NASA Astrophysics Update

Astrophysics Advisory Committee | July 20, 2022

Paul Hertz
Director, Astrophysics Division
Science Mission Directorate
@NASAUniverse @NASAExoplanets @NASAWebb

Outline

- The NASA Team
- APAC Recommendations
- Decadal Survey Recommendations
- FY23 Budget Update
- Selected Program Updates
- Big Finish
- Backup

The NASA Team

NASA Astrophysics Division

Division Director

Paul Hertz
Astrophysics Division Director

Sandra Cauffman
Astrophysics Division Deputy Director

Program Executives

Rachele Cocks
Dep COSI, Dep Ariel/CASE CubeSats

E. Lucien Cox
SOFIA, GUSTO, XRISM, ExEP

Julie Crooke
GOMAP

Ed Griego
Roman, CGI

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

Janet Letchworth
Operating Missions, Decadal

Mark Sistilli
Explorers Program SPHEREx, COSI Balloons

Cross Cutting

Eric Smith
Chief Scientist Webb Precursor Sci

Vacant

Vacant
Assoc Dir for Flight ASM Program Manager

Mario Perez
Chief Technologist SAT, RTF, ISFM, Swift

Omid Noroozian
Deputy Chief Technologist

Not Pictured

Lisa Wainio
Information Manager, Public Affairs Liaison

Administrative Support

Jennifer Baker
Administrative Assistant

Ingrid Farrell
Program Support Specialist

Kelly Johnson
Administrative Assistant

Sara Schwartzman
Program Support Specialist

Program Scientists

Manuel Bautista

Dominic Benford
Roman, CGI, APRA Lead

Terri Brandt
COSI Dep APRA Dep Pioneers Dep Precursor Sci

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

Antonino Cucchiara

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 ExEP, Explorers

Patricia Knezek
Explorers Program Astrophysics Probe SOFIA, Hubble Fellows

William Latter
APRA (Lab Astro) SPHEREx, Fermi

Sangeeta Malhotra
Roman/CGI Dep ATP/TCAN Dep

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

Joshua Pepper
Deputy TESS, Deputy ADAP, Deputy ExEP

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

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

Astrophysics Staffing Updates

New Staff: Jennifer Baker, Manuel Bautista, Julie Crooke, Antonino Cucchiara, Omid Noroozian, Joshua Pepper

Division Director: Mark Clampin, start date is August 15

Associate Director for Flight: Applications received, decision process is underway

Associate Director for Research: Eric Smith officially starts Oct 1

ASMP Program Manager: Non-selected from recent ad, will re-advertise next year, Sandra Cauffman is Acting but seeking alternate solution

Program Scientists:

- Astrophysics will participate in SMD-wide PS ad in July, can add up to 3 new program scientists from combination of sources (new hires, new IPAs, new detailees)
- Eric Tollestrup's IPA concludes in Nov 2022

Program Executives

- Astrophysics is participating in the recent SMD-wide PE ad, can add up to 2 new program executives

Evolving Astrophysics Division

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Astrophysics Division Director

Sandra Cauffman
Astrophysics Division Deputy Director

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Dep COSI, Dep Ariel/CASE CubeSats

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SOFIA, GUSTO, XRISM, ExEP

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Operating Missions, Decadal

Mark Sistilli
Explorers Program SPHEREx, COSI Balloons

+2 PEs (ad closed)

Cross Cutting

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In Process

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+3 PSs (ad opens July 22)

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XRP, TESS ExEP, Explorers

Patricia Knezek
Explorers Program Astrophysics Probe SOFIA, Hubble Fellows

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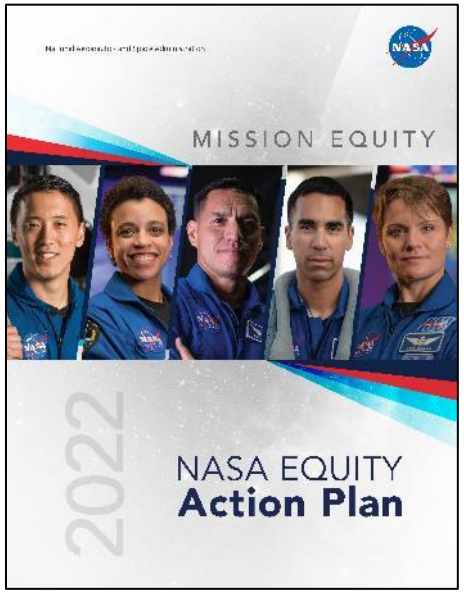
Importance of Inclusion, Diversity, Equity, Accessibility (IDEA)

"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 & 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 & Diversity

- IDEA is infused throughout everything we do. It is not a standalone or separate activity.
- Astrophysics has pioneered and piloted IDEA activities that are now adopted across SMD:
  1. Inclusion Plans adopted in ROSES elements across all SMD
  2. Code of Conduct now adopted for panel reviews
  3. Dual Anonymous Peer Reviews adopted
  4. Inclusion Criteria in Senior Review … across all SMD divisions *
  5. Increasing diversity … expected across all SMD divisions
- Other SMD …
  7. … and publication of demographics of ROSES proposers and awardees *
  8. … port data on proposal submissions and success rates *
  9. … Bridge Program funded for better engagement with MSIs *
  10. National Academies study of barriers to inclusion in mission leadership
  11. National Academies study of demographic data required to assess the health of the community *
  12. Regular participation at meetings such as SACNAS and NSBP
  13. PI Launchpad to incubate next generation of diverse leaders for missions *
  14. IDEA criteria being added to Announcements of Opportunity *

Additional initiatives are being considered for inclusion in the FY24 NASA budget request *

* Responsive to an Astro2020 Decadal Survey recommendation

APAC Recommendations

APAC Recommendations from March 2022

Recommendation (general)	Response
The APAC requests regular updates on the cost and schedule of the Roman Observatory.	See Julie McEnery's "Roman Update" presentation on Day 2 of this meeting.
The APAC requests an update regarding the next MIDEX opportunity now delayed.	The MIDEX selection and competitive Phase A/downselection will take place as announced. An extended Phase B will be baselined resulting in a delayed launch.
The APAC requests a presentation on the status of GUSTO at its next meeting.	See Paul Hertz's "Astrophysics Division Update" presentation on Day 1 of this meeting.
The APAC requests a presentation on the SOFIA close out process plans, including mission data archive completion at the NASA/IPAC Infrared Science Archive (IRSA) and aircraft asset preservation.	See Paul Hertz's "Astrophysics Division Update" presentation on Day 1 of this meeting.
The APAC recommends that NASA extend the SOFIA mission close-out process to FY2023 to carry out the Cycle 10-selected peer reviewed proposals.	Since SOFIA never selected any Cycle 10 proposals, there is no need to extend the mission to carry them out.
The APAC requests APD initiate a review of whether the community research and analysis funding profiles and formulae used in pointed GO mission models (e.g., Hubble, Webb) is applicable to survey missions (e.g., Roman, Euclid) to maximize the scientific return.	It is premature to conduct such a review at present; APD will take this under consideration for a future study as Roman approaches launch. The GO/GI budget will be revisited at KDP-D.

APAC Recommendations from March 2022

Recommendation (general)	Response
The APAC requests a presentation on the evolution of the NASA Science Mission Directorate (SMD) Bridge program and a broad strategic overview of the implementation of IDEA initiatives at the committee's next meeting.	A presentation will be provided at a future APAC meeting.
The APAC advises APD to communicate effectively and in a timely fashion with the astrophysics community and other stakeholders with regard to release of a Probe Announcement of Opportunity (AO), envisaged in the Astro2020 Decadal Survey.	A community announcement was released on May 19, 2022. A Draft AO is planned for Summer 2022.
The APAC requests APD to provide frequent updates on action related to time-domain and multi-messenger science.	See Valerie Connaughton's "Time Domain and Multi-Messenger Astronomy" presentation on Day 2 of this meeting.
The APAC advises APD to continue close evaluation of the ROSES Inclusion Plans Initiative, as it extends to different programs.	APD's Inclusion Plan Initiative has been adopted by SMD. Continuous evaluation is planned.
The APAC requests Kevin Murphy, Transform to Open Science (TOPs) lead, to discuss with the committee at a future meeting the developments in this area, with a particular focus on the national needs and sensitivities to national security awareness of widely accessible and distributed scientific software codes.	See Cynthia Hall's "Transform to Open Science" presentation on Day 1 of this meeting.

APAC Recommendations from March 2022

Recommendation (JWST)	Response
The APAC requests the APD strongly encourage the NASA historian and their team to document fully and completely in a written report the current status of the ongoing investigation of archival materials, conversations, and other sources by the committee's 2022 July meeting.	The NASA historian plans to release additional information on the historical research conducted.
The APAC advises that advancing the resolution of the Webb investigation may require additional future work and requests a schedule for timely and crisp completion of these activities.	The NASA historian has completed the historical research and will be briefing NASA leadership in the near future.
The APAC requests the NASA historian be invited to provide a thorough debrief to the committee for the record at the committee's 2022 summer meeting.	The NASA historian will be invited to address the APAC after the additional information on the historical research is released.
The APAC advises APD to consider development of written policies and guidelines-of-practice of naming flagship missions that could build community trust and endorsement.	APD has taken this recommendation under advisement. Policies for naming NASA projects are held by the Agency, so internal discussions are required.

APAC Recommendations from March 2022

Recommendation (JWST)	Response
The APAC suggests that the findings of the NASA historian, the issue of James Webb memorialization, and the naming of future observatories be discussed by the NASA Advisory Council (NAC).	This recommendation is not addressed to APD.
The APAC strongly advises the APD to work aggressively to sustain full funding of investigators' research and analysis requirements to ensure a sustained scientific return from the observatory, its archives, and the theoretical and laboratory endeavors that JWST will engender.	See Eric Smith's "JWST Update" presentation on Day 1 of this meeting.
The APAC requests an update on the on-orbit JWST mission status and early release science at the committee's next meeting.	See Eric Smith's "JWST Update" presentation on Day 1 of this meeting.
The APAC requests additional information regarding the JWST project's initial science release and publication plans, following precedents established by prior flagship missions, to assure that there is a coherent strategy to disseminate science results within the astrophysics community.	See Eric Smith's "JWST Update" presentation on Day 1 of this meeting.

APAC Recommendations from March 2022

Recommendation (Roman)	Response
The APAC requests an update on Covid-19 and other supply chain issues that could further impact schedule and cost at the committee's next meeting.	See Julie McEnery's "Roman Update" presentation on Day 2 of this meeting.
The APAC requests an update on the status of the Committee on Astrophysics and Astronomy (CAA) non-advocate review of Roman's capacity for large ambitious community driven surveys at a future meeting.	See Julie McEnery's "Roman Update" presentation on Day 2 of this meeting.
The APAC requests Roman return to the committee to discuss specifically details of managing the enormous data volumes and data utilization and distribution schemes to maximize the science return of the mission commensurate with the opportunities and constraints in the NASA TOPS initiatives.	See Julie McEnery's "Roman Update" presentation on Day 2 of this meeting.

APAC Recommendations from March 2022

Recommendation (balloon task force)	Response
The APAC requests APD modify the TOR to include a specific charge within the subcommittee's remit to study a comprehensive and appropriate approach to data archiving associated with balloon mission science return.	Data archiving is covered by SPD-41. SMD is providing policies for archiving of suborbital and research data across SMD.
The APAC suggests APD advise the BPIR Subcommittee to consider in their deliberations the recommendation and findings within the PAG 2020 Balloon Roadmap Report and to consider including members of the Balloon Working Group on the BPIR Subcommittee.	TOR was adjusted.
The APAC suggests APD not limit the review to 18 months, but provide an option to extend, while also providing interim updates to the Division to permit a timely response to recommendations and findings.	TOR was adjusted.
The APAC recommends not restricting the number of meetings to six, but to allow for additional meetings as budget permits (ideally meetings could be a combination of in-person and virtual gatherings).	TOR was adjusted.

APAC Recommendations from March 2022

Recommendation (sounding rockets)	Response
The APAC recommends APD implement a strategy to enable more frequent sounding rocket campaigns from Australia if science demands warrant.	Now that the diplomatic and technical challenges have been solved, APD accepts this recommendation within budgetary constraints.
The APAC suggests APD develop a coherent process to track metrics of scientific impact across the entire Sounding Rocket portfolio to assess the return on investment, technology readiness level advancement, and work-force development.	APD requests further discussion on this recommendation.
Recommendation (archive modernization)	**Response**
The APAC requests an update on the Archive Modernization at a future meeting.	A presentation will be provided at a future APAC meeting.
The APAC recommends assembling an advisory group of experts for this work. Such a group should be led by users from the community and have representation from the commercial and national security sectors.	The Astrophysics archives are still working to define the platform. We plan to convene a requirements review with potential community users, software engineers, and representatives from other SMD divisions to be our initial advisory group. Security practices will follow NASA requirements. Cloud resources will be accessed through existing NASA cloud contracts. We expect that this advisory group will evolve as needed with time as the platform develops.

APAC Recommendations from March 2022

Recommendation (PAG reports)	Response
The APAC recommends APD accept and close out the ExoPAG SAG21, and SAG22 final reports, posting the documents to the 2022 March APAC document website.	The SAG 21 and SAG 22 reports were approved on March 31, 2022. Both have been posted to the ExoPAG website.
The APAC recommends APD accept the TOR for the Exozodi SAG of the ExoPAG.	The TOR for ExoPAG SAG 23 was approved on April 21, 2022.
The APAC requests a report from the COPAG on the IRSTIG workshop on Astro2020 planning.	This recommendation is not addressed to APD.
The APAC suggests the PhysPAG draft a TOR for the cross-PAG SAG on synergies between the Next Generation Great Observatories noted in the Astro2020 Decadal Survey report. This TOR should be submitted two weeks before the next APAC meeting for review and discussion.	This recommendation is not addressed to APD.
The APAC requests the leads finalize cross-PAG TOR for the AWESOM SAG on removing barriers to participation in the APD research enterprise by the next meeting of the committee, which should have as a focus an examination of APD programs that have led to expanded participation, the sustainability of these initiatives, and new pathways to maximize their impact.	This recommendation is not addressed to APD.

APAC Recommendations from March 2022

Recommendation (R&A)	Response
The APAC requests a complete debrief on the Inclusion Plan Pilot Program findings at its next meeting.	See Dara Norman's "Advancing Inclusion II: Assessing Community Readiness for Inclusion Plans" presentation on Day 1 of this meeting.
The APAC requests a discussion on how the inclusion plan critiques are being relayed to the proposers and what efforts are being made to educate potential proposers in this area at the committee's next meeting.	See next chart.
The APAC recommends an analysis of the ATP program for either direct augmentation in funding or restructuring in a way for the field to be properly funded.	See Stefan Immler's "Astrophysics Theory Program Update" presentation on Day 1 of this meeting.
The APAC requests a status update describing how APD is meeting Astro2020 Decadal Survey recommendations with specific asks regarding how the Division is considering potential responses in the areas of "…undergraduate and graduate "traineeship" funding…" and "...augmentation and improved coordination of Laboratory Astrophysics funding…" at the committee's next meeting.	See chart after next chart,

APAC Recommendations from March 2022

The APAC requests a discussion on how the inclusion plan critiques are being relayed to the proposers and what efforts are being made to educate potential proposers in this area at the committee's next meeting.

All solicitations that require an Inclusion Plan include the following language:

> "Note that while the assessment of the Inclusion Plan will not be part of the adjectival rating for the proposal and will not inform the selection of proposals, funding will be released to selected institutions only once a satisfactory Inclusion Plan is approved by the selection official. If additional funding is needed to implement the Inclusion Plan, that request for funding should be clearly identified and justified in the budget as a separate budget element so it can be assessed. Reviewers and proposers will be invited to provide comments and suggestions to improve this program after the review is completed.

A resource that some proposers may find useful in this regard is the NASA MSI Exchange at https://msiexchange.nasa.gov/."

The Inclusion Plan initiative is therefore not a one-way road and PIs have the opportunity to engage with NASA Program Officers, both before and after review of Inclusion Plans. Furthermore, NASA's Office of Diversity and Inclusion has posted resources in their web site:

https://www.nasa.gov/offices/odeo/diversity-and-inclusion

APAC Recommendations from March 2022

The APAC requests a status update describing how APD is meeting Astro2020 Decadal Survey recommendations with specific asks regarding how the Division is considering potential responses in the areas of "…undergraduate and graduate "traineeship" funding…" and "...augmentation and improved coordination of Laboratory Astrophysics funding…" at the committee's next meeting.

NASA has very limited options to provide training opportunities (usually limited to STEM education for teachers and students; the Department of Education provides more opportunities) and generally only funds research investigations through the ROSES programs. However, NASA provides funding for the FINESST solicitation that includes training aspects for early-career researchers. Immediately following the Spring meeting of the APAC, the Astrophysics Division has increased the funding allocation of the FINESST solicitation from $2M to $2.5M annually to increase opportunities for early-career researchers in this area.

As presented at the APAC meeting in March, NASA and NSF will convene a broad panel under FACA committee / AAAC to identify the needs of laboratory data to interpret the results of astronomical and astrophysical observatories and missions; the Agencies will gather Lab Astro data on spending across larger community to improve accuracy of spending data. Results of this effort will be presented at a future APAC meeting.

APAC Recommendations from March 2022

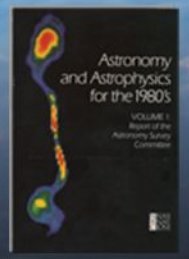
Recommendation (R&A)	Response
The APAC encourages APD to review whether a rebalanced program might more efficiently achieve NASA's strategic 5th pillar goal, in particular increasing the impact of the IDEA objectives.	APD is willing to consider rebalancing and requests discussion by APAC on the criteria and metrics for a balanced program (within a given budgetary constraint).
Recommendation (TDAMM)	**Response**
The APAC advises APD to consider the merits of establishing a Time Domain and Multi-Messenger Astrophysics (TDAMM) sub-committee of the APAC and develop a draft TOR for the committee's consideration at its 2022 fall meeting.	See Valerie Connaughton's "Time Domain and Multi-Messenger Astronomy" presentation on Day 2 of this meeting.

