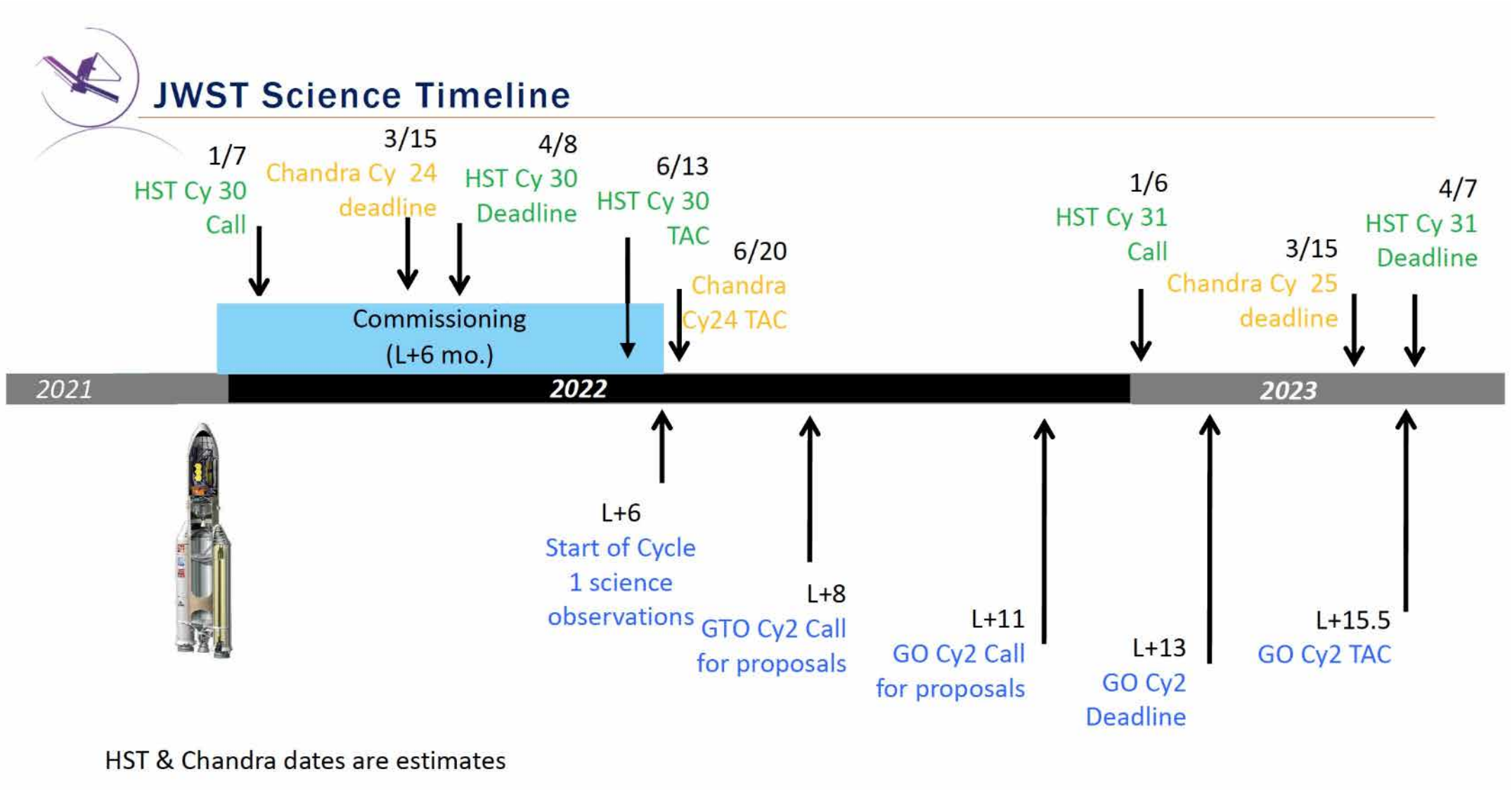
Category	Total Time [hrs]	Total Planned Time [hrs] (%)
GO	6090.1[1]	5749.7 (94%)
GTO	3774.0[2]	3667 (98%)
ERS[3]	529.5	529.5 (100%)
Cal	659.6	659.6 (100%)
Total	11023.2	10491.0 (95%)

[1]Includes 200.5 hrs of ToO's which do not get planned until activation
[2]Includes 5.2 hrs of ToO's which do not get planned until activation
[3]Bulk of ERS programs are schedule in the first 5 months of Cycle 1

https://www.stsci.edu/contents/news/jwst/2022/schedule-for-cycle-1-science-operations-released

