Astrophysics Program Office

Technology Gap Prioritization Process: Astrophysics Biennial Technology Report 2021

Presentation for the COPAG QUEST Series

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Presentation Outline

- Overview of Astrophysics Division's (APD) strategic technology development
- Objectives and purposes of gap prioritization
- Technology gap prioritization process
- Gap submission guidelines
- 2019 results as a starting point for 2021
- Takeaways

NASA Astrophysics Funds all Levels of Technology Maturity to Enable Future Missions

- **Astrophysics Research and Analysis (APRA) program** solicits basic research proposals relevant to NASA's astronomy and astrophysics programs, from basic principles through flight missions (Technology Readiness Level, TRL, 1 through 9). Includes suborbital investigations (balloons, sounding rockets). Up to five years award duration.
- **Strategic Astrophysics Technology (SAT) program** matures key technologies that address the needs of future strategic missions, taking them from proof of concept through validation in relevant environment (TRL 3 to 6). Two- or three-year award duration.
- **Flight projects** address the final maturation stages (TRL 6 through 9) proving technology flight-worthiness for a mission-specific application.

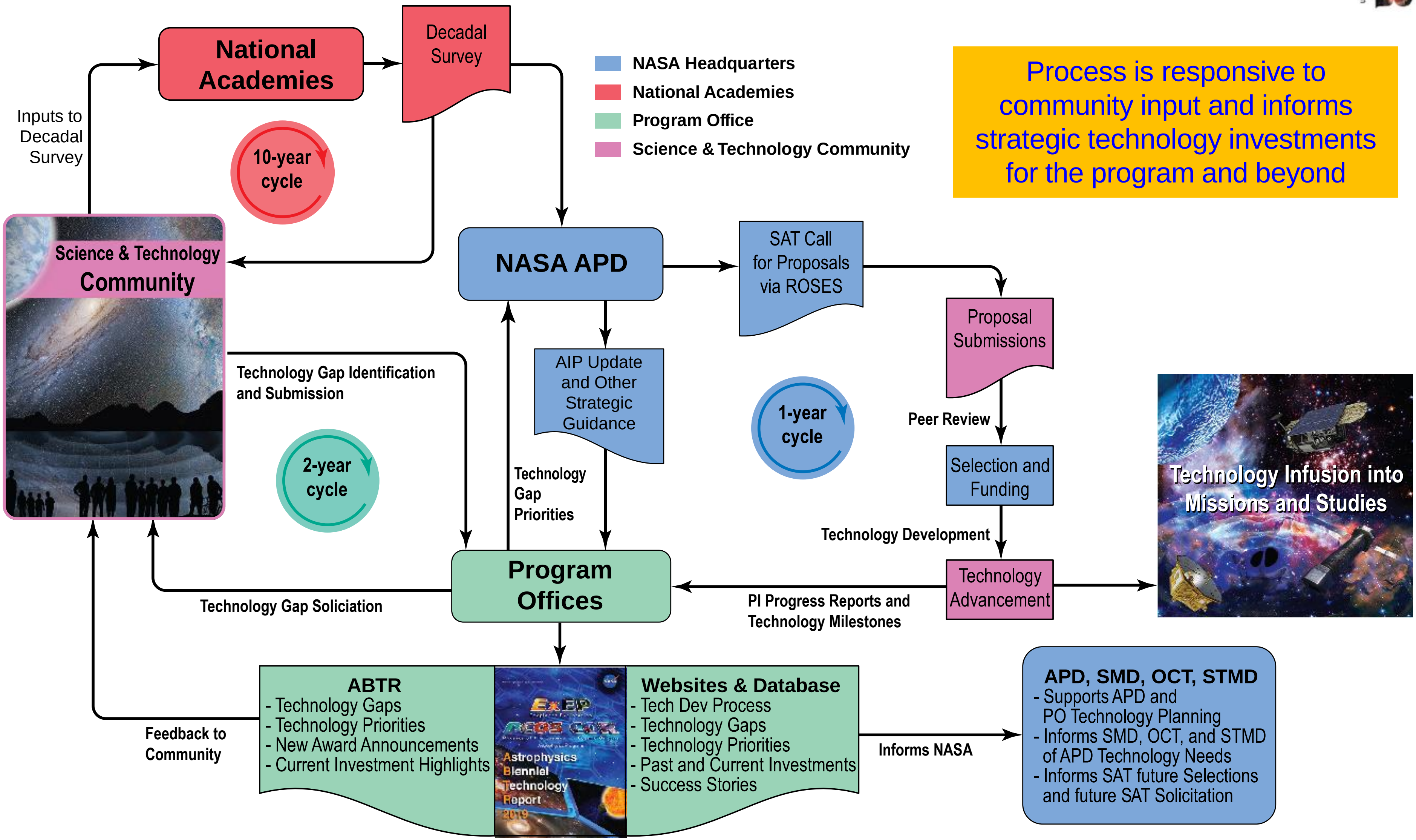
Tech gap prioritization informs APD strategic technology investments

