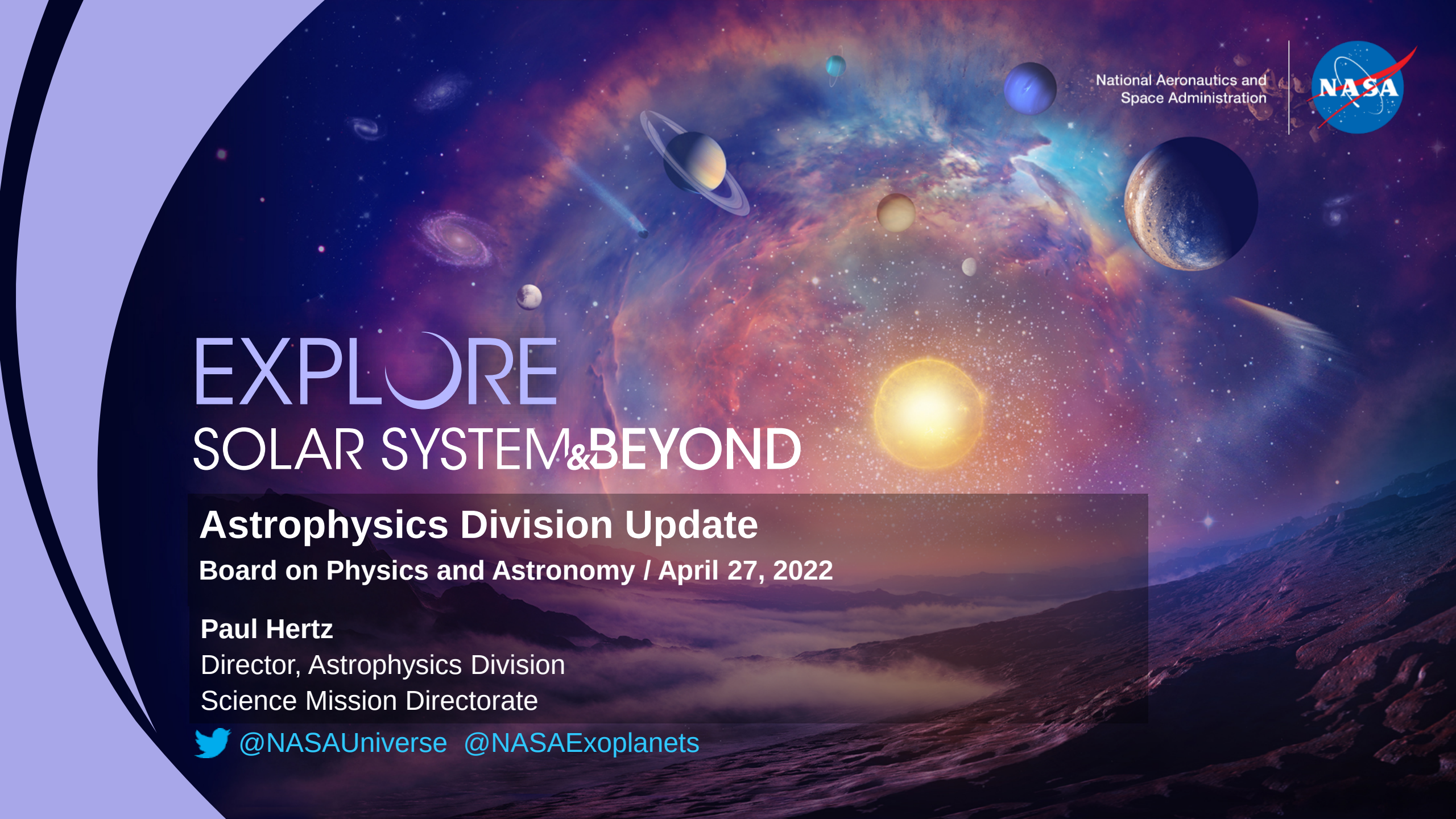


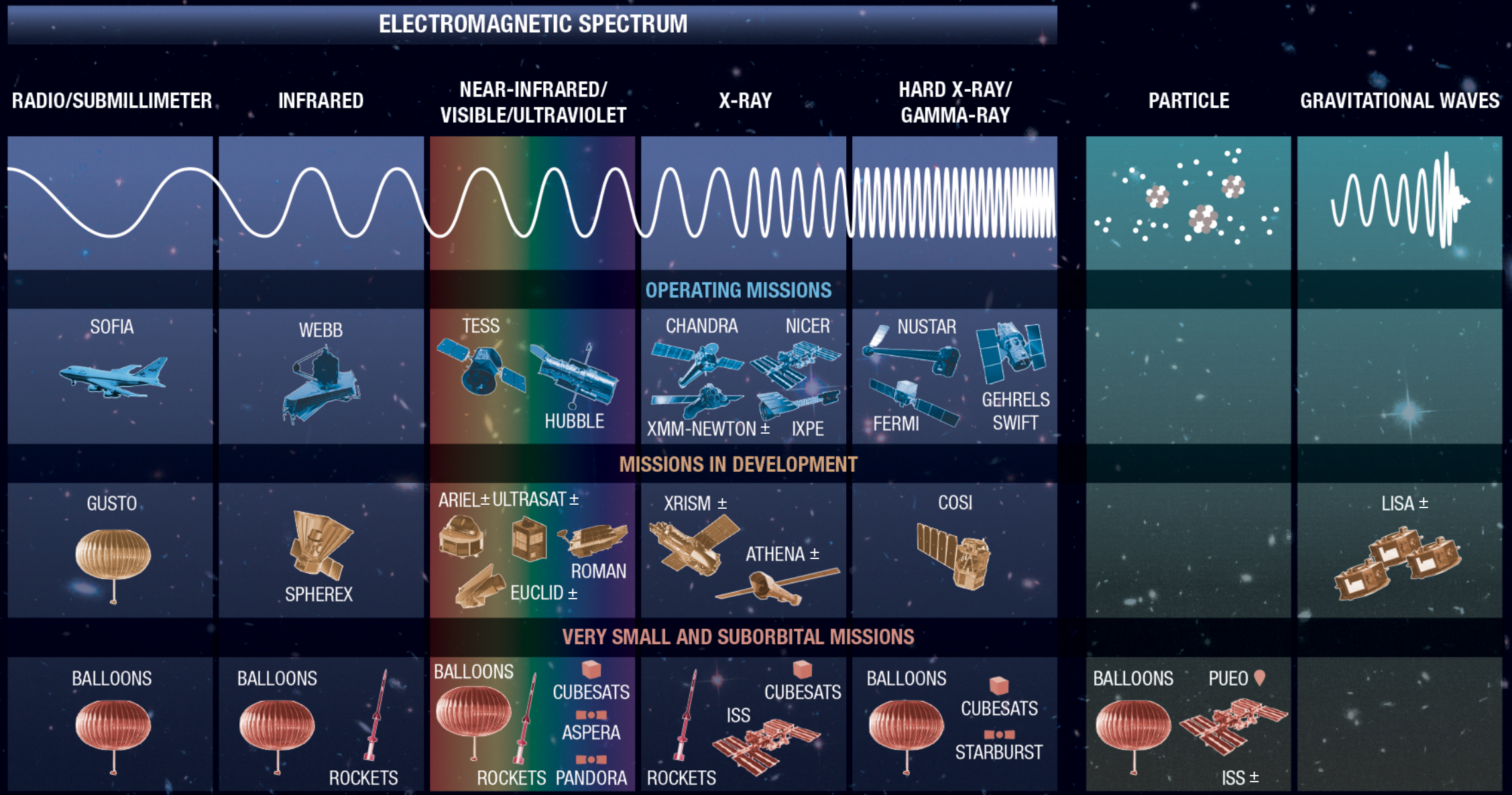
Astrophysics Division Update

Board on Physics and Astronomy / April 27, 