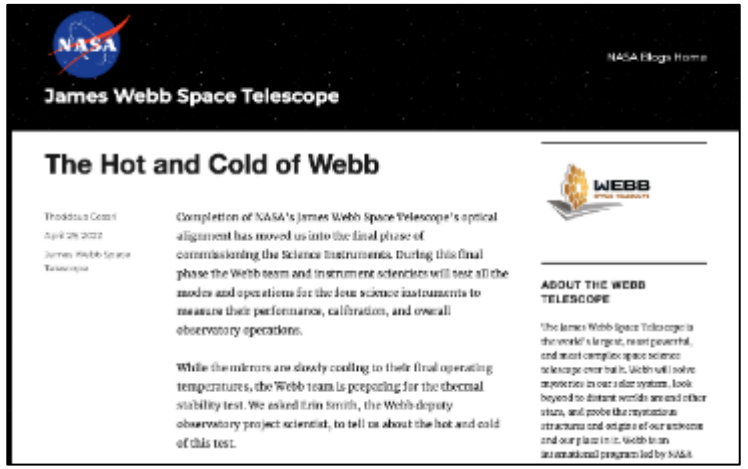
Data courtesy N. Reid, STScI

Science Timeline

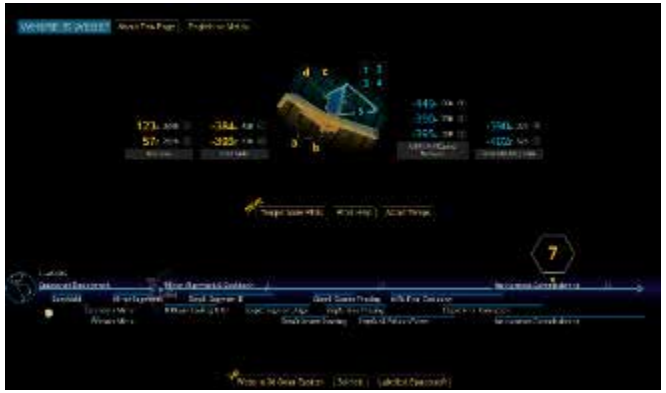


JWST online

nasa.gov/webb



Webb Blog — blogs.nasa.gov/webb

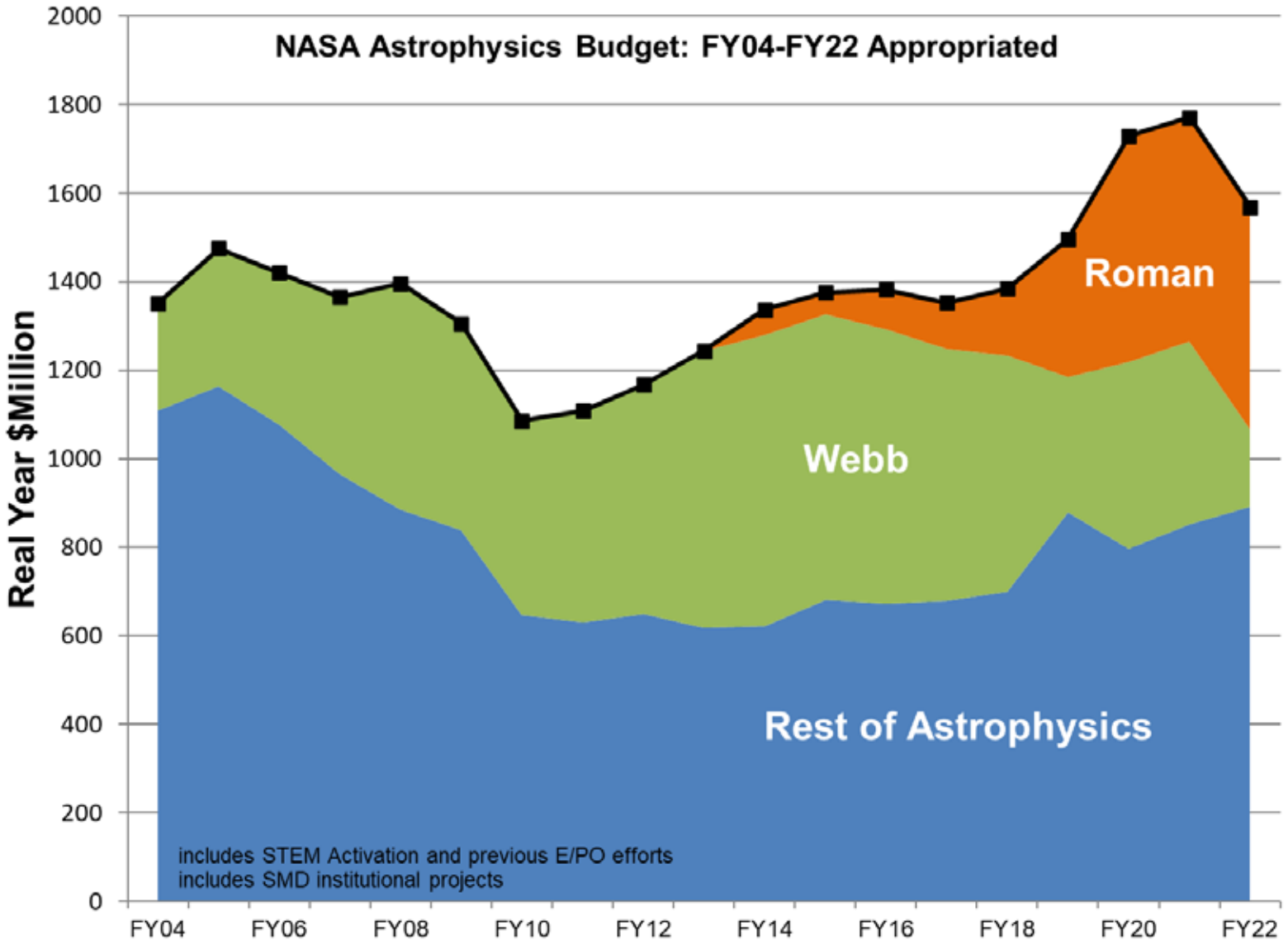


Where is Webb
https://jwst.nasa.gov/content/webbLaunch/whereIsWebb.html

Twitter:	@NASAWebb, @JWSTObserver
Facebook:	nasawebb
YouTube:	NASAWebbTelescope
Flickr:	nasawebbtelescope
Instagram:	nasawebb

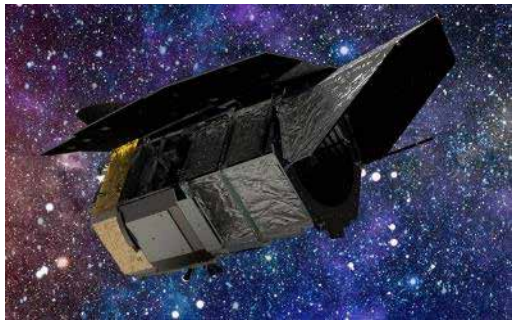
FY23 President’s Budget Request

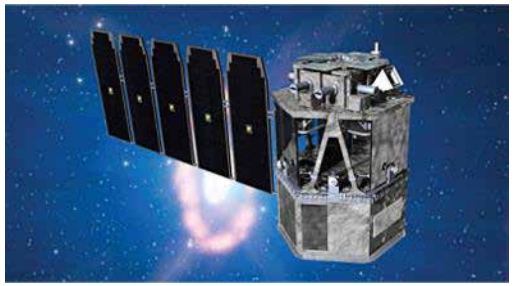
FY22 Appropriation



- 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.”

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

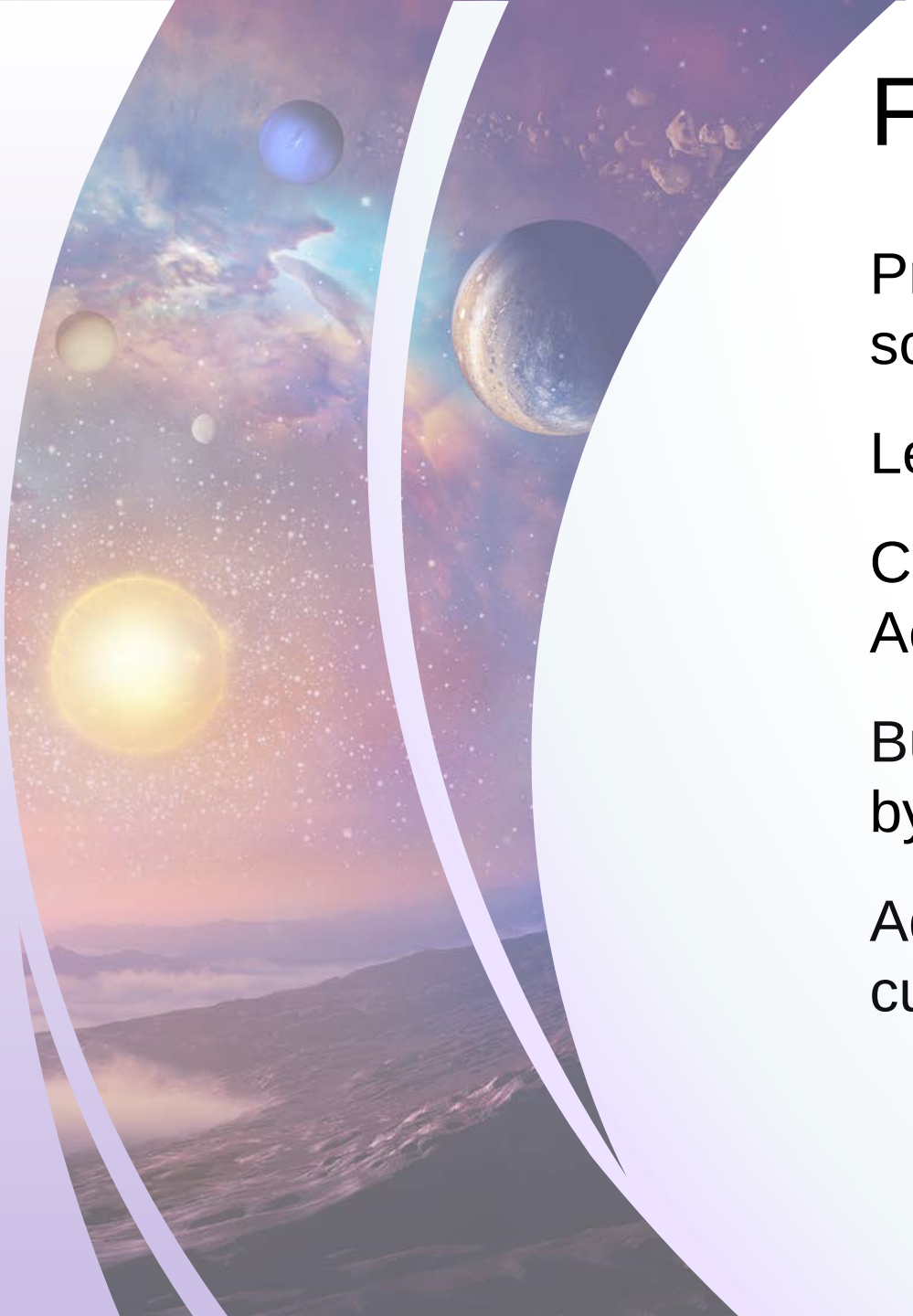
- In May 2021, the Nancy Grace Roman project was replanned to accommodate the impacts of COVID-19 on the workforce and supply chain
- In September 2021, the Nancy Grace Roman Space Telescope passed its critical design review (CDR) meeting all technical and programmatic commitments, and began fabrication,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

