NASA Develops Technology Today to Enable Breakthrough Observations Tomorrow

The Cosmic Origins (COR) and Physics of the Cosmos (PCOS) Programs mature critical technologies for space observatories that seek to answer these questions:

How Did We Get Here? How Does the Universe Work?

The Strategic Astrophysics Technology (SAT) Program supports technology development for strategic missions that observe throughout the entire electromagnetic spectrum, as well as gravitational waves

The COR and PCOS Programs Support Strategic Mission Studies

The COR and PCOS Programs, along with the Exoplanet Exploration Program (ExEP), work with four Science and Technology Definition Teams (STDTs), each studying a large-mission concept for the 2030s and beyond to inform the next astrophysics Decadal Survey. Lynx operates at X-ray wavelengths. The Origins Space Telescope (OST) is a far-IR mission. The Large UV/optical/IR Surveyor (LUVOIR) has a joint focus on general astrophysics and exoplanet science. As indicated by its name, the priority science goal of the Habitable Exoplanet Observatory (HabEx) is exoplanet science using visual and IR wavelengths. In addition to these four, NASA is participating in the Laser Interferometer Space Antenna (LISA), a European Space Agency (ESA) gravitational-wave mission.

How can you influence the technology priorities for NASA? The Programs' technology gap prioritization process was carried out annually until 2017. The gaps and their priorities, as established by our Technology Management Boards (TMBs), were published in the COR and PCOS Program Annual Technology Reports (PATRs). Following new guidance from NASA's Astrophysics Division, the gap prioritization cadence is now biennial, with the next prioritization to be conducted in late 2019, incorporating technology gaps identified in the 2019 final reports of the large-mission STDTs. In place of the PATRs, the three Program Offices will collaborate on a joint, high-level, Astrophysics Biennial Technology Report (ABTR), which will report gap priorities along with technology-related highlights. You can participate in this process by submitting a technology gap entry by June 1, 2019 for prioritization. Gap submission forms are available on our website (see bottom right of the poster).

COR and PCOS Program Annual Technology Reports (2011-2017) and Astrophysics Biennial Technology Reports (2019 and beyond)

- Overview of the Programs and their technology development activities
- Status of the Programs' strategic and targeted technology development
- Prioritized list of technology gaps to inform Program technology planning and SAT proposal calls and selection decisions

PATRs from 2011 through 2017 can be found on our website (see bottom right of the poster). The detailed PATRs are being phased out and replaced with the ABTR, a biennial brochure that will be published starting 2019, and will provide:

- Highlights of Program technology development activities and successes for the prior two years
- Prioritized list of technology gaps to inform Program technology planning and SAT proposal calls and selection decisions

Full details of technology gaps and progress reports of our technology investments will be posted annually on our website, with PI status reports and quad charts available via AstroTech, our new searchable database.

Other Strategic COR and PCOS Technology Investments

The Astrophysics Division is funding two Phase I industry projects studying segmented-mirror telescope technology from a system perspective, in support of potential implementation of LUVOIR, OST, and/or HabEx. These one-year projects are planned to be followed by larger studies through Phases II, III, and possibly IV.

- ULTRA: Ultrastable Large Telescope Research & Analysis (Ball Aerospace & Technologies Corporation) PI: Scott Knight
- System-Level Segmented Telescope Design (Lockheed Martin, Inc.) PI: Larry Dewell

In addition to supporting technology development for the four strategic mission concepts and LISA, COR and PCOS invest in technologies for NASA contributions to ESA's Athena X-ray mission, and the Inflation Probe.

SAT Solicitations and Funding

Informed by the gap priority rankings, the SAT Program solicits technology-maturation proposals through the Research Opportunities in Space and Earth Sciences (ROSES) announcement of opportunity. SAT projects mature technologies at mid-range Technology Readiness Levels (TRLs 3-5), in preparation for eventual infusion into instruments, missions, and studies pursuing COR and PCOS science objectives. To date, 96 COR and 86 PCOS SAT proposals have been received, with 22 COR and 28 PCOS projects selected. To help develop and mature technologies for the challenging strategic missions of the future, we encourage you to respond to the SAT solicitation.

Notices of Intent are mandatory and are expected to be due in late January 2019. Proposals are expected to be due by late March 2019.

The next Astrophysics Decadal Survey will recommend a Flagship mission to follow WFIRST. NASA is already developing enabling technologies for such a mission. To support this effort, please consider responding to the upcoming SAT solicitation.