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

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

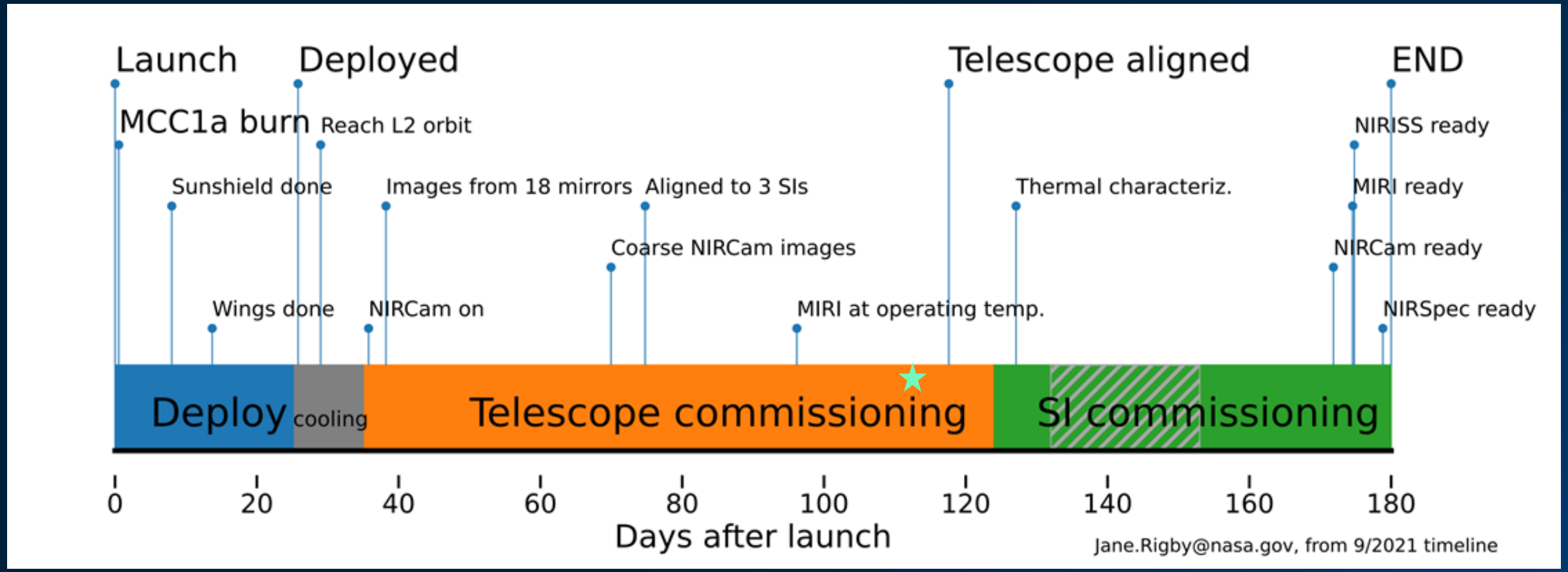
https://webb.nasa.gov/ https://www.stsci.edu/jwst/