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

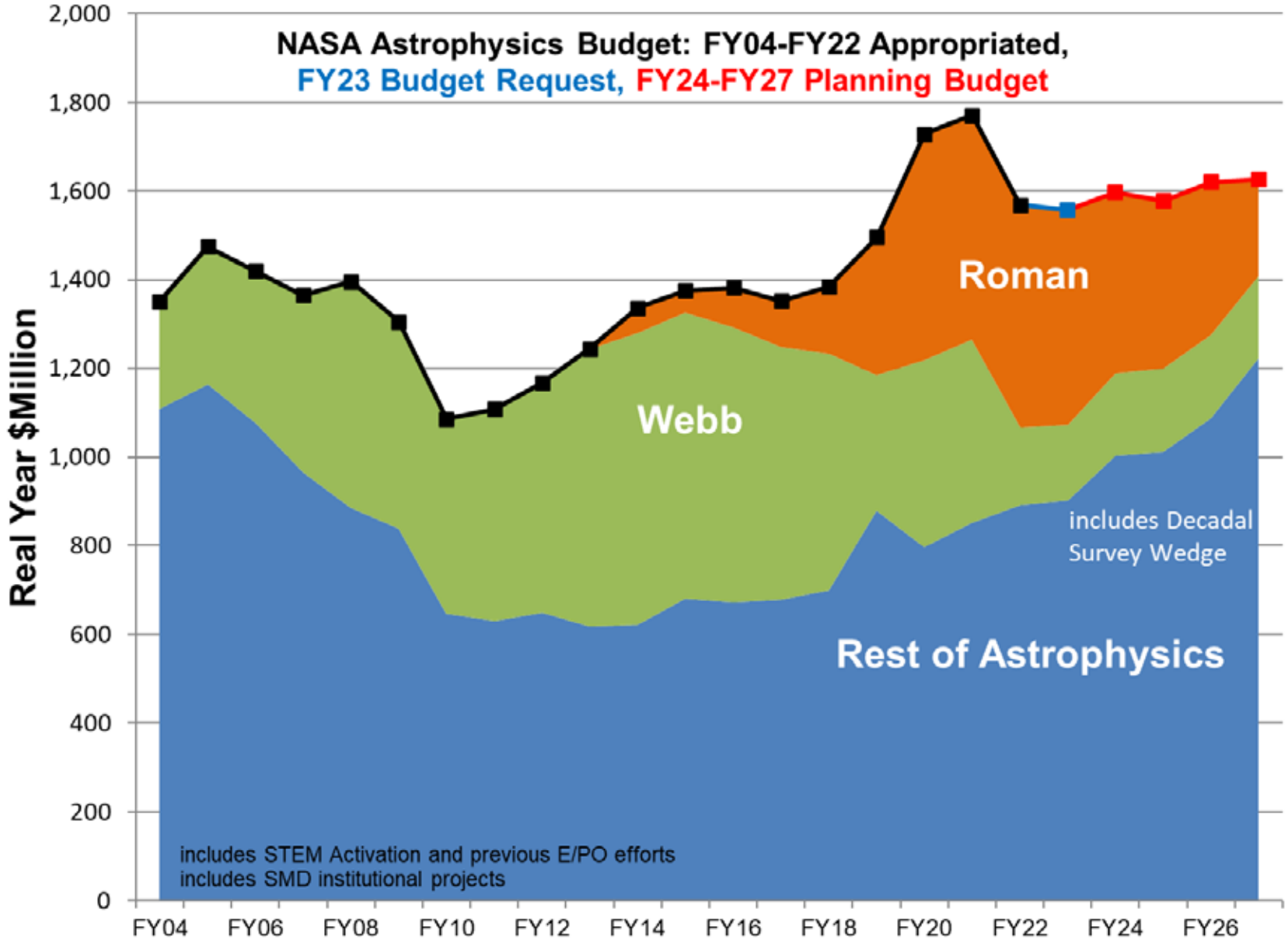
Lead Artemis Science

Champion Inclusion, Diversity, Equity and Accessibility

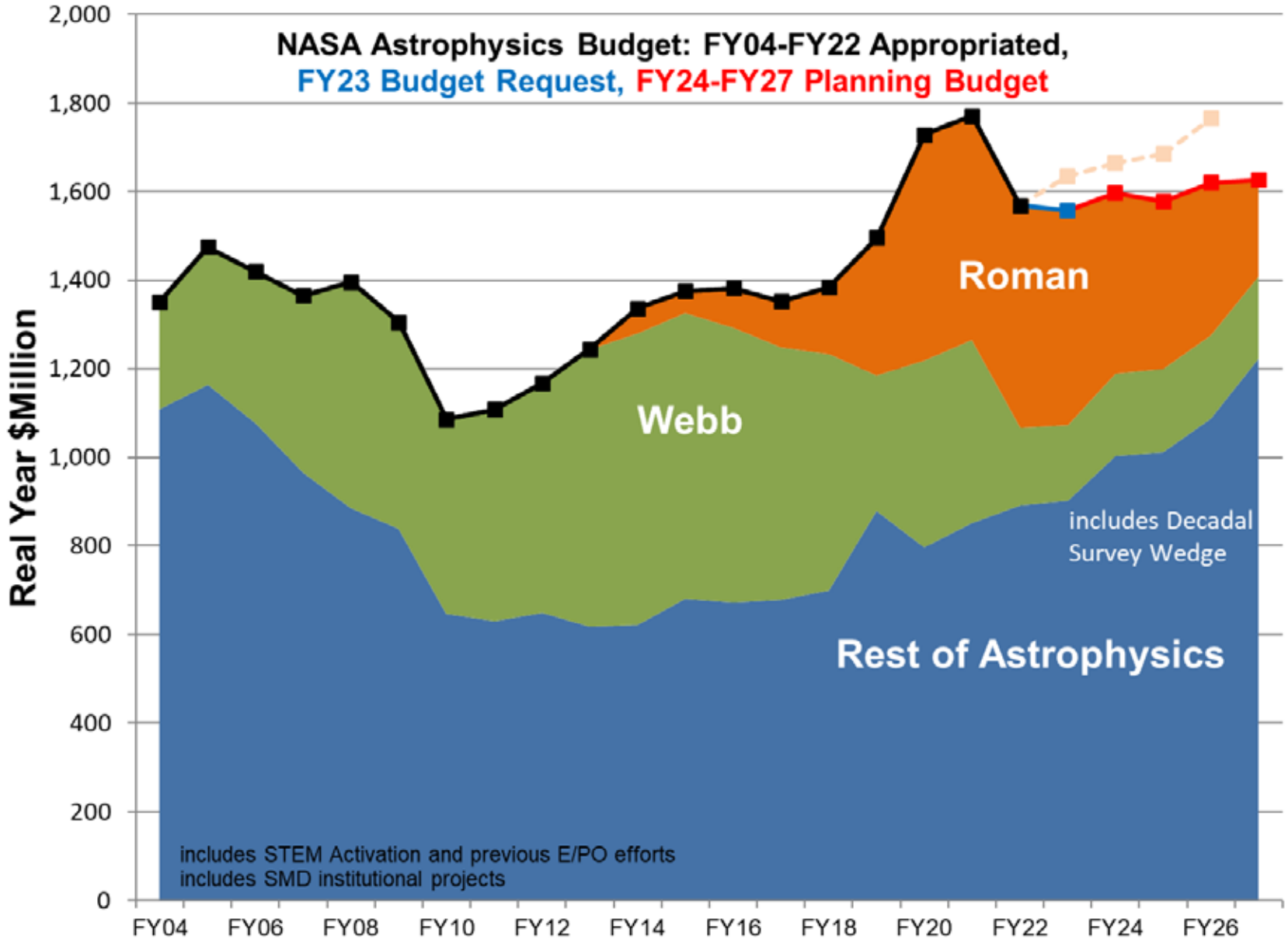
Build a balanced and innovative program driven by the highest national priorities