Decadal Survey Recommendations

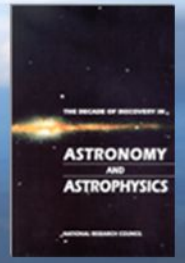
Astrophysics

Decadal Survey Missions

1972
Decadal Survey
Hubble



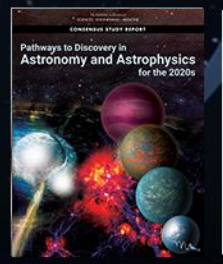
1982
Decadal Survey
Chandra



1991
Decadal Survey
Spitzer

2001
Decadal Survey
Webb

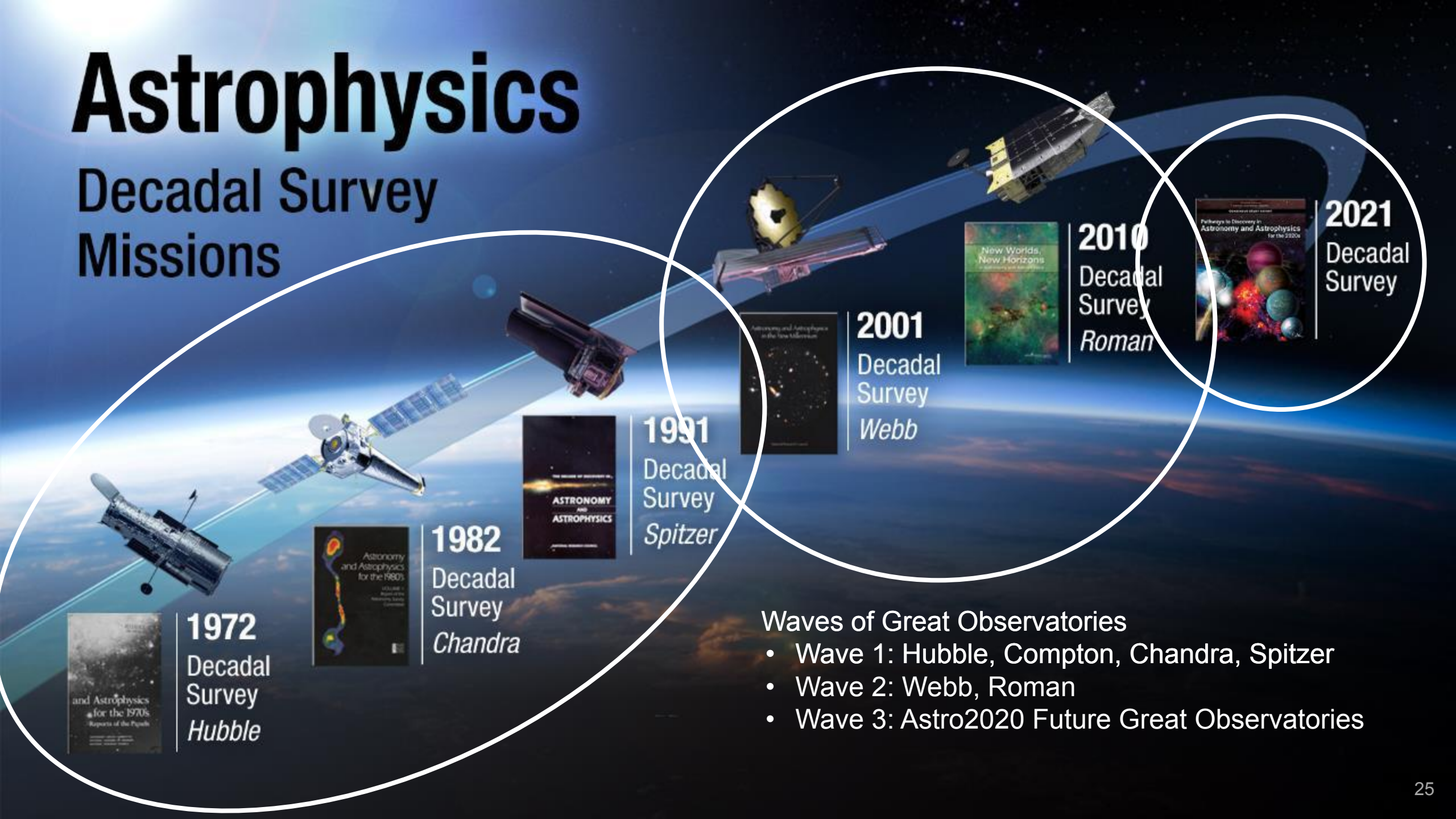
2010
Decadal Survey
Roman



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



Waves of Great Observatories

- Wave 1: Hubble, Compton, Chandra, Spitzer
- Wave 2: Webb, Roman
- Wave 3: Astro2020 Future Great Observatories

Astrophysics Probe

NASA is drafting an AO for a PI-led Astrophysics Probe

A Community Announcement laying out the primary parameters of the upcoming Astrophysics Probe AO was released on Jan 11, 2022

A second Community Announcement with two updates was released on May 19, 2022

- The target date for the final Probe AO was revised to July 2023
- Due to European Space Agency (ESA) consideration of whether the Athena mission will be substantially replanned, it was no longer practical to require proposed X-ray probes to "complement ESA's Athena Observatory." This requirement was therefore removed. Astrophysics will now accept proposals for:
  - A far-infrared imaging and/or spectroscopy mission
  - An X-ray probe

Community announcements and FAQ at https://explorers.larc.nasa.gov/2023APPROBE/

Release of draft AO:	August 2022 (target)
Release of final AO:	July 2023 (target)
Proposals due:	NET 90 days after AO release

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 is making 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 to 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

Presentation by Valerie Connaughton on Day 2 of this APAC meeting

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 passed its Post Launch Assessment review (PLAR) on July 15 and is now in its 5-year prime mission conducting normal science operations
- Roman is progressing well in Mission Phase C "Final Design and Fabrication" and is on track for a mid-2027 launch

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

- The report from the House CJS Appropriation Subcommittee markup of the NASA FY23 budget request states, "The Committee supports NASA's emphasis on developing the Roman Space Telescope before investing heavily in the recommendations of the next Decadal."

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

- NASA is formulating a Great Observatories Mission and Technology Maturation Program (GOMAP)

GOMAP Principles & Goals

Mature FGO-1 (IROUV) science, technologies, and architecture to enable mission new start this decade

- Promote active engagement and seek buy-in from everyone invested in the success of the Astro2020 flagships (academia, industry, NASA, other governmental agencies, international partners)
- Mitigate future programmatic risks by implementing lessons learned from past NASA flagships
  - Draw from multiple sources including SMD Large Mission Study
- Build a community on IDEA principles to ensure an inclusive, equitable culture and broad, diverse participation
- Be inclusive in assembling teams, with open and fair competition & compensation
- Execute systematic trades with multi-NASA & multi-sector teams and document assessments for transparency
- Focus first on Future Great Observatory 1 (FGO-1 aka IROUV) and make progress on maturation activities for X-ray and Far-IR Flagships (FGOs-2 and -3)
  - Ensure each step & decision sets subsequent flagships up for success
- 80% of mission lifecycle funding goes outside the Agency

GOMAP Stages

High-level explanation of Stages 1 – 4, and what each means upfront:

Stage 1

Programmatic preparation

Stage 2

Prepare for IROUV Pre-Phase A

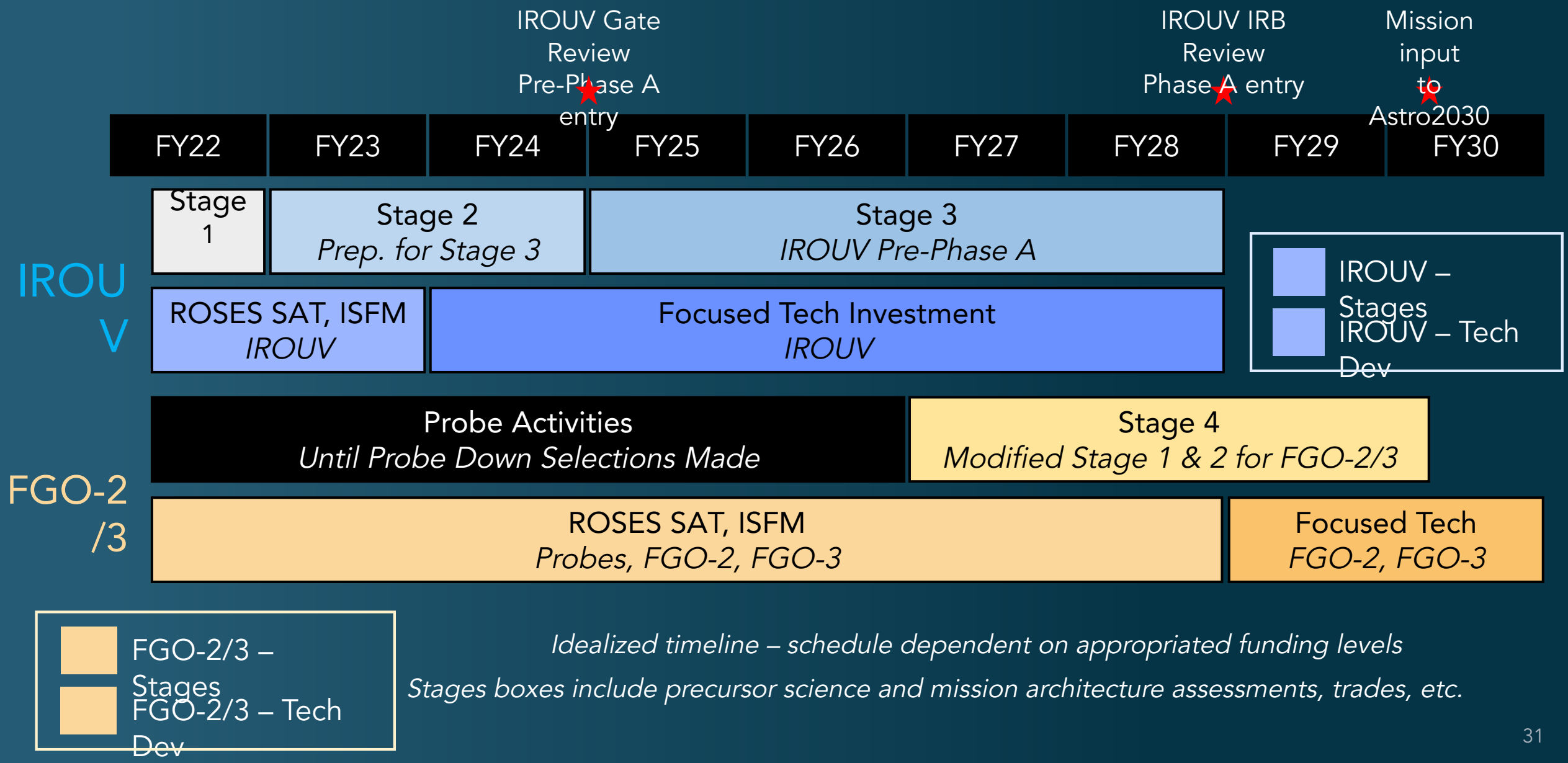
Stage 3

Evolved Pre-Phase A for IROUV

Stage 4

Modified Stage 1 & 2 for FGO-2 and FGO-3

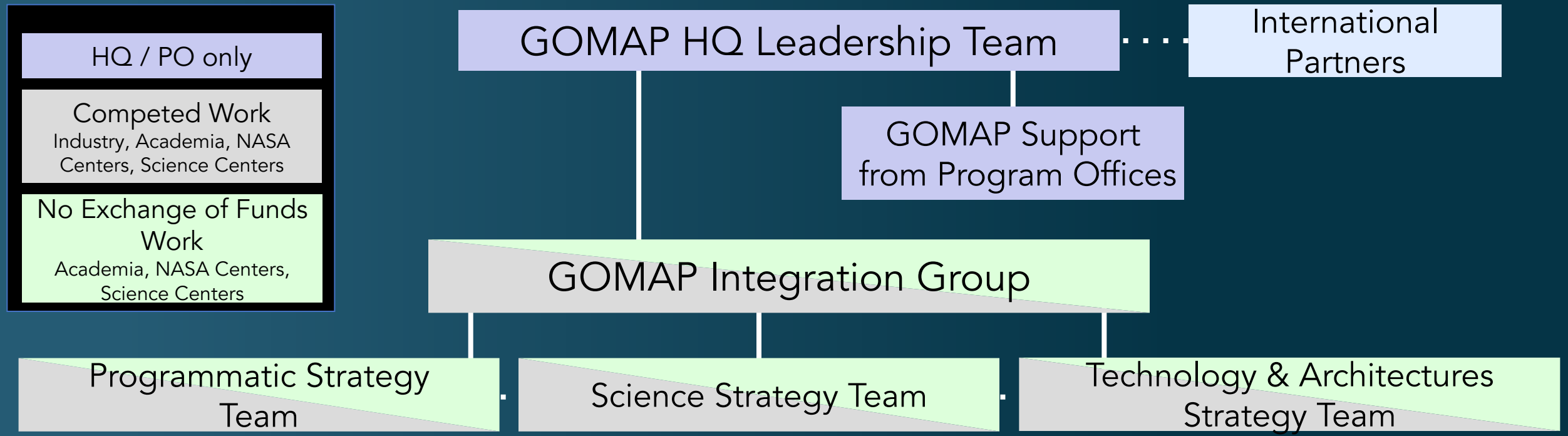
Notional GOMAP Timeline



Idealized timeline – schedule dependent on appropriated funding levels

Stages boxes include precursor science and mission architecture assessments, trades, etc.

GOMAP Teams Structure for Stages 1 & 2



Teams will be assembled expeditiously in Stage 1, but not necessarily simultaneously.

Avenues for participant support will be determined on a case-by-case basis
(pick the right people then figure out how to support them).

GOMAP Next Steps

Organize and populate GOMAP Teams

- Develop and approve GOMAP Code of Conduct
- Approve Terms of Reference for all teams
- Send out open calls for self-nominations

Reach out to academia and industry for ideas

- Issue an RFI for mission, architecture, technology, process, etc. ideas to inform strategy teams

Leverage PAGs

- Establish appropriate SAGs for informing GOMAP strategy teams

Focus solicitations

- Ensure that future SAT and ISFM calls reflect technology strategies developed by GOMAP strategy teams

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 with… Mission Directorate in FY22, with $5M for FY22 and increasing amount… years • Partnerships with NASA's Office of STEM E… upport of HBCUs, TCUs, and other MSIs • Presentation by Padi Boyd at…
Traineeship Funding pg. 3-23	• Under study by th… EA task force • Astrophysi… er school, to help train new PIs, in 2023
Postdoc Fellowships pg. 3-23	• …pendent review of the NASA Hubble Fellowship Program in 2021 to …creasing the effectiveness of the program and bolstering its excellence, with …diversity, equity, and inclusion of the program. NASA is working on an …plementation 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

Additional initiatives are being considered for inclusion in the FY24 NASA budget request

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 • Diversity and inclusion of teams in evaluation of AO proposals starting in 2022
Satellite Interference pg. 3-38	• Impacts of satellite interference on NASA includes space traffic management risk, orbital debris risk, and interference to NASA operations risk • These risks are managed at the Agency level, and mitigations are developed and implemented by OSMA and OCE • Mitigations include agreements with (some) satellite providers that reduce impacts to NASA
Climate Change Actions pg. 3-42	• TBD

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 • See chart later in this presentation
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 • Discussion led by Stefan Immler on Day 1 of this meeting
Archive Coordination pg. 4-20	• NASA, NSF, and DOE have established a cross-agency working group to improve coordination among U.S. archive centers • SMD has established an Open Source Science Initiative to improve coordination among NASA science archives • See presentation by Cynthia Hall on Day 1 of this meeting
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

Preliminary Response to Astro2020

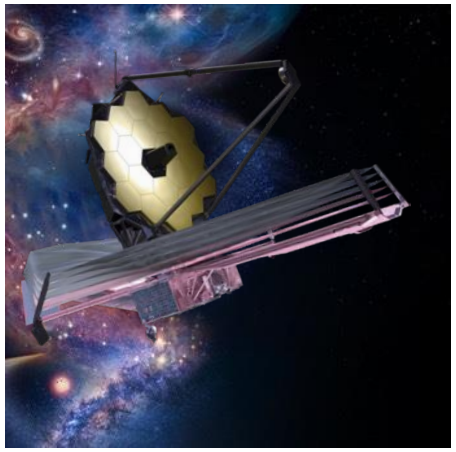
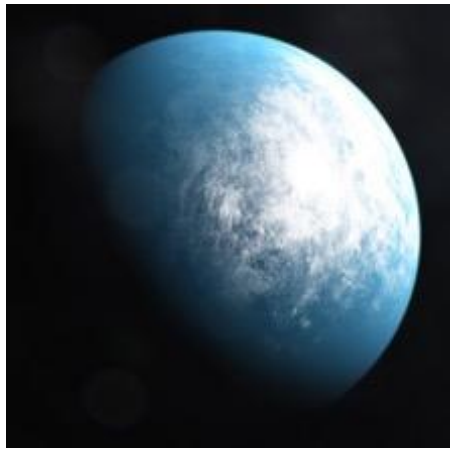
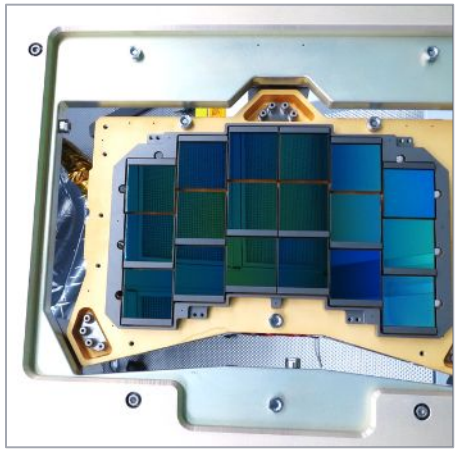
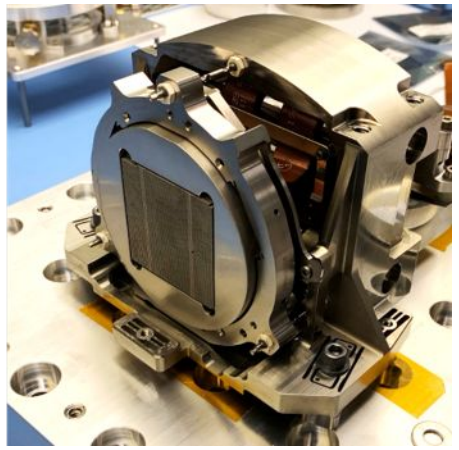
Recommendation	Preliminary response
SOFIA pg. 5-12	• On April 28, NASA and DLR (the German Space Agency) jointly announced that they will conclude the SOFIA mission, after a successful eight years of science • SOFIA will finish out its scheduled operations for the 2022 fiscal year, followed by an orderly shutdown • See chart later in this presentation
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	• Following a recommendation of the APAC at its Spring 2022 meeting, a Subcommittee has been established • See chart later in this presentation
Explorer Cadence pg. 6-9 (not in Table S.1)	• NASA has maintained a cadence of Astrophysics Explorer AOs every 30 months (4 per decade) since 2011

