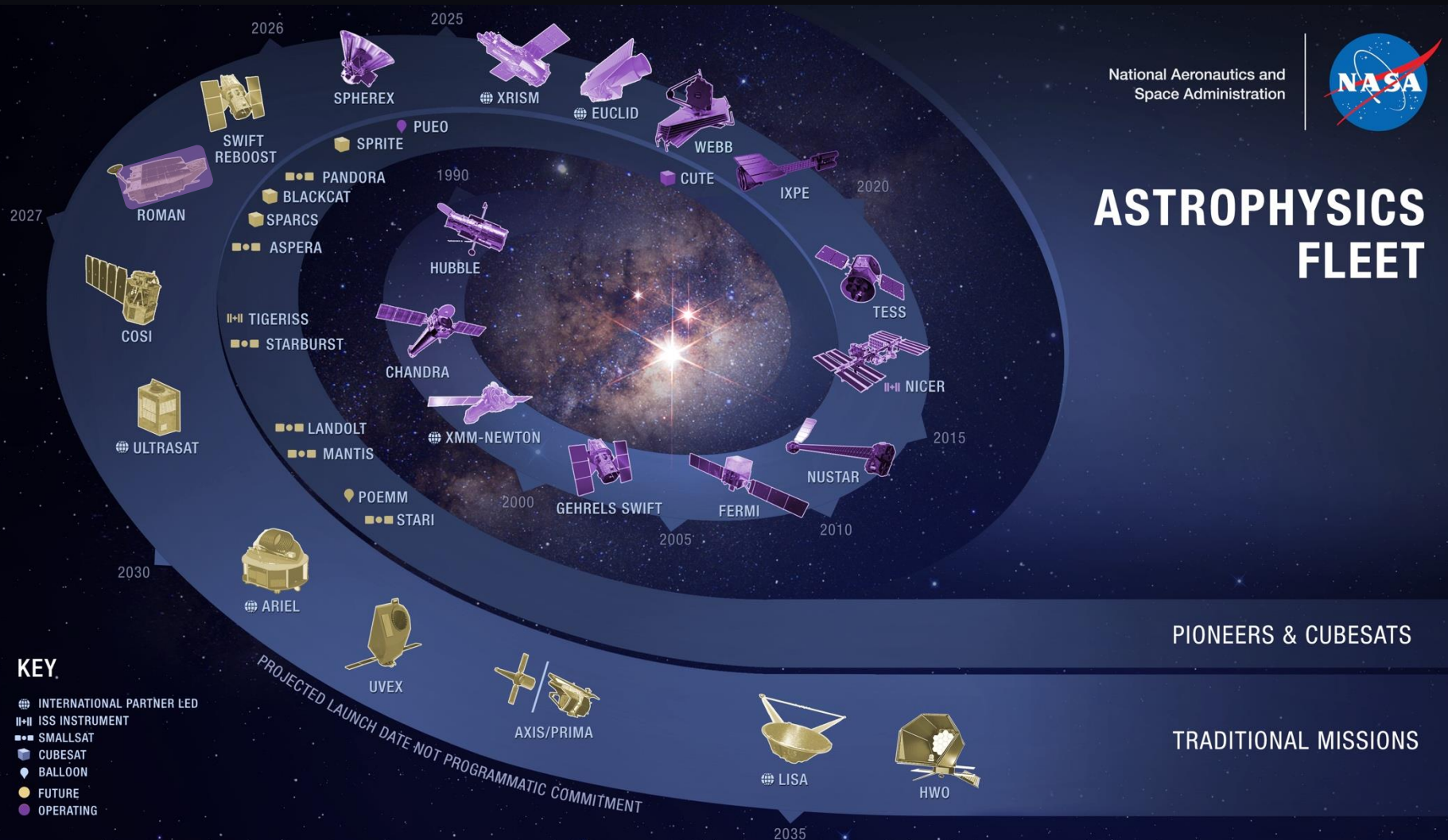

Ground- and Space-Based Astronomy in the 2030s/2040s

Dr. Tiffany Kataria
(JPL/Caltech)