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

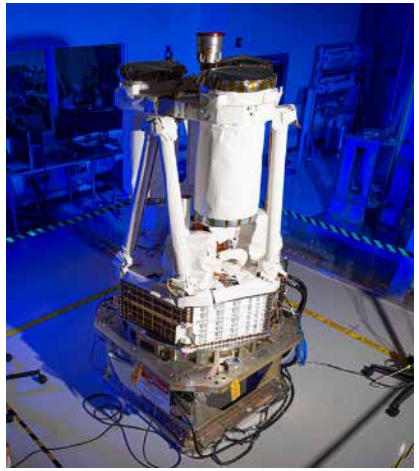
FY23 President's Budget Request

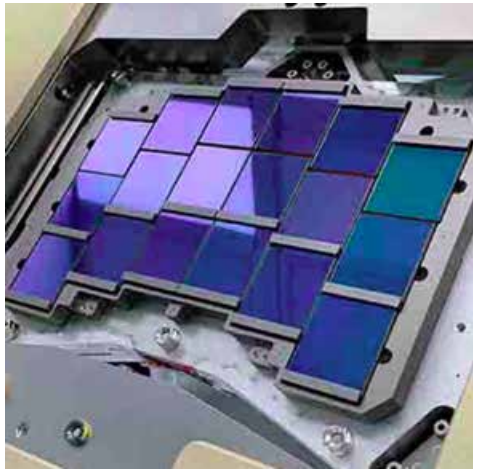


FY23 President's Budget Request



Astrophysics Budget Features





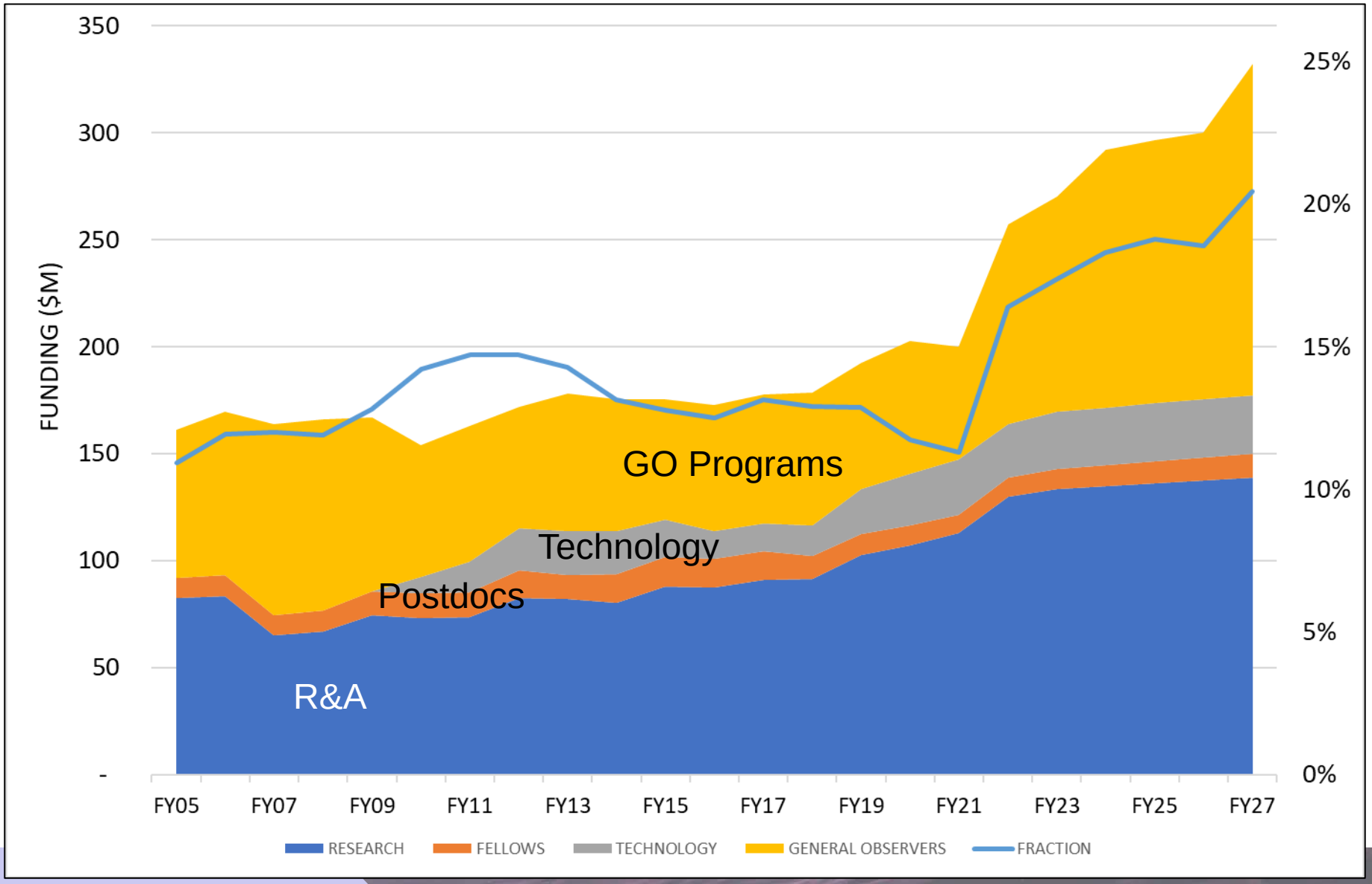
What's Changed since FY22 budget was submitted in 2021

- Additional Webb General Observer funding
- Roman budget adjustments and 7-month delay, consistent with replan due to COVID impacts
- Additional Pioneer selections & increased Pioneers cadence
- Support Great Observatory Precursor Science and Time Domain Astrophysics infrastructure systems for Decadal Survey
- 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 delayed from January 2023

What's the Same as the runout of the FY22 budget request

- 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

R&A Funding / Fraction of Budget



Program Update

NANCY GRACE ROMAN SPACE TELESCOPE

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.