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 • NASA is initiating a Great Observatories Mission and Technology Maturation Program (GOMAP) to implement lessons learned, best practices, and Astro2020 recommendations leading to the development of Future Great Observatories
IROUV Great Observatory pg. 7-17	• NASA will undertake a three-stage GOMAP leading to a future decision to begin formulation of NASA's next great observatory; the first stage has already been initiated
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 • See presentation by Valerie Connaughton on Day 2 of this meeting
Astrophysics Probes pg. 7-20	• NASA issued a second community announcement on May 19, 2022, with details regarding a planned AO for an Astrophysics Probe mission • An Astrophysics Probe AO is planned for July 2023
Roman Sci Prog 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
LISA Success pg. 7-37 (not in Table S.1)	• NASA is a strong partner to ESA in the development and operation of LISA

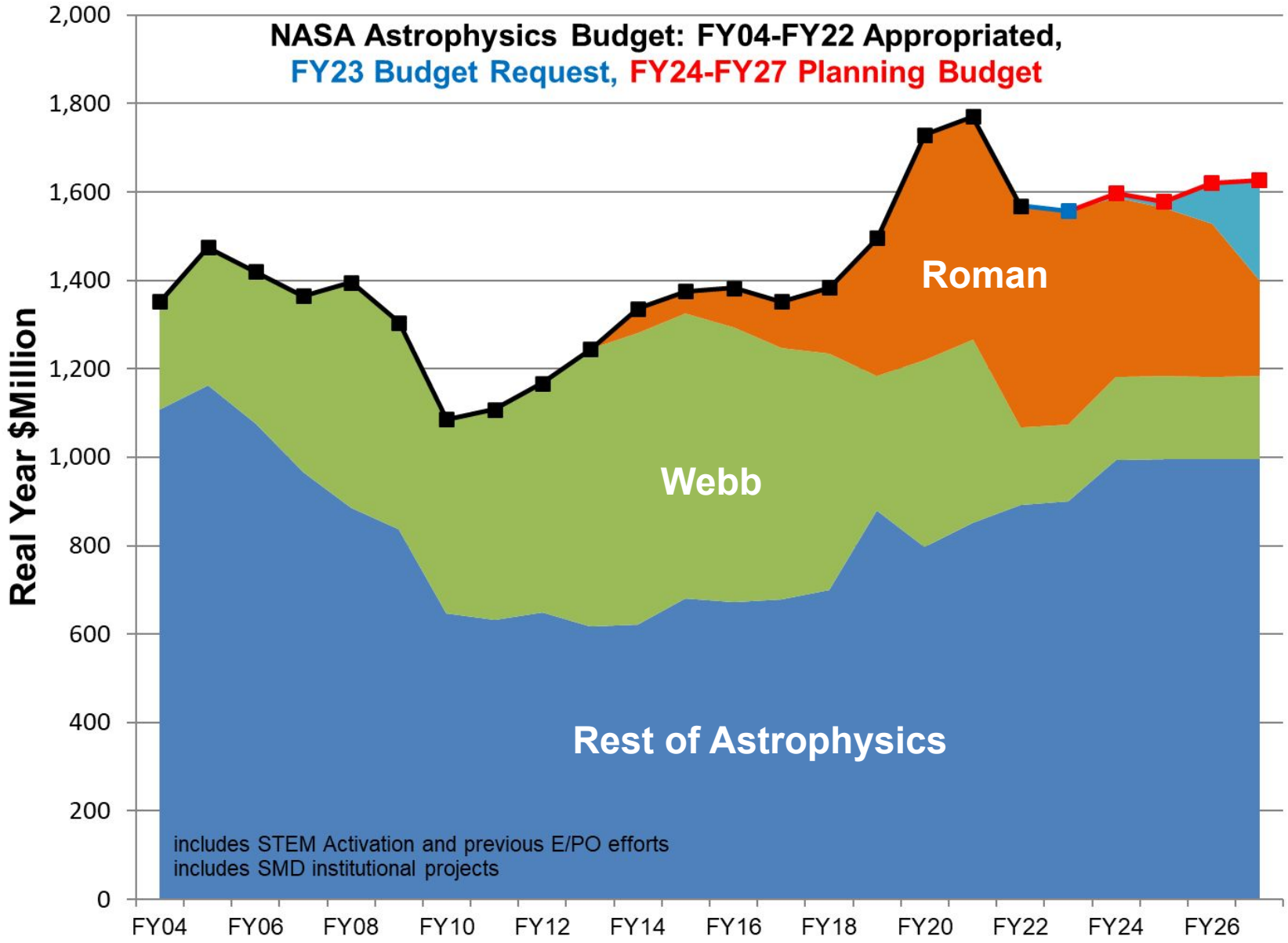
FY23 Budget Update

Planned Milestones FY22-23

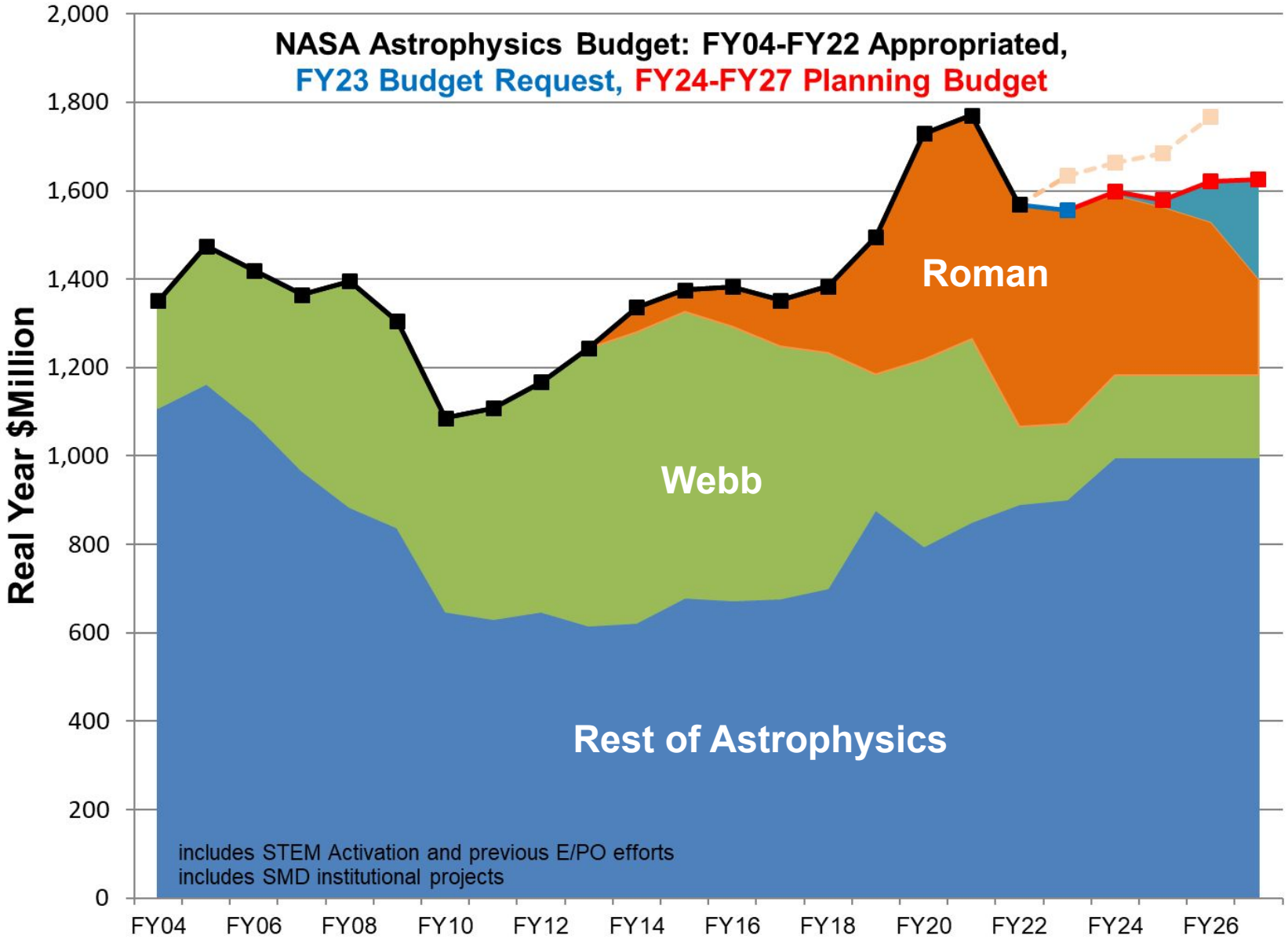
- ✔ Conduct Senior Review of Operating Missions in FY 2022
- ✔ Initiate Webb Telescope science in FY 2022
- ✔ Conduct sounding rocket campaign in Australia in FY 2022
  - Select MIDEX missions for competitive Phase A studies in FY 2022
- ✔ Conduct four scientific balloon campaigns in FY 2022 and four campaigns in FY 2023
  - Release Astrophysics Probe AO in FY 2023
  - Select Webb Cycle 2 science observations in FY 2023
  - Begin integration and test of the Roman Space Telescope instruments and telescope 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

FY23 President's Budget Request



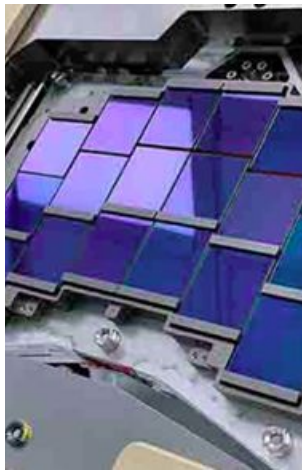
Decadal Survey Wedge

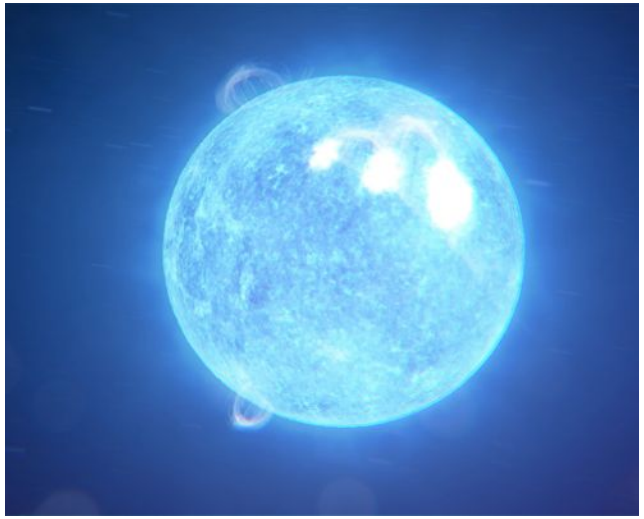
FY23 President's Budget Request



Decadal Survey Wedge

Astrophysics FY23 Budget Features





Increased funding planned compared to a year ago

- Additional Webb General Observer funding
- Roman adjusted for 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

Same funding planned compared to a year ago

- Healthy 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
- Funded operating missions per Senior Review

Decreased funding planned compared to a year ago

- 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
- Delayed implementation of Decadal Survey recommendations

FY23 Congressional Markups

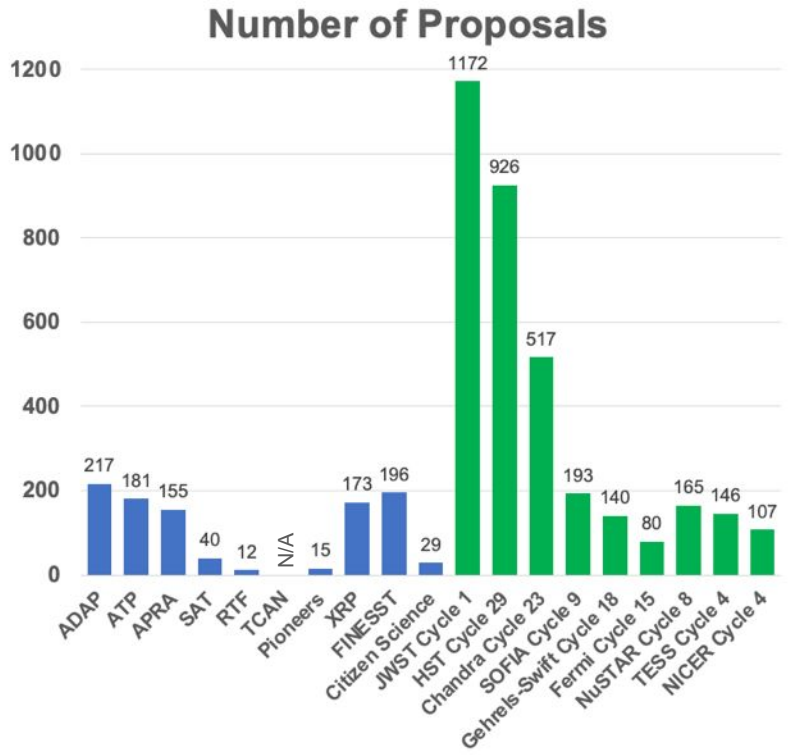
$M	FY23 PBR	FY23 House	FY23 Senate	Comments
Astrophysics	1,556.0	1,525.0		$31M reduction to top line
Explorer Futures	23.9	23.9		Compete Probe in 2023
Hubble	93.3	93.3		
Webb	172.5	172.5		
Roman	482.2	482.2		Develop Roman before investing heavily in Decadal Survey recommendations
SOFIA	10.0	30.0		Concerned about NASA's decision; 30-day report on mitigating loss to science and on closeout plans
Rest of Astrophysics	774.1	723.1		$51M undistributed reduction

Selected Program Updates

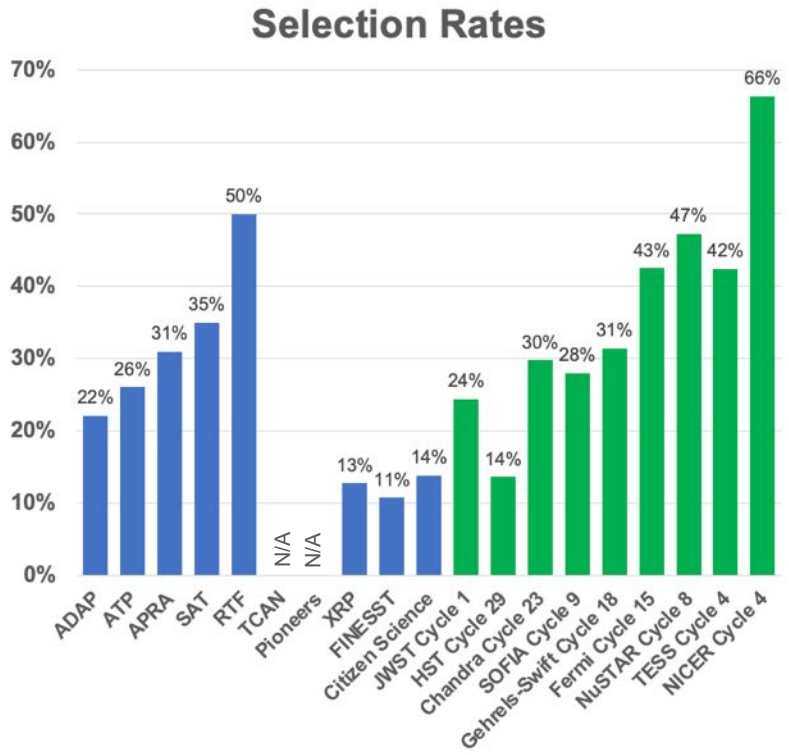
For a more complete Program Update, see the
NASA Town Hall at the June 2022 AAS Meeting
Charts at https://science.nasa.gov/astrophysics/documents
Recording at https://aas.org (requires registration)