Lynx

Lynx is setting its sights on black holes. It is designed to observe the birth of the first seed black holes in the farthest reaches of the universe; carry out a black hole census throughout the universe; and measure their impact on their interstellar, circumgalactic, intracluster, and intergalactic neighborhoods. Lynx will deploy a grazing-incidence telescope and X-ray detectors of unprecedented size and precision, allowing it to map hot gas around galaxies and in the Cosmic Web, to trace stellar activity including its effects on planet habitability, and to transform our knowledge of the endpoints of stellar evolution. To achieve these challenging goals, the Lynx STDT submitted to the PCOS TMB a list of technology gaps. The TMB placed the following of these into the top two priority tiers:

- High-resolution, large-area, lightweight X-ray optics
- Large-format, high-spectral-resolution, small-pixel X-ray focal plane arrays
- Fast, low-noise, megapixel X-ray imaging arrays with moderate spectral resolution
- High-efficiency X-ray grating arrays for high-resolution spectroscopy
- Non-deforming X-ray reflective coatings
- Long-wavelength-blocking filters for X-ray micro-calorimeters

Origins Space Telescope

Seeking to trace the history of our origins from the time dust and heavy elements permanently altered the cosmic landscape to present day life, OST will study light from distant galaxies, protoplanetary disks, and exoplanets at mid- and far-IR wavelengths. OST will improve on the Herschel Space Observatory with at least 1000× higher sensitivity, improved angular resolution, and new spectroscopic capability. To achieve these and related goals, the OST STDT identified several gaps between our current technological capabilities and those needed for a successful mission. Of those gaps, the COR TMB placed the following in the top two priority tiers:

- Large-format, low-noise and ultralow-noise far-IR direct detectors, and associated readout electronics
- Ultra-stable mid-IR detectors
- Heterodyne far-IR detector arrays and related technologies
- Large cryogenic optics for the far-IR
- Advanced cryocoolers
- High-performance, sub-Kelvin coolers
- Compact, integrated spectrometers for 100 to 1000 μm
- Cryogenic deformable mirror

Laser Interferometer Space Antenna

LIGO's dramatic February 2016 announcement of the first-ever detection of gravitational waves opened a new window to observe some of the most extreme phenomena in the universe, such as rapidly orbiting massive binary black holes. LISA, decades in the making, is a gravitational-wave observatory planned to be launched in the 2030s by ESA with NASA participation. This challenging observatory will be the largest experiment ever constructed by humanity, with three spacecraft flying in a triangular formation more than 1.5 million miles on a side, following the Earth in its orbit around the sun. When a gravitational wave traverses this constellation of satellites, it deforms space, minutely changing the separation between satellites. Such a measurement requires that we close a range of technology gaps. The LISA Study Team submitted a list of such gaps to the PCOS TMB, which placed the following into the top two priority tiers:

- High-dimensional-stability low-scattered-light telescope
- Low-mass, long-term-dimensional-stability optical bench
- Precision low-noise micro-newton thrusters
- High-power, narrow-line-width laser sources
- Phase-measurement system (PMS)
- Non-contact charge control for Gravitational Reference Sensors (GRS)

Large UV/Optical/IR Surveyor

LUVOIR is intended to follow in the footsteps of the Hubble Space Telescope as a large space observatory covering wavelengths from the far ultraviolet (far-UV) to the near infrared (near-IR). This mission would enable great leaps forward in a broad range of science, from the epoch of reionization, through galaxy formation and evolution, star and planet formation, to solar system remote sensing. LUVOIR also has the major goal of characterizing a wide range of exoplanets, including those that might be habitable, or even inhabited. Achieving the latter goal requires a large telescope with extreme stability and a means to occult the light from the bright star around which a faint exo-Earth orbits. These technologies are pursued by ExEP. LUVOIR's general astrophysics program also requires closing some technology gaps identified by the STDT and placed in the top priority tier by the COR TMB are:

- Large-format, high-dynamic-range UV detectors
- High-reflectivity broadband far-UV-to-near-IR mirror coatings

The following LUVOIR gaps tied for the top 1st, 2nd, or 3rd ExEP priority score:

- Coronagraph demonstrations and modeling
- Deformable mirrors
- Large aperture primary mirrors
- Mirror segment phasing, sensing, and control
- Telescope vibration sense/control or reduction
- Ultra-low-noise near-IR detectors
- Ultra-low-noise visible detectors
- Wavefront-sensing and control

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For more information, visit our technology page at https://apd440.gsfc.nasa.gov/technology