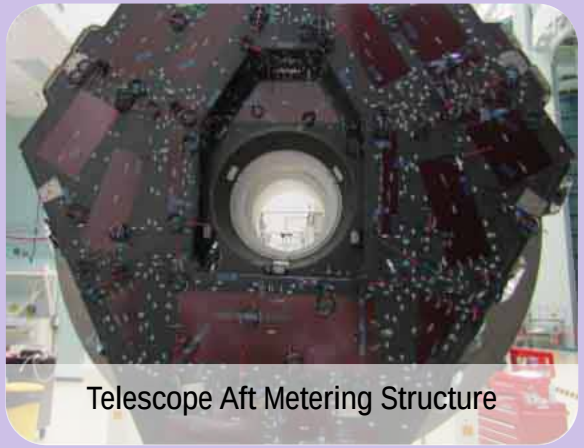
Project continues to make progress in spite of continued COVID inefficiencies at NASA, subcontractors, and partners; schedule reserves are adequate to cope with this.

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 will be offered in ROSES-2022; draft solicitation has been posted.

NANCY GRACE ROMAN SPACE TELESCOPE

Optical Telescope Assembly Hardware



Telescope Aft Metering Structure

Primary Mirror undergoing environmental testing

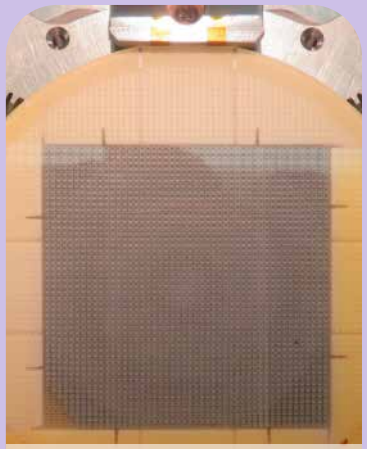
Tertiary OptoMechanical Assembly

Wide Field Instrument Hardware

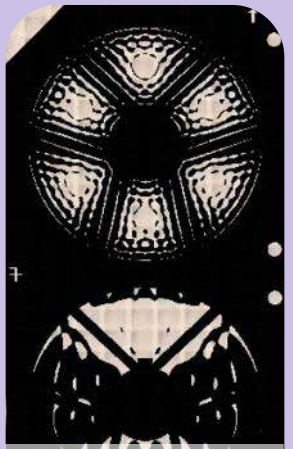
Instrument Structure readied for Vibration Testing

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

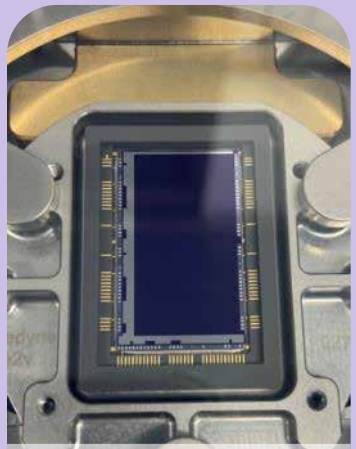
Coronagraph Instrument Technology Demonstration Hardware



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). Draft solicitation has been posted.
- 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

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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.

SOFIA

The Decadal Survey therefore recommended NASA end the SOFIA mission after its current mission extension.

On April 28, NASA and DLR (the German Space Agency) jointly announced that they will conclude the SOFIA mission, after a successful eight years of science.

SOFIA will finish out its scheduled operations for the 2022 fiscal year, followed by an orderly shutdown.

During FY 2022, SOFIA will carry out a full program of science operations including multiple deployments to the southern hemisphere.

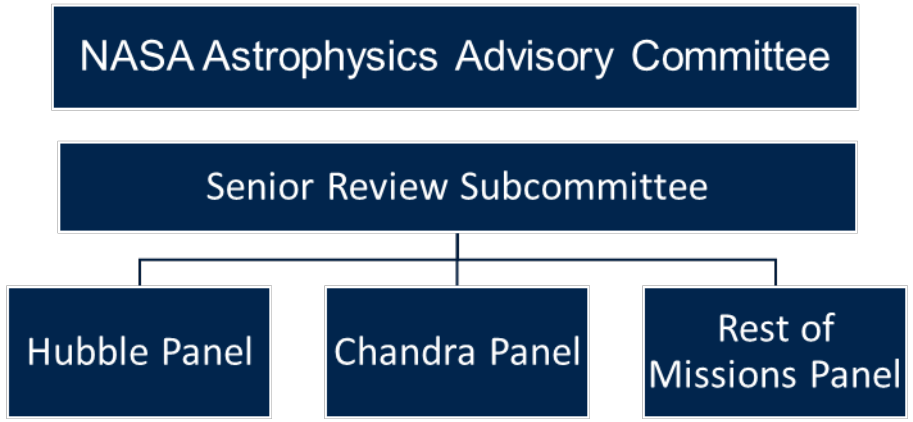
During FY 2022, SOFIA will prioritize completing legacy surveys to establish an enduring archive of data for community use. Over 80% of Cycle 9 selected investigations will be completed; some selected proposals will not get conducted due to scheduling conflicts.

Airborne Astronomy Ambassadors (AAA), the SOFIA teachers-in-flight program, will continue to operate during FY 2022.

Proposals for Cycle 10 (FY 2023) were received earlier this year; no selections will be made from the Cycle 10 proposals.

The SOFIA project has been directed to develop a project closeout plan for FY 2023.

Senior Review Update

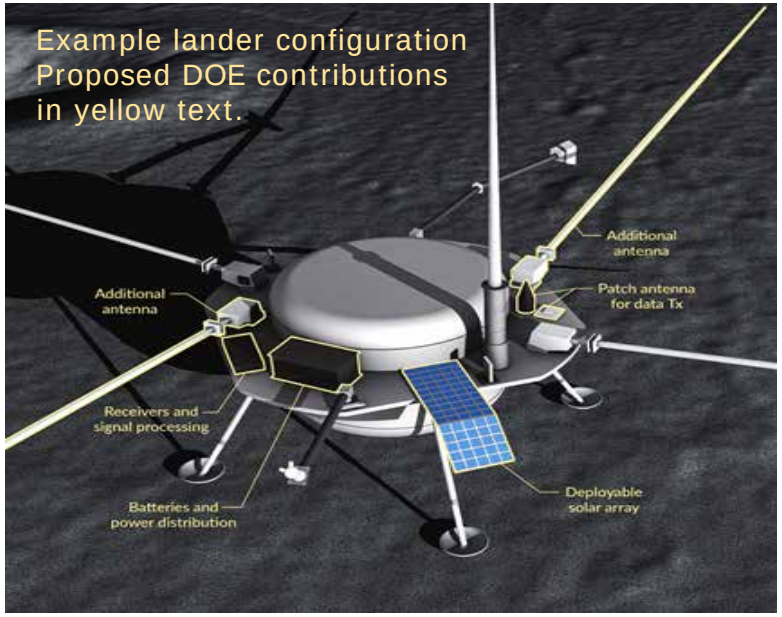


Activity	Date
Final Call for Proposals issued	September 30, 2021
Proposals due	February 11, 2022
Hubble panel meeting (virtual)	March 15, 16, 17, 2022
Rest-of-Missions panel (virtual)	March 29-April 1, 2022
Chandra panel meeting (virtual)	April 5, 6, 7, 2022
Senior Review Subcommittee meeting	May 4-5,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