Astrophysics R&A Selection Rates

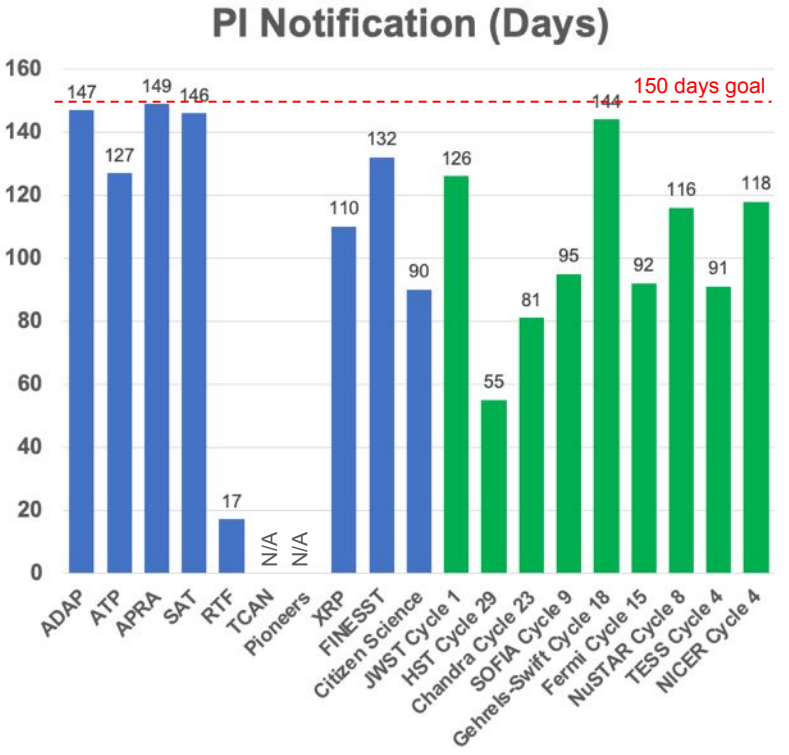
June 2021-2022



R&A: 1,018 proposals
GO/GI: 3,446 proposals
Total: 4,464 proposals

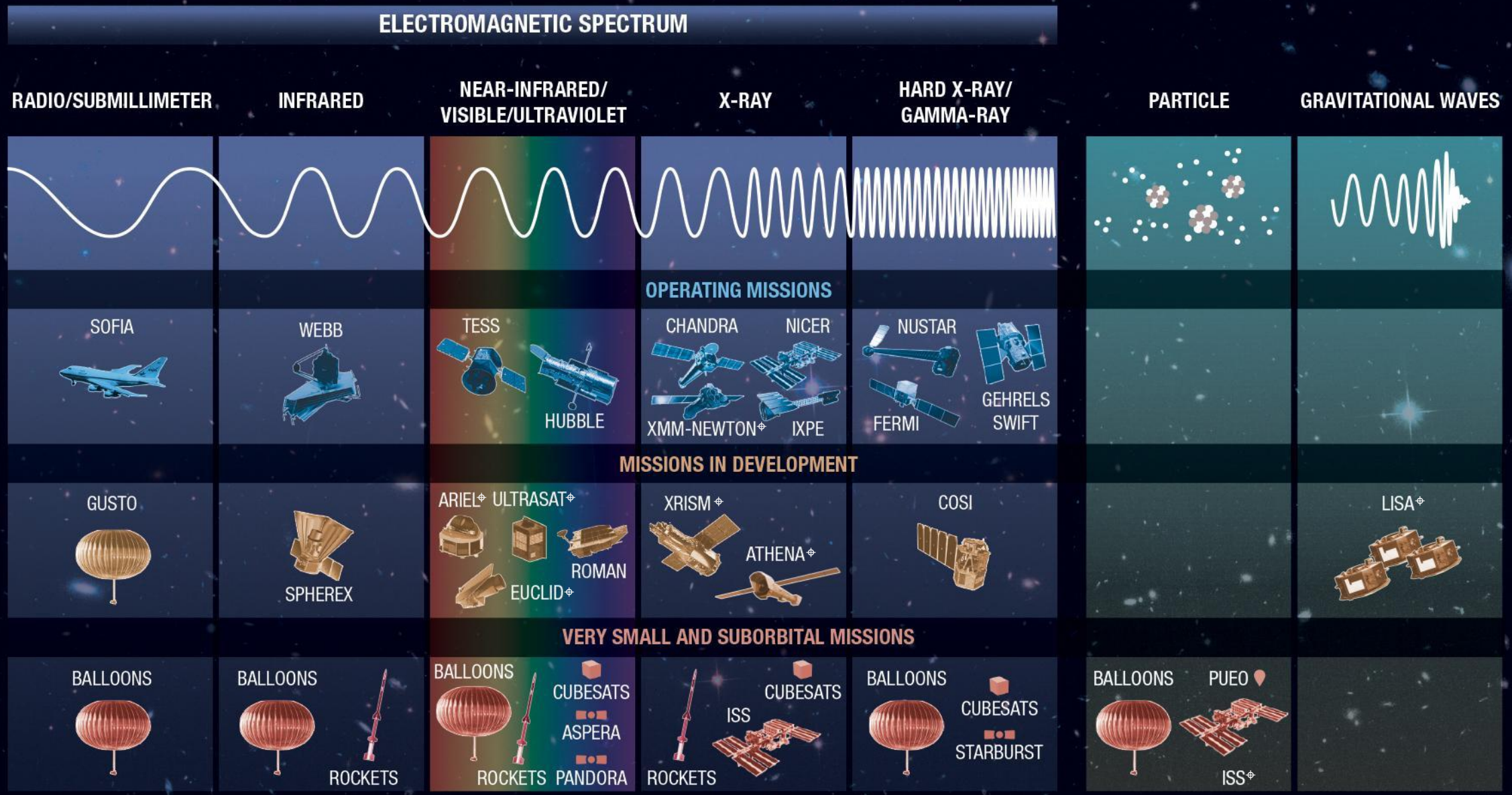


R&A: 20%
GO/GI: 27%
Average: 25%



80% of PI notification:
R&A: 147 days
GO/GI: 122 days

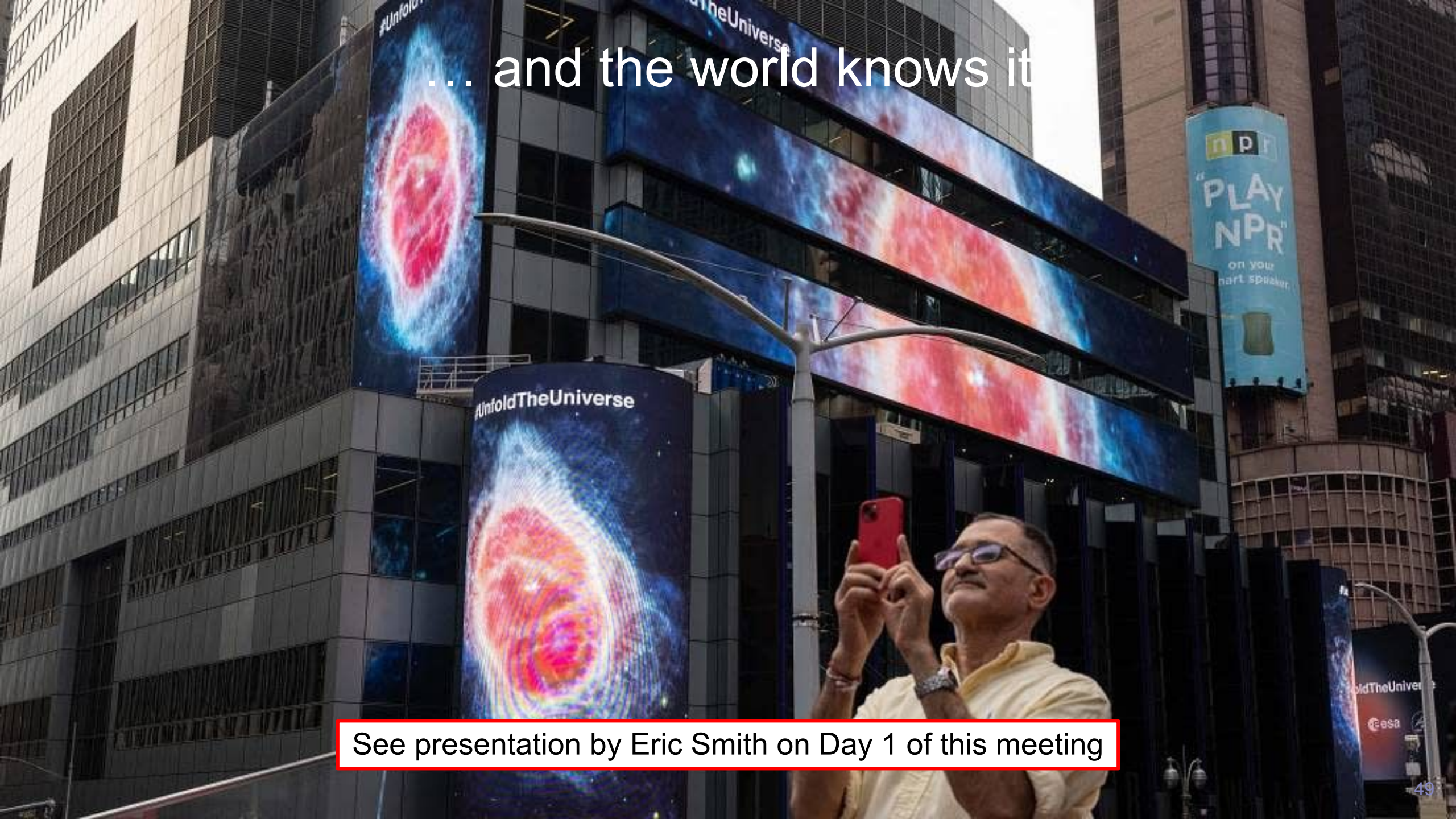
* Only programs with selections made and PIs notified


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
ISS
CUBESATS
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

JWST has begun normal science operations …

See presentation by Eric Smith on Day 1 of this meeting

… and the world knows it



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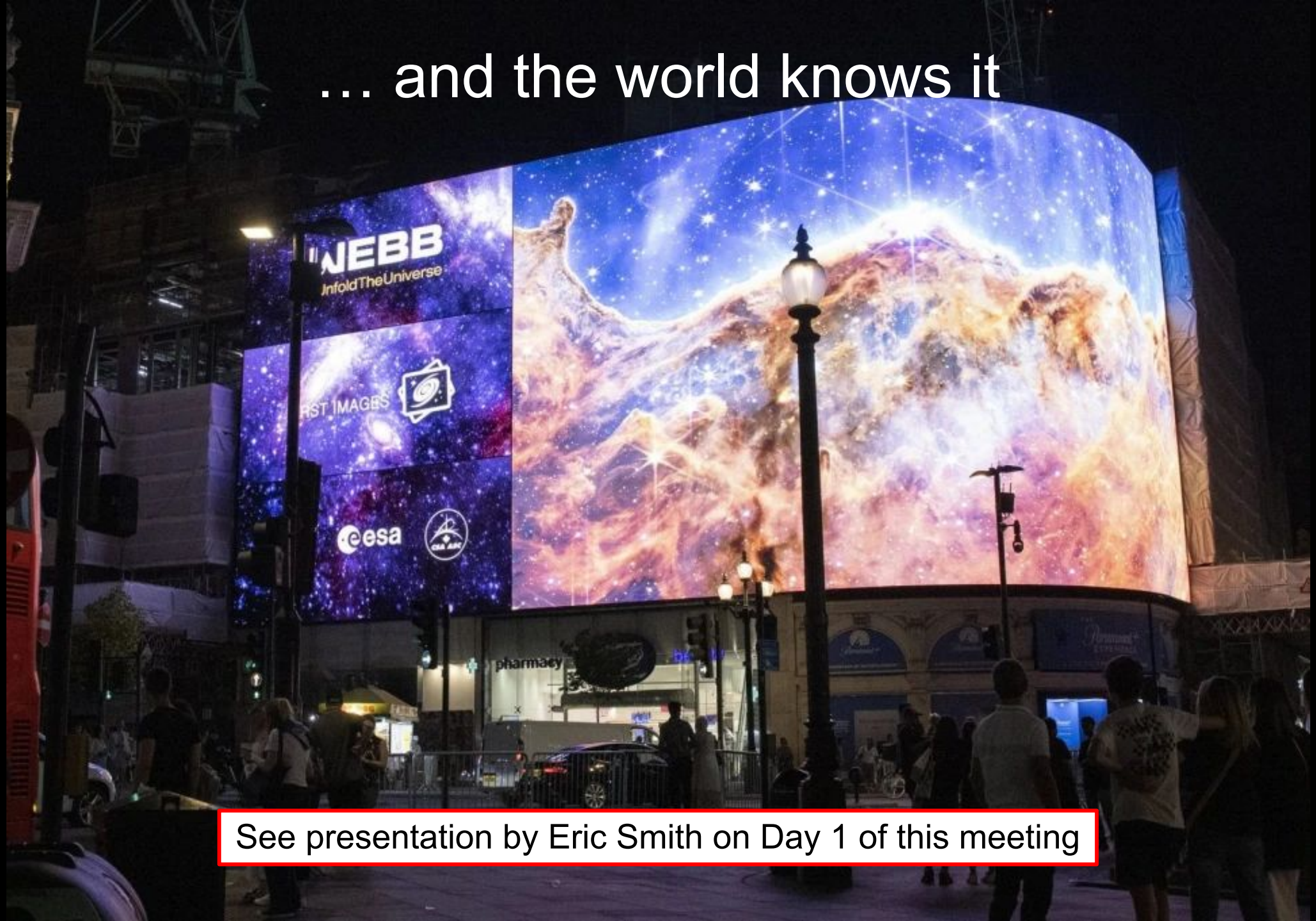


See presentation by Eric Smith on Day 1 of this meeting

NANCY GRACE ROMAN SPACE TELESCOPE

All major flight hardware procurements complete; substantial flight hardware completed – Heritage Telescope completion expected late 2022. Transitioning to assembly & test: Coronagraph late 2022; Wide Field Instrument early 2023; Spacecraft late 2023. Launch Vehicle selection imminent.

NASA launch commitment date remains May 2027.

NASA has asked the CAA to conduct a non-advocate review of the Roman Space Telescope science program and observing plan, as per Astro2020.

Opportunities for participation in Roman Space Telescope research and support are offered in ROSES-2022

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

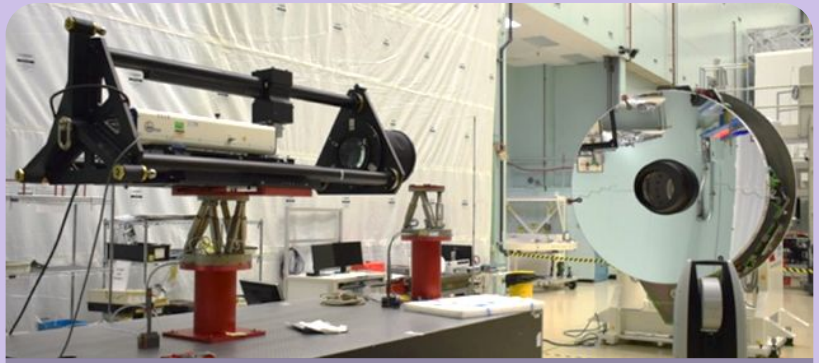
See presentation by Julie McEnery on Day 2 of this meeting

NANCY GRACE ROMAN SPACE TELESCOPE

Optical Telescope Assembly Hardware

Tertiary Optical Mirror Assembly

Secondary Mirror Support Tube

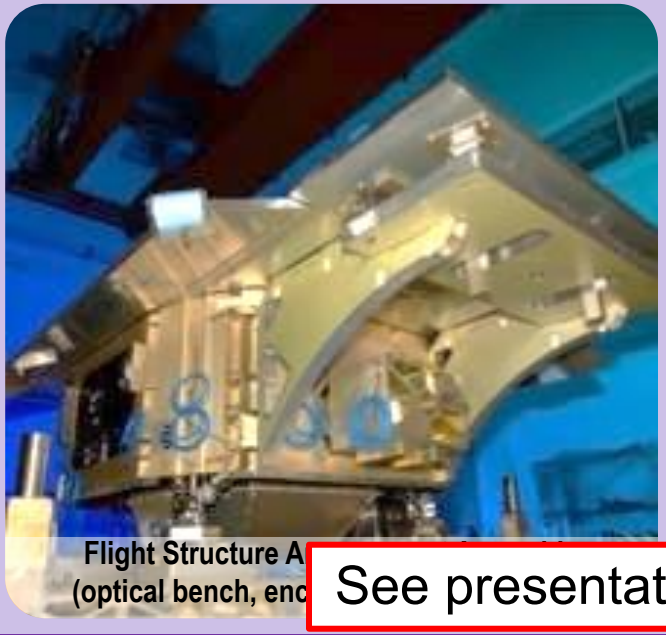


Primary Mirror horizontal optical test

Forward Metering Shell w/thermal control hardware installed

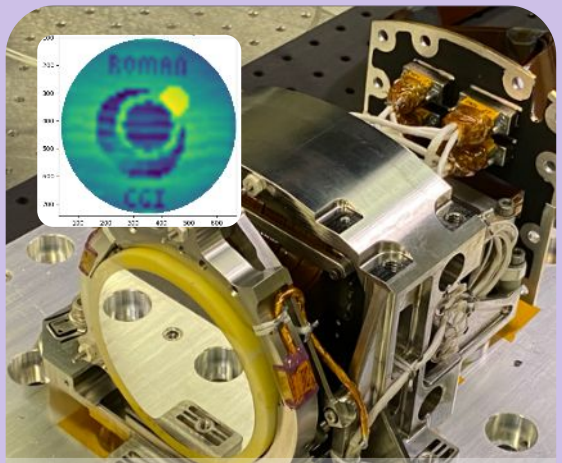
Wide Field Instrument Hardware

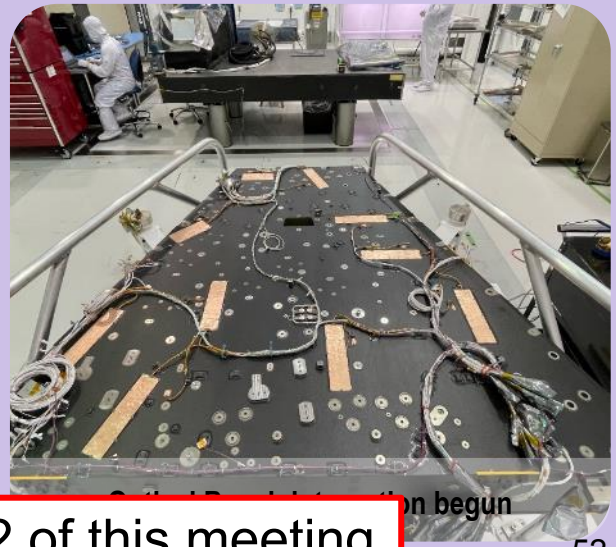
Flight Element Wheel Assembly completed; done thermal vac test



Flight Structure A
(optical bench, enc

Coronagraph Instrument Technology Demonstration Hardware





n begun

See presentation by Julie McEnery on Day 2 of this meeting

SOFIA

The Decadal Survey 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.