WEBB
SPACE TELESCOPE

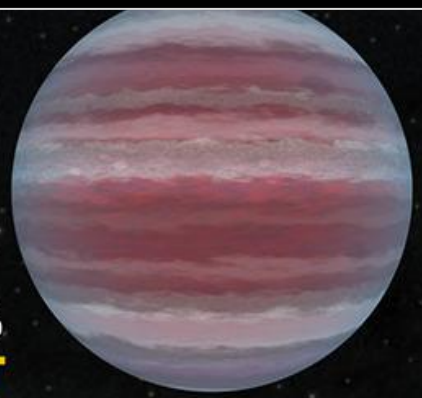
Webb has successfully worked through the second and third out of seven total phases of mirror alignment. On the right, you can see the completion of the third phase – Image Stacking. The individual segment images now fall precisely at the center of the field to produce one unified image instead of 18. After future alignment steps, the image will be even sharper.

Commissioning

Commissioning begins at launch and is ~ 180 days* long marked by the following key events:



★ *We are here*

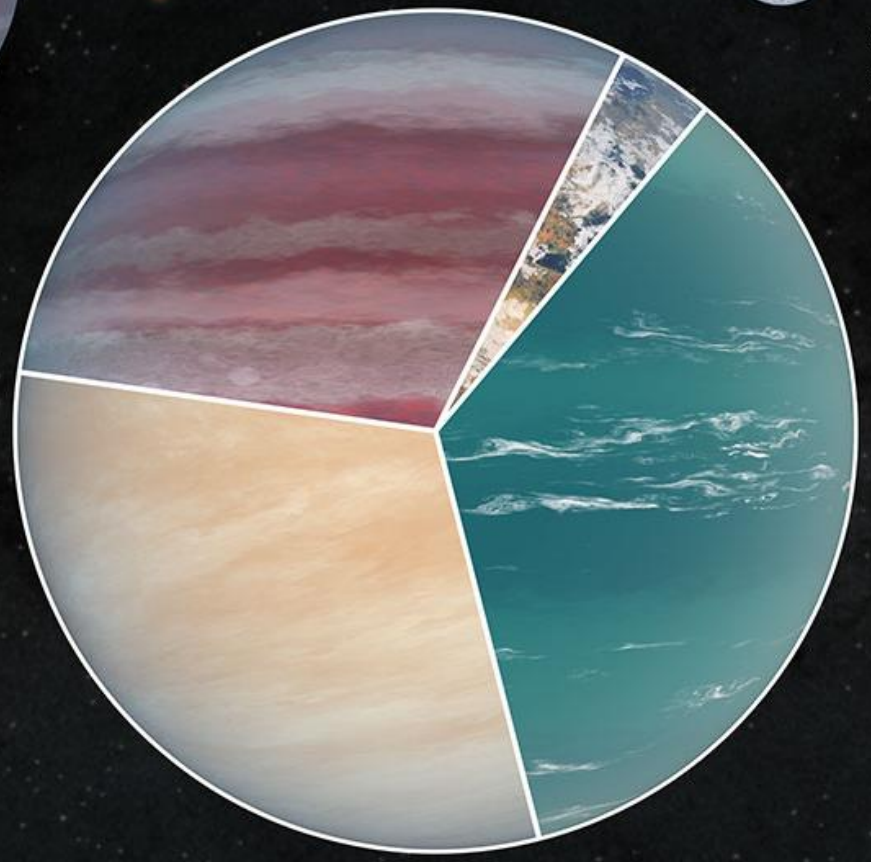


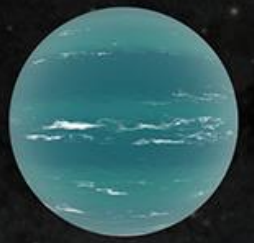
30%
GAS GIANT

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

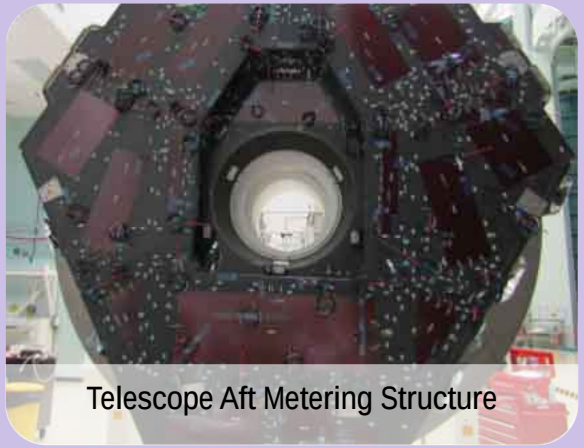
Planets in this size range between Earth and Neptune don’t exist in our solar system. Super-Earths, a reference to larger size, might be rocky worlds like Earth, while mini-Neptunes are likely shrouded in puffy atmospheres.