LuSEE Night

LuSEE Night Details

Lead Developer Org:	**U. California at Berkeley**
LuSEE Payload PI:	**Stuart Bale**
Payload & Science Team:	**DOE Lab under UCB/Bale**
Lunar Landing Location:	**Lunar Farside**
Payload Mass:	**90 kg (including ~50 kg batteries)**
Launch Schedule:	**Landing on lunar surface in Q1 CY25 to coincide with giant planets below lunar horizon**



NASA/DOE Partnership

NASA Scope

- Baseline LuSEE instrument provision
- Systems, mechanical, thermal engineering; Flight qualification; Instrument integration and testing
- Mission operations

DOE Scope

- Added instrumentation design and development
- Leadership of DOE Scientific Team, theory studies, data planning, processing and analysis
- Night survival batteries, solar array for recharging

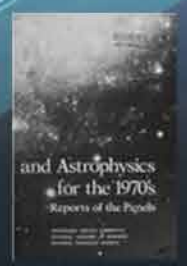
Science Theme: Dark Ages Science

- Pathfinder mission to understand the moon's radio environment & potentially make the first-ever measurement of the Dark Ages
- Capability to measure the radio environment and observe the long-wavelength radio signal through the lunar night
- Place the most sensitive constraints on the Dark Ages signal to date
- Aligned with the DOE High Energy Physics "P5" Science Drivers - Cosmic Acceleration and Dark Matter - as well as the recommendation for small projects
- Astro2020 "Discovery Area" with great potential

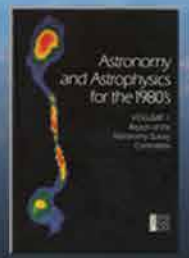
NASA’s Implementation of the 2020 Decadal Survey

Astrophysics

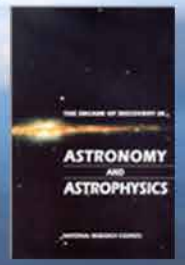
Decadal Survey Missions



1972
Decadal Survey
Hubble



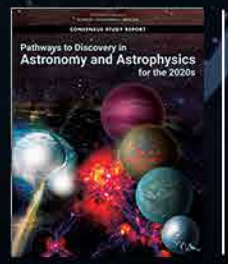
1982
Decadal Survey
Chandra



1991
Decadal Survey
Spitzer

2001
Decadal Survey
Webb

2010
Decadal Survey
Roman

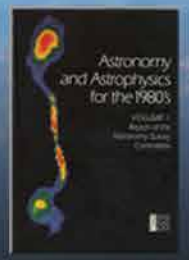


2021
Decadal Survey

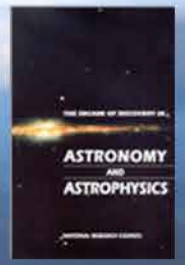
Astrophysics

Decadal Survey Missions

1972 Decadal Survey *Hubble*



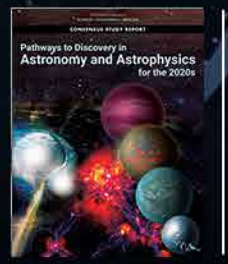
1982 Decadal Survey *Chandra*



1991 Decadal Survey *Spitzer*

2001 Decadal Survey *Webb*

2010 Decadal Survey *Roman*



2021 Decadal Survey

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

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

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*	★	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.
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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 completed telescope commissioning; science instrument commissioning is progressing well; preparations are underway for science to commence in July 2022.
- Roman is progressing well in Mission Phase C "Final Design and Fabrication" and is on track for a mid-2027 launch (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 – Begin the Decadal Survey recommended "Great Observatories Maturation Program". Focus on enabling science and technology; begin Stage 1 now
- Stage 2 – 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
				SCIENTIFIC ASSESSMENT →		
Science Evaluation	Stand up Team	Develop initial Metrics	Develop input 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

Next Steps for Stage 1

Community Participation via

Technology

- Update Gap lists: present at **June** AAS PAG meetings
- SAT proposals due **Dec 15**
- A TST will begin technology activities in CY22; numerous community Task Groups are expected to be stood up to ohelp in CY23.
- Community technology workshop(s) in **CY 2023**

Time Domain & Multi-Messenger Initiative

Operating Missions

- Hubble
- Chandra
- Gehrels Swift
- Fermi
- CALET (w/ JAXA)
- AMS (DOE mission)
- NICER
- TESS

Missions in Development

- BurstCube (cubesat)
- BlackCat (cubesat)
- PUEO (balloon payload)
- StarBurst (Pioneer)
- ULTRASAT (w/ ISA)
- COSI (SMEX)
- Roman

Future Missions under study or being proposed

- THESEUS (w/ ESA)
- Proposed CubeSat
- Proposed Pioneer
- Proposed Mission of Opportunity
- Proposed MIDEX
- Future Probe

Time Domain & Multi-Messenger Initiative

Actions are being developed to address Time Domain Astrophysics and Multi Messenger (TDAMM) recommendations of the 2020 Decadal Survey

- Operating NASA missions continue to make significant contributions to TDAMM and NASA expects future missions to pursue this science:
  - NASA plans investments in infrastructure – transient alerts, data archives, communications, software – which are essential to maximize scientific return; funding for these investments is included in the FY23 budget request.
  - Responding to transient astrophysical phenomena involves multiple ground- and space-based assets and NASA is studying efficiencies in how do deploy its fleet
  - Astro 2020 urges TDAMM be addressed across agencies and NASA is standing up interagency and international working groups to address this coordination
- TDAMM will be an initiative with extensive interagency and international cooperation, shaped using broad community input
  - Prioritizing the science NASA should address. Community workshop this 22-24 August 2022: https://pcos.gsfc.nasa.gov/TDAMM/
  - Partner-led TDAMM missions with NASA contributions
  - NASA missions with international partner contributions