Strategic Technology Development Sequence

1. **Decadal Survey**	Prioritizes the science
2. **Astrophysics Division**	Develops an implementation plan
3. **Astrophysics community**	Identifies strategic technology gaps
4. **Tech Management Board**	Prioritizes technology gaps
5. **Astrophysics Division**	Solicits and makes investments
6. **Astrophysics community**	Develops and matures technologies
7. **Program Offices**	Monitor, track, and advocate for technology developments

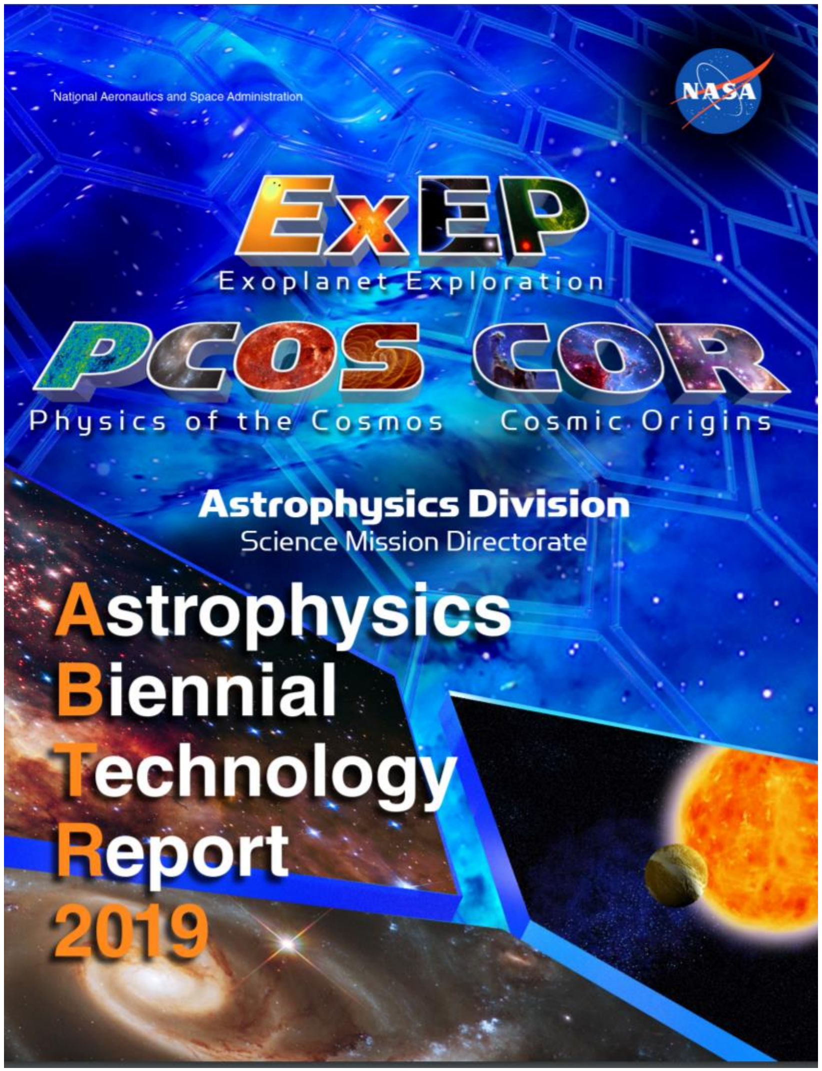
Technology gap identification is a critical step in our process

Strategic Technology Development Flow



ABTR = Astrophysics Biennial Technology Report

What is the ABTR?