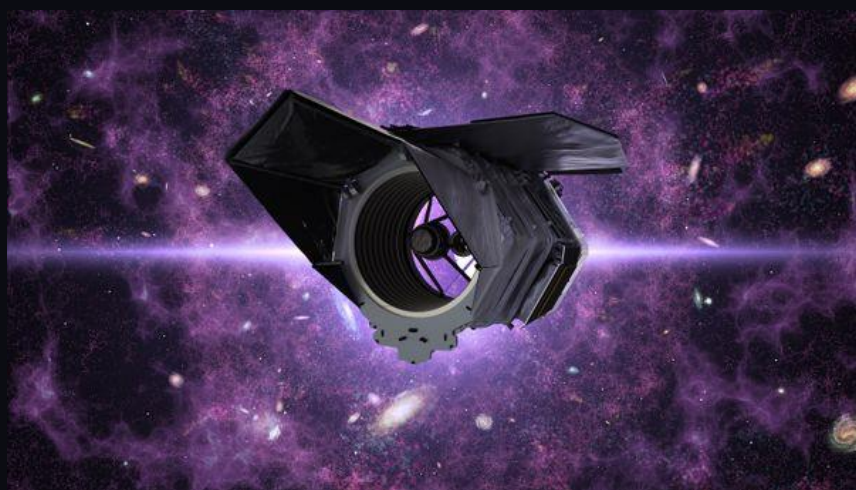
With thanks to: Rob Petre, Mercedes Lopez-Morales, Emma Loudon,
Eleanora Alei, Lia Corrales, Erika Hamden, Takahiro Sumi, Ana Inés
Gómez de Castro

Current (Space-Based) Astrophysics Fleet



Fleet balanced across new and extended missions anchored by legacy flagships ([Hubble](#), [Chandra](#), [Swift](#), [JWST](#)) and the survey influx coming online ([Roman](#), [Euclid](#), [Rubin](#), [Ariel](#)). Enabled by major international partnerships!

Graphic from Jessica Gaskin

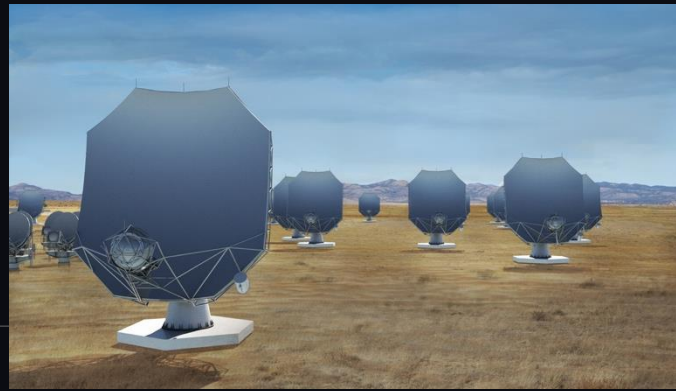


The 2030s landscape: A focus on depth, breadth and cadence

	Space Facilities	Ground Facilities	Notable Capabilities
Flagships and Large Telescopes	JWST (extended), Roman (extended) HWO (Phase A), Athena, LISA, X-ray Flagship?	30-m telescopes (GMT, TMT, E-ELT), Advanced LIGO / Virgo / KAGRA (2G+ upgrades), SKA Phase 1.	Sub-mas angular resolution & coronagraphy; deep faint-target spectroscopy.
Medium- and Probe-Class Missions	UVEX, Ariel, PLATO, PRIMA(?)	8–10m telescopes (Keck, VLT, Gemini, Subaru), CTA, CCAT-Prime, ALMA	Wide field-of-view survey mapping, population statistics.
Smallsats, Pioneers, Arrays	Pandora, Aspera, StarBurst, TIGERISS, SPARCS, SPRITE, COSI	Rubin, LFAST, Argus, DSA	Continuous time-domain monitoring & fast-transient observations.

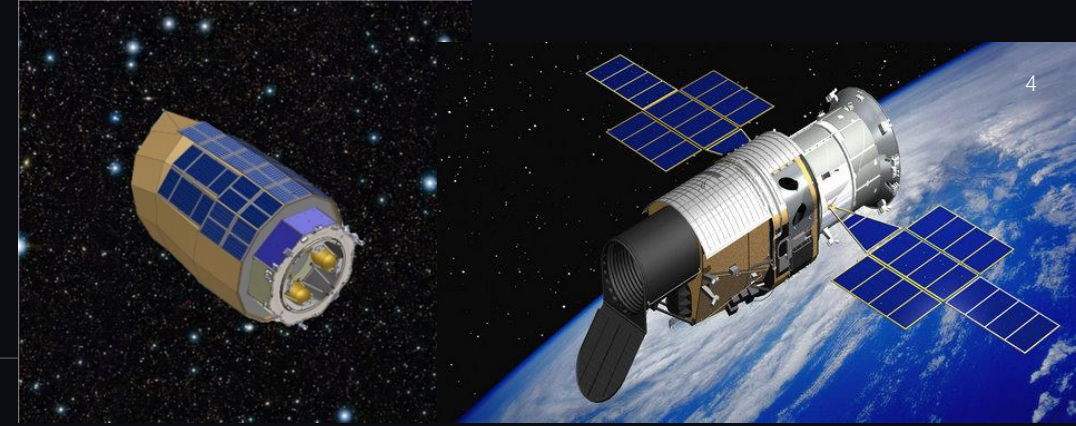
How will the landscape shift in the 2040s?