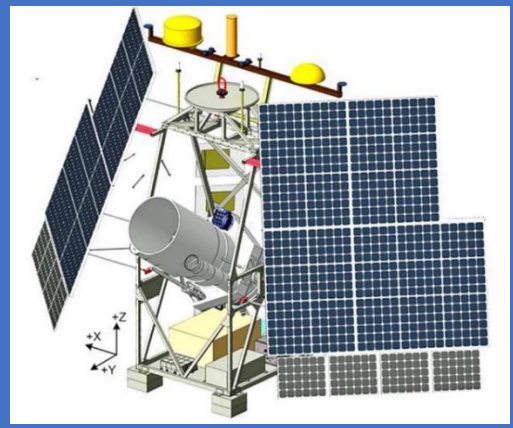
Airborne Astronomy Ambassadors (AAA), the SOFIA teachers-in-flight program, will continue to operate during FY 2022.

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. The closeout plan will include processing and archiving all SOFIA data at IRSA.

Discussions have begun regarding disposition of Government property associated with SOFIA.

GUSTO Mission Overview

Science Description	
GUSTO will provide the first complete study of 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 Magellanic Cloud.	**Mission Phase:** C **Launch Date:** 12/2023 **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 (UA)	**Partners:** • Principle Investigator: Christopher Walker (UA) • Project Management: JHU/APL • Payload: UA • Gondola: JHU/APL • Mission Ops: JHU/APL • Science Ops: UA

GUSTO Update & Path Forward

GUSTO removed from the 2022/2023 NASA Antarctic Long Duration Balloon (LDB) Campaign due to a launch readiness schedule breach by the GUSTO payload team.

The GUSTO Project directed to present a delayed launch plan to NASA that includes a credible schedule, test plan, and a minimum budget that would result in a completed observatory fully capable of producing robust science return

The NASA SMD Astrophysics Division conducted a Continuation/Termination Review on May 19, 2022, to assess the GUSTO Project's replan and request to receive an additional one-year extension to the 2023/2024 NASA Antarctica LDB Campaign

Decision: The GUSTO Project was approved for an extension provided critical launch readiness milestones are met:

1. Complete the GUSTO payload and meet the success criteria for an instrument TVAC Pre-Ship Review in early August 2022;
2. Conduct the instrument TVAC test and pass the instrument TVAC Review based on criteria set by the GUSTO SRB/IRT in August 2022; failure to meet and pass these milestones will result in mission termination.
3. The GUSTO Team will plan to integrate the completed payload and telescope before the planned storage period and will use air shipment to deliver the complete, integrated observatory to Antarctica in 2023.

GUSTO Path Forward/Progress

Resolution of problems with the payload optical bands – B1, B2, and B3 has progressed very well since the C/T Review (May 19, 2022)

- Sensitivity and stability of B1 and B2 has improved with rebuild of LO mirrors and optical alignment adjustments that reduced “cross-talk”; pixels identified out of the 16 total available that reduce “cross-talk” and support measurements
- B1/B2 currently meet Level 1 threshold science requirements, with some margin, in a 50 days of a planned 75-day mission
- B1/B2 configurations are being “frozen” for flight
- B3 stabilization is currently “functional”; 7 of 8 pixels have been pumped; L1/L2 lenses being remanufactured to improve telescope coupling
- B3 performance to meet Level 1 threshold + margin science requirements will be tested by the end of July to truly know/understand actual functionality

Schedule: GUSTO team on track to meet Aug. 8 Pre-Ship Review (PSR) and begin TVAC; will conduct TVAC and TVAC Success Review in August at CSBF (Palestine, TX)

Review of Balloon Program

Balloon Program Independent Review Subcommittee (BPIRS) of the Astrophysics Advisory Committee (APAC) has been established

NASA will use the findings from this Review to assess the funding and mission model of the Balloon Program. NASA will also use the findings from this Review to:

- Define an implementation approach and mission model to achieve SMD science goals and astrophysics strategic objectives;
- Prioritize the activities of the Balloon Program to maximize flight rates and science return;
- Leverage the capabilities of commercial suborbital platform and system providers; and
- Issue initial funding guidelines for the Balloon Project and payload development programs including the suborbital investigations elements within the APRA program.

The Subcommittee will prepare a report that includes findings and recommendations to assist the Astrophysics Division implement a more effective Balloon Program:

- Prioritized list of balloon technologies/capabilities needed to enable science investigations and technology maturations for future missions;
- Prioritized list of launch site requirements and what constitutes a healthy campaign cadence and expected number of launches per campaign;
- For the Astrophysics Research and Analysis Program, a healthy number of balloon investigations and notional funding profiles;
- Capabilities of commercial suborbital flight providers and efficiency gains to be leveraged; and
- Ways to reduce barriers to entry, particularly for new PIs and new (to the Balloon Program) organizations, including underrepresented people and organizations.

Report due in 18 months

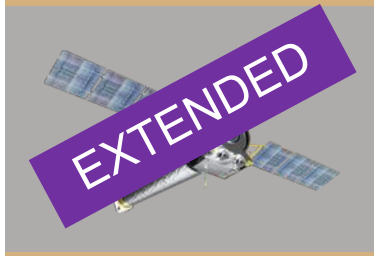
Next steps: Appoint Chair, appoint members as SGEs, establish first meeting

Astrophysics Missions in Operations Outcome of Senior Review

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

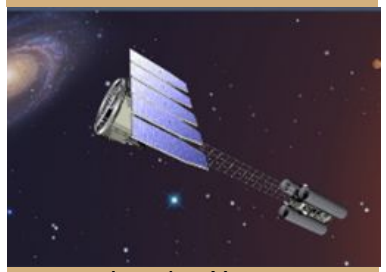
ISS-NICER 6/17
NASA Explorers Miss. of Oppty

Neutron Star Interior Composition Explorer

TESS 4/18
NASA MIDEX Mission

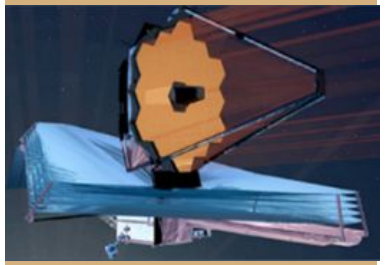
Transiting Exoplanet Survey Satellite

IXPE 12/21
NASA SMEX Mission



Imaging X-ray Polarimetry Explorer

Webb 12/21
NASA Strategic Mission

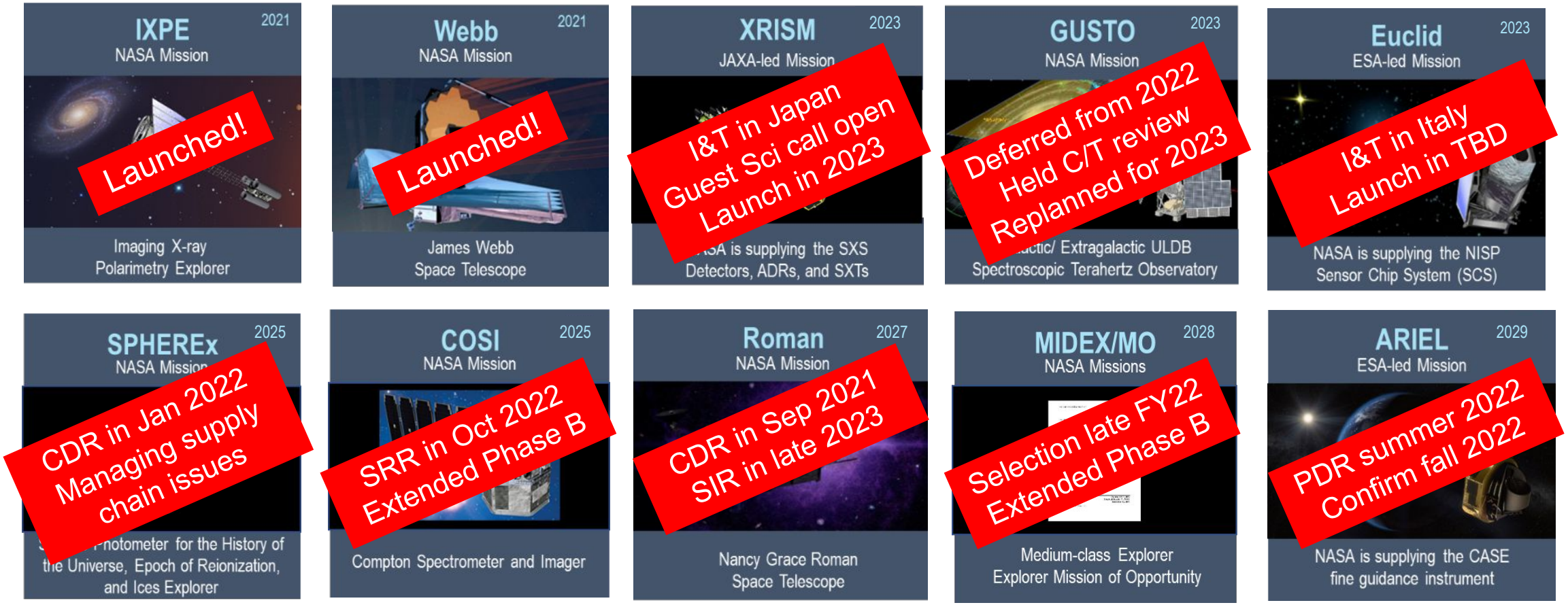


James Webb Space Telescope

Balloon Program
Four Campaigns per Year

Managed by the Astrophysics Division

Astrophysics Missions in Development

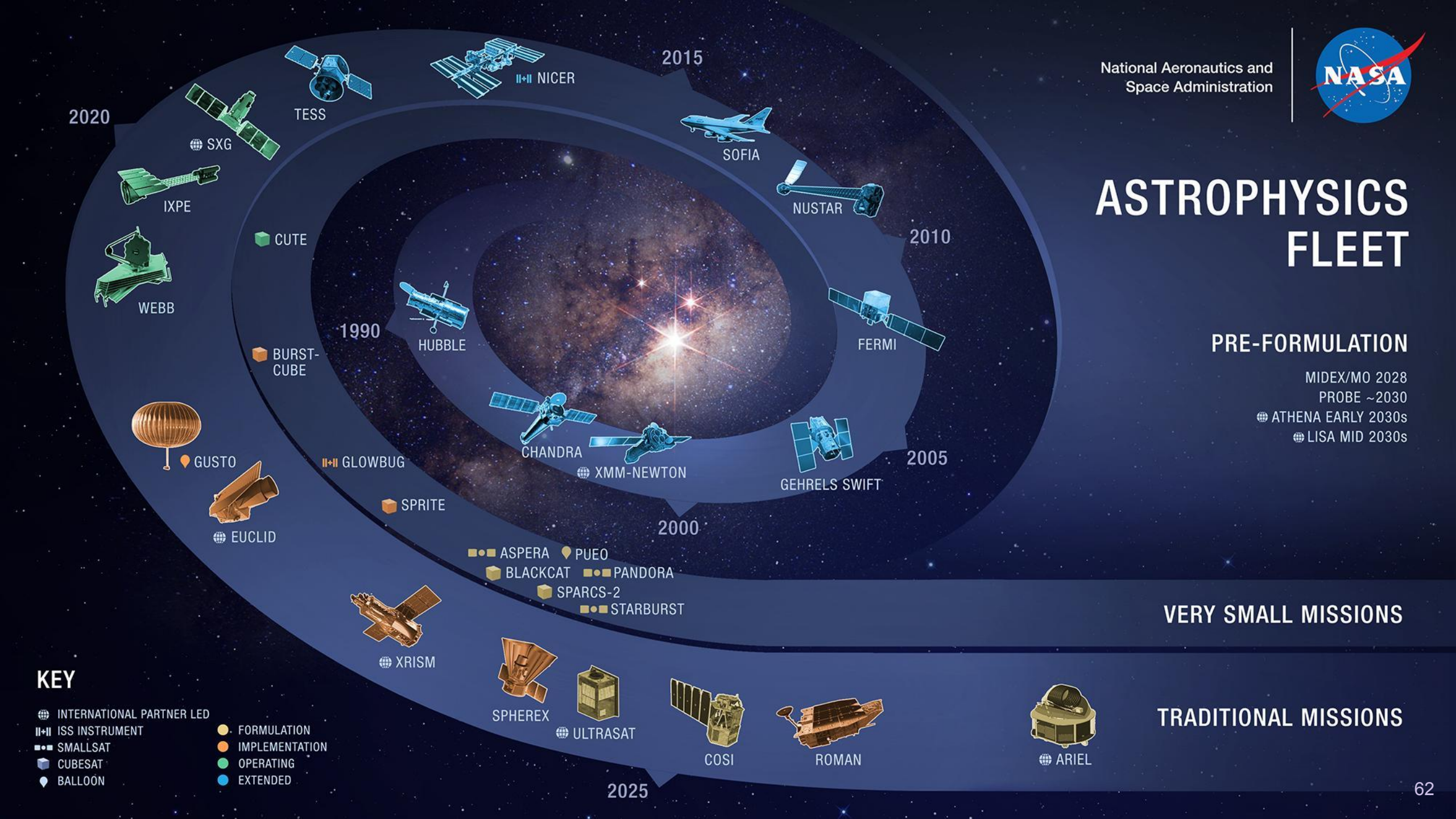


Launch dates are current project working dates through XRISM; Agency Baseline Commitment launch date could be later