Click here to see the 2019 ABTR

The Astrophysics Biennial Technology Report (ABTR) is published every other year, that summarizes APD technology development activities over the prior two years

- Provides an overview of APD technology development activities and processes (“big-picture” investment summary and metrics)
- Lists current technology development portfolios, highlights significant progress, identifies technology infusions, and announces new SAT award selections, if any
- Provides a prioritized list of technology capability gaps to inform SAT proposal calls and selection decisions for the coming two years, as well as future technology development planning

Objectives and Purposes of Technology Gap Prioritization

- **Objectives**
  - Identify technology gaps applicable and relevant to APD strategic objectives as described in the Decadal Survey and Astrophysics Implementation Plan (AIP)
  - Rank these technology gaps with respect to strategic alignment, benefits and impacts, urgency, and cross-cutting capabilities

- **Purposes**
  - Inform the SAT solicitation and other NASA technology development programs (APRA, SBIR, and other SMD, OCT, and STMD activities)
  - Inform technology developers of APD technology gaps to help focus efforts
  - Inform selection of technology awards to align with APD goals and science objectives
  - Improve transparency and relevance of APD technology investments
  - Inform the community and engage it in our technology development process
  - Leverage technology investments of external organizations by defining our strategic technology gaps and identifying NASA as a potential customer

Technology Gap Prioritization Process

1. **Technology gaps are solicited from the community**
   - Usually due June 1 of the prioritization year, but due to Astro2020 release schedule, this year it is due 3 weeks after that release
2. **Program Office (PO) staff review the gap inputs and assign each to the Program that would be most impacted by closing it**
3. **Each PO consolidates the inputs for its Program and asks its community to review the gaps for accuracy and completeness before prioritization**
4. **A Technology Management Board (TMB) reviews and prioritizes the technology gaps**
   - TMB membership is diverse and includes senior members of APD and POs, STMD, and subject matter experts
   - Prioritization is based on a published set of criteria that addresses strategic alignment, benefits and impacts, urgency, and scope of applicability
   - Prioritization is done with participation of technologists and scientists from all three POs
5. **The prioritized gap list will inform the SAT solicitation amendment in Sep, be posted on POs' websites, and published in the ABTR**

The community plays a crucial role in the prioritization process

Four Prioritization Criteria

- **Strategic Alignment:** How well does the technology align with astrophysics science and/or programmatic priorities set out in the Decadal Survey and Astrophysics Implementation Plan?
- **Benefits and Impacts:** How much impact does the technology have on applicable missions? To what degree does it enable and/or enhance achievable science objectives, reduce cost, and/or reduce mission risks?
- **Urgency:** Given the anticipated difficulty of maturing from current TRL of a full solution to TRL 6, assessed against the time available until anticipated launch and/or other schedule drivers, how urgently does the gap need to be addressed?
- **Scope of Applicability:** How crosscutting is the technology? How many Astrophysics programs and/or mission concepts (strategic or other) would benefit by closing the gap?

Gap Submission Guidelines

1. Focus on technology gaps associated with missions prioritized in Astro2020 and/or Astrophysics Implementation Plan
2. Submit technology gaps directly applicable to Program objectives. Don't include gaps that are not in our purview such as ones associated with launch vehicle, rover, avionics, spacecraft systems, etc.
3. Don't include gaps that don't require technology development, that are not well defined, that are redundant (duplicate, similar, or subsets of existing gaps), or where solutions are at TRL 6 or higher for the relevant strategic mission(s)
4. Inputs should be submitted as gaps between the current state-of-the-art and what's required to achieve the science objective targeted, not specific solutions
5. Inputs should not endorse or advertise any organization, mission, or person
6. Inputs should not contain proprietary, or EAR/ITAR-restricted information