- As HWO anchors optical/UV space astronomy in the 2040s, how do 3G gravitational-wave detectors and ELTs reframe the remaining flagship discovery space?
- What key wavelength gaps will persist across the transition from retiring flagships to incoming Probe-class missions?
- To what extent can high-element ground arrays and SmallSat networks offload survey science from 2040s flagships?



	Space Facilities	Ground Facilities
Flagships and Large Telescopes	JWST and Roman retired? HWO (Operations), LISA (extended), Astro2030-prioritized flagship	ELTs (2nd-gen), 3G GW (Cosmic Explorer, Einstein Telescope), SKA Phase 2, ngVLA.
Medium- and Probe-Class Missions	2030s Probe selections? regular Explorer cadence?	Upgraded 8–10m network, CMB-S4, CTA, ALMA upgrades.
Smallsats, Pioneers, Arrays	Rideshare telescopes? Smallsat networks? Lunar payloads?	DSA-2000...

The Diversifying Astrophysics Backdrop



Category	Key Initiatives & Facilities	Strategic Implication
Industry	• Commercial satellite buses (e.g, Rocket Lab, Apex) • CLPS lunar landers • Heavy-lift launch (e.g,Starship, Vulcan, New Glenn)	Shifts budgets away from bespoke spacecraft engineering toward pure instrument development and faster mission cadences.
Other gov't agencies	• Dept. of Energy / DOE (e.g, Rubin LSST Camera, DESI, CMB-S4) • DoD / Space Force / DARPA (e.g,Space Domain Awareness, optical comms)	Lowers mission costs by leveraging interagency funding and defense production volume.
Philanthropic & Private Initiatives	• Schmidt Sciences (e.g, Lazuli, Argus, DSA, LFAST) • Simons Foundation • Breakthrough	Funds medium-scale observatories faster than traditional decadal cycles.
International Agencies	• JAXA (e.g., LiteBIRD) • China / CNSA (e.g., Xuntian CSST, eXTP, Tianlin concept) • ISRO (e.g., XPoSat)	Presents both competitive pressure for discovery space and opportunities for joint facilities.

Questions for the 2030s/2040s: Science and Operational Strategies

Maximizing Scientific Yield

- What strategies maximize science in a static budget environment?
- How do we balance capabilities (e.g., wide-field survey speed, deep spectroscopy) across ground- and space-based facilities?

Launch & Servicing Architectures

- How will larger rocket payloads lower complexity/cost of manufacturing space optics?
- What role should L2/GEO robotic servicing play in extending probe and flagship lifespans?

LEO Satellites & Orbit Selection

- How will constellations alter orbit selection for future telescopes?
- How can commercial rideshares expand launch cadences for SmallSat, CubeSat, and Pioneer payloads, freeing up funding for larger missions?

Lunar Surface & Farside Infrastructure

- What unique observational opportunities does the lunar farside unlock for sub-30 MHz radio science?
- To what extent can the lunar surface enable long-baseline interferometry unreachable from LEO?

Questions for the 2030s/2040s: Workforce, Institutions, Data

Workforce

- As small missions commercialize and flagships stretch to decades, where do early-career researchers gain end-to-end mission leadership experience?
- How does academic astronomy retain top technical and data talent against tech and aerospace competition?

Open Science

- How do we maintain open-access science policies when partners operate under conflicting data restrictions?
- As software pipelines and data archives grow more centralized, how do we ensure access for smaller institutions with limited resources?

Partnerships

- In a landscape spanning global agencies, commercial space, and private philanthropy, what criteria should dictate where we compete versus where we co-invest in major facilities?
- How do we integrate non-traditional and commercial capabilities into strategic missions without relinquishing community-driven science?

AI and Autonomy

- How do we prevent automated triage pipelines from filtering out unexpected physics?
- What operational architectures are needed to transition 2040s space observatories into autonomous, multi-messenger networks?

Aspects to Consider for ASTRA and the Decades Ahead

Synergy between the Ground and Space

HWO anchors the 2040s landscape. Payloads launched pre-HWO, as well as probes and flagships operating alongside and after, should be designed to maximize its science yield or cover the physics outside HWO's capability.

Maintaining a balanced portfolio across ground and space, spanning a range of telescope sizes, scales, and science scopes, remains essential for maximizing scientific return.

Co-Evolving Science & Technology

Scientific discovery and technological capability exist in a continuous feedback loop. Emerging technology unlocks unexpected science, while new physics questions push hardware limits.

Commercial buses, heavy-lift launch vehicles, and modular architectures grant unprecedented flexibility in how we design and deploy hardware in space.