5000+
PLANETS FOUND

https://exoplanets.nasa.gov

NANCY GRACE ROMAN SPACE TELESCOPE

Optical Telescope Assembly Hardware



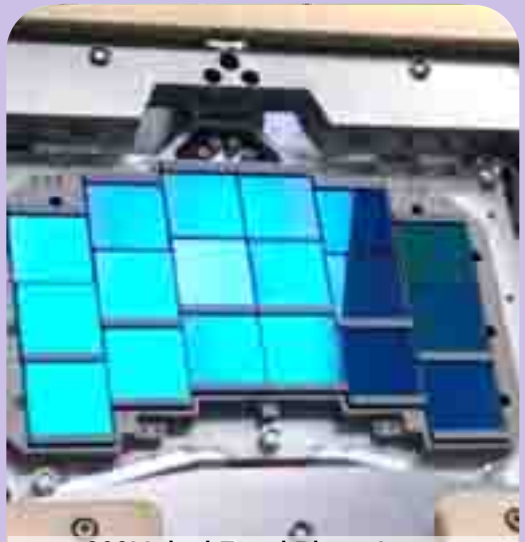
Telescope Aft Metering Structure

Primary Mirror undergoing environmental testing

Tertiary OptoMechanical Assembly

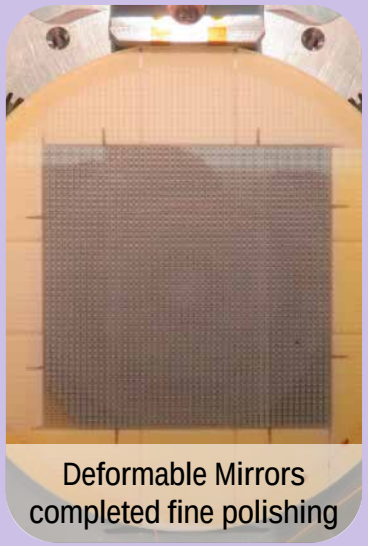
Wide Field Instrument Hardware

Instrument Structure readied for Vibration Testing



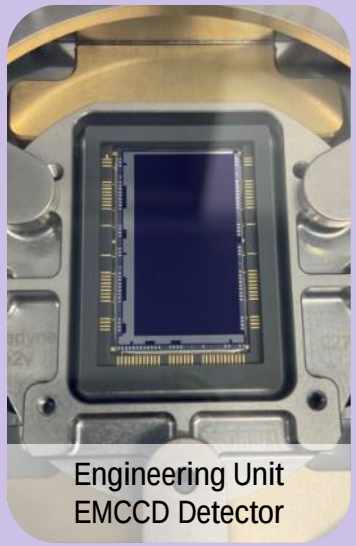
300Mpixel Focal Plane Array Flight Assembly – all 18 detectors!

Coronagraph Instrument Technology Demonstration Hardware



Deformable Mirrors completed fine polishing

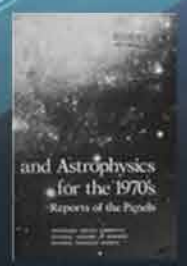
Flight Masks (Pupil)



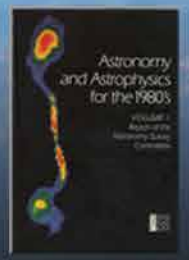
Engineering Unit EMCCD Detector

Astrophysics

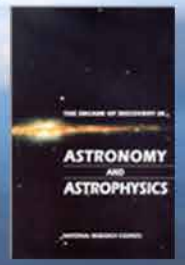
Decadal Survey Missions



1972
Decadal Survey
Hubble



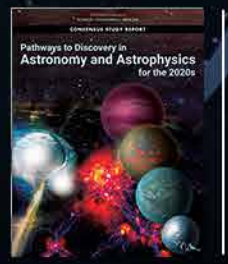
1982
Decadal Survey
Chandra



1991
Decadal Survey
Spitzer

2001
Decadal Survey
Webb

2010
Decadal Survey
Roman



2021
Decadal Survey

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

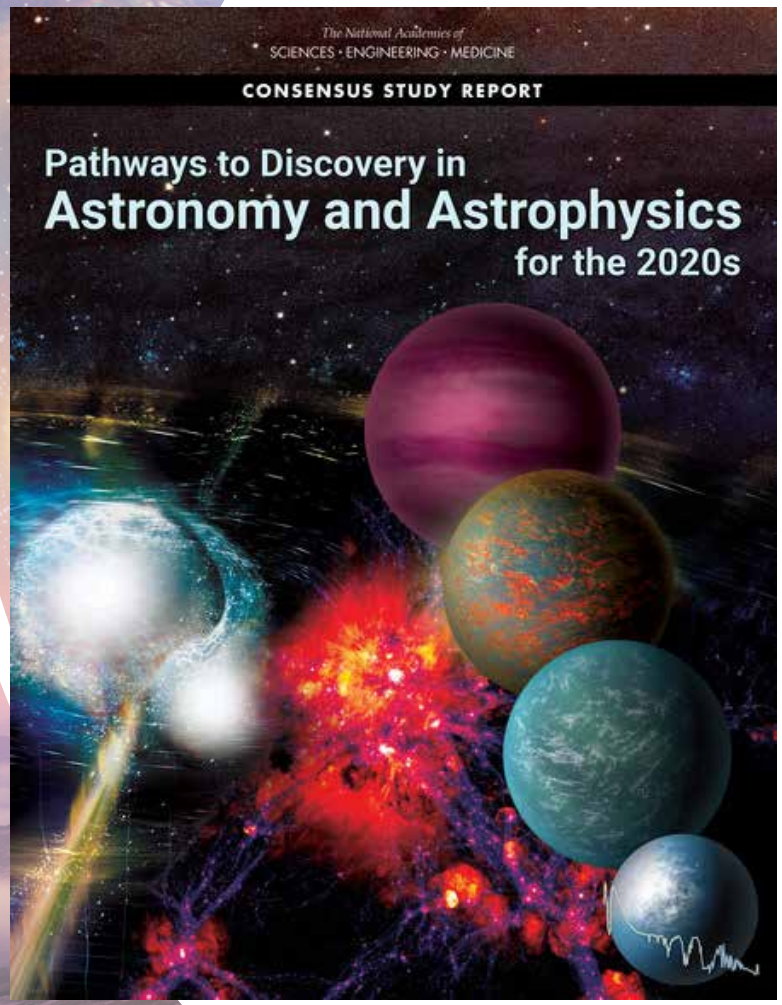
"The panel [on the State of the Profession and Societal Impacts] asserts that fundamentally, the pursuit of science, and scientific excellence, is inseparable from the humans who animate it."