Full details are provided in the gap submission form instructions

Technology Gap Submission Form

Technology gap submission form can be downloaded here

1. Name of technology capability gap
2. Strategic Missions enabled or enhanced
3. Description of technology capability needed
4. Assessment of current state-of-the-art technologies, including their Technology Readiness Levels (TRLs) with justification
5. Description of quantitative/ measurable performance goals and objectives to fill this capability gap
6. Scientific, engineering, and/or programmatic benefits of achieving this capability (filling the "gap")
7. Potential applications and relevant mission(s) (not limited to strategic Astrophysics missions)
8. Urgency, estimated launch date or other schedule driver, complexity, and difficulty

Astrophysics Strategic Technology Gap Input Form

Technology Capability Gap Name:	Date Submitted:
Submitter Name:	Organization:
Telephone:	Email Address:

Prioritization Information (see accompanying instructions)

Identify Strategic Missions Enhanced or Enabled by Closing this Technology Gap:

☐ HabEx ☐ LUVOIR ☐ Lynx ☐ Origins ☐ IP ☐ SOFIA ☐ Other (write in below the mission name and reference where it is mentioned in Astro2020):

Brief Description of the Technology Capability Needed (100 – 150 words):

Assessment of the current State-of-the-Art (SOTA) and references justifying full-solution TRL quoted at right (100 – 150 words):	Estimated TRL of full solution addressing all key performance parameters of this gap:

Technical Goals and Objectives (Key Performance Parameters) to Fill the Capability Gap:

Scientific, Engineering and/or Programmatic Benefits (100 – 150 words):

Applications and Potential Relevant Missions for Astrophysics Division:

Urgency:

Years to estimated launch or other schedule driver:

Level of complexity (single tech, system of techs, or system of tech systems):

Level of difficulty (straightforward, stretch, or major stretch):

Sample Excerpt of Technology Gap Details

Astrophysics Program Offices

2019 Astrophysics Strategic Technology Gaps

View/download as PDF

Jump to : Tier 1 | Tier 2 | Tier 3 | Tier 4 | Tier 5

Gap Name	Description	Current State-of-the-Art	TRL SOTA	TRL Solution	Performance Goals and Objectives	Scientific, Engineering, and/or Programmatic Benefits	Applications and Potential Relevant Astrophysics Missions	Urgency
Large-Format, Low-Noise and Ultralow-Noise Far-IR Direct Detectors	The most important technology for the FIR/submillimeter is large-format detectors that operate with high efficiency (≥ 80%), low noise, and relatively fast time constant. Arrays containing thousands of pixels are needed to take full advantage of spectral information content. Arrays containing tens of thousands of pixels are needed to take full advantage of the focal plane available on a large, cryogenic telescope.	Kilopixel arrays at lower sensitivity are at TRL ~5, but demonstrated array architectures are lagging at TRL ~3. (Staguhn, 2018) Sensitive (noise-equivalent power .NEP, of low 10^{-19} W/√Hz), fast detectors (TES bolometers, and MKIDs in kilo pixel arrays) are at TRL 3.(Suzuki, 2015), (Baselmans, 2017)	3	3	Detector format of at least 10^4 pixels with high fill-factor and sensitivity (NEP) of ~1×10^{-19} W/√Hz are needed for wide-band photometry.(enabling) Detector sensitivities with NEP of ≈ 3×10^{-20} W/√Hz are needed for spectroscopy (enabling), available in a close-packed configuration in at least one direction. NEPs of 3×10^{-21} W/√Hz would enable background-limited sensitivity(Echternacht, 2018) (enhancing)	Sensitivity reduces observing times from many hours to a few minutes (≈ 100× faster), while array format increases areal coverage by ×10-100. Overall mapping speed can increase by factors of thousands. Sensitivity enables measurement of low-surface-brightness debris disks and protogalaxies with an interferometer. This is enabling technology. Suborbital and ground-based platforms can be used	FIR detector technology is an enabling aspect of all future FIR mission concepts, and is essential for future progress. This technology can improve science capability at a fixed cost much more rapidly than larger telescope sizes. This development serves Astrophysics almost exclusively (with some impact on planetary and Earth studies).	Need to demonstrate credibility before the 2020 Decadal Survey, and would require TRL 6 by mission PDR anticipated in the mid-2020s.