A Broadening Astrophysics Backdrop

Philanthropic entities, international agencies, industry and other gov't agencies are developing missions with overlapping and competitive capabilities alongside NASA.

Success across the 2030s and 2040s relies on recognizing this changing backdrop and identifying complementary strengths across traditional and non-traditional facilities.

Call for ExoExplorer Applications

[Welcome](#) | [Organizers](#) | [Events](#) | [Presentations](#) | [Meet the ExoGuides](#) | [Meet the ExoExplorers](#) | [Call for ExoExplorer Applications](#) | [Call for ExoGuide Nominations](#)



The ExoExplorers program, sponsored by NASA's Exoplanet Exploration Program Office and the ExoPAG Executive Committee, will focus on the professional development of 10 “ExoExplorers” (early career researchers who are either PhD candidates or postdoc researchers within 2 years of completing their PhD) at US and international¹ institutions. Each member of the cohort will be featured in a webinar that will be live-streamed to the exoplanet community and posted to the ExoExplorer's presentation archive, helping to increase their visibility within the field. The cohort will also learn from the experiences of established exoplanet researchers and engineers in the field (“ExoGuides”) via a combination of tailored presentations and small group discussions.

Applications Now Open!

Applications are due **Thursday, October 15th, 2026 at 6 PM Pacific** and should be submitted using [this Google Form](#).

Questions about the program?

Ask exoexplorers_questions@jpl.nasa.gov
Please also see the FAQ page.



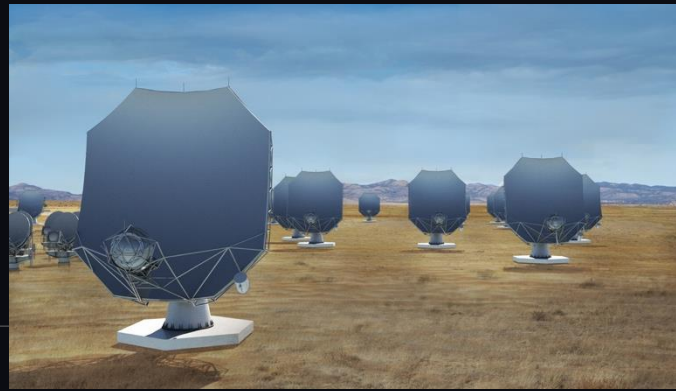
Jet Propulsion Laboratory
California Institute of Technology

jpl.nasa.gov

Landscape in the 2030s

	Key Facilities	Primary Capabilities	Primary Science
Flagships and Other Large Telescopes	JWST (extended), Roman, GMT, TMT, E-ELT, HWO (phase A)	Sub-mas angular res; high-contrast coronagraphy; deep spectroscopy.	Provides direct imaging and characterization of faint, individual targets.
Medium- and Probe-Class missions	UVEX, PRIMA, Lazuli, PLATO.	Wide field-of-view; single-waveband mapping; statistical population samples.	Acts as the strategic engine, solving population-scale physics and feeding targets to flagships.
Smallsats and Arrays	LFAST, Argus, DSA, COSI, Pioneers.	Continuous temporal monitoring; unconstrained pointing; sub-minute slews.	Tracks stellar variability and captures rapid transient events flagships miss.

How will the landscape shift in the 2040s?



Messenger / Domain	Key Facilities	Wavelength/Frequency	Primary Science	Unaddressed Gaps
Optical / Near-IR	Mature ELTs (GMT, TMT, E-ELT), HWO	0.3-2.4 μm (ground) 0.1-2.4 μm (space)	High-contrast exoplanet atmospheric characterization, biosignature searches around all stellar types.	Dedicated UV spectroscopy to complement ELT and HWO observations
Radio / Sub-mm	SKA Phase 2, ngVLA, CMB-S4, ALMA upgrades	50 MHz-116 GHz 30-300 GHz	Mapping cold gas reservoirs, dust masses, and 21-cm power spectra.	Sub-30 MHz radio coverage to complement ground-based array observations
Gravitational Waves	Cosmic Explorer, Einstein Telescope, LISA	1 Hz – 10 kHz (ground) 10^{-4} - 10^{-1} Hz (LISA)	Tracking compact object mergers across the full mass range.	Decahertz GW coverage (0.1–10 Hz) to bridge LISA and ground-based detectors
High Energy, X-ray & Neutrinos	CTA, IceCube-Gen2, eXTP, X-ray flagship	0.1–10 keV (X-ray) 25 GeV-200 TeV 100 TeV-10 PeV neutrinos	Probing extreme shocks, relativistic jets, and cosmic particle acceleration.	X-ray and MeV coverage to bridge existing facilities (Chandra, XMM) and 2040s flagships