- *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

NASA and Astro2020



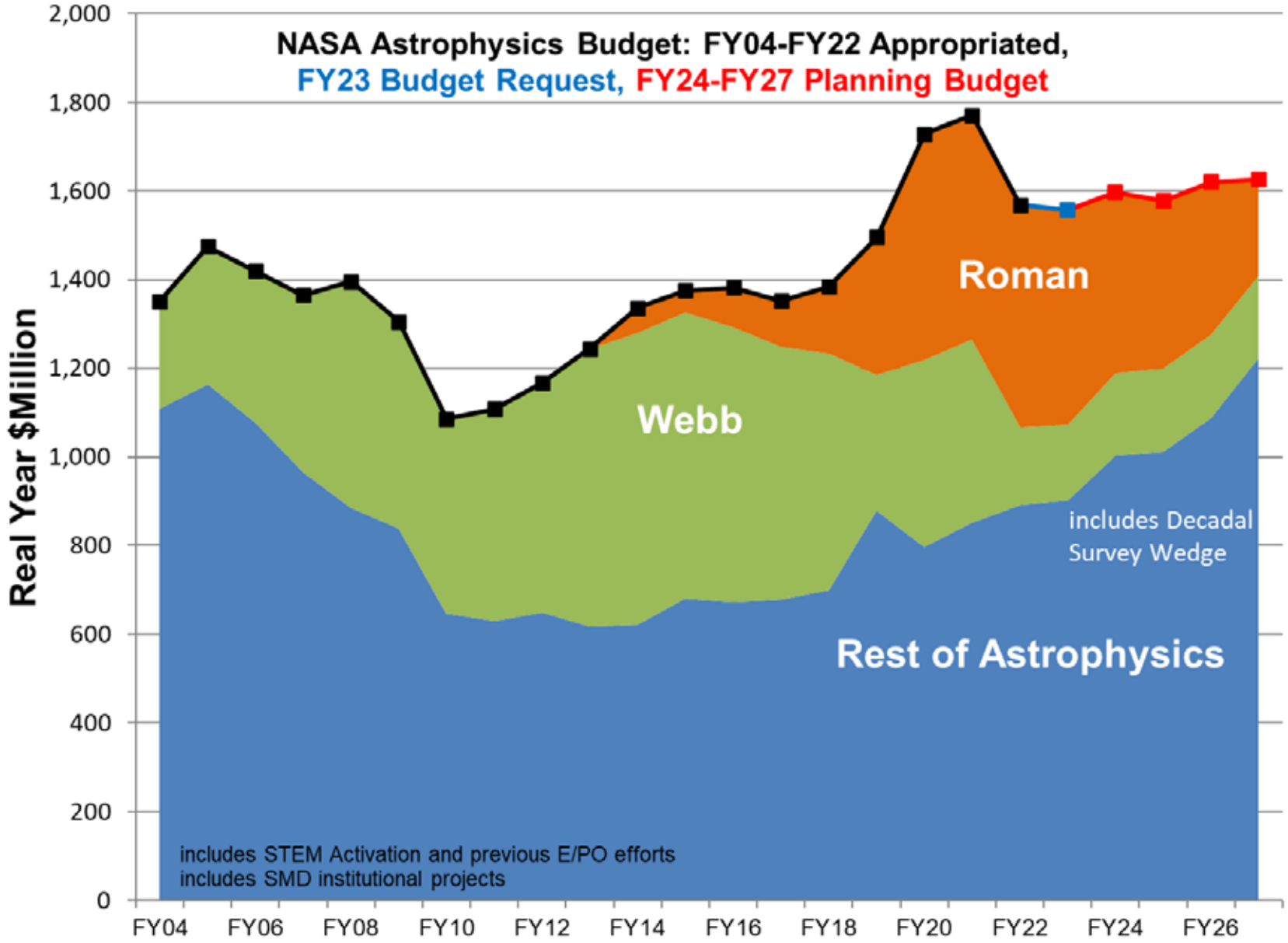
This is an exciting and ambitious plan for the next decade and beyond