Big Finish

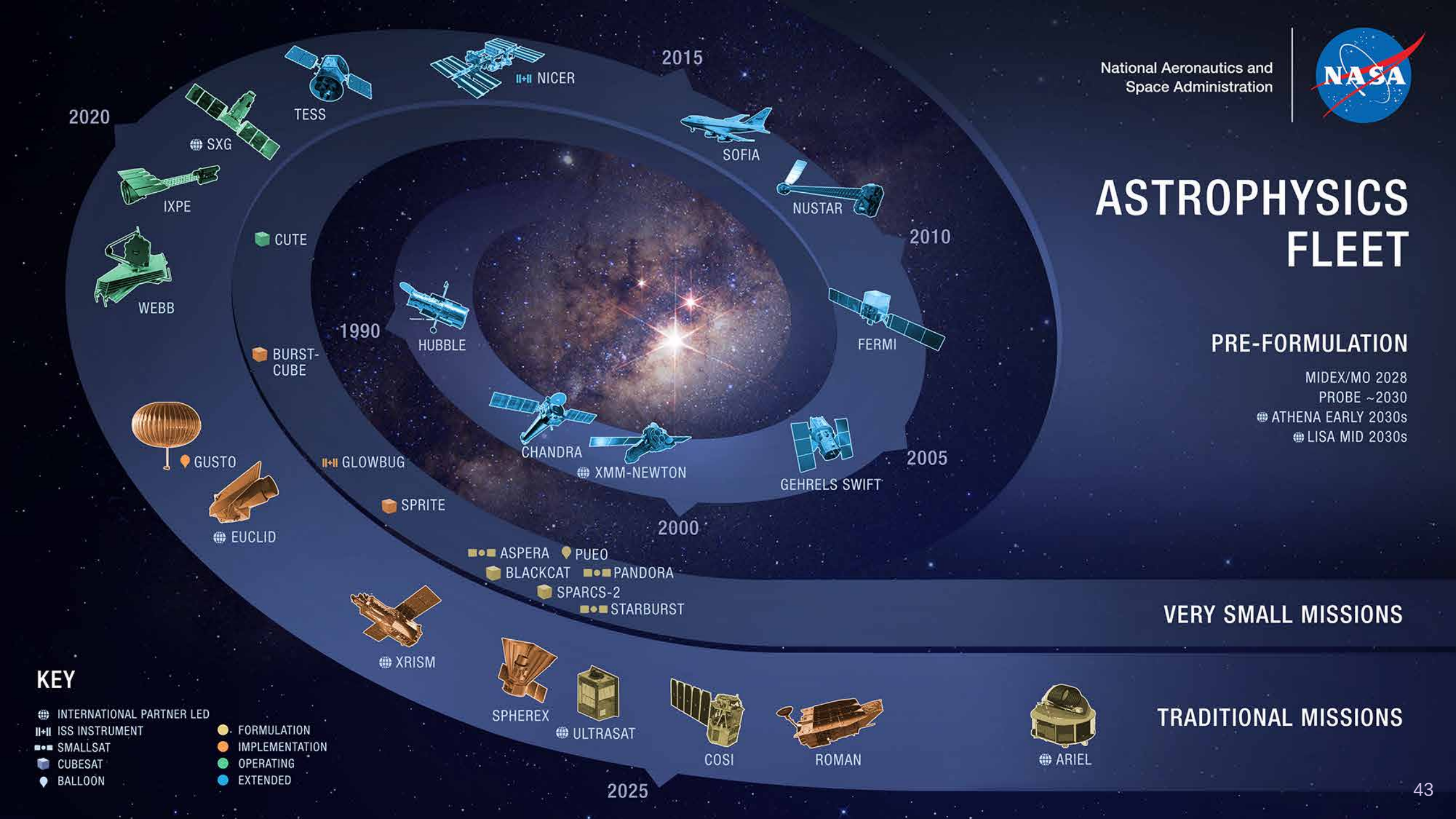
What's next for Astrophysics?

Paul Hertz will be stepping down this summer after more than 10 years as Director of Astrophysics (the best job at NASA)

- Hertz is the longest serving Director of Astrophysics in the history of NASA
- Once the new Director of Astrophysics is in place, Hertz will move to the SMD Front Office as Senior Advisor to the SMD Associate Administrator

Who will lead NASA astrophysics in the upcoming era of increasing inclusion and diversity, growing R&A, Webb science, Roman development, exoplanet characterization, time domain and multi-messenger astrophysics, dark energy and dark matter, first Astrophysics Probe, more Explorers / Pioneers / cubesats, future great observatories, and realizing Decadal Survey priorities?

- The application period closed on March 21, 2022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ASTROPHYSICS FLEET
PRE-FORMULATION
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PROBE ~2030
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SOFIA
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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
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CUBESAT
BALLOON
FORMULATION
IMPLEMENTATION
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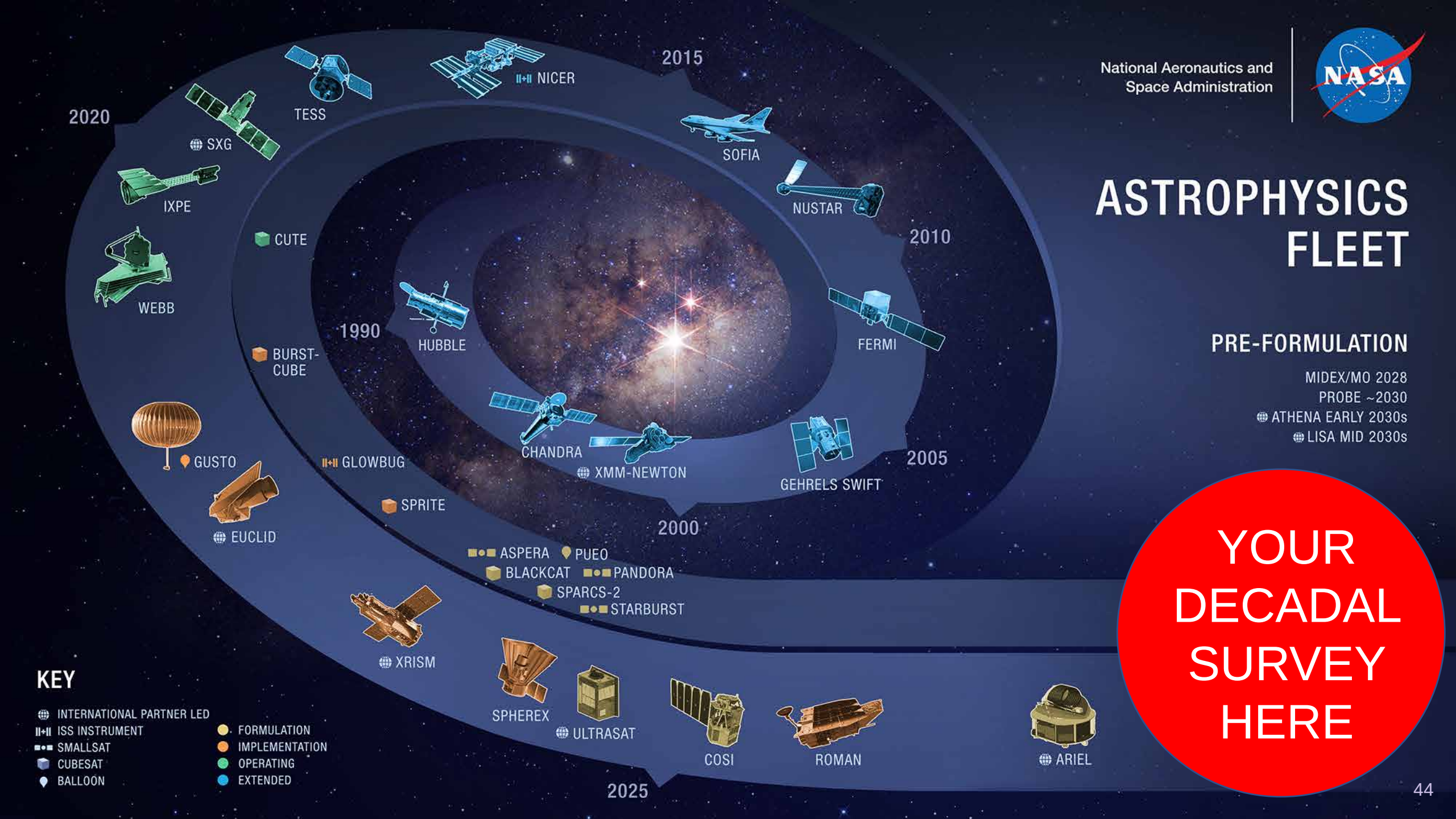
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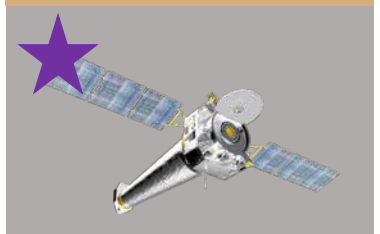
EXTENDED
YOUR DECADAL SURVEY HERE