Full details of current gaps available here

2019 Technology Gap Priorities List

Tier 1 Technology Gaps
Angular Resolution (UV/Vis/NIR)
Coronagraph Contrast
Coronagraph Contrast Stability
Cryogenic Readouts for Large-Format Far-IR Detectors
Fast, Low-Noise, Megapixel X-Ray Imaging Arrays with Moderate Spectral Resolution
High-Efficiency X-Ray Grating Arrays for High-Resolution Spectroscopy
High-Resolution, Large-Area, Lightweight X-Ray Optics
Large-Format, High-Resolution, UV/Vis Focal Plane Arrays
Large-Format, High-Spectral-Resolution, Small-Pixel X-Ray Focal-Plane Arrays
Large-Format, Low-Noise and Ultralow-Noise Far-IR Direct Detectors
Large-Format, Low-Noise, High-QE Far-UV Detectors
Next-Generation, Large-Format, Object Selection Technology for Multi-Object Spectrometers for LUVOIR
Vis/NIR Detection Sensitivity

Tier 2 Technology Gaps
Advanced Millimeter-Wave Focal-Plane Arrays for CMB Polarimetry
Detection Stability in Mid-IR
Heterodyne FIR Detector Arrays and Related Technologies
High-Efficiency Object Selection Technology for UV Multi-Object Spectrometers
High-Performance Spectral Dispersion Component/Device
High-Reflectivity Broadband FUV-to-NIR Mirror Coatings
High-Throughput Bandpass Selection for UV/VIS
Large-Format Object Selection Technology for Multi-Object Spectrometers for HabEx
Starshade Deployment and Shape Stability
Starshade Starlight Suppression and Model Validation
Stellar Reflex Motion Sensitivity – Astrometry
Stellar Reflex Motion Sensitivity – Extreme Precision Radial Velocity

Tier 3 Technology Gaps
Advanced Cryocoolers
High-Performance, Sub-Kelvin Coolers
Large Cryogenic Optics for the Mid-IR to Far-IR
Long-Wavelength-Blocking Filters for X-Ray Micro-Calorimeters
Low-Noise, High-QE UV Detectors
Low-Stress, Highly Stable X-Ray Reflective Coatings
Photon-Counting, Large-Format UV Detectors
Polarization-Preserving Millimeter-Wave Optical Elements
UV Coatings
UV Detection Sensitivity
UV/Vis/NIR Tunable Narrow-Band Imaging Capability
Warm Readout Electronics for Large-Format Far-IR Detectors

Tier 4 Technology Gaps
Compact, Integrated Spectrometers for 100 to 1000 μm
Optical-Blocking Filters
Rapid Readout Electronics for X-Ray Detectors
Short-Wave UV Coatings

Tier 5 Technology Gaps
Advancement of X-Ray Polarimeter Sensitivity
Far-IR Spatio-Spectral Interferometry
High-Precision Low-Frequency Radio Spectrometers and Interferometers
Mid-IR Coronagraph Contrast
Ultra-High-Resolution Focusing X-Ray Observatory Telescope
Very-Wide-Field Focusing Instrument for Time-Domain X-Ray Astronomy
Wide-Bandwidth, High-Spectral-Dynamic-Range Receiving System for Low-Radio-Frequency Observations on the Lunar Far Side

Tiers are in descending priority order. Gaps within any given tier are considered equally prioritized which is why they are arranged alphabetically within each tier. Go here for more information.

Takeaways

- APD is prioritizing technology gaps this year, and gap inputs are accepted up to 3 weeks after the release of Astro2020
- Technology gap prioritization will be used to inform APD's strategic technology investments
- Refer to Astro2020, and review the 2019 gap list, to make your gap submission unique and relevant to APD's strategic plan
- The new technology gap priority list will be posted on POs websites and published in the 2021 ABTR

Thank you very much in advance for your support!