- 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

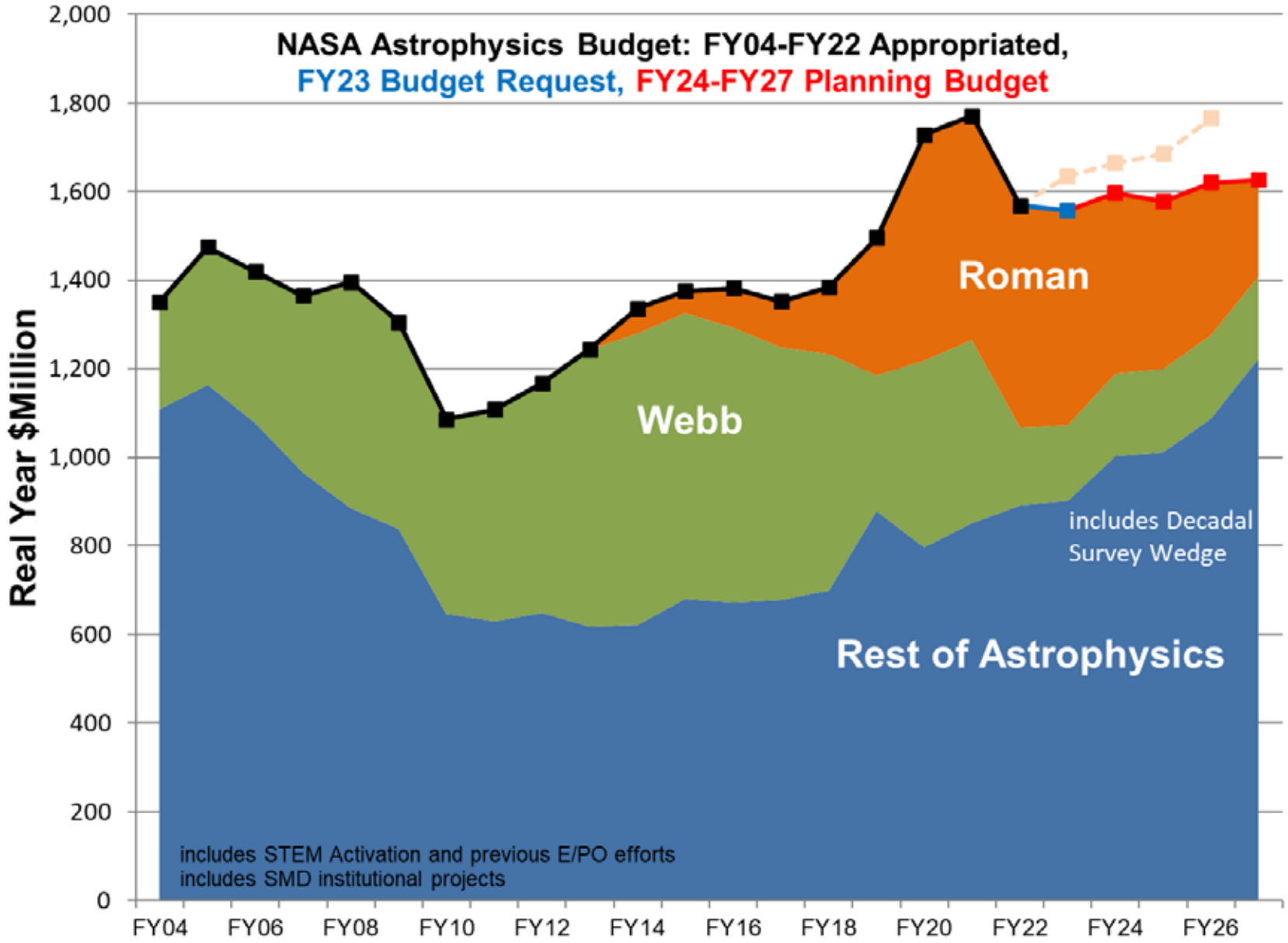
We are bound by the budgets that we have