BACKUP

Astrophysics Missions in Operations

4/90

7/99



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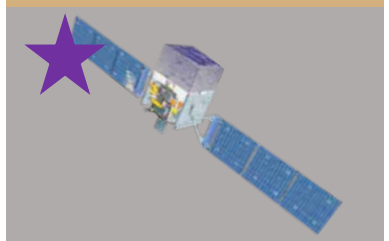

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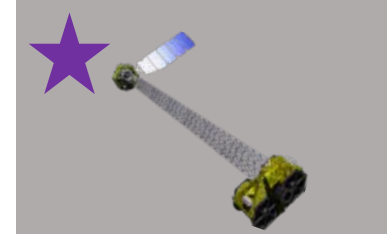

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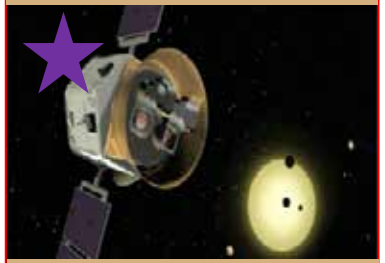

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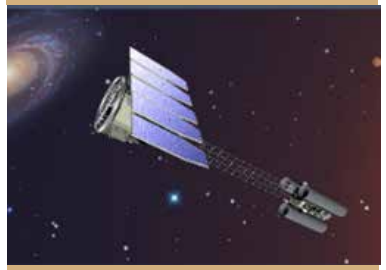

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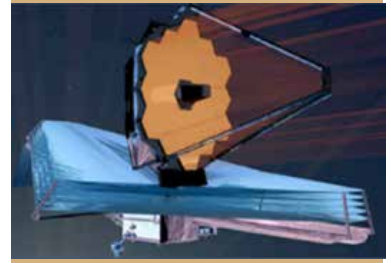


★ Senior Review of Operating Missions in Spring 2022

Astrophysics Missions in Development

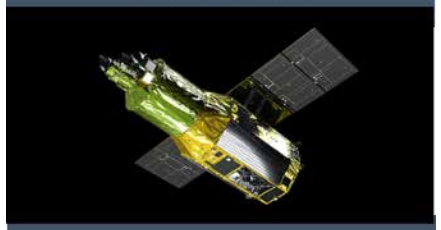
IXPE 2021
NASA Mission

Imaging X-ray Polarimetry Explorer

Webb 2021
NASA Mission

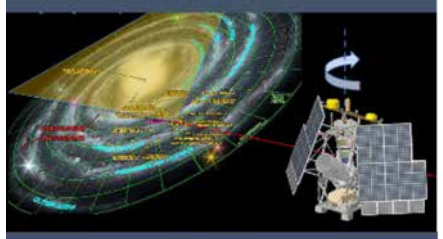
James Webb Space Telescope

XRISM
JAXA-led Mission



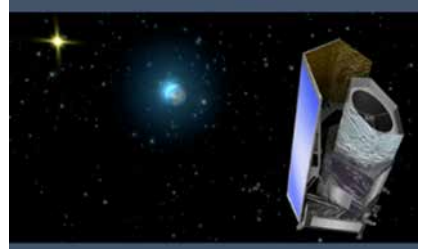
NASA is supplying the SXS Detectors, ADRs, and SXTs

GUSTO
NASA Mission



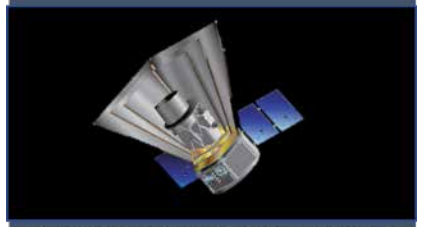
Galactic/ Extragalactic ULDB Spectroscopic Terahertz Observatory

Euclid
ESA-led Mission



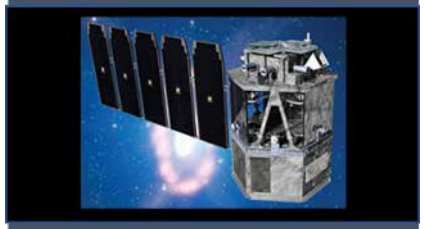
NASA is supplying the NISP Sensor Chip System (SCS)

SPHEREx
NASA Mission



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

COSI
NASA Mission



Compton Spectrometer and Imager

Roman
NASA Mission

Nancy Grace Roman Space Telescope

MIDEX/MO
NASA Missions

Medium-class Explorer Explorer Mission of Opportunity

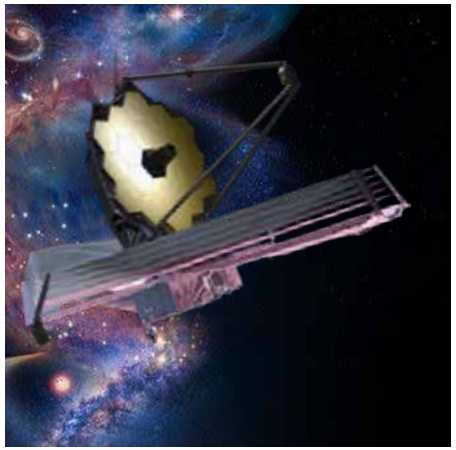
ARIEL
ESA-led Mission

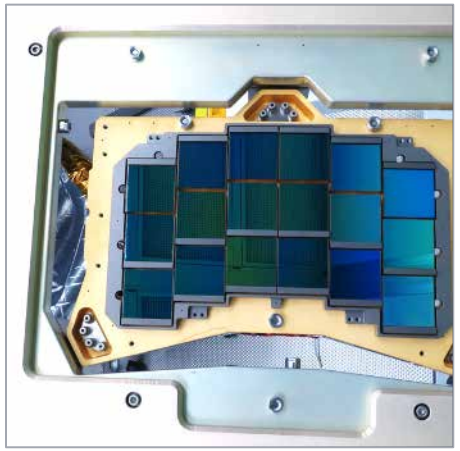
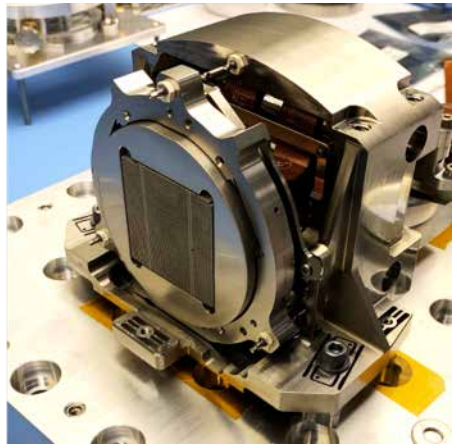
NASA is supplying the CASE fine guidance instrument

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

Does not include Pioneers or CubeSats

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 sounding rocket campaign in Australia 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 Science Program Content ($M)

	Actual	Enacted	Request	Out-Years			
	FY21	FY22	FY23	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