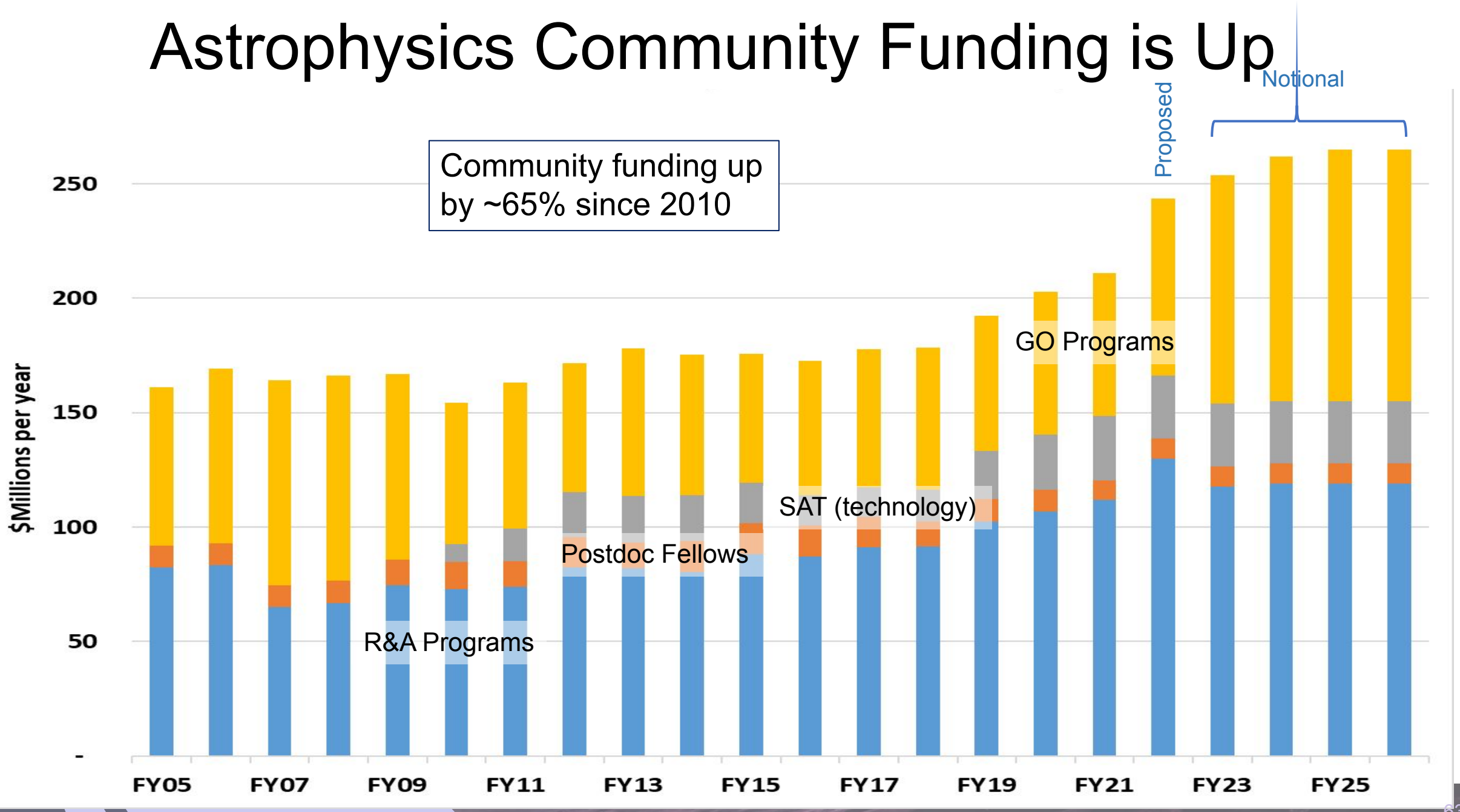
Does not include Pioneers or CubeSats

Big Finish

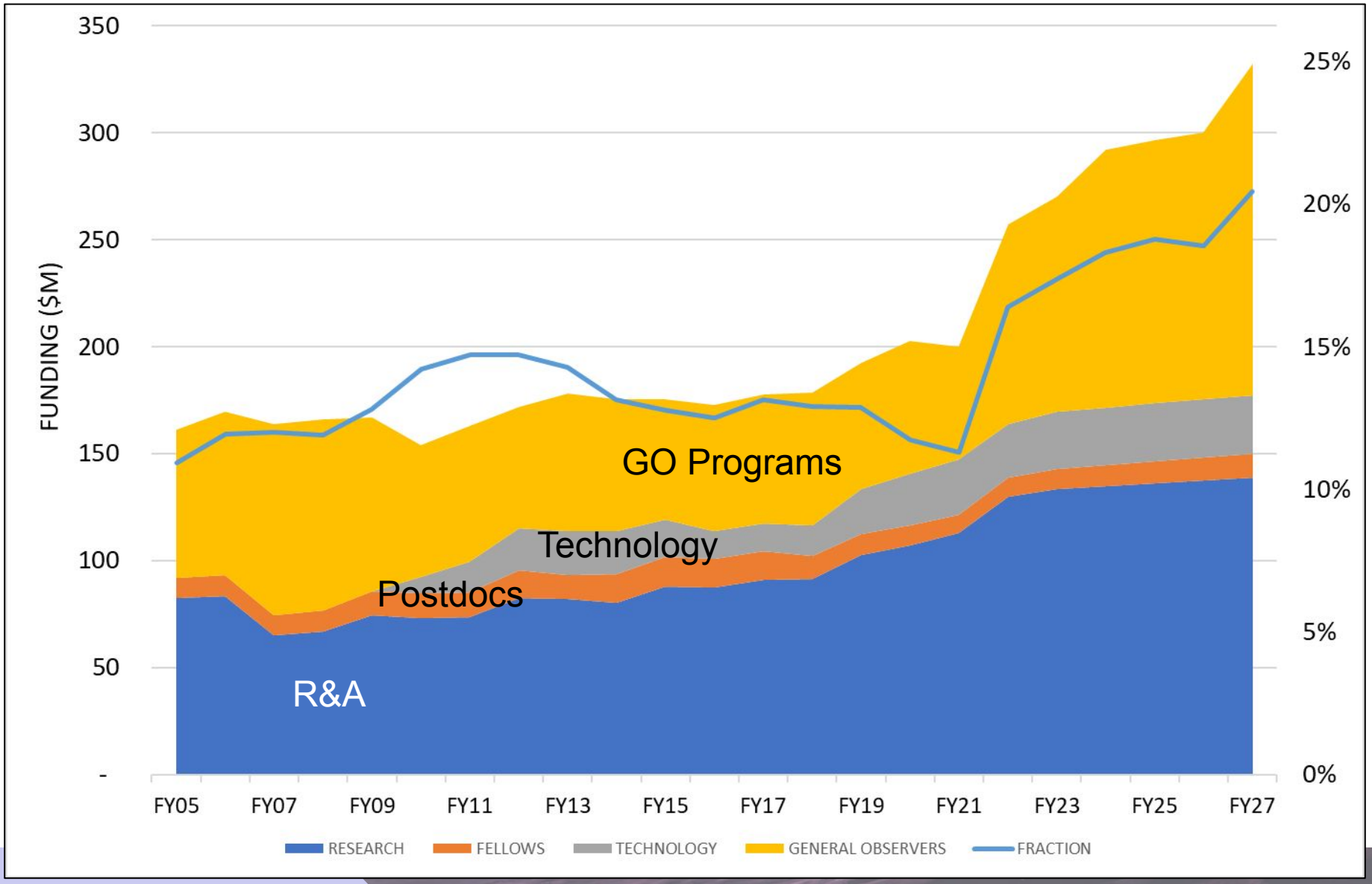
Big Finish
to Paul's Last Update to the APAC


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

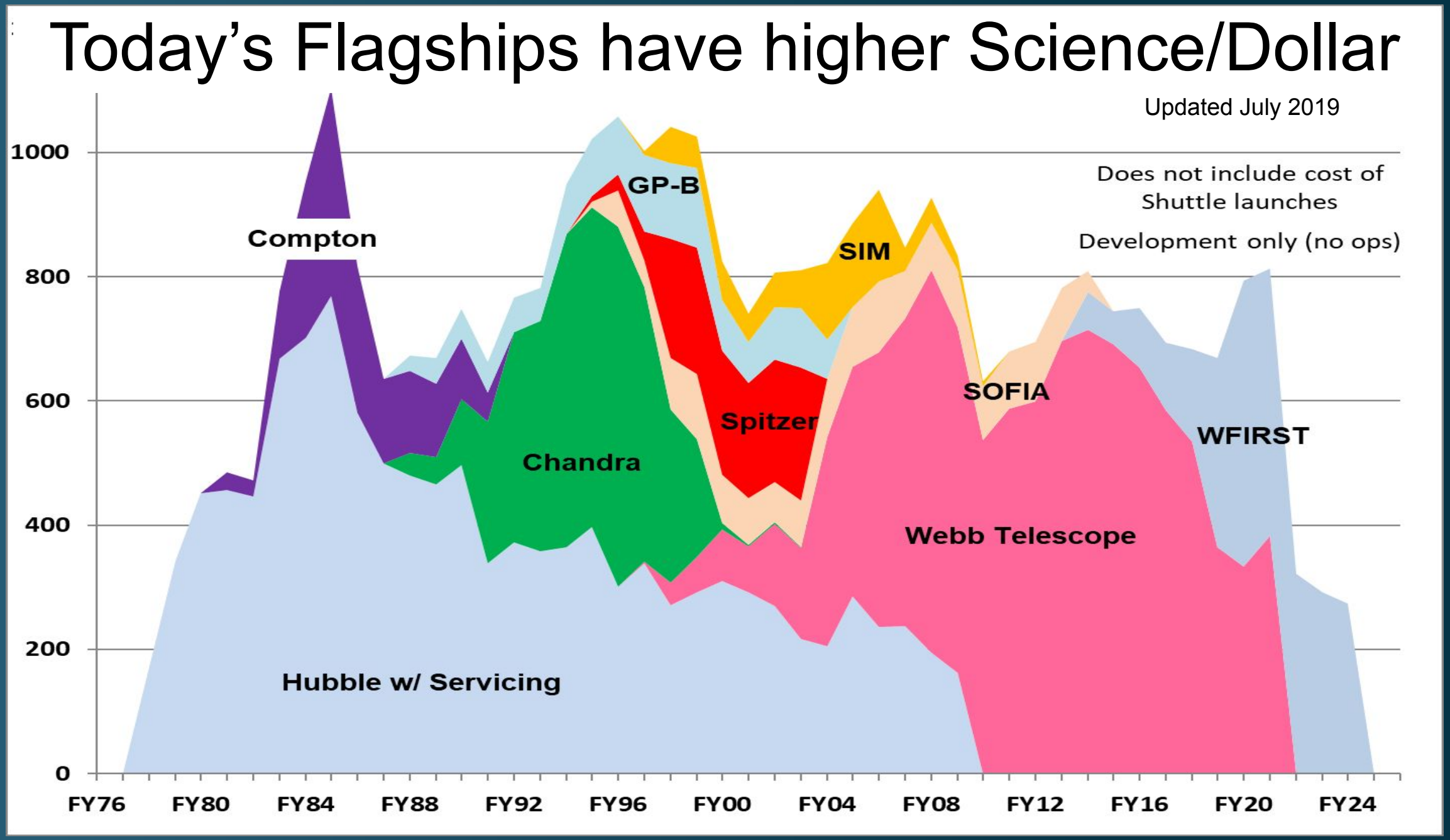
Astrophysics Community Funding is Up



Community Funding / Fraction of Budget



Today's Flagships have higher Science/Dollar



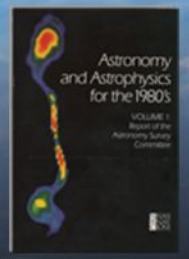
Decadal Survey Goal

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

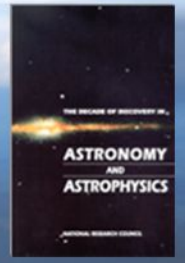
Astrophysics

Decadal Survey Missions

1972
Decadal Survey
Hubble



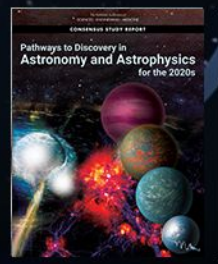
1982
Decadal Survey
Chandra



1991
Decadal Survey
Spitzer

2001
Decadal Survey
Webb

2010
Decadal Survey
Roman



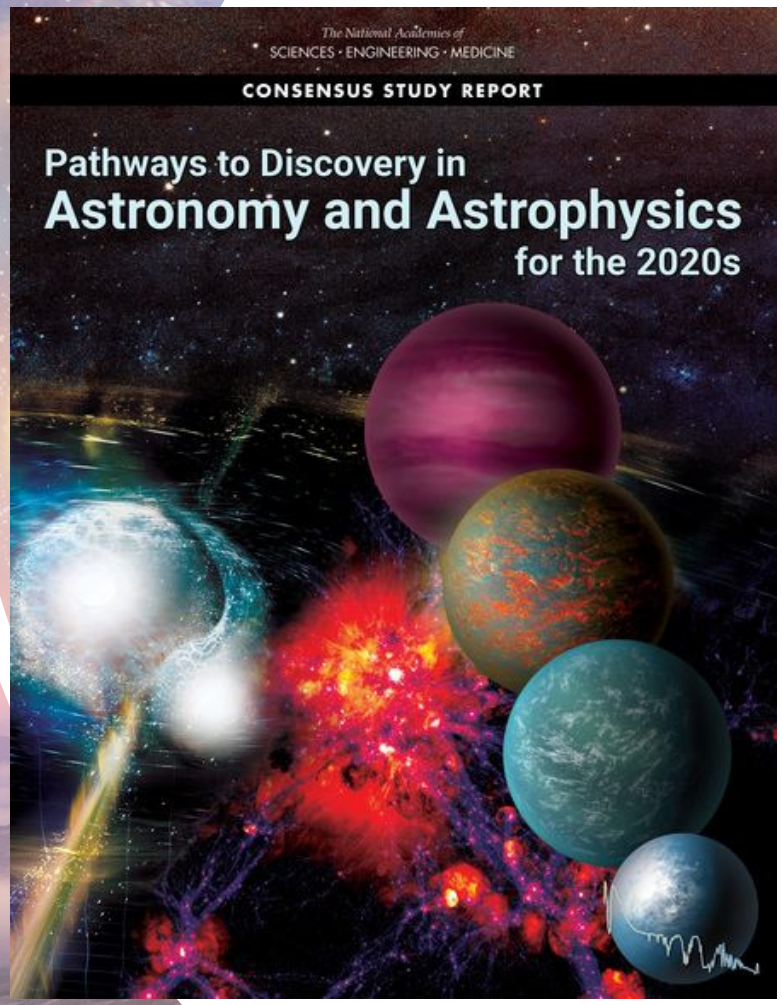
2021
Decadal Survey

PH to Astrophysics Division (2012) – Create the Future

PH to Astro2020 (2019) – Carpe Posterum

PH to everyone (2022) – We got what we asked for!

Carpe Posterum: a How-To Guide



- Every decade has its challenges
- It's time to begin the work of the 2020s!
  - We have an ambitious and inspiring Decadal Survey recommending investments to study the time domain universe, produce the first Astrophysics Probe, and characterize Earth 2.0.
  - We also have a reduced and flattened planning budget.
  - This feels like déjà vu all over again.
- Astrophysics holds a key position in our culture
  - It is one of the most accessible sciences, is generally apolitical, and inspires people the world over.
  - The U.S. is the world leader in space astrophysics
- The goals of the 2020s will take the hard work that it took to realize the dreams of previous decades and Decadal Surveys:
  - Unity of purpose for Decadal Survey priorities
  - Leverage all the diverse talent of the Nation
  - Focus on consistent messages to stakeholders
  - Diligence in controlling scope creep
  - Innovation in science, technology, and architecture
  - An "All of Humankind" approach

Carpe Posterum

BACKUP

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

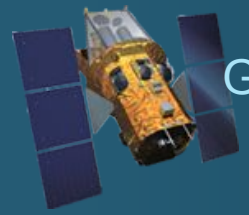
Astrophysics Science Program Content ($M)

	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 Technology 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 FY21	Enacted FY22	Request FY23	Out-Years 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

Astrophysics Explorers Program

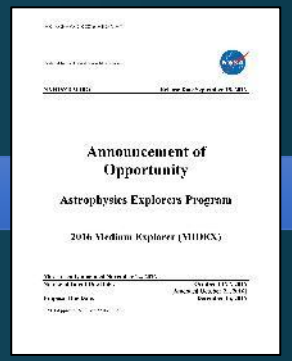

Gehrels
Swift


NuSTAR

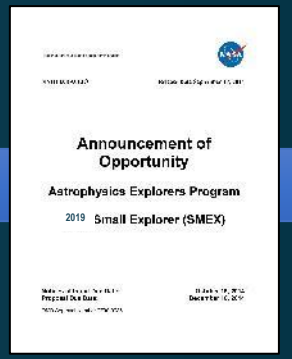
4 AOs per decade

MIDEX
2011

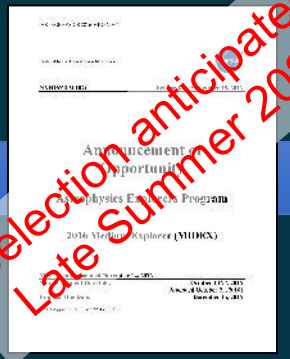
SMEX
2014



MIDEX
2016



SMEX
2019


MIDEX
2021

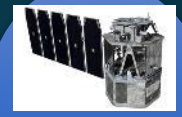
Selection anticipated
Late Summer 2022

Small and
Mid-Size
Missions

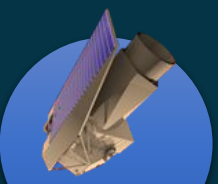

TESS


IXPE

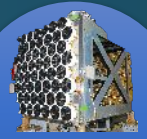

SPHEREx


COSI

Directed
2013


Euclid

Missions of
Opportunity


NICER


GUSTO


ARIEL

Directed
2017


XRISM

XRISM

X-ray Imaging and Spectroscopy Mission

- JAXA, NASA, and ESA partnership
  - XRISM will investigate the X-ray sky using high-resolution spectroscopy and imaging
- NASA *Resolve* and JAXA *Xtend* instruments are integrated with the spacecraft in Japan at NEC
- NASA X-Ray Mirror Assemblies delivered to Japan for optical alignment prior to final integration to the spacecraft in Fall 2022
- Functional tests in 2022 to prepare for JAXA launch in Spring 2023
- XRISM Guest Scientist program for broader US participation in Performance Verification phase through ROSES-22 – proposals due July 21

Photo ©JAXA/NEC

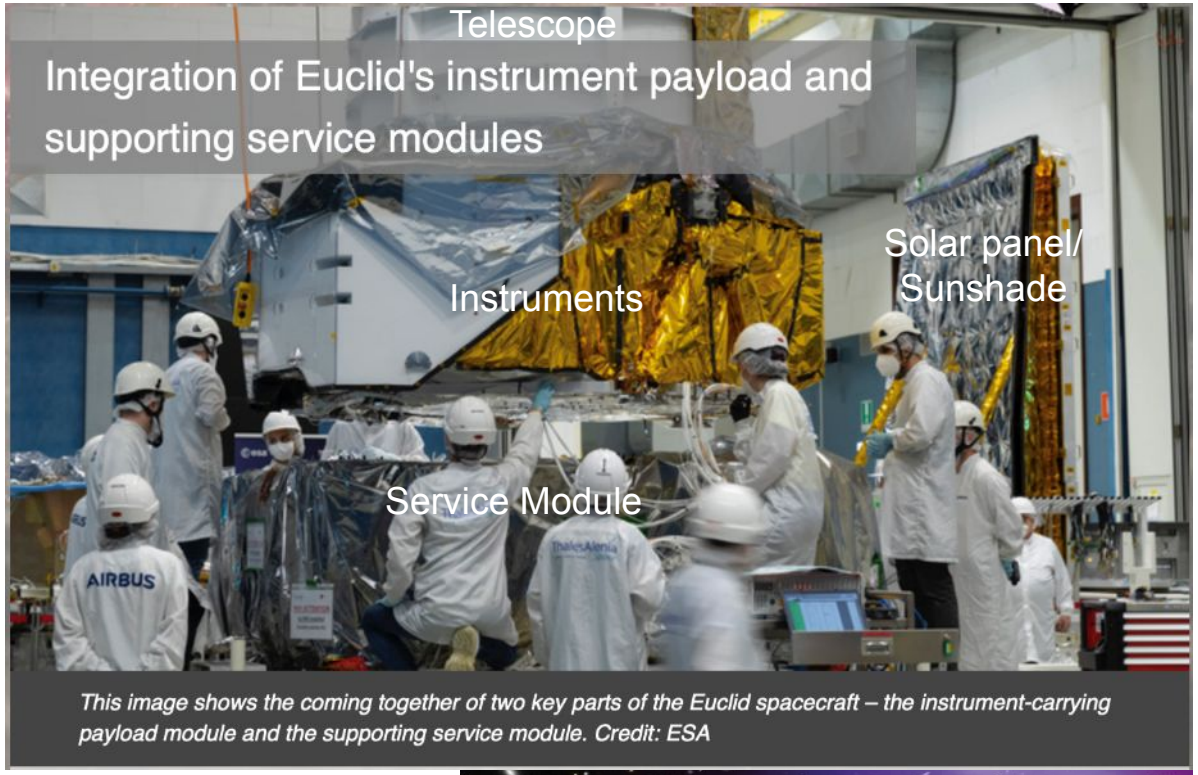
Euclid

ESA and NASA partnership

- Euclid will study the nature of Dark Energy, Dark Matter, and General Theory of Relativity

NASA's contribution:

- Sensor Chip System for the Near Infrared Spectrometer Photometer instrument
- Euclid NASA Science Center at IPAC
- Over 70 US Science Team members



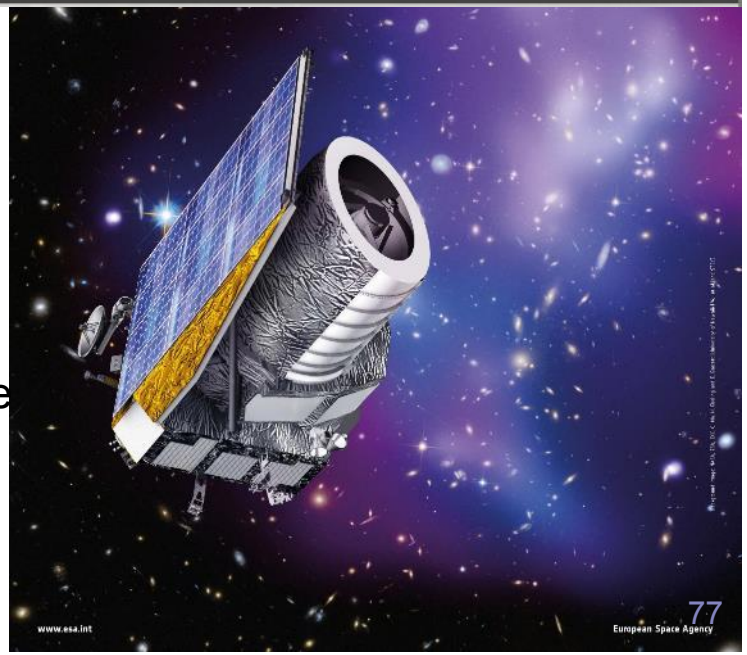
This image shows the coming together of two key parts of the Euclid spacecraft – the instrument-carrying payload module and the supporting service module. Credit: ESA

NASA Status:

- NASA hardware successfully delivered and integrated into NISP
- IPAC science ground segment software deliveries on track
- Three NASA science teams continue science preparation

ESA Status

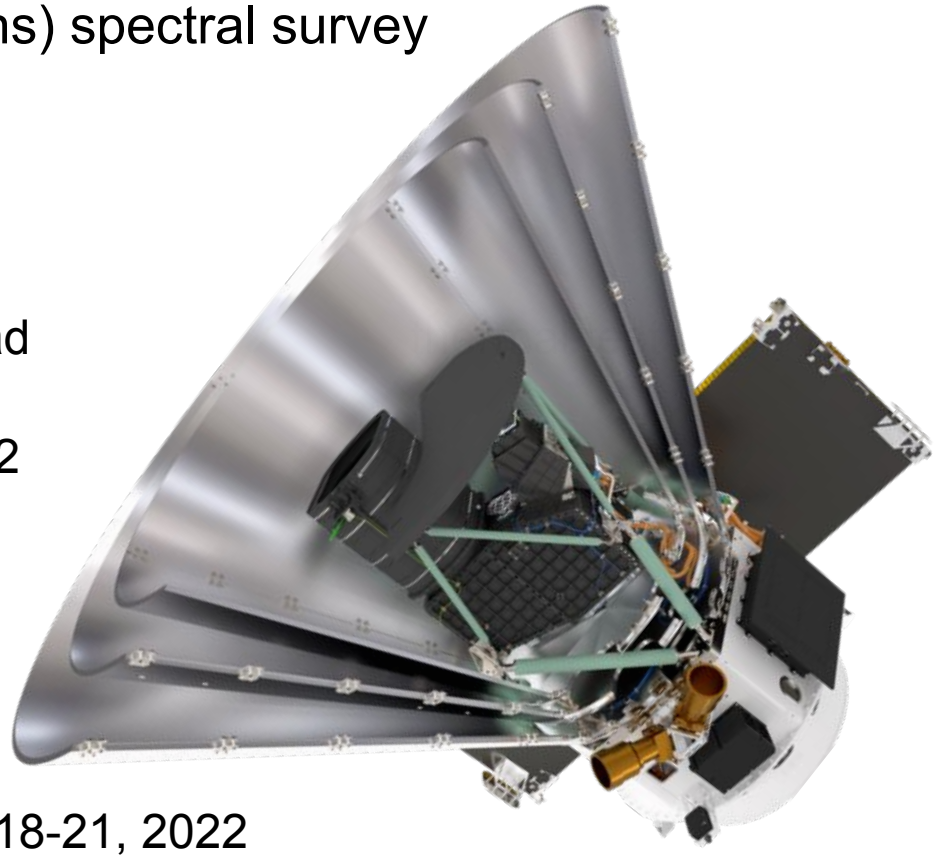
- Instrument-carrying payload module and service module successfully integrated in March 2022 at Thales-Alenia, Italy.
- Additional I&T activities (e.g., solar panels/sunshade) planned through June 2022.
- Launch delays expected
  - Was early-2023 on a Soyuz ST2-1b; Russian cooperation suspended
  - ESA moving towards an Ariane-6 launch with TBD launch date



SPHEREx

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

NASA's first all-sky near-infrared (0.75microns – 5 microns) spectral survey



Status:

- Development of flight detectors completed
- KASI (Korea Astronomy and Space Science Institute) payload chamber delivered to Caltech May 31, 2022
- Payload thermal subsystem delivery planned for August 2022
- Flight telescope delivery planned for February 2023
- Photon shield payload thermal subsystem is in vendor procurement process, with flight hardware delivery planned for July 2023

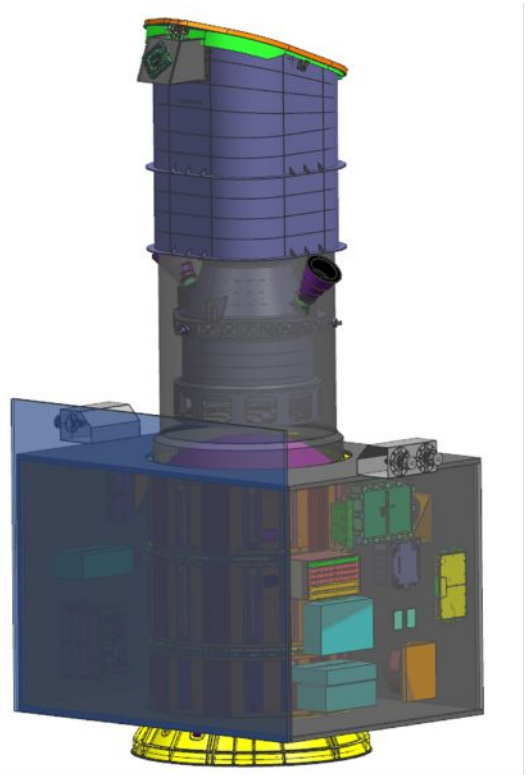
Critical Design Review (CDR) successfully completed January 18-21, 2022

Systems Integration Review (SIR) planned for December 2023

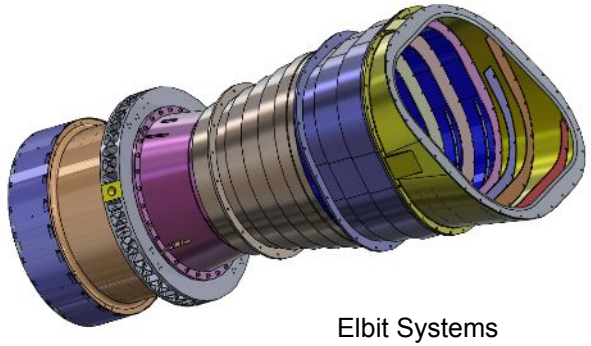
Current Agency launch readiness date is April 2025

ULTRASAT

- ULTRASAT: a wide-field (>200 sq deg) UV survey & transient detection mission will be located at the geostationary orbit. Mission funded by the Israel Space Agency and managed by the Weizmann Institute of Science
  - NASA providing commercial launch ~ June 2025 for a 3-yr prime mission to geo-transfer orbit
  - Data public at IPAC following 12-mo exclusive data use period
  - Public alerts within 20-min of trigger.
- Science: main focus on gravitational wave sources, supernovae, variable and flare stars, and time domain astronomy. Status
  - ULTRASAT mission CDR completed in April 2022
  - NASA-ISA MOU under State Dept review and finalization
  - US Participating Scientist program planned as a ROSES-22 amendment



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

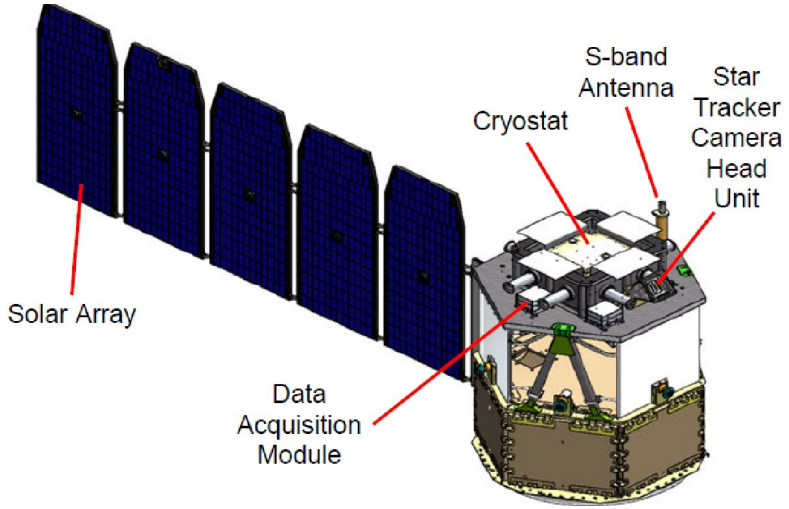
COSI will provide an understanding of the positron excess; map ^{26}Al (half-life 60yr) to study element formation; make the first map of ^{60}Fe (half-life 2.6Myr, only source is core-collapsed SN) to trace past core collapse supernovae; and discover new young supernovae in ^{44}Ti (half-life 0.7Myr).

COSI will gain insight into extreme environments with polarization, such as accreting black holes (AGN and Galactic) and γ-ray bursts (GRBs).

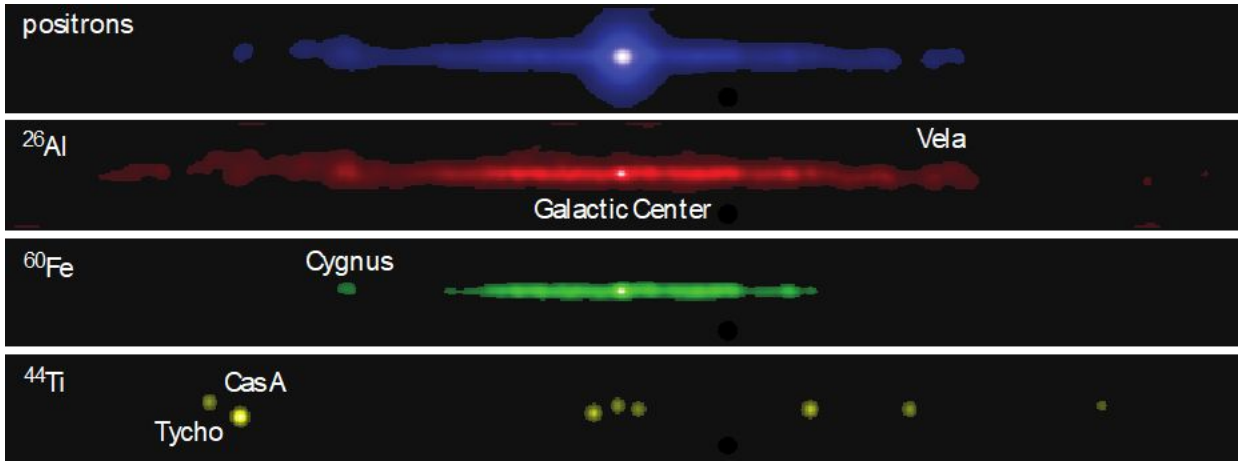
COSI will localize the γ-ray counterparts to GW events (short GRBs) and detect high-energy neutrino counterparts.

System Requirements Review (SRR) currently planned for October 2022.

Launch Readiness Date: Under review.



Simulated Radioactive Milky Way



ARIEL

Atmospheric Remote-sensing Infrared Exoplanet Large survey

ESA and NASA partnership

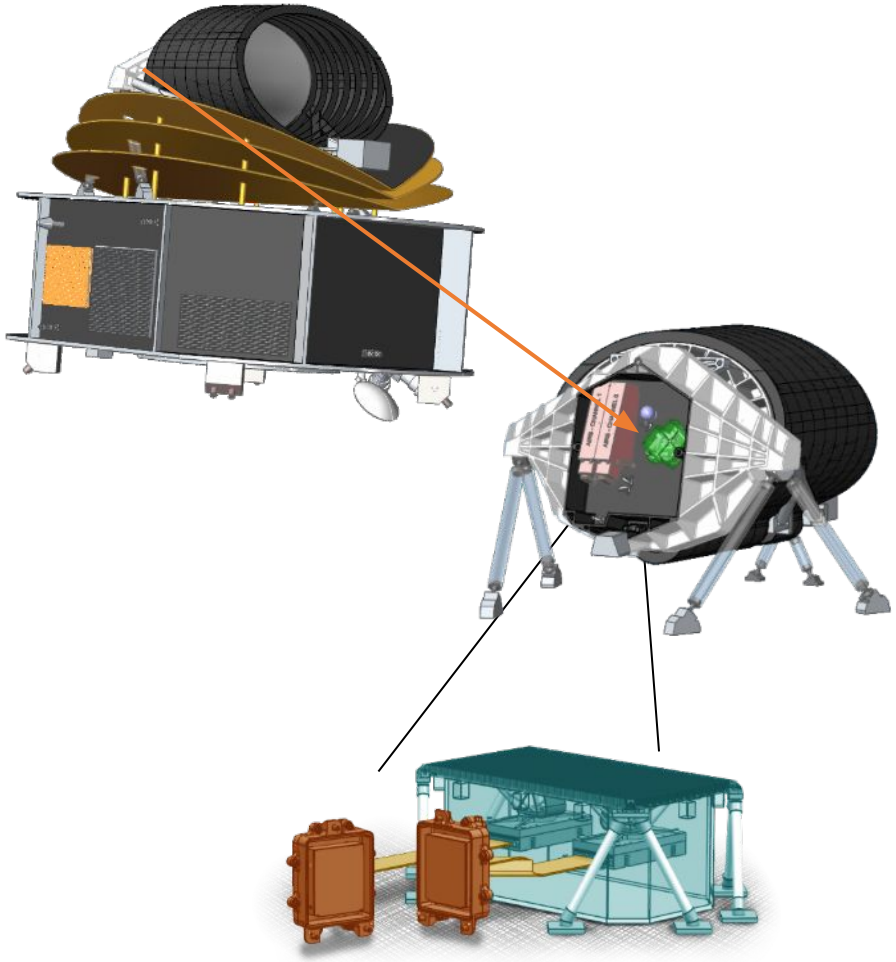
- Observe ~1000 exoplanets
- Survey and characterize exoplanet atmospheres

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 State Dept review
- Summer 2022 – NASA Preliminary Design Review
- ~ Oct 2022 – NASA Confirmation
- Fall 2023 – NASA Critical Design Review
- 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 and determining their physical properties, search for supermassive black holes in the Hot and Energetic Universe

NASA contributions:

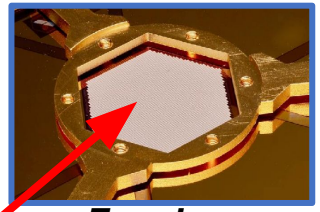
- X-IFU Focal Plane Array (GSFC, NIST-Boulder, LLNL, Stanford, UMBC, UC-Boulder)
- Use of NASA Testing Facilities (MSFC XRCF facility for mirror calibration)
- Vibration Isolation System
- WFI VERITAS ASIC Design and WFI Background Analysis Model
- US Athena Science Center
- Science Grant Program for US Co-Is and Guest Observers

STATUS:

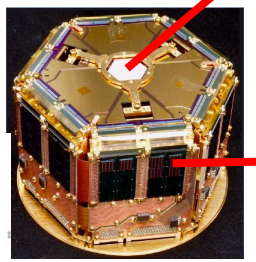
- NASA transitioned from ATHENA study phase to ATHENA project on September 30, 2021. GSFC is the implementing Center
- ESA mission adoption review currently scheduled for June 2024
- Per ESA independent study, mirror will not meet 5” resolution requirement
- ESA presented the study results to the Science Program Committee on June 9, 2022, for further direction
- SPC decided on a replan with a design-to-cost constraint

x 120

Vibration Isolation System



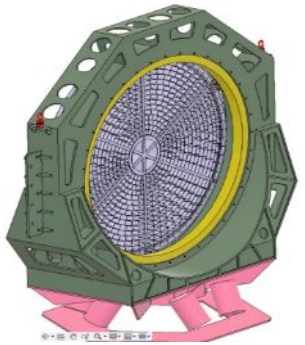
Focal Plane Array



Sensor Assembly

Readout

X-IFU Focal Plane Array



XRCF Mirror Assembly

LISA

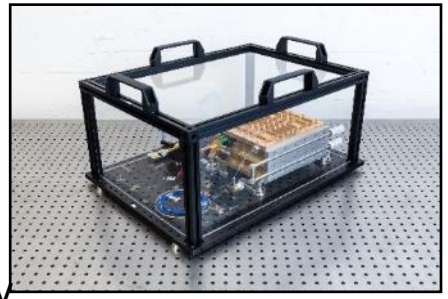
Laser Interferometer Space Antenna

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)
- NASA in pre-Phase A Study and technology development managed by Physics of the Cosmos Program Office at GSFC. Systems engineering & science support from JPL & MSFC.