- 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

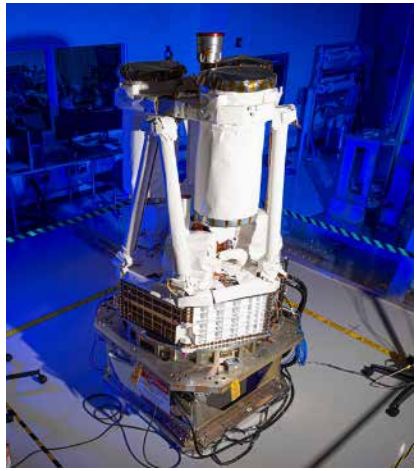
FY23 President's Budget Request

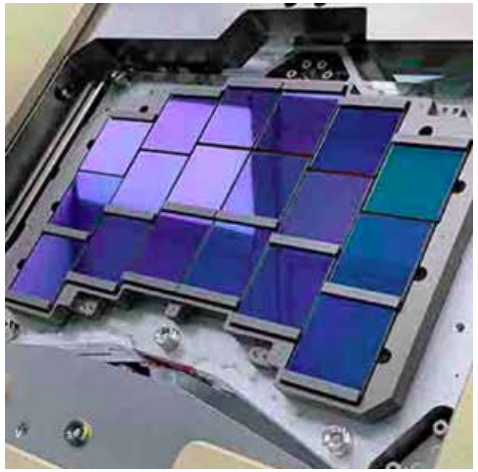


FY23 President's Budget Request



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

Preliminary Response to Astro2020

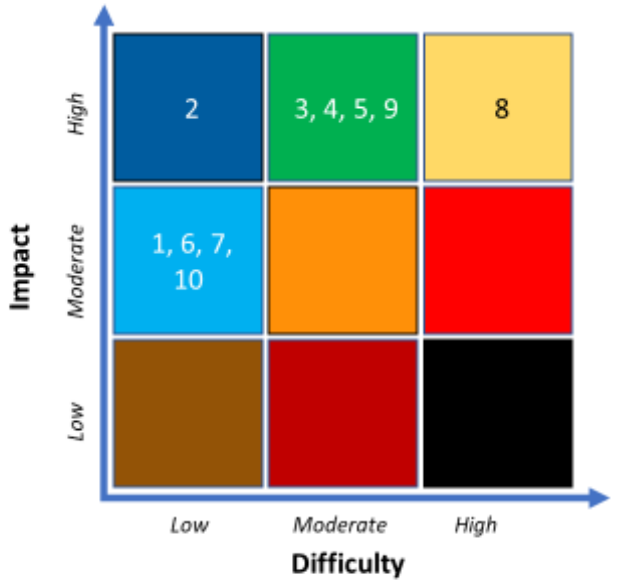
Recommendation	Preliminary response
Great Observatories Maturation pg. 7-11	• NASA conducted a Large Mission Study of lessons learned from the development of large space missions in the past; many of the practices that NASA has committed to in the Large Mission Study Implementation Plan match elements 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*	★	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*	★	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)*	★	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

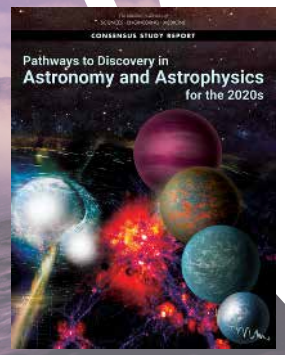
Today NASA's priority is ensuring mission success for Webb and Roman

- 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)



Next Steps for Stage 1

Community Participation via

Technology

- Update Gap lists: present at **June** AAS PAG meetings
- SAT proposals due **Dec 15**
- Plan RFP release to industry **early CY 2023**, for start in late CY 2023
- Community technology workshop(s) in **CY 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 Strategy Team: Identify, categorize, and iterate community precursor science investigations relevant to successful maturation of Astro2020's three great observatories. Work with stakeholders/Program Analysis Groups (PAGs).
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 Strategy Team: Identifies the capability needs and corresponding technology gaps for each of the future great observatories and develops high-level plans to close them. Stands up task groups to develop detailed development plans.
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

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 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

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

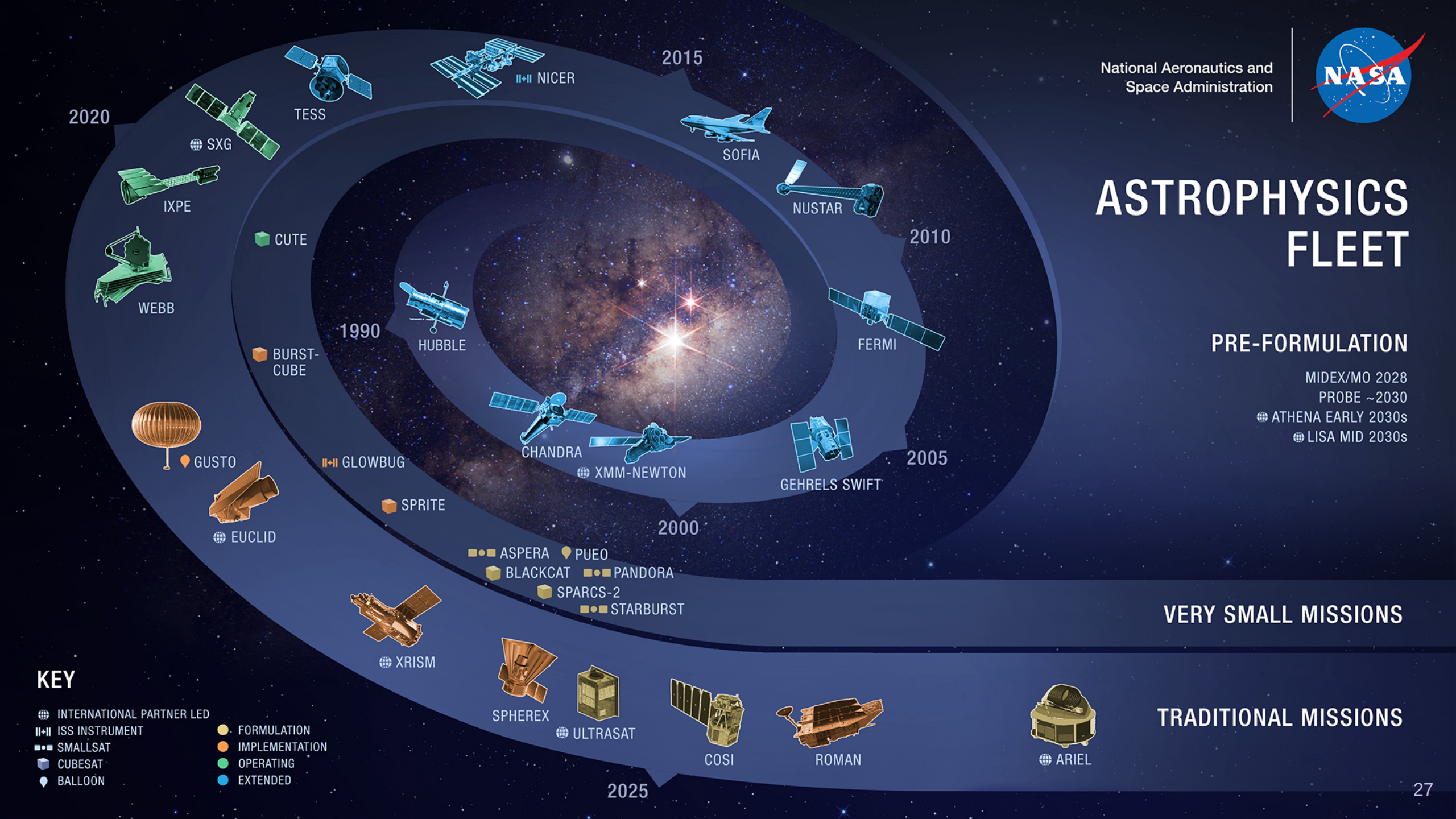
Recommendation	Preliminary response
Proposal Demographics pg. 3-29	• NASA is collecting self-reported demographic data through NSPIRES on proposers, co-investigators, awardees, and reviewers • NASA has charged the National Academies with conducting a study that will enumerate the types of data that NASA 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

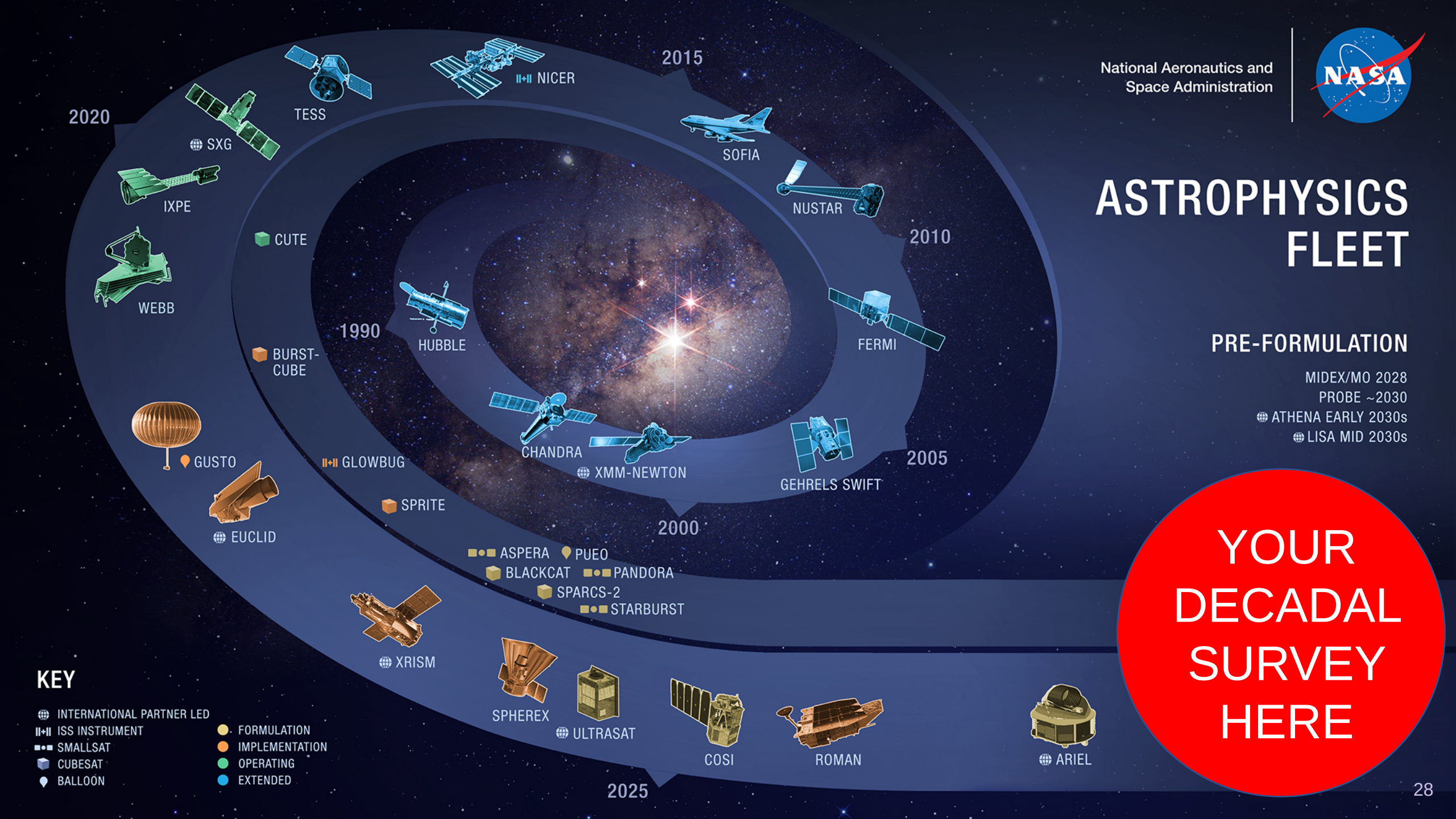
Preliminary Response to Astro2020

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


National Aeronautics and Space Administration
NASA
ASTROPHYSICS FLEET
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
XRISM
SPHEREX
ULTRASAT
COSI
ROMAN
ARIEL
PRE-FORMULATION
MIDEX/MO 2028
PROBE ~2030
ATHENA EARLY 2030s
LISA MID 2030s
VERY SMALL MISSIONS
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
2015
2020
2010
1990
2005
2000
2025
NICER
TESS
SOFIA
SXG
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