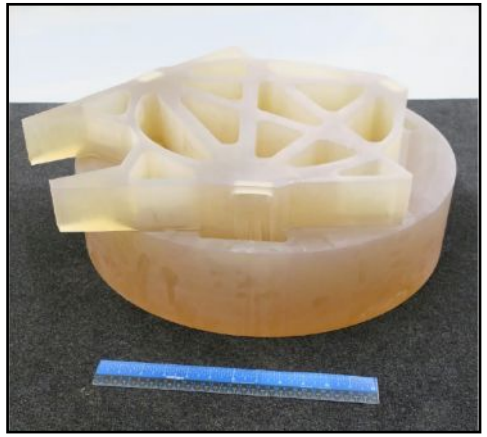


TRL4 laser brassboard

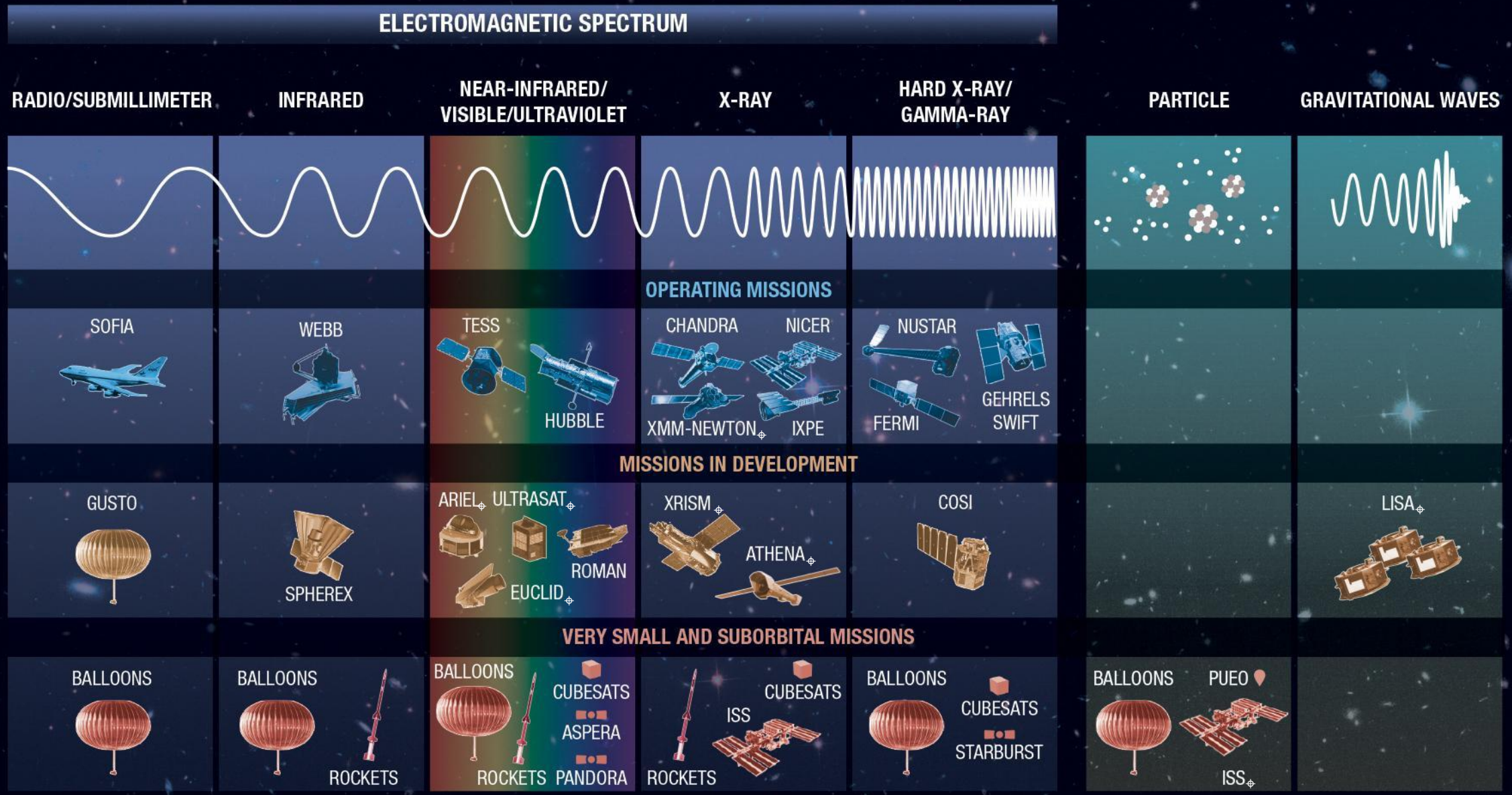
TRL5 Charge Management Unit

STATUS

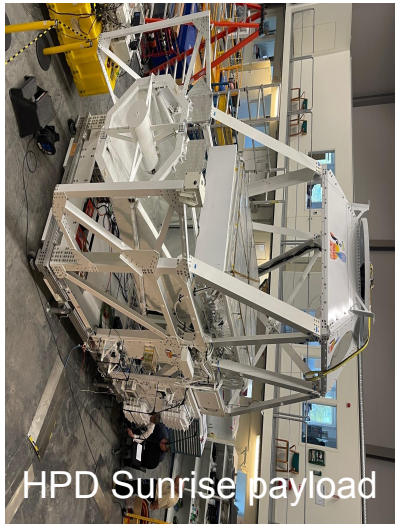
- ESA development in phase B1
- NASA TRL 4/5 laser shipped in 2021 to ESA designated lab (CSEM) Switzerland for performance testing
- Charge Management Device TRL 6 unit under development
- Telescope Engineering model under development at L3Harris
- September 2023 – NASA KDP A
- February 2024 – ESA Mission Adoption
- 2026 – NASA KDP C
- ESA Launch >2035

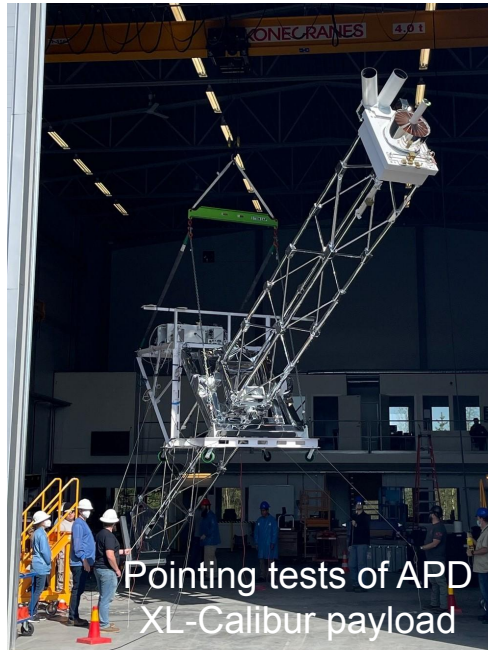


Primary mirror blank for EDU telescope


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
CUBESATS
ISS
ROCKETS
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

Balloon Program


HPD Sunrise payload



Pointing tests of APD XL-Calibur payload

Campaigns cancelled due to COVID-19: Spring 2020 (New Zealand), Summer 2020 (Palestine TX), Fall 2020 (Ft Sumner NM), Winter 2020 (Antarctica), Spring 2021 (New Zealand), and Winter 2021 (Antarctica).

Successfully demonstrated Return to Flight using COVID-safe procedures with Spring and Fall **Ft Sumner NM** campaigns in 2021 launching 10 missions with 4 piggy-backs.

Wanaka, New Zealand super-pressure balloon campaign (Mar-May) launch attempt resulted in an abort due to an anomaly in non-NASA ground support equipment. For Spring 2023 two science missions planned for Wanaka.

Sweden Campaign is ongoing with two science payloads: Sunrise (heliophysics) and XL-Calibur (astrophysics) plus a 60 MCF qualification test flight. First Launch expected for Mid June.

The Fall **Fort Sumner, NM Campaign**, with launch window opening in Aug, has 9 missions plus 7 piggy-backs on the manifest.

The **Antarctica 2022/2023** long-duration balloon campaign has two science missions: SPIDER (astrophysics) and AESOP-lite (heliophysics) on the manifest. Due to delays in meeting payload milestones, the GUSTO mission slipped to the Antarctica 2023/2024 manifest.

Australia Sounding Rocket Campaign

XQC (X-ray Quantum Calorimeter Experiment)

PI – D McCammon / Univ. Wisconsin (ELA) **2022-06-26**

The purpose of this mission is to measure the spectrum of the diffuse X-ray emission from the interstellar medium over the energy range 0.07 to 1 keV.

SISTINE (Sub-orbital Imaging Spectrograph for Transition Region Irradiance from Nearby Exoplanet Host Stars)

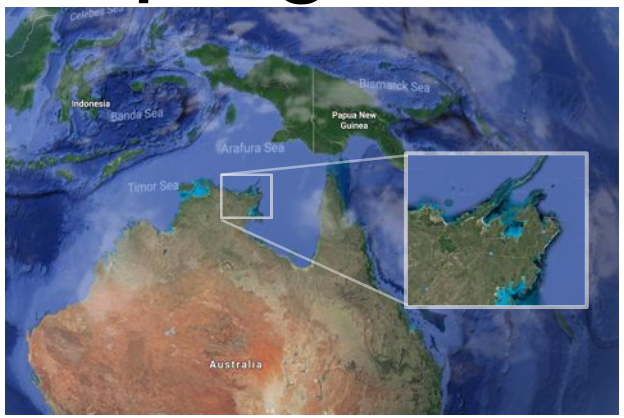
PI - K. France / Univ. Colorado (ELA) **2022-07-04**

Measurements UV spectra of M and K type dwarf stars. Goals assist in identification and characterization of nearby habitable exoplanets and advance TRL for future missions, such as LUVOIR.

DEUCE (Dual-channel Extreme Ultraviolet Continuum Experiment)

PI – I. Fleming / Univ. of Colorado (ELA) **2022-07-12**

Technology development for future UV missions, physics of re-ionization from B stars at extreme UV.

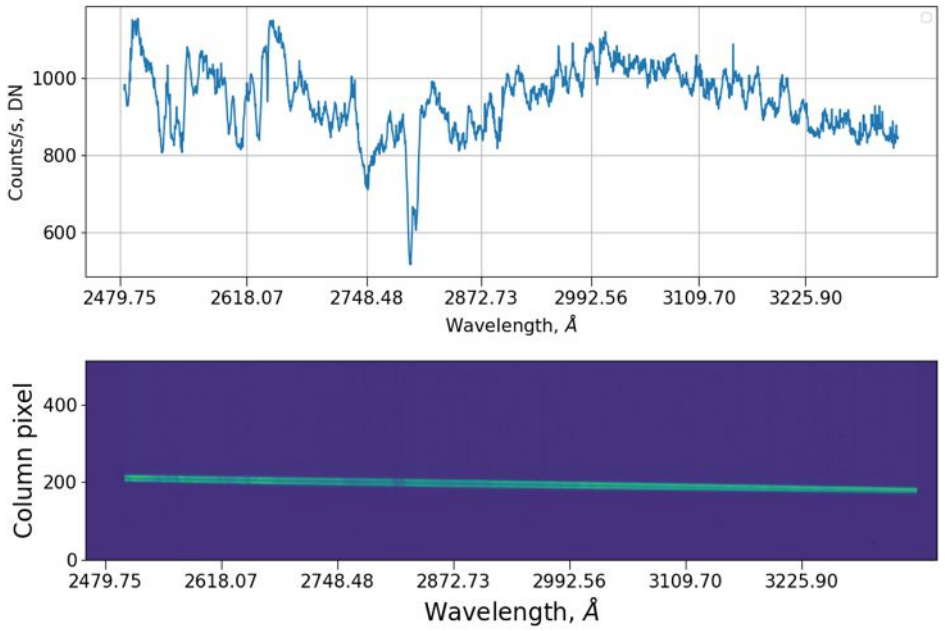


Equatorial Launch Australia (ELA) is a commercial launch site
near Arnhem, Northern Territory
Launches planned for Jun/Jul 2022

Images from the RSPO Site set-up travel in Oct 2021.

Colorado Ultraviolet Transit Experiment (CUTE) In Science Operation

- 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

LuSEE Night

LuSEE Night Details

Lead Developer Org: U. California at Berkeley

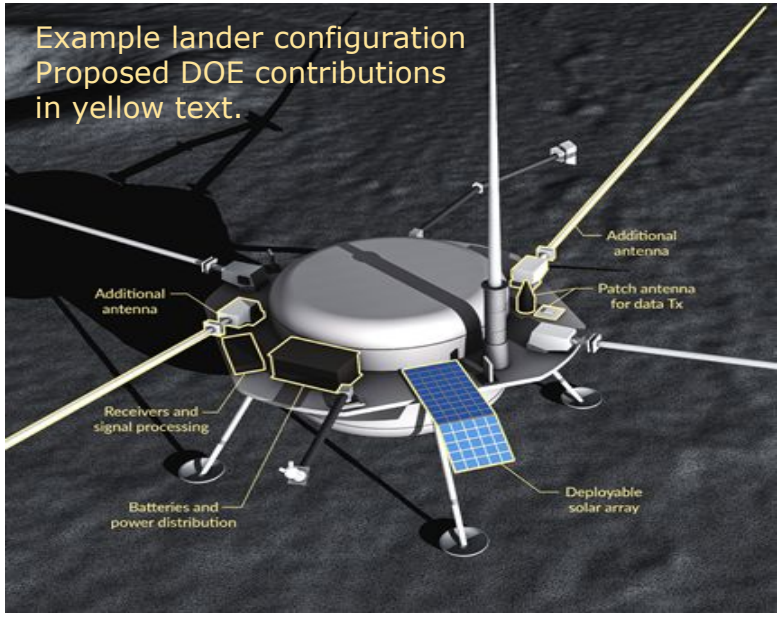
LuSEE Payload PI: Stuart Bale

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

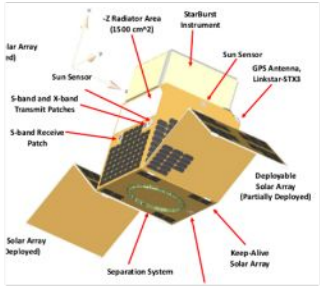
- Pathfinder mission to understand the moon's radio environment & potentially make the first-ever measurement of the Dark Ages
- Capability to measure the radio environment and observe the long-wavelength radio signal through the lunar night
- Place the most sensitive constraints on the Dark Ages signal 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

Astrophysics Pioneers

- A new class of small missions solicited annually in ROSES. Includes SmallSats, CubeSats >6U, major balloon payloads, modest ISS attached payloads, and cis-lunar payloads (via CLPS); $20M maximum PI cost cap
- Fills in the gap between existing ROSES investigations (<$10M for APRA) and existing Explorers MO investigations (~$35M for SmallSats)

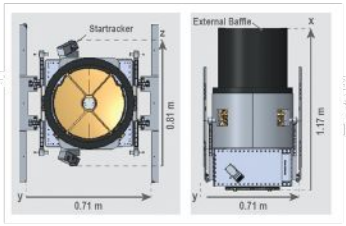
Astrophysics Pioneers – Cycle 1 Selections

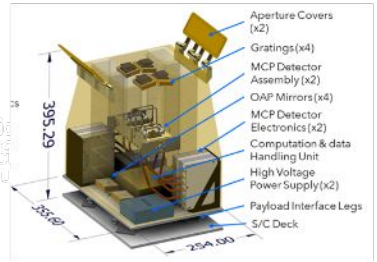
PUEO: A Long-duration Balloon-borne Instrument for Particle Astrophysics at the Highest Energies (PI Abigail Vieregg, U. Chicago) APPROVED for DEVELOPMENT



StarBurst: Gamma-ray ASM, Simultaneous detection of NS/NS mergers with LIGO (PI Daniel Kocevski, NASA MSFC) APPROVED for DEVELOPMENT

Pandora: Multiwavelength Characterization of Exoplanets and their Host Stars (PI Elisa Quintana, NASA GSFC) APPROVED for DEVELOPMENT





Aspera: IGM Inflow/outflow from galaxies via OVI 10^5K emission line imaging (PI Carlos Vargas, U. Arizona) APPROVED for DEVELOPMENT

- ROSES-2020, 24 Proposals, 4 selected, all 4 passed gate review!
- ROSES-2021, 18 proposals received, review completed, selections soon
- ROSES-2022 proposals due March 16, 2023

Imaging X-ray Polarimetry Explorer (IXPE)

Launched Dec 9

Boom deployed Dec 15

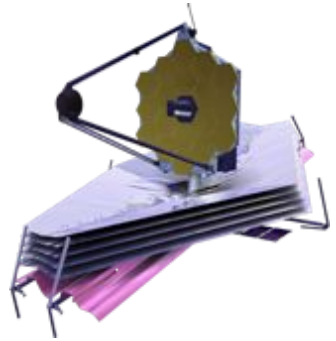
Science started Jan 10

Special Session on IXPE Initial Results
Tuesday 14 June, 8:30 am in Con Rm 101

- Positive, statistically significant detections of polarization!
  - CAS-A, 4U 0142, Mrk 501, Crab and Vela pulsar wind nebulae, Her X-1
  - Discovery papers to Nature, Science, and the Astrophysical Journal are in progress and/or have been submitted

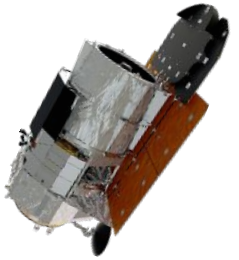
Today's Flagships have higher Science/Dollar

Hubble cost ~$3B (not including servicing missions)



If we started Hubble in 2007, it would have cost $8.3B in inflated dollars

We started Webb in 2007, it cost $9.9B*, and it has ~10x the collecting area of Hubble



If we started Hubble in 2016, it would have cost $9.7B in inflated dollars

We started Roman in 2016, it will cost $4.3B*, and it has the same collecting area and 100x the field-of-view of Hubble

Today's flagships benefit from decades of investment in technology and capabilities across NASA and the aerospace industry

* Including COVID adjustments

July 2019 presentation to Astro2020 Steering Committee